REGOLITH BENCHMARK ATLAS, GAWLER CRATON, SOUTH AUSTRALIA

Complied by M.J. Sheard

CRC LEME Openfile Report 210
Volume 1

June 2008

(PIRSA-Minerals and Energy Resources Group,
South Australia, Report Book, 2008/07)

CRC LEME is an incorporated joint venture between CSIRO-Exploration & Mining, and Land & Water, The Australian National University, Curtin University of Technology, University of Adelaide, Geoscience Australia, Primary Industries & Resources SA, NSW Department of Mineral Resources and the Minerals Council of Australia.

Headquarters: CRC LEME, C/o CSIRO-Exploration and Mining, PO Box 1130, BENTLEY WA 6102, Australia.

This report presents outcomes of a CRC LEME project involving the Department of Primary Industries and Resources, Adelaide, South Australia (PIRSA) that commenced in mid 2006 and continued until late 2007. There were no confidentiality agreements entered into regarding any aspects of this project or covering any primary data and images or derived data and images obtained during the execution of this project. All contents, data and samples associated with this report are open file items. All reference materials (regolith samples, thin and polished sections) have been retained by PIRSA at their Drill Core Storage Facility, 23 Conyngham St, Glenside, South Australia, 5065. Those materials can be viewed without restriction by prior arrangements with the Drill Core Storage Facility Manager [ph: (08) 8379 9574 ; Fax: (08) 8338 1925].

Electronic copies of the publication in PDF format can be downloaded from the CRC LEME website: http://crcleme.org.au/Pubs/OFRSindex.html. Information on this or other CRC LEME publications can be obtained from http://crcleme.org.au
Hard copies will be retained in the Australian National Library, the J. S. Battye Library of West Australian History, and the CSIRO Library at the Australian Resources Research Centre, Kensington, Western Australia.

Reference:
Sheard, M.J., 2008. Regolith Benchmark Atlas, Gawler Craton, South Australia. *CRC LEME Open File Report 210. PIRSA Report Book 2008/07*, Volume 1 201 pages.

Keywords
1. Regolith – South Australia. 2. Benchmarks – South Australia. 3. Central Gawler Gold Province – South Australia. 4. Christie Domain – South Australia. 5. Harris Domain – South Australia. 6. Nuyts Domain – South Australia.

ISSN: 1329-4768
ISBN: 1 921039 54X

Address and Affiliations of the Author:
M.J. Sheard
Principal Geologist
Cooperative Research Centre for Landscape Environments and Mineral Exploration,
C/- PIRSA, Minerals & Energy Resources Group, Geological Survey Branch,
GPO Box 1671, ADELAIDE SA 5001, Australia

Published by: CRC LEME, c/o CSIRO Exploration and Mining, PO Box 1130, Bentley, Western Australia 6102

Disclaimer

The user accepts all risks and responsibility for losses, damages, costs and other consequences resulting directly or indirectly from using any information or material contained in this report and attached maps. To the maximum permitted by law, CRC LEME excludes all liability to any person arising directly or indirectly from using any information or material contained in this report.

REGOLITH BENCHMARK ATLAS, GAWLER CRATON, SOUTH AUSTRALIA

Complied by M.J. Sheard

CRC LEME Openfile Report 210
Volume 1

June 2008

(PIRSA-Minerals and Energy Resources Group,
South Australia, Report Book, 2008/07)

Contents **Page**

Figure Listing V
Table Listing IX
Plate Listing XI
Abstract 1
Acknowledgements 2
Introduction 3
Background 3
Benchmarking 3
Benchmark Types 5
Type 1 5
Type 2 5
Type 3 5
Methods 7
Samples and maps 7
Regolith Profile Terminology 7
Relict Class 8
Bedrock 9
Saprock 9
Saprolite 9
Megamottles 9
Pedolith 10
Soils 10
Depositional Class 10
Erosional Class 11
BENCHMARKS 11
Harris Greenstone Domain 12
Lake Harris, NW corner 15
Benchmark 1, cored drillhole KLHRDD-1 15
***In situ* Regolith (greenstone)** 18
Transported Regolith 19
Petrography 21
Geochemistry 27
Distinguishing cover from basement 29
Basalt classification and prospectivity 29
Lake Harris Shoreline Silcrete 30
Benchmark 2, drillhole KOK 3 (drill cuttings) 31
***In situ* Regolith (Glenloth Granite)** 33
Transported Regolith 33
Geochemistry 34
Benchmark 3, weathered Glenloth Granite escarpment 36
Challenging Regolith Architecture 36
***In situ* Regolith (silcreted weathered granite)** 37
Geochemistry 39
Hopeful Hill 40
Benchmark 4, cored drillhole THHRDD-1 40
***In situ* Regolith (greenstone)** 43
Transported Regolith 44
Petrography 45
Geochemistry 51
Mullina Well 53
Benchmark 5, cored drillhole TMWRDD-1 53
***In situ* Regolith (greenstone)** 56
Transported Regolith 57
Petrography 61
Geochemistry 62

Continued

<u>Benchmark 6</u>, drillhole TAR 46 (drill cuttings) 66
***In situ* Regolith (gneissic granite)** 68
Transported Regolith 68
Geochemistry 69
Central Gawler Gold Craton 71
Boomerang Gold Prospect *(northern Central Gawler Gold Province)* 72
<u>Benchmark 7</u>, drillholes BG-47 & GB-47 (drill cuttings) 73
Background 73
***In situ* Regolith** 76
Transported Regolith 76
Geochemistry 79
<u>Benchmark 8</u>, drillholes BG-32 & GB-32 (drill cuttings) 82
Background 82
***In situ* Regolith** 85
Transported Regolith 85
Geochemistry 86
Earea Dam Gold Field *(northern Central Gawler Gold Province)* 88
Regolith 89
<u>Benchmark 9</u>, Ian's Mine (pit-excavation) 90
Background 90
***In situ* Regolith** 90
Transported Regolith 91
Mineralogy 93
Geochemistry 94
<u>Benchmark 10</u>, cored drillhole EDD-3 101
Background 103
***In situ* Regolith** 103
Geochemistry 103
Old Well Gold Prospect *(northern Central Gawler Gold Province)* 105
Geological Setting 106
Mineralization 106
Regolith 106
Geochemical expression 108
<u>Benchmark 11</u>, drillhole DH-6 (drill cuttings) 110
Background 110
***In situ* Regolith** 110
Transported Regolith 111
Geochemistry 111
<u>Benchmark 12</u>, drillhole DH-2 (drill cuttings) 113
Background 113
Transported Regolith 113
Geochemistry 114
Eyre Peninsula *(southern Central Gawler Gold Province)* 116
Barns & Baggy Green gold prospects 117
Background 117
Geology 118
Mineralization 118
***In situ* Regolith** 121
Transported Regolith 124
Geochemistry 125
<u>Benchmark 13</u>, drillhole RCBN-87 (Barns gold prospect) 133
Background 133
***In situ* Regolith** 135
Transported Regolith 135
Geochemistry 135
<u>Benchmark 1</u>4 drillhole RHBN-188 (Barns gold prospect) 136
Background 136
***In situ* Regolith** 138
Transported Regolith 138
Geochemistry 139

Benchmark 15, drillhole WUD6-693 (Baggy Green gold prospect) 140
Background 140
***In situ* Regolith** 142
Transported Regolith 142
Geochemistry 142
Benchmark 16, drillhole BGRC-1057 (Baggy Green gold prospect) 143
Background 143
***In situ* Regolith** 145
Transported Regolith 145
Geochemistry 146
Yorke Peninsula *(Moonta-Wallaroo Copper District)* 147
Geological Setting 148
Regolith 148
Poona & Wheal Hughes Copper-Gold Mines 149
Background 149
Mineralization 149
***In situ* Regolith** 150
Transported Regolith 151
Geochemistry 151
Benchmark 17, Poona Pit Profile E 155
Background 155
***In situ* Regolith** 158
Transported Regolith 158
Mineralogy: XRD & PIMA 158
Geochemistry 161
Benchmark 18, Poona Pit Profile W1 164
Background 164
***In situ* Regolith** 166
Transported Regolith 166
Mineralogy: XRD & PIMA 166
Geochemistry 167
Benchmark 19, Wheal Hughes Pit Profile WH99A 171
Background 171
***In situ* Regolith** 172
Transported Regolith 173
Mineralogy: PIMA 173
Geochemistry 174
Benchmark 20, Wheal Hughes Pit Profile WH99B 177
Background 177
***In situ* Regolith** 179
Transported Regolith 179
Mineralogy: XRD & PIMA 180
Geochemistry 181

REFERENCES 184

VOLUME 2 contains the following benchmarks:

Christie Domain
Challenger Gold Deposit, **Benchmarks 21-23**
Jumbuck Gold prospect, **Benchmarks 24-25**
Golf Bore Gold prospect, **Benchmarks 26-27**
South Hilga Gold prospect, **Benchmarks 28-29**
Monsoon Gold prospect, **Benchmarks 30-31**
Edoldeh Tank (ET) Gold prospect, **Benchmarks 32-33**

Figures **Page**

1 Gawler Craton and surrounding region Regolith Investigation sites, CRC LEME – PIRSA 1996-2006 **4**

2 Benchmark Types and their essential details (Types 1-3) **6**

3 Generalised Regolith Terminology after Robertson and Butt (1997) modified slightly to better represent South Australian regolith. Weathering can affect both crystalline basement and sedimentary cover, but later erosion may have also truncated portions of any original weathering. Therefore in many areas this idealised weathering profile may span both the sedimentary cover and underlying crystalline basement, and may be repeated more than once over sedimentary basins **8**

4 State and regional scale location plans (after Davies, 2002b) **13**

5 Interpreted subsurface extent of the komatiitic Harris Greenstones and locations of investigative drilling (after Davies, 2002b) **14**

6 Localised site plan indicating where Benchmark 1 (cored drillhole KLHRDD-1) plus Benchmark 2 (aircore drillhole KOK 3) and Benchmark 3 escarpment are sited (after Sheard and Robertson, 2004) **16**

7 Lake Harris Regolith profile (after Sheard and Robertson, 2004). Benchmarks 1 and 2 (drillholes KLHRDD-1 & KOK 3) are indicated **17**

8 **Benchmark 1**, drillhole KLHRDD-1, selected drill core (Sheard and Robertson, 2004) **20**

9 Thin-section petrography of annotated photomicrographed samples from cored drillhole KLHRDD-1 and a portion of cored drillhole THHRDD-1 (Sheard and Robertson, 2004) **23-24**

10 Thin-section petrography of annotated photomicrographed samples from cored drillhole KLHRDD-1 (Sheard and Robertson, 2004) **25-26**

11 Comparison ternary plots of major elements (Si, Al, Fe) for (A) the Lake Harris drillhole, (B) the Hopeful Hill drillhole and (C) the Mullina Well drillhole showing weathering trends in the weathered basement and sedimentary rocks, and weathering trends in the overlying sediments (Sheard and Robertson, 2004) **27**

12 Log and geochemistry of Benchmark 1 at Lake Harris (Sheard and Robertson, 2004). [A3 fold out sheet]. Refer to Figure 16 for graphic log explanation **28**

13 Bivariate plots (A-C) and a trivariate plot (D) illustrating how basement rocks may be largely distinguished geochemically from the covering sediment (Sheard and Robertson, 2004) **29**

14 Bivariate ratio plots of minimally mobile elements to illustrate classification of mafic basement rocks at the two sites (after Sheard and Robertson, 2004) **30**

15 **Benchmark 2** chiptray samples with key regolith features indicated **33**

16 Down hole assay data plots for Benchmark 2, oxides on upper chart and traces on lower chart. The graphic log column (LHS) is based upon Table 7 logged primary features with secondary features in the text column **35**

17 **Benchmark 3**, view W of E facing escarpment, regolith horizons-zones, and description **37**

18 **A** – The transition between silcrete and saprolite; **B** – The massive, grey, rounded and jointed blocks of the upper part of the silcrete; **C** – Pale grey-green blocks of silcrete at the top of the breakaway **38**

19 **A** – Internal structure of silcrete: shardy quartz + quartz grit in white QAZ cement; and **B** – Internal structure of ferruginous silcrete lag fragment **38**

20 Ternary Si-Al-Fe diagram showing the silcretes and the weathered granites from which some of them developed **39**

21 Localised site plan indicating where Benchmark 4 (cored drillhole THHRDD-1) is sited. Two of the three ~NW drill lines, totalling 18 drillholes (those marked in blue) are displayed as a composite regolith profile in Figure 22 **41**

22 The composite regolith profile for two drill lines at Hopeful Hill. Benchmark 4 (cored drillhole THHRDD-1) location is indicated **42**

23 **Benchmark 4**, Hopeful Hill drillhole THHRDD-1 selected regolith core **46**

24 Thin-section petrography to photomicrographs from Benchmark 4 (cored drillhole THHRDD-1) and Benchmark 5 (cored drillhole TMWRDD-1) **47-48**

25 Thin-section petrography to photomicrographs from Benchmark 4 (cored drillhole THHRDD-1) **49-50**

26 Log and Geochemistry of Benchmark 4 at Hopeful Hill {A3 fold out sheet]. Refer to Figure 16 for graphic log explanation **52**
27 Localised site plan indicating where Benchmark 5 (cored drillhole TMWRDD-1) and Benchmark 6 (aircore drillhole TAR 46). The ~NNE drill line of 25 drillholes is displayed in part as a regolith profile in Figure 28 **54**
28 A portion of the ~NNE Mullina Well regolith profile (after Sheard and Robertson, 2004). Benchmark 5 (cored drillhole TMWRDD-1) and Benchmark 6 (aircore drillhole TAR 46) are indicated and places these reference sites into context **55**
29 **Benchmark 5**, Mullina Well drillhole TMWRDD-1 selected regolith core. **Note** this core is reversed to normal layout and runs right to left **59-60**
30 Thin-section petrography to photomicrographs from Benchmark 5 (cored drillhole TMWRDD-1) **63-64**
31 Log and geochemistry of Benchmark 5 at Mullina Well [A3 fold out sheet]. Refer to Figure 16 for graphic log explanation **65**
32 **Benchmark 6**, chiptray samples with key regolith features indicated **68**
33 Down hole assay plots for Benchmark 6, oxides on upper chart and traces on lower chart. The graphic log column (LHS) is based upon Table 16 logged primary features with secondary features in the text column **70**
34 Central Gawler Gold Province, as indicated by Thomas (2004) after the proposed definition of Ferris and Schwarz (2003) **71**
35 **Benchmark 7** locality map, basement geology is partially overlain by the Kingoonya Palaeochannel (blue hatch) **72**
36 Regolith landform map of the Boomerang gold prospect showing the exploration drill lines, the Regolith Study Lines of Lintern *et al*. (2006), plus Benchmarks 7 and 8 **74**
37 Benchmark 7 aircore chiptray samples (secondary 0-6 m regolith drillhole GB-47). Site is ~5 m E of drillhole BG-47 **74**
38 Benchmark 7, aircore chiptray samples (exploration drillhole BG-47) with key regolith features indicated **75**
39 Regolith profile, extracted from Lintern *et al*. (2006) indicating Benchmark 7 location and weathering zonation within its vicinity (*c.f.* Benchmark 8; Figure 46) **77**
40 Contoured mineralogy (arbitrary units), using PIMA derived data for selected holes from Boomerang regolith section (after Lintern *et al*., 2006) **78**
41 Gold regolith geochemistry at Boomerang prospect (along grid line 449200N). Data in ppb. See Figure 36 for location of section. Dashed line indicates unconformity **80**
42 Lead distribution in regolith (ppm) at Boomerang (along grid line 449200N). Dashed line indicates unconformity **80**
43 Arsenic distribution in regolith (corrected for Fe content) at Boomerang (along grid line 449200N). Dashed line indicates unconformity **81**
44 Bismuth distribution in regolith (ppm) at Boomerang (along grid line 449200N). Dashed line indicates unconformity **81**
45 **Benchmark 8** aircore chiptray samples (secondary 0-6 m regolith drillhole GB-32). Site is ~5 m E of drillhole BG-32 **83**
46 Regolith profile, extracted from Lintern *et al*. (2006) indicating Benchmark 8 location and weathering zonation within its vicinity (*c.f.* Benchmark 7; Figure 39) **83**
47 Benchmark 8, aircore chiptray samples (exploration drillhole BG-32) with key regolith features indicated **84**
48 Uranium distribution in regolith (ppm) at Boomerang (along grid line 449200N). Dashed line indicates unconformity. Benchmarks 7 and 8 are indicated **87**
49 Thorium distribution in regolith (ppm) at Boomerang (along grid line 449200N). Dashed line indicates unconformity. Benchmarks 7 and 8 are indicated **87**
50 Location of Earea Dam Goldfield. Red boxed area indicates approximate regolith landform map boundary (see **Benchmark 9**). Colours used as a guide only to the ages of geological units (Lintern, 2004a) **88**
51 Local geology, mining activity (including location of Ian's Mine) and boundary of the geochemical study described in Lintern (2004a). Benchmark 9 (Ian's Mine) and Benchmark 10 (cored drillhole EDD-3) are indicated **89**

52 Regolith Landform Map of the Earea Dam Goldfield of Lintern (2004a) showing location of observation points (open circles), Ian's Mine (crossed pickaxe symbol; Benchmark 9) and geochemical study area (outlined in red) ________ **92**
53 Location plan of profiles sampled at Ian's Mine by Lintern (2004a). Photo inset displays the E and S faces in early afternoon light. The upper pale horizon is dominated by pedogenic carbonate accumulations (calcrete) ________ **93**
54 Bar charts from Lintern (2004a) showing concentration of selected elements in grab samples from Benchmark 9 (Ian's Mine) ________ **95**
55 View of Benchmark 9 (Ian's Mine) S face in foreground with valley and dunes in background. Fifteen profiles were sampled from the S face and the data generated are contoured in Figure 56a-c ________ **97**
56 Parts a-c: Distribution of selected elements in the southern pit wall of Benchmark 9 (Ian's Mine) ________ **98-100**
57 **Benchmark 10**, HQ drillcore + some RAB cuttings (interval 1.00-6.00 m). Core loss and poor core recovery occur between ~0.50-8.00 m and is indicated above or on the regolith log (Table 26). Core is highly fractured. Full core recovery to 13.5 m would normally require three core trays to accommodate all of it, however, enough of the *in situ* weathered regolith profile has been recovered to serve as a reference ________ **101**
58 Locality map for Old Well prospect and the regolith study area (red box) of Gibbons (1997). Tunkillia Rockhole is near the SE corner of that boxed area; Yerda Outstation and Well are located in the map NE quadrant. [An extract from the CHILDARA 1:250,000 topographic-cadastral sheet SH 53-14 (RASC, 1986)] ________ **105**
59 Local area DEM displaying topography over the Old Well gold prospect and study area of Gibbons, 1997 (boxed). Calcrete-Au anomalism (10-20 ppb) is outlined in white. Black lines and dots indicate the extensive exploration drilling at Tunkillia gold prospect ________ **106**
60 A summarised regolith map for Old Well gold prospect. Gold anomaly extent is courtesy of MIM Exploration (after Gibbons and Lintern, 1998). Yellow numbered solid circles are drillholes from Gibbons (1997) Honours Degree project. Benchmarks 11 and 12 (drillholes 6 and 2 respectively) are indicated. Regolith architecture and mineralization for MIM exploration drill lines 1-4 are displayed in Figure 61 ________ **107**
61 Regolith architecture and mineralization at Old Well gold prospect. For locations see Figure 60. Gold data courtesy of MIM Exploration (after Gibbons and Lintern, 1998) ________ **108**
62 Gold and Ca distribution down profile to 5.5 m for the eight sites at Old Well prospect investigated by Gibbons (1997). Regolith architecture for each site is indicated by the graphic logs. Locations are indicated on Figure 60. Site 6 (in weathered *in situ* regolith) is Benchmark 11, Site 2 (in transported regolith) is Benchmark 12 ________ **109**
63 **Benchmark 11**, chiptray photo and regolith log. This site has minimal transported cover (<0.5 m). Note that the *in situ* regolith has been truncated by erosion, the pre-calcrete pedolith zone is missing. ________ **111**
64 Benchmark 11 (DH-6) down hole graphic log and simplified geochemistry (refer to Figure 62 for symbol key). A strong association between Au and Ca is developed within this mostly *in situ* profile. Note that Au is at relatively low concentrations here. ________ **112**
65 **Benchmark 12**, chiptray photo and regolith log. This site has significant transported cover (~12 m, as revealed by earlier exploration drilling, see Figure 61) ________ **114**
66 Benchmark 12 (DH-2) down hole graphic log and simplified geochemistry (refer to Figure 62 for symbol key). A wholly transported profile displaying a strong association between Au and Ca, developed mostly within the carbonate-rich horizon; although lower levels persist to the end of hole. Note that Au is at quite high concentrations in the top metre ________ **115**
67 Location of the Proterozoic Central Gawler Gold Province, Hiltaba Suite granite plutons, gold mineralization and named deposits-prospects. An E-W trend in the otherwise ~N-S defined gold mineralization trend is apparent S of Ceduna towards Wilcherry Hill at the northern end of Eyre Peninsula (Drown, 2003) ________ **116**
68 Wudinna to Minnipa, Eyre Highway and northern area. Regional Parks (green boundary), the Regolith Landform Map and Study Area of Sheard (2007a, b) are boxed in purple, and the Barns + Baggy Green gold prospects are highlighted ________ **117**

69 Interpreted basement geology for the Wudinna region, based upon geophysical data, exploration drilling and outcrop evidence. On the LHS map a white box locates the lower right enlargement image, it covers the ~19 x 23 km regolith study and map area of Sheard (2007a, b) **119**
70 Barns gold prospect, Au-in-calcrete anomaly pattern (after Drown, 2003) **120**
71 Barns gold prospect, E-W section along white line in Figure 69. Drillhole Au intersections are marked in red (Drown, 2003) **120**
72 Barns and Baggy green areas: weathered *in situ* regolith forms from bedrock (least weathered) to pedolith (extremely weathered); plus transported (aeolian) regolith (after Sheard, 2007b) **122-123**
73 Barns gold prospect area, extracted from the Regolith Landform Map of Sheard (2007a) displaying selected exploration drillholes (black dots) and the regolith profile line A-B of Figure 74 **127**
74 Barns gold prospect, regolith profile section A-B (located on Figure 73; extracted from Sheard, 2007a). Aeolian cover (De-1, De-2) and palaeochannel sediment are thickest over the W and NE ends. RgQm represents ferruginous pedolith dominated by a collapsed megamottle horizon; Cs represents silcrete. Locations for Benchmarks 13 and 14 are indicated **128**
75 Baggy Green gold prospect area, extracted from the Regolith Landform Map of Sheard (2007a) displaying selected exploration drillholes (black dots) and the regolith profile line C-D of Figure 76 **129**
76 Baggy Green gold prospect, regolith profile section C-D (located on Figure 75; extracted from Sheard, 2007a). Aeolian cover (De-5) and palaeochannel sediment are thickest over the northern half. RgQm represents ferruginous pedolith dominated by a collapsed megamottle horizon. Locations for Benchmarks 15 and 16 are indicated **130**
77 Regional calcrete assay data plots for Au, Ag and Cu over Barns and Baggy Green prospects (after Sheard, 2007b). Grid projection is AMG88. Original data supplied by Adelaide Resources Ltd. **131**
78 Regional calcrete assay data plots for As and Ni over Barns and Baggy Green prospects (after Sheard, 2007b). Grid projection is AMG88. Original data supplied by Adelaide Resources Ltd. **132**
79 **Benchmark 13**, Barns gold prospect drillhole RCBN-87, chiptrays and regolith zonation (image extracted from Sheard, 2007b). Bedrock at 53 m, E.O.H. at 61 m **134**
80 **Benchmark 14**, Barns gold prospect drillhole RHBN-188, chiptrays and regolith zonation (image extracted from Sheard, 2007b). Bedrock at 54 m, E.O.H. at 60 m **137**
81 **Benchmark 15**, Baggy Green gold prospect drillhole WUD6-693, chiptrays and regolith zonation (image extracted from Sheard, 2007b). Bedrock at 42 m, E.O.H. at 49 m **141**
82 **Benchmark 16**, Baggy Green gold prospect drillhole BGRC-1057, chiptrays and regolith zonation (image extracted from Sheard, 2007b). Bedrock at 36 m, E.O.H. at 196 m **144**
83 Proterozoic geology of the Moonta-Wallaroo area showing where historic and recent Cu-Au mining has taken place (Parker, 1993) **147**
84 Location of Cu-Au mines in the Moonta area, and the orientation of the numerous Cu-sulphide lodes (Cornish and Drew, 1999) **147**
85 Moonta area regolith-landform map of Hartley (2000) with modifications by Lintern (2004b). Locations to Poona and Wheal Hughes Cu Mines and sampling profile sites are indicated. Compare with Figures 83, 84 **148**
86 Diagrammatic representation of the mineralized lodes at Poona Mine, their parallel nature is typical of the Moonta area (after Janz, 1990). Benchmarks 17 & 18 locations are indicated **150**
87 Diagrammatic representation of the mineralized lodes at Wheal Hughes Mine, their parallel nature is typical of the Moonta area (after Conor, 1996). Benchmarks 19 & 20 locations are indicated **150**
88 Poona Mine open cut pit, regolith profile exposed on the southern wall, haulage way is cut into saprolith. Regolith zonation is indicated, a red line marks the unconformity (Hartley, 2000). Benchmark 17 profile location is indicated **150**

89 Copper concentrations in different materials within transported regolith of the Moonta study area (Hartley, 2000). Note higher Cu concentrations in sample media from the mine pits (1-5), in comparison with the sample media from the coast, at least 2 km distant (6-8). Adapted from Hartley (2000) and Lintern (2004b) ____ **152**
90 Down profile distributions of Cu *vs* Fe (plots a, b) and Au *vs* Ca (plots c, d) for selected profiles from Poona Mine (LHS) and Wheal Hughes Mine (centre), (after Hartley, 2000; Lintern, 2004b) ____ **153**
91 **Benchmark 17**, Poona Mine, regolith profile E (upper portion), image is angled up profile from haulage road, so vertical scale is not linear, hammer head at saprolith-bedrock join ____ **156**
92 Benchmark 17, Poona Mine Profile E, three chiptrays (0->27 m) ____ **157-158**
93 XRD plots, Benchmark 17; **A** calcrete zone at ~0.5 m, **B** alunite seam in transported red-brown clay at 2.30 m, **C** megamottled saprolite at 6.4 m, and **D** saprolitic Moonta Porphyry at 7.4 m ____ **160**
94 Down profile stacked PIMA spectra for Benchmark 17, 0-6.9 m. Note the shift in the clay water absorption feature approximately halfway down (right of centre); and the increasing FeOx adsorption feature with depth on the LHS (extracted from Hartley, 2000) ____ **161**
95 Benchmark 17 down profile distributions of Cu *vs* Fe (plot A) and Au *vs* Ca (plot B), (after Hartley, 2000; Lintern, 2004b) ____ **162**
96 Benchmark 17, down profile plots for 48 selected elements (Hartley, 2000) ____ **163**
97 **Benchmark 18**, Poona Mine Profile W1, three chiptrays (0->18 m) ____ **165-166**
98 Down profile stacked PIMA spectra for Benchmark 18, 0-5.7 m. Note the near consistency with depth in the clay water absorption feature (right of centre); and similarly with the FeOx adsorption feature on the LHS (extracted from Hartley, 2000) ____ **168**
99 Benchmark 18 down profile distributions of Cu *vs* Fe (plot A) and Au *vs* Ca (plot B), (after Hartley, 2000; Lintern, 2004b) ____ **169**
100 Benchmark 18, down profile plots for 48 selected elements (Hartley, 2000) ____ **170**
101 **Benchmark 19**, Wheal Hughes Mine Profile WH99A, chiptray (0.0-11.3 m) ____ **172**
102 Down profile stacked PIMA spectra for Benchmark 19, 0-11.15 m. Note the progressive change in the clay water absorption feature (right of centre) with depth until the unconformity; and similarly with the FeOx adsorption feature on the LHS (extracted from Hartley, 2000). ____ **174**
103 Benchmark 19 down profile distributions of Cu *vs* Fe (plot A) and Au *vs* Ca (plot B), (after Hartley, 2000; Lintern, 2004b) ____ **175**
104 Benchmark 19, down profile plots for 48 selected elements (Hartley, 2000) ____ **176**
105 **Benchmark 20**, Wheal Hughes Mine Profile WH99B, chiptrays (0.0-14.6 m). Samples collected while sampler abseiled down the pit wall. ____ **178**
106 XRD plots, Benchmark 20; **A** calcrete zone at 1.50 m, **B** transported red-brown clay at 1.70 m, and **C** transported red-brown clay at 4.15 m. ____ **180**
107 Down profile stacked PIMA spectra for Benchmark 20, 0-14.55 m. Note the consistency in the clay water absorption feature (right of centre) with depth until the unconformity; and a less consistent FeOx adsorption feature with depth on the LHS (extracted from Hartley, 2000) ____ **181**
108 Benchmark 20 down profile distributions of Cu *vs* Fe (plot A) and Au *vs* Ca (plot B), (after Hartley, 2000; Lintern, 2004b) ____ **182**
109 Benchmark 20, down profile plots for 48 selected elements (Hartley, 2000) ____ **183**

Tables

1 A listing of some obvious and more cryptic limitations to a broad scale use of the available Benchmark Profile sites ____ **5**
2 Benchmark reference data that will be displayed where available ____ **11**
3 **Benchmark 1** reference data, drillhole KLHRDD-1 (Type 2, drill cored profile) ____ **15**
4 Summary log of Benchmark 1, Lake Harris cored drillhole KLHRDD-1 (Sheard and Robertson, 2004) ____ **18**
5 Thresholds for distinguishing greenstones from sedimentary regolith (Sheard and Robertson, 2004) ____ **30**
6 **Benchmark 2** reference data, drillhole KOK-3 (Type 2, drill cuttings profile) ____ **31**

7 Summary log of Benchmark 2, drillhole KOK-3 (Type 2, drill cuttings profile), (Sheard and Robertson, 2004) **32**
8 Generalized *in situ* regolith components from drillholes in Glenloth Granite, bedrock to most weathered (after Sheard and Robertson, 2004) **32**
9 Generalized transported regolith components from surface regolith mapping and drill cuttings at Lake Harris; oldest to youngest units (after Sheard and Robertson, 2004) **34**
10 **Benchmark 3** reference data, weathered Glenloth Granite (Type 1, outcrop) **36**
11 **Benchmark 4** reference data, drillhole THHRDD-1 (Type 2, drill cored profile) **40**
12 Summary log to Benchmark 4, Hopeful Hill cored drillhole THHRDD-1 (not to scale) **43**
13 **Benchmark 5** reference data, drillhole TMWRDD-1 (Type 2, drill cored profile) **53**
14 Summary log to Benchmark 5, Mullina Well cored drillhole TMWRDD-1 (not to scale) **56**
15 **Benchmark 6** reference data, drillhole TAR-46 (Type 2, drill cuttings profile) **66**
16 Summary log of Benchmark 6, drillhole TAR-46 (Type 2, drill cuttings profile). **67**
17 Generalized *in situ* regolith components from drill cuttings penetrating foliated granite along the southern part of the Mullina Well drill line (after Sheard and Robertson, 2004) **67**
18 Generalized transported regolith components from drill cuttings taken over the Mullina Well drill line; oldest to youngest units (after Sheard and Robertson, 2004) **69**
19 **Benchmark 7** reference data, drillholes BG-47 & GB-47 (Type 2, drill cuttings profiles) **73**
20 Benchmark 7, selected intervals (drillhole BG-47) with elevated Au and associated base metal concentrations **79**
21 **Benchmark 8** reference data, drillholes BG-32 & GB-32 (Type 2, drill cuttings profiles) **82**
22 **Benchmark 9** reference data, Ian's Mine (Type 3, pit – excavation) **90**
23 Selected mineralogy of four profiles from Benchmark 9 (Ian's Mine: Lintern, 2004a). Estimates of mineral abundances were based on peak height **94**
24 Summary of elemental association and interpretation for S face of Benchmark 9 **97**
25 **Benchmark 10** reference data, drillhole EDD-3 (Type 2 drill cored profile) **101**
26 Summary log to Benchmark 10**,** cored drillhole EDD-3 (Not to scale) **102**
27 Extracted Au assay data from Benchmark 10 (drillhole EDD-3) displaying significant Au intersections (extracted from Crettenden and Fradd, 1992) **104**
28 **Benchmark 11** reference data, drillhole DH-6 (Type 2 drill cuttings) **110**
29 Benchmark 11 (drillhole DH-6) assay values for nine selected elements from the 51 assayed for Gibbons (1997) investigations. The detail in 0.0 to 0.6 m involves samples from an adjacent soil pit **112**
30 **Benchmark 12** reference data, drillhole DH-2 (Type 2 drill cuttings) **113**
31 Benchmark 12 (drillhole DH-2) assay values for nine selected elements from the 51 assayed for Gibbons (1997) investigations. The detail in 0.0 to 0.5 m involves samples from an adjacent soil pit **115**
32 **Benchmark 13** reference data; drillhole RCBN-87 (Type 2, drill cuttings profile) **133**
33 Summary log of Benchmark 13, drillhole RCBN-87 (Type 2, drill cuttings profile) **135**
34 **Benchmark 14** reference data; drillhole RHBN-188 (Type 2, drill cuttings profile) **136**
35 Summary log of Benchmark 14, drillhole RHBN-188 (Type 2, drill cuttings profile) **138**
36 **Benchmark 15** reference data; drillhole WUD6-693 (Type 2, drill cuttings profile) **140**
37 Summary log of Benchmark 14, drillhole WUD6-693 (Type 2, drill cuttings profile) **142**
38 **Benchmark 16** reference data; drillhole BGRC-1057 (Type 2, drill cuttings profile) **143**
39 Summary log of Benchmark 16 drillhole BGRC-1057 (Type 2, drill cuttings profile) **145**
40 Moonta district sample media summary tabulation (Keeling and Hartley, 2005). Data adapted from Hartley (2000) with background and dispersion estimates taking into account data in Mazzucchelli *et al*. (1980) and unpublished calcrete data from Adelaide Resources Ltd **154**
41 **Benchmark 17** reference data; Pit Profile E, Poona Cu-Au Mine (Type 3, mine profile) **155**
42 Summary log of Benchmark 17, modified after Hartley (2000) with additional logging by M.J. Sheard (for 6.9-27.8 m). **159-160**
43 **Benchmark 18** reference data; Pit Profile W1, Poona Cu-Au Mine (Type 3, mine profile) **164**
44 Summary log of Benchmark 18, modified after Hartley (2000) with additional log detail by M.J. Sheard **167**
45 **Benchmark 19** reference data; Pit Profile WH99A, Wheal Hughes Cu-Au Mine (Type 3, mine profile) **171**

46 Summary log of Benchmark 19, modified after Hartley (2000) with additional log detail by M.J. Sheard __________ **173-174**
47 **Benchmark 20** reference data; Pit Profile WH99B, Wheal Hughes Cu-Au Mine (Type 3, mine profile) __________ **177**
48 Summary log of Benchmark 20, modified after Hartley (2000) with additional log detail by M.J. Sheard __________ **179-180**

Plates Page

1 Part of a silcrete block from the Lake Harris greenstone outcrop area, near the lake shore where it forms low stony rises and a blocky capping on weathered greenstone (Sheard and Robertson, 2004) __________ **30**
2 **Benchmark 9**, SEM photomicrograph of haematite within quartz containing a 20-30 µm Au grain (arrowed, and with <1% Ag) and "shards" of Bi oxide. Other Bi minerals found contained Ba and/or V __________ **96**
3 **Benchmark 10**, a close-up of cored calcrete (~0.00-0.05 m) cut to display encapsulated yellow-brown angular clasts of ferruginous pedolith. Ferruginous clasts are matrix supported. Core is dry __________ **106**
4 Poona Cu-Au Mine open cut pit, view is ~W towards the coast. The sulphide lode was located on the LHS wall, dipping ~50° towards 40° N. Underground workings have been flooded by groundwater pumped in from nearby Wheal Hughes Mine __________ **149**
5 Wheal Hughes Cu-Au Mine open cut pit, view is ~SW. The Cu-Au lode is located within the dipping greenish area of the end wall. Underground workings now form an educational 'Tourist Mine' __________ **149**
6 Dark rinded lag clasts of silicified Cambrian sandstone from the unconformity contact with overlying Cainozoic clay, Wheal Hughes Mine, SW face (Hartley, 2000). __________ **151**
7 Fractured Cambrian sandstone at Wheal Hughes Mine, SW pit face adjacent to haulage way (Hartley, 2000) __________ **151**
8 White alunite seams in transported Cainozoic red-brown clay at Poona Mine (Hartley, 2000) __________ **151**

•——oo0oo——•

ABSTRACT

Transported regolith and deeply weathered basement, together conceal large tracts of prospective crystalline basement (cratonic and geosyncline rocks) in South Australia, and that cover forms a major exploration impediment for much of the Gawler Craton. Interpreting and understanding that cover sequence (the regolith) has proven to be problematic for many explorers over the last several decades. To help overcome this impediment South Australian regolith research over the last eleven years has involved PIRSA Geological Survey in tandem with the Cooperative Research Centre for Landscape Environment and Mineral Exploration (CRC LEME) agencies (CSIRO Exploration & Mining Division and Geoscience Australia) and included several exploration companies with a number of Honours student projects. Since October 1996 there have been many collaborative regolith studies carried out over the Gawler Craton, western Stuart Shelf, Adelaide Geosyncline and the Curnamona Craton. Combined, those investigations now offer the possibility for a more regional understanding and presentation of regolith cover for significant portions of the afore mentioned prospective terranes. This Atlas focuses on the Gawler Craton.

In geology a Type Section is really just another name for a Geological Benchmark. However, regolith profiles commonly involve weathering zones that variably transgress geological boundaries. Therefore the term “type section” has been avoided for this new Atlas in preference for regolith benchmark. A methodology for the Atlas is drawn from examples used in pedology and geomechanics where data are presented from drillholes and/or excavations to form key reference columns or benchmark profiles. Each benchmark provides a well located representative reference column that has been fully described and examined by a number of regolith methods (*i.e.* materials logging, petrology, assay, PIMA, XRD, *etc*.). A key feature of all benchmarks described herein is that all drilled samples and other specimens are readily available for visual or microscopic inspection, or perhaps further analysis where warranted, through PIRSA’s Glenside Drillcore Storage Facility.

Three types of regolith exposure can form a Benchmark, those include: Type 1 – natural outcrop; Type 2 – drilled samples; and Type 3 – human made excavations (road and rail cuttings, tunnels, borrow pits, pipeline or cable trenches, quarries, costeans and mines, *etc*.). Profile complexity and/or depth limitations, can be partially overcome within a specific locality by compiling a composite profile by utilising two of the three of the locally available Types (*i.e.* 1 + 2, or 1 + 3, or 2 + 3).

Representative benchmarks are sited within well studied locations, and those studies have been summarised for the Atlas. Each selected profile has a tabulated summary of data, source papers-reports, and profile photo(s) + log(s) + assay plots, and the following if available: petrology, PIMA, XRD mineralogy, and dating. Accounts of the weathered *in situ* (residual) regolith and transported regolith, as well as, the geochemistry and suitable sample media, are provided for each benchmark. Most locations have at least two representative benchmarks but a few have three or four.

Benchmarks can augment new in-field studies within a relevant location or tenement area; or can assist with more thorough evaluation of proposed investigations from an office—laboratory context. They also provide a training opportunity for geological staff unfamiliar with regolith, its terminology and/or its appropriate sampling for assay. Such training may involve accessing samples at PIRSA’s Glenside Drillcore Storage Facility; or in-the-field, using the nearest benchmarks for comparison with natural outcrop, excavated exposures and/or drilled samples on/from the area or tenement under scrutiny.

Benchmarks in this Atlas are presented within a cratonic domain or a defined region for ready comparisons. For example: **Volume 1** covers Benchmarks 1-20 within the Harris Domain, the Central Gawler Gold Province (includes Earea Dam Goldfield) and Yorke Peninsula (includes the Poona and Wheal Hughes Cu-Au Mines). **Volume 2** covers Benchmarks 21-33 from the Christie Domain (including the Challenger Gold Mine).

Acknowledgements

The author wishes to acknowledge the assistance and input received from the following: those many earth scientists whose published work via CRC LEME Open File Reports plus PIRSA’s geoscience publications, technical reports and maps, along with the mostly unpublished work of University postgraduate students; PIRSA Drillcore Storage Facility staff who were very accommodating when asked at short notice to locate and lay out exploration samples (including items at the time that were not formally database-access coded); L. Tucker, PIRSA Petroleum Group for some chiptray and core tray digital photography; P. Aagaard, PIRSA Geological Librarian for tracking down obscure references and interlibrary loan materials; M.J. Lintern for over viewing some benchmarks and providing diagrams-images; J.L. Keeling for report peer and editorial review; S. Game & A. Vartesi for final document assembly and CD production. All these contributions are noted with appreciation.

REGOLITH BENCHMARK ATLAS, GAWLER CRATON, SOUTH AUSTRALIA.

Introduction

Background

Transported regolith and deeply weathered crystalline basement, together form a major exploration impediment over much of the Gawler Craton. Therefore, finding ways to make exploration more efficient would further encourage exploration investment and improve the chances of mineral discovery. South Australia's Government sponsored Targeted Exploration Initiative (TEiSA), operating during the late 1990's to 2000's (through PIRSA) has encouraged exploration in the Gawler Craton and surrounding regions. More recently the SA Government's PACE Initiative has carried forward the earlier Government sponsored exploration initiatives. Regolith research over the last decade or so has been instigated under the auspices of PIRSA Geological Survey and CSIRO Exploration & Mining Division through the Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME). Several mineral exploration companies availed themselves of that opportunity, to become involved by offering: access to surface Au-in-calcrete anomalism, mineralized ground, cash and/or in-kind support, as well as copious data to assist research into mineral plus geochemical dispersal within the regolith. In order to achieve a larger number of investigated sites, CRC LEME and PIRSA have encouraged University post graduate students (Honours, Masters, PhDs) to take on regolith research at numerous sites.

Since October 1996 there have been 18 collaborative Regolith Studies carried out over the Gawler Craton, western Stuart Shelf and Adelaide Geosyncline (Figure 1). These have involved researchers from the following agencies: PIRSA-Geological Survey, CSIRO-Exploration & Mining, Geoscience Australia, University of Adelaide, Melbourne University, and the University of South Australia. Additional collaboration and support from exploration and mining companies holding active tenements over those study areas has also been instrumental in facilitating that research. Results have been released under the CRC LEME Open File Report series, or as university Honours theses, and several published papers. A synopsis and modelling of a large portion of that work has been compiled by Lintern (2004b; a report covering the period 1996-2001). Additional study sites investigated during 2002 to 2006 are included herein.

Benchmarking

Why Benchmark? Benchmarks provide a well located representative information reference site that has been described and examined by a number of methods (logging, assay, petrology, PIMA, XRD, *etc*). The general methodology used herein is drawn primarily from Sheard and Bowman (1996) with modifications to suit a more regional context. Benchmarks can augment in-field study within a relevant location or tenement sized area, or can assist with more thorough evaluation of proposed studies—investigations from an office environment. Where possible they should have drill core or drill cuttings or hand specimens readily available at a central repository for visual or microscopic inspection or perhaps further analysis where warranted (Sheard, 1996).

Herein, a set of selected reference Regolith Benchmarks is presented, drawing upon the 18 regolith studies mentioned above. Some limitations are to be expected because, while the aim herein is to keep data points per study area to a workable minimum (*i.e.* 1 to 3), the degree of profile variability across most sites is usually moderate to high. Transported regolith thicknesses and type can vary considerably over just a few metres, *i.e.* an uneroded *in situ* weathering profile can be of variable thickness, and more so where erosion is either active or has occurred in the past. Table 1 provides a listing of the perceived limitations to a broad scale use of the available Benchmarks presented in this report.

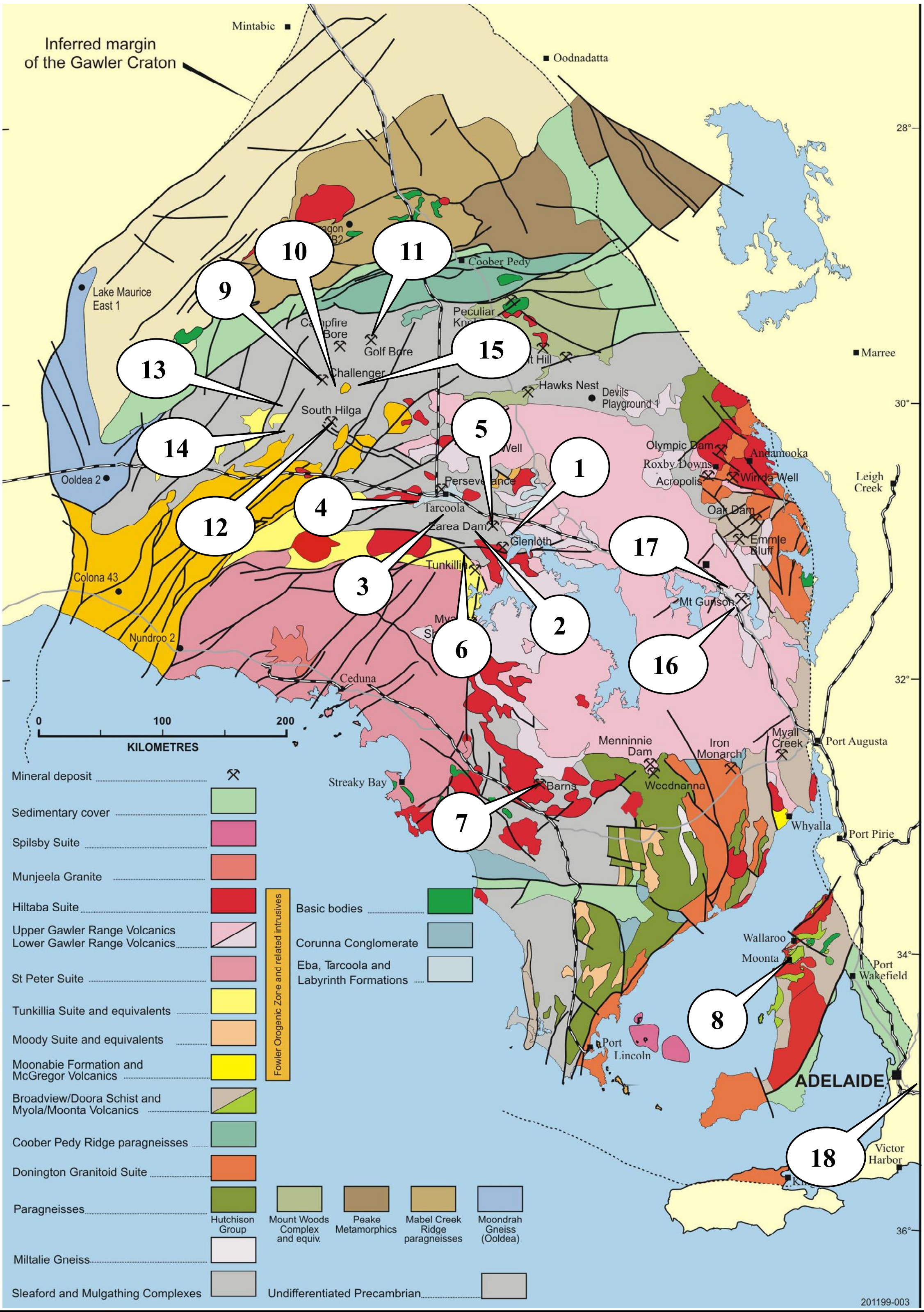


Figure 1: Gawler Craton and surrounds regolith investigation sites, CRC LEME + PIRSA 1996-2006: **1** Lake Harris greenstone, **2** Hopeful Hill greenstone, **3** Mullina Well greenstone, **4** Boomerang gold prospect, **5** Earea Dam Goldfield, **6** Old Well gold prospect, **7** Barns & Baggy Green gold prospects, **8** Wheal Hughes & Poona copper-gold Deposits, **9** Challenger Gold Deposit, **10** Jumbuck gold prospect, **11** Golf Bore gold prospect, **12** South Hilga gold prospect, **13** Monsoon gold prospect, **14** ET gold prospect, **15** Birthday gold prospect, **16** Mt Gunson Cattlegrid Copper Mine, **17** Windabout Cu-Co prospect, and **18** Glen Osmond Silver-Lead Mines.
NOTE: **Volume 1** covers Sites 1 to 8; **Volume 2 covers** Sites 9 to 14. **But** sites 15-18 (Lintern *et al.*, 2000; Lintern *et al.*, 2007; Carragher, 1999; Baker, 1999) **have been excluded** (external to Craton or sample access issues).

Table 1: a listing of some obvious and more cryptic limitations to a broad scale use of the available Benchmark Profile sites.

A majority of sites are within a single host lithotype (*i.e.* seven are within Christie Gneiss) and are clustered within an area roughly enclosed by one 1:100,000 scale map sheet. However, this provides an opportunity to see how weathering profiles and cover sequences vary where there is a relatively consistent underlying bedrock.
The majority of Gawler Craton lithotypes remain unrepresented by any regolith study. This remains a major limitation.
Gold is the dominant target element examined by the studies, followed by: Ni, Cr, Ag & Cu.
There are huge distances between the three most isolated studies and also between those of the more clustered investigations. This remains a major limitation.
Regolith mapping that would assist potential users of Regolith Benchmarks exists for only about half of the study sites presented herein.
Regolith mapping schemes used in SA are varied and not very compatible: RTmap, RED, modified RED and student's own. Some have low utility. This remains a major limitation.
PIMA data exists for relatively few sites–profiles; HyLogger scanned cores are numerically fewer.
Petrology, XRD and SEM rock analyses are limited to only a few studies.
Benchmark Profile sites will provide a **regional substitute** for broad-scale regolith understanding while adding in the vital 3rd and 4th dimensional framework that has been so lacking from nearly all previous conventional regolith map products.

Benchmark Types

Three types of regolith exposure can form a Benchmark, these are: Type 1 – natural outcrop; Type 2 – drilled; and Type 3 – human made excavations (Figure 2. Profile complexity mentioned earlier may be partially overcome within a Benchmark where samples are limited by compiling a composite profile from the variants and by utilising two of the three available Types (*i.e.* 1 + 2, or 1 + 3, or 2 + 3).

Type 1: natural regolith profile exposures are relatively rare over the Gawler Craton and tend to consist of: retreating escarpments, eroding catena sections, valley sides, landslide scarps, and basement inliers protruding younger cover. These tend to expose only part of the full regolith profile but can usefully demonstrate lateral variations in at least 2 and perhaps in 3 dimensional presentations. Natural exposures give access for sampling large blocks ± vertical and horizontal samples at varying spacings and of all materials present. Where used herein Type 1 profiles will be matched up with available drillhole data.

Type 2: drilled profiles yield either core or cuttings. Cuttings typically provide less than 20% of the information that whole drillcore can do regarding: regolith zone contacts, where the pedoplasmation front is actually located; the size and type of primary and secondary or weathering alteration fabrics and textures; types and size of veining and void forms. Cuttings may be available in kilogram quantities but more commonly only chiptrays are retained after a drilling program has either ended or the tenement abandoned. Chiptrays can still provide a useful visual reference, although they can also display a sampler's logging—interest or bias (*i.e.* clay fines aren't retained within the weathering zone nor from the cover sequence, single large chips preferentially displace more numerous smaller chips). Chiptrays can in addition, provide material for PIMA and/or HyLogger spectral analysis, XRD and or ion probe analysis, where the latter two tests require only a tiny sample.

Type 3: human made excavations (road and rail cuttings, tunnels, borrow pits, pipeline or cable trenches, quarries, costeans and mines). These can have similarities with Type 1 exposures but currently are of highly variable spacing and utility across the Gawler Craton. Many of these features are short-term exposures, being back filled or otherwise rehabilitated soon after completion, or degrade through landslides and erosion when no longer in use. A few specifically targeted regolith investigation pits and dozer-cut trenches have been excavated for specific regolith studies on the Gawler Craton, these are an exception rather than a typical occurrence.

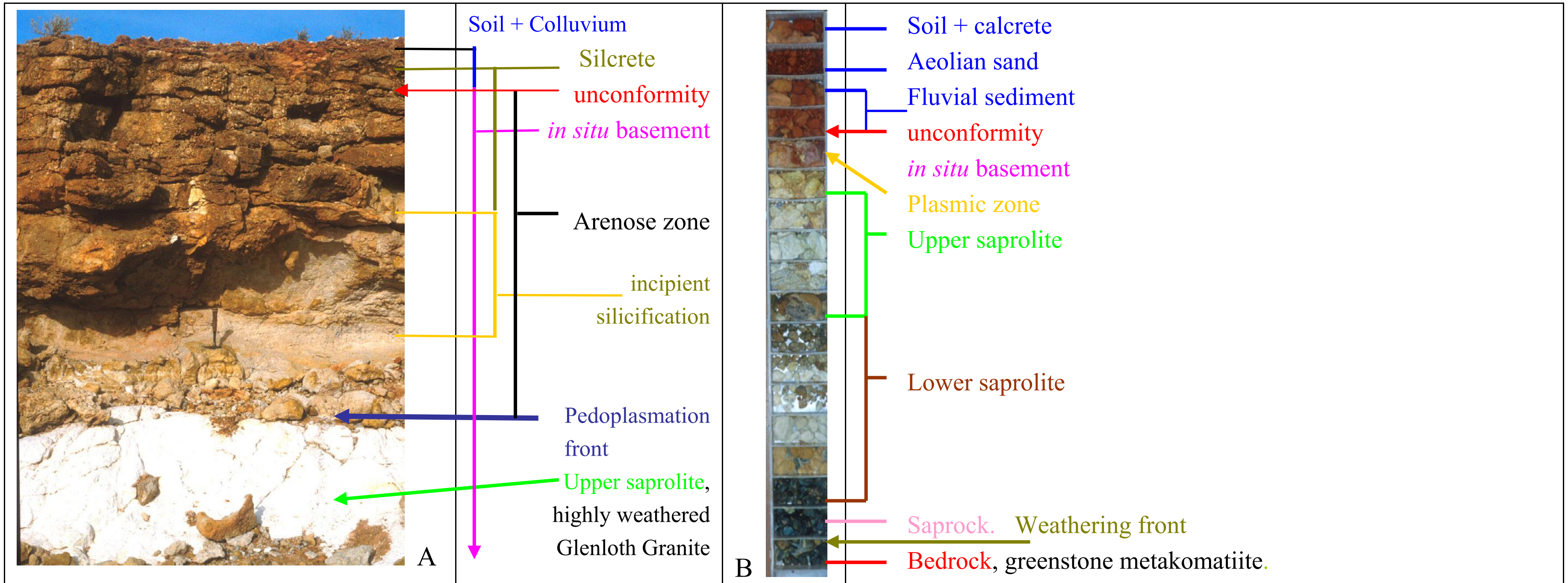
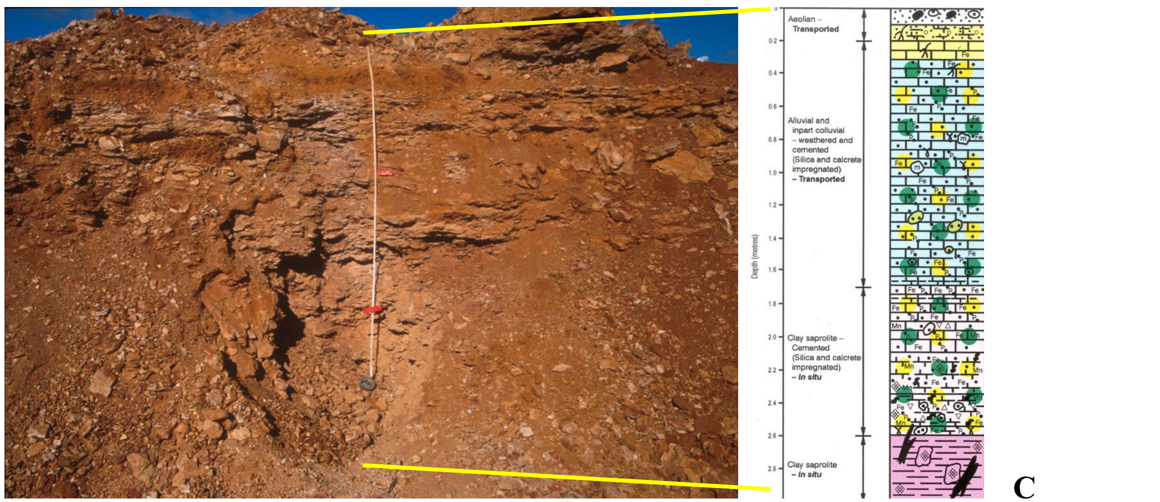


Figure 2: Benchmark Types and their essential details. Example A is Type 1 (natural exposure), a retreating escarpment at the NW corner of Lake Harris. Example B is Type 2 (drilled profile), a drill cuttings chiptray from Hopeful Hill (sample interval 2 m, depth 36 m). Example C is Type 3 (an excavation), a regolith investigations blast-dozer-cut pit over the Challenger Gold Deposit pre mining. Pit depth 3 m, unconformity is marked on the hanging tape measure by a red pin-flag. A logging derived graphic representation appears on the RHS.



Methods

The selected profile details forming Benchmarks, as presented herein, are drawn from numerous CRC LEME Open File Reports, university post graduate theses, unpublished reports and some published papers, bulletins and reports. A range in presentation formats has been used throughout that collection of case histories, some reformatting and redrafting of figures and graphics has been necessary to improve on benchmark uniformity.

Samples and Maps

The gathering of surface information, samples and mapping for the areas described herein utilised ground traverses on foot and by vehicle. All described locations were obtained by a hand-held GPS (coordinates used herein are in GDA94 format unless otherwise indicated). Surface sampling, excavation of soil profiles, use of drill chips and cores, surface photography and air photograph interpretation, together augmented that work. No sampling occurred at sites of cultural or tourist significance. Colour standards of Munsell (1975) plus Kelly and Judd (1976) provided useful references and guidance for sample descriptions in the field and laboratory contexts. Geological and geomorphological mapping principles were used within a regolith landform context. Depth information has been drawn from exploration company drillhole data, digital DEM's, published topographic maps, District Council borrow pits and natural exposures. Regolith cross-section construction involving substantial vertical exaggeration have followed the principles set out by Rod (1974).

Regolith boundaries have in most cases been mapped in the field directly onto colour air photographs, derived from original colour air photography, while some have employed remotely sensed digital colour images from satellite platforms. Regolith maps have been assembled by the South Australian PIRSA-Spatial Information Services; Geoscience Australia (Canberra); CSIRO Exploration & Mining ARRC Visual Resources Unit (Perth); various university and commercial drafting-cartographic facilities.

Sample examination under magnification in the field employed standard hand lenses (10-15x's), and in the laboratory binocular and petrographic microscopes were used. Many hand and core specimens were sawn for further examination, whereupon some selected sawn slabs were sent to either CSIRO Exploration & Mining or to commercial petrographic enterprises for thin-section and impregnated polished block preparation. Subsequent petrographic observations and descriptions were either performed by the authors of the specific reports or carried out by commercial petrologists.

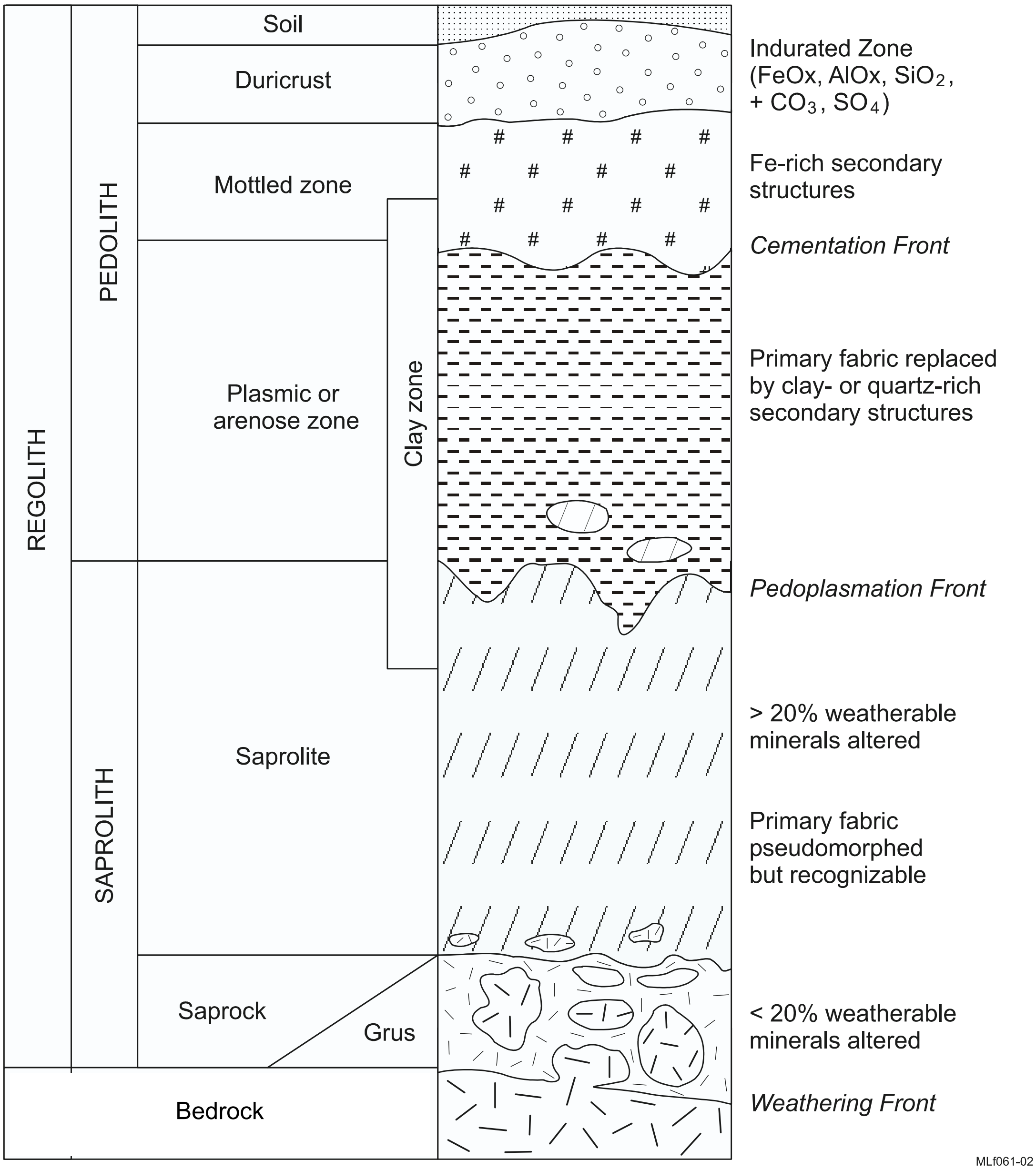
Photography in the field and laboratory involved standard 35 mm cameras with zoom lenses, using 100 and 200 ASA colour slide and print film. Selected frames were then scanned with a Nikon LS-2000 slide scanner or a digital paper–image scanner to produce high resolution digital images. Some in-field and specimen photography has also employed digital cameras. Chiptray photography involved laying selected chiptrays on a purpose-built jig (usually displaying only the 0-40 + 41-80 m trays) and the jig angled to facilitate maximum natural daylight illumination. Rock slab photography involved lightly oiling the sample's cut surface, then with an added scale bar, each was scanned at high resolution using a colour digital paper–image scanner.

Geochemistry has been done by commercial assay enterprises engaged specifically for each project, additional data have been provided by mineral exploration company tenement holders, while assays done for university postgraduate thesis work may also have used university in-house laboratory facilities.

PIMA infrared spectral analysis of selected sub-samples from various sediments and *in situ* weathered materials were first air dried, then powdered in a mortar and pestle prior to examination by the Portable Infra-red Mineral Analyser (PIMA) device. Any samples still containing too much moisture for interpretable PIMA spectra production, were then oven dried to remove that excess moisture. Clay and other mineral species present were subsequently determined by a visual inspection of each individual spectral absorption curve features, followed by comparison with the Ausspec International "The Spectral Geologist" (TSG) mineral library spectra. Some finer point reference was also made to data contained within Pontual *et al*. (1997).

Regolith Profile Terminology

Regolith terminology used herein follows that of Eggleton (2001), Robertson and Butt (1997), and Robertson *et al*. (1996), refer to Figure 3. Regolith units encountered on the Gawler Craton encompass a wide range of *in situ* weathered relict units, numerous transported regolith materials, various duricrusts and significant soils. Full section regolith profile exposures are not abundant but toposequence regolith architecture over catena exposures has provided additional profile segments. Road-track-railway cuttings, roadside borrow pits and quarries, natural erosional escarpments, exposures via biological activity (burrow spoil, tree-throws, *etc*.), and exploration drilling have added to the descriptions. An account of the key regolith zones follows, where for Relict Class units the least weathered are described first and the most highly weathered last; following are the Depositional and Erosional Class definitions.



(Adapted from: CRC LEME - Atlas of Weathered Rocks 1997, Open File Report 1; CSIRO Division of Exploration Geoscience, Report 390, 1st Revision.)

Figure 3: Generalised Regolith Terminology after Robertson and Butt (1997) modified slightly to better represent South Australian regolith. Weathering can affect both crystalline basement and sedimentary cover, but later erosion may have also truncated portions of any original weathering. Therefore in many areas this idealised weathering profile may span both the sedimentary cover and underlying crystalline basement, and may be repeated more than once over sedimentary basins.

Relict Class

The term relict, as used herein, means “*remnant basement (fresh or weathered) lying within a broader area of younger, transported regolith*”. A major portion of basement outcrop and subcrop in the Gawler Craton is deeply weathered (*in situ*), some has been partially eroded in the past and then reburied, or is actively eroding today. All of the relatively fresh crystalline basement (bedrock) has been exhumed from below the Weathering Front by Mesozoic to Cainozoic landscape modification and sculpturing processes.

Bedrock

Bedrock, as used herein is a general term for parent material from which the regolith is formed (Figure 3). Bedrock is *in situ* and regolith deriving from it is said to have formed *in situ* even where some vertical profile collapse has occurred. In regolith terminology, fresh bedrock can contain up to 5% of weatherable minerals altered by weathering processes, and is commonly referred to as 'fresh rock' or 'basement' (Robertson and Butt, 1997). Note: the term "protolith" has previously been used in some regolith terminology to mean bedrock, but that has conflicted with other longer standing usage. Protolith has therefore been dropped from more recent regolith nomenclature, although some of the older figures used herein will still display that term.

Saprock

Compact slightly weathered rock with low porosity; defined as rock in an early phase of weathering, where >5-<20% of the weatherable minerals are altered but generally requiring a hammer to break (Eggleton, 2001; Robertson and Butt, 1997; Figure 3). As outcrop, saprock is typically a minor component and tends to occur as a narrow halo-zone or rim to most bedrock outcrop and subcrop. However, within thicker weathered *in situ* regolith profiles (>50 m) this zone may comprise a more significant horizon <1-~18 m thick (commonly ~2-8 m) near the weathering front.

Saprolite

Saprolite is rock in an advanced state of weathering, where >20% of weatherable minerals are altered and where rock competence is low enough to break easily with a single hammer blow. It typically retains relict primary texture and metamorphic fabric because the weathering alteration is essentially isovolumetric (Eggleton, 2001; Robertson and Butt, 1997; Figure 3). Saprolite in South Australia commonly has a pallid or highly leached upper sub-zone which may be partially exposed at numerous retreating escarpments in eroding terrain where weathered basement is being actively exposed. Within un-eroded weathered *in situ* regolith profiles this zone may make up an interval ~12-~60 m thick (commonly >15-~35 m) where the upper pallid sub-zone typically comprises half to two thirds of this entire zone.

Megamottles

According to Eggleton (2001) mottles are segregations of a subdominant colour that is different from the surrounding dominant material's colour. In regolith, mottles can have sharp, distinct or diffuse boundaries. They typically range in size from <10-100 mm, but may reach several metres in size—whereupon the term megamottle is used. Megamottles are generally >200 mm across and commonly consist of haematite-rich and goethite-rich segregations displaying strong hues (reds, yellows, browns).

In the recognised Lateritic Profile model of Robertson and Butt (1997) and Eggleton (2001) a 'mottled zone' is commonly developed within the pedolith where pedogenic processes overprint all pre-existing textures and replace metamorphic fabric with a new pedogenic fabric (Figure 3). Anand (2005) and Anand and Paine (2002) demonstrate that mottling can also develop within saprolite. In that case, weathering has been near isovolumetric and therefore megamottles commonly exhibit no significant loss of primary rock texture or igneous-metamorphic fabric. The afore mentioned authors also report megamottles occurring within the arenose or plasmic horizons of pedolith where weathering is typically not isovolumetric.

Megamottled horizons are widespread over the Gawler Craton, and those horizons are typically expressed within the upper highly leached saprolite. Arguments have been put forward by a number of regolith scientists, that extensive megamottling implies a long-term saturation of the weathering profile via an overlying active fluvial channel, swamp or lake. But the vast regional extent of megamottling across the Gawler Craton seems to preclude such a localised model operating on its own. Therefore, in South Australia this phenomenon requires more research to adequately explain.

Within *in situ* regolith profiles (residual), megamottles may form a colourful horizon ranging over ~2-10 m thick (commonly 2-5 m) at the top of the upper saprolite and into the lower pedolith. Post development, well cemented or indurated megamottles can coalesce via profile collapse to form a newer pedolith horizon of collapsed megamottles, these may form a distinctive landscape capping (see below).

Silicified megamottle horizons within highly weathered rocks have been observed in many areas, these tend to form colourful silcrete resembling red or brown or yellow jasper.

Pedolith

Upper part of the regolith (weathered *in situ*), above the pedoplasmation front, that has been subjected to soil forming processes (pedogenesis) resulting in the loss of all primary igneous or metamorphic or depositional textures of the parent material and the development of new pedogenic textures and fabrics (after Eggleton, 2001; Figure 3). Pedolith includes soil, duricrusts (calcrete, gypcrete, silcrete, ferricrete, aluminocrete), mottled zone, plasmic (clayey) or arenose (grit-rich) horizons. True Fe-laterite profiles are rare on the Gawler Craton and when observed they are typically remnants, where erosion has stripped much of their original Fe-pisolith containing horizon. Where present the haematitic-goethitic pisoliths (<1-8 mm diam., formed *in situ*) have well developed cutans, and this horizon may contain Fe-stained relict vein quartz fragments. All primary texture and metamorphic fabric have been destroyed by the ferruginous overprinting, quartz veins tend to be disrupted and at shallower angles than deeper in the regolith. As stated above, megamottles may extend into the pedolith, and any collapsed megamottle horizon is within the pedolith (see below). Because the Fe-laterite horizon is a true pedolith component it may carry anomalous residual signatures to base and/or precious metals if the associated subsurface bedrock has been mineralized.

<u>Collapsed</u> <u>megamottle</u> <u>horizons</u>: these horizons consists of Fe-cemented megamottles that have been collapse merged through clay and fines removal during near surficial exposure and via a deflationary process that may have involved acid groundwater and/or aeolian mechanisms. The fines-removal process leaves the more indurated Fe-rich megamottles as prismoidal blocks coalesced with abundant residual quartz grit plus colluvially and alluvially derived clasts incorporated from above (*c.f.* Anand, 2005). Outcrop evidence suggests that a megamottle profile collapse of 25% to >60% is needed to achieve such a thick Fe-rich capping. Incorporated exotic quartz clasts include: rounded to subangular sand-sized grains to granules and occasional gravel to pebbles, these have worked their way further down into the profile from above by as much as 1-5 m via the cavities left between megamottle blocks and by normal surface cracking (developed during seasonal aridity). The resultant collapsed megamottle horizon forms a very distinctive Fe-rich pedolith (Fe-duricrust) over both localised and broad scale regions. It commonly forms a distinctive surface armouring to a residual landscape. This can lead to distinctive escarpment development where erosion penetrates, then undercuts that armouring. Upper surface fragmentation of that armouring can lead to the development of an Fe-rich gravel lag accumulation ranging from 50-300 mm in thickness.

Thickness range is<0.5-1.5 m and it can have an irregular basal contact with any remaining un-collapsed megamottle zone below. Typically it is dark red to dark red-brown to brown or occasionally a yellow-brown, and these hues tend to mimic the undisturbed megamottles hue(s) immediately below. Haematite + quartz ± goethite ± kaolinite are the typical mineral assemblages represented. Collapsed or disrupted Fe-stained vein quartz may also be present.

A broad weathering time frame from Mesozoic to Cainozoic is suggested, however, silcreted megamottles in some areas suggest that mottling occurred prior to massive silicification to silcrete in those areas. Silicification of <u>collapsed</u> megamottles has <u>not</u> been observed in South Australia and so it is possible that the collapse–deflationary process post dates major silcrete episodes.

Soils

There are many soils of significance recognised on the Gawler Craton (Northcote *et al*., 1975; Stace *et al*., 1968, Northcote *et al*., 1960-68), these have developed within *in situ* weathered and transported materials. All are pedolith components but for ease of recognition, and as distinct landscape elements, they are commonly treated under their own pedological names. Textural descriptions herein (*i.e.* sandy clay) follow those of Northcote (1979, pp. 26-28), classification into more formally recognised soil types has not been attempted for this report because there are many differing and/or conflicting classifications used within Australia and such designations are unnecessary for this presentation. Furthermore, some soil terminology used herein also derives from Eggleton (2001, pp. 39-44, 110-112), and where important for land use and engineering purposes there may be references to soil sodicity (after Northcote and Skene, 1972).

Depositional Class

This class of regolith materials is essentially sedimentary (transported); it includes lacustrine, paludal, alluvial, colluvial, aeolian and marine provenances. By far the most dominant on the Gawler Craton are the aeolian component but the more cryptic buried palaeochannel sediments are proving to be ubiquitous in some areas. Next in importance is the lacustrine and marine deposits, with minor paludal, colluvial and Holocene fluvial components. These materials together form a cover to the crystalline basement sequence and therefore can impede surface based exploration. An understanding of the distribution and thickness of these units is essential to surface geochemical anomaly interpretation and choice of sites for follow-up testing by drilling.

Erosional Class

The Erosional Class involves many of the Relict Class and Depositional Class landforms described above. Erosional Class is a dynamic landform classification where wind ± water, or water ± wind, and more rarely gravity ± water, act to remove material from outcropping areas and thereby modify that outcrop. This is an important Class because erosion can have a profound affect on any pre-existing geochemical signatures or footprints. Such is especially true where an *in situ* weathered profile is partially eroded to expose its leached zones or where fines removal has lead to profile collapse. Pre-existing geochemical signatures that originated from subcropping mineralization can therefore be laterally displaced to depositional sites overlying unmineralized or geochemically barren ground. Mineral explorers should make themselves aware of any currently active and palaeo-active erosional landforms or areas on their tenements prior to attempting any surface sampling for metal signature assay. A failure to do this will lead to an inability to distinguish between true (positive and negative) anomalism and false (positive and negative) anomalism.

BENCHMARKS

Benchmark profile details are drawn from many sources where uniformity of presentation and data between sources was not consistent. Ideal formats would include the items as set out in Table 2, however, not every site will necessarily have data or those particular items for each indicated level because benchmarking was not the original investigative focus. New photography has been taken where samples or sites were amenable and additional data drawn from other sources to infill any major gaps.

Table 2: Benchmark data that will be displayed where available.

#	**Type 1 (natural outcrop)**	**Type 2 (drilled profiles)**	**Type 3 (excavations)**
1	Regional location map	Regional location map	Regional location map
2	Local-site location map	Local-site location map	Local-site location map
3	GPS coordinates & elevation	GPS coordinates, attitude & elevation	GPS coordinates & elevation
4	Site access, owner	Site access, owner	Site access, owner
5	Related sites	Related drillholes	Related excavations
6	Profile photos + logs	Drill sample photos + logs	Excavation photos + logs
7	Sample storage location	Sample storage location	Sample storage location
8	Lithotypes	Lithotypes	Lithotypes
9	Petrology (if available)	Petrology (if available)	Petrology (if available)
10	Geochemistry (if available)	Geochemistry (if available)	Geochemistry (if available)
11	XRD data (if available)	XRD data (if available)	XRD data (if available)
12	PIMA data (if available)	PIMA data (if available)	PIMA data (if available)
13	Dating (if available)	Dating (if available)	Dating (if available)
14	Target Elements	Target Elements	Target Elements
15	Potential Pathfinder Elements	Potential Pathfinder Elements	Potential Pathfinder Elements
16	Useful sampling media	Useful sampling media	Useful sampling media
17	Key reference sources	Key reference sources	Key reference sources

Harris Greenstone Domain

Komatiitic greenstones were first recognised in South Australia from drillcore at Lake Harris NW corner on the Gawler Craton (~480 km NW of Adelaide) by Mines and Energy SA personnel in 1991 (Daly and van der Stelt, 1992; Daly and Fanning, 1993). Subsequent petrography and detailed aeromagnetic data interpretation led to two targeted drilling programs by PIRSA Geological Survey during 2001-2002 (Figures 1, 4, 5). That drilling aimed to confirm greenstone strike continuity, establish stratigraphy and contact relationships, elucidate details of the lava flows, establish the depth of cover, regolith assemblages, geochemistry and landscape evolution of targeted areas. Over 130 aircore holes were drilled into regolith, unweathered greenstone and quartzo-feldspathic basement. Eleven had additional diamond core tails and significant diamond core into fresh basement was retrieved from another eight holes (Davies, 2002a, b). A regolith study was run in parallel with the 2001-2002 basement drilling programs and used a selection of the available aircore samples, augmented by an additional three fully cored regolith profiles drilled in mid 2002. Those provided control on the earlier aircore chip logging and more detail of weathering, residual regolith textures and fabrics, and related geochemical dispersion. Together, these greenstone investigation projects have provided significant new information for key sections of the Harris Greenstone Belt (Sheard and Robertson, 2004).

That investigative work has promoted a more formal definition for the Harris Greenstone Domain (formerly part of the Wilgena Domain). The Harris Greenstone Domain comprises supercrustal Archaean ultramafic (komatiitic) and mafic volcanics, and Archaean aluminous metasediments (Christie Gneiss), felsic extrusives and/or intrusives (Kenella Gneiss) and syntectonic acid intrusives (Glenloth Granite) (Daly and Fanning, 1993). Mafic and/or ultramafic packages in the Christie Domain are generally intrusive whereas in the Harris Greenstone Domain they are dominantly extrusive. This may be due to significantly different crustal levels exposed within the different domains. Alternatively, the intrusive and extrusive ultramafics may be different geological units. Yerda Shear Zone represents the southern boundary and the northern boundary is a lithological boundary with the Wilgena Domain rocks (as redefined; Fairclough and Schwarz, 2003). The Harris Greenstone Belt (as used herein and elsewhere) refers specifically to the Archaean ultramafic and/or mafic greenstones and associated metasediments (Figure 5), and these form a significant portion of the total Harris Greenstone Domain.

Regolith investigations over the Harris Greenstone Belt utilised the new aircore drill cuttings, these provided a good orientation sample set within this deeply weathered and sediment covered terrain. Drill cuttings and core required revisiting and log reinterpretation when assay, petrographic and other results became available. When the regolith drillcore (very clay-rich) dried out, some subtle features became more apparent to the naked eye. Erosion of the deeply weathered greenstones has produced, in at least one area, a mass wasting or landslip of a surface to form a debris flow deposit (>5 m thick) with remarkably similar physical properties to its subsequent underlying regolith (*c.f.* Benchmark 5). Ferruginous pedolith cappings on the Harris Greenstone Belt residual regolith are very thin (<1 m) or have been removed by erosion (*c.f.* Benchmark 1 & Figure 8D). Greenstone spinifex textures in the serpentinised komatiite are preserved in saprolite at Lake Harris to within 17 m of the ground surface and to within about 2.5 m of the main unconformity (transported on residual *in situ* regolith; *c.f.* Petrology section for Benchmark 1).

Bioturbation of greenstone-derived ferruginous resistate materials may provide a supplementary exploration sample medium and may make it possible to 'see through' 5-10 m of transported regolith. Soil sampling revealed komatiite indicator elements (Mg, Co, Cr, Fe, Mn, Ni, V, and As) are elevated over exposed weathered greenstones or where that lithology is mantled by very thin cover. Mineralization-related elements (Au, Bi, Cu, Pb and W) are elevated there too, indicating prospective ground for base metals. Detailed regolith mapping at prospect or 1:10 000 scale can provide an 'outcrop *versus* transported regolith' framework to better target surficial geochemical sampling. It can also lead to landscape evolution models that may provide vectors to dispersed mineral signatures or from those towards mineralization (Sheard and Robertson, 2004).

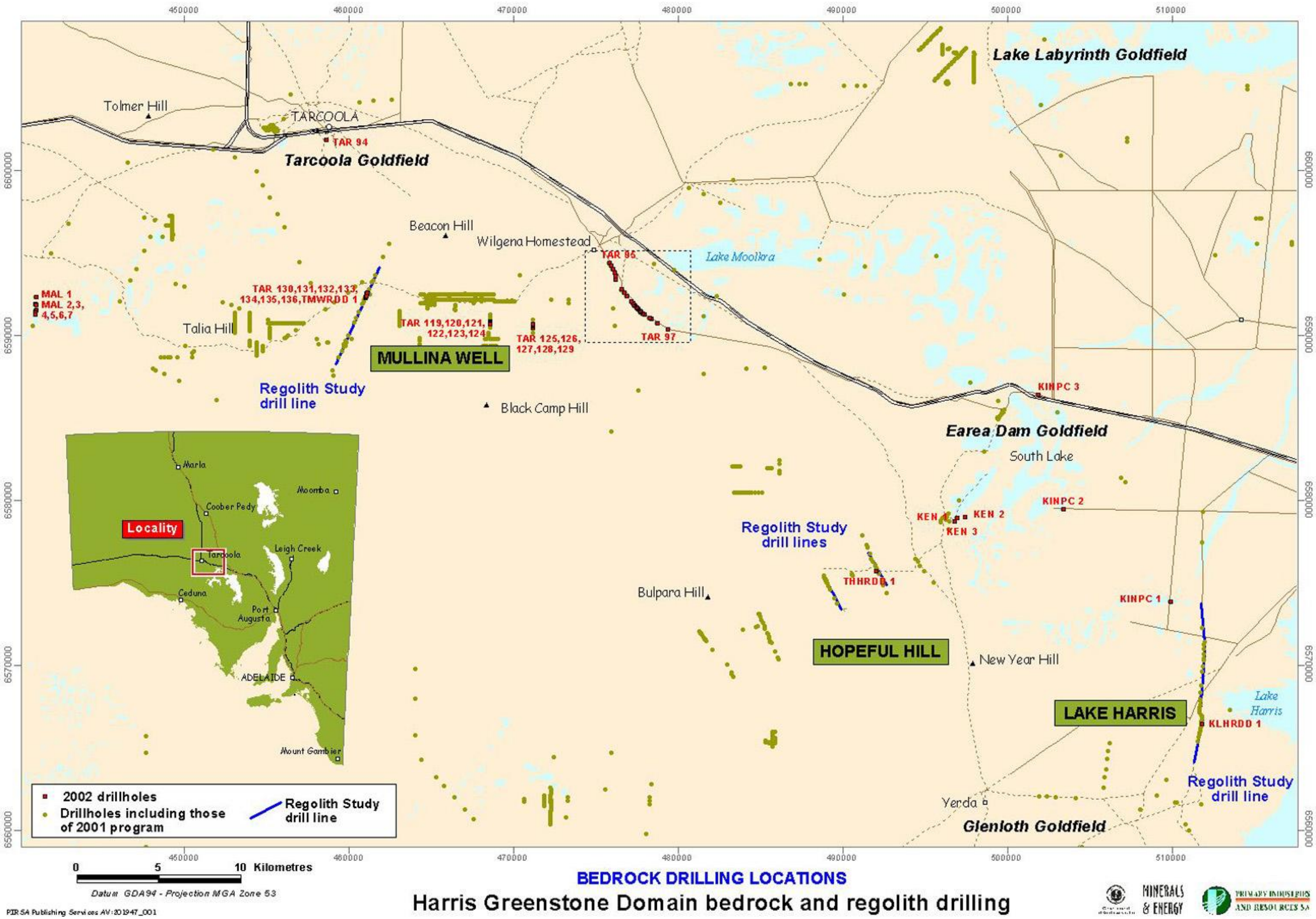


Figure 4: State and regional scale location plans (after Davies, 2002b; Sheard and Robertson, 2004).

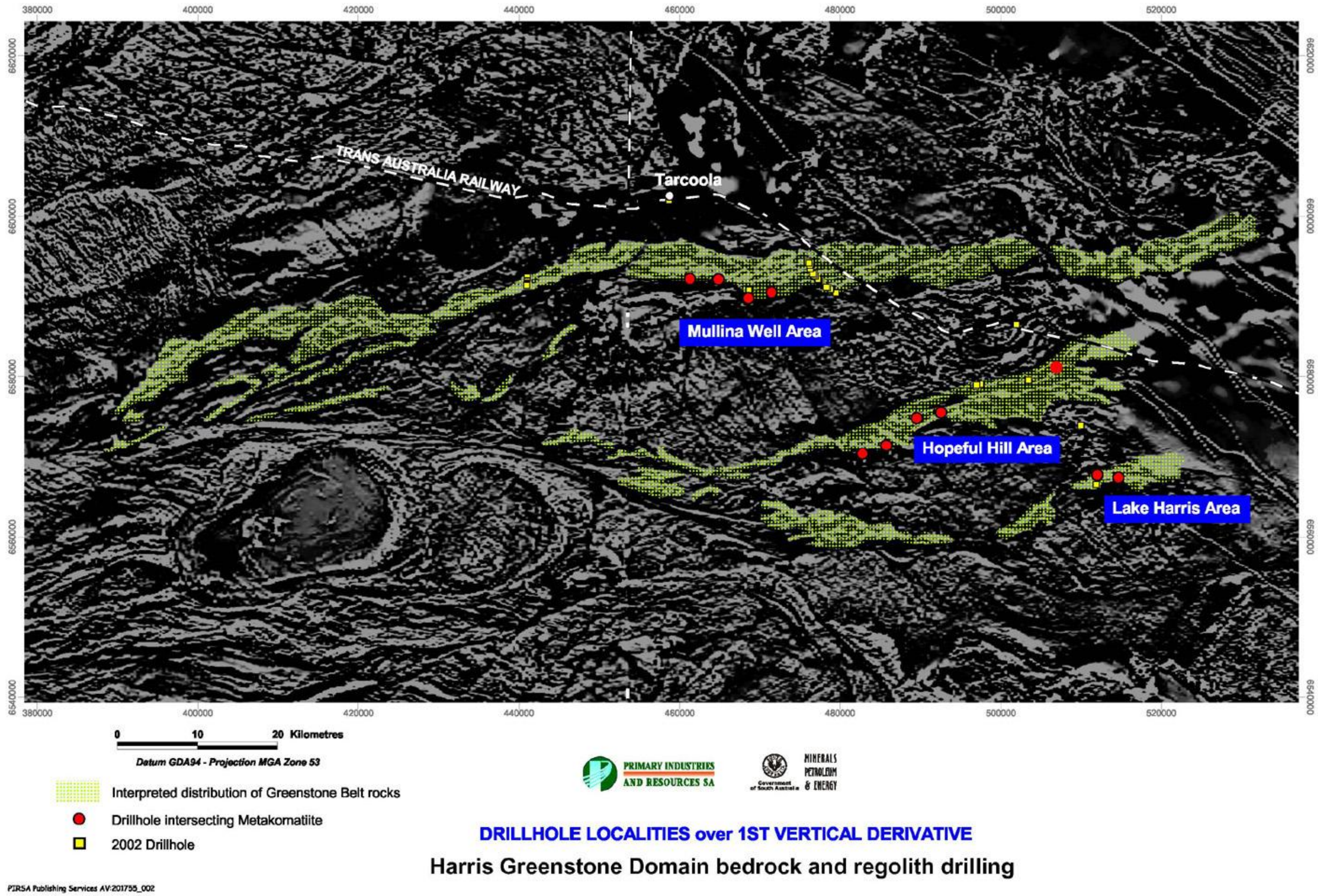


Figure 5: Interpreted subsurface extent of the komatiitic Harris Greenstones and locations of investigative drilling (after Davies, 2002b).

Lake Harris, NW corner

Benchmark 1, cored drillhole KLHRDD-1

Quick reference items are set out in Table 3; detailed descriptions, figures and data tables follow on below. This location is ~480 km NW of Adelaide, ~55 km ESE of Tarcoola and ~23 km SW of Kingoonya. A site about 6 m S of the aircore drillhole KOK 07 (W side of track to Glenloth Gold Mines) was selected as being representative of the regolith profile over weathered greenstone with a reasonable drilling depth to unweathered serpentinized metakomatiite Figures 6, 7. Drilling was vertical into a subvertical greenstone; the drilled profile most likely only intersects one or two narrow subvertical bands within the weathered and folded metakomatiite. A summary of that profile is provided in Table 4 and selected core photographs are in Figure 8; petrological photomicrographs and descriptions are presented in Figures 9, 10 + Plate 1; and geochemical data are presented in Figures 11-14 plus Table 5.

Table 3: Benchmark 1 reference data, drillhole KLHRDD-1 (Type 2, cored profile).

Items	**Figures, Data, Sources**
Regional location map	Figures 4, 5.
Local-site location map	Figures 6, 7.
GPS coordinates, attitude & elevation	Zone 53, 511991 E, 6566623 N, GDA 94. Vertical. **AHD:** 147.6 m (digital barometric survey from survey benchmark).
Site access, owner	~480 km NW of Adelaide, ~55 km ESE of Tarcoola and ~23 km SW of Kingoonya. On W side of track to Glenloth Gold Mines, on North Well Pastoral Station, W of the Lake Harris NW corner inlet.
Related drillholes	Near aircore drillhole KOK 07, part of NS drill line of 31 drillholes.
Drill sample photos + logs	Yes, Figure 7 and Table 4.
Sample types	Continuous core, HQ size, 0 to 51.25 m, chiptrays for adjacent drillhole KOK 07 are also available for comparison.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered serpentinitic komatiitic lavas.
Petrology	Yes, Figures 9, 10 + Plate 1.
Geochemistry	Yes, Figures 11-14 and Table 5.
XRD mineralogy	Yes, within core, petrology & geochemistry descriptions.
PIMA spectral data	Yes + HyLogged, but spectra have not been interpreted.
Dating	Yes but from Mullina Well area. Rhyodacite volcanics intercalated with greenstones yielded a U-Pb zircon age of 2522 ± 7.9 Ma (Fanning, 2002; Swain *et al*., 2005; Fanning *et al*., 2007).
Target Elements	Potential for Au, PGE, Ni, Cr, V, Co, Cu, Pb and W.
Potential Pathfinder Elements	Komatiite indicator elements (Mg, Cr, Ni, As, Co, Fe, Mn and V) Mineralization-related elements (Au, Bi, Cu, Pb and W).
Useful sampling media	Transported regolith-soil where <5-10 m thick and separated heavy minerals (bioturbated relict chromite), calcrete and silcrete (higher Cr, Ni & V over ultramafics), Fe-pedolith where preserved (outcrop & subcrop) see geochemistry Figures 11-14 and Table 5.
Key reference sources	Daly and van der Stelt, 1992; Fanning, 2002; Daly and Fanning, 1993; Davies, 2002a, b; Sheard and Robertson, 2003, 2004; Swain *et al*., 2005.

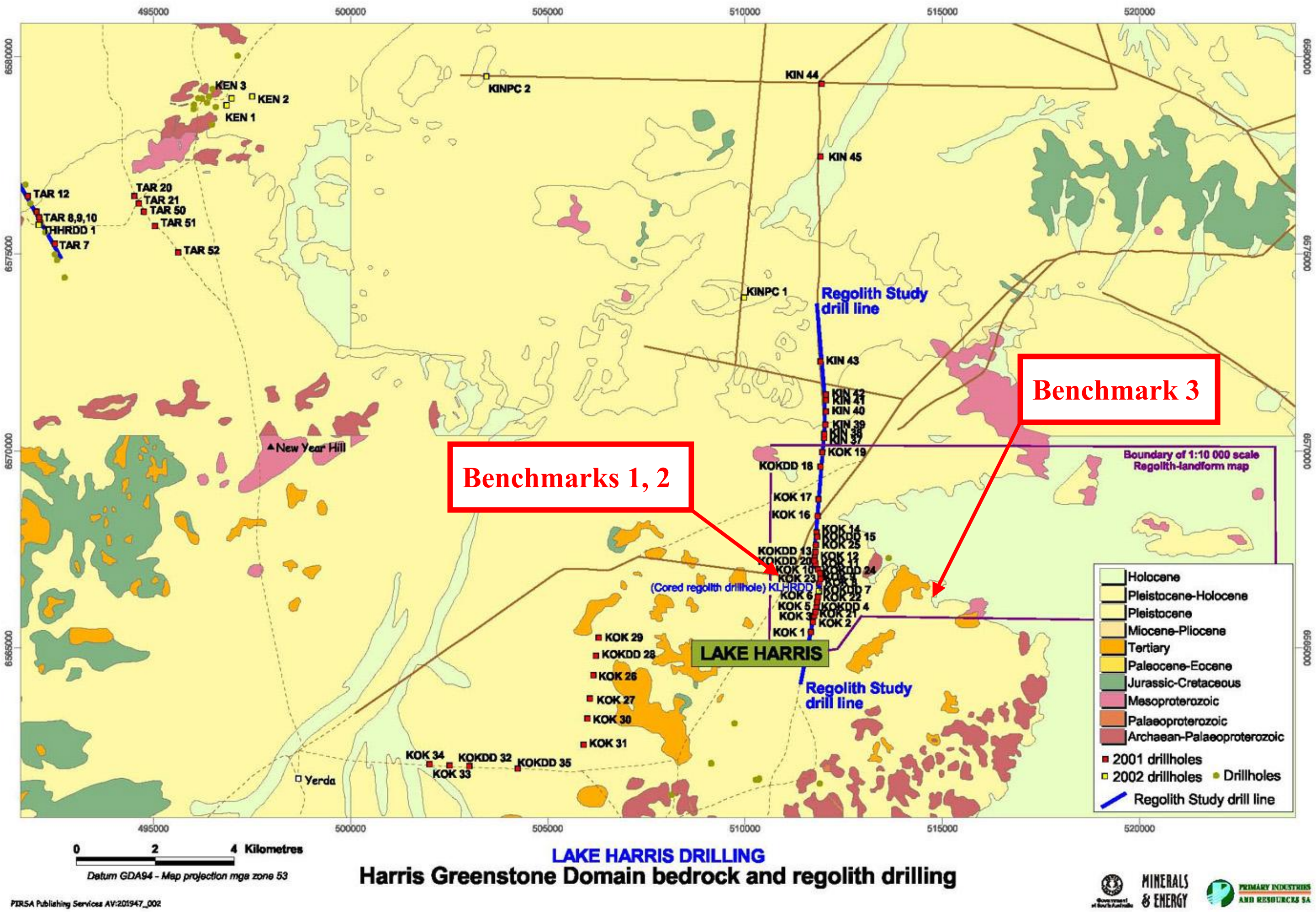


Figure 6: Localised site plan indicating where Benchmark 1 (cored drillhole KLHRDD-1) + Benchmark 2 (aircore drillhole KOK 3) and Benchmark 3 escarpment are sited (after Sheard and Robertson, 2004). The NS drill line of 22 drillholes is displayed as a regolith profile in Figure 7.

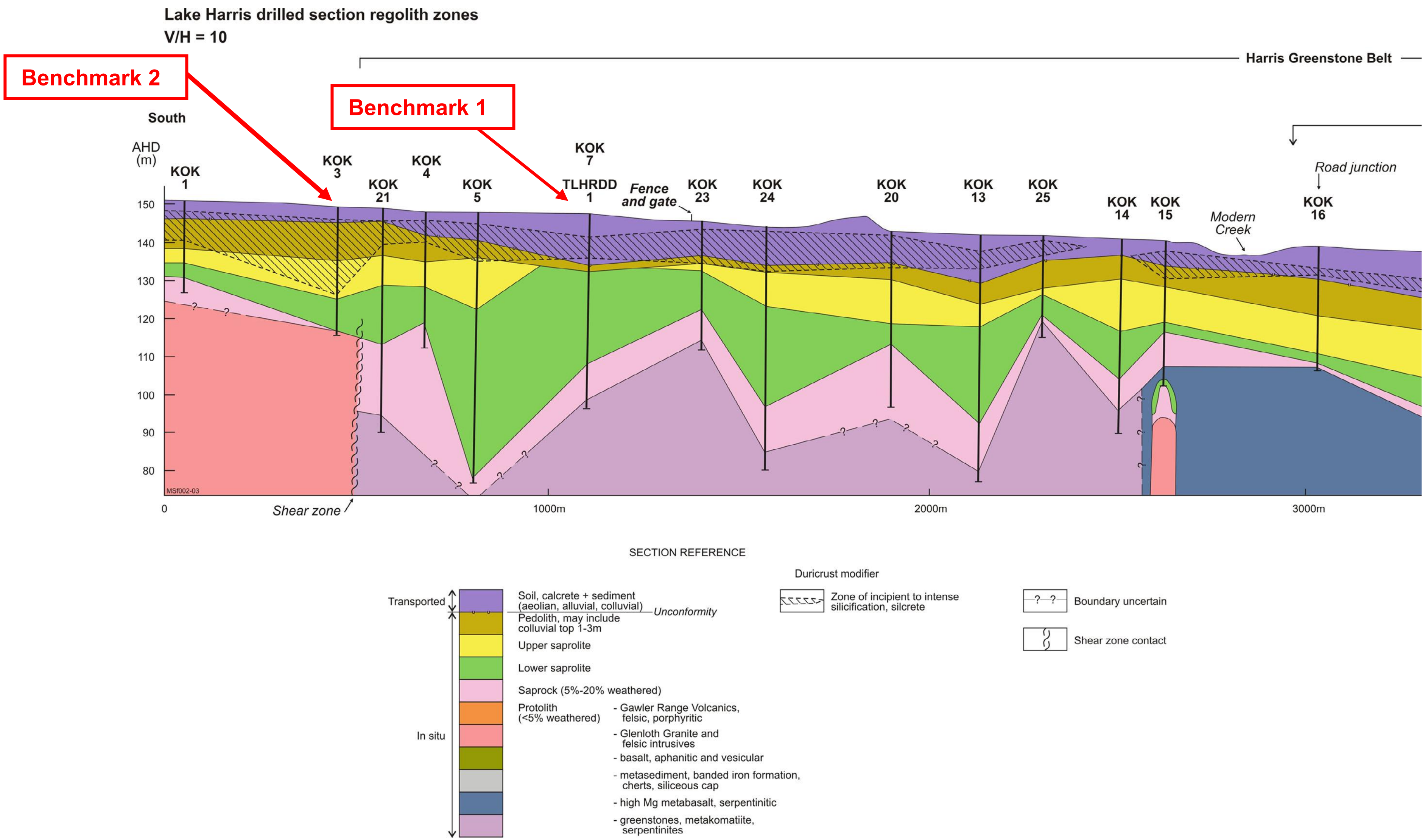


Figure 7: A portion of the NS Lake Harris Regolith profile (after Sheard and Robertson, 2004). Benchmark 1 (cored drillhole KLHRDD-1) is indicated near the southern end and places this reference site into context. Note the very irregular weathering front and variable saprolite thicknesses – irrespective of lithotype.

Table 4: Summary log of Benchmark 1, Lake Harris cored drillhole KLHRDD-1 (Sheard and Robertson, 2004).

Depth Range (m)	**Graphic Log** (vert. not to scale	**Regolith Zone**	**Description**
0.00-0.70		soil-sand	soil in loose red-brown aeolian sand with ~300 mm of calcrete.
0.70-10.50		sediment	alluvial clay + sand + gravel + cobbles, weakly bound to silicified. Upper 1-~5 m is red-brown hardpan colluvium-alluvium, the remainder is an older fluvial channel to overbank deposit with silcrete bands.
10.50-14.52		colluvium	pale clays plus rip-up pedolith clasts, quartz sand and grit with fragmentary Fe-pisoliths, locally deriving from eroded pedolith of both felsic and ultramafic terrains, red Fe-megamottled.
14.52-14.75	# # # #	***in situ*** Pedolith (plasmic)	extremely weathered greenstone residuum; pedogenic clay-rich breccia, pale green to bluish and greyish, Fe-stained, top eroded, NO ferricrete cap.
14.75-41.60		upper saprolite	Highly weathered greenstone; upper ~1 m displays weathering brecciation. Mostly a complex sub-zone with several enclaves of less + more highly weathered material. Clay-rich, soft to stiff and sticky-plastic clay (smectitic) light to bright greens + blue-greens + yellow-greens + blue-greys. Relict foliation and conjugate joint sets, red Fe-mega-mottling and yellow to brown Fe-staining, white to pale grey chalcedony veins, black MnOx flecks and dendrites. Some intervals have a distinctly greasy feel (talc). Sub-zone is smectite (dominant above 29 m), chlorite, talc + relict serpentine.
41.60-49.15		lower saprolite	Weathered greenstone; complex sub-zone, has several enclaves of less or more highly weathered rock. Sub-zone is generally darker hued and more competent than the one above (less altered). Blue-green-grey weathered serpentinite + bright green and brown clay seams + talc and yellow Fe-staining, well jointed, relict metamorphic fabric–foliation.
49.15-51.25		saprock – bedrock	Partially weathered greenstone; serpentinite, dark green-grey, some clay fracture infill, progressively more competent with depth but still retains enclaves of more weathered material. Weathering Front probably just below end of drillhole.

The following lithology and petrographic descriptions are taken from Sheard and Robertson (2004).

In situ Regolith (greenstone)

Bedrock (<5% weathered minerals) forms only a very minor component of this diamond core, as small enclaves within the saprock below about 49.6 m. Drilling did not terminate in true bedrock. The bedrock enclaves are dark grey to dark blue-green-grey with minor yellow-brown and lime-green clays along fractures. Relict primary fabric and metamorphic foliation occur within the serpentinitic greenstone. Cuttings from the nearby aircore drilling (KOK 07) imply that the bedrock should have been intersected at or near 48 m, well above the actual weathering front in the diamond core (>51.25 m). It is concluded that i) cuttings alone are not the best medium for regolith boundary identification and ii) the depth of the weathering front varies significantly, even over short lateral distances.

Saprock (49.15-~49.6 m) has >5-<20% of weatherable minerals weathered, mostly to clay, infilling fractures and as patchy incipient alteration of the dominant serpentinite. The saprock is dark blue-green to green-grey with minor bright green and brown clay seams. Yellow Fe-oxides have stained the joint surfaces. Relict primary fabric and metamorphic foliation are preserved in less weathered greenstone. Talc is also present and makes these materials feel very greasy; although originally formed by hydrothermal-metamorphic processes, it easily survives weathering and is probably left in the clay matrix as the only bedrock remnant complex mineral.

The **lower saprolite** sub-zone (41.6-49.15 m) of weathered greenstone has several patches of both clay saprolite and greenstone saprock enclosed within it (each >2 m thick). The lower saprolite is generally darker than the upper saprolite, is more competent, the clay is stiffer and serpentine is obvious. It is blue-green-grey to dark green-grey. Bright yellow-green and brown ferruginous clay fills fractures and forms stains around fractures in some of the more highly weathered intervals. Regular conjugate joint sets lie at 45°, 60° and 80° to the core axis and are variably slickensided.

A thick and complex, highly weathered **upper saprolite** sub-zone occurs between 14.75-41.6 m. It is predominantly light to bright green with minor blue-green, yellow-green to blue-grey colours. This includes patches of more and less weathered greenstone; some of these patches are >2 m in size. The upper saprolite is dominated by clay and is variably soft to stiff, with the clay being sticky and plastic due to abundant smectite. Towards the top, a weathering-induced breccia occurs that has jig-saw-fit clay-rich blocks without fracture infill. Talc- and vermiculite-like minerals give many intervals in this sub-zone a distinctive greasy feel. There is also a weak relict metamorphic foliation and regular conjugate sets of slickensided joints at 30°, 45° and 60° to the core axis. These joints indicate compression induced movement, possibly related to gross volume changes caused by mineral weathering and/or hydration. In spite of the deformation and weathering, there are relict primary structures preserved such as spinifex quench textures (at about 17 m, see petrology section). Red, ferruginous megamottles and bright yellow to brown Fe-oxide staining are common in this sub-zone (Figure 8A). Differential weathering has yielded pseudo-breccias having differently coloured rims on geometric or irregular shaped greenstone blocks on scales of 5-100 mm (Figure 8B). White to pale grey chalcedony veins (about 2-35 mm thick) occur throughout. Black Mn-oxide flecks and dendrites occur in some intervals (14.75-16.5, 23.4-25.9 m). Dark red-brown to brown, strongly ferruginous intervals, where Mn-oxide is also abundant, occur at 37.45 m and at 38.5 m (both 300-350 mm thick). The upper saprolite is mostly composed of smectite-hydromuscovite clays with talc, chlorite and relict serpentine.

XRD analysis shows that the deeper saprolites and bedrock (>27 m) contain major proportions of clinochlore, tremolite and a ferruginous ortho-amphibole. Above this, smectites and interstratified smectite-chlorites dominate, with palygorskite developed above about 20 m. Palygorskite is probably related to the saline alkaline environment with abundant Mg in solution (Taylor and Eggleton, 2001: J. Keeling, PIRSA, pers. comm. 2004). Petrography indicates remnants of a pyroxene spinifex fabric and possibly some olivine spinifex textures as well.

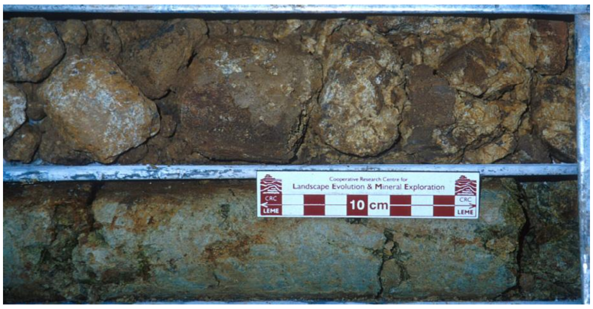
The top of this extremely weathered greenstone was intersected at 14.52 m where a relict pedolith forming a truncated **plasmic zone** 0.23 m thick occurs, the upper surface of which forms an angular unconformity (about 45°) to the overlying transported regolith (colluvium). The unconformity is only visible on the dry core; its true location was not visible when the core was first logged damp and required petrography to refine a likely interval to examine in more detail (Figure 8C). This zone consists of pale grey-green smectite- to hydromuscovite-rich material with bluish intervals, yellow stains and streaks. It has a jig-saw fit smectitic clay-rich breccia fabric (similar to the upper saprolite below) but here the darker pale grey-green clay fragmental blocks are cemented together or have their surrounding fractures infilled by a slightly paler bluish grey-green less smectitic clay. There is no ferruginous capping although remnants of this can be seen at the nearby recently exhumed greenstone outcrop area (.21 km ~E of this Benchmark) and evidence for it once having been here is in the overlying colluvium (see below). Pedogenesis has destroyed any primary foliation or fabric; the brecciation appears to be related to weathering and pedogenic processes.

Transported Regolith

Transported regolith here is 14.52 m thick Table 4, consisting of >4 m of clay-rich colluvium resting on the unconformity, overlain by 5.4 m of alluvium, overlain in turn by 4.6 m of red-brown hardpanized colluvium-alluvium, and the whole then covered by <1.0 m of aeolian sand.

A pale, mottled **colluvial unit** forms the basal 4.02 m of the sedimentary cover sequence. It consists of pale grey-green or pale blue-grey clays grading upwards into yellow to pale brown clay, quartz sand and grit, and broken 3-5 mm ferruginous pisoliths (Figure 8D). There are angular to subrounded rip-up clasts of pedolith and saprolith clays floating within the unstructured clay-rich colluvium between 14.40-14.52 m. Widespread red to brown Fe-oxide staining and megamottles imply this unit has been affected by pedogenesis. Much is locally reworked pedolith derived from weathered greenstone and adjacent granitic terrain. The ferruginous pisoliths all exhibit broken or missing cutans, having been dislodged from an eroding surface and transported a short distance. They seem to be the only remaining evidence of a pre-existing, probably thin ferruginous cap, once developed on the greenstones but now mostly eroded. There is an angular unconformity (~45° to the core axis) at the base of this multicoloured colluvial interval. Later silicification has partially indurated the interval 10.5 to ~13.5 m.

Overlying the colluvium, a mostly brown coloured unnamed **alluvium** (5.10-10.50 m) that consists of clast-supported channel sand to cobbles in which well-rounded to subangular quartz-rich clasts predominate. Some pebble to gravel sized clasts, consisting of reworked, silicified, weathered granite are conspicuous components (Figure 8E, F). Interlayered with those coarse-grained layers are overbank clays with rhythmic cycles 300-500 mm thick. Some of the more porous intervals of the alluvium have been silicified to silcrete. This duricrust is pedogenic and probably marks an early or middle Cainozoic silicification episode.



A. Core depth 37.5-37.75 m, Fe-mottled upper saprolite (upper core).

B. Core depth 16.98-17.16 m, upper saprolite displaying a subtle weathering induced pseudo-breccia.

C. Core depth 14.40-14.72 m, subtle unconformity at 14.52 m (lower core, 2 cm from LH end of blue scale bar). Weakly mottled colluvium in upper core.

D. Core depth 12.90-13.10 m, lower core, weakly mottled colluvium with small dark brown Fe-pisolith fragments distributed randomly throughout.

E. Core depth 9.2-9.4 m (upper core) & 10.3-10.5 m (lower core), fluvial sediment containing silcrete cobbles displaying variably altered rims, polymict gravel and cemented by a later silcrete.

F. Core depth 5.50-5.70 m (upper core) & 6.40-6.60 m (lower core) both displaying partially silicified alluvium with variably clayey matrix. Clasts are of mixed lithotypes and display a wide range in transport history degree of rounding.

Figure 8: Benchmark 1, drillhole KLHRDD-1, selected drill core (Sheard and Robertson, 2004).

Red-brown hardpan (as used herein) refers to a dominantly colluvial-fluvial material (0.7-5.1 m deep). It has a strong reddish brown colour, is a clayey to sandy material containing abundant matrix-supported polymictic gravel. The hardpan is variably cemented by carbonate, hyaline silica, and Fe-oxides, thereby making this sediment variably competent. The hardpanization is presumed to be Pliocene to Pleistocene in age based upon stratigraphic evidence elsewhere in this region.

Pedogenic **calcrete** forms an earthy to moderately compact but low-density, white to creamy layer within the soil-sand profile. Exposures of aggregated calcrete nodules that laterally become laminated or massive sheets in the nearby drill sump demonstrated the variability of this soil B_{Ca} horizon. There are additional but less obvious carbonate cementing materials to a depth of 5.1 m.

Thin **aeolian sand** covers the drill site and has not cored well (poor recovery). It is red-brown to orange, less than a metre thick, uniformly sorted and hosts later formed calcrete (see above).

NOTE: There is a significant discrepancy of nearly 10 m between the position of the residual regolith—transported regolith unconformity in adjacent diamond cored and air-cored drilling (about 6 m apart) this demands an explanation. Logging of aircore drillhole KOK 07, that had bulked 2 m interval cuttings, determined the major unconformity at about 4 m; but diamond core from KLHRDD-1 determined it at 14.52 m. The majority of this difference is due to drill sampling methods, 2 m bulked regolith cuttings are inferior to continuous core. Cuttings of colluvial clay-rich materials strongly resemble deeply weathered residual regolith, making the major unconformity position difficult to locate with certainty. It required the assistance of petrography, XRD mineralogy and geochemistry to locate properly. Here the pedolith commonly has an upper portion of mixed provenance, allowing the major unconformity in KOK 07 to be adjusted downwards to about 7 m depth. Local variations in a steep palaeotopography between two adjacent sites may also contribute to the difference (*i.e.* on the slope of a palaeovalley). This example demonstrates very well the efficacy of regolith drill core over cuttings when working with transported materials on highly weathered basement (Sheard and Robertson, 2004).

Petrography

Depth 49.7 m. ULTRAMAFIC BEDROCK.

Pale, acicular tremolite, probably after pyroxene, forms a mesh of randomly oriented needles in which lie patches of chlorite and tremolite, after olivine (Figure 9E, F). Grains of anhedral chromite, ilmenite or magnetite, occur mainly in the chlorite or between chlorite and tremolite and some form parallel bands, probably outlining an original olivine spinifex structure. Weathering is very minor and occurs along cracks that are partly filled with goethite and some goethite has lightly stained the amphiboles adjacent to the cracks. Specimen R406683.

Depth 28.75 m. Fe-STAINED SAPROCK OF ULTRAMAFIC.

The fabric and mineralogy of this saprock is similar to the bedrock below but large, diffuse patches have been stained by goethite developed along grain margins. Cracks in the fabric are infilled with clays and the material around the cracks appears bleached of iron staining, suggesting a cycling water table which placed this saprock alternately in an oxidising and then in a reducing environment. The iron oxides show a slight parallel alignment, suggesting some palimpsest olivine spinifex structures as in the rocks below. Specimen R406682.

Depth 17.0 m. LOWER SAPROLITE OF ULTRAMAFIC WITH SPINIFEX FABRIC.

The saprolite consists of a very fine mesh of hydromuscovite, smectite and chlorite, in which there are remnant needles of unaltered tremolite. However, this fine mesh still preserves the distinctive bladed pyroxene spinifex structure in which illitic clay has replaced the pyroxene and the very fine, dusty iron oxides have picked out the interstices of the spinifex structure (Figure 9C, D). Some of the pyroxene pseudomorphs are cored with a concentration of Fe-oxides. Weathering has lightly stained the rock. Specimen R406681.

Depth 13.75 m. COLLUVIAL SEDIMENT.

Subround to subangular grains, mainly of quartz with minor chert, sericitized plagioclase, clay pellets and goethite-quartz nodules, are loosely packed into a matrix of kaolinite, smectite and hydromuscovite (Figure 9A). This has been mottled to yellow and brown by goethite that has variably stained the matrix. Some voids have been infilled by banded cryptocrystalline aluminosilicate (Figure 9B). Specimen R406680.

Depth 13.47 m. COLLUVIAL SEDIMENT.

Clasts of quartz are dispersed in a clay-hydromuscovite matrix. This section varies from loosely packed at the base to closely packed at the top. Feldspars are absent. Mottling by goethite and some hematite has variably stained the matrix throughout. Sinusoidal veins of cryptocrystalline silica meander throughout the matrix and are probably related to hardpanization. Specimen R406679.

Depth 12.15 m. COLLUVIAL SEDIMENT.

Round, large grains (3 mm) and smaller angular grains (0.5 mm) are loosely packed in a kaolinite-smectite-hydromuscovite matrix that has been mottled by Fe-oxides (Figure 10H). Some quartz clasts are a strained compound mosaic of sutured to granoblastic grains. Specimen R406678.

Depth 10.65 m. COLLUVIAL SEDIMENT.

The sediment consists of fine-grained, angular quartz (1-2 mm), coarser (5 mm) subround strained quartz, minor sericitized plagioclase, a trace of fresh microcline and chert, loosely packed into a flaky phyllosilicate (kaolinite-smectite-hydromuscovite) matrix. A few larger fragments (10 mm) are of gneiss (highly strained quartz and sericitized plagioclase). Parts of the matrix are brown and mottled with goethite. Specimen R406677.

Depth 9.33 m. COLLUVIAL SEDIMENT.

Smaller (0.5 mm) subangular grains of quartz and sericitized plagioclase and larger grains (1-1.5 mm) of subrounded quartz, sericitized feldspar and ferruginous silcrete are loosely packed into a matrix of flaky clay and banded aluminosilicate (Figure 10G). There is more matrix than in those at a shallower depth. Specimen R406676.

Depth 6.5 m. COLLUVIAL SEDIMENT.

The clasts are small, angular to subround and are largely of quartz, vein quartz (with some comb fabrics) and lesser sericitized feldspar and minor fresh microcline. With these are a few larger clasts (10-30 mm) of ferricrete, silcrete, chert and weathered granite (Figure 10E). These are closely packed in an Fe-mottled phyllosilicate matrix with some banded aluminosilicate cement (Figure 10F). Specimen R406675.

Depth 4.95 m. COLLUVIAL SEDIMENT.

Closely packed subangular to subrounded grains of quartz, chert, vein quartz and lesser sericitized plagioclase, fresh microcline and ferricrete clasts, set in an aluminosilicate/phyllosilicate cement (Figure 10C, D) which is less Fe-stained than that higher in the profile. There is less microcline and feldspar and more quartz than in the sediments at a shallower depth. The feldspars are more weathered and Fe-stained (prior to sedimentation). The ferricrete contains both angular, shardy quartz grains and highly rounded grains (water worn). Specimen R406674.

Depth 2.8 m. HARDPANIZED COLLUVIUM.

Closely packed subangular to subround quartz grains, probably from a dismembered granite (relatively fresh), are set in an Fe-stained aluminosilicate cement. The grains consist of sutured quartz, fresh microcline, sericitized plagioclase (Figure 10A, B) and compound grains of these three component minerals. There is also a trace of epidote and chert grains. The dark red cement is banded in part and probably infilled voids in a sedimentary grain mesh. A small amount of the matrix consists of red-stained phyllosilicates. Specimen R406673.

Petrographic Comments

- It seems likely that the sediments were deposited on soft, easily eroded ultramafic rocks that occupied low parts of the topography.
- The smectitic clay of the matrix was probably largely from erosion of mafic-ultramafic rocks and the kaolinite and hydromuscovite from weathered granitic materials. The upper part of the sediment is cemented to a hardpan by banded aluminosilicate. The matrix of the sediments below the hardpan consists of phyllosilicate and becomes more abundant with depth. Where it is less stained, it is a flaky mixture of phyllosilicates (XRD and petrography indicates kaolinite, smectite and hydromuscovite) and varies in birefringence from grey to first order yellow.
- The quartz clasts appear to have been derived locally from deeply weathered granites (characterized by small shardy grains), however some larger grains are more rounded, probably also granitic and have been transported further. Vein quartz was another source.

- Predominance of quartz clasts in the lower part of the sediments and the appearance of microcline and sericitized feldspar towards the top imply the progressive erosion of and provenance from a deeply weathered granitic/gneissic profile that progressively exposed less weathered materials with time.
- The bedrock intersections are relatively undeformed, allowing some of the original igneous fabrics to persist into the saprolite. It seems likely that different parts of the ultramafic flows have been intersected to show both olivine and pyroxene spinifex structures.

Figure 9 Explanation: Thin-section petrography to photomicrographs from Benchmark 1 (cored drillhole KLHRDD-1) and a portion of Benchmark 4 (cored drillhole THHRDD-1), (Sheard and Robertson, 2004).

A. Subrounded to subangular grains of quartz (QZ) and clay pellets (CP) loosely set in a pale grey clay matrix (MX). The clay has been mottled yellow-brown with a goethite stain (GO). Close up photograph of colluvial sediment. Specimen R406680: Drillhole KLHRDD-1, Depth 13.75-13.80.	**B.** Loosely packed nodules of goethite and quartz (GO), angular to subrounded quartz (QZ), chert (CT), and sericitized plagioclase (PL) in a matrix (MX) of flaky kaolinite, smectite and hydromuscovite. The matrix has been stained brown by goethite. Some voids are infilled with banded aluminosilicate (AL). Photomicrograph of colluvial sediment under transmitted light with crossed polars. Specimen R406680: Drillhole KLHRDD-1, Depth 13.75-13.80.
C. Yellow-green hydromuscovite pseudomorphs after bladed pyroxene spinifex fabric (SP) surrounded by massive, bright green, plasmic, smectitic clay (SM) with remnants (RM) of the previous illitic material. Close up photograph of saprolite of ultramafic rock with spinifex fabric. Specimen R406681: Drillhole KLHRDD-1, Depth 17.0-17.07.	**D.** Bladed pyroxene spinifex structure (SP) now pseudomorphed by illitic clay and the interstices (IS) and pyroxene cores (PC) are accentuated by dusty Fe-oxides. Photomicrograph of saprolite of ultramafic rock with a spinifex fabric under plane polarized transmitted light. Specimen R406681: Drillhole KLHRDD-1, Depth 17.0-17.07.
E. A fresh mass of pale, acicular tremolite (TM) and patches of dark green chlorite (CL). Cracks are partly filled with goethite (GO) from which a staining has spread. Close up photograph of ultramafic bedrock. Specimen R406683: Drillhole KLHRDD-1, Depth 49.70-49.77.	**F.** A mesh of acicular tremolite (TM) after pyroxene with patches of chlorite (CL) after olivine. Minor goethite staining (GO) along cracks. Photomicrograph of ultramafic bedrock under plane polarized transmitted light. Specimen R406683: Drillhole KLHRDD-1, Depth 49.70-49.77.
G. Larger subrounded grains of ferricrete (FC) and quartz (QZ) and smaller, angular to shardy quartz grains (QS) loosely packed into a brown-stained kaolinitic matrix (MX). Cracks are partly lined by siliceous clay (CL). Close up photograph of hardpanized colluvium-alluvium. Specimen R406684: Drillhole THHRDD-1, Depth 4.52-4.58.	**H.** Ferruginous nodules (FN) and large, subround to subangular clasts of creamy claystone (CS) containing smaller white claystone clasts (CL) and clear subangular quartz grains (QZ). These are set in a in a matrix of fine-grained angular quartz and deep brown stained kaolinite (KA). Close up photograph of hardpanized sedimentary breccia. Specimen R406685: Drillhole THHRDD-1, Depth 8.08-8.15.

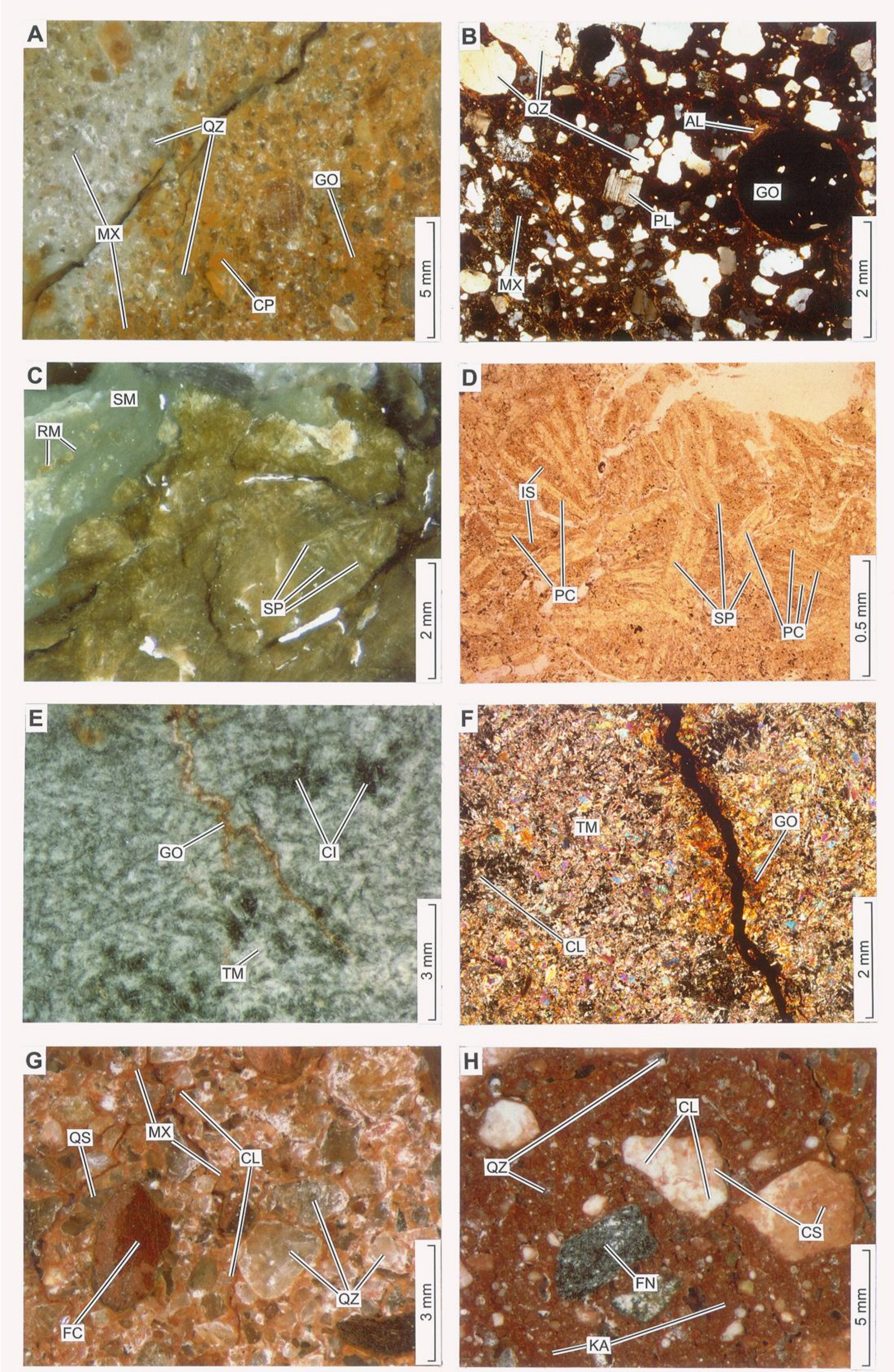


Figure 9: Annotated thin-section photomicrographs from Benchmark 1 (cored drillhole KLHRDD-1) and a portion of Benchmark 4 (cored drillhole THHRDD-1), (Sheard and Robertson, 2004).

Figure 10 Explanation**:** Thin-section petrography to photomicrographs from Benchmark 1 (cored drillhole KLHRDD-1), (Sheard and Robertson, 2004).

A. Grains of vein quartz (VQ), granitic quartz (QZ) and feldspar (FS) in a red hardpanized aluminosilicate and phyllosilicate matrix (MX). Cementation by siliceous, banded clays (BC) has taken place along cracks. Close up photograph of hardpanized colluvium. Specimen R406673: Drillhole KLHRDD-1, Depth 2.80-2.87.	**B.** Closely packed grains of fresh microcline (MC), quartz (QZ) and sericitized plagioclase (PL) set in a dark red matrix of Fe-stained aluminosilicate and Fe-stained phyllosilicates (AL). Photomicrograph of hardpanized colluvium under transmitted light with crossed polars. Specimen R406673: Drillhole KLHRDD-1, Depth 2.80-2.87.
C. Angular to subrounded grains of white vein quartz (VQ), quartz (QZ) closely packed into a matrix of Fe-stained phyllosilicates (PH) and aluminosilicate patches (AL). Close up photograph of colluvial sediment. Specimen R406674: Drillhole KLHRDD-1, Depth 4.95-5.02.	**D.** Close-packed subangular to subrounded compound grains of quartz (QZ), chert (CT), vein quartz (VQ) and minor sericitized plagioclase, fresh microcline and ferricrete clasts in a slightly Fe-stained aluminosilicate-phyllosilicate matrix (MX). The ferricrete contains both rounded and shardy quartz. Photomicrograph of colluvial sediment under transmitted light with crossed polars. Specimen R406674: Drillhole KLHRDD-1, Depth 4.95-5.02.
E. Angular to subrounded clasts of dark brown ferricrete (FC), yellow silcrete with a partial white weathered rind (SC) and quartz (QZ) in a matrix of grey clay (CL) and banded aluminosilicate cement (AL). Close up photograph of colluvial sediment. Specimen R406675: Drillhole KLHRDD-1, Depth 6.50-6.58.	**F.** Large, lithic clasts of ferricrete (FC), consisting of angular quartz grains (QZ) in a hematite cement (HT) and smaller mineral grains comprising quartz, vein quartz, lesser sericitized feldspar (FS) and minor fresh microcline (MC) set in an Fe-mottled matrix of phyllosilicates (PH). Photomicrograph of colluvial sediment under plane polarized transmitted light. Specimen R406675: Drillhole KLHRDD-1, Depth 6.50-6.58.
G. Subrounded clasts of Fe-stained silcrete (SC) ultramafic saprolite (US) and grains of quartz (QZ) loosely packed into a matrix of slightly mottled clay (CL). Close up photograph of colluvial sediment. Specimen R406676: Drillhole KLHRDD-1, Depth 9.33-9.40.	**H.** Larger subrounded and smaller angular grains of quartz (QZ) in an abundant matrix of grey-green kaolinite-smectite-hydromuscovite clay (CL) slightly mottled (MO) with goethite. Close up photograph of colluvial sediment. Specimen R406678: Drillhole KLHRDD-1, Depth 12.15-12.20.

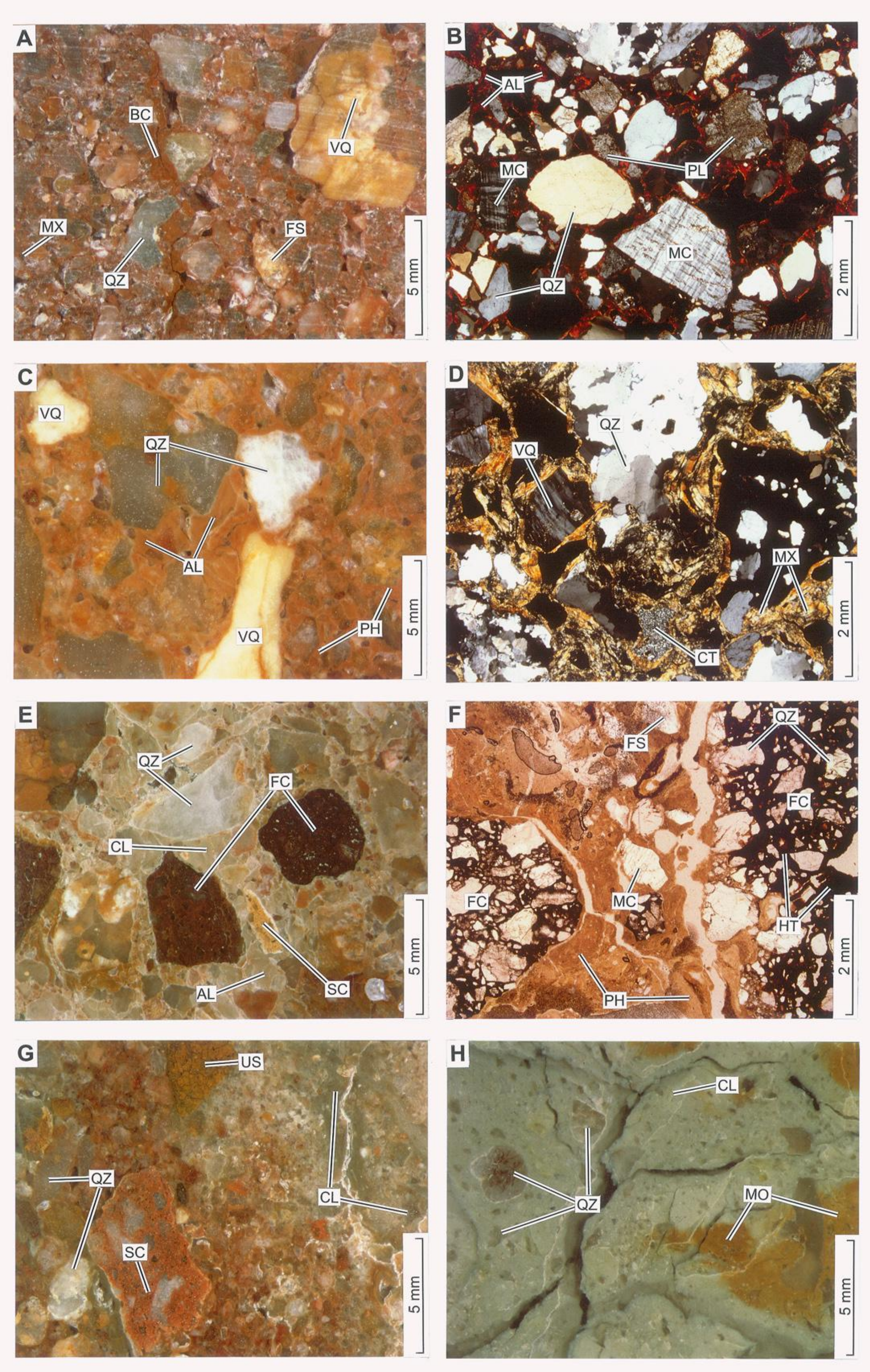


Figure 10: Annotated thin-section photomicrographs from Benchmark 1 (cored drillhole KLHRDD-1), (Sheard and Robertson, 2004).

Geochemistry

The following descriptions are taken from Sheard and Robertson (2004).

Half core spot samples, up to 100 mm long, were taken at selected points from the HQ diamond core to indicate chemical variations but, at the same time, preserve at least the other half core as a record. Thus, the geochemistry is not continuous. Graphic results are displayed in Figures 11, 12.

A ternary plot of the major components (Si-Al-Fe; Figure 11A) indicates that ferruginisation is the major weathering trend in the residual part of the profile. However, it must be kept in mind that structurally and stratigraphically complex Archaean rocks were intersected and these were not necessarily originally chemically equivalent prior to weathering. Figure 12 displays the down hole log against geochemistry for this drillhole. The upper part of the residual profile is particularly rich in Ni, Co, Cu and Cr (2000-4000 ppm; 300-400 ppm; 120-170 ppm; and 4000-6000 ppm, respectively). The petrography and XRD indicate less weathering throughout the saprolite than implied by the logging and this is supported by the high Mg contents. However, the petrographic and geochemical materials represent only a small part of the logged core. The high Mg contents reflect both remnant primary minerals (clino-amphibole and chlorite) and secondary smectite. It is suggested that at least some of the residual profile is lower saprolite to saprock, as weathering, penetrating along grain fracture boundaries and consuming comparatively little of the bulk of the rock, can lead to a very friable material. High Na in the upper saprolite is correlated with Cl, implying an influence from saline water and halite (confirmed by XRD mineralogy).

The sediments have a similar Si-Al spread (Figure 11A) to the other sites, due to varying sand and clay contents; one of the sediments is ferruginous. The observed increase in relatively fresh granitic detritus towards the top of the sedimentary column is supported by progressive increases in K, Rb and Ba. In contrast, the Si and Zr contents are variable but consistently high in the sediment, reflecting weathering-resistant quartz and zircon. Calcification of the top two metres is also reflected in Ca and Sr. Maxima in As, Sb, Bi and V are associated with high Fe. The clay-rich material at the base of the sedimentary column is comparatively rich in Ni, Cr and Co, suggesting at least some input from a greenstone saprolite provenance.

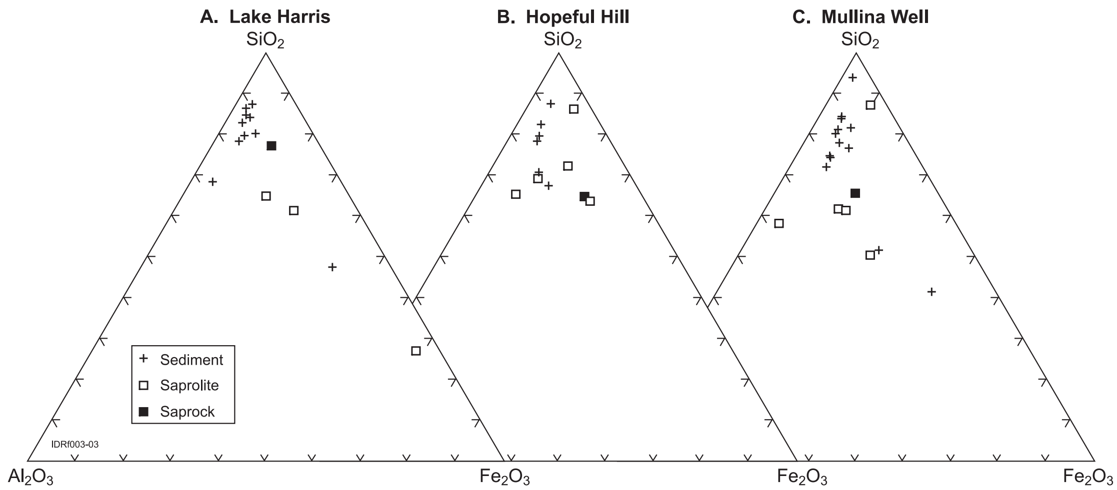


Figure 11: Comparison ternary plots of major elements (Si, Al, Fe) for (A) the Lake Harris drillhole, (B) the Hopeful Hill drillhole and (C) the Mullina Well drillhole showing weathering trends in the weathered basement and sedimentary rocks, and weathering trends in the overlying sediments (Sheard and Robertson, 2004).

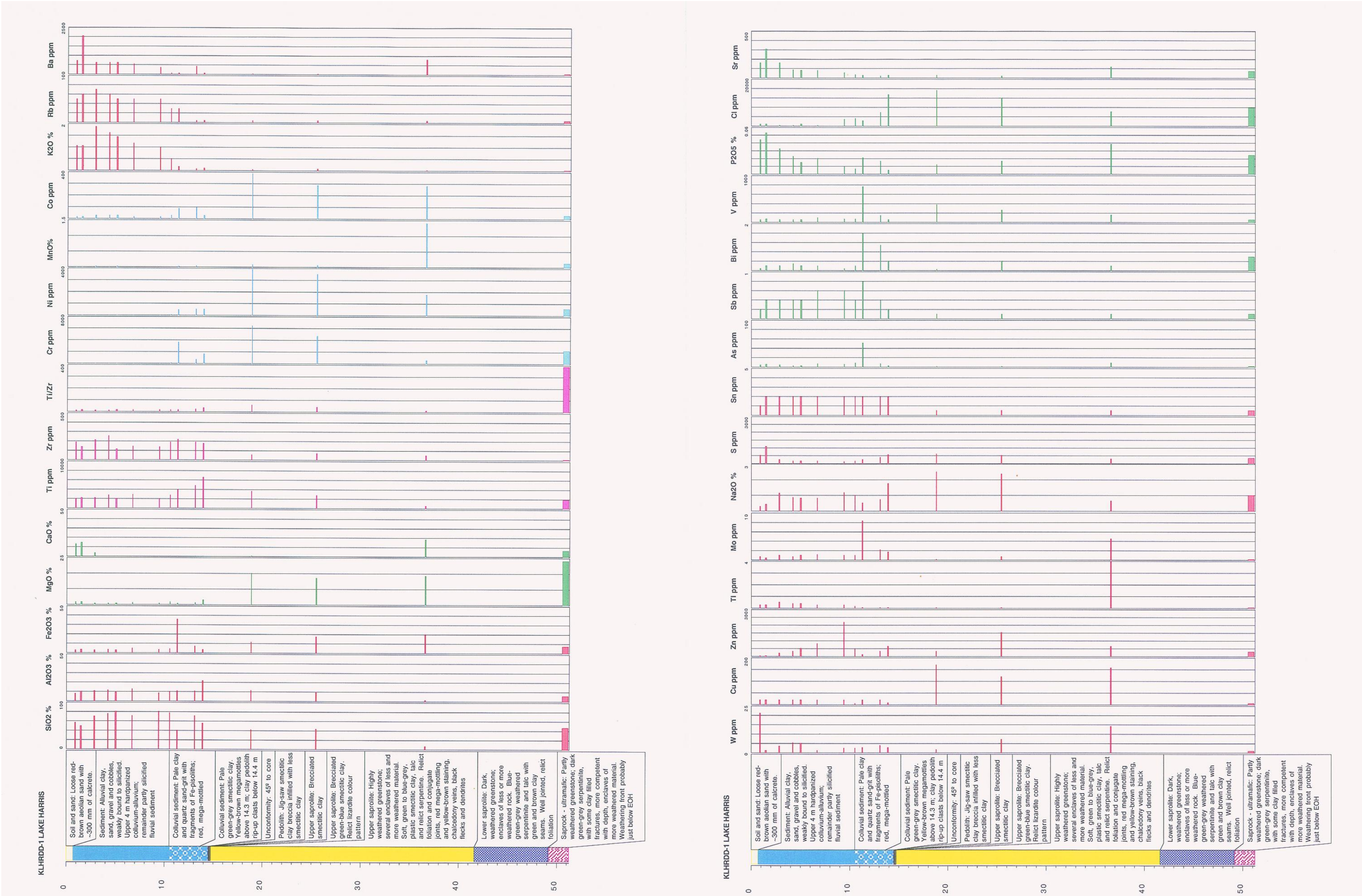


Figure 12:
Log and geochemistry of Benchmark 1 at Lake Harris [A3 fold out sheet] (Sheard and Robertson, 2004).
Refer to Figure 16 for graphic log explanation.

Distinguishing cover from basement (Sheard and Robertson, 2004)

Probably one of the most useful distinctions in exploration is differentiating between transported regolith (cover) and weathered bedrock. Normally, chemically distinguishing granite-derived sedimentary regolith from a weathered ultramafic basement would present little difficulty. However, within the Harris Greenstone Belt there are exceptions to this general rule (see later section covering the Mullina Well Benchmark 5, where the lower part of the sediment is clay rich and was probably at least partly derived from nearby up-slope weathered saprolite of mafic and ultramafic rocks). Also, the greenstones at Mullina Well are Ni- and Cr-poor. This results in overlap of some characteristic elements. If the Harris Greenstone Belt cored drillholes are considered separately, good univariate distinctions can be made. Pooling the data from the three drillholes makes the distinction more difficult. However, Zr is still able to separate the two groups at all three sites on a univariate basis (Table 5). Although this would only be useful where the basement is known to include ultramafic lithotypes.

Bivariate treatment of the pooled data shows slightly imperfect separation using K-Mg (Figure 13A) and K-Ni, both of which show independent orthogonal trends of the two fields (sediment and greenstone basement) with overlap at low values. Potassium-Sr (Figure 13B), As-Cu (Figure 13C) and Mn-Rb show broader fields with good separation. A particularly good separation is achievable using a rotated Rb-Sr-Mn plot (Figure 13D). Multivariate data analysis was not attempted, as the number of cases are too few (sediment 30, basement 16) for the number of variables (30) to be meaningful.

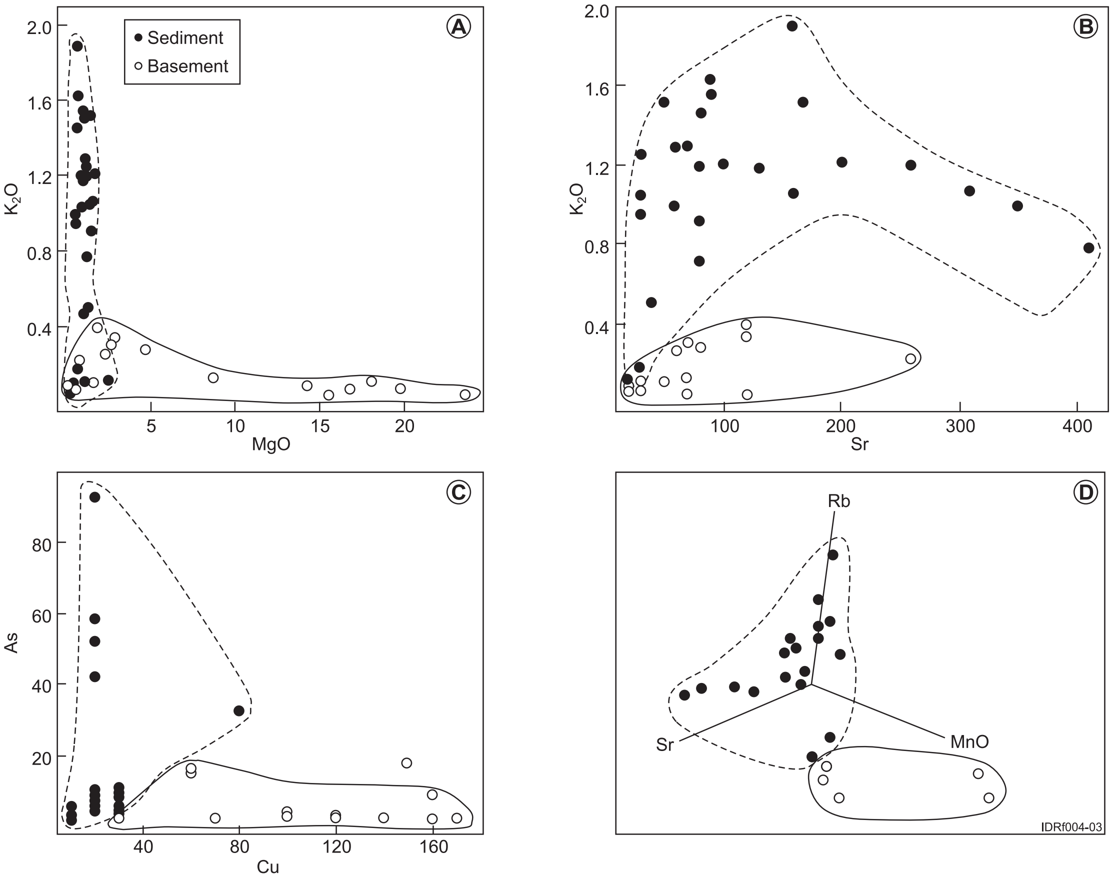


Figure 13: Bivariate plots (A-C) and a trivariate plot (D) illustrating how basement rocks may be largely distinguished geochemically from the covering sediments (Sheard and Robertson, 2004).

Basalt classification and prospectivity (Sheard and Robertson, 2004)

Provided there has been minimal mobility of the generally stable elements (Ti, Zr and Al), Al/Ti-Zr/Ti plots and Ni/Ti-Ni/Cr plots might be used to determine the affinities of these mafic-ultramafic rocks (S.J. Barnes, CSIRO Exploration & Mining, pers. comm., 2003). The basalts from Mullina Well appear to be komatiites (Al/Ti-Zr/Ti plot; Figure 14A) and, more specifically, fractionated komatiitic basalts on the Ni/Ti-Ni/Cr plot (Figure 14B). Those greenstones from Hopeful Hill and Lake Harris appear to be komatiites (Ni/Ti-Ni/Cr plot; Figure 14B) typical of thin, differentiated flows, possibly contaminated, increasing their Ni prospectivity. Although some outlying points are probably due to Al mobility in the regolith, the quite good fit with data from fresh rocks would support the hypothesis of incomplete weathering proposed for some of the lower saprolite at the Lake Harris and Hopeful Hill sites.

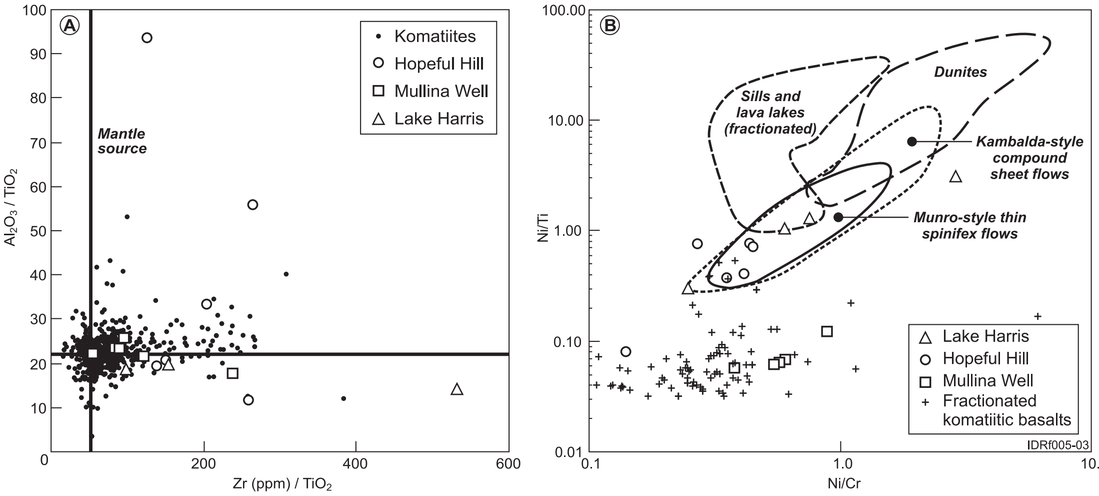


Figure 14: Bivariate ratio plots of minimally mobile elements to illustrate classification of mafic basement rocks at the two sites (Sheard and Robertson, 2004).

Table 5: Thresholds for distinguishing greenstone from sedimentary regolith (Sheard and Robertson, 2004)

MgO	*In situ* greenstones	Sediments	**Ni**	*In situ* greenstones	Sediments
Lake Harris	>14%	<2.5%	Mullina Well	>50 ppm	<50 ppm
K_2O	*In situ* greenstones	Sediments	Hopeful Hill	>150 ppm	<60 ppm
Lake Harris	<0.09%	>0.09%	Lake Harris	>570 ppm	>520 ppm
Hopeful Hill	<0.40%	>0.40%	**Zr**	*In situ* greenstones	Sediments
Rb	*In situ* greenstones	Sediments	Mullina Well	<90 ppm	>90 ppm
Hopeful Hill	<40 ppm	>40 ppm	Hopeful Hill	<90 ppm	>90 ppm
MnO	*In situ* greenstones	Sediments	Lake Harris	<90 ppm	>90 ppm
Lake Harris	>0.06%	<0.06%			
Mullina Well	>0.03%	<0.03%			

Lake Harris shoreline Silcrete (Sheard and Robertson, 2004)

Benchmark 1 does not intersect silcrete in the forms seen within Lake Harris western shoreline escarpment exposures (~1.78 km E of Benchmark 1). Silcrete in that locality is generally <1-3 m thick over weathered basement but in the overlying colluvium is thinner (<1 m), it can also form many thin bands within the Palaeogene-Neogene fluvial sediments. Silcrete is the dominant palaeo-duricrust, is generally quite hard and can yield eroded clasts that form gravel to pebbles within the sediments or lags on their surfaces or be exposed as outcrop edges in the present landscape. Some carry chromite grains and chalcedony plates or fragments over greenstone terrain where greenstones are vertically and laterally adjacent (Plate 1) and can be geochemically anomalous. Refer also to Benchmark 3 silcrete descriptions and geochemistry.

Plate 1: Part of a silcrete block (polished) from the Lake Harris greenstone outcrop area, collected near the lake shore where it forms low stony rises and a blocky capping in colluvium overlying weathered greenstone. Angular laths of a translucent-grey-brown to greenish grey chalcedony are enclosed in a colluvial sand derived from both granitic and ultramafic source rocks. The greenstone—Glenloth Granite sheared contact lies only ~30 m S from where this sample was collected in 1997. Bulk assay of a portion from this specimen revealed: Cr = 63 ppm, Ni = 6 ppm, Ti = 1.83%, V = 39 ppm and Y = 11 ppm (Sheard and Robertson, 2004).

Sample No. R367509.

Benchmark 2, drillhole KOK-3 (drill cuttings)

Quick reference items are set out in Table 6; detailed descriptions, figures and data tables follow on below. This site, about 650 m S of Benchmark 1 (Figures 6, 7; on W side of track to Glenloth Gold Mines), was drilled in 2001 as part of SA Geological Survey investigations into the Harris Greenstone Belt's: architecture, age, host lithotypes and mineral prospectivity. The aircore style of drilling employed is not ideally suited to regolith investigative work because cuttings are vastly inferior to core for providing profile detail (see Notes for Benchmark 1). The bulking of drill chips into composite samples only further complicates those limitations. However, taking these into account, drillhole KOK-3 has been selected as being representative of the regolith profile over weathered Glenloth Granite with a reasonable drilling depth to unweathered granite Figures 6, 7. Drilling was vertical. A summary of that profile is provided in Table 7 and the chiptray photograph with key regolith features indicated in Figure 15; regolith descriptions are presented in Tables 7-9; and geochemical data are presented in Figures 11-14, 16.

Table 6: Benchmark 2 reference data, drillhole KOK-3 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 4, 5.
Local-site location map	Figures 6, 7.
GPS coordinates, attitude & elevation	Zone 53, 0511745 E, 6565801 N, GDA 94. Vertical. **AHD:** 140.6 m (digital barometric survey from survey benchmark).
Site access, owner	~480 km NW of Adelaide, ~55 km ESE of Tarcoola and ~23 km SW of Kingoonya. On W side of track to Glenloth Gold Mines, on North Well Pastoral Station, W of the Lake Harris NW corner inlet.
Related drillholes	Aircore drillhole KOK 1, part of a NS drill line of 31 drillholes.
Drill sample photos + logs	Yes, Figure 15 and Tables 7-9.
Sample types	Aircore cuttings as bulked 2 m composites (350 gm pots) from 0 to 34 m, chiptray samples.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered to fresh granite.
Petrology	No.
Geochemistry	Yes, Figures 11-14, 16.
XRD mineralogy	No.
PIMA spectral data	Yes, but spectra have not been interpreted.
Dating	Yes, dacite intrusives into greenstones at outcrop site ~1 km E of KOK-3, Age: 2499 ± 11 Ma (Fanning, 1997).
Target Elements	Potential for Au, Ag, Cu, Pb, Zn and W.
Potential Pathfinder Elements	Mineralization-related elements (As, Au, Bi, Cu, Pb, Zn and W).
Useful sampling media	Transported regolith-soil where <5 m thick, calcrete and silcrete (much higher Cr, Ni + V over ultramafics), see geochemistry Figures 11-14.
Key reference sources	Davies, 2002a, b; Sheard and Robertson, 2003, 2004; Fanning, 1997; Daly and Fanning, 1993.

Table 7: Summary log of Benchmark 2 drillhole KOK-3 (Type 2, drill cuttings profile). The graphic log has sedimentary regolith in blue, pedolith in pale brown, upper saprolite in yellow, lower saprolite as green, saprock in pink and granite bedrock as red. Overprint hachuring represents both silcrete and ferricrete duricrust cements. Assay intervals are marked in grey. After Sheard and Robertson (2004).

Drillhole	Depth (m)	Provenance T = transported, I = *in-situ*	Basic Colour(s)	Regolith Zone	Assay	Graphic Log	Sample Description (ar = number): calcrete acid reaction where 2 = strong, 1 = moderate, 0 = none
KOK 3						KOK 3	
	00-02	T	red-brown	sediment cover + calcrete			fluvial sand + soil with calcrete, clayey sand, angular-rounded clasts - colluvium, (ar = 2).
	02-04	T/I	red-brown	sediment + pedolith, silcreted			AA, silcreted + quartz-rich grit, clay poor plasmic zone, in part weakly ferruginous (ar = 2).
	04-06	I	red-brown	pedolith: arenose zone, silcreted			quartz-rich grit, clay poor plasmic zone, in part weakly ferruginous (ar = 0).
	06-08	I	red-brown	pedolith: arenose zone, silcreted			AA
	08-10	I	red-brown - cream	pedolith: arenose zone, silcreted			AA
	10-12	I	cream - pallid	pedolith, silicified			clay-rich zone with angular quartz grains (igneous) + black flecks (graphite or FeOx) partly silicified
	12-14	I	cream - pallid	pedolith, silcreted			clay-rich zone with angular quartz grains (igneous) + black flecks (graphite or FeOx) silcreted to partly silicified
	14-16	I	pinkish & cream + greenish	pedolith-clay saprolite			clay-rich zone, moderately coloured to pallid-tinted, little to no visible quartz.
	16-18	I	cream + green tint	clay saprolite			clay-rich zone, pallid-tinted, little to no visible quartz.
	18-20	I	cream + green tint	clay saprolite			AA
	20-22	I	cream + green tint	clay saprolite			AA
	22-24	I	cream + green tint	clay saprolite			AA
	24-26	I	cream + yellowish overprint	lower saprolite		Fe	AA with strong yellow-orange FeOH staining.
	26-28	I	cream + yellowish overprint	lower saprolite			AA with relict foliation or textural banding - similar to that seen in EOH samples.
	28-30	I	cream + yellowish overprint	lower saprolite			AA
	30-32	I	cream + yellowish overprint	lower saprolite			AA
	32-34	I	brownish - greyish	saprock-bedrock			felsic fine-grained rock, undeformed, partially to non weathered.
	EOH					EOH	

Table 8: Generalized *in situ* regolith components from drillholes in Glenloth Granite, bedrock to most weathered (after Sheard and Robertson, 2004).

Glenloth Granite	Characteristic features	Diagnostic points
Bedrock	Medium- to coarse-grained, brown, partly weathered granite, weakly foliated; quartz, fresh K-feldspar, Na-plagioclase and mica.	Typical granite appearance, igneous texture with weak metamorphic foliation.
Saprock	Pink to reddish, partly weathered granite; clay, quartz and feldspar with Fe-staining on fractures.	Relict granite fragments; mica, K-feldspar and quartz.
Lower saprolite	Weathered rock, brown clay, quartz and relict feldspars; Fe-staining.	Clay and quartz, relict metamorphic foliation and igneous texture.
Upper saprolite	Highly weathered rock, cream to grey or brown; kaolinite and quartz, some Fe-staining. Commonly leached (pallid).	Kaolinite and quartz, relict structure and igneous texture.
Pedolith	Extremely weathered rock, white to pale grey to brownish; quartz grit or kaolinite dominant; weak to mild Fe-staining, may have silicified top (silcrete).	Kaolinite and quartz, no relict primary fabric. Pedogenic fabric and siliceous duricrusting

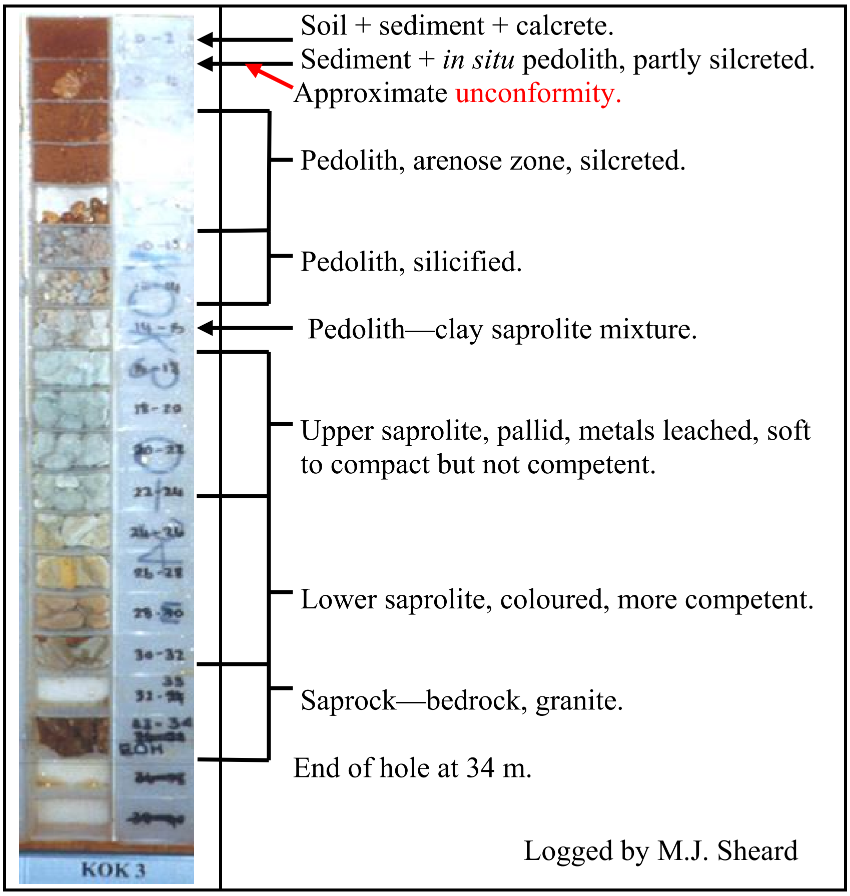


Figure 15: Benchmark 2 chiptray samples with key regolith features indicated. Sample interval is 2 m except for last two samples (1 m). Refer also to summary log and additional descriptions in Tables 7-9

The following lithology and petrographic descriptions are taken from Sheard and Robertson (2004).

In situ Regolith (Glenloth Granite)

Below the transported regolith in this area, several residual weathered *in situ* bedrock types form a distinct S-N sequence: granitic-ultramafic-mafic-sedimentary-felsic volcanic. At the S end of the section is weathered Palaeoproterozoic Glenloth Granite (drillholes KOK 1, 3), followed N by greenstones: as weathered Archaean serpentine-altered metakomatiite, weathered and altered Archaean metakomatiitic basalts, followed by weathered Archaean metasediments, and then weathered Mesoproterozoic felsic Gawler Range Volcanics (Davies 2002a, b; Sheard and Robertson, 2004).

Residual regolith developed from Glenloth Granite is straight forward in interpretation: saprock is <2 m thick, lower saprolite is ~8 m thick, upper saprolite is ~8 m thick and the complex pedolith is ~13 m thick. Pedolith complexity in detail is partly limited by the sampling method and interval bulking. A ferruginous capping is either eroded or was never developed; however, silcrete forms a substantive duricrust capping. Summaries of the residual weathered *in situ* types from drilled chip samples in this area are given in Tables 7-9.

In general, Glenloth Granite is less deeply weathered than the adjacent greenstones, perhaps because it is less fractured (*c.f.* Figures 7, 15). The weathering front is more regular in the granite than is the case for adjacent greenstones. Mapping by Daly and van der Stelt (1992) has established that Glenloth Granite intrudes the greenstones with aplitic and pegmatitic apophyses but, at the small outcrop east of the drill line, the granite-greenstone contact is a shear zone. That local relationship has been confirmed by Sheard and Robertson (2003). Dating by Fanning (1997) at 2499 ± 11 Ma, has established the granite is indeed younger than the adjacent greenstones (2522 ± 7.9 Ma).

Transported Regolith

Transported regolith at Benchmark 2 is <4 m in thickness and includes, soil, calcrete, minor Pleistocene aeolian sand, and Cainozoic fluvial sediments. Cainozoic silcrete bands cement part of the fluvial sediment and below that alluvium is a colluvium of possible Mesozoic to early Cainozoic age. Aeolian sand plains and dunes mantle most of the area. They are not recovered very well by the drilling methods used. Sediments below the soil-sand layer are dominantly fluvial and range from silty clays to sand and gravel or mixtures of these but there are also some pebbles exceeding 30 mm. These are cemented by calcrete, are incipiently silicified and pass into silcrete. Broad layering can be observed from sample to sample but finer layering can only be inferred from limited evidence in the cuttings. A modern ephemeral creek runs W of and parallel to the drill line; it crosses that line and track ~2.5 km north of drillhole KOK-3. Additional observations of the transported regolith units derived from all drilled chip samples for this area forms a summary in Table 9.

Table 9: Generalized transported regolith components from surface regolith mapping and drill cuttings at Lake Harris; oldest to youngest units (after Sheard and Robertson, 2004).

Unit, age	Characteristic features	Diagnostic points
Colluvium, ?Mesozoic-Cainozoic	Greyish to cream to pale and strong browns, clay + sand, grit & larger clasts, reworked weathered rock, mixed lithotypes, poorly sorted, angular to subrounded, matrix to clast supported (latter only seen in core or outcrop) readily forms lag.	Generally polymictic, angular to subrounded clasts, poorly sorted, fragments of contained ferruginous pisoliths.
Fluvial sediments, Cainozoic	Red-brown to grey, clay to cobbles, clast supported (latter only seen in core or outcrop);clays and quartz, loose to cemented.	Well rounded clasts amongst drill fragments of the same, <1 to >8 m thick.
Silcrete, Cainozoic	**Duricrust**, grey to pale yellow, silica cementation of alluvium, colluvium or weathered basement, partial to full cementation, poor in clay-silt fines, may contain major unconformity - (latter only seen in core or outcrop).	Cryptocrystalline semi-translucent cream to pink cement, hard to very hard drilling, clasts cemented so firmly as to force any breakage through rather than around them, thickness <0.5 to about 2 m, may occur in several horizons.
Calcrete, Quaternary	**Duricrust**, white to pale yellow to pale pink or orange, massive competent and/or nodular, pedogenic carbonate.	Noticeable pallid soil horizon, effervescent reaction with acid, may host geochemical signature.
Aeolian sands, Pleistocene	Mantles much of the landscape, orange, siliceous, dunes and sand plains, can contain nodular calcrete and platy gypsum. Sand forms a sample dilutant to any locally derived mineral-lithic grains.	Mostly loose, uniformly sorted, frosted quartz grains in fine-medium sand size, <1 to >8 m thick.

Geochemistry (Sheard and Robertson, 2004)

Cuttings samples spanning zones of interest have been assayed (Table 7, Figure 16) these were drawn from 350 gm sub-sample pots collected from the original in-field 20 kg bagged 2 m composites. Pulverised 100 gm aliquots were assayed along with a series of strategically placed but camouflaged in-house standards to assess assay repeatability, drift and any laboratory anomalism. Assay sub-sampling has preserved enough cuttings for future work and leaves a permanent record along with the chiptray samples. Thereby, the geochemistry is not continuous but does represent important variations within the regolith plus depth and between key regolith zones. Graphic results are displayed in Figure 16. A comprehensive discussion of the overall greenstone province geochemistry is provided under Benchmark 1. However, the emphasis there is on greenstone *versus* sedimentary regolith, rather than on felsic basement *versus* greenstone or overlying sediments.

By comparison with greenstones at Lake Harris; Glenloth Granite has elevated values of: Si, Ti, Zr, K, Rb, Ba, As, Cu, Mo, but a low Ti/Zr ratio, and low REE. While Lake Harris greenstones have elevated values of the following: Mg, Ni, Cr, Mn, Co, Sb, REE, a high Ti/Zr ratio and low K, Rb, Ba, As. Therefore, where sediments don't cover either highly weathered lithotype they can easily be geochemically distinguished – even where extremely weathered. Where sediments do overly these rocks then the comments made under Benchmark 1 geochemistry will apply, although distinguishing weathered granite from a sediment derived from similar materials is quite difficult.

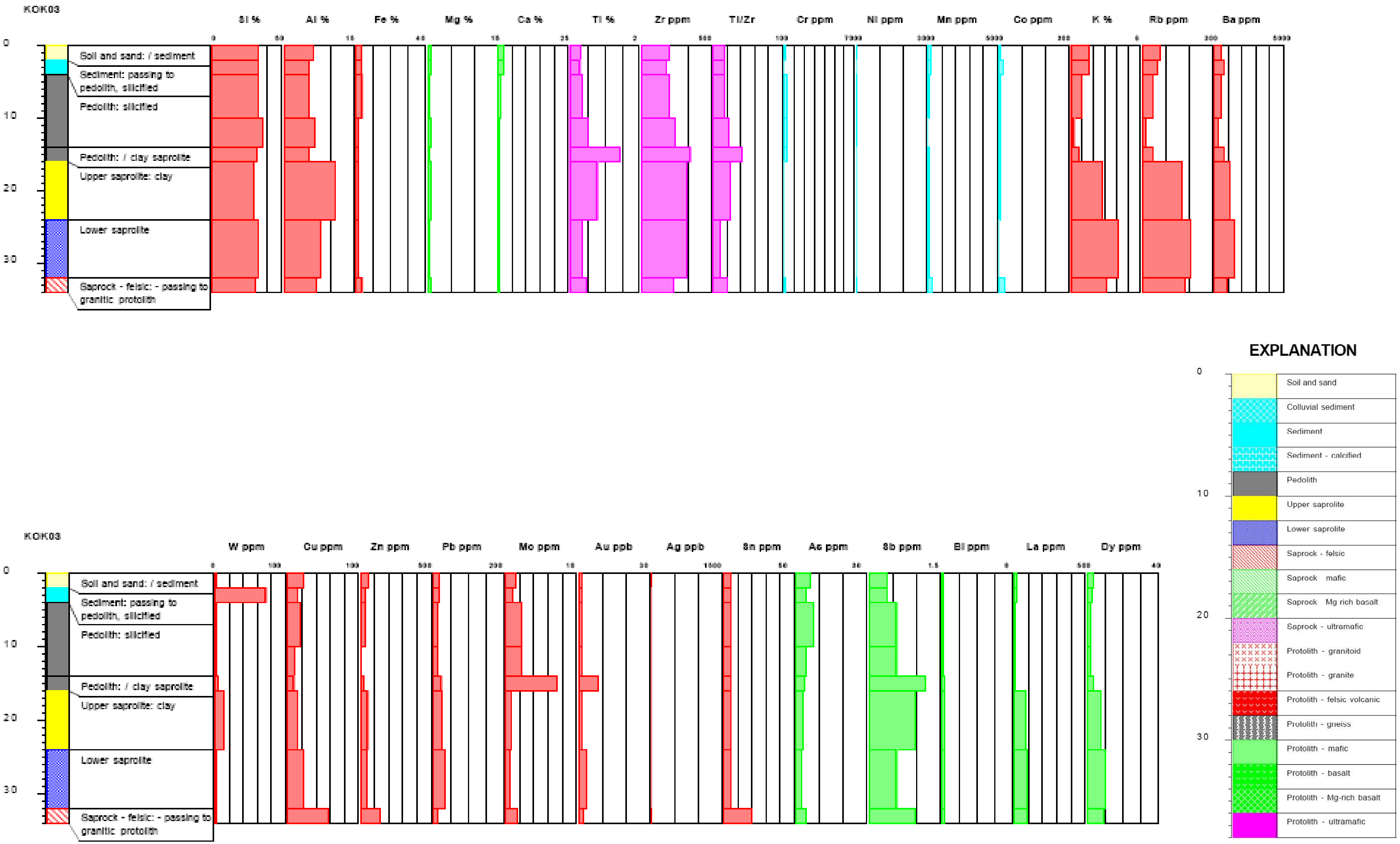


Figure 16: Down hole assay data plots for Benchmark 2, oxides on upper chart and traces on lower chart. The graphic log column (LHS) is based upon Table 7 logged primary features with secondary features in the text column. Refer to the coloured 'Explanation' column (RHS) for regolith materials and/or lithotype.

Benchmark 3, weathered Glenloth Granite escarpment

Quick reference items are set out in Table 10; detailed descriptions, figures and data tables follow below. This site is ~23 km SW of Kingoonya; access is firstly S from Benchmark 1 via the main N-S Glenloth Mines track, through the first gate and then E along the single lane fence line access track over towards prominent quartz blows atop a small rise overlooking Lake Harris (best vehicle parking area). Walk ~300 m SW across silcrete clad weathered Glenloth Granite and quartz blow lag apron, over the floor of a rarely flooded embayment in the lake shoreline towards the E facing silcrete escarpment depicted in Figures 17, 18 (after Sheard *et al*., 2003). Silcrete geochemistry is provided in Figure 20 (Sheard and Robertson, 2004).

Table 10: Benchmark 3 reference data, weathered Glenloth Granite (Type 1, outcrop, escarpment).

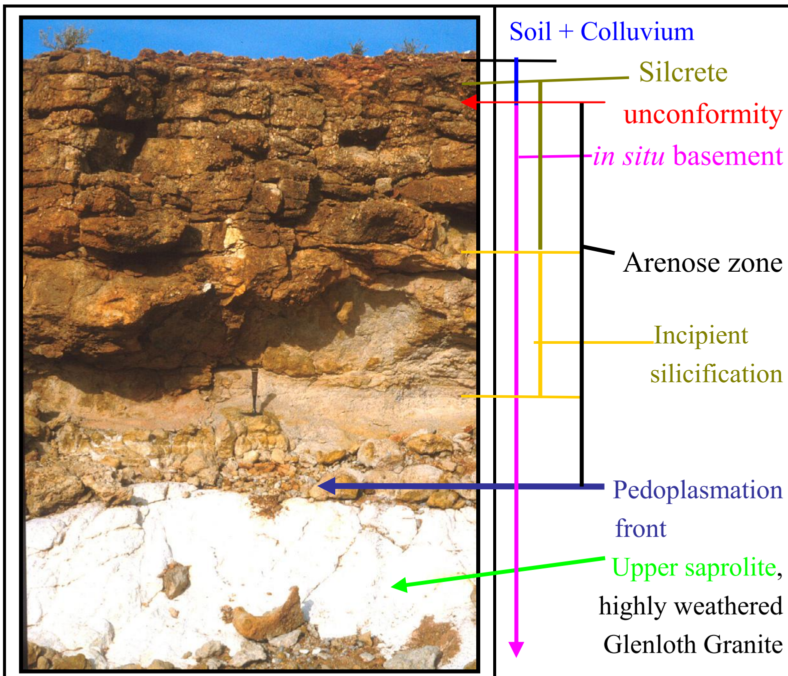
Items	Figures, Data, Sources
Regional location map	Figures 4, 5.
Local-site location map	Figure 6.
GPS coordinates & elevation	Zone 53, 513282 E, 6567010 N, GDA 94. **AHD:** 142 m (digital barometric survey from survey benchmark).
Site access, owner	~480 km NW of Adelaide, ~55 km ESE of Tarcoola, ~23 km SW of Kingoonya, and ~3 km E of track to Glenloth Gold Mines, on North Well Pastoral Station, W shores of Lake Harris, ~5 km N of Glenloth Gold Battery.
Related drillholes	~3 km E of NS drill line containing Benchmarks 1 & 2.
Site photo + log	Figures 17, 18.
Sample types	Hand specimens.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered granite & silcrete.
Petrology	Yes, Figure 19.
Geochemistry	Yes, general for locality, Figure 20.
XRD mineralogy	No.
PIMA spectral data	No.
Dating	Not from this site, see Benchmark 2.
Target Elements	Potential for Au, Ag, Cu, Pb, Zn and W.
Potential Pathfinder Elements	Mineralization-related elements (As, Au, Bi, Cu, Pb, Zn and W).
Useful sampling media	Calcrete and silcrete.
Key reference sources	Sheard and Robertson, 2003, 2004; Sheard *et al*., 2003; Daly and Fanning, 1993.

The following lithology and petrographic descriptions are taken from Sheard *et al*. (2003) and Sheard Robertson (2004).

Challenging Regolith Architecture

This Benchmark demonstrates first hand some of the challenges in working with regolith architecture and the interpretation of geochemical signatures where exposures are limited and drill cuttings are being analysed. The initial 1996 RAB drill logs for this prospect, incorrectly labeled the collapsed weathered *in situ* arenose zone as a sandstone (transported regolith). The cliff exposure forming this Benchmark was therefore crucial to an appropriate understanding of regolith on the surrounding tenement during 1996-97. Its correct interpretation by the on-site project geologist some way into their exploration, lead to a full re-evaluation of all earlier RAB drill logs and geochemical assays.

The profile here is complex, although at first sight it appears deceptively simple. Below the thin skeletal soil is a silicified pedolith, or more properly a silicified arenose horizon. In this case it actually represents an originally much thicker, but now, a significantly reduced or collapsed profile (*c.f.* idealised regolith profile of Figure 3). This upper weathering zone has been totally stripped of all fines (kaolinite, illite, *etc.*) prior to silicification and thereby it has suffered a considerable reduction in volume (at least by 50% and maybe as much as 75%). Processes that do this involve quite acidic waters (pH <3) and so any potentially soluble metallic minerals involved also leach out, thereby removing any important residual metallic signatures (Au, Ag + basemetals) that may have been present. Therefore any surface sampling of materials over these terranes can lead to assay **false nulls**. Moreover, those and the miss-identification of drill cuttings from profiles like this could lead the unwary into logging this zone as a sediment (just as the exploration geologists initially did on this tenement). **The solution** is to carefully examine as many natural outcrops as are available and/or to actually drill continuous core from surface to fresh rock in at least one site per prospect or tenement, thereby providing the opportunity for petrographic examination and interpretation (Sheard *et al*., 2003).



<u>Soil</u> here is thin, sandy with plentiful lithic lag (silcrete, exotic clasts of typically white vein quartz + various Fe-stained lithics).

<u>Silcrete</u> is: typically massive, hard and splintery when hammered, with spaced vertical and spaced horizontal joints. Its upper part commonly contains alluvial-colluvial clasts. Basal contact with incipient silicification is sharp but irregular.

<u>Incipient silicified horizon</u> is less competent than overlying silcrete, most fines are removed (>80%). This horizon is not jointed.

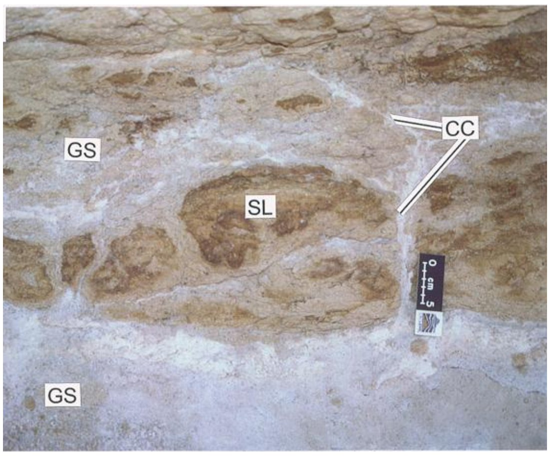
<u>Upper saprolite</u>: kaolinite + quartz with relict quartz veining. Granitic texture and fabric retained (isovolumetric alteration). [Lower saprolite to bedrock do not outcrop here but can be observed W of the Glenloth Gold Mines Battery ~5 km S.]

Figure 17: Benchmark 3, view of E facing escarpment, regolith horizons-zones, and description. Hammer scale near centre is 0.3 m long. The arenose zone represents a collapsed profile where perhaps 50-75% of the original thickness has been lost through fines removal prior to or during silicification. The conspicuous pedoplasmation front boundary is slightly undulose but the incipient silicification base above it is far more irregular. This escarpment is some 100's of metres long and strongly embayed, thereby providing an excellent 3D exposure of regolith profile variability and architecture.

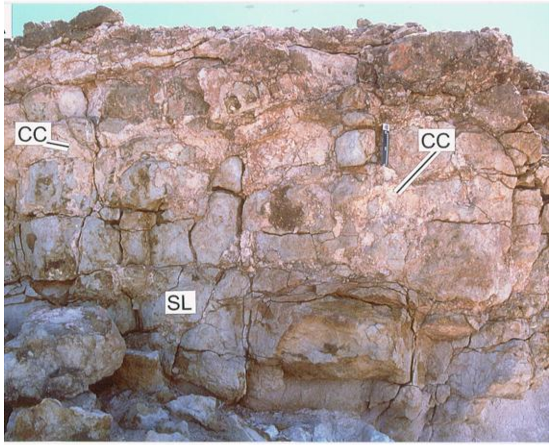
In situ Regolith (silcreted weathered granite)

Surrounding Benchmark 3 are small breakaways on the W edge of Lake Harris. Silcreted profiles consist of two types; i) those developed from weathered Glenloth Granite, which is rich in angular igneous quartz fragments set in a creamy quartz-anatase-zircon (QAZ) cement, and (ii) those developed from weathered ultramafic rocks, those silcretes are generally similar but may have additional tabular pieces of vein chalcedony derived from extremely weathered ultramafics (*c.f.* Benchmark 1; Plate 1).

Benchmark 3 forms an amphitheatre-like breakaway, floored by saprolite developed from granite (Figures 6, 17, 18B) and capped by silcrete, where in places there is a carbonate-veined silcrete breccia between the capping and saprolite (Figure 18A). That carbonate post-dates the silcrete. The silcrete upper part is also brecciated by calcrete development (Figure 18B), this calcrete shows at the surface, among the silcrete lag (Figure 18C). In other places, quartz vein remnants occur in silcrete as distinct stringers, where coarse angular vein fragments are suspended in jig-saw fit relationships.



A

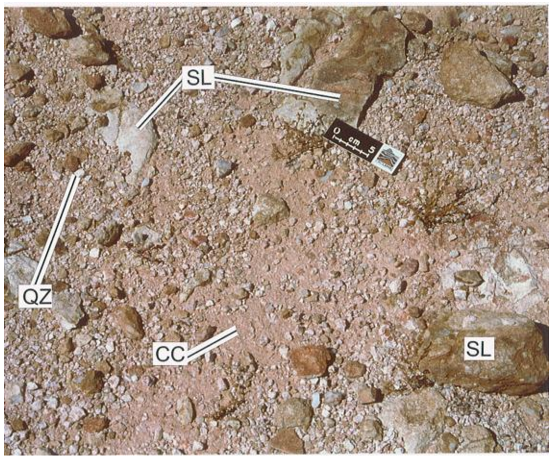


B

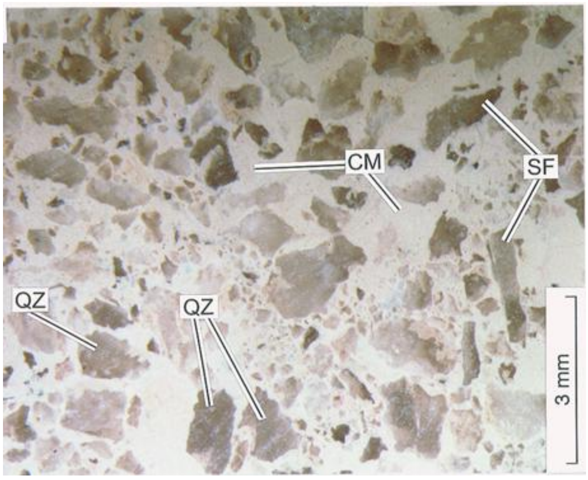
Figure 18:
A – The transition between silcrete and saprolite consisting of silcrete blocks (SL) in saprolite (GS), veined with calcrete (CC). Bar scale is 5 cm. 514681E, 6566206N.

B – The massive, grey, rounded and jointed blocks of the upper part of the silcrete (SL) veined with pink calcrete (CC). Bar scale (to left of CC) is 20 cm. 514681E, 6566206N.

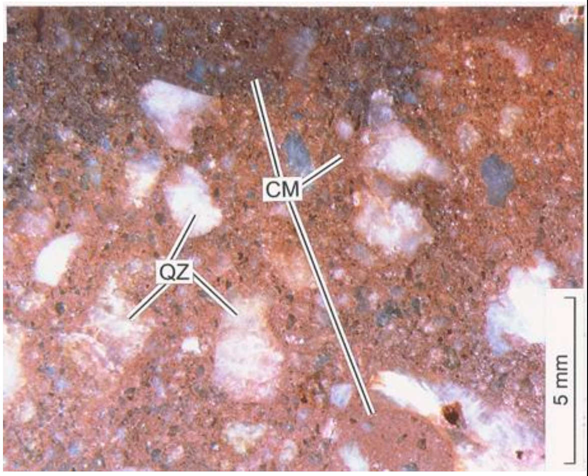
C – Pale grey-green blocks of silcrete (SL) at the top of the breakaway, invaded by pink calcrete (CC) shedding a lag of silcrete with minor vein quartz (QZ). Bar scale is 5 cm. 514681E, 6566206N.



C



A



B

Figure 19:
A – Internal structure of silcrete with shardy quartz (SF) + quartz grit (QZ) in a white QAZ cement (CM). A few meandering veinlets indicate localised removal of the cement and replacement by a light-brown aluminosilicate cement. Close up view of polished block in oblique reflected light. Specimen R622567.
B – Internal structure of ferruginous silcrete lag fragment, consisting of vein + granitic quartz (QZ) + compound metamorphic quartz grains with a sutured to polygonal fabric and smaller clasts of angular to shardy strained quartz set in a granular QAZ cement (CM). Parts of the cement are slightly stained with Fe-oxides. Close up view of polished block in oblique reflected light. Specimen R622575.

The silcrete consists largely of strained, metamorphic quartz set in a granular QAZ cement that has been partly replaced by a younger, brown aluminosilicate cement. Some of the larger subangular quartz grains are compound; other smaller ones are shardy and consist of single, strained crystals (Figure 19). The cement is probably now kaolinite stained with Ti and Fe-oxides.

Geochemistry

The following descriptions are taken from Sheard Robertson (2004).

Bulk chemistry of the two silcrete types is remarkably similar in terms of their Si-Al-Fe relationships. All show evidence of Al depletion (Figure 20) at a consistently high Si/Fe ratio. A fully developed silcrete contains about 95% silica, 2.5% titania and very little else; some of the silica may be replaced by Fe-oxides, where there has been ferruginisation. All are rich in Ti and Zr, reflecting their QAZ cement. Although the Ti/Zr ratio in the silcrete on the ultramafic is high (45), Ti/Zr ratios can be unreliable in the pedolith (Robertson and Butt, 1997). However, the most significant differences between silcrete on granite and ultramafic rocks lie in the trace elements. Silcrete developed on ultramafics are strongly enriched in Cr (2200 ppm compared to 15 ppm on granite), Co (10 ppm compared to 4 ppm), Ni (35 ppm compared to 2 ppm), V (115 ppm compared to 40 ppm), Zn (160 ppm compared to 1 ppm) and W (10 ppm compared to 2 ppm) and, to a lesser extent, in Mn (0.24% compared to 0.008%) and Ba (425 ppm compared to 200 ppm).

The petrology and chemistry of the silcrete developed on the ultramafic rock, to the N of this Benchmark, suggests a composite origin. The inherited tabular chalcedony fragments were probably derived by collapse of a partly silicified ultramafic saprolite. This contributed some of the Si and most of the Cr, Ni, V, Zn, Ti and Mn. This was incorporated in a soil and mixed with granite-derived colluvial detritus, which contributed more Si and most of the Zr before silicification. This observation is consistent with the location for this type of silcrete which is within about 50 m of the sheared contact between granite and ultramafic exposed along the modern creek line (Sheard and Robertson, 2004).

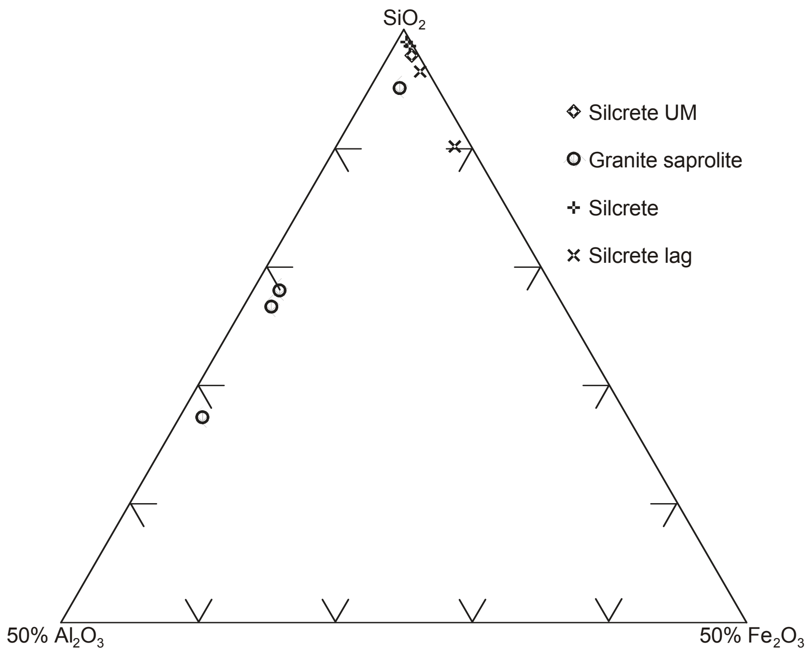


Figure 20: Ternary Si-Al-Fe diagram showing the silcretes and the weathered granites from which some of them developed. The silcrete with chalcedony fragments (silcrete UM), lying on an ultramafic saprolite, is similar. A ferruginous silcrete is similarly Al depleted but has a higher Si:Al ratio.

Hopeful Hill

Benchmark 4, cored drillhole THHRDD-1

Quick reference items are set out in Table 11; detailed descriptions, figures and data tables follow on below. The location is ~500 km NW of Adelaide, ~43 km ESE of Tarcoola and ~37 km WSW of Kingoonya. A site about 14 m SW of the aircore drillhole TAR 08 (N side of pastoral station track to Hopeful Hill) and was selected as being representative of the regolith profile over weathered greenstone in this area Figures 4, 5, 21, 22. Drilling was vertical into a subvertical greenstone; the drilled profile most likely only intersects one or two narrow subvertical bands within the weathered and folded metakomatiitic mafics. A summary of that profile is provided in Table 12 and selected core photographs are in Figure 23; petrological photomicrographs and descriptions are presented in Figures 9, 23-25; and geochemical data are presented in Figures 11-14, 20, 26 plus Table 5.

Table 11: Benchmark 4 reference data, Drillhole THHRDD-1 (Type 2, drill cored profile).

Items	Figures, Data, Sources
Regional location map	Figures 4, 5.
Local-site location map	Figures 21, 22.
GPS coordinates, attitude & elevation	Zone 53, 0492082 E, 6575794 N, GDA 94. Vertical. **AHD:** ~179 M (estimated from map survey data).
Site access, owner	~500 km NW of Adelaide, ~43 km ESE of Tarcoola and ~37 km WSW of Kingoonya. North of track to Hopeful Hill from Yerda Out Station, on Wilgena Pastoral Station, ~1.5 km SW of Kenella Well & ~ 22 km W of Lake Harris.
Related drillholes	Near aircore drillhole TAR 08, part of 3 lines totalling 18 drillholes.
Drill sample photos + logs	Yes, Figure 23 and Table 12.
Sample types	Continuous core, HQ size, 0 to 39.25 m + . Aircore cuttings from adjacent drillhole TAR 08 (for comparison) as bulked 2 m composites (0 to 36 m, 350 gm pots and chiptrays).
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered serpentinitic komatiitic lavas.
Petrology	Yes, Figures 23-25.
Geochemistry	Yes, Figures 11-14, 20, 26 + Table 5.
XRD mineralogy	Yes, within core, petrology & geochemistry descriptions.
PIMA spectral data	Yes + HyLogged, but spectra have not been interpreted.
Dating	Yes but from Mullina Well area. Rhyodacite volcanics interlayered with greenstones yielded a U-Pb zircon age of ~2520 Ma (Fanning, 2002).
Target Elements	Potential for Au, PGE, Ni, V, Cr, Co, Cu, Pb and W.
Potential Pathfinder Elements	Komatiite indicator elements (Mg, Cr, Ni, As, Co, Fe, Mn and V) Mineralization-related elements (Au, Bi, Cu, Pb and W).
Useful sampling media	Transported regolith-soil where <5-10 m thick and separated heavy minerals (bioturbated relict chromite), calcrete and silcrete (higher Cr, Ni & V over ultramafics), Fe-pedolith where preserved (outcrop & subcrop) see geochemistry Figures 11-14, 20, 26 and Table 5.
Key reference sources	Davies, 2002a, b; Sheard and Robertson, 2003, 2004; Daly and Fanning, 1993; Fanning, 1997, 2002.

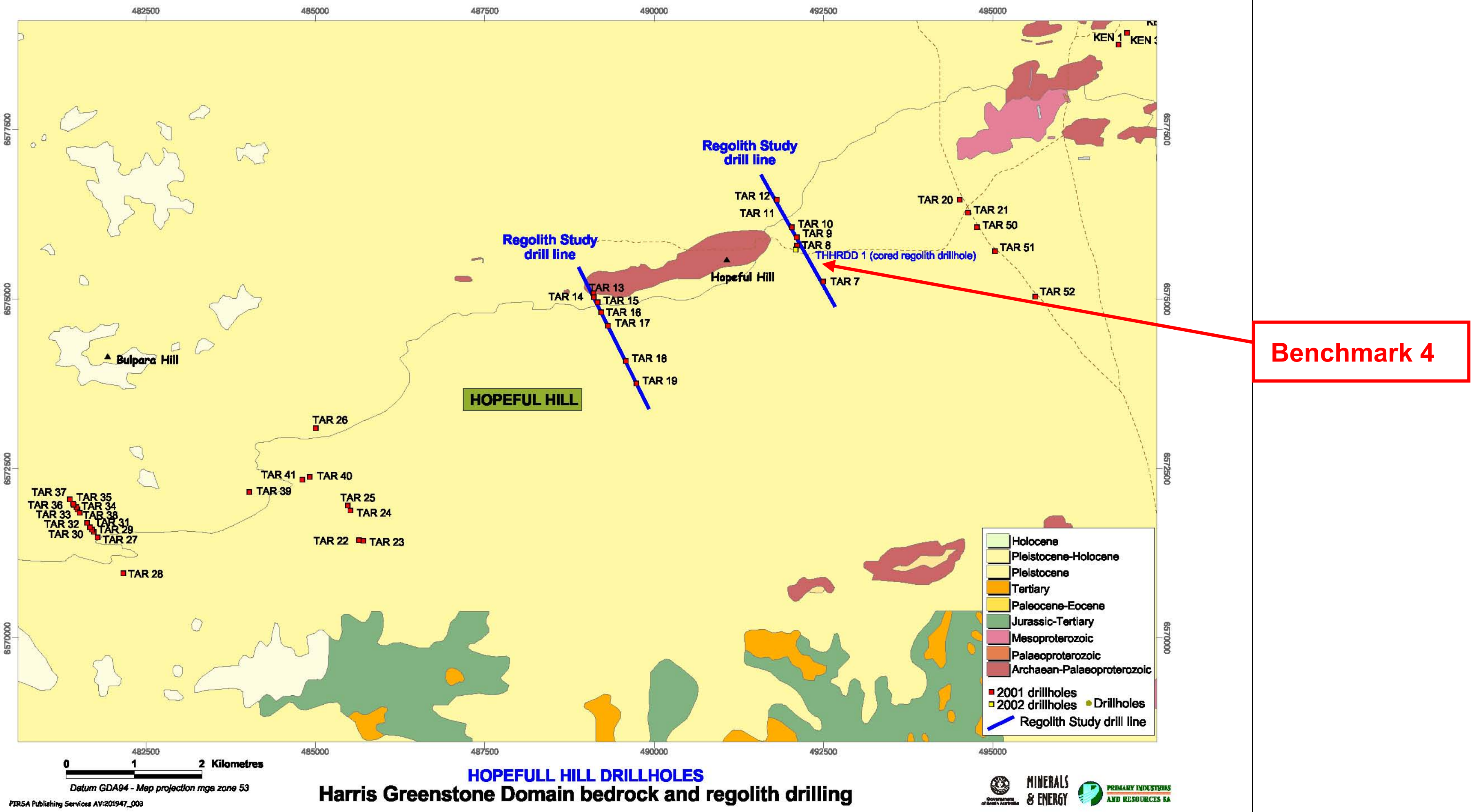


Figure 21: Localised site plan indicating where Benchmark 4 (cored drillhole THHRDD-1) and Benchmark 5 (pillow basalt outcrop) are sited. Two of the three ~NW drill lines, totalling 18 drillholes (those marked in blue) are displayed as a composite regolith profile in Figure 22.

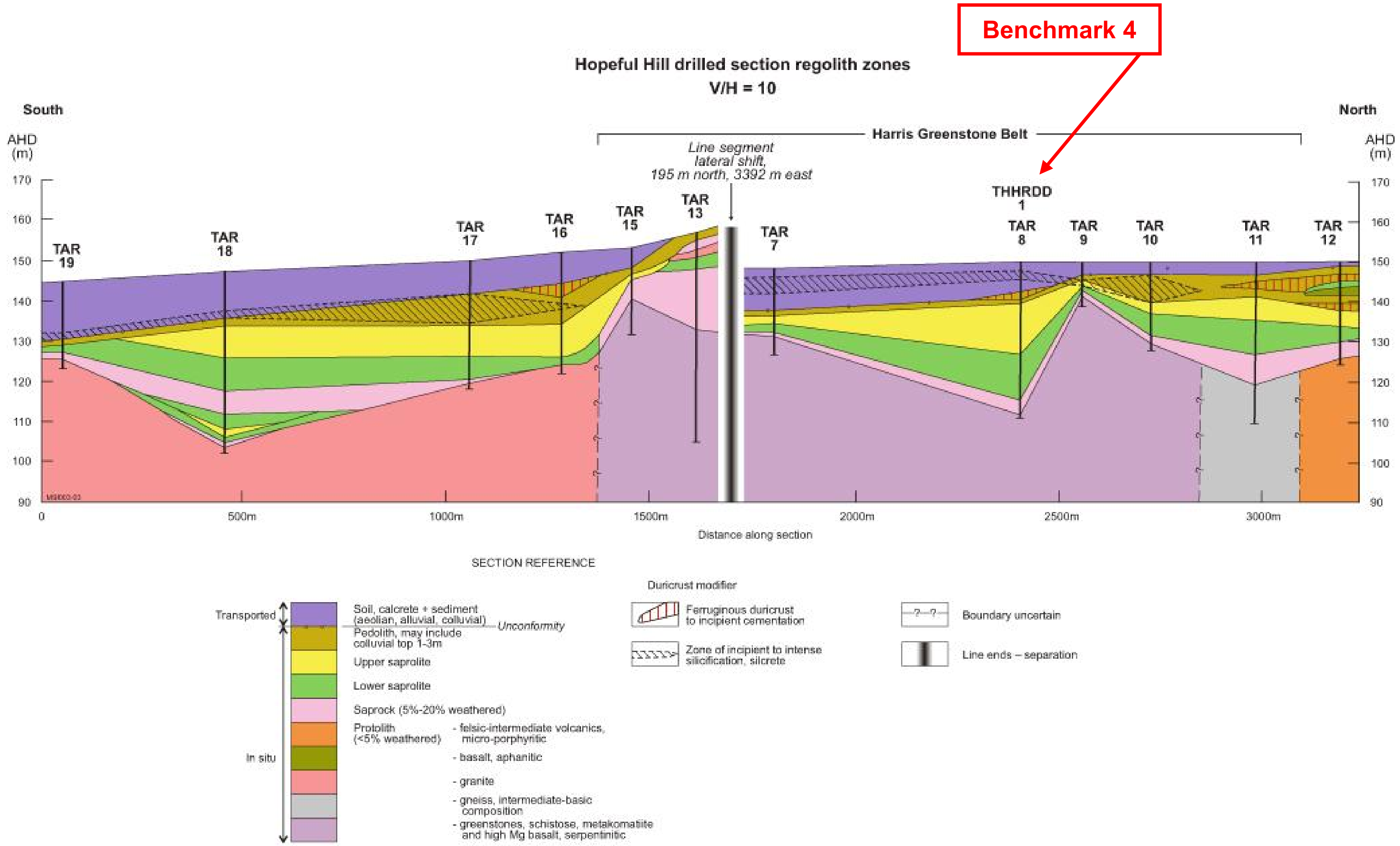


Figure 22: The composite regolith profile for two drill lines at Hopeful Hill (Sheard and Robertson, 2004). Benchmark 4 (cored drillhole THHRDD-1) location is indicated. Note the very irregular—complex weathering front and variable saprolite thicknesses – irrespective of lithotype.

Table 12: Summary log to Benchmark 4, Hopeful Hill cored drillhole THHRDD-1 (Sheard and Robertson, 2004).

Depth Range (m)	Graphic Log (vert. not to scale	Regolith Zone	Description
0.00-0.50		soil-sand	soil in loose red-brown aeolian sand with 300 mm of calcrete.
0.50-8.45		sediment	alluvial clay + sand + gravel + pebbles, weakly bound to partly silicified. Upper 1-~5 m is red-brown hardpan colluvium-alluvium, the remainder is an older fluvial sheet flow deposit with minor channel bed material, irregular silcrete bands.
8.45-9.05		colluvium	gley clay + quartz sand-grit with fragmentary Fe-pisoliths, locally deriving from eroded pedolith, red to brown Fe-megamottled.
9.05-9.65	# | # | # | #	*in situ* Pedolith (plasmic)	extremely weathered greenstone; pedogenic, clay-rich, strong red and brown to pale greens, megamottled, pedogenic jig-saw-fit breccia, illuviated clay fracture infill, top eroded, part silicified.
9.65-23.00	| | | | | |	upper saprolite	Highly weathered greenstone; complex sub-zone with several enclaves of less + more highly weathered material. Clay-rich, soft to stiff and sticky-plastic clay (smectitic) bright greens + blue-greens + yellow-greens + blue-greys. Relict foliation and conjugate joint sets, red Fe-megamottles + yellow to brown Fe-staining, white to pale turquoise chalcedony veins, black MnOx flecks and dendrites. Some intervals have a distinctly greasy feel (talc). Sub-zone is mostly smectite + talc + relict serpentine. Fe-rich interval between 15.20-15.95 m
23.00-34.50		lower saprolite	Weathered greenstone; complex sub-zone, has several enclaves of less or more highly weathered rock. Generally darker hued and more competent than the sub-zone above. Dark grey or green-grey weathered serpentinite + bright green and brown clay seams + talc, yellow Fe-stains, well jointed, relict metamorphic foliation, chalcedony veins.
34.50-39.25		saprock – bedrock	Partially weathered greenstone; serpentinite, dark green-grey, some clay fracture infill, progressively more competent with depth but still retains enclaves of more weathered material. Weathering Front probably just below end of drillhole.

The following lithology and petrographic descriptions are taken from Sheard and Robertson (2004).

In situ Regolith (greenstone)

A continuous **Bedrock** was not intersected because significant weathering reaches to the bottom of the drillhole (39.25 m). However, enclaves of what appears to be remnant bedrock (irregular core stones) occur within saprock and lower saprolite. Bedrock is dark grey to dark green-grey, with minor brown alteration and thin, pale green clay along fractures. Relict primary textures and metamorphic foliation are preserved in the serpentinite. Cuttings from the nearby aircore drillhole (TAR 08) suggest bedrock occurs at or above 30 m, higher than that indicated by the diamond core (>39.25 m). However, drill cuttings are not the best medium for regolith boundary identification and the depth of the weathering front may vary significantly, even over short distances.

A thin (4.75 m) **Saprock** zone occurs just below 34.5 m. It is a dark green-grey to dark grey, partially weathered serpentinite with minor bands and seams of bright green and brown clay. There is minor brown staining by Fe-oxides, mostly along joints. Relict primary fabric and metamorphic foliation occur in the less weathered serpentinite. Joints angled at 60° to the core axis are variably altered and/or stained. Talc is a minor relict mineral from an earlier metamorphic-hydrothermal alteration process.

Above the saprock a more weathered **lower saprolite** sub-zone occurs between 23-34.5 m; it is complex and contains several patches of more or less weathered greenstone. This sub-zone is thicker (11.5 m) than that at Benchmark 1 (7.55 m). Included clay saprolite and saprock enclaves are <1.5 m in size. The lower saprolite is mostly darker than the upper saprolite, with more neutral hues, higher competency, the clay is stiffer, and weakly altered serpentinite is abundant. Highly fissile fractured material occurs throughout and was difficult to drill. Typically, this sub-zone is dark grey to dark green-grey with bright yellow-green clay filling fractures. Yellow and brown Fe-oxide staining and more pervasive alteration occurs around fractures and, in places, expands to more broadly weathered intervals. Regular conjugate joint sets occur at 45-60° to the core axis and these are variably slickensided, altered and stained with Fe-oxides.

An **upper saprolite** sub-zone (9.65-23.00 m) occurs above the lower saprolite, it is highly weathered and a complex sub-zone. Upper saprolite consists mostly of smectite, chlorite, hydromuscovite, talc and relict serpentinite. Here the sub-zone is 13.35 m thick, which is about half that intersected at Benchmark 1 (27.1 m). Upper saprolite is multicoloured with bright greens that contrast sharply with the adjacent dark olive and medium-greens below (Figure 23B). Subordinate colours include blue-green, yellow-green and blue-grey. This sub-zone includes several patches or enclaves of more or less weathered greenstone; some enclaves are >2 m thick. Upper saprolite is dominated by clays and is variably soft, friable to coherent, or stiff, and in places, is quite competent. The clays are sticky and plastic (smectitic), sub-plastic (illitic) or are intermingled. Talc and vermiculite-like minerals, in places, make this sub-zone variably greasy to touch. Relict metamorphic foliation is preserved, and regular conjugate joints occur at about 45° and 60° to the core axis. These joints are strongly slickensided, indicating compressive movement, possibly in response to weathering-induced gross volume changes. Differential weathering has formed pseudo-breccias that appear as paler or more brightly coloured rims to geometric or irregular shaped less altered greenstone blocks on scales of 50 to 100 mm (Figure 23A-C). Red ferruginous megamottles and blotches of brown Fe-oxide staining occur here (Figure 23B, C). Pale grey and turquoise chalcedony veins, 2 to >10 mm in thickness, are scattered throughout. Black Mn-oxide flecks and dendrites occur in some intervals (*i.e.* at 11.35 m and 11.75 m). There is a dark brown, strongly ferruginous interval between 15.20-15.95 m, that contains branching fracture veins of a pale bluish to turquoise translucent clay; similar veining occurs near 17.7 m (<1 to 5 mm, possibly a Ni- or Cr-stained kaolinite (Figure 23B).

Extremely weathered greenstone forms a truncated **plasmic zone** 0.6 m thick, the upper surface of which forms an angular unconformity with the overlying transported regolith at 9.05 m (Figure 23C). Materials of the plasmic zone consist of a pale green and grey smectite- and hydromuscovite-rich clay with brown, less smectitic, illuviated clay infilling fractures. This interval is variably brecciated but retains a jig-saw-fit relationship to the blocks, has conspicuous red to brown megamottles and is extensively stained. All these attributes are pedogenic. There is no remnant ferruginous cap here but there is evidence in the overlying colluvium for a pre-existing Fe-cap (see below). Pedogenic dissolution and precipitation of clays has removed any primary textures or metamorphic foliation but relict joints persist, imparting a blocky structure to this shallowest residual zone.

Transported Regolith

The **sedimentary regolith** is 9.05 m thick, consisting of a basal colluvium overlain by alluvium, hardpan and aeolian sands. The lower parts have been partly cemented by Fe-oxides, the middle parts have been partly silicified to silcrete and hardpan, and the upper parts partly cemented by calcrete.

A **colluvial unit,** variably and subtly tinted greyish (gley coloured), is strongly megamottled and forms a basal 0.5 m interval to the sedimentary sequence. It consists of pale yellow-grey to very pale brown clay, quartz sand and grit containing broken 3-5 mm ferruginous pisoliths (Figure 23E, F). Widespread red to brown Fe-oxide staining and megamottling imply this unit has been affected by pedogenic processes. Much of this interval is locally reworked pedolith from weathered medium-grained felsic rocks and fine-grained greenstones. The ferruginous pisoliths have broken or missing cutans; these seem to have been eroded and transported only a short distance. They appear to be the only remaining evidence of a pre-existing, thinly developed ferruginous cap on the residual greenstone regolith. The base to this multicoloured colluvial interval is an angular unconformity at 9.05 m.

Overlying the colluvium is an unnamed variably silicified red-brown **fluvial unit** (5.15-8.45 m) consisting of clast-supported channel sand to pebbles with predominantly well rounded to subangular quartz-rich clasts. Layer selective silicification of this to a silcrete banded unit probably occurred in the early or middle Cainozoic based on stratigraphic evidence from elsewhere (Figure 23E).

A **red-brown hardpan** occurs between 0.5-5.15 m, it is clayey to sandy and strongly coloured. Where polymictic gravel is locally abundant, this is a matrix-supported material (Figure 23E, G). It is variably cemented by calcrete, hyaline silica and Fe-oxides, making it relatively competent. The hardpanization is presumed to be Pliocene-Pleistocene in age based on stratigraphic evidence from elsewhere

Pedogenic **calcrete** forms an earthy to moderately compact white to creamy layer within the soil-sand profile between 0.2-0.5 m. Calcrete nodules, that laterally become laminated or massive sheets, were exposed in the temporary drilling mud pit. Thereby demonstrating the variability of this soil B_{Ca} horizon. Additional obvious calcrete and less obvious carbonate cements occur to a depth of 5.15 m.

Aeolian sand to a depth of about 0.2 m covers the drill site and was only partly recovered by the coring process. It is red-brown to orange, uniformly sorted and hosts later formed pedogenic calcrete.

NOTE: There is a small difference in logged position for the major unconformity between adjacent drill sites (~14 m apart) where dissimilar drilling-sampling methods were used. For aircore drillhole TAR 08, bulked 2 m interval cuttings suggest the boundary is between 6-8 m; but in continuous core from drillhole THHRDD-1 it is clearly at 9.05 m (a difference of 1-2 m). A major portion of this difference comes directly from uncertainties caused by the sampling and bulking of aircore cuttings, continuous core is therefore preferable. Moreover, the pedolith zone indicated on the aircore cuttings logs and derived cross-sections commonly has had a mixed provenance within its upper 1-3 m.

Petrography

Depth 38.63 m. HIGHLY DEFORMED FRESH ULTRAMAFIC BEDROCK.

A highly schistose fine-grained mat of acicular tremolite and flakes of chlorite in which chlorite and a dusting of Fe-oxide picks out at least two acutely intersecting, closely spaced cleavages. Coarser granules of Fe-oxide are scattered throughout. Coarser tremolite and chlorite occur in a few small lenses and boudins. There has been only slight staining along some cleavage planes.
Specimen R406691.

Depth 16.13 m. SAPROCK OF ULTRAMAFIC.

Large islands, consisting of a mat of chlorite and talc, contain acicular pseudomorphs after either metamorphic tremolite of after pyroxene spinifex structures. These are surrounded by broad, meandering veins of coarse, flaky kaolinite in which lie small, unconsumed remnants of the talc-chlorite mat (Figure 24C, D). Fragments of pale, delicately banded aluminosilicate cement has filled voids and been later brecciated (Figure 24D). Specimen R406690.

Depth 13.35 m. SAPROCK OF ULTRAMAFIC.

Patches of largely opaque material, heavily dusted with Fe-oxides, pseudomorphed olivine grains cut by serpentine/antigorite veinlets in what was probably an adcumulate (Figure 24A, B). This is surrounded by chlorite and talc. The whole is cut by meandering veinlets of cryptocrystalline silica and fibrous brucite (Figure 24A). Weathering along specific bands has altered the fabric to stained clay (smectite and kaolinite) obliterating the original fabric. Specimen R406689.

Depth 9.78 m. POROUS SAPROLITE.

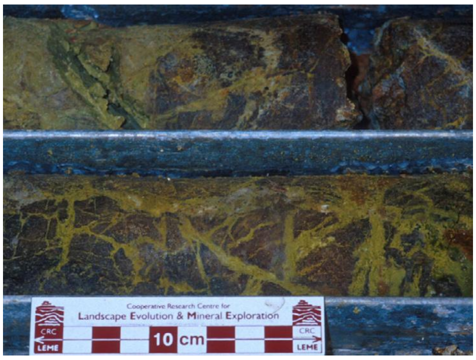
The saprolite consists of a fine-grained flaky mat of smectite and kaolinite with some remnant talc and chlorite, all dusted with Fe-oxides. This has been veined by early gypsum or brucite and later brecciated by near-surface weathering. Voids are now filled with sediment from above, containing a polymict assemblage of saprolite, Fe-oxide granules and small quartz grains in a clay matrix (Figure 25G, H). A few voids and cracks in this porous material are filled with banded, light brown aluminosilicate cement. Specimen R406688.

Depth 8.65 m. CLAYSTONE-QUARTZ ARENITE.

A highly complex sediment consisting mainly of large clasts (5-20 mm) largely of a dark claystone, some of which itself contain smaller clasts of claystone and subangular to subround quartz grains (Figure 25E). Other, less abundant, clasts are Fe-oxide granules. These are set in a matrix of fine-grained angular quartz and dark-brown stained kaolinite. Parts of the matrix have been broken and re-cemented and coated by brown, banded aluminosilicate that also lines voids. Some of the aluminosilicate has also been broken and re-cemented. Some of the larger claystone clasts show evidence of infilled burrows (Figure 25F), which might explain the bimodal nature of the materials in this claystone by bioturbation and mixing of originally separate, stratified and sorted materials.
Specimen R406687.

Depth 8.28 m. CLAYSTONE-QUARTZ ARENITE.

A polymictic sediment of poorly sorted, rounded fragments of claystone, quartz and Fe-oxide nodules (Figure 25C, D) tightly packed into a clay matrix that has been brecciated and partly dissolved and the voids filled with several generations of banded aluminosilicate. The claystone fragments contain quartz clasts but are not as complex as those from higher in the profile. Specimen R406686.



A. Core depth: 18.98-19.15 m (lower core), saprolite consisting of a weathering pseudo-breccia where fracture-like features are composed of bright yellow-green smectite in contrast to the less altered dark olive-grey centres.

B. Core depth: 17.70 m is on centre core at bar scale mid point. Colourful saprolite with alteration veining – some of which is pale blue (LH end centre core; Ni or Cr stained kaolinite). Upper core displays red Fe-staining, lower core includes similar material as displayed in image A.

C. Core depth: 13.3-13.6 m, (upper core) 14.25-14.55 m (lower core), upper saprolite displaying a weathering pseudo-breccia in many greens and randomly spaced red Fe-staining.

D. Core depth: 9.78-9.85 m, a jig-saw-fit breccia developed in upper saprolite, fracture infill matrix is clay weakly stained by Fe.

unconformity (lower core).

E. Core depth: 5.15-9.85 m. Transported materials: red-brown hardpan + alluvium + colluvium on *in situ* weathered greenstone. Unconformity is at 9.05 m, (lower core, arrowed near LH end).

F. Core depth: 8.50-8.75 m, (lower core} colluvium above unconformity, derived from both weathered felsic and ultramafic sources. Red-brown hardpan and alluvium above the paler basal colluvium.

G. Core depth: 4.40-4.60 m, (lower core), red-brown hardpan.

Figure 23: Benchmark 4, Hopeful Hill drillhole THHRDD-1 selected regolith core.

Figure 24 explanation. Thin-section petrography to photomicrographs from Benchmark 4 (cored drillhole THHRDD-1) and Benchmark 5 (cored drillhole TMWRDD-1), after Sheard and Robertson (2004).

A. Dark serpentine pseudomorphs after olivine (OL) outlined by a dusting of Fe-oxides set in a mass of chlorite and talc (CT). This has been cut by veinlets of asbestiform minerals (AS) and voids have been filled by opaline silica (OP). Minor weathering has stained the margins of cracks with goethite (GO). Close up photograph of ultramafic saprock. Specimen R406689: Drillhole THHRDD-1, Depth 13.35-13.45.	**B.** Serpentine pseudomorphs after olivine grains (OL) shown by a dusting of Fe-oxides cut by serpentine/antigorite (AN) with the fabric of an adcumulate, surrounded by chlorite and talc (TC). Photomicrograph of ultramafic saprock under plane polarized transmitted light. Specimen R406689: Drillhole THHRDD-1, Depth 13.35-13.45.
C. Green chlorite and talc (CT) saprolite cut by white veins of kaolinite (KA). Close up photograph of ultramafic saprock. Specimen R406690: Drillhole THHRDD-1, Depth 16.13-16.22.	**D.** A mass of chlorite and talc (CT) with acicular pseudomorphs cut by veins of coarse flaky kaolinite (KA). Some veins have been lined by brown, delicately banded aluminosilicate (AL) that has been subsequently brecciated. Photomicrograph of ultramafic saprock under plane polarized transmitted light. Specimen R406690: Drillhole THHRDD-1, Depth 16.13-16.22.
E. A fragment of a quartz-claystone arenite (QC) cemented by clay and quartz and two fragments of calcrete cemented sediment clay-quartz arenite (CX). Close up photograph of claystone-quartz arenite. Specimen R406692: Drillhole TMWRDD-1, Depth 8,05-8.10.	**F.** Clasts of ferruginised claystone-quartz arenite (QC) set in a matrix of smaller quartz (QZ) and feldspar (FS) grains and very fine-grained carbonate (CC). Photomicrograph of calcrete cemented claystone-quartz arenite under transmitted light with crossed polarisers. Specimen R406692: Drillhole TMWRDD-1, Depth 8,05-8.10.
G. Claystone (CL), quartz (QZ) and variably weathered ultramafic saprolite (UM) clasts in a matrix (MX) of fine quartz and clay that is variably stained with Fe-oxides. The fabric of this rock is accentuated by Fe-staining of the matrix. Close up photograph of claystone-quartz arenite. Specimen R406695: Drillhole TMWRDD-1, Depth 12.45-12.50.	**H.** Clasts consist mainly of quartz-bearing claystone (CS) with minor saprolites of ultramafic rocks (UM) in various states of weathering and ferruginisation, set in a clay matrix (MX) that has been mottled by Fe-oxides (border MO). Photomicrograph of claystone-quartz arenite under plane polarized transmitted light. Specimen R406695: Drillhole TMWRDD-1, Depth 12.45-12.50.

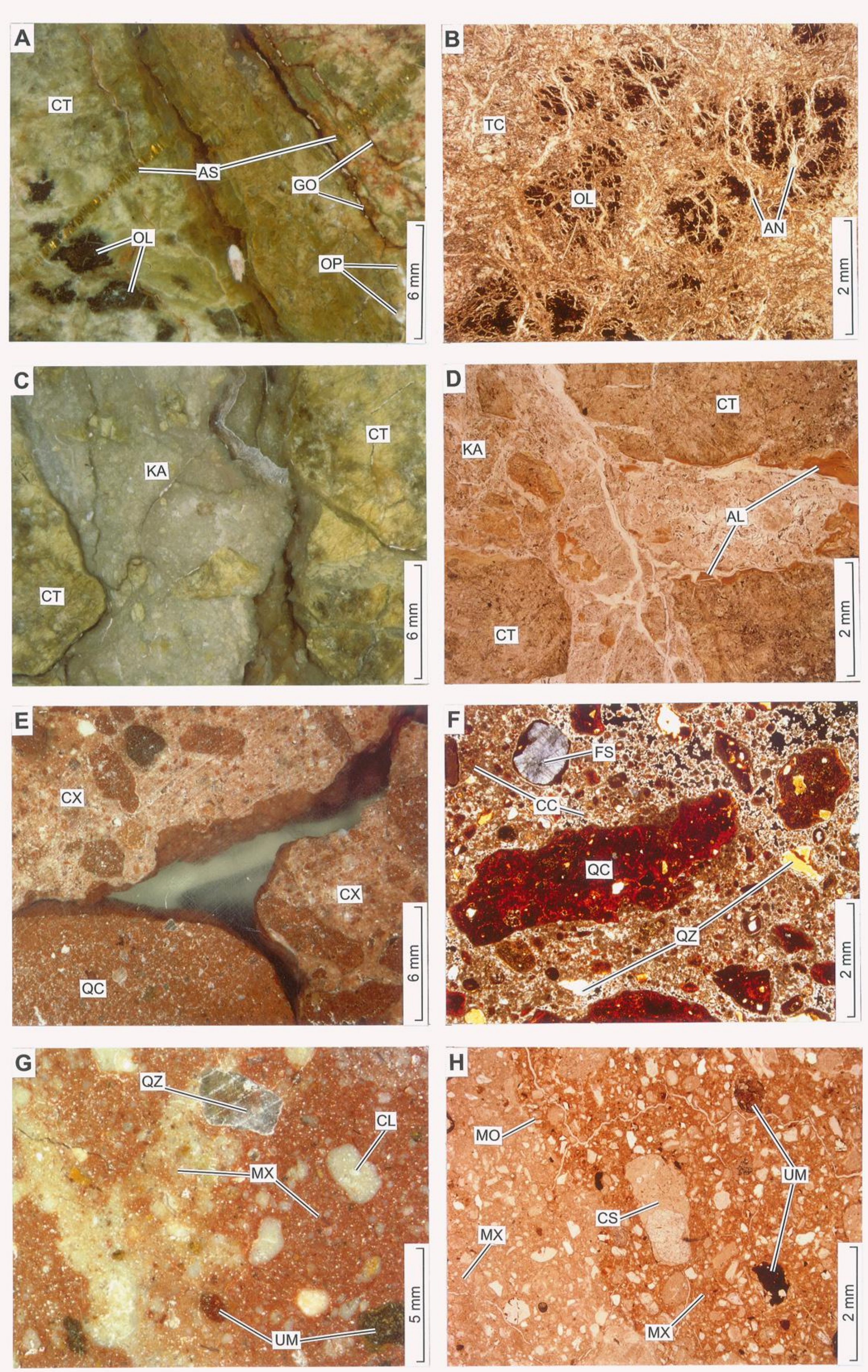


Figure 24: Annotated thin-section photomicrographs from Benchmark 4 (cored drillhole THHRDD-1) and Benchmark 5 (cored drillhole TMWRDD-1), (Sheard and Robertson, 2004).

Figure 25 explanation: Thin-section petrography to photomicrographs from Benchmark 4 (cored drillhole THHRDD-1) after Sheard and Robertson (2004).

A. A large clast of claystone containing smaller clasts of claystone (CL), ferricrete (FC) and subangular to subround quartz (QZ). The matrix consists of quartz grains (QZ) set in brown, Fe-stained kaolinite (KA) with cracks and voids (VO). Photomicrograph of a sedimentary breccia under plane polarized transmitted light. Specimen R406685: Drillhole THHRDD-1, Depth 8.08-8.15.	**B.** Part of the matrix, consisting of ferruginous granules (FG) and quartz (QZ in stained kaolinite (KA) which has been partly dissolved and re-cemented by banded aluminosilicate (AL). The aluminosilicate has been further brecciated (AB) and again re-cemented. Photomicrograph under plane polarized transmitted light. Specimen R406685: Drillhole THHRDD-1, Depth 8.08-8.15.
C. Rounded to angular fragments of a variety of claystones (CL), quartz grains (QZ) and Ferricrete (FC) in a clay matrix (MX). Close up photograph of polymictic sediment. Specimen R406686: Drillhole THHRDD-1, Depth 8.28-8.34.	**D.** Ferruginous granules (FG) and clasts of claystone (CL) in a finer-grained groundmass of ferruginous granules and clay pisoliths (CP) in a clay matrix (MX). Voids (VO) have been lined with banded aluminosilicate (AL). Photomicrograph of polymictic sediment under plane polarized transmitted light. Specimen R406686: Drillhole THHRDD-1, Depth 8.28-8.34.
E. Complex claystone clasts containing an earlier generation of pale claystone clasts (CO) and Fe-oxide granules (FG) in a matrix (MX) of angular quartz and brown-stained kaolinite. Close up photograph of sedimentary breccia. Specimen 406687: Drillhole THHRDD-1, Depth 8.65-8.73.	**F.** A claystone clast (CL) containing part of an infilled burrow (BR). This is set in a matrix (MX) of clay and claystone granules. Photomicrograph of sedimentary breccia under plane polarized transmitted light. Specimen 406687: Drillhole THHRDD-1, Depth 8.65-8.73.
G. A saprolite (SP), consisting of kaolinite and smectite, has been brecciated by near-surface weathering processes. Voids are now filled with a polymictic assemblage of saprolite (SP), hematite granules (HM) and small quartz grains set in clay (CL). Close up photograph of porous saprolite. Specimen R406688: Drillhole THHRDD-1, Depth 9.78-9,85.	**H.** Brecciated saprolite fragments (SP) in a clay matrix (MX) with quartz (QZ) and pieces of Fe-oxides. Photomicrograph of porous saprolite under transmitted light with crossed polarisers. Specimen R406688: Drillhole THHRDD-1, Depth 9.78-9,85.

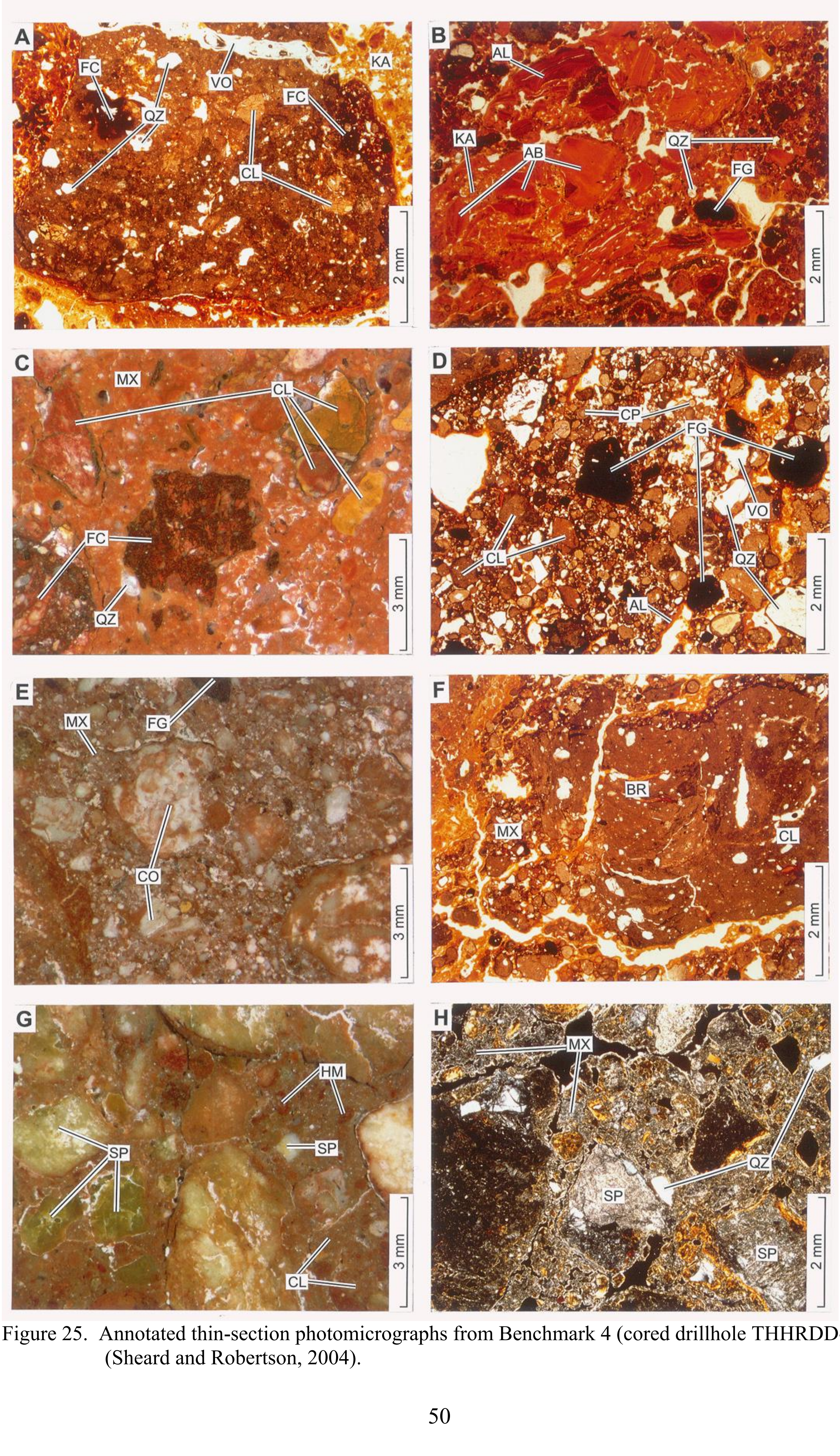


Figure 25. Annotated thin-section photomicrographs from Benchmark 4 (cored drillhole THHRDD-1), (Sheard and Robertson, 2004).

Depth 8.08 m. CLAYSTONE-QUARTZ ARENITE.

A highly complex sediment consisting mainly of large clasts (5-20 mm) largely of a dark claystone which itself contains smaller clasts of claystone and subangular to subround quartz grains (Figure 15A). Other less abundant clasts are of Fe-oxide granules and ferricrete. These are set in a matrix of fine angular quartz and deep brown-stained kaolinite. Parts of the matrix have been broken and re-cemented and coated by brown, banded aluminosilicate that also lines voids. Some of the aluminosilicate has also been broken and re-cemented (Figure 25B). Specimen R406685.

Depth 4.52 m. HARDPANIZED COLLUVIUM-ALLUVIUM.

Larger grains (2 mm) of rounded quartz and smaller grains (0.5 mm) of angular to shardy quartz with minor microcline and granules of Fe-oxides are loosely packed into a brown-stained phyllosilicate (kaolinitic) matrix (Figure 9H) which contains numerous voids lined and some filled with a finely banded, brown aluminosilicate cement. Among the larger rounded grains are a few rounded clasts of ferricrete (Figure 9G) containing angular quartz. There is evidence of erosion and redeposition of this material as some clasts have the same quartz clasts and stained phyllosilicate matrix as the main part and are coated with banded aluminosilicate that also forms veins in the matrix. Specimen R406684.

Comments

- The ultramafic bedrocks show significant but variable deformation and metamorphism that have largely obscured their character, although some hints of cumulate fabrics remain. The top of the saprolite contains cavities filled with sedimentary materials.
- The majority of the overlying sediments consist of fragments of claystone that imply a pre-existing claystone, consisting of clays and quartz that have been mixed by bioturbation, before being broken up and redeposited on the ultramafic saprolites.
- Only the top of the sediments are different and probably had a granitic provenance.
- The aluminosilicate cementing material had a complex history, showing evidence of several cycles of cementation, break-up and re-cementation.

Geochemistry

The following paragraphs adapted from Sheard and Robertson (2004).

Half core spot samples, up to 100 mm long, were taken at selected points from the HQ sizes core to indicate chemical variations but, at the same time, preserve at least the other half core as a record. Thus, the geochemistry is not continuous. Graphic results are displayed in Figures 11, 12, 20, 26.

The reader is referred to Benchmark 1 Geochemistry and the three following related sections as they compare data from Benchmarks 1, 4, & 5 along with data from related aircore drilling. A ternary plot of the major components (Si-Al-Fe; Figure 11A) indicates that ferruginisation is the major weathering trend in the residual part of the profile. However, it must be kept in mind that structurally and stratigraphically complex Archaean rocks were intersected and these were not necessarily originally chemically equivalent prior to weathering (Sheard and Robertson, 2004). Figure 26 displays the down hole log against geochemistry for Benchmark 4.

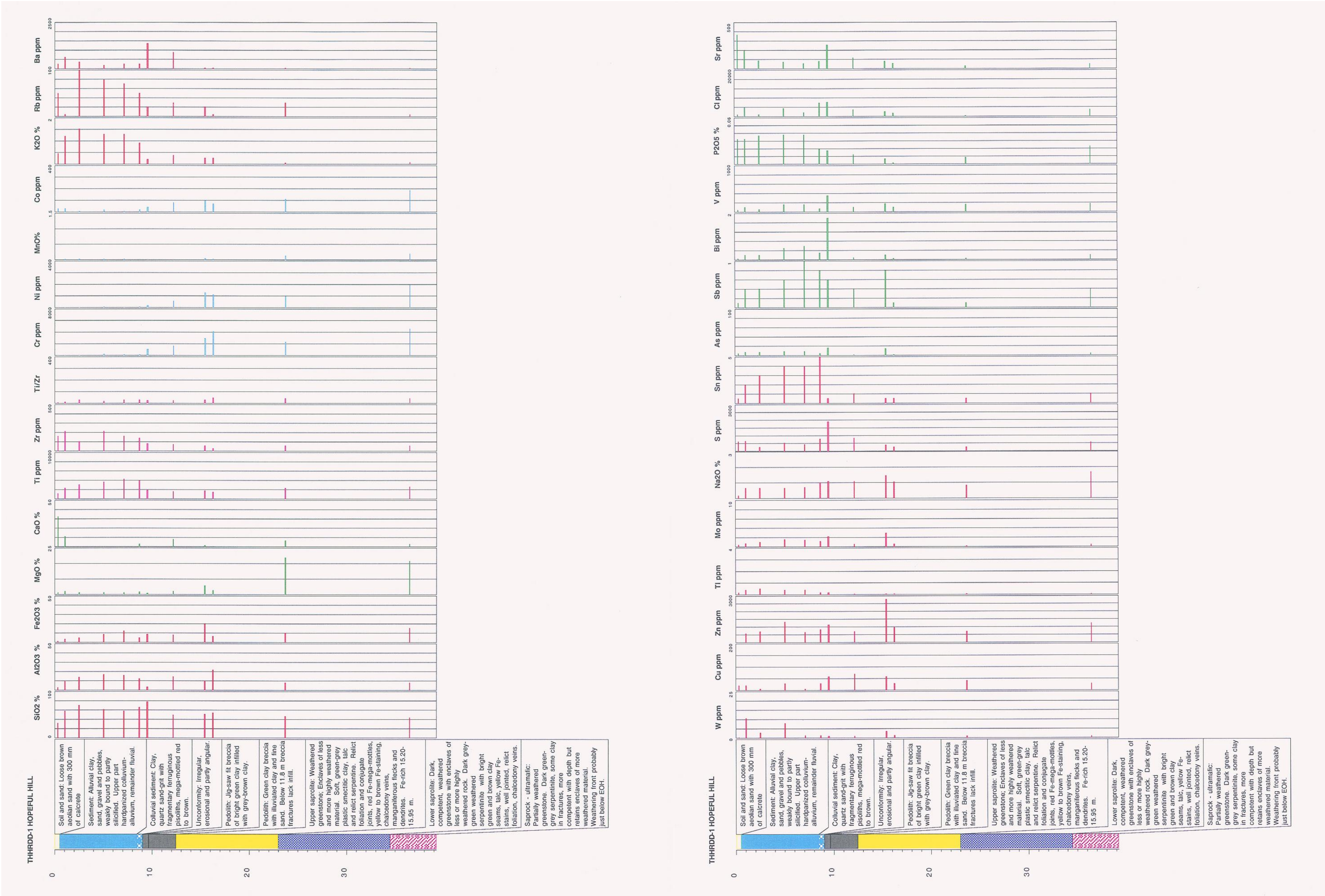


Figure 26:
Log and Geochemistry of Benchmark 4
at Hopeful Hill [A3 fold out sheet],
(Sheard and Robertson, 2004).
Refer to Figure 16 for graphic log explanation.

Mullina Well

Benchmark 5, cored drillhole TMWRDD-1

Quick reference items are set out in Table 13; detailed descriptions, figures and data tables follow on below. This location is ~540 km NW of Adelaide and ~11 km S of Tarcoola. A site about 10 m E of the aircore drillhole TAR 56 (E side of vermin proof fence, ~1 km S of the pastoral track from Mullina Well, heading W), was selected as being representative of the regolith profile over weathered greenstone in this area Figures 4, 5, 27, 28. Drilling was vertical into a subvertical greenstone; the drilled profile most likely only intersects one or two narrow subvertical bands within the weathered and folded metakomatiitic mafics and ultramafics. A summary of that profile is provided in Table 14 and selected core photographs are in Figure 29; petrological photomicrographs and descriptions are presented in Figures 24, 30; and geochemical data are presented in Figures 11-14, 20, 31 and Table 5.

Table 13: Benchmark 5 reference data, Drillhole THHRDD-1 (Type 2, drill cored profile).

Items	Figures, Data, Sources
Regional location map	Figures 4, 5.
Local-site location maps	Figures 27, 28.
GPS coordinates, attitude & elevation	Zone 53, 461096 E, 6592412 N, GDA 94. Vertical. **AHD:** 162.00 m (differential GPS data).
Site access, owner	~540 km NW of Adelaide and ~11 km S of Tarcoola, ~14 km WSW of Wilgena Pastoral Station Homestead, ~10 km W of Mullina Well, ~1 km SW along the Vermin Proof Fence (E side) cutting the pastoral access track from Wilgena Station Homestead to Mullina Well, and ~60 km W of Lake Harris.
Related drillholes	Near aircore drillhole TAR 56, part of an ~NNE-SSW drill line of 26 drillholes.
Drill sample photos + logs	Yes, Figure 29 + Table 14.
Sample types	Continuous core, HQ size, 0 to 40 m + chiptrays from adjacent drillhole TAR 56 for comparison.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered serpentinitic komatiitic lavas.
Petrology	Yes, Figures 24, 30.
Geochemistry	Yes, Figures 11-14, 20, 31 and Table 5.
XRD mineralogy	Yes, within core, petrology & geochemistry descriptions.
PIMA spectral data	Yes + HyLogged, but spectra have not been interpreted.
Dating	Yes, from this area. Rhyodacite volcanics interlayered with greenstones yielded a U-Pb zircon age of ~2520 Ma (Fanning, 2002).
Target Elements	Potential for Au, PGE, Ni, V, Cr, Co, Cu, Pb and W.
Potential Pathfinder Elements	Komatiite indicator elements (Mg, Cr, Ni, As, Co, Fe, Mn and V) Mineralization-related elements (Au, Bi, Cu, Pb and W).
Useful sampling media	Transported regolith-soil where <5-10 m thick and separated heavy minerals (bioturbated relict chromite), calcrete and silcrete (higher Cr, Ni & V over ultramafics), Fe-pedolith where preserved (outcrop & subcrop) see geochemistry Figures 11-14, 20, 31 and Table 5.
Key reference sources	Davies, 2002a, b; Sheard and Robertson, 2003, 2004; Daly and Fanning, 1993; Fanning, 1997, 2002.

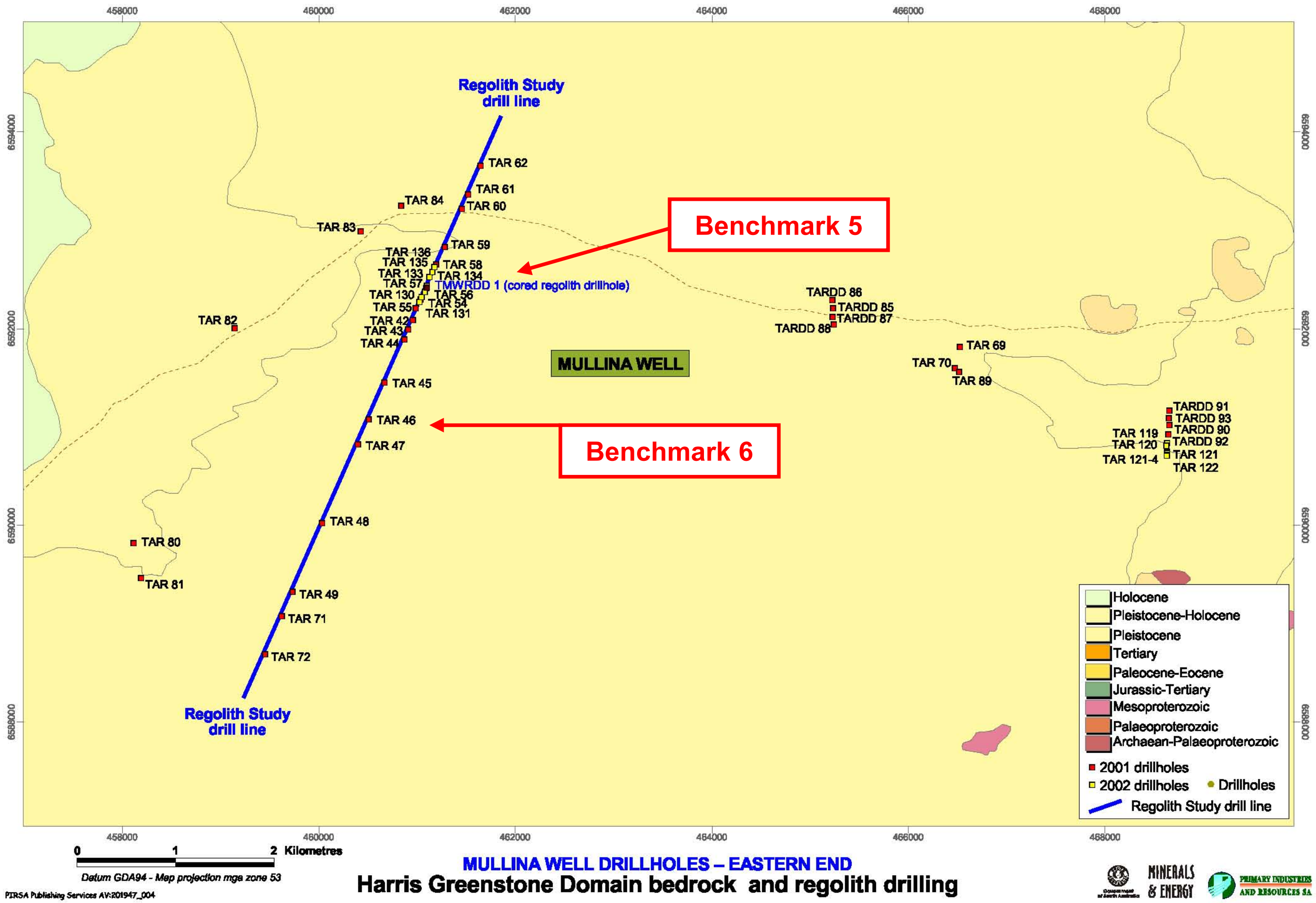


Figure 27: Localised site plan indicating where Benchmark 5 (cored drillhole TMWRDD-1) and Benchmark 6 (aircore drillhole TAR 46). The ~NNE drill line of 25 drillholes is displayed in part as a regolith profile in Figure 28 (after Sheard and Robertson, 2004).

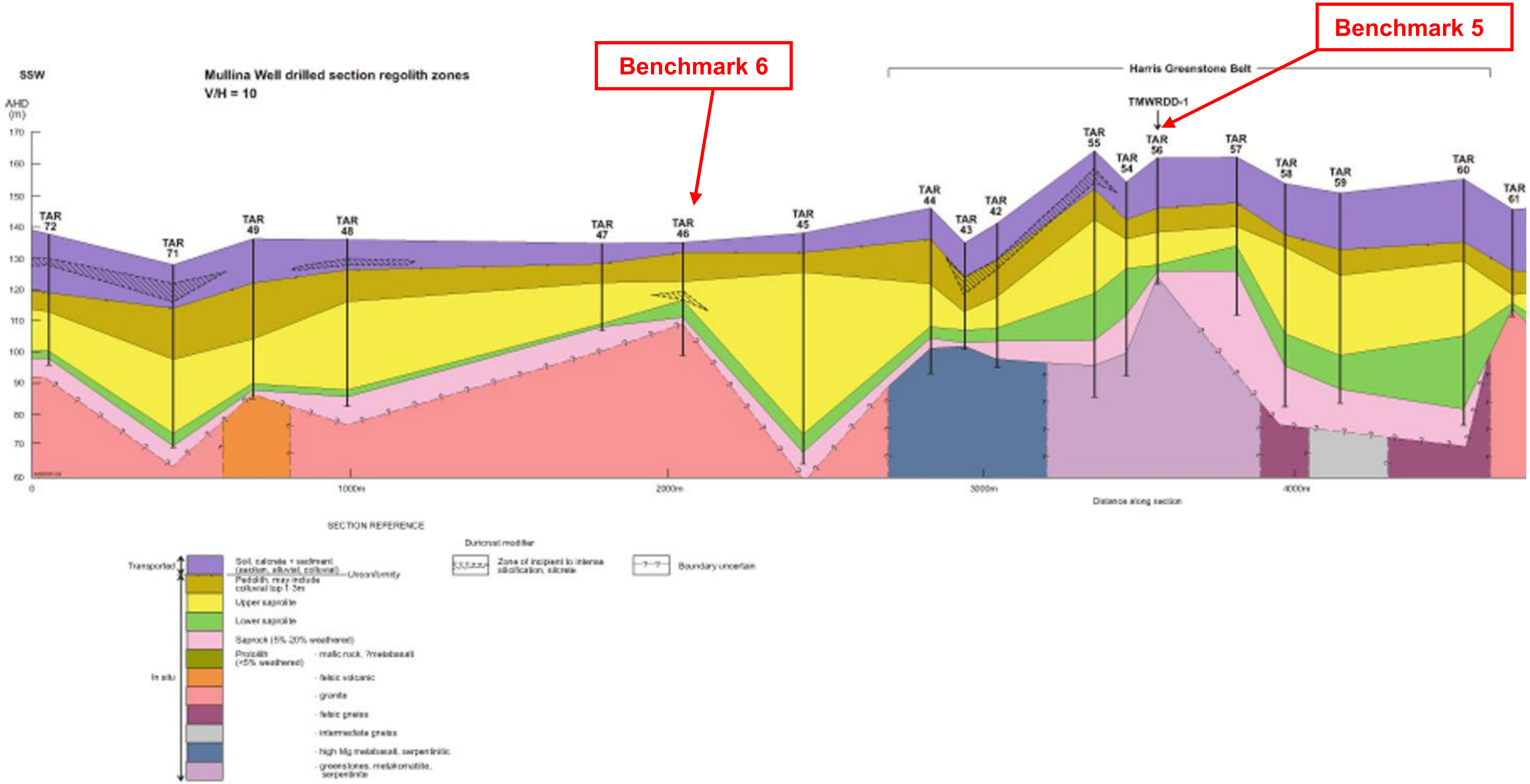


Figure 28: A portion of the ~NNE Mullina Well regolith profile (after Sheard and Robertson, 2004). Benchmark 5 (cored drillhole TMWRDD-1) and Benchmark 6 (aircore drillhole TAR 46) are indicated and places these reference sites into context. Note the very irregular weathering front and variable saprolite thicknesses – irrespective of lithotype.

Table 14: Summary log to Benchmark 5, Mullina Well cored drillhole TMWRDD-1 (Sheard and Robertson, 2004)

Depth Range (m)	**Graphic Log** (vert. not to scale	**Regolith Zone**	**Description**
0.00-0.80		soil-sand	soil in loose red-brown aeolian sand with ~300 mm of calcrete.
0.80-~10.00		sediment	red-brown alluvial clay + sand + gravel, weakly bound to partly cemented. Carbonate to ~6 m. Upper ~6 m is red-brown hardpan colluvium-alluvium, the remainder is an older fluvial overbank to sheet flow + channel deposit, irregularly silicified, silcrete bands.
~10.00-11.47	# # # # # #	colluvium	brown clay, plastic and sticky, + quartz sand-grit, silicified, red to brown Fe-megamottles + MnOx staining.
11.47-17.35	# # # # # # # # # # # #	sediment	sedimentary clays to claystones, silty to sandy at top, mostly structureless & unbedded, yellowish grey grading to greenish grey (gleyed), clays are stiff & plastic, smectitic to kaolinitic. Bright yellow and/or red Fe-megamottles. some Fe-pisoliths within megamottles, MnOx dendrites in a few intervals.
17.35-22.70		debris flow colluvium	Landslide deposit. Unsorted jumble of clay-rich saprolitic blocks to 500 mm, angular to subrounded, clast to matrix supported, matrix clay structureless + polymict quartz & lithic clasts from mixed source, rests unconformably on partly eroded pedolith, unit represents a wet mass wasting event yielding a debris flow.
22.70-23.30	Fe Fe Fe |#|#|#| # | #	***in situ*** Pedolith (plasmic)	remnant pedolith, extremely weathered greenstone; upper part is ferruginous, brown fines-rich, cemented & partially eroded to an angle of ~15^{o}. Lover 2/3 is pale grey-green or yellowish grey + variable Fe-mottling, has pedogenic breccia & illuvial clay infill
23.30-37.90		upper saprolite	Highly weathered greenstone; complex sub-zone with several enclaves of less + more highly weathered material. Clay-rich, soft to stiff and sticky-plastic clay (smectitic) bright greens + blue-greens + yellow-greens + blue-greys. Relict foliation + lizard skin-like patternation, conjugate joint sets, red Fe-megamottles + yellow to brown Fe-staining throughout, black MnOx flecks and dendrites in sub-zone 34.5-35.3 m. Some intervals have a distinctly greasy feel (talc). Sub-zone is mostly smectite + kaolinite + chlorite + talc + relict serpentine. Dark brown Fe-rich intervals between 36.15-37.90 m
37.90-38.50		lower saprolite	Weathered greenstone; generally darker hued and more competent than the sub-zone above. Dark green-grey weathered serpentinite + bright green and brown clay seams + talc, yellow Fe-stains, well jointed, micro to macro fractured, relict metamorphic foliation.
38.50-39.12		saprock	Partially weathered serpentinite + clay enclaves, dark green-mid grey, some clay fracture infill, hard to brittle, Fe-staining.
39.12-40.00		bedrock	Schistose serpentinite, incipiently weathered, dark green-grey, cross cut by white quartz and chalcedony veins. Weathering Front is near the 40 m level.

The following lithology and petrographic descriptions are taken from Sheard and Robertson (2004).

In situ Regolith (greenstone)

Greenstone **bedrock** was penetrated at 39.12 m but the ~0.9 m of core recovered is very fissile, schistose and the serpentinitic character is therefore masked. The core has a pervasive alteration that is difficult to define as incipient weathering, tectonic shearing or hydrothermal modification. Bedrock here, of serpentinite, is grey to dark green-grey (dominant) with subordinate brownish alteration and thin, pale-green clays along large fractures.

The **saprock** zone is thin (0.62 m) and begins at 38.5 m. It is dark green to grey-green, partly altered serpentinite with a relict primary fabric and metamorphic foliation, and has minor bright green and brown clay seams and minor brown Fe-oxide staining, mostly along joints. Joints at about 75^{o} to the core axis are variably altered and stained.

The **lower saprolite** sub-zone is less complex than the overlying, thick, upper saprolite. It is thin (37.9-38.50 m) compared with the other cored sites and is mostly darker than the upper saprolite. It is also more competent, the clay is stiff, and there is abundant unaltered serpentinite. Typically, it is dark to pale green plus some grey, with yellow to brown clay infillings to fracture voids. Fracture surfaces have yellow and brown ferruginous staining which becomes pervasive in places. Regular conjugate joints occur at 45-60^o to the core axis and are variably slickensided.

The strongly leached **upper saprolite** is moderately thick (23.3-37.9 m) and is a complex, multicoloured sub-zone where various medium green and variably subtly tinted greyish colours (gleys) are overprinted by red ferruginous megamottles and black Mn-oxide staining (Figure 29A-E). Subordinate colours include blue-green, blue-grey and bright yellow-greens. The top ~5 m interval is highly leached, mostly pallid (near white to very pale grey) containing dark red-brown megamottles and fracture wall staining (>100 mm wide) in similar red-browns to the megamottles (Figure 29D, E). The upper saprolite includes patches or enclaves of less weathered greenstone; some are >2 m in size and they demonstrate an incomplete or irregular weathering process. Between 25.35 and 27.85 m there was **no** core recovery. Here, the drill rods fell under their own weight through either an open subvertical fracture (>200 mm wide) or through a 2.5 m interval filled with a low-strength hydrous smectite-rich gel at or near its liquid limit (geomechanical term, *i.e.* in this case the moisture content was probably much greater than 100% by dry weight of clay). However, the open fracture hypothesis is the more likely. Upper saprolite is clay-rich, variably soft to moderately stiff, and friable to compact. Its clays are sticky and plastic (smectitic) to sub-plastic (illitic). Talc and vermiculite-like minerals give this sub-zone a variably greasy feel in places. There is relict foliation and ghosts of a primary fabric (lizardite) in some parts and not in others. Regular conjugate joints occur at about 45-60° to the core axis; many are strongly slickensided. Black Mn-oxide flecks and dendrites occur in a few intervals of 200-300 mm (at 34.5 and 35.1 m; Figure 29B). Strongly ferruginous dark brown intervals occur at 36.15, 37.7 and 37.9 m, and contain Mn-oxides. The upper saprolite generally consists of smectite-hydromuscovite, kaolin and chlorite with relict serpentinite and talc.

An eroded remnant **pedolith** plasmic zone interval of intensely weathered greenstone was intersected between 22.7 to 23.3 m. Its thin upper portion (22.7-22.9 m) is a competent fine-grained ferricrete, containing pedogenic structures such as wavy parallel dark brown Fe-banding, incipient Fe-nodule development, and brecciation with re-cementation (Figure 29F). There is an eroded upper surface forming an angle of about 15^o to the core axis. Below the ferricrete, a pedogenic breccia occurs, comprising a jig-saw-fit set of fragments in pale yellow, pale yellow-grey, and very pale brown clay-rich material, to 100 mm in size. The fracture infill is pale grey clay but this has no associated obvious sedimentary sand- or grit-sized clasts. It is unclear how much of this zone has been eroded, nor is it clear whether that erosion was totally or partially related to the overlying debris flow.

Transported Regolith

Sedimentary regolith here is 22.7 m thick, consisting of a substantial debris flow deposit, alluvial clays, colluvium, alluvium and a hardpan, with an aeolian sand plain mantling the whole area. Boundaries are indistinct below the hardpan, especially the unconformity, due to similar materials occurring above and below.

A **debris flow** (wet landslide or avalanche deposit) occurs between 17.35 and 22.7 m; it forms the basal unit to the transported regolith sequence. Typically it consists of a highly weathered jumbled mix of angular to subrounded clay-rich saprolitic boulders to irregular small clasts (500 to <10 mm), either matrix or clast supported, with an unstructured similarly coloured but less smectitic colluvial clay infill to the inter-clast portions. That infill clay also contains felsic-terrain derived quartz grit to sand with other small lithic rip-up clasts – all showing some degree of abrasion due to transportation. Much of this deposit is pallid (near white to greyish) but some clasts are pale yellow-green or pale yellowish grey. It generally has a randomly occurring red-brown megamottle overprint (Figure 29G, H). The whole interval represents a mass-wasting landslide that has involved some water and has been deposited as a debris flow. Reference to the cross-section derived from aircore drillhole data (Figure 28) reveals that this cored site is on a topographic rise that has persisted for a considerable time, and the site is also adjacent to a palaeo-valley. Undercutting of a water-saturated, deeply weathered creek bank or escarpment by storm water or the erosional over steepening of a slope of waterlogged saprolite could induce a landslip and result in a mass-flow debris deposit.

This significant unit was not recognized in the core at first because of its similarity to underlying, highly weathered *in situ* saprolite. Moreover, the clay-rich boulder to pebble sized subangular clasts are not visible in moist core. Petrography, with assistance from geochemistry and XRD mineralogy, helped define a 4.9 m interval where careful logging of the now dry core was able to locate the main unconformity and recognize the colluvial fabric above it.

A **clay-sand-silt** sediment overlies the debris flow deposit between 11.47 and 17.35 m. An upper metre or so of this unit is sandy with subdominant silt; the remainder is clay-rich. The clay is typical of a fluvial overbank deposit as it is generally structureless and unbedded with pale greys to pale grey-green (gleyed colours, Figure 29I) that become more yellowish grey between 12.6 and 13.5 m. Later pedogenesis has overprinted the bulk clay colours with spaced but conspicuous red megamottles (Figure 29J). Clay stiffness, plasticity, degree of stickiness and, to a lesser degree, the XRD mineralogy all suggest this clay is derived from an eroding deeply weathered ultramafic to mafic terrain rather than a felsic terrain.

A variably silicified **colluvium-alluvium** occurs between 9.9 and 11.47 m. It consists of red-brown plastic clay and minor quartz sand to grit and is unlike units in equivalent positions at Lake Harris or Hopeful Hill. Here it has indistinct widespread dark red to brown Fe-oxide staining and megamottling. Much of this interval was probably derived locally from a weathered mixed lithotype basement terrain.

Overlying the colluvium is a variably silicified red-brown **fluvial clay-silt-sand unit** about 2.0 m thick, consisting of overbank and sheet flow deposited materials. Variable pedogenic silicification within this unit probably occurred during the early or middle Cainozoic based on stratigraphic evidence from elsewhere (Figure 29K).

A strongly coloured **red-brown hardpan** overlies the alluvium and is dominantly a colluvial-alluvial unit of clay, sand and grit, variably cemented with carbonate, hyaline silica and Fe-oxides, making it relatively competent. Pedogenic hardpanization of this unit probably occurred during the early Pleistocene based on stratigraphic evidence from elsewhere This unit is 7.1 m thick.

Pedogenic **calcrete** forms a moderately compact cream coloured layer within the soil-sand profile between 0.3-0.5 m but additional overt and less obvious carbonate cements transported regolith to a depth of about 6.00 m. Exposures of calcrete in the drilling mud pit, next to the cored drillhole, laterally changed from nodules to aggregated nodules to a laminated pan to a massive sheet over only a short distance and amply demonstrated the variability of this soil $B_{\mathbf{Ca}}$ horizon.

Aeolian sand to a depth of about 0.8 m forms the uppermost transported regolith unit. It is red-brown to orange, uniformly sorted and hosts later formed calcrete (see above).

NOTE: The significant discrepancy of nearly 15 m between the position of the unconformity in adjacent diamond cored and air-cored drilling, roughly 10 m apart requires explanation. Logging of aircore drillhole TAR 56, that had bulked 2 m interval cuttings, determined the unconformity to be at about 6-12 m; while logging of the diamond core from TMWRDD-1 determined it to be at 22.7 m. The majority of this difference is due to drill sampling methods – 2 m bulked regolith cuttings are inferior to continuous core. Cuttings of colluvial clay-rich materials strongly resemble deeply weathered *in situ* materials, making the unconformity very cryptic to the human eye. It required the assistance of petrography, XRD mineralogy and geochemistry to locate precisely. The pedolith commonly has an upper portion of mixed provenance (aircore samples) allowing the unconformity in TAR 56 to be changed to about <18 m depth. The debris flow material, derived from saprolitic greenstone, is impossible to differentiate by eye alone in drill cuttings from *in situ* saprolitic greenstone. This example demonstrates very well the efficacy of at least **some** strategic regolith drill core (from the surface) to augment the more commonly available drill cuttings when working with transported materials on weathered basement. It is especially so when trying to elucidate landscape evolution, palaeo-surfaces, the subtleties of palaeodrainages and mechanical transport of basement mineralization pathfinders.

Figure 29 explanation: Benchmark 5, Mullina Well drillhole TMWRDD-1 selected regolith core. **Note** this core is reversed to normal layout and runs right to left (Sheard and Robertson, 2004).

A. Core depth: 36.70-36.83 m, pale green clay-rich saprolite with subtle yellow staining.	**B.** Core depth: 34.45-34.70 m, black Mn-oxides as stains, flecks and dendrites in pale green clay-rich saprolite.
C. Core depth: 32.90-33.15 m, pale green upper saprolite displaying fracturing. yellow staining and pale yellow alteration (?mottling).	**D.** Core depth: 24.6-24.95 m (upper core) [no core between 25.35-27.85 m] & 28.19-28.45 m (lower core). Iron mega mottles in pallid clay saprolite.
E. Core depth: 23.65-23.87 m, pale grey clay saprolite with white clay veins (moist), same interval is white when dry.	**F.** Core depth: 22.70-22.83 m, a megamottle in the pedolith plasmic zone. Iron oxide is not uniformly distributed within the mottle. Host clay is pallid.
G. Core depth: 18.80-18.94 m, mottled debris flow colluvium.	**H.** Core depth: 18.50-18.75 m, debris flow colluvium, some clasts are selectively Fe-stained and some random mottling is also present.
I. Core depth: 15.75-15.90 m, alluvial clay, mottled.	**J.** Core depth: 12.70-12.92 m (upper core) alluvial clay, mottled. 14.15-14.40 m (lower core), complex Fe-staining and mottling in alluvial clay.
K. Core depth: 8.05-8.17 m, weakly cemented (silica & carbonate) alluvial gravel and sand with minor clay.	

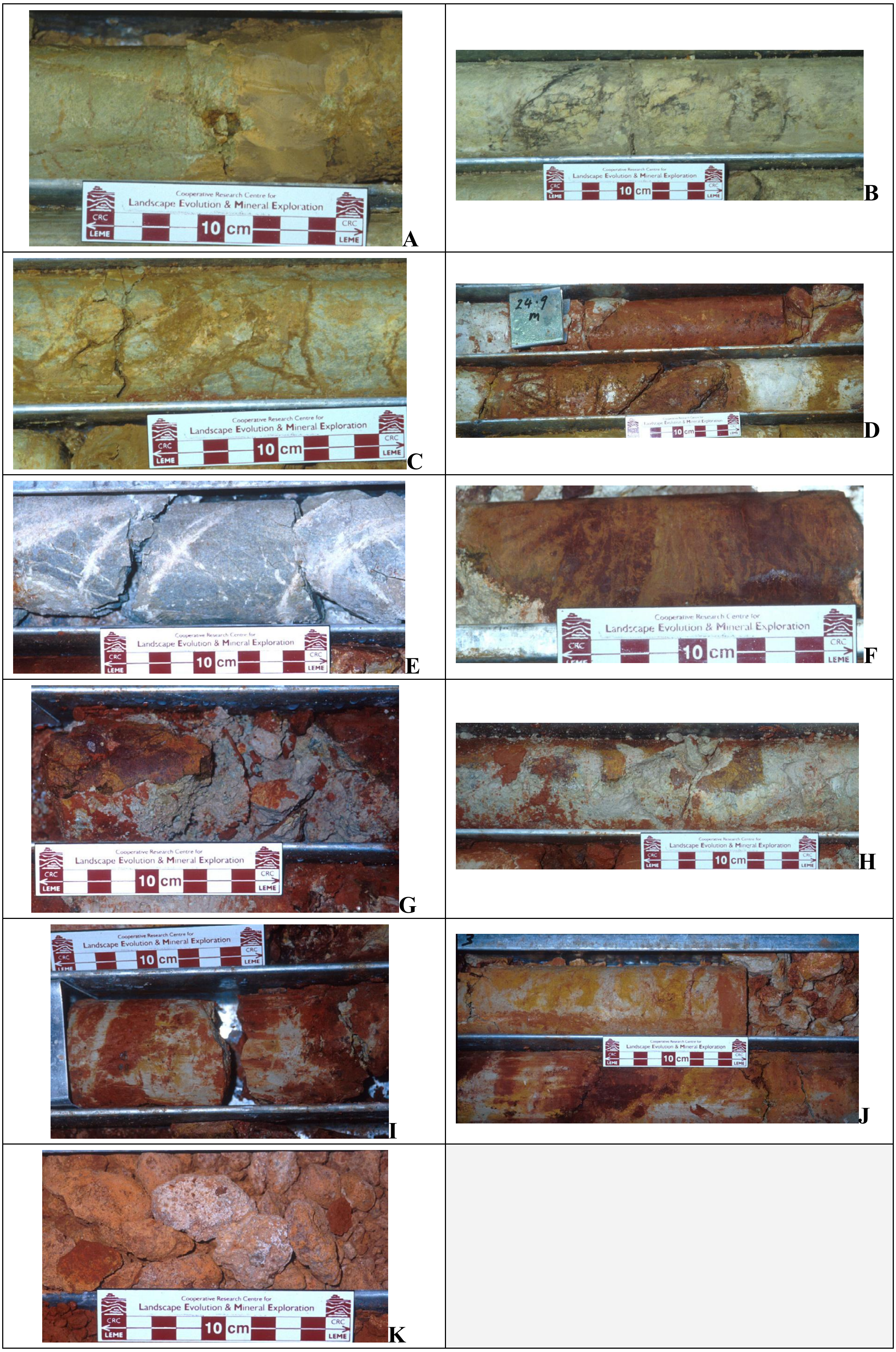


Figure 29: Benchmark 5, Mullina Well drillhole TMWRDD-1 selected regolith core.. **Note** this core is reversed to normal layout and runs right to left (Sheard and Robertson, 2004).

Petrography

Depth 39.15 m. RELATIVELY FRESH MAFIC BEDROCK.

Fine-grained acicular tremolite and fibrous chlorite forms a mesh with interstitial plagioclase and minor quartz. The whole is dusted with granular Fe-oxides and brown rutile. The proportions of mafic and felsic minerals varies. Some parts are schistose, with a cleavage of aligned mafic minerals and small lenses of granular quartz. Cracks have developed, some along the cleavage, and these are lined with clay and goethite. Goethite has spread from these to a limited extent, to stain the mafic minerals. Specimen R406702.

Depth 34.45 m. SAPROCK OF ULTRAMAFIC.

A mat of talc and chlorite, dusted with fine-grained Fe-oxides contains some acicular structures pseudomorphed by the talc. Small diffuse patches and veinlets within the metamorphic fabric have altered to very fine-grained flaky clay (smectite and kaolinite) that has lost the acicular structure. The clays are very faintly stained and the metamorphic fabric is unstained. Specimen R406701.

Depth 30.08 m. SAPROLITE OF ULTRAMAFIC.

A mat of talc and chlorite with veinlets and patches of granular metamorphic quartz has been intensely altered to very fine-grained clay (smectite and kaolinite) in numerous diffuse patches (Figure 16H) that contain unconsumed or partly consumed remnants of the metamorphic assemblage. Iron staining, which has largely penetrated from fractures, cleavages and along quartz vein margins has spread into the metamorphic fabric to a limited extent (Figure 30G, H). Specimen R406700.

Depth 23.70 m. SAPROLITE OF PRESUMED ULTRAMAFIC.

The ultramafic has been altered pervasively, leaving only minute remnants of the talc fabric in a mass of circular patches of very fine-grained, flaky clay and vermiform clay stacks between, dusted with opaque Fe-oxides and rutile (Figure 30E, F). Clays have penetrated between the grains of the veins and patches of metamorphic quartz, producing a loose jig-saw structure or patches of disaggregated grains. Iron staining is confined to cracks and these and voids are filled with brown, banded aluminosilicate. Specimen R406699.

Depth 18.80 m. MOTTLED GRITTY SEDIMENT OF SAPROLITE FRAGMENTS.

A complex matrix-supported polymictic gritty sediment (Figure 30D). It contains large subangular clasts, mainly of the underlying saprolite (characterized by patches and 'blasts' of fine-grained clay, disaggregated quartz crystals and relics of the metamorphic fabric) and lesser quantities of clasts of claystone with quartz inclusions. This is set in a matrix of rounded similar materials but with claystone and quartz dominating, all in a clay matrix. Part of the specimen, probably representing a large mottle (Figure 30C), is intensely ferruginised to goethite, obscuring much of the fabric. Specimen R406698.

Depth 15.80 m. MOTTLED CLAYSTONE.

A mottled claystone with numerous subround to subangular quartz clasts (0.1-0.5 mm) and a few ferruginous granules (2 mm). Coarse mottling has stained the clays brown in diffuse zones (Figure 30B). There is faint evidence for curved burrows about 5 mm diameter and 15 mm deep. Specimen R406697.

Depth 12.92 m. MOTTLED CLAYSTONE.

This is similar to the sediment below but minor microcline occurs among the sand-sized quartz clasts and these are more unevenly distributed throughout. Goethite mottling has stained some clays and minor goethite has been deposited along cracks (Figure 30A). Specimen R406696.

Depth 12.45 m. GRITTY SEDIMENT OF CLAYSTONE FRAGMENTS.

Mottling of the matrix of this matrix-supported grit has accentuated its fabric (Figure 24G). It consists of clasts of quartz-bearing claystone, talc-chlorite-clay saprolite with a variety of fabrics and weathering states and quartz. These are set in a matrix of Fe-stained clay (Figure 24H). Specimen R406695.

Depth 10.90 m. MOTTLED GRITTY SEDIMENT.

Large rounded to subround and small angular to shardy quartz grains are densely packed into a matrix of ferruginous clay which has been partly replaced by a deep brown aluminosilicate cement. Specimen R406694.

Depth 9.15 m. GRAVELLY SEDIMENT.

Polymictic gravel containing rounded clasts of ferricrete, claystone and saprolite set in a matrix of clay scattered with quartz and ferruginous nodules. Specimen R406693.

Depth 8.05 m. CALCRETE CEMENTED CLAYSTONE.

This section consists of two samples each of two different materials (Figure 24E).

i) The first material is a complex sediment of clasts of clay-rich material and both angular and round quartz set in a clay and fine quartz matrix. The clays of both the matrix and the clasts are stained brown by goethite. Numerous cracks and voids within the matrix have been lined with a delicately banded aluminosilicate cement that also forms papules. This fragment has a partial cutan of brown aluminosilicate. The other fragment is similar but has been more intensely stained a deep red-brown.

ii) The second material consists of clasts of a broad range of sizes of the first material, ferruginised to varying degrees, set in a very fine-grained carbonate matrix (calcrete) with clasts of angular to subround quartz and minor rounded very fine-grained granular carbonate (Figure 24F). Specimen R406692.

Comments

- The mafic-ultramafic bedrocks show significant deformation, which have largely obscured their original character, although some hints of cumulate fabrics remain. The top of the saprolite contains cavities filled with sedimentary materials.
- Although the base of the sediments is a breccia of saprolite fragments, succeeding layers are of a claystone, similar to that of the palaeochannel sediments on the Yilgarn Craton, consisting of a bimodal mixture of clays and quartz. These have been broken up and redeposited higher in the succession.
- Logging of even diamond core through regolith, and locating the unconformity between transported and weathered *in situ* residual materials are very difficult in places. The core can have different appearances when wet and dry and can show different features in these two states. Thus, it is inevitable that the core needs revisiting and initial logs need revision, particularly when additional chemical, mineralogical and petrographic evidence becomes available.

Geochemistry

Half core spot samples, up to 100 mm long, were taken at selected points from the HQ sized core to indicate chemical variations but, at the same time, preserve at least the other half core as a record. Thus, the geochemistry is not continuous. Graphic results are displayed in Figures 11, 12, 20, 31.

The reader is referred to Benchmark 1 Geochemistry and the three following related sections as they compare data from Benchmarks 1, 4, & 5 along with data from associated aircore drilling. A ternary plot of the major components (Si-Al-Fe; Figure 11A) indicates that ferruginisation is the major weathering trend in the residual part of the profile. However, it must be kept in mind that structurally and stratigraphically complex Archaean rocks were intersected and these were not necessarily originally chemically equivalent prior to weathering. Figure 31 displays the down hole log against geochemistry for Benchmark 5 (Sheard and Robertson, 2004).

Figure 30, explanation: Thin-section petrography to photomicrographs from Benchmark 5 (cored drillhole TMWRDD-1), (Sheard and Robertson, 2004).

A. Pale grey claystone (CL) with minor quartz grains (QZ) distributed throughout and a few claystone fragments (CF). The rock is stained and mottled by goethite (GO) and hematite (HM) has penetrated along cracks. Close up photograph of claystone. Specimen R406696: Drillhole TMWRDD-1, Depth 12.92-12.97.	**B.** A mottled claystone, consisting of pale yellow-grey kaolinite and fine quartz with a variety of brown ferruginous nodules (FN) and clasts (FC). Mottling by Fe-oxides has stained parts of the rock red (HM) and yellow (GO). Close up photograph of claystone. Specimen R406697: Drillhole TMWRDD-1, Depth 12.92-12.97.
C. A gritty sediment of greenish subangular clasts of quartz-kaolinite saprolite (SP), clasts of grey claystone (CL) and small quartz crystals in a matrix (MX) of finer, similar materials and clay. Part is a large, clearly defined yellow and brown mottle (MO) where much of the saprolite clasts and the clay rich matrix are obscured by Fe-oxides, leaving only a few recognizable saprolite relics and quartz grains. Close up photograph of claystone arenite. Specimen R406698: Drillhole TMWRDD-1, Depth 18.80-18.87.	**D.** Quartz-clay saprolite (SP) clasts, claystone (CL) and ferruginous claystone (FC) clasts in a matrix of quartz (QZ) and lightly stained clay (KA). Photomicrograph of claystone arenite under plane polarized transmitted light. Specimen R406698: Drillhole TMWRDD-1, Depth 18.80-18.87.
E. Greenish ultramafic saprolite (SP) with clay filled voids (KA). Close up photograph of ultramafic saprolite. Specimen R406699: Drillhole TMWRDD-1, Depth 23.70-23.78.	**F.** Remnants of talc (TC) and vermiform clay stacks (VC) in a mesh of equant patches of very fine-grained flaky kaolinitic clay (CL) all dusted with opaque Fe-oxides (FO). Photomicrograph of ultramafic saprolite under transmitted light with crossed polarisers. Specimen R406699: Drillhole TMWRDD-1, Depth 23.70-23.78.
G. Greenish saprolite (SP) has been penetrated and stained by yellow-brown goethite marking a complex cleavage network (NT). Close up photograph of ultramafic saprolite. Specimen R406700: Drillhole TMWRDD-1, Depth 30.08-30.18.	**H.** Patches (CL) of fine-grained clay (smectite and kaolinite) with unconsumed remnants (ME) of the metamorphic assemblage (talc, chlorite and quartz). Iron staining (GO) has penetrated from fractures and cleavages. Photomicrograph of ultramafic saprolite under transmitted light with crossed polarisers. Specimen R406700: Drillhole TMWRDD-1, Depth 30.08-30.18.

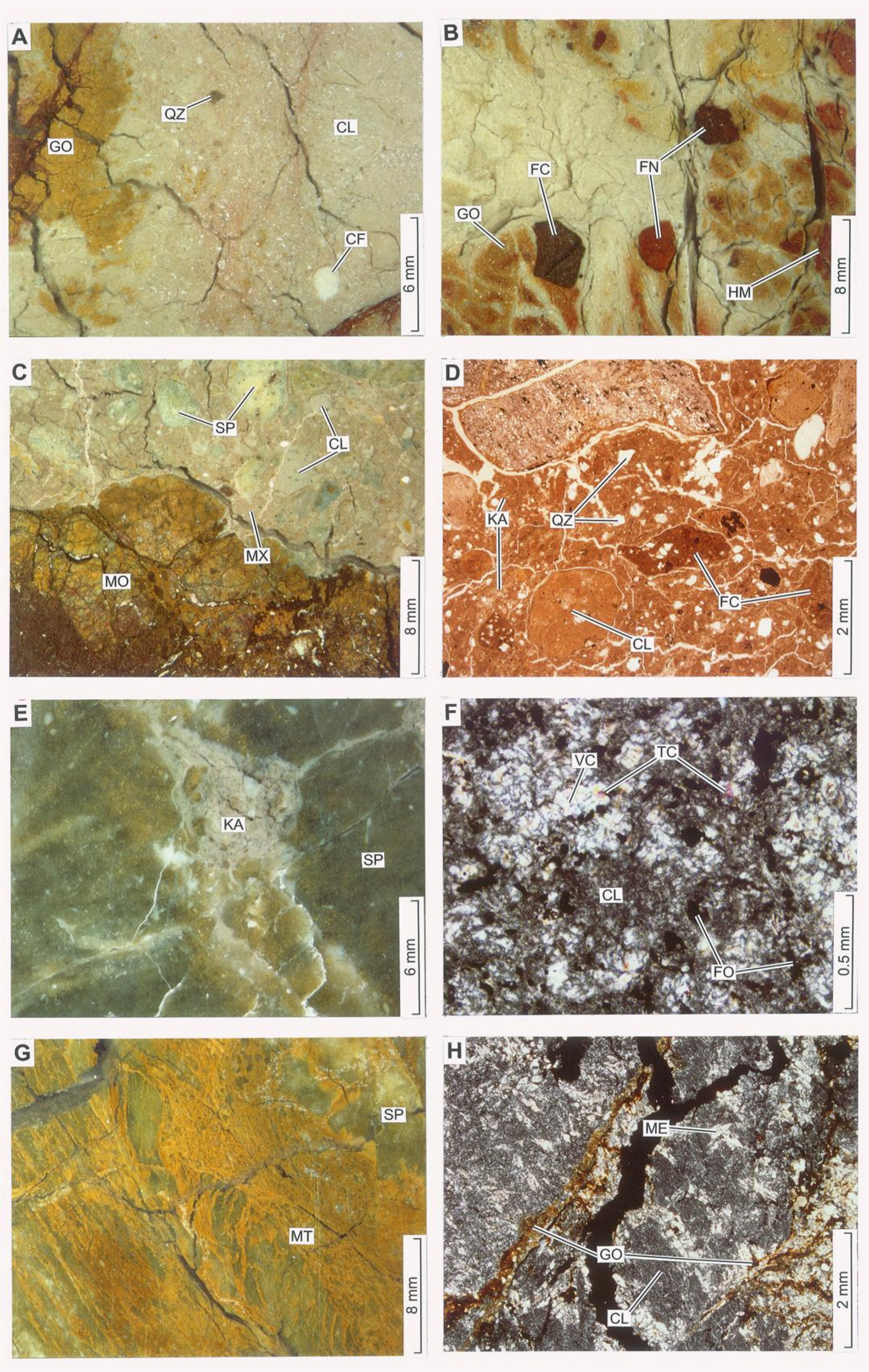


Figure 16: Annotated thin-section photomicrographs from Benchmark 5 (cored drillhole TMWRDD-1), (Sheard and Robertson, 2004).

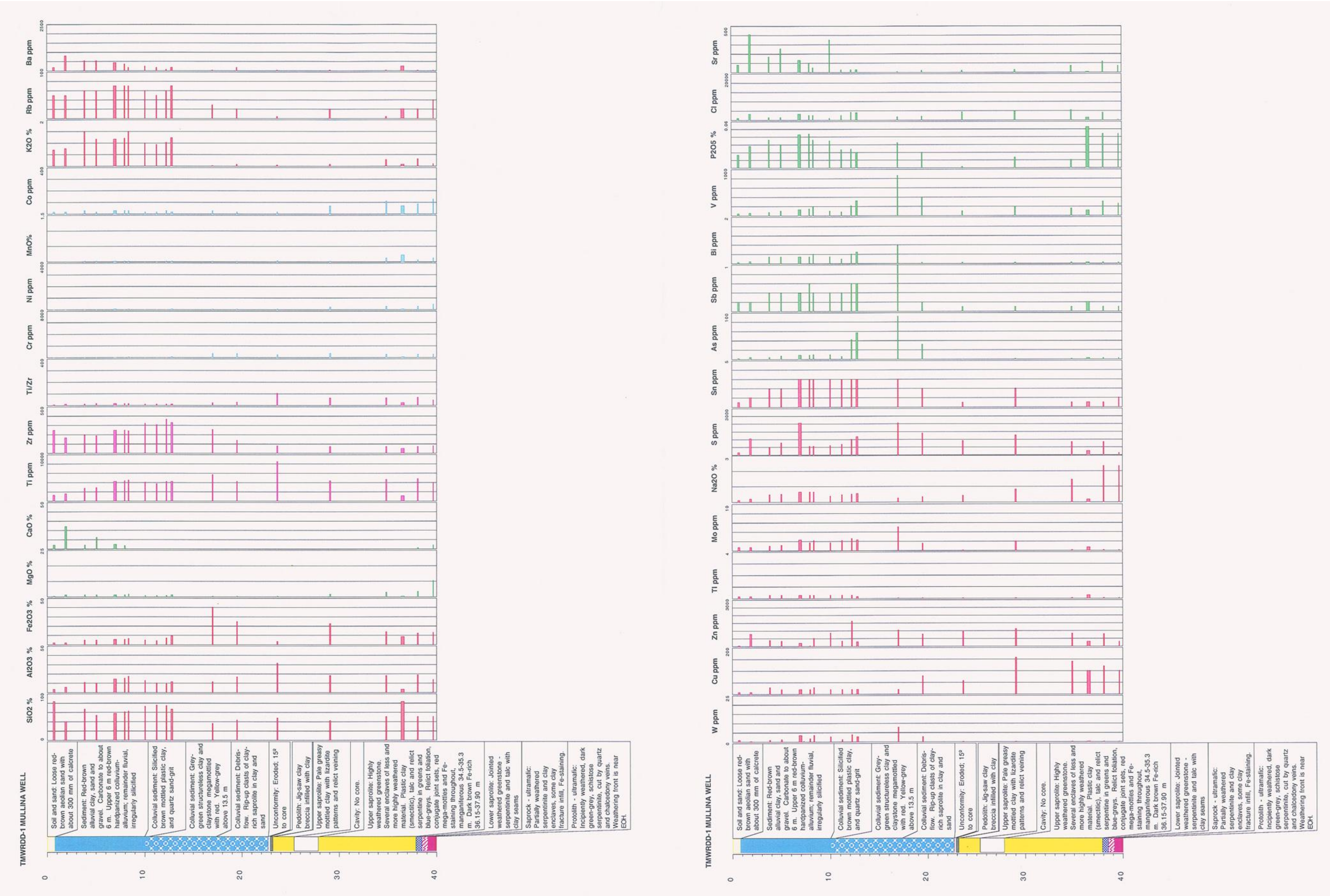


Figure 31:
Log and geochemistry of Benchmark 5 at Mullina Well [A3 fold out sheet], (Sheard and Robertson, 2004).
Refer to Figure 16 for graphic log explanation.

Benchmark 6, drillhole TAR-46 (drill cuttings)

Quick reference items are set out in Table 15; detailed descriptions, figures and data tables follow on below. This location is ~540 km NW of Adelaide and ~12 km S of Tarcoola. The site is about 700 m S of Benchmark 5 (Figures 27, 28; E side of Vermin Proof Fence access track. It was drilled in 2001 as part of SA Geological Survey investigations into the Harris Greenstone Belt's: architecture, age, host lithotypes and mineral prospectivity. The aircore style of drilling employed is not ideally suited to regolith investigative work (see Notes for Benchmarks 1, 4, 5). However, taking the sampling limitations into account, drillhole TAR-46 has been selected as being representative of the regolith profile over weathered mylonitic granite (schistose to gneissic) with a reasonable drilling depth to unweathered bedrock Figure 28. Drilling was vertical; yielding aircore cuttings and short bottom of hole cores (<50 mm long). A summary of that profile is provided in Table 16 and the chiptray photograph with key regolith features are indicated in Figure 32; regolith descriptions are presented in Tables 16-18; and geochemical data are presented in Figure 33.

Table 15: Benchmark 6 reference data, drillhole TAR-46 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 4, 5.
Local-site location map	Figures 27, 28.
GPS coordinates, attitude & elevation	Zone 53, 0460505 E, 6591076 N, GDA 94. Vertical. **AHD:** 135.00 m (differential GPS data).
Site access, owner	~540 km NW of Adelaide and ~12 km S of Tarcoola. On E side of Vermin Proof Fence access track and ~700 m S of Benchmark 5, on Wilgena Pastoral Station, ~60 km W of Lake Harris.
Related drillholes	Aircore drillholes TAR 45 – TAR 48, part of ~NNE-SSW line of 26 drillholes.
Drill sample photos + logs	Yes, Figure 32 and Tables 16-18.
Sample types	Aircore cuttings as bulked 2 m composites from 0 to 36 m (350 gm pots and chiptray samples).
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered to fresh mylonitic granite.
Petrology	No.
Geochemistry	Yes, Figure 33.
XRD mineralogy	No.
PIMA spectral data	Yes, but spectra have not been interpreted.
Dating	No.
Target Elements	Potential for Au, Ag, Cu, Pb & Zn.
Potential Pathfinder Elements	Mineralization-related elements (Au, Ag, Bi, Cu, Pb and Zn).
Useful sampling media	Transported regolith-soil where <5 m thick, calcrete and silcrete.
Key reference sources	Davies, 2002a, b; Sheard and Robertson, 2003, 2004.

,**Table 16:** Summary log of Benchmark 6, drillhole TAR-46 (Type 2, drill cuttings profile). The graphic log has sedimentary regolith in blue, pedolith in pale brown, upper saprolite in yellow, lower saprolite as green, saprock in pink and mylonitic granite bedrock as red. Overprint hachuring represents both silcrete and ferricrete duricrust cements. Assay intervals are marked in grey. After Sheard and Robertson (2004).

Drillhole	Depth (m)	Provenance T = transported, I = *in-situ*	Basic Colour(s)	Regolith Zone	Assay	Graphic Log	Sample Description (ar = number): calcrete acid reaction where 2 = strong, 1 = moderate, 0 = none
TAR 46						TAR 46	
	00-02	T	orange & pale pink	sediment + cement			aeolian sand, fine- to medium-grained + massive calcrete, (ar = 2).
	02-04	T/I	red-brown	sediment + cement + Fe-pedolith		Fe	colluvial sandstone-gritstone to arenaceous collapse interval, FeOH stained, polymict ang. qtz grains (ar = 2).
	04-06	I	red-brown	pedolith			clay + silty-gritty quartz, friable, weakly to moderately coloured (ar = 1)
	06-08	I	red-brown	pedolith			AA (ar = <1).
	08-10	I	tan - pale brown	pedolith			AA (ar = 0).
	10-12	I	tan - pale brown	pedolith			AA
	12-14	I	white - off-white, pale grey	upper saprolite			clay-rich material, some relict foliation, thin silicified bands common..
	14-16	I	white - off-white, pale grey	upper saprolite			AA
	16-18	I	white - off-white, pale grey	upper saprolite			AA
	18-20	I	khaki - tan & brownish	lower saprolite			clay-rich material, relict foliation & pale bluish-white vein quartz.
	20-22	I	khaki - tan & red-brown	lower saprolite		Fe	AA with FeOH staining or ?mottling
	22-24	I	khaki - tan & red-brown	lower saprolite		Fe	AA
	24-26	I	red-brown - greyish brown	saprock		Fe	weathered mylonitic felsic rock, FeOH staining.
	26-28	I	grey & pale brown	protolith			incipiently weathered mylonitic granite with ultramylonite & schistose interbands, fine- to medium-grained.
	28-30	I	grey & pale brown	protolith			AA
	30-32	I	grey & pale brown	protolith			AA
	32-34	I	grey & pale brown	protolith			AA
	34-36	I	grey & pale brown	protolith			AA
	EOH					EOH	

Table 17: Generalized *in situ* regolith components from drill cuttings penetrating foliated granite along the southern part of the Mullina Well drill line (after Sheard and Robertson, 2004).

Southern granite	Characteristics	Diagnostic points
Bedrock	Medium- to coarse-grained pink to brown granite.	Typical foliated granite.
Saprock	Partly weathered, grey to brown relict granite; clay, mica, quartz and feldspar.	Relict granite fragments; mica, K-feldspar and quartz.
Lower saprolite	Weathered, khaki to mid-grey to brown-grey; clay, quartz and relict feldspar.	Clays and quartz; relict metamorphic foliation.
Upper saprolite	Highly weathered, greyish to pink, reddish and yellow to white, clay – weakly plastic; kaolinite and quartz.	Kaolinite and quartz; relict igneous fabric and metamorphic foliation.
Pedolith	Extremely weathered, tan to brown and white, reddish to maroon, brown or red, Fe-mottled; silicified top; quartz grit or kaolinite dominant.	Kaolinite and quartz; strong colours, no relict primary fabric or foliation.

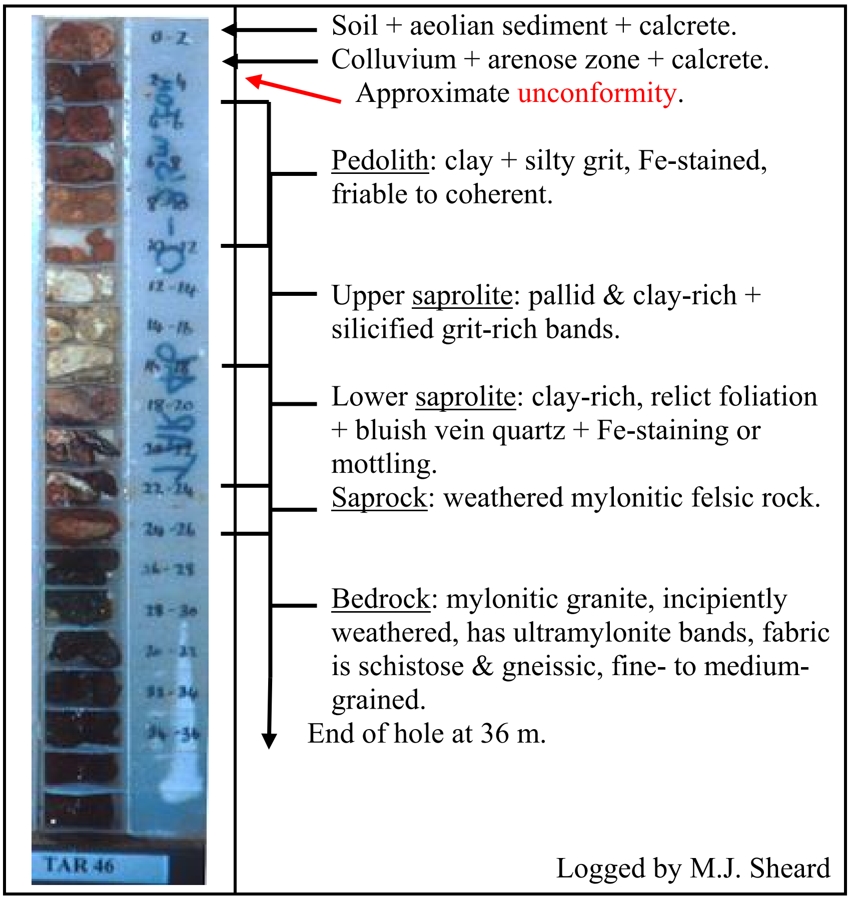


Figure 32: Benchmark 6, chiptray samples with key regolith features indicated. Sample interval is 2 m. Refer also to summary log and additional descriptions in Tables 16, 17.

The following lithology and petrographic descriptions are taken from Sheard and Robertson (2004).

In situ Regolith (gneissic granite)

Below the transported regolith, rocks of the weathered crystalline basement form a broad S to N sequence including: felsic volcanic, granitic, metasedimentary, mafic-ultramafic, felsic volcanic, and granitic rocks respectively. At the S end of the N-S section, a mixture of variably weathered granites and felsic porphyry (?Mesoproterozoic) were intersected (TAR 49-45). TAR 44 intersected weathered and unweathered Archaean metasediments. More detailed lithic-regolith descriptions, over and above those set out above in the summary logs (Table 17 and Figure 32) of weathered foliated granitic rocks, are not feasible from drill cuttings.

Transported Regolith

Transported regolith, blue on the section (Figure 28, Table 16) ranged from about 2-30 m in thickness and includes, soil, calcrete, Pleistocene aeolian sand, Cainozoic fluvial sediment and some presumed Mesozoic- Cainozoic colluvium, and laterally discontinuous Cainozoic silcrete bands were intersected. Aeolian sandplains and sand dunes mantle much of this area but are not recovered well by the drilling method employed. Sediments below the soil-sand layer are predominantly fluvial and range from silty clays to sand and gravel, or are mixtures of these and have gravel plus a few pebble clasts up to 20 mm. Cements include calcrete, incipient silicification and silcrete. There can be broad layering inferred from sample to sample but finer layering can only be inferred from cuttings evidence. A summary of residual weathered *in situ* basement rocks from drilled chip samples in this area is provided in Table 18.

Table 18: Generalized transported regolith components from drill cuttings taken over the Mullina Well drill line; oldest to youngest units (Sheard and Robertson, 2004).

Unit, age	Characteristics	Diagnostic points
Colluvium, ?Mesozoic-Cainozoic	Brown clay with fine sand and grit, difficult to distinguish from fluvial clay if sample is drill cuttings.	Any clasts are generally polymictic angular to subrounded and poorly sorted, fragments of Fe-pisoliths.
Fluvial sediments, Cainozoic	Red-brown to brown, clay and sand to minor gravel, loose to cemented, matrix supported – (latter only seen in core); clay and quartz.	Clay-rich to sandy with well rounded clasts among drill fragments of the same, <1 to >34 m thick.
Silcrete, Cainozoic	**Duricrust**, grey to pale yellow, silica cementation of alluvium, colluvium and weathered basement, partial to full cementation, may contain major unconformity (latter only seen in core); poor in clay and silt fraction.	Cryptocrystalline semi-translucent cement, hard to very hard drilling, clasts bound so firmly as to force any breakage through rather than around clasts, thickness <0.5 to >2 m, may occur as several horizons.
Calcrete, Quaternary	**Duricrust**, white to pale reddish brown as nodules or aggregates, fragmentary to competent, pedogenic.	Noticeable pallid soil horizon, effervescent reaction to HCl; may host geochemical metal signature.
Aeolian sand, Pleistocene	Mantles much of the landscape, orange, siliceous, dunes and sand plains; can contain nodular to massive calcrete. Sand forms a sample dilutant to any locally derived mineral-lithic grains.	Mostly loose, uniformly sorted, frosted quartz grains in fine-medium sand size, <1 to about 8 m thick.

Geochemistry

Assayed cuttings samples, spanning zones of interest, as indicated on Table 16, were drawn from 350 gm sub-sample pots collected from the original in-field 20 kg bagged 2 m composites. Pulverised 100 gm aliquots were assayed along with a series of strategically placed but camouflaged in-house standards to assess assay repeatability, drift and any laboratory anomalism. Assay sub-sampling has preserved enough cuttings for future work and leaves a permanent record along with the chiptray samples. Thereby, the geochemistry is not continuous but does represent important variations within the regolith and between key regolith zones. Graphic results are displayed in Figure 33. A comprehensive discussion of the overall Harris Greenstone province geochemistry is provided under Benchmark 1. However, the emphasis there is on greenstone *versus* sedimentary regolith, rather than on felsic basement *versus* greenstone or overlying sediments (Sheard and Robertson, 2004).

By comparison with the Mullina Well greenstones; the foliated granite has elevated values of: Si, Ti, Zr, K, Rb, Ba, Cu, but a low Ti/Zr ratio, and low REE. While the greenstones have elevated values of the following: Mg, Ni, Cr, Mn, Co, Sb, REE, a high Ti/Zr ratio and low K, Rb, Ba, As. Therefore, where sediments don't cover either highly weathered lithotype they can easily be geochemically distinguished – even where extremely weathered. Where sediments do overly these rocks then the comments made under Benchmark 1 geochemistry will apply, although distinguishing weathered granite from a sediment derived from similar materials is quite difficult (Sheard and Robertson, 2004).

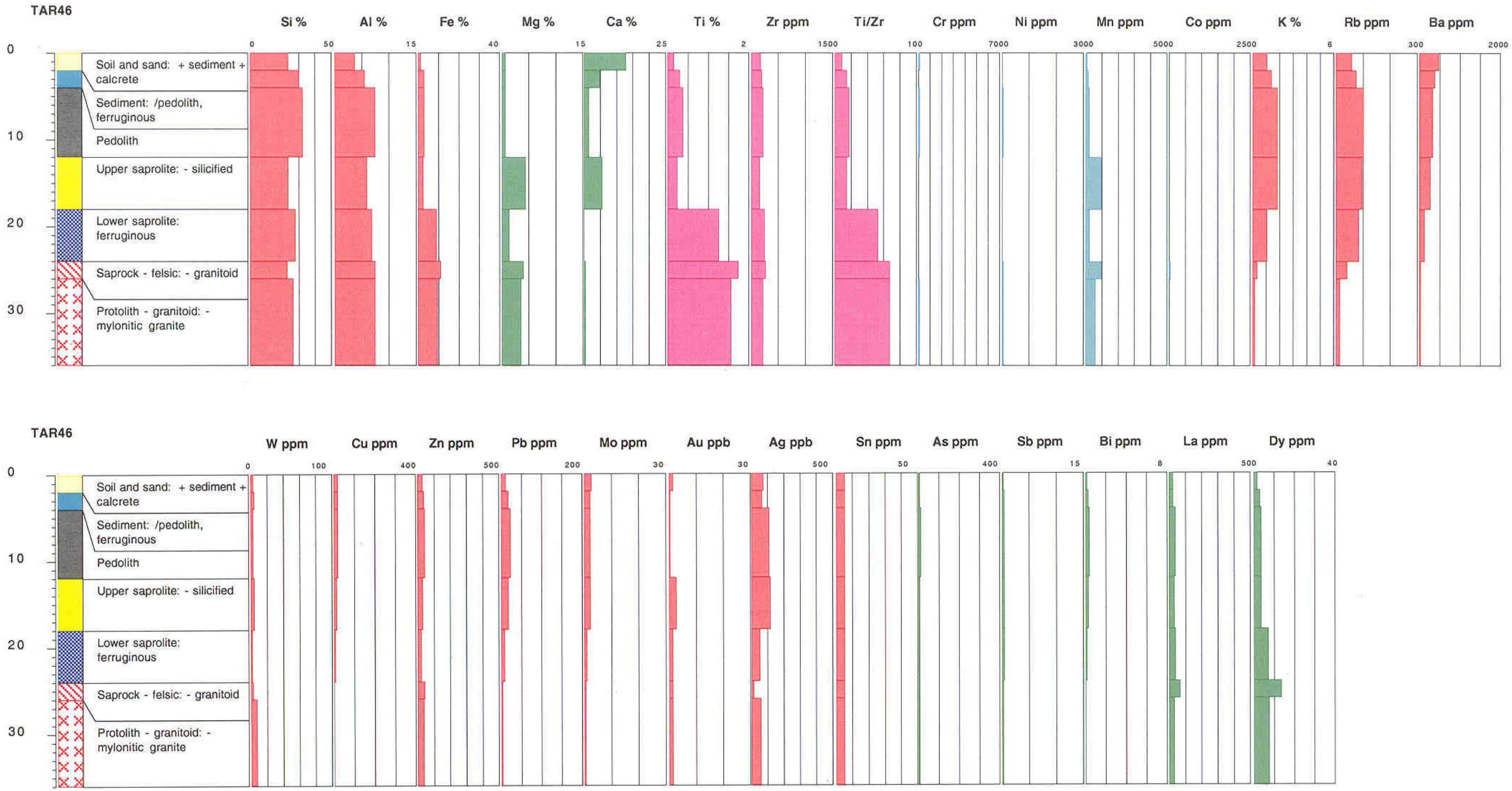


Figure 33: Down hole assay plots for Benchmark 6 (Sheard and Robertson, 2004), oxides on upper chart and traces on lower chart. The graphic log column (LHS) is based upon Table 16 logged primary features with secondary features in the text column. Refer to the coloured 'Explanation' column in Figure 16 for details.

Central Gawler Gold Province

The Central Gawler Gold Craton includes a central portion of the larger Gawler Craton, where gold-only mineralization is associated with the Mesoproterozoic Hiltaba Suite magmatic and tectonic event, and where Au mineralization differs to the Iron-Ore-Copper-Gold (IOCG) mineralization styles associated with the more easterly Olympic Dam Cu-Au province (Ferris and Schwarz, 2003). Those authors attribute the main difference as being due to the regional tectonic setting and that the IOCG deposits exhibit highly oxidised high temperature mineralization plus alteration; while conversely Central Gawler Gold Province Au mineralization is associated with lower temperature alteration (sericite, chlorite) suggesting a more reduced mineralization style.

A number of Au deposits and prospects are enclosed by the Central Gawler Gold Province (Figure 34) including the long established goldfields of Tarcoola, Glenloth, Earea Dam, and the more recent discoveries, including: Boomerang, Tunkillia, Old Well, Nuckulla Hill, Menninnie Dam, Barns, Baggy Green, and Weednanna gold prospects.

Descriptions and relevant Benchmarks are set out below for the following gold prospects: Boomerang, Old Well, Barns and Baggy Green.

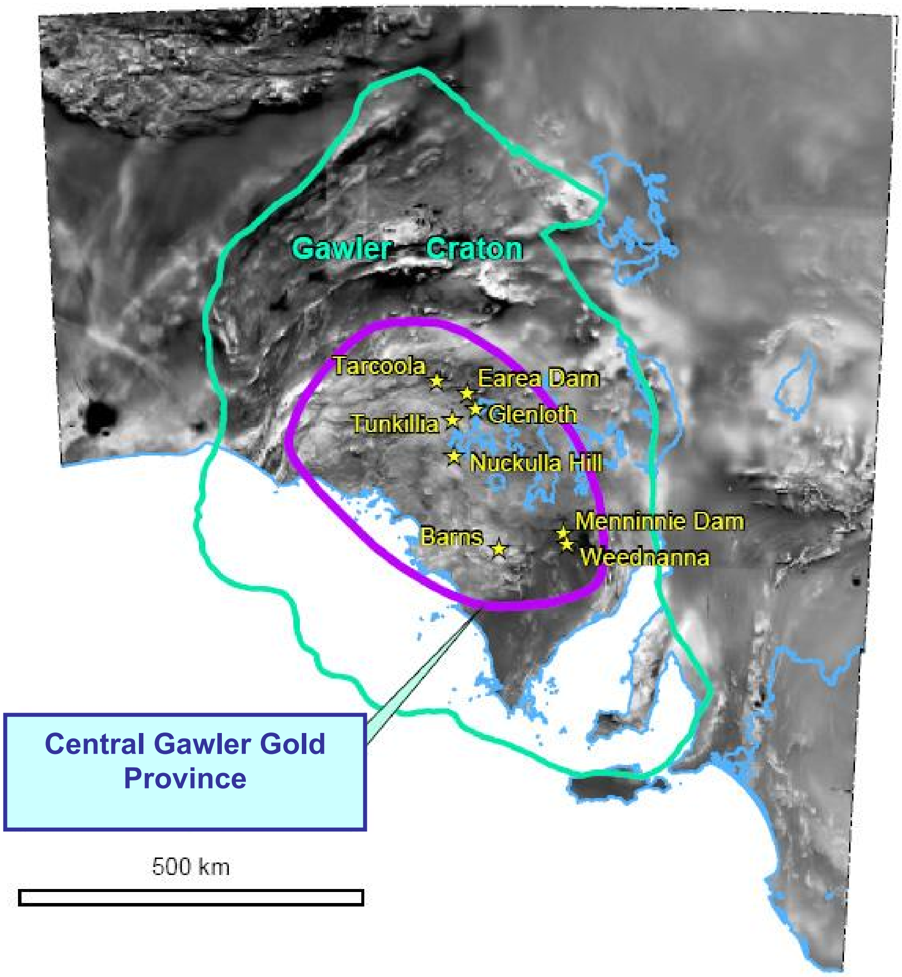


Figure 34: Central Gawler Gold Province, as indicated by Thomas (2004) after the proposed definition of Ferris and Schwarz (2003).

Boomerang Gold prospect *(northern Central Gawler Gold Province)*

The Boomerang gold prospect is located ~10 km SW of Tarcoola (Figure 34) and ~650 km NW of Adelaide in undifferentiated Proterozoic rocks incorporated within Archaean Harris Greenstone Belt mafic to ultramafic rocks (Figure 35). This Au and basemetals anomalous prospect (ELs 1777 & 2413) was originally discovered in 1995 by Grenfell Resources NL, using regionally sampled calcrete geochemistry. It is situated beneath a gypseous to calcareous dune clad area on the edge of a saline drainage system bordering the Great Victoria Desert. There is little regional relief, but dunes covering basement highs and a significant palaeochannel provide local undulations to ~5 m. Vegetation is sparse and dominated by low open woodland of *Acacia* and *Casuarina* with an understorey of chenopods and other drought-tolerant plants; the area is heavily grazed. Climate there is arid with mean rainfall of ~170 mm per annum (from nearby Tarcoola Met. Stn), falling mostly in early or late summer or during the cooler winter. Two regolith traverses or sections across mineralization at Boomerang have been investigated and documented, they partly cross a broad palaeochannel (Lintern *et al*., 2006; Figure 36).

Drilling of calcrete Au anomalies has revealed widespread sub-economic Au mineralization at or near the weathering front. Host lithotypes include quartzo-feldspathic gneissic rocks, foliated granite (partly chlorite and epidote altered), and relatively undeformed coarse-grained mafic rocks. Gold in bedrock is largely associated with quartz veining, commonly in altered and brecciated zones. Lead, Cu, Ni, and Zn appear to be associated with some mineralized zones (Lintern *et al*., 2006).

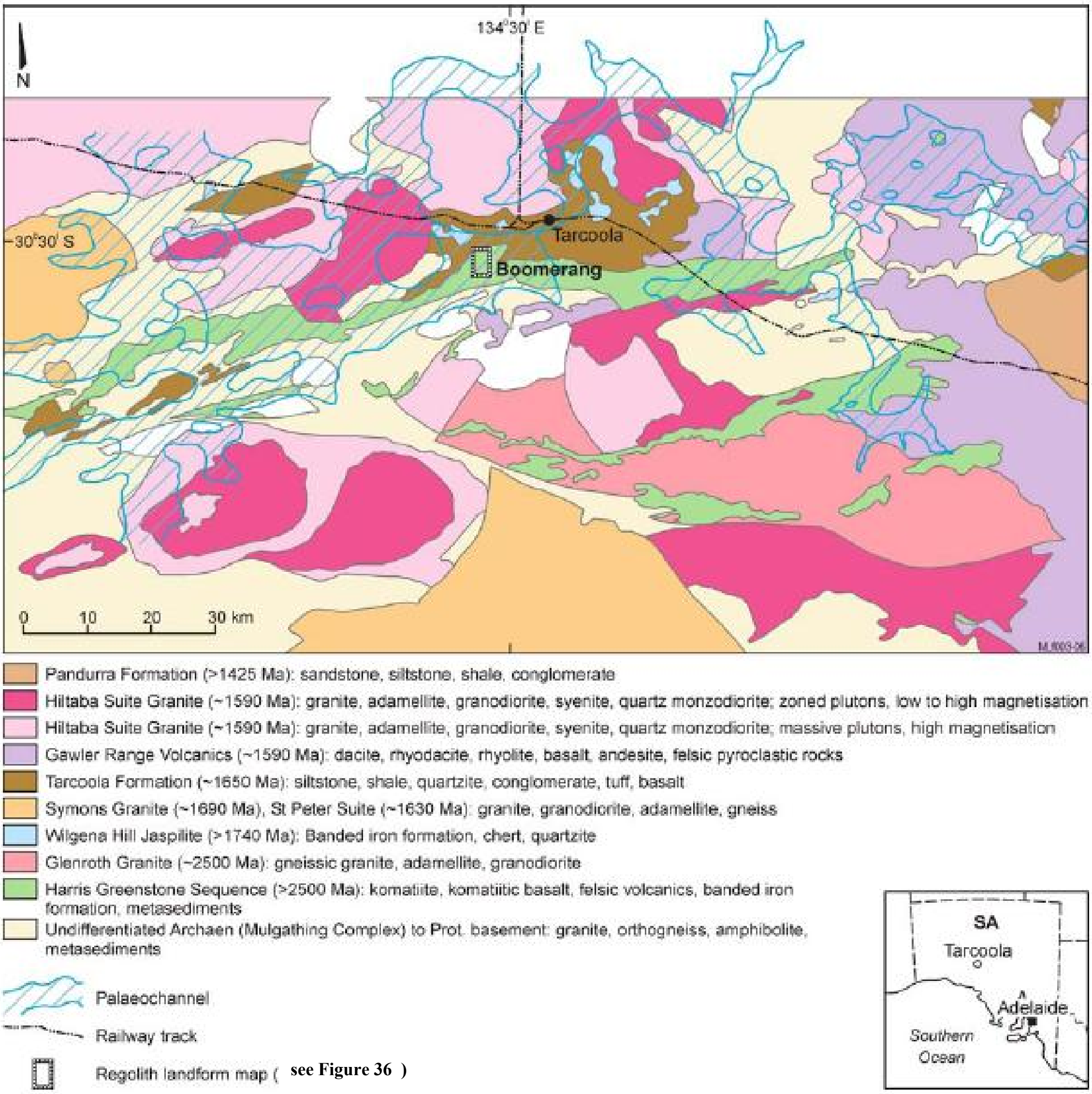


Figure 35: Benchmark 7 locality map, basement geology is partially overlain by the Kingoonya Palaeochannel (blue hatch). Basement geology is after Hoatson *et al*. (2002); palaeochannel outline is after Hou (2004).

Benchmark 7, drillholes BG-47 and GB-47 (drill cuttings)

Quick reference items are set out in Table 19; detailed descriptions, figures and data tables follow on below. This site, occurs about 1.6 km SE of Pinding East Tank and Yards (Figures 35, 36); on the S side of the paddock fence access track. The RAB + aircore styles of drilling employed are not ideally suited to regolith investigative work. The bulking of drill chips into composite samples complicates interpretative observations (see Notes for Benchmarks 1, 4, 5). Drillholes BG-47 + GB-47 have been selected as being representative of the regolith profile over weathered granitic basement with a reasonable drilling depth to unweathered bedrock. Herein both drillholes are presented as a single benchmark. Drilling was vertical; yielding cuttings and fines. A summary of those profiles is provided in the chiptray photographs where key regolith features are indicated (Figures 37, 38). Interpreted PIMA spectra mineralogy sections occur as Figure 40 and geochemical data are presented in Figures 41-44 plus Table 20.

Table 19: Benchmark 7 reference data, drillholes BG-47 & GB-47 (Type 2, drill cuttings profiles).

Items	Figures, Data, Sources
Regional location map	Figures 34, 35.
Local-site location map	Figures 36, 39.
GPS coordinates, attitude & elevation	Zone 53, 0460633 E, 6591248 N, GDA 94. Vertical. **AHD:** 112.96 m (differential GPS data).
Site access, owner	Site is on the Malbooma Pastoral Station, ~1.6 km SE of Pinding East Tank and Yards, S side of the paddock fence access track.
Related drillholes	RAB drillholes BG-28–BG-54 + 6 m aircore drillholes GB-28–GB-54.
Drill sample photos + logs	Yes, Figures 37, 38.
Sample types	RAB cuttings, as bulked 2 m composites (0 to 54 m) in chiptrays + aircore cuttings (0 to 6 m) in chiptrays + >1 kg samples.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered to near fresh foliated granite.
Petrology	No.
Geochemistry	Yes, Figures 41-44 + Table 20.
XRD mineralogy	No.
PIMA spectral data	Yes, Figure 40.
Dating	No.
Target Elements	Potential for: Au, ?Ag, Cr, Cu, Ni, Pb & Zn.
Potential Pathfinder Elements	Mineralization-associated (Ag, As, Cd, Cr, Cu, In, Ni, Pb, Sb & Zn).
Useful sampling media	Transported regolith-soil where <5 m thick, calcrete.
Key reference sources	Lintern *et al*., 2006; Lintern, 2004b.

Background

Drill sampling through the regolith (to bedrock or saprock) was initially carried out by the licensed exploration tenement holder (drillholes BG-28–BG-54, depth range typically 0->50 m). Later near surface (0-6 m) regolith investigative drilling was carried out along a selected N-S drill line (tenement local grid 449200 E), adjacent to the earlier exploration drillholes (holes GB-28–GB-54, ~<5 m away) to improve upon the original near surface cuttings sampling (*i.e.* provide better hole-to-hole sample hygiene and sample quality). The latter drilling program was carried out for CRC LEME and PIRSA Geological Survey in 1997. Regolith drilling was sampled at 1 m intervals to provide better control on near surface weathering-pedogenic zones than did the exploration 2 m bulked sampling.

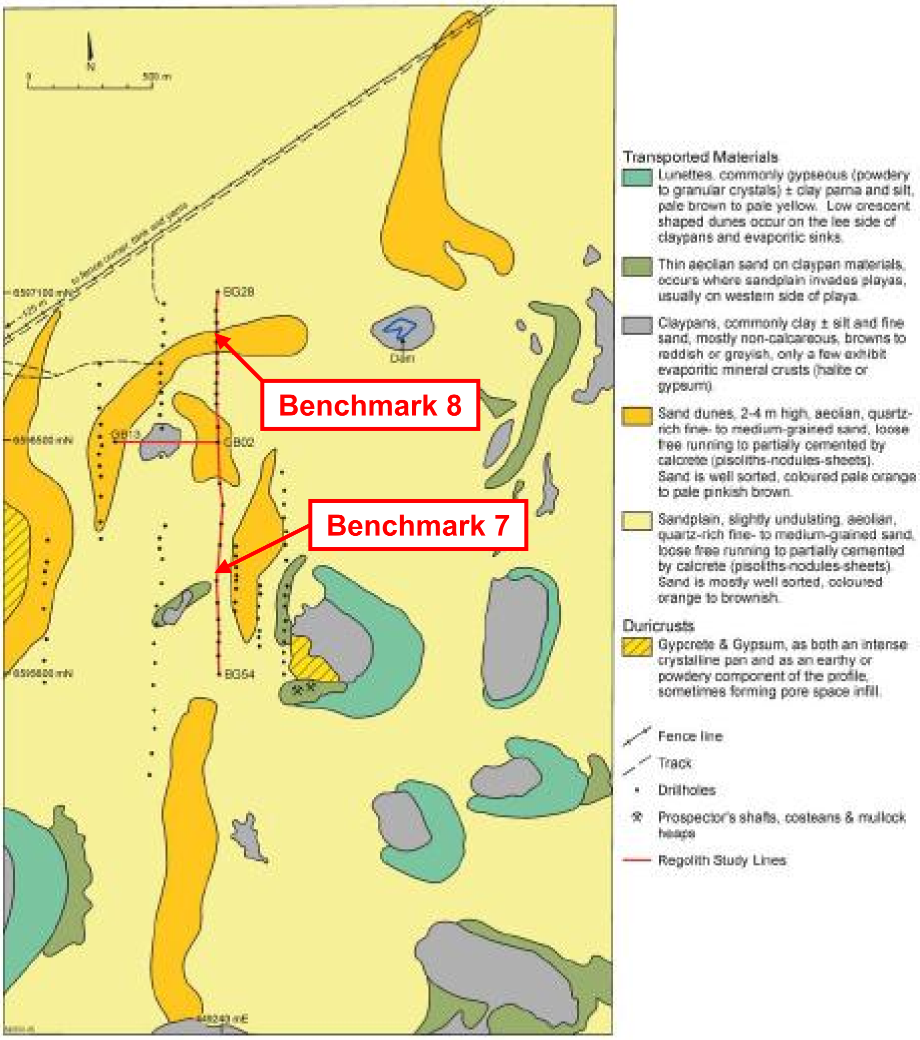


Figure 36: Regolith landform map of the Boomerang gold prospect showing the exploration drill lines, the Regolith Study Lines of Lintern *et al*. (2006), plus Benchmarks 7 and 8.

Regolith investigation drillhole GB-47

Transported: brownish orange aeolian quartz sand (silty) + minor fluvial quartz sand, overprinted by calcrete as pisoliths, nodules and aggregates.

Transported: brownish orange clayey quartz sand (fluvial) + some calcrete, all overprinted by abundant gypcrete.

Transported: brownish clayey sand (fluvial) + gypcrete + red-brown hardpan + silcrete + minor amounts of brown FeOH-stained sandstone +down-hole calcrete contaminant.

Indeterminate: gypcrete + moderate orange loamy sand + red-brown hardpan. Sample swamped by gypsum + conspicuous calcrete as down-hole contamination.

Indeterminate: gypcrete + moderate orange sandy clay + red-brown hardpan. Sample swamped by gypsum.

?*In situ*: abundant gypsum + brownish light clay + trace of quartz grit. Sample swamped by gypsum. This interval is presumed to have penetrated a pedolith plasmic zone. Conspicuous calcrete as down-hole contamination.

End of hole. Scale bar in cm.

Log adapted from Lintern *et al*., 2006.

Figure 37: Benchmark 7 aircore chiptray samples (secondary 0-6 m regolith drillhole GB-47). Site is ~5 m E of drillhole BG-47. **Note:** there are >1 kg bulks in storage of these samples.

First chiptray

Transported materials, 0-<6 m: aeolian sand + calcrete over fluvial-colluvial sediment, heavily gypcreted 2-~6 m, + red-brown hardpan + silcrete

In situ materials <6-~16 m: **pedolith**, variably Fe-mottled, some evidence for arenose and plasmic components, dominantly clay-rich, mottling pales off towards the base. **Note:** it's possible that the basal 4 m are in fact megamottled upper saprolite, but cuttings alone do not provide enough information to be certain nor what zone boundary conditions exist. Variably competent.

Upper saprolite, 16-50 m: pallid zone, kaolinite + lesser quartz grit, primarily a clay-rich zone, chalky to weakly coherent.

Second chiptray

Fe-stained (FeOH) **upper saprolite**, 44-48 m: bright yellow-orange to yellow-brown, primarily a clay-rich zone, chalky to weakly coherent.

Lower saprolite, 50-~53 m, khaki to olive-grey, variably weathered foliated felsic rock, stiff to moderately competent.

Saprock, ~53-<54 m; dark brown to dark olive-grey partially weathered foliated granite, moderately to very competent.

Bedrock, ~54 m: greenish to pink foliated chloritic granite.

End of hole.

empty chamber

Bottom hole rock fragments, pink granite to pinkish biotite orthogneiss, medium grained, variably chlorite and epidote altered, no visible weathering of fractures. Competent rock.

Logged by M.J. Sheard

Figure 38: Benchmark 7, aircore chiptray samples (exploration drillhole BG-47) with key regolith features indicated. Sample interval = 2 m, but = 1 m for last 2 chambers before EOH.

The following lithology and regolith descriptions are drawn from Lintern *et al*. (2006).

In situ Regolith

Regolith zonation architecture is displayed in the cross section on Figure 39.

Bedrock (<5% weathered). Very few of the exploration drillholes on this tenement penetrated bedrock and the following description relies upon a few bottom hole large fragments. Drillhole BG-47 just penetrates granite (<1 m): pink to greenish, medium-grained, variably foliated, variably chlorite and epidote altered. Some chlorite minerals were detected by PIMA (Figure 40). Although, in adjacent drillholes there is abundant quartz veins, on millimetre to centimetre thickness scales, none were observed in this drillhole's samples.

Saprock (>5-<20% weathered). A thin zone in drillhole BG-47, brown and yellow-brown Fe-staining is commonly present on, or forming coatings to, fractures and sometimes permeates the more weathered mineral components. This zone is also quite chloritic here.

Lower Saprolite (>20% weathered). Lower saprolite is commonly clay-rich and usually darker coloured (grey-brown to olive-brown), it is also firmer or stiffer than upper saprolite. Lower saprolite retains relict primary texture and tectonic fabric in coarser grained materials and is <3 m thick here. Some chlorite minerals were detected by PIMA to persist well into this sub-zone (Figure 40).

Upper Saprolite (>50% weathered). Upper saprolite is clay-rich, sometimes quartz grit bearing, commonly pallid but may also be partly reddish to yellow-brown if mottles are present. Material density, stiffness and hardness are much less than in the lower saprolite. Upper saprolite bulk colours are pale grey-brown to pale brownish and may be nearly white near the top. This zone retains relict texture and tectonic fabric in coarser grained more coherent materials. Upper saprolite represents the most consistently thick weathering unit over much of the drill line investigated; in drillhole BG-47 it is 34 m thick.

Pedolith (extremely weathered), is mostly clayey to clay-rich, grey-brown to brownish but strong reds and strong browns occur where mottling is present. All relict primary textures and tectonic fabrics have been obliterated by pedogenesis yielding a new pedogenic fabric with associated oxide-sesquioxide colourings and overprinting cements. The pedolith may have a thin ferruginous capping, that is commonly arenose (fine-grained siliceous grit with Fe-oxide-oxyhydroxide and silica cements plus void infill). The Fe-capping probably forms a persistent but thin coherent dark brown to red-brown horizon. Pedolith thickness here is ~11 m.

Mineral overprinting. Ferruginous staining (reds, browns and yellows) is present, some relating to megamottles, on or adhering to cuttings, or permeating cuttings. Manganese oxide overprinting, forming black dendrites, stains and spots, are occasionally present in the weathering profile.

Transported Regolith

Collectively from the oldest up, these encompass Neogene fluvial fine-grained overbank sediments; those are overlain or partially interdigitate with a discontinuously present red-brown hardpan; and inturn this is overlain by ubiquitous orange to pink siliceous aeolian sand (dunes and sandplain). The upper 4-5 m of the transported materials profile may be indurated by a variety of cements including calcrete, gypsum and silcrete, all to varying degrees of intergrain void infill. Over the southern half of regolith section (449200E, Figure 39) transported materials range from <4 m to >6 m in thickness and are dominated by aeolian sand or fluvial overbank deposits of clay and sand.

Alluvium, occurs predominantly as fluvial sand, silt and clay – in mixtures or as more discrete better sorted grain-dominant bands to lenses. The alluvium is cemented by gypsum and in places by silica (silcrete ± porcelanite). It is also possible that some calcrete cementation also occurs in the upper 3 m.

Red-brown hardpan is a widespread Plio-Pleistocene unit in the Gawler Craton, it is a strongly coloured colluvial sediment, strongly to moderately cemented by FeOx, silica, calcrete and/or gypsum. Red-brown hardpan can form a useful marker horizon where present. However, along the drillhole study line at Boomerang this unit is discontinuous and is restricted to within the upper 1-4 m depth range.

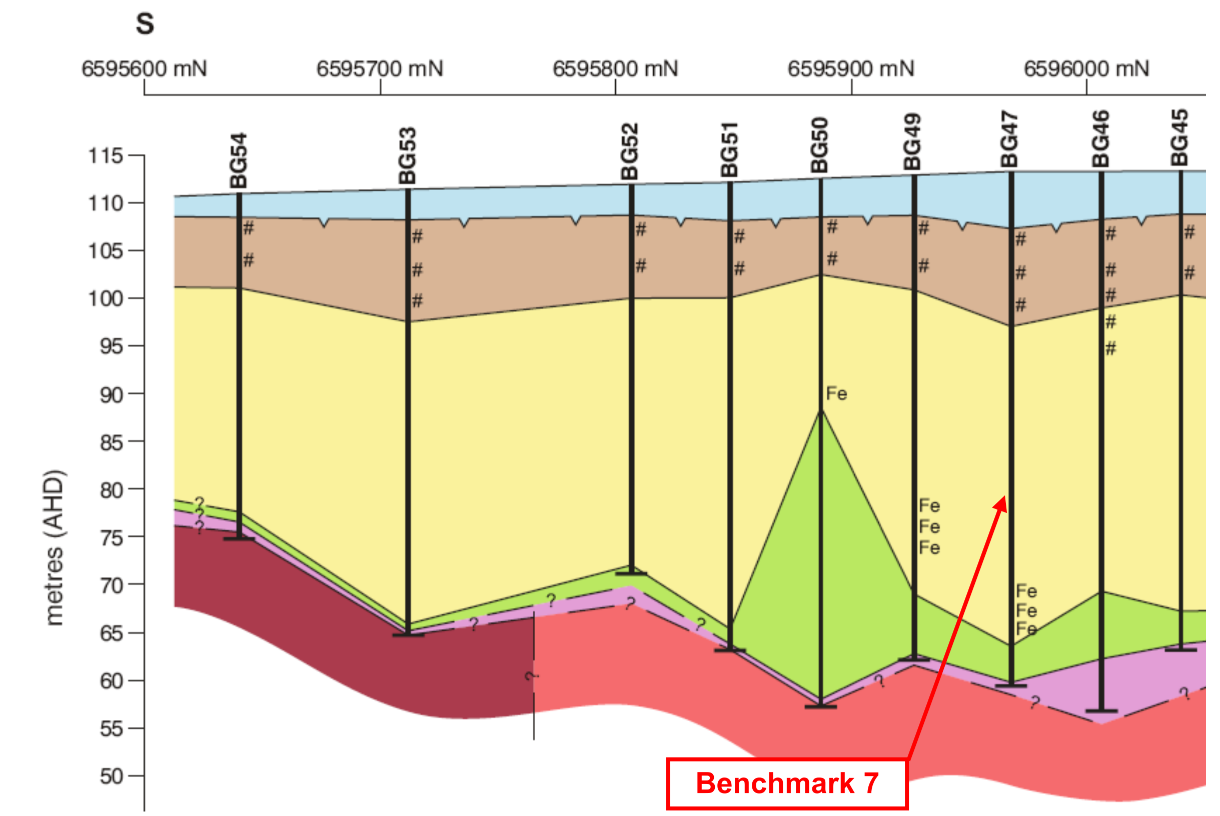
Aeolian sand forms both distinct dunes and broader sandplains, consisting of pale orange to pale pinkish brown, well-sorted, quartz-rich, fine- to medium-grained sand in a loose to partially cemented form. Aeolian sand grains are distinctly different from those of the underlying alluvium, as the aeolian grains have frosted surfaces, are uniformly sorted and display a distinct surficial orange Fe-staining.

The dominant grain cement is calcrete and this typically forms horizons of pisoliths or nodules or more massive sheets. Minor gypsum cementation may also be present, however this is more common in the underlying units. Along the study drillhole section aeolian sand ranges from <1->2 m but across the tenement it may attain a thickness at dune crests of 4-5 m.

Silcrete occurs deeper in the 0-6 m section where it forms thin bars and thicker silicified horizons – mostly within the sandier alluvium. Colours range from yellowish to greenish to greyish. Enclosed granular components include quartz sand, gravel and some silt. Where a clay-rich host is silicified then yellowish to very pale grey porcelanite has formed.

Gypcrete is quite abundant, forming an intense pan of coarsely crystalline gypsum in interlocking rosettes or as densely interlocking ‘fish tail’ gypsum crystal-rich horizons where individual crystals are many centimetres long. It may form >40% of the pan’s bulk and crystals range in colour from orange to colourless water-clear, and it also occurs as isolated coarse- to fine-grained cryatals or pore space linings and infill within sandy to silty strata.

Calcrete forms the second most abundant near surface duricrust, forming horizons of pisoliths or nodules to more massive sheets ~0.30-0.50 m thick that may just subcrop or be exposed around tree throws and animal burrows, or be located at depths of 0.5-1.0 m. It is generally coloured pale yellow-brown to pale pink or pale red-brown.



Key: transported regolith, pedolith, upper saprolite, lower saprolite, saprock, bedrock (granites)

Figure 39: Regolith profile, extracted from Lintern *et al*. (2006) indicating Benchmark 7 location and weathering zonation within its vicinity (*c.f.* Benchmark 8; Figure 46). Grid coordinates on this figure are in AGD66 projection.

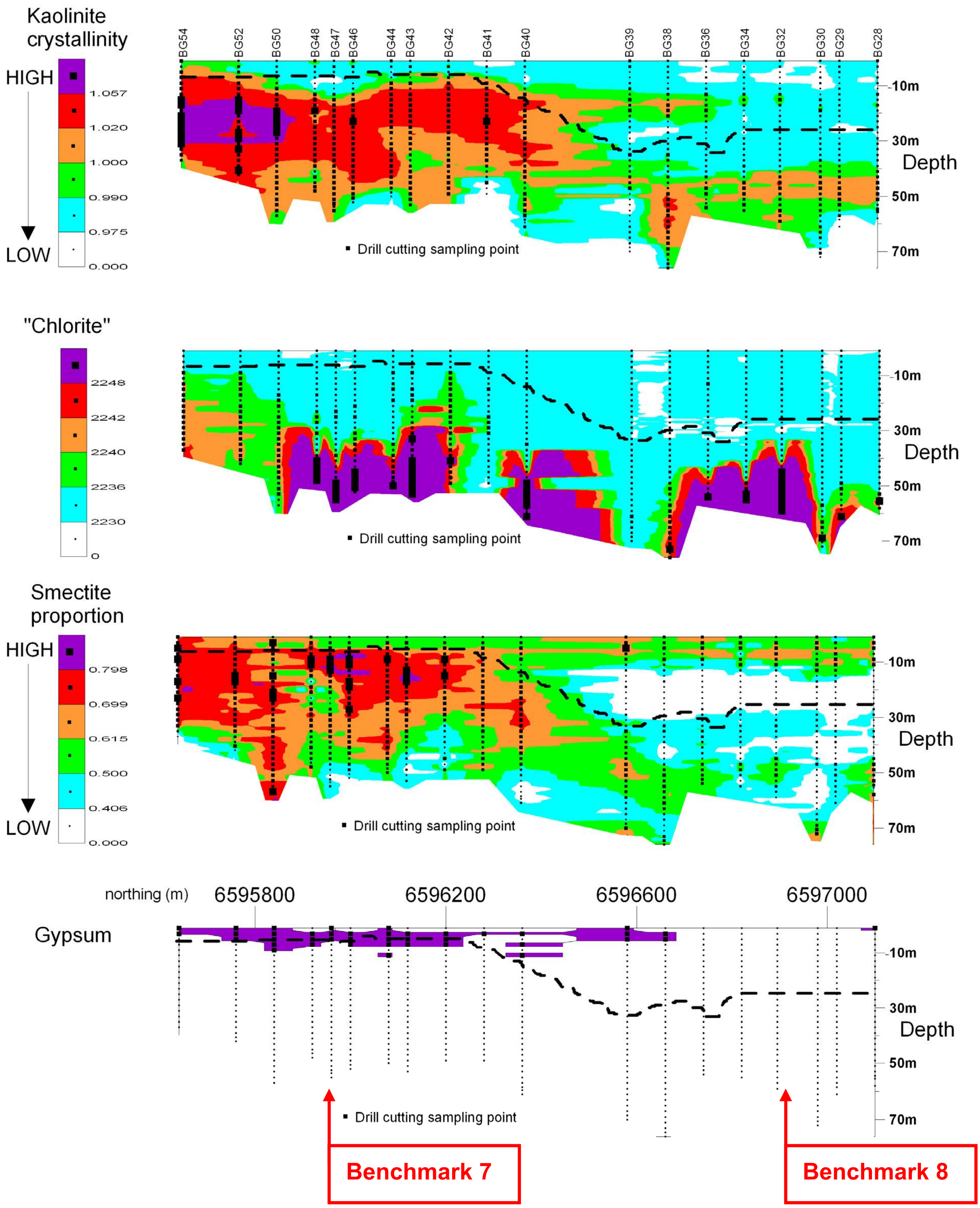


Figure 40: Contoured mineralogy (arbitrary units), using PIMA derived data for selected holes from Boomerang regolith section (after Lintern *et al.*, 2006). Kaolinite crystallinity calculated from peak mean value at 2180 nm divided by 2164 nm. "Chlorite" refers to a maximum peak location at the specified wavelength (nanometres) indicated in the scale but may not specifically be a chlorite mineral; variation may be due to different chlorite phases. Smectite proportion estimated from relative spectral absorption depth at 1915 nm added to deepest absorption at 2265 nm. Dashed line indicates approximate position of unconformity as assessed from drill cuttings detailed examination.

Geochemistry

Benchmark 7 selected assay intervals and elements are displayed in Table 20. The geochemistry set out below is more generalised though, applying more to the whole section investigated by Lintern *et al*., 2006. Note – that it is also applicable to Benchmark 8.

Gold: Two zones of mineralization (Zones 1, 2) are crossed by the N-S regolith section of Lintern *et al*., 2006; and Figures 36, 41. At Zone 1, Au concentrations increase with depth to the bottom of hole and forms a 600 m wide anomaly. Another dispersion halo (200 m wide), albeit much weaker and beneath the palaeochannel (N end of x-section, see Benchmark 8), is related to quartz veining and is associated with Zone 2 mineralization.

Gold concentrations in the upper regolith (0-6 m: soil, lag, calcrete + sediment-pedolith) range from 33 ppb in calcrete to <1 ppb in all materials. Gold in calcrete is locally anomalous (>10 ppb) over Zone 1 mineralization, reaching a concentration of 26 ppb. However, the highest Au concentration (35 ppb) occurs in the northern part of the regolith line over thick, barren palaeochannel sediments, and corresponds with a similar anomaly in (calcareous) coarse lag. These northern anomalous samples are located on an arcuate (dune) ridge that is anomalous in Au and extends 300 m to the SW. The soil is calcareous over Zone 1 mineralization and is also anomalous (>1 ppb) in Au reaching concentrations of 3 ppb. Samples from 0-1 m are weakly anomalous (>1 ppb) in Au (maximum of 6 ppb) over mineralization as are several 0-1 m and calcrete samples in the northern part of the traverse. Samples from 1-6 m show no Au anomalism over mineralization, possibly due to dilution by gypsum. Fine lag Au concentrations are all below detection.

Vegetation: *Maireana* (Blue Bush) leaves and small branches are not particularly useful at delineating mineralization since samples show little variation in concentration (range 0.15-1.2, mean 0.34 ppb Au). The two most Au-rich *Maireana* samples (1.2 and 0.9 ppb) are located at either ends of the traverse and are associated with Au-calcrete anomalies, the former coincident with Zone 1 mineralization. For *Acacia* trees, sampling was restricted to the southern part of the traverse over the gypsum dune. As with *Maireana*, the *Acacia* bark and phyllodes showed little variation in concentration (bark 0.17-0.9, mean 0.31; phyllodes 0.05-0.45, mean 0.27). Assessing *Acacia* parts for use as sample media was not possible due to its limited distribution only over mineralization and adjacent areas.

Elements associated with mineralization: several other elements associated with mineralization and anomalous in saprolite above it include: Ag, As, Cd, Cr, Cu, In, Ni, Pb, Sb and Zn. The most notable of these is Pb, which has a broader footprint (>800 m wide) than Au and extends beyond the southern extent of the studied traverse-section (Figure 42). Anomalous Pb (>100 ppm) extends to near the surface (3-4 m) in the southern part of the line. Correcting for Fe content further enhances the As anomaly in the saprolite (Figure 43). The other metals are not anomalous in the upper regolith (soil, lag, calcrete and 0-6 m) although Ag, Cd and Sb are below detection.

Other metals: Bismuth (Figure 44), W, U, Nb, Ti, Mo and Ag are anomalous in the palaeochannel and may reflect higher concentrations of these elements in country rock, or have been physically (e.g. as ilmenite, rutile and/or anatase) and/or chemically mobilized and concentrated in the palaeochannel.

Table 20: Benchmark 7, selected intervals (drillhole BG-47) with elevated Au and associated base metal concentrations (after Lintern *et al*., 2006).

Interval (m)	Analyses (ppm except Au in ppb)	Regolith type
32-36	Au (450), Pb (1200).	clay-rich saprolite
44-48	Au (1200), Cu (110).	saprolite
48-52	Au (1700), Cr (1000), Cu (125), Pb (500), Ni (550), Zn (1500).	saprolite
52-54	Au (630), Ni (600), Pb (550), Zn (1100).	saprolite

Geochemistry Discussion: many calcrete Au anomalies (as defined by the 10 and 20 ppb contours) are present at Boomerang. There is an association between the Au anomalies in calcrete and mineralization at Zone 1, but, other anomalous concentrations are only weakly associated with known mineralization, if at all, and require further investigation. Higher Au concentrations in calcrete may be associated with weakly anomalous saprolite located under thin transported material or the Au may have been transported by fluvial or aeolian activity. Detailed microscope studies of drill hole material, as undertaken in this project, from other parts of the prospect (and outside the scope of this study) are required to fully understand the 3D architecture of the regolith and hence to better interpret the origin of specific calcrete anomalies.

Whilst the surficial regolith expression of Au above mineralization is reflected in calcrete (and partly in soil), its tenor in other surficial regolith materials may be subdued by the presence of abundant gypsum. Some Au in gypsum was found at the Challenger Gold Deposit and concentrations were lower when compared with calcrete and saprolite (Lintern and Sheard, 1999). A systematic study at Challenger was not undertaken as gypsum was restricted in its occurrence. Studies on possible Pb incorporation in calcrete have been undertaken at the Bou Grine Pb-Zn deposit in Tunisia. Leduc (1986) suggested that it was not necessary to avoid calcrete when sampling, while Guedria *et al*. (1989) indicate that Pb concentrations were reduced by the presence of calcrete and recommended that sampling beneath the hard calcrete layer was better.

In the deeper regolith, leaching of Au in the upper part of the saprolite has lead to a zone of depletion in Au but supergene processes have led to a broader footprint to mineralization in the deeper saprolite. Pathfinder elements have not been entirely leached from the saprolite. Lead and As may provide better vectors to mineralization than Au if drill cuttings are used as a sample medium.

The Boomerang study of Lintern *et al*. (2006) highlights the difficulty of exploring in terrain covered by recent wind blown materials. From all the materials studied, calcrete (and possibly soil) provide the only viable geochemical sample media to locate mineralization in this area. These anomalies and adjacent ground should then be drilled and cuttings analysed for Au and a range of other pathfinder elements, including Pb and As.

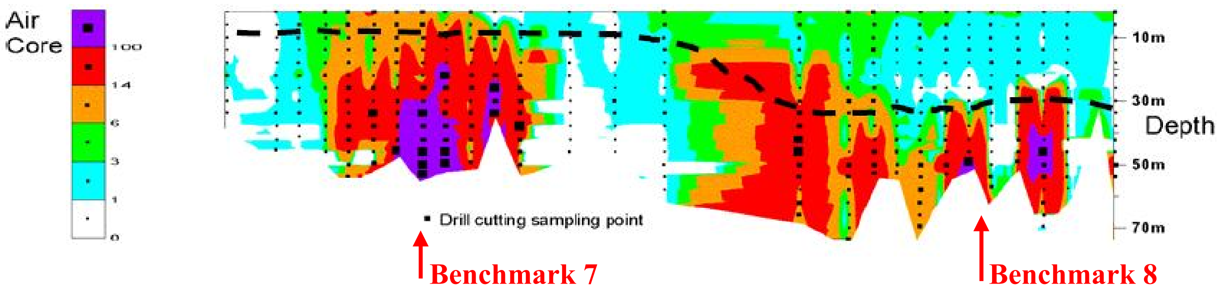


Figure 41: Gold regolith geochemistry at Boomerang prospect (along grid line 449200N). Data in ppb. See Figure 36 for location of section. Dashed line indicates unconformity. Benchmarks 7 and 8 are indicated.

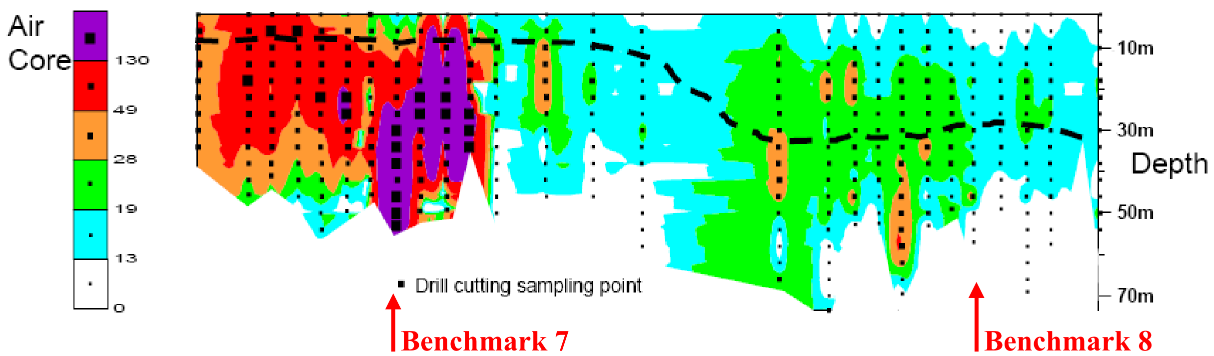


Figure 42: Lead distribution in regolith (ppm) at Boomerang (along grid line 449200N). Dashed line indicates unconformity. Benchmarks 7 and 8 are indicated.

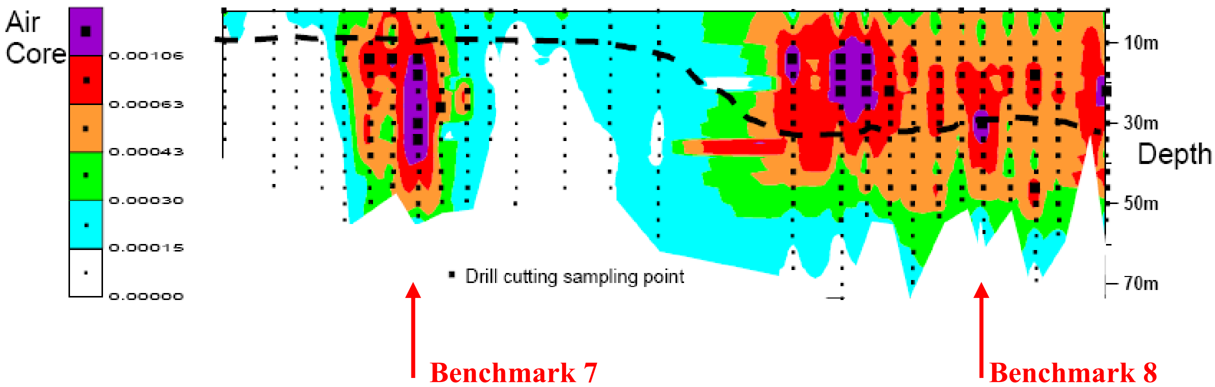


Figure 43: Arsenic distribution in regolith (corrected for Fe content) at Boomerang (along grid line 449200N). Dashed line indicates unconformity. Benchmarks 7 and 8 are indicated.

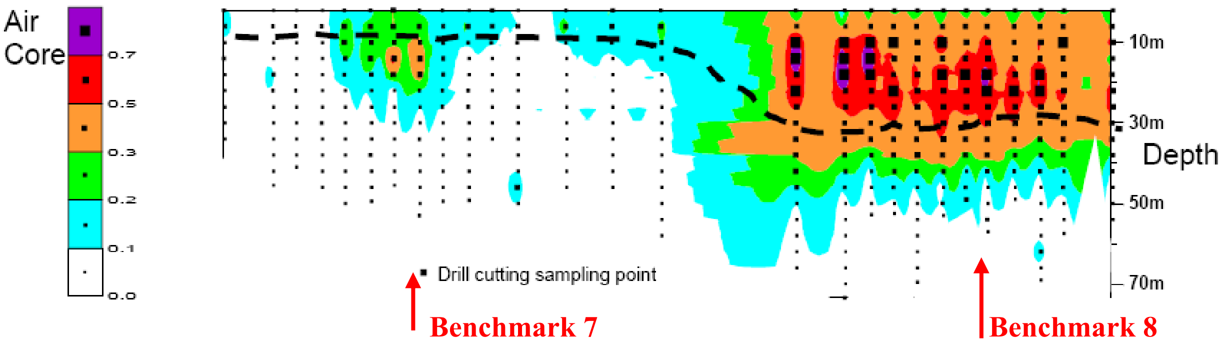


Figure 44: Bismuth distribution in regolith (ppm) at Boomerang (along grid line 449200N). Dashed line indicates unconformity. Benchmarks 7 and 8 are indicated.

Benchmark 8, drillholes BG-32 and GB-32 (drill cuttings)

Quick reference items are set out in Table 21; detailed descriptions, figures and data tables follow on below. This site, occurs ~1.5 km SE of Pinding East Tank and Yards (Figures 35, 36; on the S side of the paddock fence access track. The RAB + aircore styles of drilling employed are not ideally suited to regolith investigative work (see Notes for Benchmarks 1, 4, 5 & 7). Drillholes BG-32 + GB-32 have been selected as being representative of the regolith profile through palaeochannel sediments plus the underlying weathered crystalline basement within a reasonable drilling depth. Herein both drillholes are presented as one benchmark. Drilling was vertical; yielding cuttings, and fines. A summary of those profiles is provided in the chiptray photographs where key regolith features are indicated (Figures 45, 47). Interpreted PIMA spectra mineralogy sections occur as Figure 40 and broad geochemical data are presented in Figures 41-44, 48, 49 plus Table 20 under Benchmark 7.

Table 21: Benchmark 8 reference data, drillholes BG-32 & GB-32 (Type 2, drill cuttings profiles).

Items	Figures, Data, Sources
Regional location map	Figure 34, 35.
Local-site location map	Figures 36, 46.
GPS coordinates, attitude & elevation	Zone 53, 0460761 E, 6591420 N, GDA 94. Vertical. **AHD:** 112.399 m (differential GPS data).
Site access, owner	Site is on the Malbooma Pastoral Station, ~1.6 km SE of Pinding East Tank and Yards, S side of the paddock fence access track.
Related drillholes	RAB drillholes BG-28 to BG-54 + 6 m aircore drillholes GB-28 to GB-54.
Drill sample photos + logs	Yes, Figures 45, 47.
Sample types	RAB cuttings, as bulked 2 m composites (0 to 58 m) in chiptrays + aircore cuttings (0 to 6 m) in chiptrays + >1 kg samples.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Palaeochannel sediments + weathered to bedrock as chlorite altered ?mafic rock.
Petrology	No.
Geochemistry	Yes, Figures 41-44, 48, 49 + Table 20.
XRD mineralogy	No.
PIMA spectral data	Yes, Figure 40.
Dating	No.
Target Elements	Palaeochannel potential for: U & REE.
Potential Pathfinder Elements	Mineralization-associated (Bi, Cs, Lu, Mo, Nb, U, W,).
Useful sampling media	Transported regolith-soil where <5 m thick, calcrete.
Key reference sources	Lintern *et al*., 2006; Lintern, 2004b.

Background

Drill sampling through the regolith (to bedrock or saprock) was initially carried out by the licensed exploration tenement holder (drillholes BG-28 to BG-54, depth range typically 0->50 m). Later near surface (0-6 m) regolith investigative drilling was carried out along a selected N-S drill line (local grid line 449200 E), adjacent to the earlier exploration drillholes (holes GB-28 to GB 54, ~<5 m away, *c.f.* Benchmark 7). The latter drilling program was carried out for CRC LEME and PIRSA Geological Survey in 1997. Regolith drilling was sampled at 1 m intervals and gave better control on near surface weathering-pedogenic zones than did the exploration 2 m bulked sampling.

Regolith investigation drillhole GB-32

Transported: orange aeolian quartz sand (silty) + red-brown hardpan (clayey) + minor fluvial-colluvial quartz sand, overprinted by calcrete as pisoliths, nodules and aggregates.

Transported: red-brown clayey quartz sand (fluvial, fine- to medium-grained, rounded) + some calcrete and gypcrete.

Transported: red-brown hardpan (silicified sandy clay) + quartz sand (fluvial, f- m-grained, rounded) + porcelanite + abundant gypcrete + down-hole calcrete contaminant.

Transported: brown sandy clay loam + minor red-brown hardpan + minor fluvial sand + abundant gypcrete. Much reduced granular matter; channel fill clay-rich sediment.

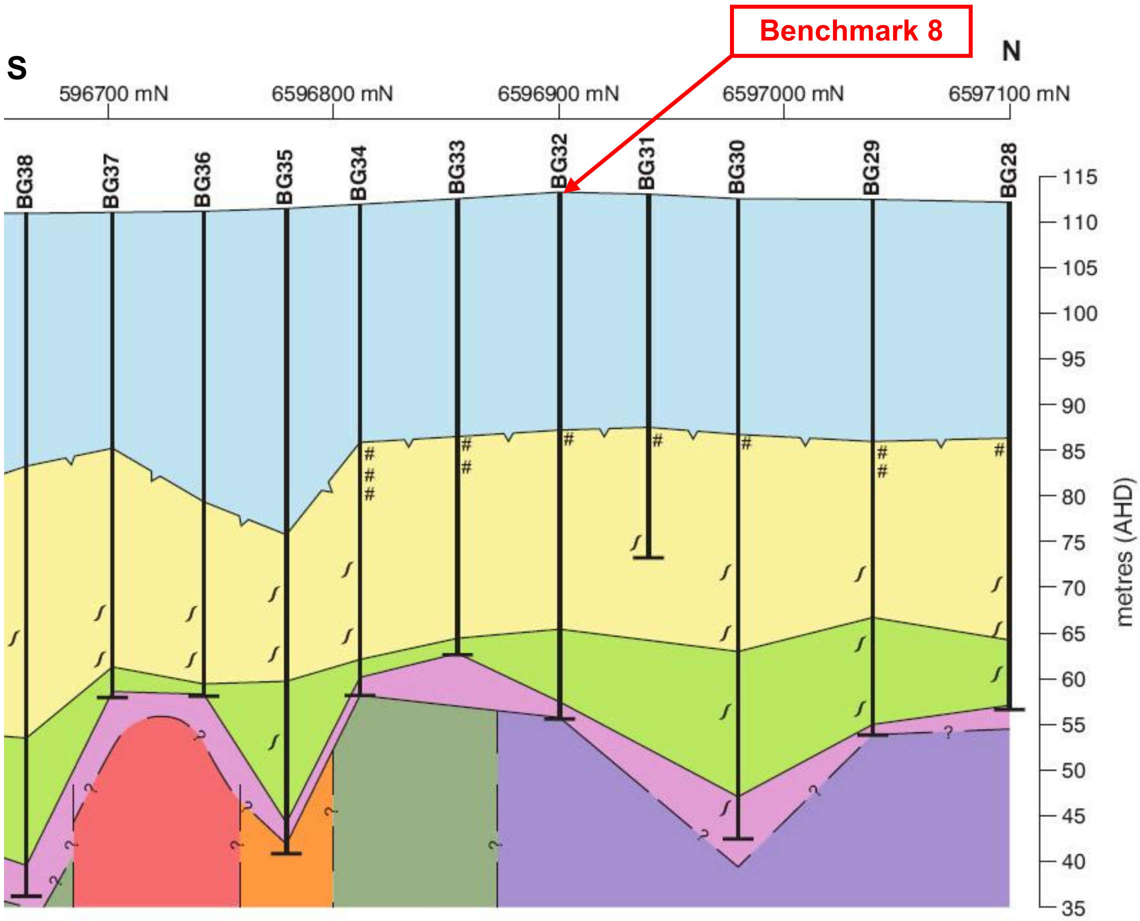
Transported: reddish mottled/streaked pallid clay + minor sand + abundant gypcrete + red-brown hardpan, less granular matter than 3-4 m; channel fill clay-rich sediment.

Transported: reddish mottled/streaked pallid clay (light sandy clay loam) + minor sand + abundant gypcrete, less granular matter than 4-5 m; channel fill clay-rich sediment.

End of hole. Scale bar in cm.

Log adapted from Lintern *et al*., 2006.

Figure 45: Benchmark 8 aircore chiptray samples (secondary 0-6 m regolith drillhole GB-32). Site is ~5 m E of drillhole BG-32. **Note:** there are >1 kg bulks in storage of these samples.



Key: transported regolith, pedolith, upper saprolite, lower saprolite, saprock, bedrock (foliated granites, gneisses & mafics).

Figure 46: Regolith profile, extracted from Lintern *et al*. (2006) indicating Benchmark 8 location and weathering zonation within its vicinity (*c.f.* Benchmark 7; Figure 39). Grid coords in AGD66.

First chiptray

Transported materials, 0-26 m: consisting of 1-2 m aeolian sand with abundant calcrete over fluvial-colluvial sediment, heavily gypcreted (2-~6 m). Red-brown hardpan + minor silcrete occur within the 2-6 m interval. Fluvial quartz sand (fine- to medium-grained, well rounded) + clay + silty mixtures of both form channel infill to a palaeo-valley.

In situ materials 26-48 m: **upper saprolite**, top eroded off, pallid variably Fe-mottled red, dominantly clay-rich with gritty interval 30-34 m. Mottling fades towards 30 m, kaolinite + lesser quartz grit, primarily a clay-rich zone, chalky to weakly coherent.

Second chiptray

Fe-stained (FeOH) **upper saprolite**, 46-48 m: muted yellow-orange to yellow-brown, primarily a clay-rich zone, chalky to weakly coherent.

Lower saprolite, 48-~56 m, khaki to olive-grey, variably weathered altered mafic rock, stiff to moderately competent.

Saprock, ~56-<58 m; dark olive-grey to moderate olive-grey partially weathered altered mafic, moderately to very competent.

Bedrock, ~58 m: greenish chloritic fine-gained mafic rock.

End of hole.

Bottom hole rock core and fragments, variably chlorite and/or epidote altered fine-grained mafic rock (?basalt or dolerite), variable weathering along fractures. Moderately competent rock.

Logged by M.J. Sheard

Figure 47: Benchmark 8, aircore chiptray samples (exploration drillhole BG-32) with key regolith features indicated. Sample interval = 2 m.

The following lithology and regolith descriptions derive from Lintern *et al*. (2006).

In situ Regolith

Regolith zonation architecture is displayed in the cross section on Figure 46 extracted from Lintern *et al*., 2006.

Bedrock (<5% weathered). Very few of the exploration drillholes on this tenement penetrated bedrock and the following description relies upon a few bottom hole large fragments. Drillhole BG-32 just penetrates chlorite-epidote altered mafic rock (by <1 m): greenish, fine- to medium-grained, variably foliated, variably altered. Some chlorite minerals were detected by PIMA (Figure 40). Although in adjacent drillholes there is abundant quartz veins, on millimetre to centimetre thickness scales, none were observed in this drillhole's samples.

Saprock (>5-<20% weathered). A thin zone in drillhole BG-32, brown and yellow-brown Fe-staining is commonly present on, or forming coatings to, fractures and sometimes permeates the more weathered mineral components. This zone is also quite chloritic.

Lower Saprolite (>20% weathered). Lower saprolite is commonly clay-rich and usually darker coloured (grey-brown to olive-brown or olive-grey), it is also firmer or stiffer than upper saprolite. Lower saprolite retains relict primary texture and tectonic fabric in coarser grained materials and is 8 m thick here. Some chlorite minerals were detected by PIMA to persist well into this sub-zone (Figure 40).

Upper Saprolite (>50% weathered). Upper saprolite is clay-rich, sometimes quartz grit bearing, commonly pallid but may also be partly reddish to yellow-brown if mottles are present. Material density, stiffness and hardness are much less than in the lower saprolite. Upper saprolite bulk colours are pale grey-brown to pale brownish and may be nearly white near the top. Saprolite retains relict texture and tectonic fabric in coarser grained more coherent materials. This sub-zone represents the most consistently thick weathering unit over much of the drill line investigated, in Benchmark 8 it is 22 m thick; however, erosion during palaeochannel development has reduced the original saprolite thickness here by an uncertain quantity.

Pedolith (extremely weathered), is absent due to erosion during palaeochannel development, therefore its true original thickness here can only be inferred from other drill holes along the cross-section.

Mineral overprinting. Ferruginous staining (reds, browns and yellows) is present, some relating to probable megamottles, on or adhering to cuttings, or permeating cuttings. Manganese oxides overprinting, forming black dendrites, stains and spots, are occasionally present in the weathering profile.

Transported Regolith

Collectively from the oldest up, these sediments encompass Palaeogene to Neogene fluvial fine- to medium-grained palaeochannel infill; which is overlain or partially interdigitates with a discontinuously present red-brown hardpan; and that inturn is overlain by ubiquitous orange to pink siliceous aeolian sand (dunes and sandplain). The upper 4-5 m of the transported regolith profile may be indurated by a variety of cements including calcrete, gypsum and silcrete, all to varying degrees of intergrain void infill. Over the northern half of regolith section (local grid line 449200E, Figure 46) transported regolith materials range from <4 m to >30 m in thickness and are dominated by aeolian sand or fluvial channel infill deposits of clay and sand.

Alluvium, occurs predominantly as fluvial sand, silt and clay – in mixtures or as more discrete better sorted grain-dominant bands to lenses. The alluvium is cemented by gypsum near surface but deeper in the profile by variable amounts of silica (silcrete ± porcelanite). It is also possible that some carbonate (other than calcrete) cementation also occurs in the upper 3 m. Palaeochannel sediment in Benchmark 8 is >23 m thick, dominantly of clay-rich materials but is sandier near the top and bottom.

Red-brown hardpan is a widespread Plio-Pleistocene unit in the Gawler Craton, it is a strongly coloured colluvium, strongly to moderately cemented by FeOx, silica, calcrete and/or gypsum. Red-brown hardpan can form a useful marker horizon where present. However, along the study drill line at Boomerang this unit is discontinuous and is restricted to within the upper 1-4 m depth range. Cuttings samples prevent comment upon true thickness or internal structures.

Aeolian sand forms both distinct dunes and broader sandplains, consisting of pale orange to pale pinkish brown, well-sorted, quartz-rich, fine- to medium-grained sand in a loose to partially cemented form. Aeolian sand grains are distinctly different from those of the underlying alluvium, as the aeolian grains have frosted surfaces, are uniformly sorted and display a distinct surficial orange Fe-staining. The dominant grain cement is calcrete and this can form horizons of pisoliths or nodules or more substantial plates to sheets. Minor gypsum cementation may also be present, however this is more common in the underlying units. Along the study drillhole section, aeolian sand ranges from <1->2 m but across the tenement it may attain a thickness at dune crests of 4-5 m.

Silcrete occurs in the 0-6 m section and deeper too, it forms thin bars and thicker silicified horizons – mostly within the sandier alluvium. Colours range from yellowish to greenish to greyish. Enclosed granular components include quartz sand, gravel and some silt. Where a clay-rich host is silicified then yellowish to very pale grey porcelanite has formed.

Gypcrete is the most abundant duricrust, forming an intense pan of coarsely crystalline gypsum in interlocking rosettes. It may form >40% of the pan's bulk within the <2 to 6 m interval and crystals range in colour from orange to colourless water-clear and it also occurs as isolated coarse- to fine-grained cryatals or pore space linings and infill within sandy to silty strata.

Calcrete forms the second most abundant near surface duricrust, comprising horizons of pisoliths or nodules to more massive sheets ~0.30-0.50 m thick that may just subcrop, or to outcrop around tree throws and animal burrows, or be located at depths of 0.5-1.0 m. It is generally coloured pale yellow-brown to pale pink or pale red-brown.

Geochemistry

A generalised geochemistry for this prospect area is set out under Benchmark 7, the following description covering the palaeochannel sediments derives from Lintern *et al*., 2006.

Anomalism associated with the palaeochannel includes the following elements: Bi (Figure 44), W, U, Nb, Ti, Mo and Ag. These may reflect higher concentrations of those elements in country rock, or they may have been physically (*e.g*. as ilmenite ± rutile ± anatase) and/or chemically mobilized and concentrated within the palaeochannel.

Of note to REE exploration; U is anomalous within the channel but not external to it, while Th is detectable in both channel infill and channel bank materials (Figures 48, 49). Most of the remaining REEs are either not anomalous or are partly anomalous within the palaeochannel. There is no visible evidence for redox zones within the drill cuttings here, but the Kingoonya Palaeochannel is a broad and very long feature in this region, so there is potential for U-roll fronts to have formed somewhere within it.

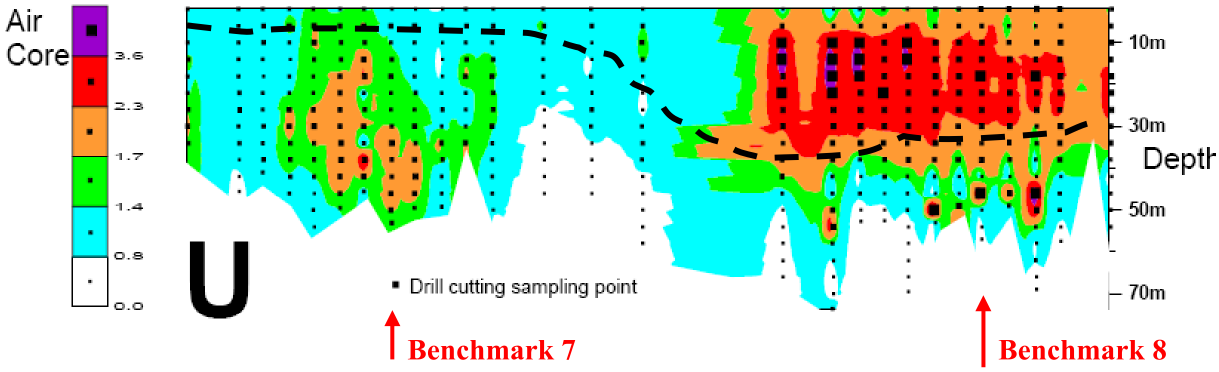


Figure 48: Uranium distribution in regolith (ppm) at Boomerang (along grid line 449200N). Dashed line indicates unconformity. Benchmarks 7 and 8 are indicated.

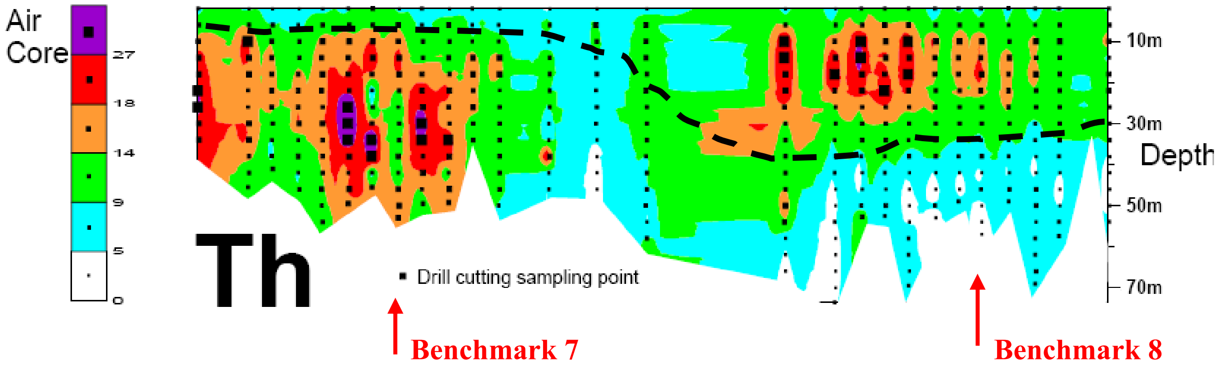


Figure 49: Thorium distribution in regolith (ppm) at Boomerang (along grid line 449200N). Dashed line indicates unconformity. Benchmarks 7 and 8 are indicated.

Earea Dam Goldfield *(northern Central Gawler Gold Province)*

Earea Dam Goldfield is located 550 km NW of Adelaide and 34 km W of Kingoonya (Figures 34, 50), just S of the Glendambo to Tarcoola road (goldfield centroid: Zone 53, 0499572 E, 6586249 N, GDA 94). Access is via a track running S for 0.5 km from the Glendambo to Tarcoola road. This goldfield is situated amongst rolling hills with landforms characterised by gentle crests and simple gently- to moderately-inclined slopes to colluvial-alluvial-dominated plains. Topographic relief is ~30-40 m. Previous gold prospecting and small scale mining has been confined to a very gently sloping valley, 100 m wide at its head and broadening to >300 m wide to the south, it is ~600 m long. The valley is bounded to the N, E and W by hills of partly weathered gneissic rock, and by sand hills to the south.

This area is semi-arid with hot summers and mild to warm winters. The nearest official weather station is at Tarcoola, 43 km WNW where the mean rainfall is 173 mm, falling mostly in early or late summer or during the cooler winter. Vegetation is sparse and highly variable: sparse shrubland, isolated shrubs and an understory of open chenopod shrubland (Lintern, 2004a).

Gold was first discovered at Earea Dam in 1899 in an outcrop of “magnetic iron ore and quartz” capped by limestone [*calcrete*] (Brown, 1908, pp. 307-310). Total recorded production from the field was 59.2 kg of Au from 1,870 tonnes of ore. It was intermittently mined until the 1940’s by open shafts, small pits or costeans, and many of these remain open.

Mineralization is mostly restricted to a narrow shear zone with a 25-40 degree E-ESE dip and a 600 m strike length (Figure 51). The shear zone has cross cutting dykes, gneiss and granulite. Gold is associated with both vein quartz and haematitic material within the shear zone (Brown, 1908; Circosta and Gum, 1989) and is also visible in the gneiss. Drilling and rock-chip sampling by the SA Geological Survey in 1988 returned values of 1.46 and 0.09 ppm Au from the dolerite dykes occurring close to the shear zone (Crettenden and Fradd, 1992).

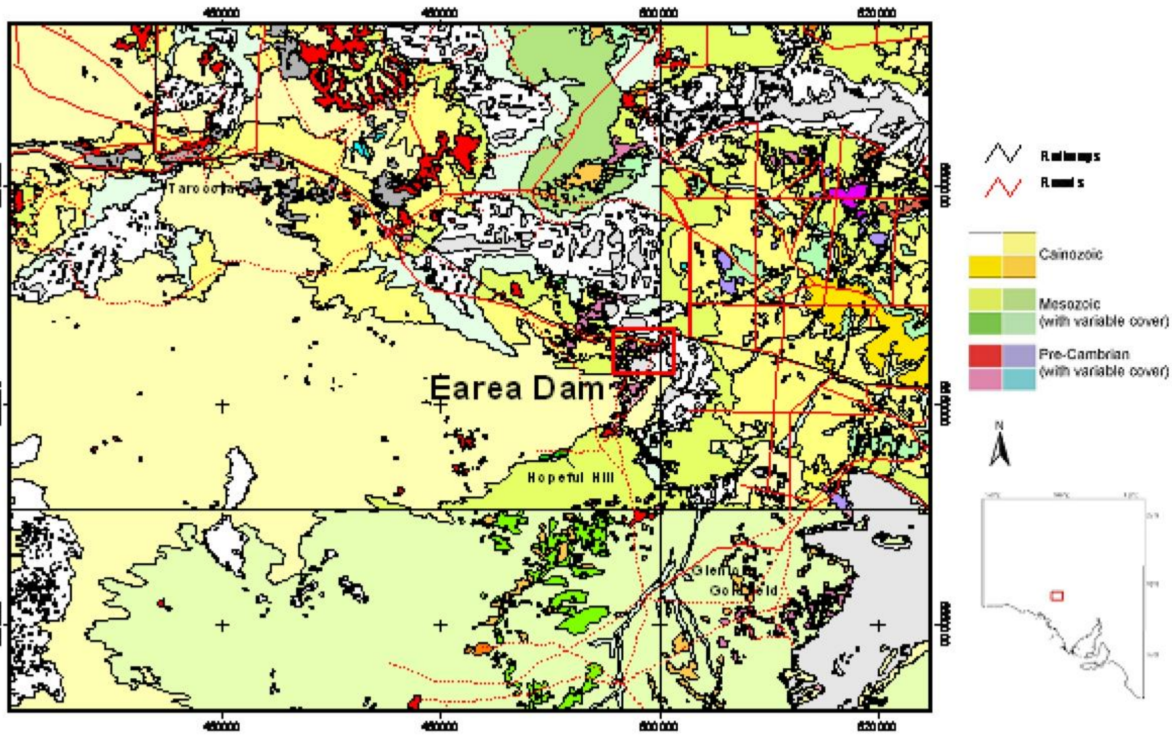


Figure 50: Location of Earea Dam Goldfield. Red boxed area indicates approximate regolith landform map boundary (see Benchmark 9). Colours are used only as a guide to the ages of geological units (Lintern, 2004a).

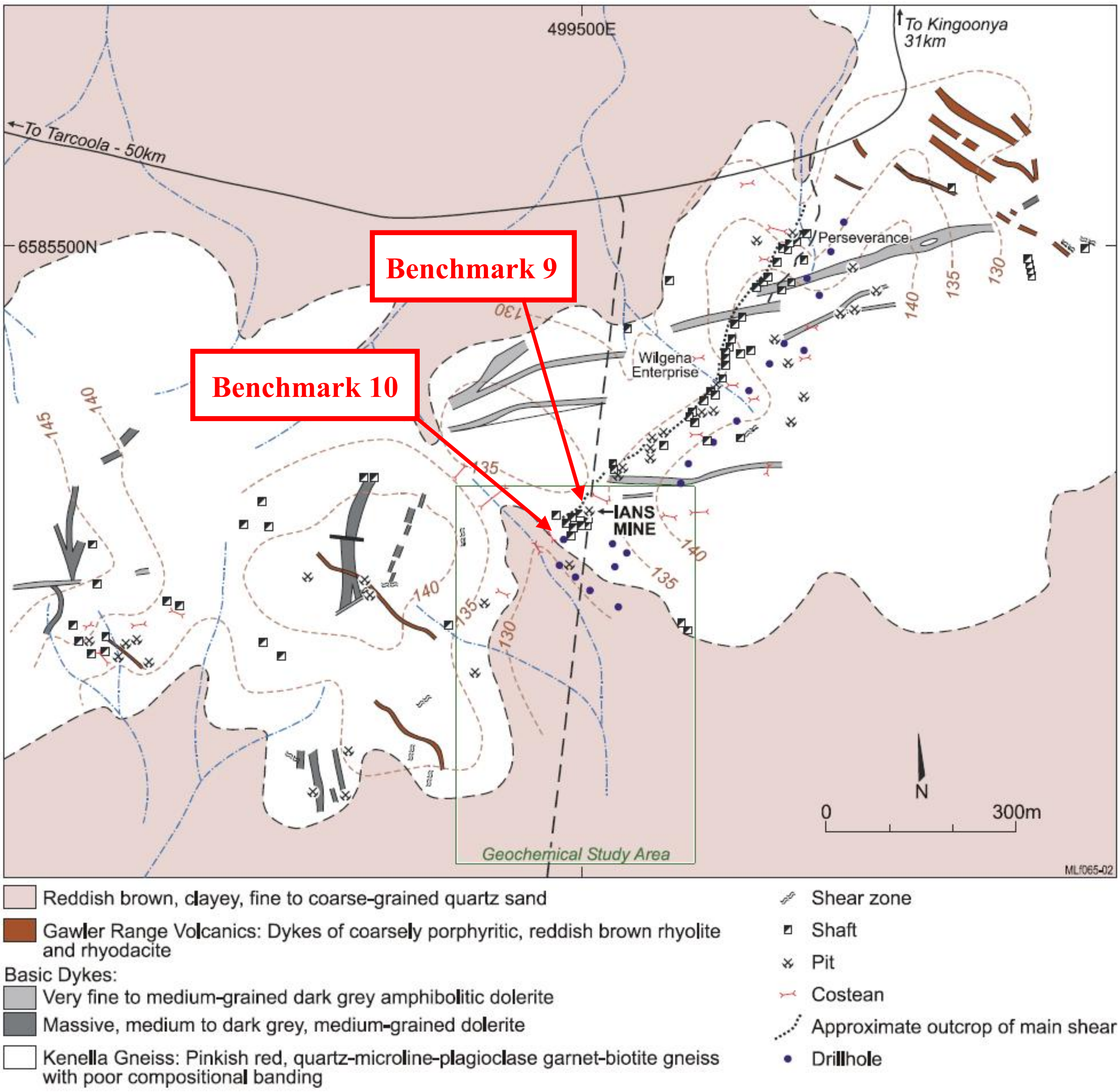


Figure 51: Local geology, mining activity (including location of Ian's Mine) and boundary of the geochemical study described in Lintern (2004a). Benchmark 9 (Ian's Mine) and Benchmark 10 (cored drillhole EDD-3) are indicated. Figure modified after Crettenden and Fradd (1992).

Regolith

The principal bedrock types of this area's erosional regime are: Archaean Kenella Paragneiss and intrusions of mafic dykes (Figures 50, 51). Gneissic bedrock typically crops out on hill tops, hill slopes and in creek lines, but elsewhere is mostly covered by fine-grained red-brown soil that has a distinct aeolian component. The local hills are littered with fine to coarse lag composed mostly of angular to rounded bedrock cobbles (Lintern, 2004a).

Ferruginous residuum and silcrete (pedolith) are absent in this area but calcrete is common in the upper metre of erosional units. A dearth of systematic drilling has prevented construction of a meaningful depth-to-unweathered basement map. However, examination of pits and costeans around Ian's Mine (Benchmark 9) and some locally sourced drill core indicates the depth to saprolite is generally <5 m. Depth to unweathered basement is quite variable (10-40 m, average ~30 m; Circosta and Gum, 2002; Lintern, 2004a). Saprolite, if near surface, may be in part impregnated by pedogenic carbonate.

Weathered *in situ* regolith in depositional areas, is overlain by fine-grained alluvium-colluvium (<1 to ~3 m thick) around the mines and costeans but is thicker S of them where dune sands over ride the colluvium. Sediment consists of clay, silt, sand and angular lag, overlying red-brown hard pan of variable thickness. Carbonate accumulation is weak to moderate within the colluvium (Lintern, 2004a).

Benchmark 9, Ian's Mine (pit–excavation)

Quick reference items are set out in Table 22; detailed descriptions, figures and data tables follow on below. This site, occurs ~34 km W of Kingoonya (Figures 34, 50, 51). Access is via a dirt track for ~400 m S from the Glendambo to Tarcoola road. Pit profile data and photographs with key regolith features are provided (Figures 53, 55). Interpreted XRD mineralogy is described, geochemical data are presented in Figures 54, 56 and Table 24.

Table 22: Benchmark 9 reference data, Ian's Mine (Type 3, pit – excavation).

Items	Figures, Data, Sources
Regional location map	Figures 34, 50.
Local-site location map	Figures 51, 52.
GPS coordinates, attitude & elevation	Zone 53, 0499450 E, 6585080 N, GDA 94 (Ian's Mine centroid). Vertical. **AHD:** ~134 m (estimated from survey map data).
Site access, owner	Site is ~34 km W of Kingoonya, ~400 m S of Glendambo-Tarcoola Rd on North Well Pastoral Station.
Related drillholes	Cored drillholes Earea EDD-3 & EDD-4 (see Benchmark 10).
Pit photos + logs	Yes, Figures 53, 55.
Sample types	~200 gm channel samples from pit profile.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered to bedrock, as fractured felsic (Kenella Paragneiss) + mafic dykes.
Petrology	Yes, Plate 2, see Lintern, 2004a.
Geochemistry	Yes, Figures 54, 56a-c + Table 24.
XRD mineralogy	Yes, Table 23 & Lintern, 2004a.
PIMA spectral data	No.
Dating	Basement, yes, Kenella Paragneiss: 2488±130 Ma (Rb-Sr); 2600-2560 Ma (U–Pb); 2530 Ma (Sm–Nd), Swain *et al*. (2005). Regolith, no.
Target Elements	Au.
Potential Pathfinder Elements	Ag, Bi, Cu, Sn, Te, U and W.
Useful sampling media	Calcrete + ?soil.
Key reference sources	Lintern, 2004a; Crettenden and Fradd, 1992; Brown, 1908.

Background

Ian's Mine is a stretched trapezoidal shaped pit–excavation with the narrower western entrance having a ramped access way, while the remaining pit walls are vertical. Pit long axis orientation is ~EW, where pit dimensions are ~25 m long by ~12 m wide by ~4.5 m deep. Access can be made by vehicle or on foot, the pit is unfenced, its walls are relatively stable but anyone accessing this pit should wear a protective hard hat. A 1 m wide and deep costean set within the pit floor, is oriented to intersect with the E face. The costean exposes dark grey mafic dyke bedrock, and abundant black specula haematite is also in evidence. Benchmark 9 now forms a readily accessible exposure through the regolith on this goldfield. Drilling nearby, carried out for Tarcoola Gold Limited, has representation within the PIRSA Drill Storage Facility (see Benchmark 10).

In situ Regolith

Bedrock (<5% weathered): Kenella Paragneiss commonly crops out on hill tops and slopes, it is also exposed in the prospect shafts, pits and costeans. This rock is a pinkish red, quartz-microcline-plagioclase-garnet-biotite gneiss with poor compositional banding and localised pegmatite separations. Stratigraphically the Kenella Paragneiss forms part of the larger Archaean Mulgathing Complex containing the Christie Gneiss + the Kenella Paragneiss + the mafic and ultramafic rocks of the Harris Greenstone Belt + the calc-alkaline Devil's Playground Volcanics + the syn-tectonic Glenloth Granite. Dating by a variety of methods (Swain *et al*., 2005) has demonstrated the following age constraints: 2488±130 Ma (Rb-Sr); 2600-2560 Ma (U–Pb zircon); 2530 Ma (Sm–Nd). Geochemical and petrographic evidence for this gneiss being a regionally metamorphosed sedimentary sequence is discussed in Swain *et al*. (2005). Mafic granulite bands occur throughout the Kenella Paragneiss in the Earea Dam region (Crettenden and Fradd, 1992). Those bands consist mostly of mafic minerals with varying amounts of quartz, biotite and pyrrhotite. They are commonly altered and coarsely recrystallised. Three sets of dykes intrude the gneissic basement at Earea Dam, fine- to medium-grained dolerite + fine- to medium-grained amphibolitic dolerite (both of the Kimban Orogeny) and porphyritic brown rhyolite + rhyodacite of the Gawler Range Volcanics. These dykes cropout poorly, vary in width from 2-16 m, have near vertical dips and sheared margins (Crettenden and Fradd, 1992). They cross-cut the gneissic banding trend (Circosta and Gum, 2002).

Saprolite (>5% weathered): this zone of highly weathered rock rarely crops out in this locality, except within mine workings. Weathering of bedrock has formed two types of product: one is dominated by kaolinite + quartz fragments and is derived from felsic precursors like Kenella Paragneiss; whereas the other is dominated by smectitic clays derived by weathering of mafic dykes. Saprolite in the pit exposures contain numerous bedrock clasts which have been commonly coated with pedogenic carbonate – especially towards the saprolite upper portions, making the boundary with the pedolith either diffuse or indistinct (Lintern, 2004a).

Calcrete: horizons occur in weathered residuum displaying a variety of forms at Earea Dam, including powdery (earthy, loose and/or as coatings) to nodular, laminar and cobbles (massive). Where saprock or competent saprolite is located close to the surface, calcrete partly or wholly coats the weathered *in situ* material to form cobbles or boulders. Thus, calcrete in those areas often includes large clasts (up to 10 cm) of saprolite that may drastically elevate the geochemical concentrations of certain elements, including Au. In Ian's Mine, calcrete encloses the haematitic host material with some analyses reporting several hundred ppb Au.

Transported Regolith

Hardpan: at Earea Dam, is mostly comprised of silicified alluvium-colluvium, is confined to the depositional regime and is commonly observed in the costeans close to Ian's Mine. Hardpan is a convenient field term used to describe the distinct, red-brown to brown, clay-rich and typically silicified unit found beneath soil in valleys and depressions (Eggleton, 2001). Hardpan is characterised by dark brown to black Fe and Mn oxide and oxy-hydroxide occurring as coatings and dendritic overgrowths. At Earea Dam it contains a variety of clasts including quartz, bedrock and saprolite, and frequently exhibits pedogenic and/or digenetic carbonate in its upper part. Hardpan is covered with variable thicknesses (>20 cm) of loose clay-rich soil. It is probably a ubiquitous unit in the valley sediments as suggested by the drilling limitation of ~50 cm expressed by a power auger sampling program (Lintern, 2004a).

Dune Sand: aeolian dunes blanket the southern part of Earea Dam Goldfield and conceals older depositional and residual regolith regimes (Figure 52). Exposures on the edges of nearby salt lakes and clay pans indicate the dunes can be up to ~5 thick in places. Wind-blown sand is also a significant component of the soils throughout the entire prospect and is presumably derived from the nearby dunes plus, ultimately, the eroding gneissic terrain. Dune sand is generally loose, free running, and is partly stabilised from erosion by deep rooted vegetation. These dunes are considered a recent addition to the landscape; their occurrence and extent is significant since they are likely to dilute any geochemical signals in and deriving from the older regolith units (Lintern, 2004a).

Calcrete: forms horizons of nodules to laminar and massive sheets in the thin transported material exposed at Ian's Mine. Further down slope, in the depositional regime, the calcrete is much less abundant and occurs as powdery forms coating soil peds-particles. It may also coat partings on the upper part of the underlying hardpan. The dune sands also exhibit some minor pedogenic carbonate (has a slight reaction to dilute acid), that carbonate is of aeolian origin (Lintern, 2004a).

Soils: have a variety of textures in this area. Poorly structured sandy soils (light textures) dominate the dune system to the south. A thin (<5 cm) sand-rich clay covers the valley sediments above a very compacted red-brown clay-rich sub-soil (heavy textures). This in turn overlies a hardpan. Thin clay-rich calcareous lithosols blanket the saprolite on the flanks of the valley and the hills. The SWIR[1] spectra indicate the presence of poorly-ordered kaolinite and possibly illite (after Lintern, 2004a).

[1] SWIR = short wave infra-red.

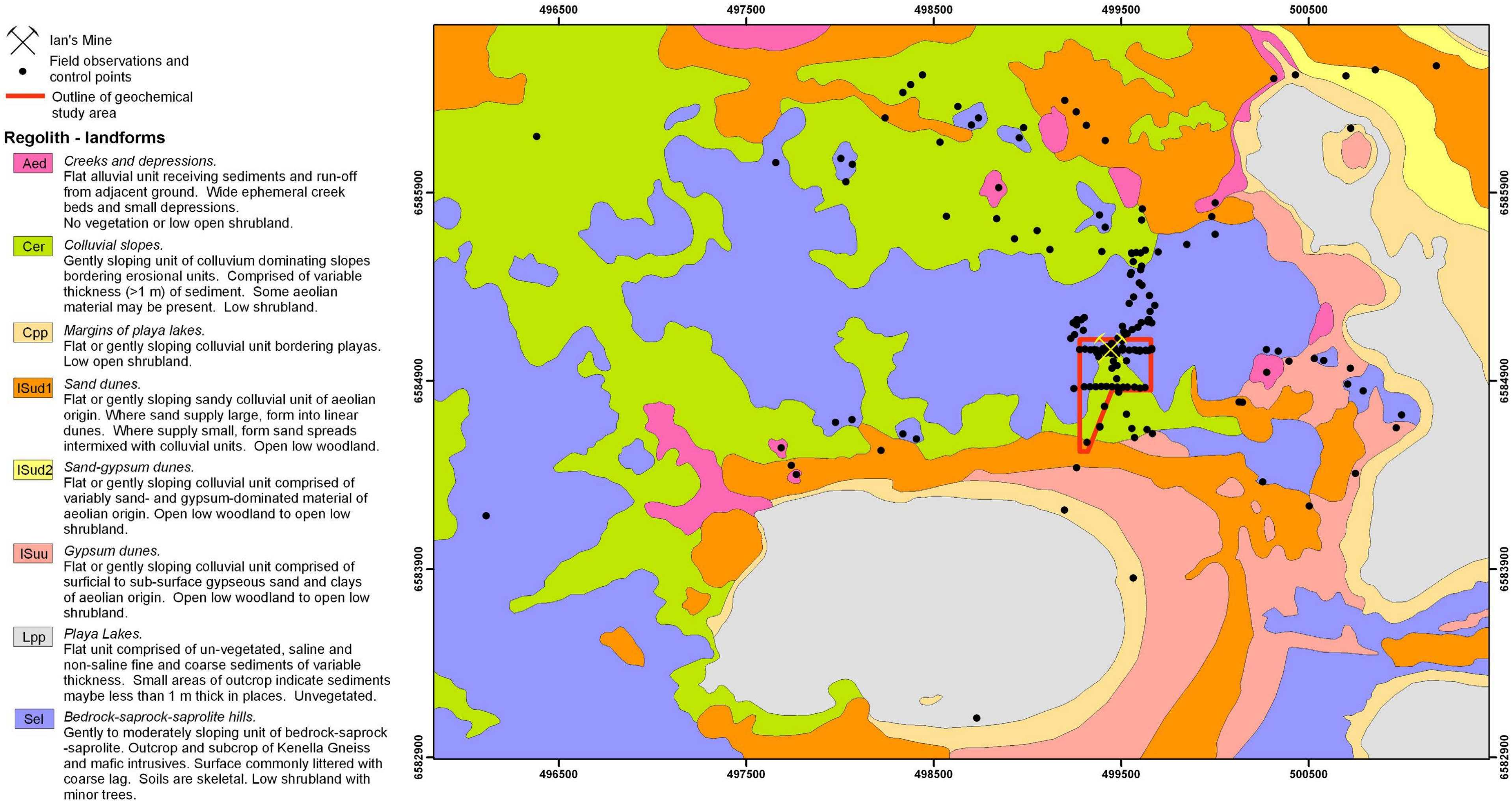


Figure 52: Regolith Landform Map of the Earea Dam Prospect of Lintern (2004a) showing location of observation points (open circles), Ian's Mine (crossed pickaxe symbol; Benchmark 9) and geochemical study area (outlined in red).

Mineralogy

Selected samples from four profiles within Ian's Mine (pit) were chosen for XRD analysis (Table 23), geochemical analysis of the same samples is presented in the geochemistry section below and described in more detail by Lintern (2004a). XRD analyses show that regolith mineralogy is mostly dominated by quartz, calcite, kaolinite, plagioclase, alkali feldspars and micas, consistent with the dominant gneissic bedrock observed in the pit. Gypsum forms a metre thick horizon in the pit's SE corner but its origin is unclear. The presence of basanite in some samples appears to be a heating artefact generated during the milling of gypsiferous materials prior to XRD analysis. Haematite is locally abundant and is, in part, associated with mineralization. A mafic dyke intrudes into the pit base (and at profile base – samples ED01 to ED11) and is dominated by hornblende and plagioclase which have weathered to produce goethite, kaolinite and smectite.

Mineralization is associated with dark haematitic quartz-rich material occurring as narrow veins in the Kenella Paragneiss. Those veins dip to the E and may have formed a tabular structure (through the pit) which has been substantially mined out. Mineralization was intersected by several of the Lintern (2004a) profiles.

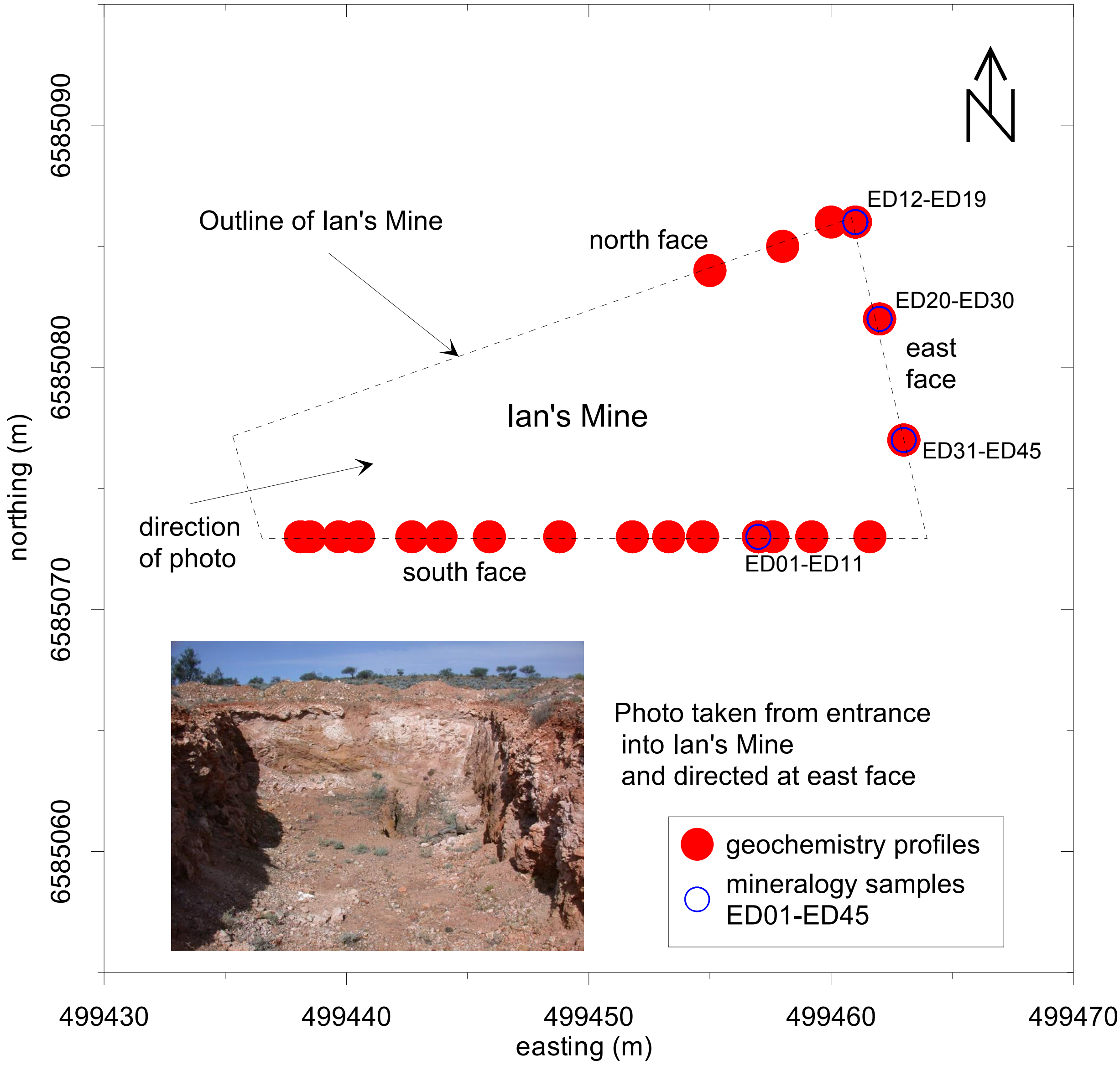


Figure 53: Location plan of profiles sampled at Ian's Mine by Lintern (2004a). Photo inset displays the E and S faces in early afternoon light. The upper pale horizon is dominated by pedogenic carbonate accumulations (calcrete).

Table 23: Selected mineralogy of four profiles from Benchmark 9 (Ian's Mine: Lintern, 2004a). Estimates of mineral abundances were based on peak height: ▬ abundant; XX moderately abundant; ▭ some; and ▭ trace. Refer to Figure 53 for sample locations, Figure 54 for geochemistry, and location of samples ED01 to ED11 (Profile D), ED12 to ED30, and ED31 to ED45.

Sample	depth (cm)	Regolith unit	QUARTZ	CALCITE	ALBITE ordered	ALBITE disordered	MICRO-CLINE	MAGNESIO HORNBLENDE, FERROAN	BIOTITE	BASSANITE GYPSUM	HEMATITE	GOETHITE	KAOLINITE	ILLITE	OTHER
ED01	10	colluvium													
ED02	25	saprolite						XXXXXXXXXX							
ED03	60	saprolite													
ED04	105	saprolite													
ED05	165	saprolite													
ED06	210	saprolite		XXXXXX											
ED07	235	saprolite													
ED08	280	saprolite									XXXXXX				
ED09	300	saprolite	XXXXXX					XXXXXXXXXX					XXXXXXX		smectite
ED10	325	saprock											XXXXXXX		
ED11	465	saprock													
ED12	10	colluvium													
ED13	30	colluvium											XXXXXXX		
ED14	50	colluvium											XXXXXXX		
ED15	95	saprolite													
ED16	170	saprolite		XXXXXX					XXXXX				XXXXXXX		
ED17	230	saprolite				XXXXXX							XXXXXXX		
ED18	250	saprock													
ED19	370	saprock				XXXXXX									
ED20	10	colluvium											XXXXXXX		
ED21	30	colluvium											XXXXXXX		
ED22	50	colluvium					XXXXXXXXX						XXXXXXX		
ED23	70	colluvium											XXXXXXX		
ED24	90	saprolite		XXXXXX		XXXXXXX							XXXXXXX		
ED25	115	saprolite				XXXXXXX				XXXXXX					
ED26	180	saprolite				XXXXXXX									
ED27	230	saprolite							XXXXX						orthoclase
ED28	245	saprolite					XXXXXXXXX		XXXXX		XXXXXXX		XXXXXXX		orthoclase
ED29	260	saprolite					XXXXXXXXX		XXXXX		XXXXXXX		XXXXXXX		orthoclase
ED30	290	saprolite													orthoclase
ED31	5	colluvium		XXXXXX											orthoclase
ED32	11	colluvium													
ED33	15	colluvium				XXXXXXX	XXXXXXXXX								
ED34	30	colluvium				XXXXXXX	XXXXXXXXX						XXXXXXX		
ED35	50	saprolite											XXXXXXX		
ED36	70	saprolite									XXXXXXX		XXXXXXX		
ED37	90	saprolite		XXXXXX							XXXXXXX		XXXXXXX		
ED38	125	saprolite		XXXXXX							XXXXXXX				
ED39	160	saprolite									XXXXXXX				muscovite
ED40	160	saprolite					XXXXXXXXX								muscovite
ED41	175	saprolite									XXXXXXX				muscovite
ED42	195	saprolite					XXXXXXXXX								muscovite
ED43	235	saprolite													muscovite
ED44	270	saprolite													muscovite
ED45	300	saprolite													muscovite

Geochemistry

Grab samples from Ian's Mine were assayed for Au and other elements in order to determine any associations of elements and to further examine the nature of this Au occurrence (Figure 54). The three grab samples with the highest Au concentrations were ED95, ED41 and ED71 (30, 32 and 33 ppm Au respectively). High Au concentrations are usually correlated with high concentrations of Ag, Bi, Cu, Sn, Te, U and W (Figure 54) and is consistent with earlier studies mentioned above (Crettenden and Fradd, 1992). Sample ED95 was sectioned, polished and examined under the SEM, this revealed the nature of its contained Au plus associated elements. Some Au with low Ag content (<1%) was found in haematite (possibly after sulphides), an SEM image from that sample is displayed in Plate 2 below.

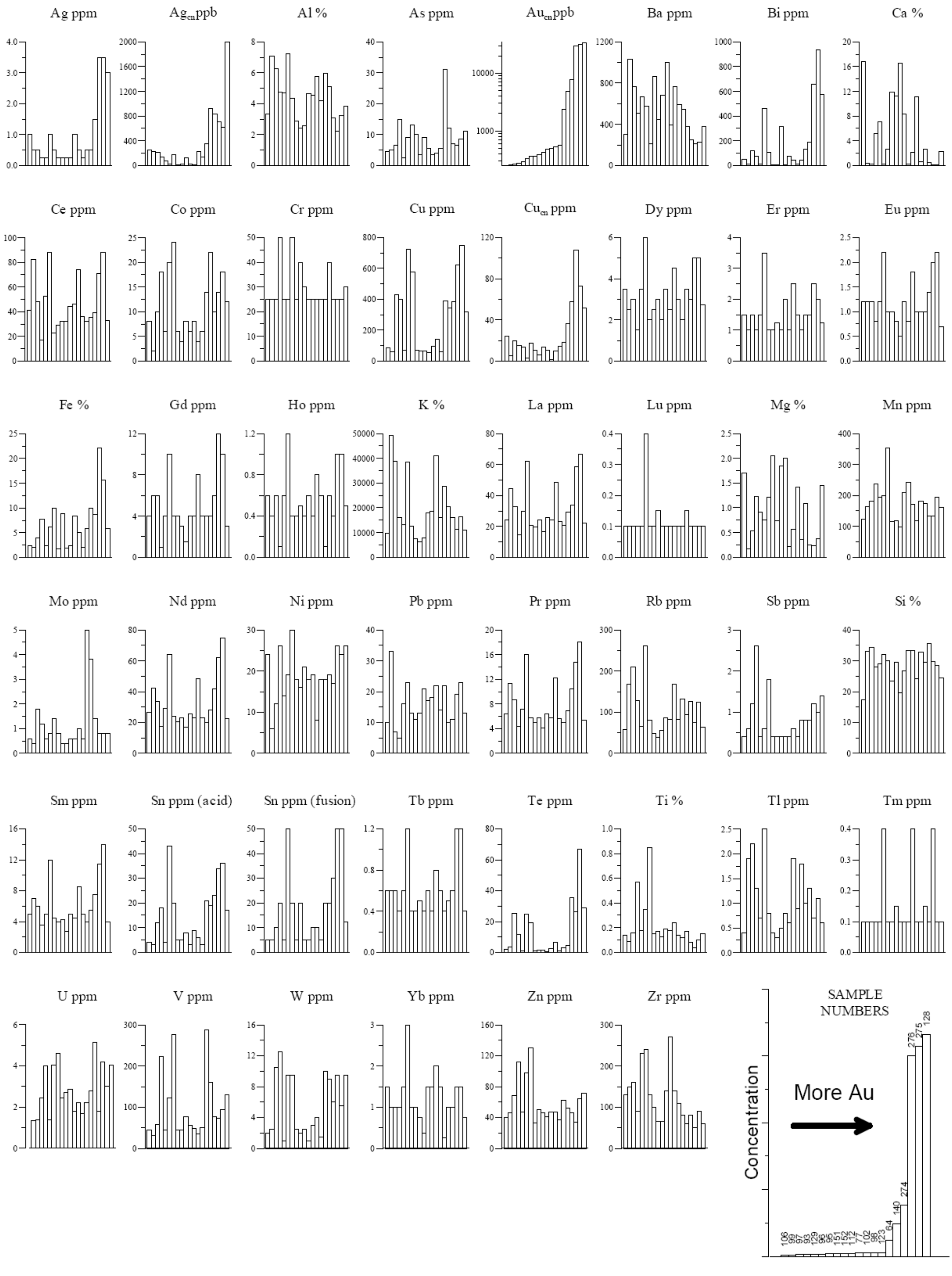


Figure 54: Bar charts from Lintern (2004a) showing concentration of selected elements in grab samples from Benchmark 9 (Ian's Mine). Samples are ranked (left to right) according to increasing Au content. Cadmium data are below 0.5 ppb. Sample numbers are indicated on the larger histogram (bottom right).

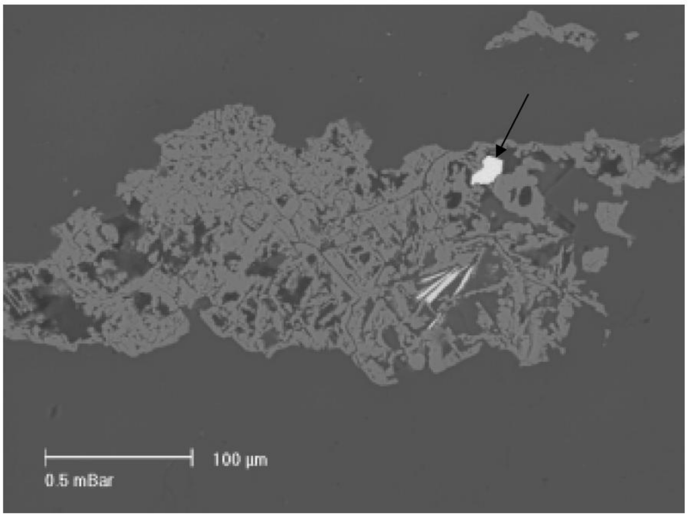


Plate 2: Benchmark 9, SEM photomicrograph of haematite within quartz containing a 20-30 µm Au grain (arrowed, and with <1% Ag) and "shards" of Bi oxide. Other Bi minerals found contained Ba and/or V.

South wall of pit (after Lintern, 2004a)

Fifteen regolith profiles (59 samples) from variable depths were sampled from across the S face of Benchmark 9 (Ian's Mine, Figure 55) and the geochemical data generated are contoured in Figure 56a-c. Elements can be grouped together and related to specific regolith units: felsic saprolite, mafic dyke, smectitic clays, and calcified colluvium and clay saprolite (Table 24).

Gold concentrations are highest (profile K, Figure 56a, 33 ppm) in samples containing haematite-quartz clasts, and occur at the contact between the smectite clays and kaolinite-rich saprolite, and part of the veining and tabular body mentioned earlier. These angular clasts also occur within calcrete in the eastern part of the profile within transported material (probably where mineralization breaches the interface) and suggests that mechanical (gravitational) dispersal of Au (and associated elements) is taking place down slope of the workings. Elements associated with Au include: Ag, Bi, Cu, Sn, Te and W with maxima of 2, 578, 388, 21, 29 and 10 ppm, respectively.

The high concentration of Au in haematite-quartz clasts provided an opportunity to examine the effects of other dispersion processes in adjacent surrounding materials. High Au values occurring in the clasts are not correlated to Au in adjacent materials including overlying calcrete, suggesting that hydromorphic processes such as capillary or diffusion are not playing a significant role in the dispersion of Au. For example, above Au-rich sample ED71 (33 ppm Au, base of profile k) Au concentrations are only weakly anomalous for this area (38, 31 and 50 ppb Au) and this includes calcrete samples. Similarly in profile D where Au values reach a maximum of 2.4 ppm (ED8), other samples (including calcrete) in the profile average <50 ppb. If hydromorphic processes were active, higher Au concentrations would have been expected.

Samples taken from profiles on the pit eastern wall yielded similar results. The highest Au value (475 ppb) occurs in one calcrete sample. Concentrations in adjacent material are lower (71 and 33 ppb) possibly suggesting that the Au is located in a rock fragment derived from up slope.

Samples taken from profiles on the pit northern wall immediately above the mineralized band (peak values of 31 ppm Au, 620 ppb Ag, 938 ppm Bi, 750 ppm Cu, 36 ppm Sn, 76 ppm Te, 11 ppm W) reach a Au concentration of 272 ppb in one calcrete but other calcrete samples are well below this value. The erratic nature of the Au distribution here again (as with other profiles) suggests the presence of detrital Au grains. Gold values in soil (0-10 cm) immediately above mineralization reach a maximum value of 15 ppb.

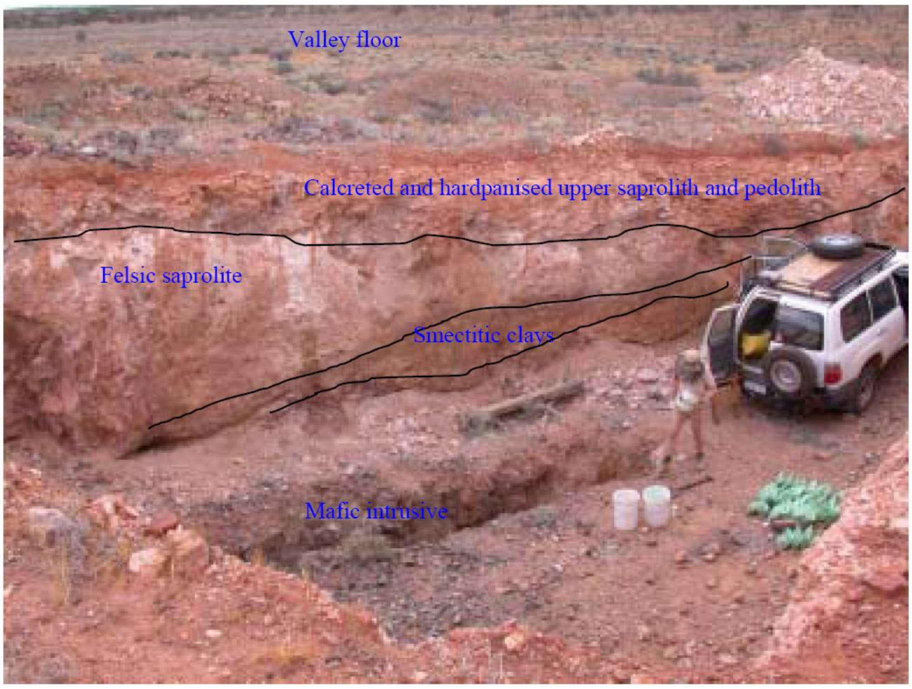


Figure 55: View of Benchmark 9 (Ian's Mine) S face in foreground with valley and dunes in background. Fifteen profiles were sampled from the S face and the data generated are contoured in Figure 56a-c. The vehicle is parked on pit's access ramp, facing west.

Table 24: Summary of elemental association and interpretation for S face of Benchmark 9.

Regolith unit	Associated elements	Comments
Pale felsic saprolite and gypsum	Ca, Al and Si.	Calcium present mainly in gypsum which dominates the eastern part of the face; Al and Si in kaolinite. There are also moderate amounts of Fe and K. Gravels of near fresh gneiss present.
Dark grey mafic intrusive	Fe, Mg, Al, Cu and Ti	Only one sample taken
Green-khaki smectite clays	Ag, Au, Bi, Cu, Fe, Sn, Te, and W	Gold and elements associated with hematite-quartz clasts at the contact between mafic-derived smectite clay and felsic saprolite
Pinky white calcrete	Ca, Ag, Au, Al, Bi, Cu, K, Mg, Si, Sn, Te, Ti, W, Zr.	Gold and elements associated with mineralization appear to be most concentrated in the western end of the pit face where hematite-quartz clasts are present within calcreted colluvium.

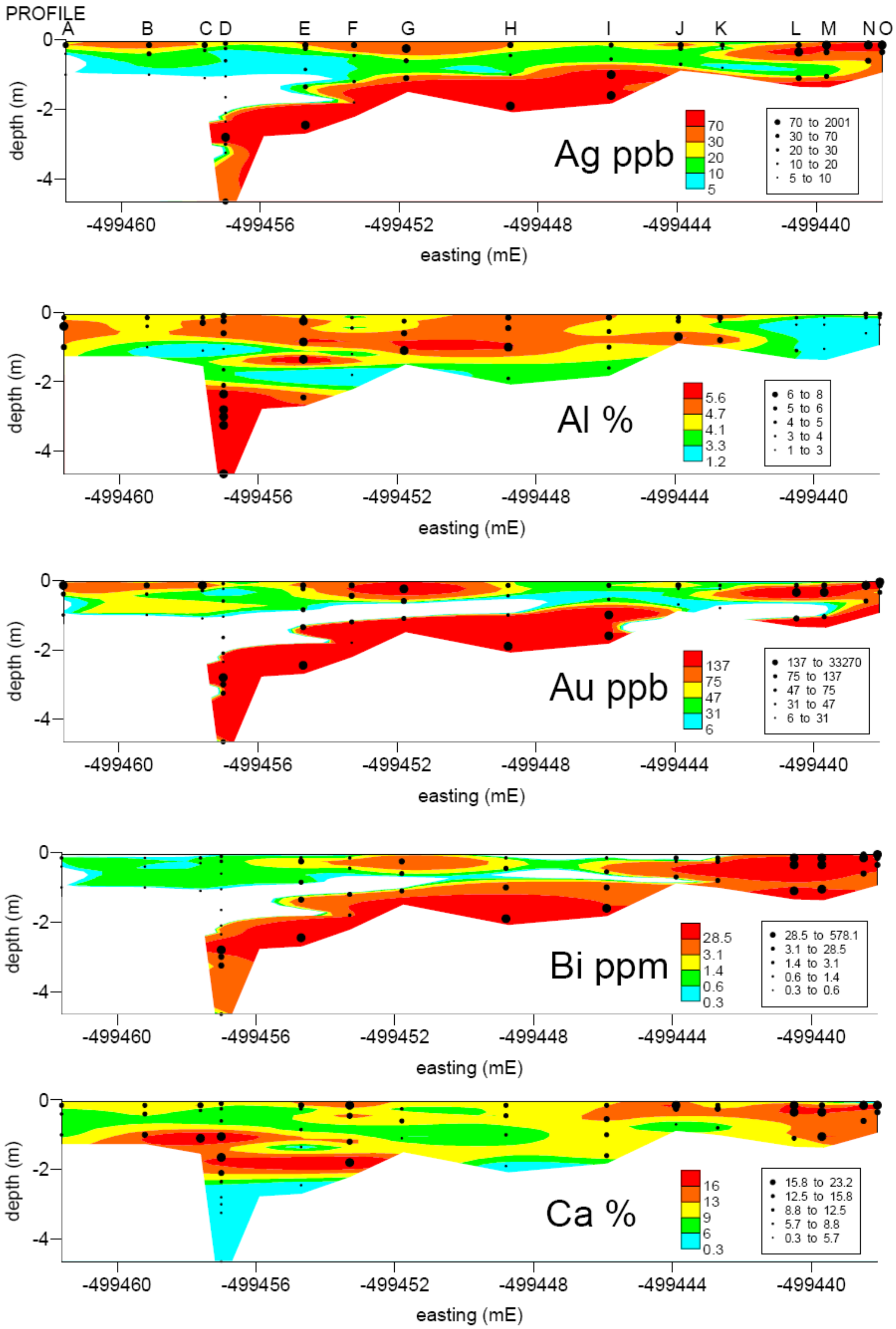


Figure 56 part a: Distribution of selected elements in the southern pit wall of Benchmark 9 (Ian's Mine).

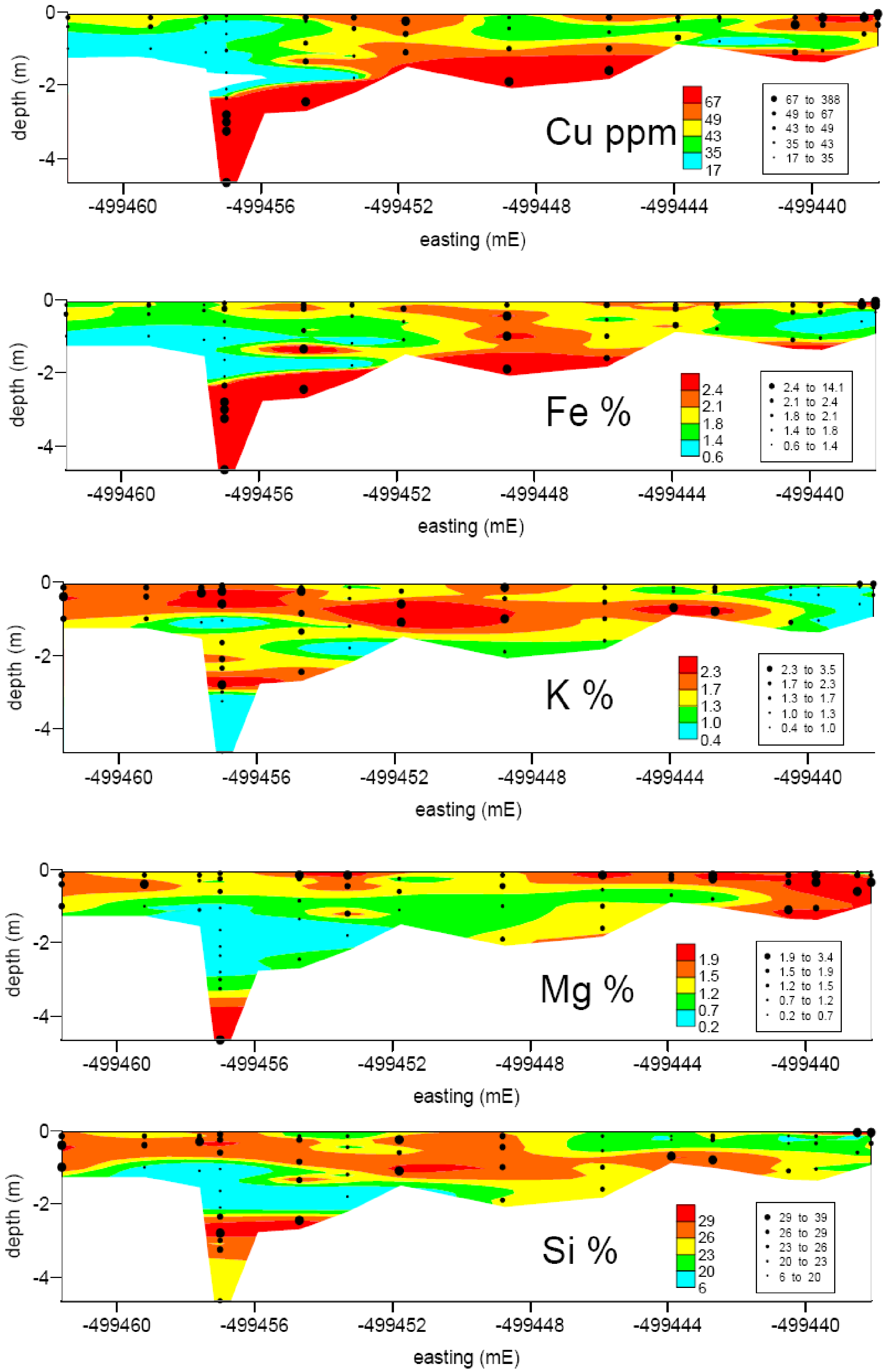


Figure 56 part b: Distribution (continued) of selected elements in the southern pit wall of Benchmark 9 (Ian's Mine).

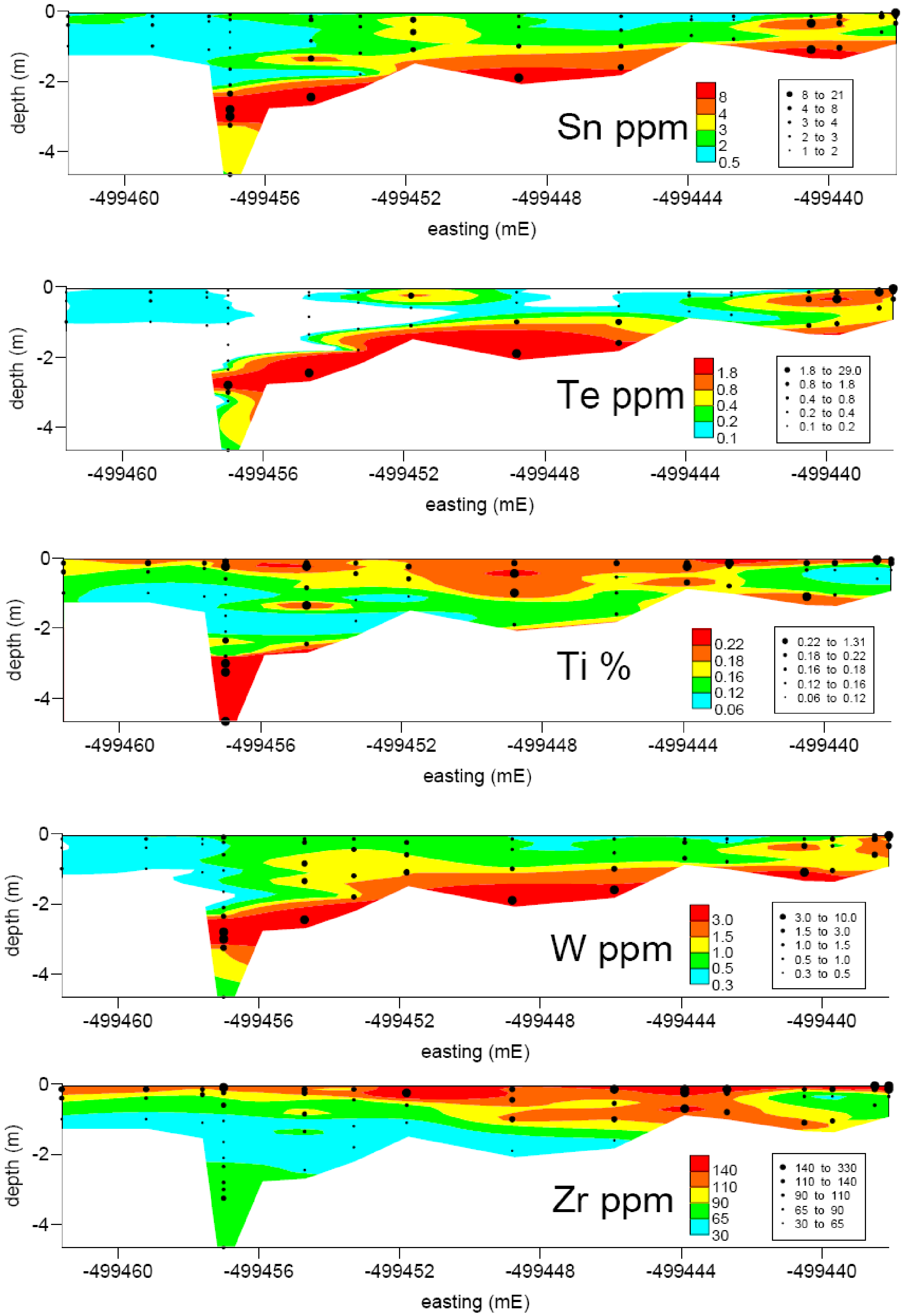


Figure 56 part c: Distribution (continued) of selected elements in the southern pit wall of Benchmark 9 (Ian's Mine).

Benchmark 10, cored drillhole EDD-3

Quick reference items are set out in Table 25; detailed descriptions, figures and data tables follow on below. This site, occurs ~34 km W of Kingoonya (Figures 50, 51). Access is via a track for ~400 m S from the Glendambo to Tarcoola road. Core profile data indicating key regolith features + lithology + mineralogy and photographs are provided in Table 26, Figure 57, Plate 3. Interpreted geochemical data are presented in Table 27.

This drillcore provides an additional but much deeper profile to Benchmark 9, here the weathering zone is thicker and the host lithotype is Kenella Paragneiss, total cored depth is 13.50 m.

Table 25: Benchmark 10 reference data, drillhole EDD-3 (Type 2 drill cored profile).

Items	Figures, Data, Sources
Regional location map	Figures 34, 50.
Local-site location map	Figures 51.
GPS coordinates, attitude & elevation	Zone 53, 0499596 E, 6585201 N, GDA 94. Vertical. **AHD:** ~133 m (estimated from survey map data).
Site access, owner	Site is on the North Well Pastoral Station, ~34 km W of Kingoonya, ~450 m S of Glendambo-Tarcoola Rd.
Related drillholes & site	Earea EDD-4 & Benchmark 9.
Photos + logs	Yes, Table 26, Figure 57, Plate 3.
Sample types	HQ core + some RAB cuttings (incomplete sample recovery).
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered to bedrock, as fractured felsic rock (Kenella Paragneiss).
Petrology	No.
Geochemistry	Yes, Table 27.
XRD mineralogy	No.
PIMA spectral data	No.
Dating	Basement, yes, Kenella Paragneiss: 2488±130 Ma (Rb-Sr); 2600-2560 Ma (U–Pb); 2530 Ma (Sm–Nd), Swain *et al*. (2005). Regolith, no.
Target Elements	Au.
Potential Pathfinder Elements	Ag, Bi, Cu, Sn, Te, U & W (similar to Benchmark 9).
Useful sampling media	Calcrete, transported regolith-soil where <5 m thick.
Key reference sources	Crettenden and Fradd, 1992; Brown, 1908.

Figure 57: Benchmark 10, HQ drillcore + some RAB cuttings (interval 1.00-6.00 m). Core loss and poor core recovery occur between ~0.50-8.00 m and is indicated above or on the regolith log (Table 26). Core is highly fractured. Full core recovery to 13.5 m would normally require three core trays to accommodate all of it, however, enough of the *in situ* weathered regolith profile has been recovered to serve as a reference.

Plate 3: Benchmark 10, a close-up of cored calcrete (~0.00-0.05 m) cut to display encapsulated yellow-brown angular clasts of ferruginous pedolith. Ferruginous clasts are matrix supported. Core is dry.

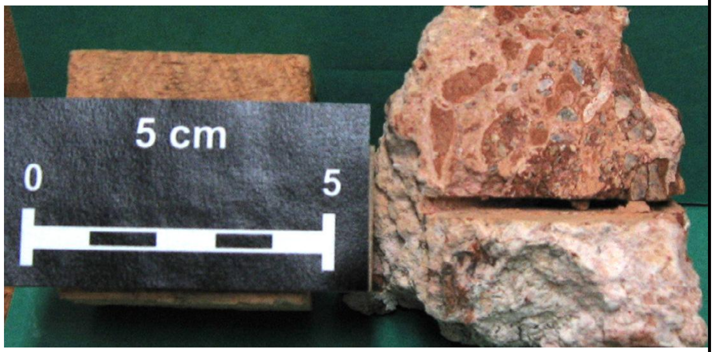


Table 26: Summary log to Benchmark 10, cored drillhole EDD-3 (Not to scale).

Depth range (m)	**Graphic Log** (vert. not to scale)	**Regolith Zone**	**Description**
0.00-1.00		Duricrust: calcrete + pedolith	Cored (~**50 cm core loss**). Pale cream calcrete (Plate 3) cementing ferruginous clasts of yellow-brown pedolith, no primary texture or fabric remain within *in situ* weathered clasts. Duricrust is mildly competent. Strong acid reaction.
1.00-~2.00		Pedolith	RAB drilled portion, poor recovery. Greyish pink calcrete cemented pedolith, incoherent granular-clayey material. Strong to weak acid reaction.
~2.00-~4.00		Pedolith – ?plasmic to arenose zone	RAB drilled portion, poor sample recovery. Greyish pink to maroon coloured, coherent to incoherent, chalky to granular to clayey weathered gruss. No acid reaction.
~4.00-6.00		Pedolith + upper Saprolite	RAB drilled portion, poor sample recovery. Greyish pink to maroon coloured, incoherent, granular and clayey weathered gruss: relict K-feldspars + abundant quartz + kaolinite + minor haematite (in-fall from above).
6.00-7.00		Lower Saprolite to Saprock	Cored (**50 cm core loss**). >5% to >20% variably weathered, relict gneissic rock: clay + K-feldspar (pinks) + quartz, relict metamorphic texture & fabric well preserved, black MnOx stains + blotches + dendrites.
7.00-8.00		Saprock	(**70 cm core loss**). As per 6-7 m but more competent.
8.00-10.20		Saprock	Fractured gneiss, pink, some core loss. Strongly fractured, weathering alteration more highly developed along fractures, breccia-like clasts less affected.
10.20-12.50		Saprock	Fractured gneiss, pink, some core loss. As per interval above but with a larger spacing between fractures, some shearing observed.
12.50-12.80		Saprock	Fractured gneiss, pink, some core loss. Strongly fractured, FeOH weathering alteration well developed along fractures, breccia-like clasts partly affected.
12.80-13.05		Bedrock	Pink gneiss (Kenella Paragneiss). Dark to pale pink foliated, felsic: K-feldspar (pinks) + dark grey quartz + minor white mica + minor chlorite alteration (greenish).
13.05-13.45		Bedrock + saprock	As above but highly fractured and variably altered-weathered with FeOH + clay along fractures.
13.45-13.50		Bedrock	Pink gneiss (Kenella Paragneiss). Dark to pale pink foliated felsic rock: K-feldspar (pinks) + dark grey quartz + minor white mica + minor chlorite alteration (green), competent rock.
EOH			Logged & interpreted by M.J. Sheard

Background

This drillhole forms part of a limited exploration drilling program carried out for Tarcoola Gold Ltd in the latter half of 1988. Cores to all four of the EDD drillholes were later lodged with PIRSA's Drillcore Storage facility, however, RC samples from 15 drillholes within the same drilling program were not archived. Drillhole EDD-3 core provides the most complete regolith profile nearest to Benchmark 9 (Ian's Mine) and thereby forms an adjunct to that Benchmarked site.

In situ Regolith

Bedrock (<5% weathered): Kenella Paragneiss (12.80->13.5 m) comprises a dark to pale pink felsic gneiss containing the following minerals: K-feldspar (pinks) plagioclase (cream) + dark grey quartz + minor white mica + minor chlorite alteration (green) with poor to no compositional banding evident. Bedrock core is in most part competent although it is quite fractured (Figure 57). There is however, a weathering inversion to saprock between 13.05-13.45 and this may represent an altered fracture zone where weathering promoting meteoric water has penetrated. Stratigraphically the Kenella Paragneiss forms part of the larger Archaean Mulgathing Complex containing the Christie Gneiss + the Kenella Paragneiss + the mafic and ultramafic rocks of the Harris Greenstone Belt + the calc-alkaline Devil's Playground Volcanics + the syn-tectonic Glenloth Granite. Dating by a variety of methods (Swain *et al*., 2005) has demonstrated the following age constraints: 2488±130 Ma (Rb-Sr); 2600-2560 Ma (U–Pb zircon); 2530 Ma (Sm–Nd). Geochemical and petrographic evidence for this gneiss being a regionally metamorphosed sedimentary sequence is discussed in Swain *et al*. (2005). Mafic granulite bands and dykes occur throughout the Kenella Paragneiss in the Earea Dam locality (Crettenden and Fradd, 1992) but Benchmark 10 does not penetrate any of those lithotypes.

Saprock (>5% to <20% weathered): a zone of moderately weathered fractured paragneiss was intersected between >6.50-12.80 m. A relict gneissic rock consisting of brown clay + K-feldspar (pinks) + grey quartz, where relict metamorphic texture and fabric are well preserved. Generally the gneiss is reddish to pink, although some black MnOx stains to blotches and dendrites occur on fracture surfaces. Weathering alteration is more highly developed along fractures but the enclosed breccia clasts remain less affected. Some shearing occurs within this zone, and fracture spacing is quite variable.

Saprolite: (>20% weathered) this zone of highly weathered rock is relatively thin here (>5.00-~6.50 m) and is poorly represented by the RAB cuttings. Weathering has formed a pallid to multi-coloured zone of low competence dominated by kaolinite + quartz grit and/or fragments, all are derived from the Kenella Paragneiss. An indistinct boundary occurs between the upper saprolite and lower pedolith, a presentation that is not enhanced by RAB sampling over that interval.

Pedolith (extremely weathered): this upper regolith zone comprises three distinct horizons: 1. calcrete duricrust; + 2. clay-rich pedolith; + 3. arenose zone.

The calcrete duricrust is pale cream and forms a pervasive cement overprint to ferruginous fragments of yellow-brown pedolith (Plate 3), no primary texture or fabric is retained within those weathered *in situ* fragments. An upper horizon (0~0.50 m) or duricrust is mildly competent and was cored successfully but below that depth the material was too soft or crumbly for coring. Calcrete duricrust here exhibits a strong acid reaction to a 10% HCl solution.

Below the calcrete duricrust is a greyish pink carbonate impregnated clay-rich pedolith. This material is incoherent, and is variably granular to clay-rich, where earthy carbonate occurs throughout. RAB drilling with limited sample recovery negates the possibility for a more definitive allocation of this material into a plasmic zone or some other pedolith category. A strong to weak acid effervescent reaction to a 10% HCl solution was noted for this zone.

Underlying the clay-rich pedolith is a possible plasmic to arenose sub-zone consisting of greyish pink to maroon coloured, coherent to incoherent, chalky to clayey to granular, extremely weathered gruss. RAB drilling with limited sample recovery negates the possibility for a more detailed description. There was no effervescent reaction to the application of a 10% HCl solution.

Soil: no soil was recovered by the drilling process and none is described in the limited logging outlined in Crettenden and Fradd (1992).

Geochemistry

Limited sampling for geochemical assay has been undertaken, an extract from the review of operations provided by Crettenden and Fradd (1992) appears below in Table 27. Six of the associated 15 RC drillholes assayed for Tarcoola Gold Ltd also yielded anomalous Au values, they ranged between 1 to

36 ppm but high grade zones appear to be sporadic and of highly variable interval thickness. Gold is associated with quartz or haematite veining, or is disseminated within fractures in Kenella Paragneiss. No trace element or associated pathfinder elements are reported by Crettenden and Fradd (1992).

Table 27: Extracted Au assay data from Benchmark 10 (drillhole EDD-3) displaying significant Au intersections (after Crettenden and Fradd, 1992).

Depth from (m)	Depth to (m)	Interval (m)	Grade g/t Au	Lithology
1.50	3.00	1.50	0.08	gruss derived from felsic gneiss.
6.00	6.00	loose	1.20	loose haematite fallen [in] from above.
10.20	12.50	2.30	0.06	broken felsic gneiss & red clay; minor shears.

Old Well gold Prospect *(northern Central Gawler Gold Province)*

The Old Well gold prospect is located about 30 km SSE of Tarcoola and about 25 km WSW of Yerda Outstation and Yerda Well (Figures 34, 58). It was discovered after regional calcrete surveys had established a substantial Au anomaly. Subsequent infill sampling by MIM Exploration located an highly elongated N-S anomaly where Au occurred at >19 ppb extending over 4 km in a N-S direction to the southern boundary of their tenement ("Yerda-Old Well" EL 1823). Later work has established that this anomaly is the northern extension to a much larger anomaly (10-20 ppb, ~15 km in length) associated with the Tunkillia gold prospect to the south (Figure 59) and coincident with a large drainage feature that extends northwards from Tunkillia to Old Well and beyond. The area is semi arid with an average annual rainfall of ~170 mm and evaporation in excess of 3000 mm/a. Pearl blue bush (*Maireana sedifolia*) is prominent throughout the area and in places is the only substantial vegetation occurring on large open plains. Mulga (*Acacia eneura*) is mostly restricted to creek channels. Other vegetation includes: saltbush *Atriplex*, and small trees: *Melaleuca*, *Casuarina*, *Acacia*, and *Eremophila* spp. shrubs. Vegetation was used, in part, as a surrogate for construction of the Regolith map of Figure 60 (Gibbons, 1997; Lintern and Gibbons, 1998; Lintern, 2004b).

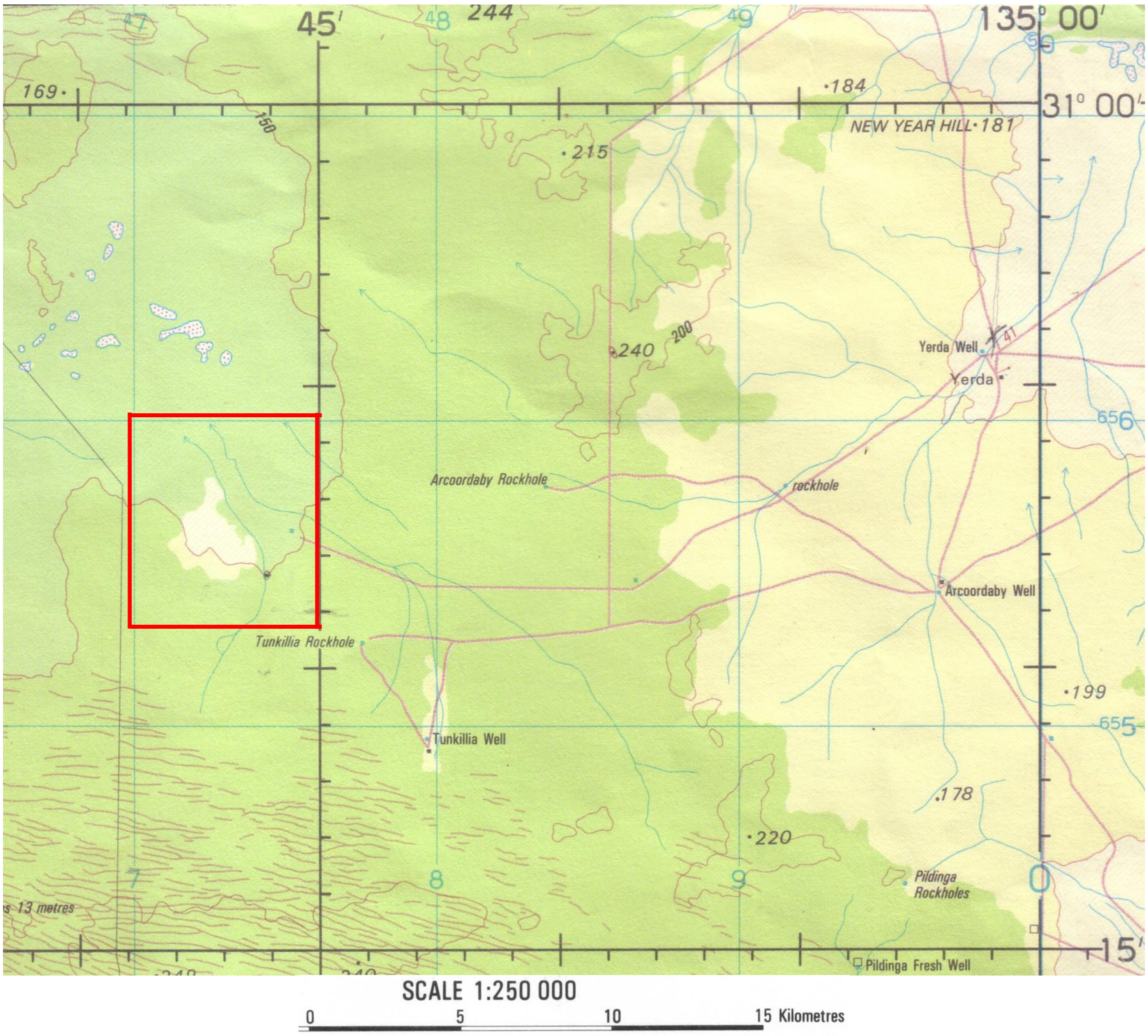


Figure 58: Locality map for Old Well prospect and the regolith study area (red box) of Gibbons (1997). Tunkillia Rockhole is near the SE corner of that boxed area; Yerda Outstation and Well are located in the map NE quadrant. [An extract from the CHILDARA 1:250,000 topographic-cadastral map sheet SH 53-14 (RASC, 1986)].

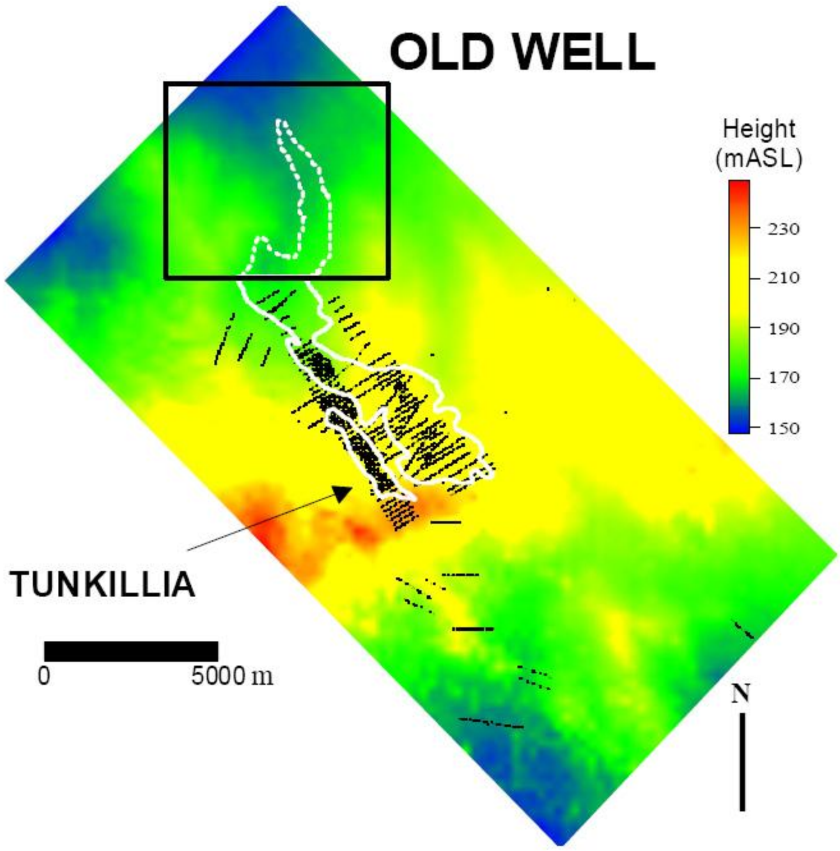


Figure 59: Local area DEM displaying topography over the Old Well gold prospect and study area of Gibbons, 1997 (boxed). Calcrete-Au anomalism (10-20 ppb) is outlined in white. Black lines and dots indicate the extensive exploration drilling at Tunkillia gold prospect.

Geological setting

Old Well is located in Quaternary alluvial sands and gravels, calcrete appears ubiquitous. The crystalline basement is Mesoproterozoic Hiltaba Suite granite, a mainly pink leucocratic medium- to coarse-grained biotite-granite or adamellite, porphyritic in places, with associated microgranite and aplite (Blissett, 1980a, b; Ferris and Fairclough, in prep. & 2007). The area has low relief with eroding remnants of variably weathered granite and a larger area of thin to thicker sequences of transported material (alluvium and colluvium). A modern ephemeral creek runs through the prospect, draining northwards and is coincident with the palaeodrainage topographic lows.

Mineralization

Immediately south of Old Well prospect the Tunkillia gold prospect contains 10.5 million tonnes grading 2.2 g/t for a calculated 750,000 oz Au reserve, but a more recent assessment of existing drill samples has indicated additional supergene Au of significance within the regolith, further exploration is attempting to increase the known reserves (Helix Resources, 2004). Gold mineralization at Old Well prospect remains sub-economic (Lintern, 2004b).

Regolith

Gibbons (1997) carried out regolith mapping at 1:20,000 scale using vegetation as a surrogate for surficial regolith features because the vegetation highlighted quite well different regolith materials. Eighteen regolith units were mapped out into terranes dominated by either erosional or depositional regimes, with the erosional units being mainly represented by remnant granite outcrops and low hills. Those features are summarised in the map (Figure 60) of Lintern (2004b). A series of 36 exploration drillholes (to 40-60 m deep; Figure 60) had been RAB drilled by MIM Exploration, delineating a series of anabranching palaeochannels, all alluvium-colluvium infilled (Figure 61). That drilling was supplemented by eight additional 6 m deep drillholes where careful siting, good sample recovery and low cross-hole contamination provided further details on the regolith regime at Old Well prospect (yellow numbered sites indicated on Figure 60). A series of soil pits (ave. depth ~0.6 m) provided additional detailed information on the near surface regolith horizons and better near surface vertical sample spacing (Gibbons, 1997; Lintern and Gibbons, 1998; Lintern, 2004b).

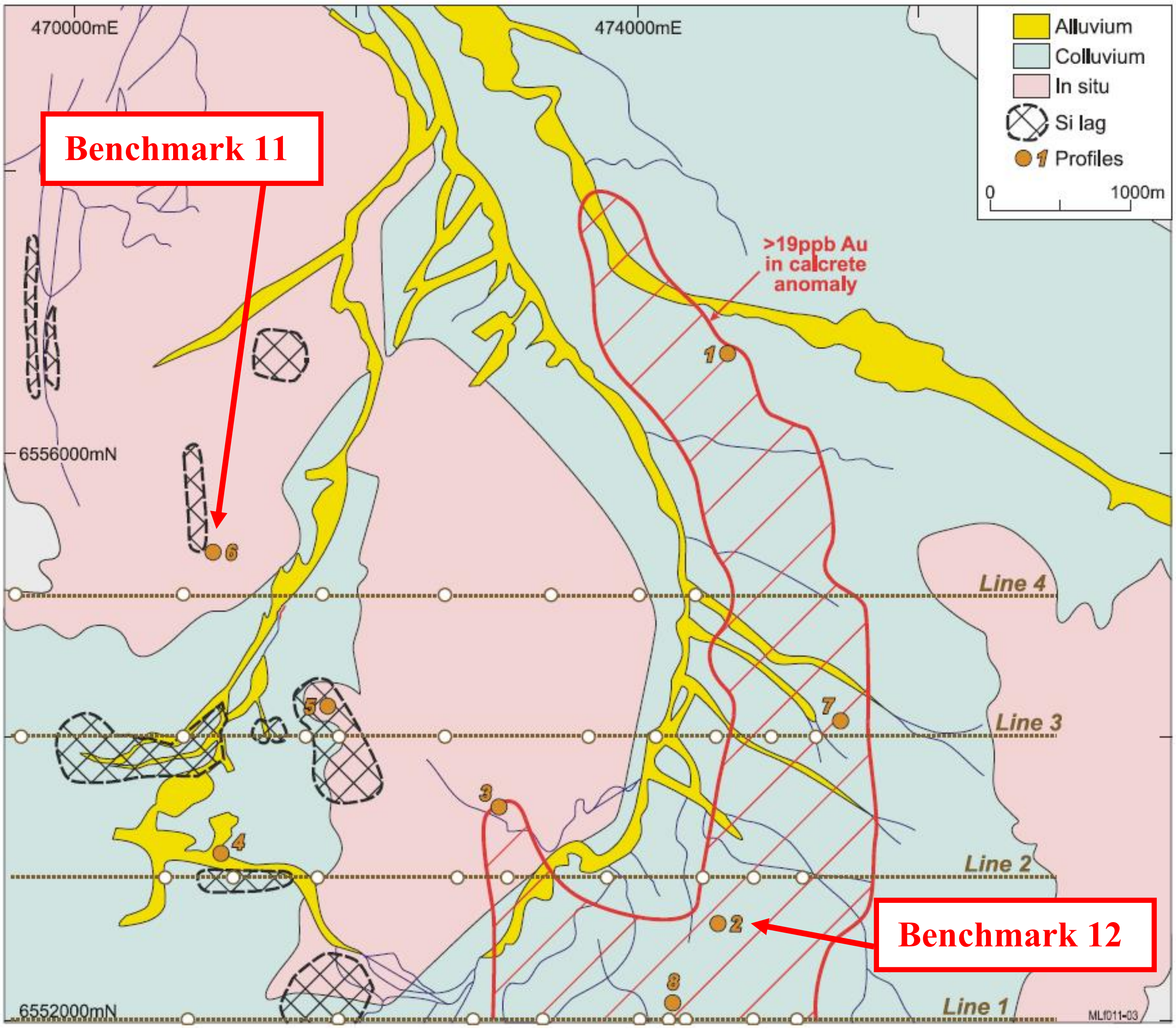


Figure 60: A summarised regolith map for Old Well gold prospect. Gold anomaly extent is courtesy of MIM Exploration (after Gibbons and Lintern, 1998). Yellow numbered solid circles are drillholes from Gibbons (1997) Honours Degree project. Benchmarks 11 and 12 (drillholes DH-6 and DH-2 respectively) are indicated. Regolith architecture and mineralization for MIM exploration drill lines 1-4 are shown in Figure 61.

The regolith architecture is variable but is generally composed of: 1. sandy clay soil (0-1 m), 2. calcrete (1-2 m), 3. ferruginous sands (0-15 m), 4. silcrete, including silicified weathered basement (0-5 m) and 5. saprolite after Hiltaba Suite granite. Unfortunately the deeper exploration drilling samples were not retained for long-term storage. However, the shallower drilling carried out for Gibbons (1997) project is available through the University of Adelaide, School of Earth and Environmental Sciences. Moreover, a subset of samples from two selected drillholes has been lodged for long-term storage at PIRSA's Drillcore Storage Facility as part of this report's Benchmarking process. They form Benchmarks 11 and 12 (see below).

Calcretes are heterogeneous and have prominent reddish and black staining in some samples. Many calcretes are siliceous with a distinctive pink colouration (similar features were noted for calcretes over the Challenger Gold Deposit, Lintern and Sheard, 1999; Mason and Mason 1998). Nodular, massive and laminar calcrete forms were observed but the vertical distribution of the different morphologies was not consistent between locations. Calcretes consist principally of low Mg calcite with no dolomite detected, but with some kaolinite and palygorskite present. SEM investigations revealed biological features in the calcrete, including bacterial filaments (Gibbons, 1997).

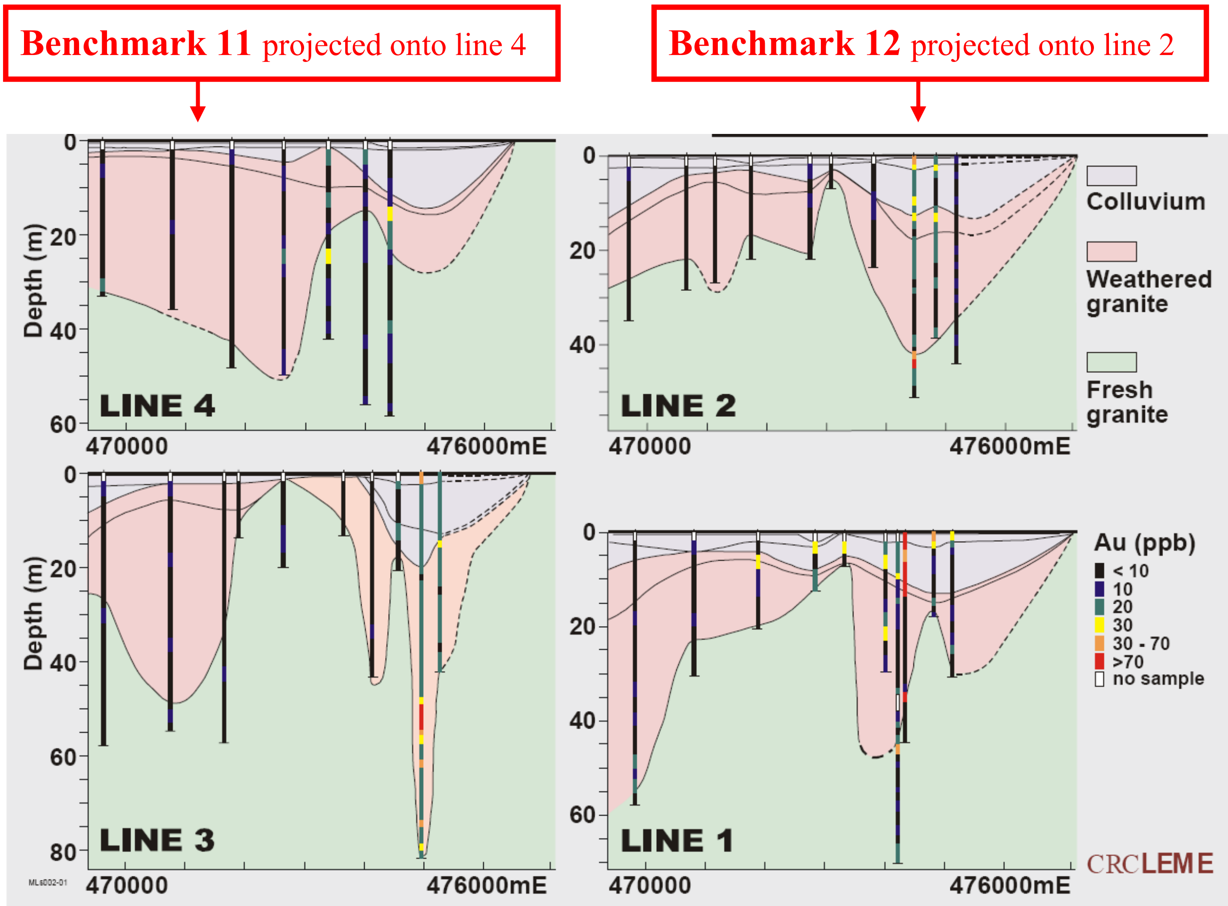


Figure 61: Regolith architecture and mineralization at Old Well gold prospect. For locations see Figure 60. Gold data courtesy of MIM Exploration (after Gibbons and Lintern, 1998).

Geochemical expression

Despite the areal extent of the calcrete Au anomaly, the mineralization to date is sub-economic at Old Well (Figure 61). A strong association between Au and Ca was observed within the soil pit profiles, although other Au maxima occur in sediments not associated with Ca (Figure 62). For example, at location 8, significant Au concentrations (>100 ppb) occur in consolidated ferruginous sand. Features of the large regional Au-in-calcrete anomaly (enclosed by the >19 ppb Au contour) at Old Well are that (i) it is located within the consolidated sands of the transported regolith, (ii) its longitudinal shape parallels the current drainage [and palaeodrainage], and (iii) underlying weak bedrock mineralization is sporadically present but is not necessarily related to the anomaly (Lintern, 2004b).

The results suggest that a Au source for this large calcrete Au anomaly is from outside the studied area of Gibbons (1997). The Old Well Au anomaly is part of a much larger anomaly associated with the Tunkillia gold prospect, upslope to the south, and may be related to: (i) detrital and/or chemical Au dispersion from a general source area, such as Tunkillia and/or (ii) a more local source within the N-S trending mineralized system, following the axis of palaeodrainage valleys and being concentrated within them. The very high Au concentrations (>100 ppb) in individual samples taken from Old Well prospect suggest a more local source overprint to the general dispersion train (Gibbons, 1997; Lintern and Gibbons, 1998; Lintern, 2004b). Lane and Worrall (2002) have postulated a similar scenario for Au dispersion northwards from the Tunkillia gold prospect, via palaeodrainage and associated groundwaters, to form a highly elongated (>15 km long) Au-in-calcrete anomaly hosted primarily by transported regolith and is mostly unrelated to the underlying weathered *in situ* and unweathered basement.

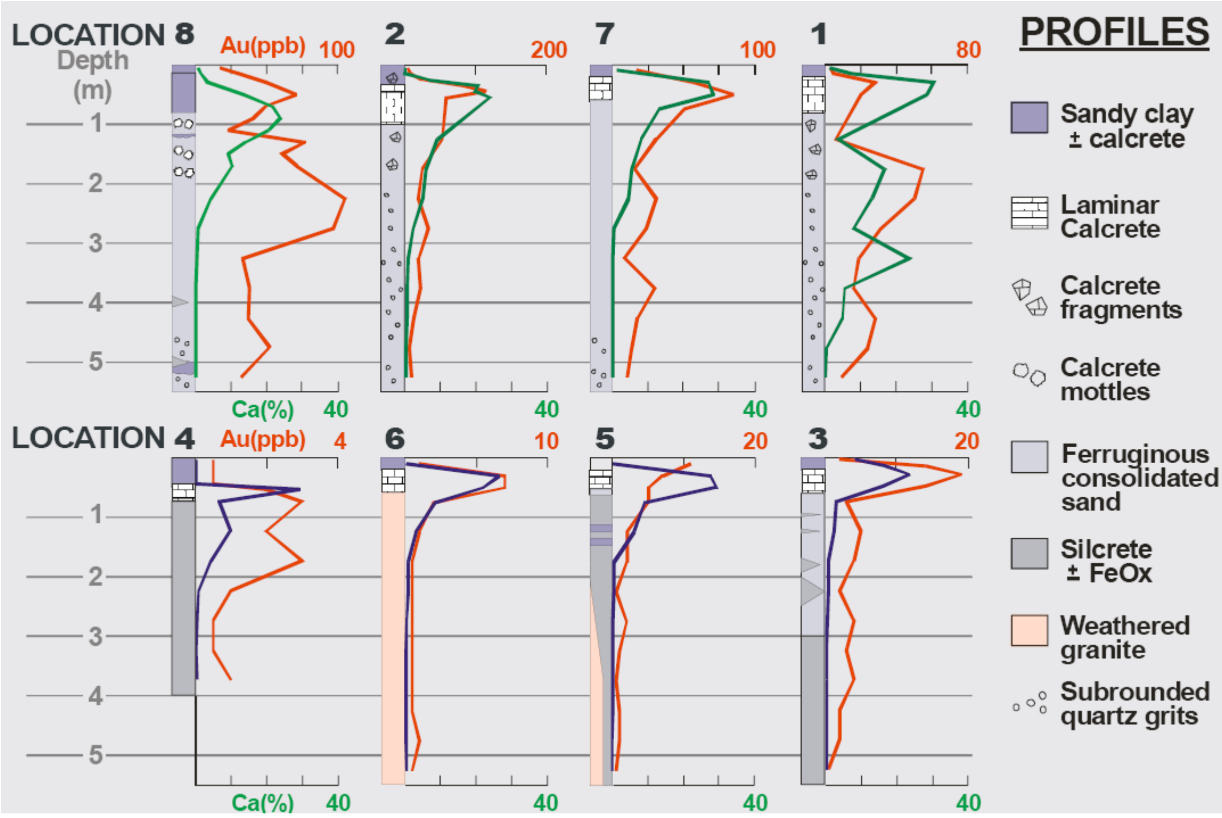


Figure 62: Gold and Ca distribution down profile to 5.5 m for the eight sites at Old Well prospect investigated by Gibbons (1997). Regolith architecture for each site is indicated by the graphic logs Locations are indicated on Figure 60. Site 6 (in weathered *in situ* regolith) is Benchmark 11, Site 2 (in transported regolith) is Benchmark 12.

Benchmark 11, drillhole DH-6 (drill cuttings)

Quick reference items are set out in Table 28; detailed descriptions, figures and data tables follow on below. This site, occurs ~30 km SSE of Tarcoola (Figures 1, 34, 58-60). Access is via pastoral tracks from Yerda Outstation towards the Tunkillia gold prospect. Drill sample profile data indicating key regolith features + lithology + mineralogy and photographs are provided in Figure 63. Interpreted geochemical data are presented in Figures 62, 64, Table 29.

Table 28: Benchmark 11 reference data, drillhole DH-6 (Type 2 drill cuttings).

Items	Figures, Data, Sources
Regional location map	Figures 1, 34, 58.
Local-site location map	Figures 59, 60.
GPS coordinates, attitude & elevation	Zone 53, 0471128 E, 6555522 N, GDA 94. Vertical. **AHD:** ~150 m (estimated from survey map data).
Site access, owner	Site is on the Wilgena Pastoral Station, ~30 km SSE of Tarcoola, ~60 km WSW of Kingoonya, and about 25 km WSW of Yerda Outstation and Yerda Well.
Related drillholes & site	Benchmark 12 (DH-2) + Sites DH-1 to 8 of Gibbons (1997) + MIM Exploration EL 1823 drilling (RAB holes YRL 1-273).
Photos + logs	Yes, Figure 63.
Sample types	RAB cuttings (chiptrays only).
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE; and University of Adelaide, School of Earth & Environmental Sciences, Mawson Building.
Lithotypes	Weathered to bedrock, Hiltaba Suite granite, + fluvial sediment.
Petrology	Yes (Gibbons, 1997).
Geochemistry	Yes, Figures 62, 64, Table 29.
XRD mineralogy	No, but some SEM work is available in Gibbons (1997).
PIMA spectral data	No.
Dating	Yes, Hiltaba Suite granite, Arcoordaby Rockhole (Figure 58, NE corner), 1574 ± 5 Ma (Fanning *et al*., 2007).
Target Elements	Au.
Potential Pathfinder Elements	Ag, ?Cu.
Useful sampling media	Calcrete, transported regolith-soil where <5 m thick.
Key reference sources	Gibbons, 1997; Gibbons and Lintern, 1998; Lintern, 2004b.

Background

This drillhole forms part of a smaller follow-up drilling program carried out by MIM Exploration to aid research by Gibbons (1997) into Au dispersion within the regolith. Cuttings in chiptrays to all eight of those DH site drillholes were lodged with the University of Adelaide, School of Earth & Environmental Sciences. Moreover, a sub-set of cuttings from drillholes DH-6 and DH-2 has subsequently been lodged with PIRSA's Drillcore Storage Facility. RAB samples from the earlier MIM Exploration drilling program of 35 deeper drillholes along four drill sections (in the same area) have not been archived and their whereabouts is uncertain.

These drill cuttings provide a snap-shot overview of near surface regolith to 5.5 m in weathered Hiltaba Suite granite terrain.

In situ Regolith

Bedrock (<5% weathered): is not penetrated by this short drillhole but it does cropout at nearby Tunkillia Rockhole (Hiltaba Suite granite) ~4 km SE of Old Well prospect centroid (Figure 58).

Saprolite (>20% weathered): Benchmark 11 penetrates upper and perhaps some lower saprolite but fragments of saprock also indicate the presence of less weathered corestones. However, the deeper exploration drilling logs indicate that the weathered zone penetrates to ~35 m near this site.

Surrounding Benchmark 11 saprolite crops out sporadically but is typically mantled by calcrete ± silcrete ± lags and ± thin sandy soil. Weathering of Hiltaba Suite granite has formed saprolite dominated by kaolinite + quartz grit + variable orange to brown FeOH staining, and with variable degrees of silicification to silcrete.

Transported Regolith

A very thin aeolian sand lightly covers parts of the terrain here. Calcrete nodules and pisoliths have developed within those sands. Lags of fragmentary silcrete, silicified saprolite and vein quartz are also scattered about the landscape.

0.0-0.5 m: orange aeolian quartz sand, fine- to medium-grained, well sorted, loose + pinkish pisolithic + nodular calcrete; acid reaction = high.
0.5-1.0 m: near white + greyish + pinkish calcrete, massive & laminar, impregnates pallid saprolite; acid reaction = high.
1.0-1.5 m: pale yellowish pink to pale pink saprolite after granite, silicified, acid reaction = trace.
1.5-2.0 m: yellowish saprolite after granite, variably silicified, relict granitic texture; acid reaction = nil.
2.0-2.5 m: yellowish saprolite after granite, kaolinite + quartz grit, relict granitic texture.
2.5-3.0 m: yellowish saprolite after granite, kaolinite + quartz grit, relict granitic texture, variably silicified.
3.0-3.5 m: pallid saprolite after granite, kaolinite + quartz grit + black MnOx flecks & dendrites, relict granitic texture.
3.5-4.0 m: pallid & yellowish saprolite after granite, kaolinite + quartz grit, silicified to silcrete, relict granitic texture.
4.0-4.5 m: pallid & yellowish saprolite after granite, kaolinite + quartz grit, variably silicified, relict granitic texture.
4.5-5.0 m: pinkish & yellowish saprolite + saprock fragments (core stones), variably silicified, weathered granitic.
5.0-5.5 m: pinkish & yellowish saprolite + saprock fragments (core stones), variably silicified, weathered granitic. Logged by M.J. Sheard & L. Gibbons.

Figure 63: Benchmark 11, (drillhole DH-6) chiptray photo and regolith log. This site has minimal transported cover (<0.5 m). Note that the weathered *in situ* regolith has been truncated by erosion, the pre-calcrete pedolith zone is missing.

Geochemistry

Assay data from the drill samples and associated soil pit samples demonstrates that Au peaks within the soil calcrete horizon (Figures 62, 64, Table 29). Calcium and Mg also peak within that horizon, whereas Fe, Mn, As and Pb are reduced in the same interval. The elevated Cu values within calcrete may reflect association with the Au, possibly as a pH buffered chelated complex. Compare this profile with the sedimentary version of Benchmark 12.

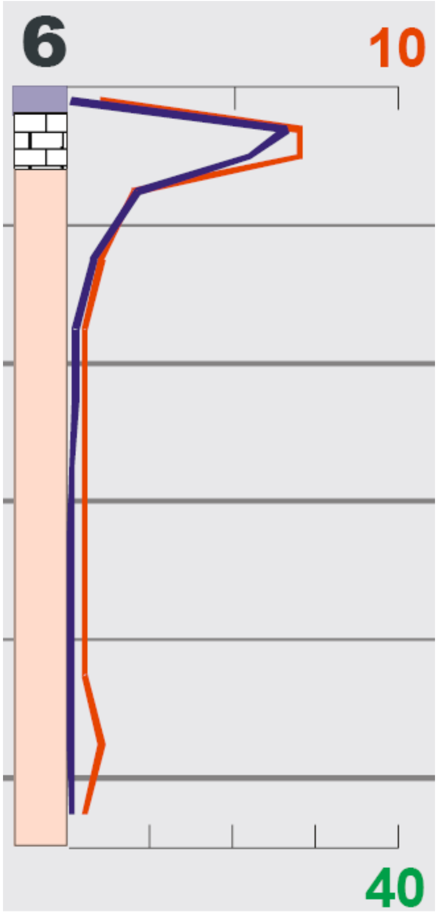


Figure 64: Benchmark 11 (DH-6) down hole graphic log and simplified geochemistry (refer to Figure 62 for symbol key). A strong association between Au and Ca is developed within this mostly weathered *in situ* profile. Note that Au is at relatively low concentrations here. Gold (red) in ppb, Ca (blue) in ppm, depth as one metre increments is marked by horizontal black lines.

Table 29: Benchmark 11 (drillhole DH-6) assay values for nine selected elements from the 51 assayed for Gibbons (1997) investigations. The detail in the 0.0 to 0.6 m interval involves samples from an adjacent soil pit.

Depth m	Au ppb	Ca ppm	Fe ppm	Mg ppm	Mn ppm	Cu ppm	As ppm	Pb ppm	S ppm
0.0-0.2	1	2250	10900	1300	105	7.5	1.5	18	<500
0.2-0.4	6	268000	5500	15100	40	29.5	2	8	900
0.4-0.6	4	251000	7050	12200	50	23.5	4	6	1100
0.5-1.0	2	84600	10700	15000	55	13	6	15	6350
1.0-1.5	1	30200	12500	4450	70	8.5	10.5	21.5	11700
1.5-2.0	0.5	8500	22300	2450	140	11.5	15.5	32.5	2000
2.0-2.5	0.5	7850	22500	2100	170	8.5	10	32	750
2.5-3.0	0.5	4300	23000	1550	185	7.5	2	34	500
3.0-3.5	0.5	4050	25500	1550	220	7.5	2	34.5	550
3.5-4.0	0.5	3300	22400	1300	165	9	1.5	42.5	<500
4.0-4.5	0.5	3800	21800	1150	160	5.5	3	48	500
4.5-5.0	1	3900	22000	1350	170	6.5	1	44	550
5.0-5.5	0.5	4350	30200	1800	120	8.5	3	34	500

Benchmark 12, drillhole DH-2 (drill cuttings)

Quick reference items are set out in Table 30; detailed descriptions, figures and data tables follow on below. This site, occurs ~30 km SSE of Tarcoola (Figures 1, 34, 58-60). Access is via pastoral tracks from Yerda Outstation towards the Tunkillia gold prospect. Drill sample profile data indicating key regolith features + lithology + mineralogy and photographs are provided in Figure 65. Interpreted geochemical data are presented in Figures 62, 66, Table 31.

Table 30: Benchmark 12 reference data, drillhole DH-2 (Type 2 drill cuttings).

Items	Figures, Data, Sources
Regional location map	Figures 1, 34, 58.
Local-site location map	Figures 59, 60.
GPS coordinates, attitude & elevation	Zone 53, 0474628 E, 6552921 N, GDA 94. Vertical. **AHD:** ~153 m (estimated from survey map data).
Site access, owner	Site is ~30 km SSE of Tarcoola, ~60 km WSW of Kingoonya, and about 25 km WSW of Yerda Outstation and Yerda Well, on the Wilgena Pastoral Station.
Related drillholes & site	Benchmark 11 (DH-6) + Sites DH-1 to 8 of Gibbons (1997) + MIM Exploration EL 1823 drilling (RAB holes YRL 1-273).
Photos + logs	Yes, Figure 65.
Sample types	RAB cuttings (chiptrays only).
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE; and University of Adelaide, School of Earth & Environmental Sciences, Mawson Building.
Lithotypes	Weathered to bedrock, Hiltaba Suite granite, + fluvial sediment.
Petrology	Yes (Gibbons, 1997).
Geochemistry	Yes, Figures 62, 66, Table 31.
XRD mineralogy	No, but some SEM work is available in Gibbons (1997).
PIMA spectral data	No.
Dating	Yes, Hiltaba Suite granite, Arcoordaby Rockhole (Figure 58, NE corner), 1574 ± 5 Ma (Fanning *et al.*, 2007).
Target Elements	Au.
Potential Pathfinder Elements	Ag, ?Cu.
Useful sampling media	Calcrete, transported regolith-soil where <5 m thick.
Key reference sources	Gibbons, 1997; Gibbons and Lintern, 1998; Lintern, 2004b.

Background

This drillhole forms part of a smaller follow-up drilling program carried out by MIM Exploration to aid research by Gibbons (1997) into Au dispersion within the regolith. Cuttings in chiptrays to all eight of those DH site drillholes were lodged with the University of Adelaide, School of Earth & Environmental Sciences. Moreover, a sub-set of cuttings from drillholes DH-2 and DH-6 has subsequently been lodged with PIRSA's Drillcore Storage Facility. RAB samples from the earlier MIM Exploration drilling program of 35 deeper drillholes along four drill sections (in the same area) have not been archived and their whereabouts is uncertain.

These drill cuttings provide a snap-shot overview of near surface regolith to 5.5 m in weathered Hiltaba Suite granite terrain.

Transported Regolith

Benchmark 12 only penetrates transported materials. The associated deeper exploration drilling indicates transported materials persist to at least 12 m (Figure 61). A very thin sandy soil with a possible aeolian sand input covers parts of this terrain; the sandy mix is poorly sorted. Underlying the soil is a thicker sequence of fluvial sediment consisting of quartz sand (mostly medium- to coarse-grained) and some occasional fine-grained gravel. Calcrete (platy to massive and laminar) has formed within the upper 1-1.5 m but amorphous calcite also occurs lower in the sequence. Silicification has developed below 1.5 m and in places achieves a solid silcrete horizon, where fine lamellae in the sands are preserved. Broader scale sedimentary structures cannot be detected from the drill cuttings.

0.0-0.5 m: thin reddish coarse-grained sandy soil, with possible fine-grained aeolian sand input (soil not well recovered) + abundant pale pinkish platy calcrete impregnating fluvial sand; acid reaction = high.

0.5-1.0 m: abundant pale pink calcrete, platy-massive to laminar, impregnates coarse-grained fluvial sand; acid reaction = high.

1.0-1.5 m: as above + dark reddish FeOx cemented fluvial quartz sand, medium- to coarse-grained; acid reaction = high.

1.5-2.0 m: dark reddish FeOx cemented fluvial quartz sand, medium- to coarse-grained, has silicified bands (silcrete); acid reaction = nil.

2.0-2.5 m: dark reddish FeOx cemented fluvial quartz sand, coarse-grained, has calcite & silicified bands; acid reaction = high.

2.5-3.0 m: reddish FeOx cemented fluvial quartz sand, medium- to coarse-grained + fine-grained gravel, silicified bands; acid reaction = nil.

3.0-3.5 m: dark reddish FeOx cemented fluvial quartz sand, coarse-grained, has calcite & silicified bands; acid reaction = high.

3.5-4.0 m: reddish & dark reddish FeOx cemented fluvial quartz sand, fine- to medium-grained, has silicified bands; acid reaction = nil.

4.0-4.5 m: reddish & dark reddish FeOx cemented fluvial quartz sand, fine- to medium-grained, has variably silicified bands.;

4.5-5.0 m: reddish & dark reddish FeOx cemented fluvial quartz sand, fine- to coarse-grained, has variably silicified bands.

5.0-5.5 m: reddish & dark reddish FeOx cemented fluvial quartz sand, fine- to coarse-grained, has variably silicified bands.

Logged by M.J. Sheard & L. Gibbons.

Figure 65: Benchmark 12 (drillhole DH-2) chiptray photo and regolith log. This site has significant transported cover (~12 m, as revealed by earlier exploration drilling, see Figure 61).

Geochemistry

Assay data from the drill cuttings and associated soil pit samples demonstrate that Au peaks within the soil calcrete horizon (Figures 62, 66, Table 31). Calcium peaks within the same horizon but Mg does not; whereas Fe is approximately halved over the same interval. Manganese, As and Pb on the other hand are more erratically dispersed throughout the whole profile (*c.f.* Benchmark 11). Copper values within the calcrete horizon are lower than below it and may indicate at this site that Cu is not dispersed by the same process that typically mobilises Au in an alkaline environment (*i.e.* as a pH buffered chelated complex; *c.f.* Benchmark 11).

The Old Well gold prospect case study by Gibbons (1997) is important in that it demonstrates just how far some Au dispersal trains can move away from their primary source mineralization. It also amply demonstrates the importance of detailed regolith mapping in delineating regolith regimes (relict, erosional, depositional) prior to doing any costly detailed drilling. Overlaying the regional Au-in-calcrete geochemistry onto a Regolith Landform Map (like that of Gibbons, 1997) by the tenement holder would have revealed a strong potential for the higher Au values to be false highs and indicative of dispersed Au from a source outside the tenement.

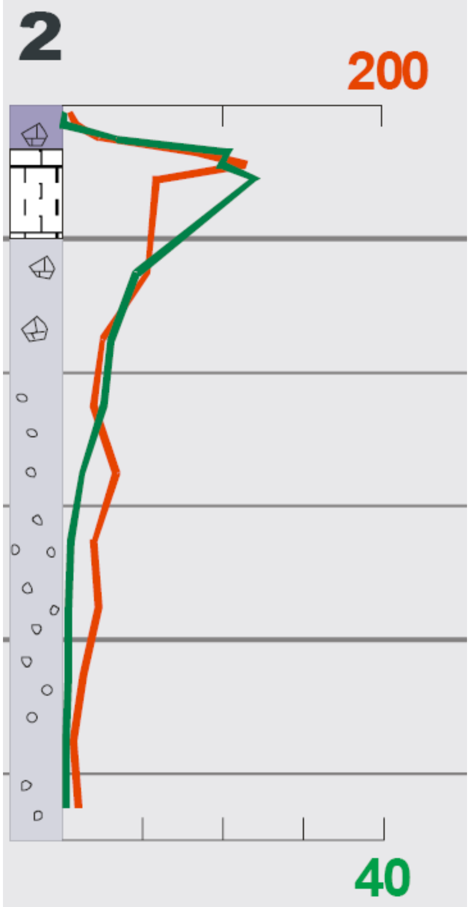


Figure 66: Benchmark 12 (drillhole DH-2) down hole graphic log and simplified geochemistry (refer to Figure 62 for symbol key). A wholly transported profile displaying a strong association between Au and Ca, developed mostly within the carbonate-rich horizon; although lower levels persist to the end of hole. Note that Au is at quite high concentrations in the top metre. Gold (red) in ppb, Ca (blue) in ppm, depth as one metre increments is marked by horizontal black lines.

Table 31: Benchmark 12 (drillhole DH-2) assay values for nine selected elements from the 51 assayed for Gibbons (1997) investigations. The detail in 0.0 to 0.5 m involves samples from an adjacent soil pit.

Depth m	Au ppb	Ca ppm	Fe ppm	Mg ppm	Mn ppm	Cu ppm	As ppm	Pb ppm	S ppm
0.0-0.1	3	2000	14600	1650	180	10	1.5	8.5	<500
0.1-0.2	8	1250	9250	1300	110	11	1	5.5	<500
0.2-0.3	110	214000	10900	7000	115	15	2	6	900
0.3-0.4	51	261000	7350	5750	105	11	2.5	10	950
0.4-0.5	58	284000	6450	6100	145	10	2.5	4	1000
0.5-1.0	60	192000	11300	9250	55	16	4	8	1150
1.0-1.5	53	93000	19500	9350	110	17.5	3.5	24.5	900
1.5-2.0	25	60300	24200	7950	185	16	5.5	17	700
2.0-2.5	19	51100	23300	8100	175	15	2.5	13	<500
2.5-3.0	34	24000	30000	7600	135	18.5	4.5	17.5	<500
3.0-3.5	20	10400	35200	6800	120	19.5	5.5	18	<500
3.5-4.0	22	7550	31100	4750	95	21	6.5	15.5	<500
4.0-4.5	13	6550	29300	3600	85	16.5	5.5	13.5	<500
4.5-5.0	7	4850	30700	3850	90	15.5	5.5	15.5	<500
5.0-5.5	10	3550	31400	3800	95	16	6	18.5	<500

Eyre Peninsula *(southern Central Gawler Gold Province)*

On northwestern Eyre Peninsula a number of gold prospects are enclosed by the Central Gawler Gold Province' southern boundary, as proposed by Ferris and Schwarz (2003), (Figures 34, 67). They include Barns, Baggy Green, Weednanna, White Tank, Belmont and Red Rag gold prospects, located north of the Eyre Highway and the towns of Wudinna and Kimba. Gold deposits occur within deformed Palaeoproterozoic crystalline rocks and their contacts with intrusive Mesoproterozoic Hiltaba Suite granites. Most of those rocks are commonly deeply weathered and are in large part covered by <1 to >35 m of Cainozoic fluvial and/or aeolian sediment. Descriptions along with Benchmarks for the adjoining Barns and Baggy Green gold prospects and surrounds are set out below.

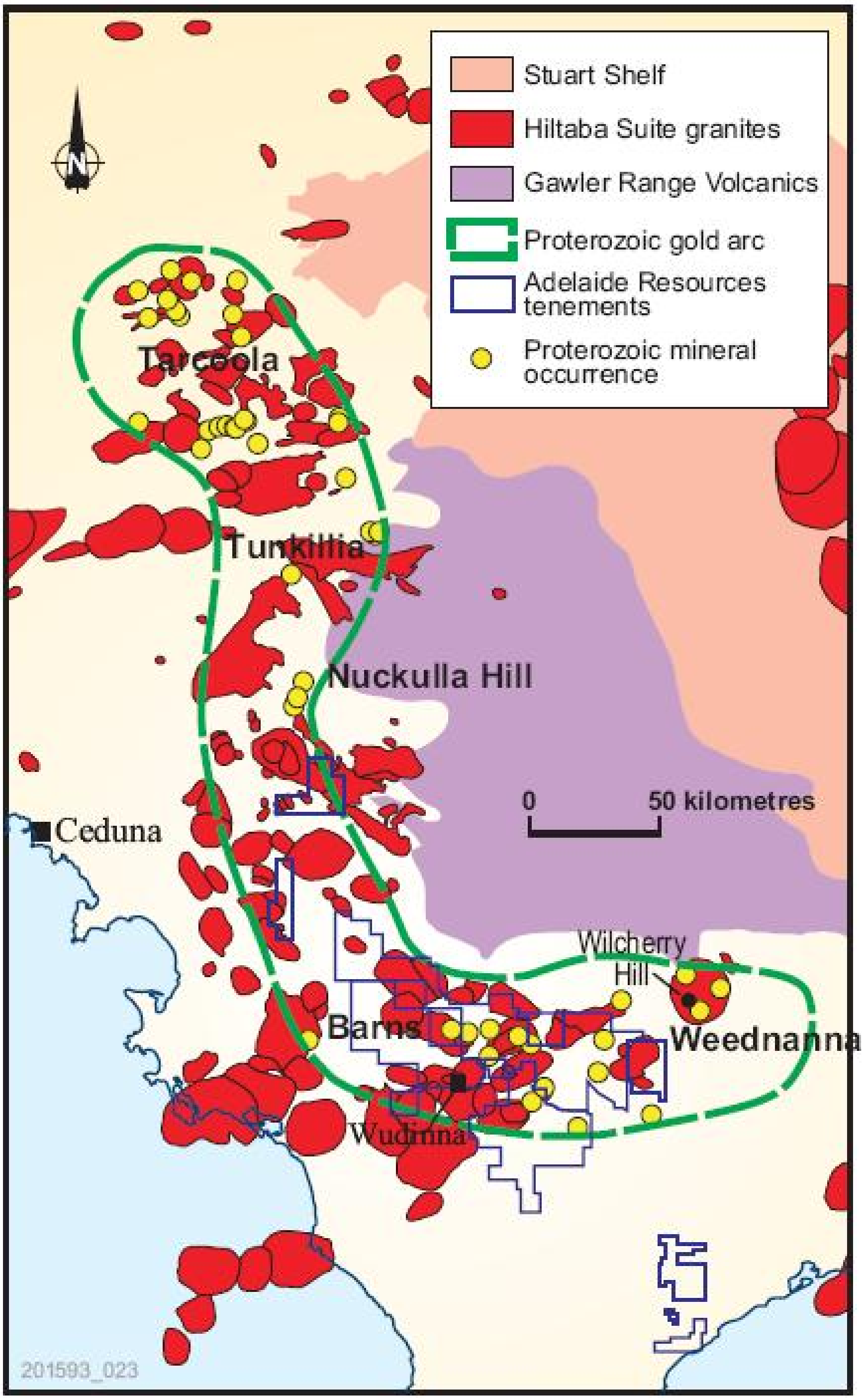


Figure 67: Location of the Proterozoic Central Gawler Gold Province, Hiltaba Suite granite plutons, gold mineralization and named deposits-prospects. An E-W trend in the otherwise ~N-S defined gold mineralization trend is apparent S of Ceduna towards Wilcherry Hill at the northern end of Eyre Peninsula (Drown, 2003).

Barns & Baggy Green gold prospects

Background

The adjoining Barns and Baggy Green gold prospects are ~5 km apart and are located ~25 km N of Wudinna and ~100 km WNW of Kimba on the YARDEA 1:250,000 map area where additional geological detail is available via the Cacuppa and Minnipa 1:100,000 sheets (Blissett *et al*., 1988a, b, c; Parker and Flint, 2005) and from the *PIRSA SA_Geology* digital database. Prospect access is via gazetted unsealed roads N of the Eyre Highway, and via Park or farm tracks (Figures 67, 68). Barns gold prospect is on privately owned agricultural land but some of its Au-in-calcrete anomalism extends N towards the Gawler Ranges National Park. However, all of the Baggy Green gold prospect is located within the Pinkawillinie Conservation Park.

Since the 1980's, substantial parts of the region have been set aside as natural history conserving parks, they include: Gawler Ranges National Park and Pinkawillinie Conservation Park (Figure 68). Access to those areas for scientific research requires notification and permission from the Department of Water, Land and Biodiversity Conservation – National Parks and Wildlife Service SA. The natural history of the region is described in Twidale and Campbell (1985).

Until recently previous mapping had recorded few exposures of crystalline basement S of the Gawler Ranges, where dominantly aeolian cover obscures the bedrock. However, recent regolith mapping at 1:20,000 scale by Sheard (2007a, b) has recognised additional weathered basement in outcrop, and thereby, has increased the total surficial basement area (weathered + incipiently weathered) by about four times to ~35%.

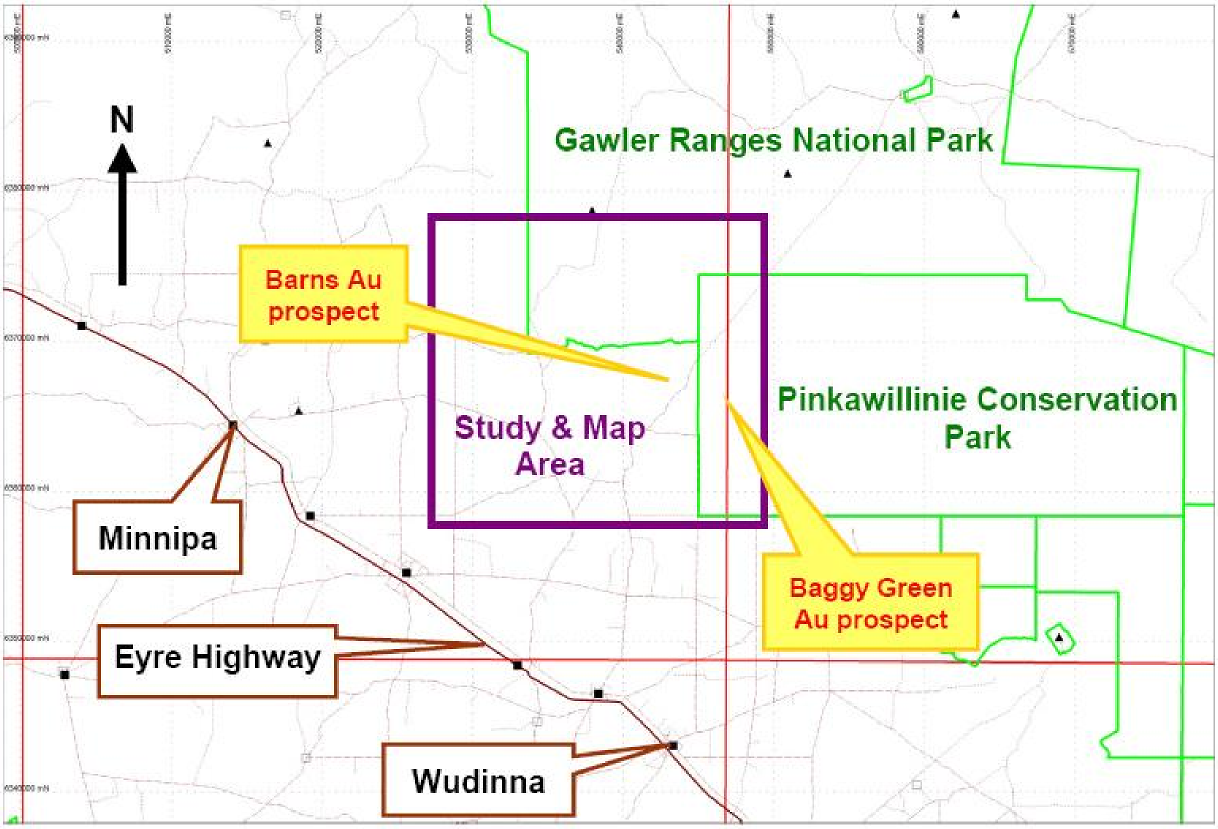


Figure 68: Wudinna to Minnipa, Eyre Highway and northern area. Regional Parks (green boundary), the Regolith Landform Map and Study Area of Sheard (2007a, b) are boxed in purple, and the Barns + Baggy Green gold prospects are highlighted.

Sampling and drilling by Adelaide Resources Ltd has delineated additional Au mineralization at a number of locations east of their initial Barns prospect Au discovery (White Tank prospect, Baggy Green prospect, Belmont zone, Red Rag prospect). This and earlier work N and E of Wudinna has indicated that an area of about 65 x 20 km hosts clustered Au anomalism that warrants further exploration (Adelaide Resources Ltd, 2003, 2004).

Barns and Baggy Green prospects have many geological, regolith and landform attributes in common, they are located only 5 km apart, and both present similar exploration challenges. Therefore herein they will be described together and their representative Benchmarks form a broader set than for other sites described earlier.

Geology

Recent accounts of the crystalline basement for northern Eyre Peninsula and the Wudinna district are given in Drexel *et al*. (1993), Schwarz, *et al*. (2002), Drown (2002, 2003), Fairclough and Schwarz (2003), Ferris and Schwarz (2003), plus Parker and Flint (2005). Descriptions of the regional transported cover sediments are provided in Twidale and Campbell (1985), Parker *et al*. (1985), Drexel and Preiss (1995), Parker and Flint (2005) and Sheard (2007a, b).

Crystalline basement in the Wudinna area includes the following broad lithic-terranes: high metamorphic grade polydeformed Archaean Sleaford Complex, and Palaeoproterozoic Tunkillia Suite orthogneiss (granitic-granodiorite) dominate the central and eastern parts; while less deformed Mesoproterozoic Hiltaba Suite granite and Gawler Range Volcanics dominate the western and northern parts respectively (Figure 69). Hiltaba Suite granitic plutons intrude the Tunkillia Suite but contacts are not exposed in this area. Meta-dolerite dykes and quartz vein stockworks of uncertain age also intrude or cross-cut the crystalline basement rocks.

Granite, as outcropping tors and whaleback inselbergs protrude the transported and eroding deeply weathered cover sequence in this region, most are Hiltaba Suite granite but a few of the smaller features are composed of deformed Tunkillia Suite granitoid. A number of these prominent outcrops have Native—cultural and/or tourist significance.

Previously recognised and named transported cover materials, with their geo-map symbols in brackets, include: Palaeogene to Neogene [Tertiary] – Garford Fm. equivalent (Tig); Quaternary – Moornaba Sand (Qhem), Pooraka Fm (Qpap); ?reworked Bridgewater Fm. or ?Wiabuna Fm. equivalent (Qpew); Bakara and/or Ripon Calcrete (Qpca) [the latter two names are now obsolete] (Blissett *et al*., 1988a ; Parker and Flint, 2005). Other previously recognised but un-named transported cover items include the following: Palaeogene to Neogene [Tertiary] – “terrazzo” style silcrete (Tsi_1, Tsi_2, TmQ_{Si1}); ferruginous cementation in the Garford Fm. equivalent (T_{fe}); and cavernous, rubbly ferruginous laterite (TmQ_{fe3}). For the Quaternary – saline and gypsiferous playa lake deposits (Ql_1); aeolian quartz sand dunes + sand spreads (Qhe_2); aeolian gypsiferous sand dunes fringing playa lakes (Qhe_4); brownish sand spreads around playa lakes (Qhe_5); thin reddish brown loamy sand containing Bakara Calcrete nodules (Qpr_4) (Blissett *et al*., 1988a; Parker and Flint, 2005).

Mineralization

Exploration for base and precious metals over the northern Eyre Peninsula, and in particular, the Wudinna district was unknown until the adoption of gold-in-calcrete methodology during the early 1990’s in South Australia (Lintern, 2004b; Drown, 2002, 2003). In 1998, Newcrest Mining Ltd defined a broad gold-in-calcrete anomaly on their tenement (Exploration Licence 2845) ~25 km north of Wudinna (later named “Barns prospect”; Figures 70, 71) with a peak Au value at 31 ppb. This anomaly had surface dimensions of 4.5 x 1.5 km, and in late 1999, Adelaide Resources Ltd acquired that tenement.

Barns prospect Au anomaly and associated mineralization had been drill tested by 2002, demonstrating significant Au intersections over an area ~700 x 700 m (Figures 70, 71; depth range 31-158 m; intersections of 2-35.5 m but typically 8-16 m; Au grades ranged between 1-67.6 g/t where 1.5-4 g/t were more common; Drown, 2002, 2003). Gold mineralization is enclosed by a defined envelope of extensively hydrothermally altered Tunkillia Suite orthogneiss. Distal propylitic alteration involves assemblages of: albite-chlorite-epidote-haematite with unaltered K-feldspar + quartz. Mineralization proximal phyllic alteration involves assemblages of: sericite (after K-feldspar and biotite) + pyrite, with recrystallised quartz. Mineralized veins are narrow, occur near the core of alteration, and include assemblages of: quartz + pyrite + sericite with traces of chalcopyrite, galena, sphalerite, fluorite, epidote, and native gold. Late stage reactivation of structures has involved prehnite deposition along vein margins and brittle fractures (Drown, 2003). Spectral logging of drill core has also demonstrated that elevated Au mineralization (>100 ppb) is associated with increased white micas (sericite) content and significantly lesser amounts of chlorite. High Au values correspond with white mica-rich zones, having a phengitic composition relative to muscovite (Keeling *et al*., 2004). Further exploration and drilling has defined a similar mineralization style ~5 km E at the Baggy Green gold prospect.

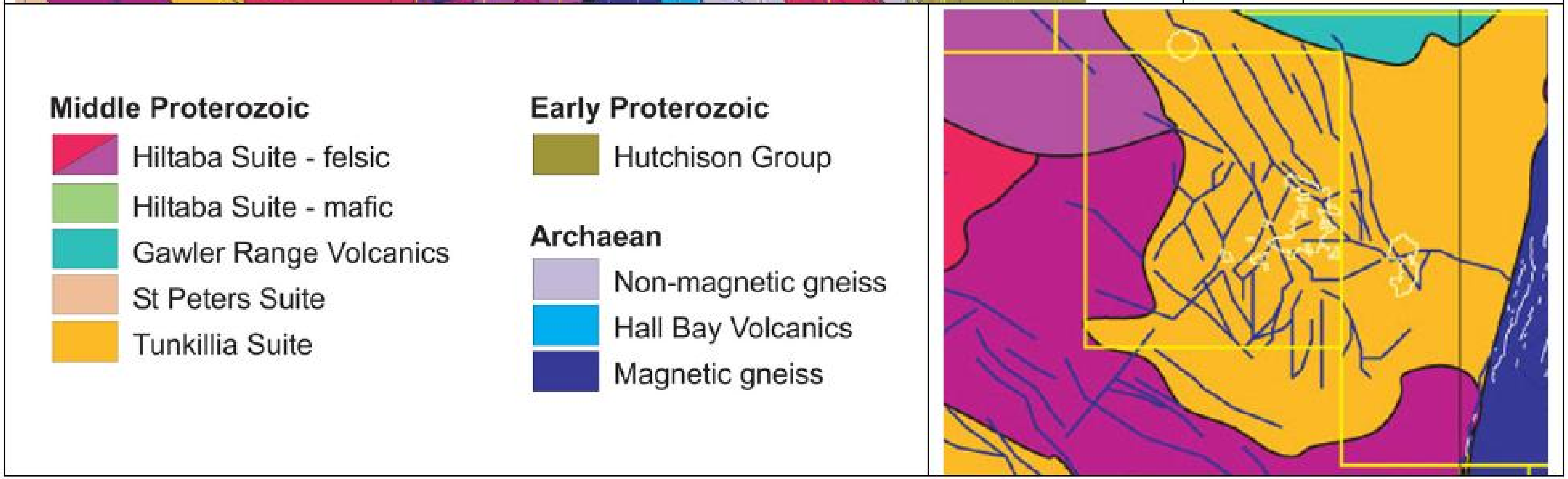


Figure 69: Interpreted basement geology for the Wudinna region, based upon geophysical data, exploration drilling and outcrop evidence. On the LHS map a white box locates the lower right enlargement image, it covers the ~19 x 23 km regolith study and map area of Sheard (2007a, b). Petrophysical similarities between the Tunkillia and Hiltaba Suite rocks leads to some uncertainties regarding their subsurface common boundaries. Images provided by Adelaide Resources Ltd.

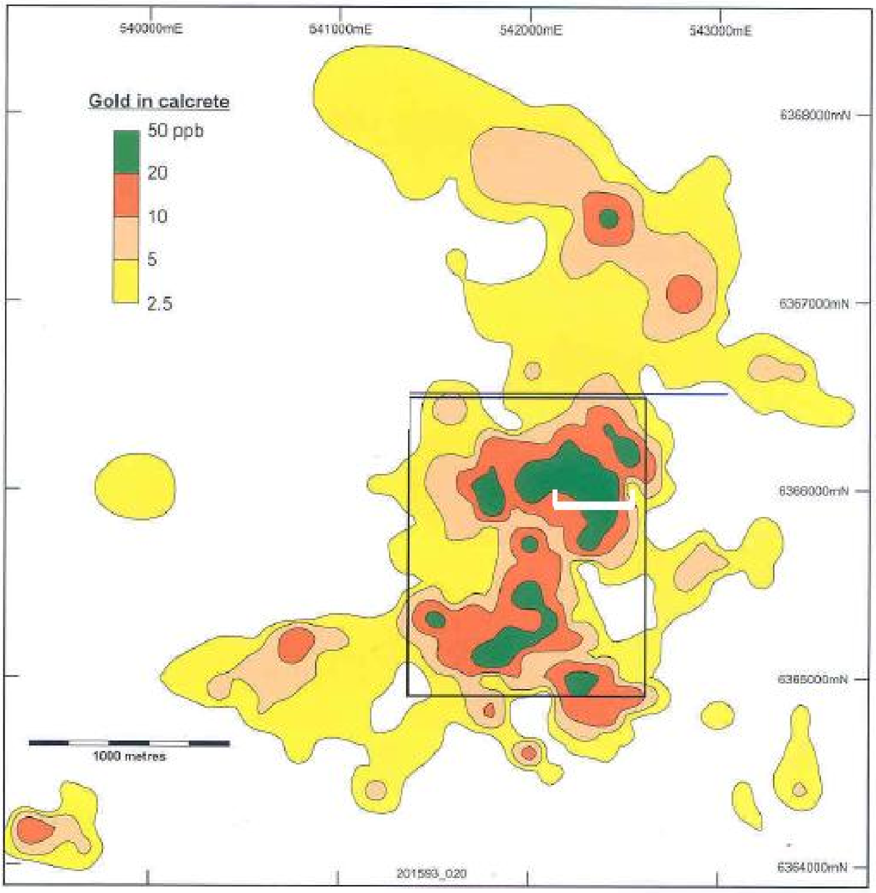


Figure 70: Barns gold prospect, Au-in-calcrete anomaly pattern (after Drown, 2003).

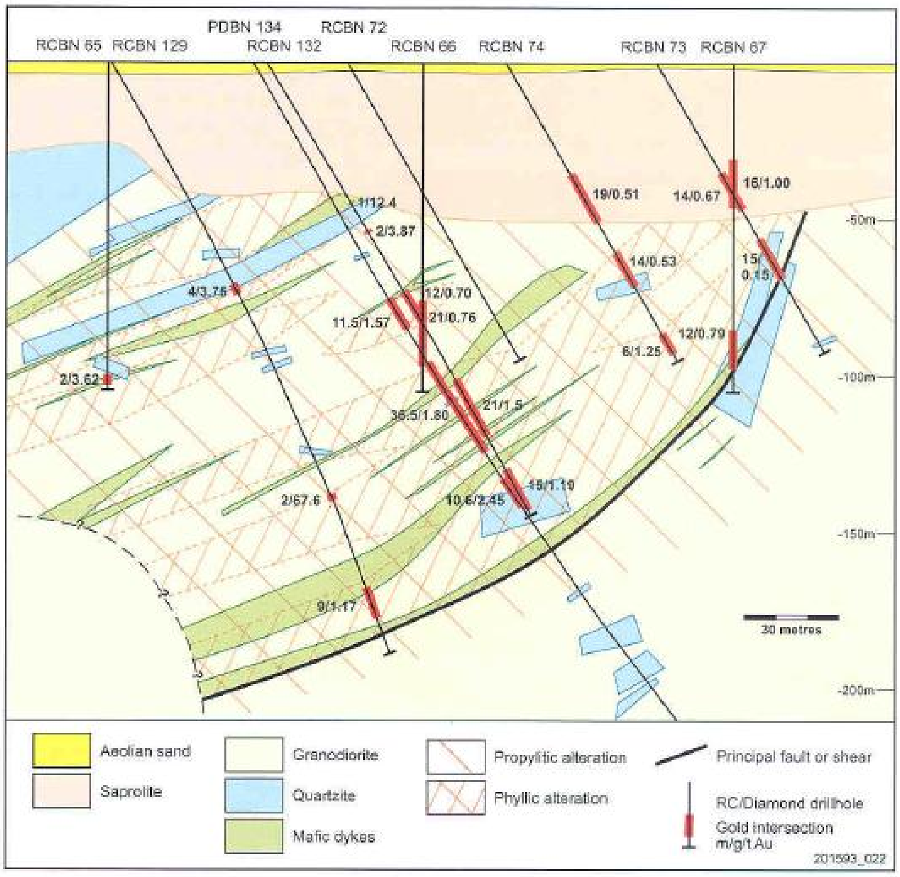


Figure 71: Barns gold prospect, E-W section along white line in Figure 69. Drillhole Au intersections are marked in red (Drown, 2003).

At Baggy Green prospect, Au intersections from 2 RC and 1 RAB drillholes of 4.79 g/t (34-42 m, includes 1 m at 30.6 g/t), 2.30 g/t (38-49 m) and 1.04 g/t (41-56 m) respectively have been reported by Adelaide Resources Ltd (2004). Barns and Baggy Green prospects mineralization are blind, in that they do not crop out as gossanous or prominently mineralized ground; and through most of the saprolite there is little or no detectable Au. However, some residual or hydromorphic Au signature is retained within the surficial saprolite-hosted calcrete, and/or pedolith hosted calcreted ferruginous gravel lags and soil (Drown, 2003; Sheard, 2007b). Additional work on the Barns geochemical anomaly has demonstrated a significant biogenic role in the accumulation of Au within calcrete – especially within the overlying late Pleistocene aeolian dune system (Lintern, 2004c, 2005, 2006; McEntegart and Schmidt-Mumm, 2004; Lintern and Rhodes, 2005).

In situ Regolith

Bedrock (<5% weathered), crops out at Little Pinbong Rockhole (Palaeoproterozoic Tunkillia Suite orthogneiss) very close to both Barns and Baggy Green prospects Au-in-calcrete anomalies. It consists of highly deformed medium- to coarse-grained, pinkish-grey orthogneiss (deformed granodiorite). Primary mineralogy includes plagioclase + K-feldspar phenocrysts + quartz + biotite, with accessory apatite, allanite, magnetite and zircon. Deformation has produced fine-grained dark grey banding within parts of the gneiss, where remnant phenocrysts-porphyroblasts are rare. This rock is commonly cross-cut by folded quartz veins and/or stockworks + less folded pegmatite and aplite veins (Figure 72A), (Fanning *et al*., 2007). Bedrock was penetrated by numerous RAB and RC drillholes at both prospects (Figures 73-76), where deep weathering and sedimentary cover push it from ~30 to >70 m below surface (Sheard, 2007a, b).

Saprock (>5% to <20% weathered), as outcrop near Barns and Baggy Green prospects, is a very minor component and tends to occur as a narrow rind or halo-zone rimming bedrock outcrop and subcrop. However, within thicker weathered *in situ* regolith profiles (>50 m) this zone may make up an horizon <1-~18 m thick (commonly ~2-10 m) near the weathering front (Sheard, 2007a, b), (Figures 73-76).

Saprolite (>20% of weatherable minerals altered), saprolitic Tunkillia Suite orthogneiss retains remnant primary texture and foliation, the upper portions are typically pallid with Fe-megamottles and/or stains in dark red, red, orange or yellow-brown (Figure 72B, C). Incipient silicification may occur at the top as a form of outcrop case hardening or where more completely developed a massive silcrete capping can occur (pedolith). Mineralogy is generally: coarse-grained quartz grit + kaolinite ± FeOx ± folded white to greyish quartz veins and stockworks. Within un-eroded weathered *in situ* profiles, a Tunkillia Suite saprolite zone may comprise an interval of ~12-~60 m thick (commonly >15-~35 m) where the pallid upper portion typically makes up two thirds to three quarters of that zone (Sheard, 2007a, b), (Figures 73-76).

Pedolith (extremely weathered, new pedogenic fabric & texture), over the Barns prospect this is commonly eroded off but where present can include: arenose and plasmic zones, a collapsed megamottle horizon, a pisolitic Fe-pedolith horizon, silcrete and soils. All occur above the Pedoplasmation Front and above saprolite. Arenose and plasmic zones, and megamottles are very difficult to recognise from drill cuttings but outcrop and excavations are useful adjunct observation sites. Profiles over the Baggy Green prospect are more complete and help explain why the Au-in-calcrete exploration method worked so well there (Sheard, 2007a, b).

<u>Arenose Zone</u>, this is a grit-dominant horizon with a grain supported (or nearly so) pedogenic fabric. All or most fines have been removed, probably by low pH solutions, leaving a collapsed profile with no primary fabric or texture remaining. At several locations this zone has later been selectively silicified to a dense silcrete. Thickness range is <0.1 to <1 m (Sheard, 2007a, b).

<u>Plasmic Zone</u>, forms a massive clay or silty clay horizon, where mesoscopically there appears to be only a homogeneous plasmic fabric remaining. This zone is more commonly developed over rocks poor in quartz. A plasmic zone is created by solution and authigenesis reactions on weathering minerals, and by various mechanical processes affecting the resultant clays (shrinkage, swelling and settling). Thickness range is <0.2 to <1 m (Sheard, 2007a, b).

<u>Collapsed megamottle horizons</u>, these distinctive pedolith horizons consist of Fe-rich megamottles that have been collapse merged through clay and fines removal around them during pedogenic and deflationary processes, which may have also involved low pH groundwater and/or aeolian mechanisms. The fines-removal process leaves the more indurated Fe-rich megamottles, as ‘blocks’, coalesced with abundant residual quartz grit plus colluvium and alluvium derived and

incorporated from the surface. Outcrop evidence suggests that a megamottle profile collapse of 25% to >60% is needed to achieve such a thick Fe-rich horizon (1-1.5 m). Incorporated exotic quartz clasts include: rounded to subangular sand-sized grains to granules and occasional gravel to pebbles; these have worked their way further into the profile from the original pedogenic surface by as much as 1-5 m via cavities left between megamottle blocks and by normal surface cracking (due to seasonal aridity). The resultant collapsed megamottle horizon forms a very distinctive Fe-rich duricrust over much of the Wudinna area E of Barns and S of the Gawler Ranges high ground. It typically forms a distinctive surface armouring to a residual landscape, this can lead to escarpment development where erosion undercuts that armouring (Figures 72B, D, 74, 76). Mostly it is dark red to dark red-brown to brown but occasionally it is yellow-brown, and these hues tend to mimic the underlying saprolite megamottle colours. Haematite + quartz ± goethite ± minor kaolinite are the typical mineral assemblages represented. Collapsed or disrupted Fe-stained quartz vein remnants may also be present. This material can have an irregular basal contact with any arenose or plasmic zones or with any remaining un-collapsed megamottled saprolite. It can also erode to yield abundant Fe-rich lags in adjacent topographic lows (Sheard, 2007a, b).

<u>Pisolitic Fe-pedolith</u>, occurs on the E edge of Barns prospect and more extensively over Baggy Green prospect. It forms an Fe-rich pisolitic horizon, ~0.3-1.0 m thick, capping the weathered *in situ* substrate. Pisolitic Fe-pedolith is dark red-brown to brown or less commonly yellow-brown (Figures 72E, F). The goethitic pisoliths (<1-8 mm), formed *in situ*, have unbroken cutans, and this profile may contain Fe-stained relict vein quartz fragments. All primary texture and metamorphic foliation have been destroyed by pedogenic overprinting – forming a pisolith fabric. Where exposed or near surface, the top or an interval within may be calcrete impregnated, commonly incorporating numerous Fe-pisoliths into that pale horizon. This residual ferruginous material may have been in-part or completely stripped in places by erosive processes (Sheard, 2007a, b).

<u>Silcrete</u>, in this area is only of the pedogenic type, while the groundwater silcrete type has not been observed. Typically silcrete is greyish to yellowish but may be orange, red to red-brown or intensely brown, where megamottles or a ferruginous host have been silica overprinted. Accessory minerals and lithic inclusions can be present in varying amounts, these can include: fine-grained anatase ± relict zircons ± opaque heavy minerals ± entrapped quartz vein fragments and remnant quartz grit ± colluvial and/or alluvial quartz (the latter two components apply only to silicified sediments). Silcrete sometimes displays internal banding parallel to the original pedogenic surface (Figure 74). Locally its thickness ranges from ~0.1 to ~0.5 m ± an underlying incipiently silicified zone of up to ~0.4 m thick. Silcrete is developed within quartz grit-rich arenaceous zones of highly weathered felsic lithotypes and within some of the Palaeogene to Neogene sedimentary deposits.

<u>Soils</u>, There are four soils of note recognised within the Barns to Baggy Green prospects by Sheard (2007a, b). Three have developed within weathered *in situ* regolith and one within transported regolith associated with palaeochannel sediment. All are pedolith components but are usually poorly represented in drill cuttings.

Figure 72: captions to images on the next page

A: Tunkillia Suite granodiorite, exposed N of Barns prospect. Intense foliation, folded mineral bands and pegmatite veins are apparent. Hammer scale is 300 mm long.	**B:** A retreating escarpment E of Little Pinbong Rockhole (N of Baggy Green prospect) exposing pallid saprolite with pale orange quartz veins + dark red-brown collapsed megamottle horizon.
C: Megamottled pallid saprolite exposed in an eroding terrace, large playa N of Barns prospect.	**D:** Collapsed megamottle horizon forming a distinctive palaeo-surface armouring, large playa N of Barns prospect.
E: Ferruginous pedolith composed of Fe-rich lag derived from collapsed megamottle horizon + goethitic pisoliths eroded from a lateritic capping. Yellow box outlines view in F opposite.	F: Close up of opposite view (E). displaying the very granular texture and the later calcrete induration. Hammer scale is 300 mm long.
G: A road cutting exposure of the orange dune sand, W of Barns prospect. A relict palaeosol containing Fe-rich segregations is evident near the hammer handle, calcrete forms paler patches in the sand above hammer.	H: Yellowish dune exposed in a research trench, Barns prospect. Dune is ~8 m thick but only 6 m in trench. Holes are ladder-like nicks are sample points. Blue arrow points to an earthy carbonate segregation. Upper ~1 m is a bleached podsol horizon (pH ~5.5) rest is (pH >8.6) of calcrete.

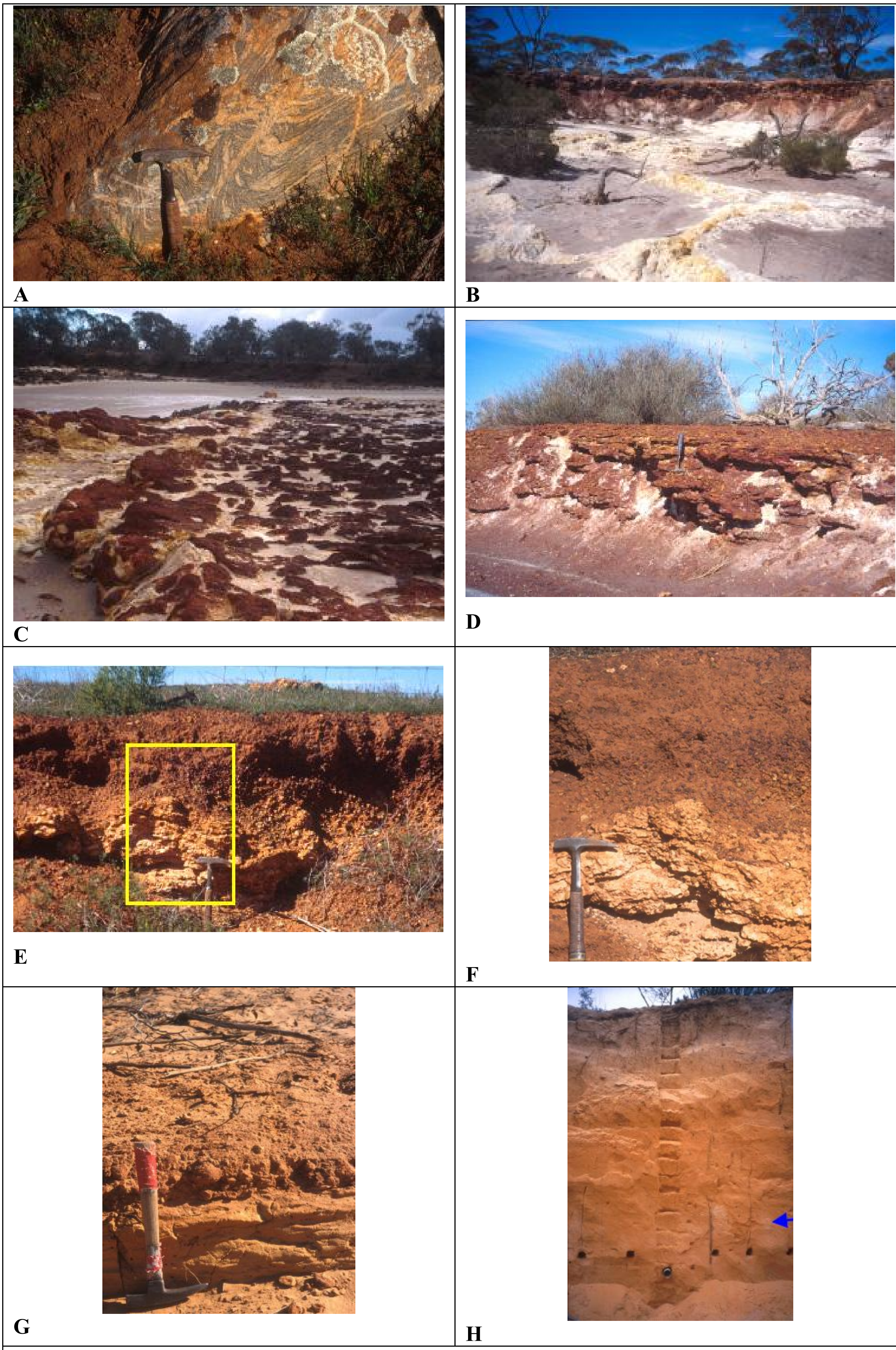


Figure 72: Barns and Baggy green areas: weathered *in situ* regolith forms from bedrock (least weathered) to pedolith (extremely weathered); plus transported (aeolian) regolith (after Sheard, 2007b).

Transported Regolith

Fluvial sediment

Palaeochannels and associated sediment form significant subsurface transported regolith, and occur W, N and NE of Barns prospect, and N to E of Baggy Green prospect (Figures 74, 76). These sediments can usually only be observed from drillhole samples or rare but small outcrop. The Corrobinnie Depression is a topographic low where the Narlaby and Yaninee Palaeochannels are concealed beneath younger aeolian deposits (see below and Benchmarks 13 to 16). Garford Fm. equivalent sands crop out as remnant bog-iron cemented sands (landform Dl-4 of Sheard, 2007a, b) or as silcreted fluvial sediment N of both prospect areas. Twelve kilometres WSW of Barns prospect there is limited outcrop in landscape lows (playas) where red mottled greenish clays and indurated sand beds can be observed. Those clays are massive and contain <3% sand (fine- to medium-grained), while the underlying sand beds contain angular to rounded, medium- to coarse-grained quartz. Other resistate mineral grains and lithics are rare to absent.

Extensive exploration drilling on the Barns and Baggy Green prospects has revealed a significant palaeochannel system containing predominantly sand and gravel (presumed Garford Fm.; Narlaby and Yaninee Palaeochannels). Some of that sediment even carries placer gold grains (pers. comm. C. Drown, Adelaide Resources Ltd, March 2006). However, the concealed complex channel architecture has only been partially delineated, as that aspect has not been focused upon by Au or the 1980's U exploration. The larger palaeochannels have deeply incised the weathered *in situ* regolith to yield truncated profiles, where all pedolith and even substantial portions of the upper saprolite are eroded away. Near the palaeochannel centres, the unconformity may be marked by a basal gravel-rich bed or a coarse-grained lithic to quartz clasted colluvium (<1-~2 m thick, with well rounded clasts 3->20 mm diam.). Thickness data for these palaeochannel sediments remains limited because drillhole spacing and location have not always penetrated the channel's lowest points nor their opposite banks (Sheard, 2007a, b).

Aeolian sediment

Ten aeolian landforms have been recognised within the mapped area of Sheard (2007a; Figures 73-76)), and a stratigraphic order (with relative ages) has been established for many of those. Aeolian landform differentiation has been based upon stratigraphic evidence, morphology, landscape position, grain mineralogy-morphology, profile colour and pedogenic indicators (soils, palaeosols, cements, sesquioxide segregations, *etc*). Aeolian grains are predominantly quartz sand to coarse silt but significant gypsum-rich and clay-rich particulates also abound in some landforms (lunettes, kopi). Sand and silt sources include locally eroded quartz-rich rocks plus resistate mineral grains derived from exposed and weathered bedrock; as well as exposed sandy sediments. Clay in the form of parna and dispersed fines within the aeolian landforms can be derived by deflation from local playas—clay pans, eroding pedolith—saprolith and eroding sediment. Sand and fines are also derived well away from this area, as demonstrated by the larger longitudinal dune systems linking as an easterly extension or outlier to the Great Victoria Desert (Sheard, 2007a, b).

Orange longitudinal dunes and associated sand plain (W & SW of Barns prospect, S side of Baggy Green prospect) are stratigraphically the oldest aeolian sand in this area. However, these may involve two or more distinct deposition cycles because some of those dunes and sand plain are quite deeply red-hued indicating a possible antiquity that stratigraphy alone is unable to refine further (Figure 72G). Generally these dunes stand <2.5-~7 m above the surrounding plain and occur in isolation or in minor dunefields but are commonly broader, are more widely spaced and usually stand lower than younger dunes. The associated but more aerially extensive orange sand plain is generally thinner (~0.3-~2.0 m) and tends to mantle any palaeo-surface undulations, sand plains therefore form a low relief undulating surface. These landforms are commonly overlain by the paler dunes and sand plains of the yellowish longitudinal dunes (see below; Sheard, 2007a, b). Previous geological mapping has included these landforms within 'Moornaba Sand'. A precise age is not available but Late Pleistocene would fit the stratigraphic evidence.

Yellowish longitudinal dunes and associated sand plains dominate much of the landscape, creating a regionally significant landscape grain of rolling downs. Stratigraphically these landforms are younger than those of the orange longitudinal dunes. Generally the yellowish dunes stand <2->12 m above the plain, are narrower and much longer than those of the orange dunes. This sand is highly siliceous, is generally coloured light yellowish brown to light greyish brown, is fine- to medium-grained, and is loose to weakly bound by earthy pedogenic carbonate below 1.5 m (Figures 72H, 73). The associated sand plains extensively mantle regional palaeo-landsurfaces, forming low rolling undulations but it may also display minor linear dunes or dendritic dune patterns. Sand is similarly coloured to the dunes, is fine- to medium-grained and highly siliceous, is loose free-running at the surface but deeper is weakly bound by earthy pedogenic carbonate. Thickness ranges from ~0.3-<2.0 m, and may be thicker (<5 m) below minor dunes. Both landforms have previously been mapped as being equivalent to Moornaba Sand, a geological formation that now seems to require redefinition (Sheard, 2007a, b). Dating of a temporarily exposed dune profile (full depth section of ~8 m) overlying the Barns gold prospect in April 2004, and employing optically stimulated luminescence methodology, has revealed an age range of 26,300 ± 1300 yBP to 17,000 ± 1300 yBP (Lintern & Rhodes, 2005).

Complex sand plain typically thinly mantles palaeo-land surfaces forming rolling undulations and minor anastomosing linear to dendritic to festoon and parabolic dune patterns overlying palaeochannel low terrain (Sheard, 2007a, b). Sand is a light greyish brown to light yellowish brown, fine- to medium-grained siliceous sand, loose free-running at the surface but may be weakly bound deeper in the profile by earthy pedogenic carbonate. Thickness range is ~0.3->2.0 m and maybe >4-7 m where minor dunes also occur. Its sand forms distinctive landform terranes in Pinkawillinie Conservation Park and Gawler Ranges National Park (N of Barns and Baggy Green prospects) as a ~WNW trending subtle valley that may form a tributary to or an outlier of the more extensive ~NW-SE trending Corrobinnie Depression-Narlaby Palaeochannel. Twidale and Campbell (1985) demonstrate a tectonic relationship between the Corrobinnie Fault and the Corrobinnie Depression – a landscape pattern that was exploited during the Palaeogene to Neogene by northwesterly flowing rivers of the Narlaby Palaeochannel system.

Numerous additional aeolian and playa landforms have been delineated and described in Sheard (2007a, b) plus Twidale and Campbell (1985) for this area but are more distal to the Barns and Baggy Green prospects, therefore will not be described further here.

Geochemistry

There has been no multi-element geochemical 3D modelling done of the regolith profile for Barns or Baggy Green gold prospects. While the available public domain down-drillhole assay profiles for Barns gold prospect are limited to only a few select holes and are specific for Au (Figure 71). Drown (2003) has established that leached upper saprolite is effectively devoid of Au above mineralization. However, regional calcrete multi-element geochemistry (from Adelaide Resources Ltd) is presented in Sheard (2007b) highlighting Ag, As, Au, Cu and Ni distributions over Barns plus Baggy Green prospects (extracts appear in Figures 77, 78). Areas of highly anomalous Au (in calcrete) indicate places where outcropping to just subcropping saprolite and/or pedolith occur. Moreover, subcropping palaeochannel sediments that carry placer Au grains also exhibit anomalous Au in calcrete. Silver and Cu pathfinder elements highlight mineralization and the subcropping palaeochannel sediments, clustering N of Barns prospect. While the highest concentrations of Ni and As seem to selectively highlight Proterozoic metasediments adjoining the Baggy Green prospect.

Gold and pathfinder element mobilisation within dunes (~8 m thick) overlying Barns prospect mineralization has been studied and reported on by Lintern (2004c, 2005, 2006), McEntegart and Schmidt-Mumm (2004), Lintern and Rhodes (2005). That body of work has led to new research via AMIRA Project P778 (ongoing as of late 2007). Conclusions drawn from those recent publications are as follows:

- Highest Au concentrations (9 ppb) in dunes are associated with carbonate accumulations around roots including the upper part of the dune.
- Trees on dunes (*Eucalyptus*, *Melaleuca*) have leaves, twigs and fruiting bodies anomalous in pathfinder and other metals (Ag, Co, Bi, Pb, Sb, Ta, W) associated with mineralization.
- *Eucalyptus* is superior to *Melaleuca* for sampling as it tends to produce stronger anomalies in more elements, particularly pathfinders. This is probably due to longer tap roots that are able to source elements deeper in the profile (nearer to or into weathered *in situ* rock / mineralization).
- Biogeochemical anomalies are not coherent and rarely spread to more than 200 m in size. Anomalously high metal concentrations can be adjacent to background levels, making interpretation and effective sampling strategies more difficult that other techniques such as calcrete and soil sampling.

- Biogeochemical sampling was **not effective** for Au (signal too erratic). Biogeochemical pathfinders (higher concentrations than Au) at Barns prospect may not always be present at other prospects (nearby or distal), leading explorers to miss potential mineralization.
- Biogeochemical sampling, sample preparation and analysis require careful handling due to the very low metal concentrations present (easily contaminated). High Resolution ICP MS required for assay to <0.1 ppb is not readily available in Australia.
- Dune age: ~27,000 years (optical luminescence). Plant recycling of soluble Au may have saturated the dune in <10,000 years (Lintern and Rhodes, 2004; Lintern, 2006).
- Calcrete appears to be a more reliable sampling method than plants and soil.
- The roles clay, Fe, pH and O_2 fugacity play on Au dissolution in dunes is not well understood.

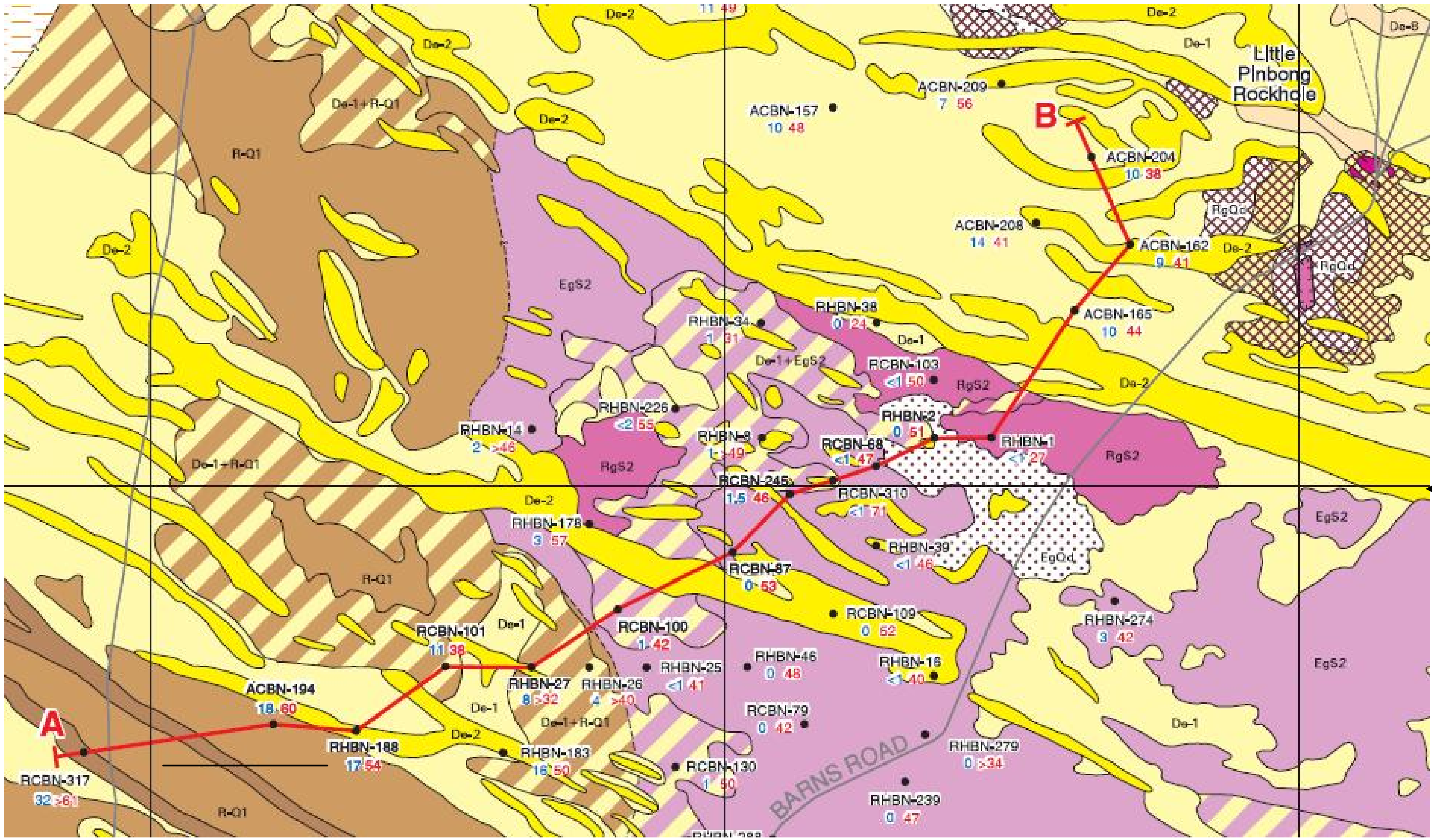


Figure 73: Barns gold prospect area, extracted from the Regolith Landform Map of Sheard (2007a) displaying selected exploration drillholes (black dots) and the regolith profile line A-B of Figure 74. Purple colours highlight regolith derived from Tunkillia Suite granodiorite; yellows highlight aeolian sand; brown R-Q1 is a soil developed in alluvium. Little Pinbong Rockhole is indicated at the top RHS. Coloured numbers below drillhole reference: blue = thickness of transported cover (m); red = depth to bedrock (m). Map scale (~1:22,000) is indicated by Easting coordinates.

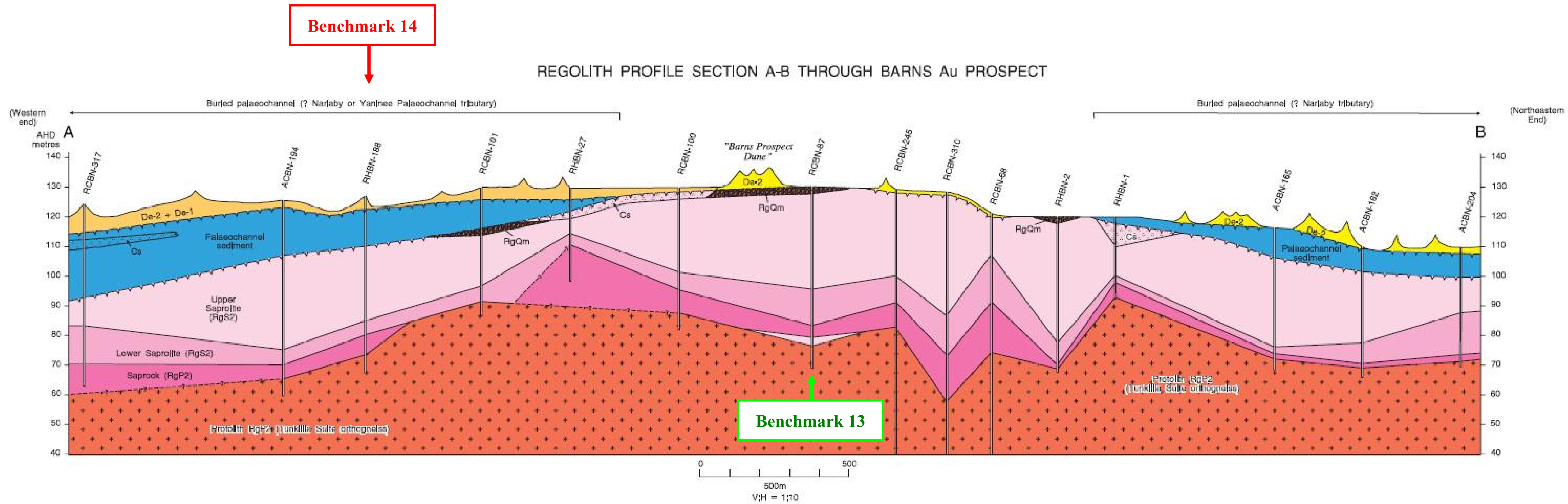
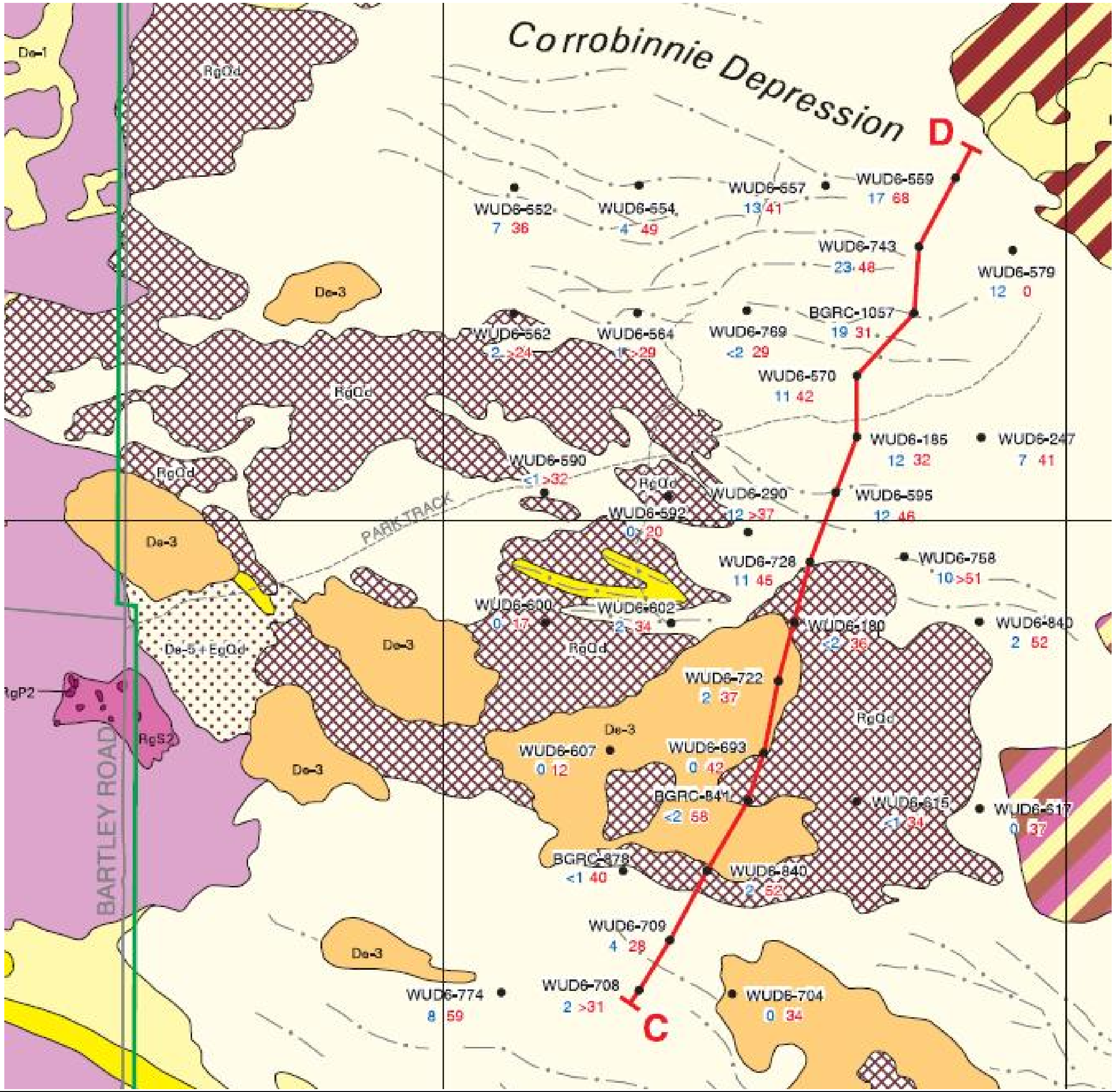


Figure 74: Barns gold prospect, regolith profile section A-B (located on Figure 73; extracted from Sheard, 2007a). Aeolian cover (De-1, De-2) and palaeochannel sediment are thickest over the W and NE ends. RgQm represents ferruginous pedolith dominated by a collapsed megamottle horizon; Cs represents silcrete. Locations for Benchmarks 13 and 14 are indicated.



6364000 m N

546000 m E

548000 m E

Figure 75: Baggy Green gold prospect area, extracted from the Regolith Landform Map of Sheard (2007a) displaying selected exploration drillholes (black dots) and the regolith profile line C-D of Figure 76. Purple colours and brown hachuring highlight regolith derived from Tunkillia Suite granodiorite, yellows highlight aeolian dune sand. Coloured numbers below drillhole reference: blue = thickness of transported cover (m); red = depth to bedrock (m). Map scale (~1:20,000) is indicated by Easting coordinates.

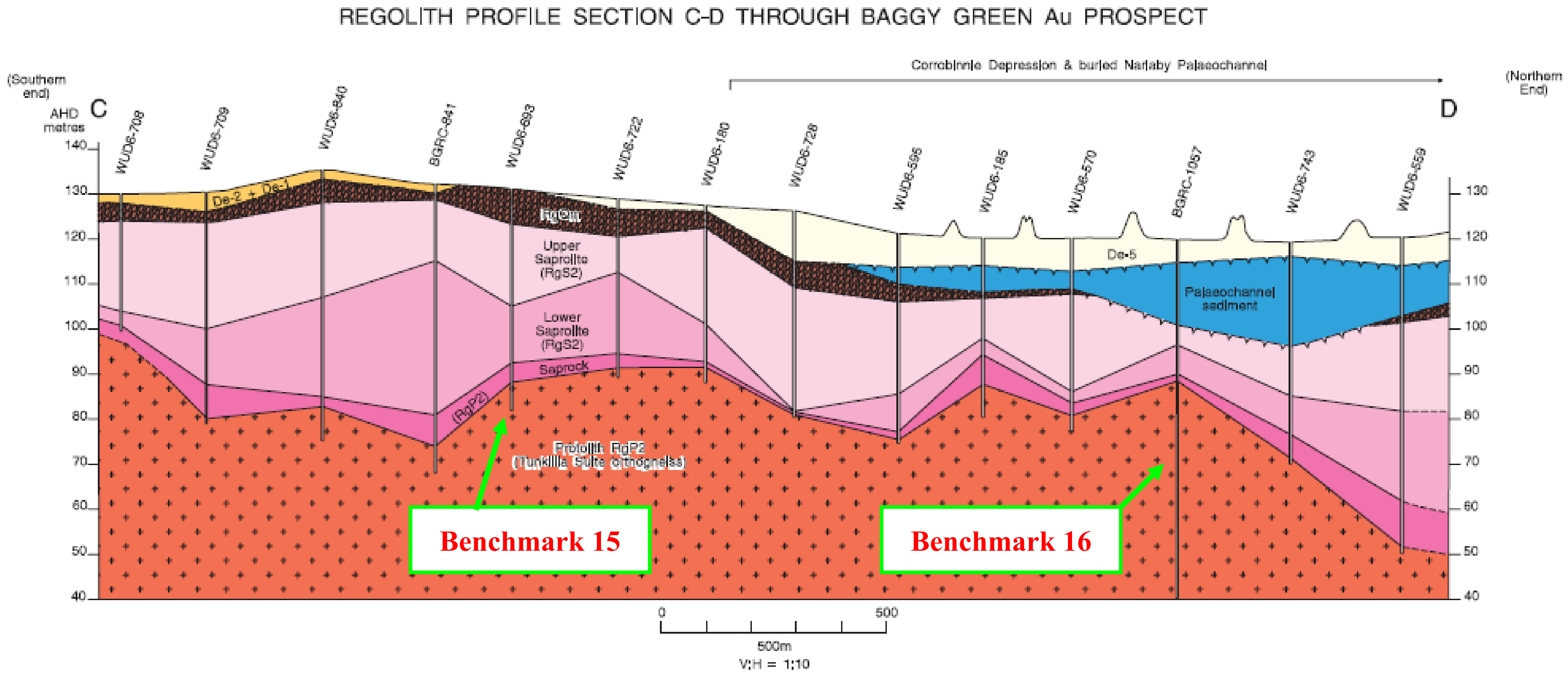


Figure 76: Baggy Green gold prospect, regolith profile section C-D (located on Figure 75; extracted from Sheard, 2007a). Aeolian cover (De-5) and palaeochannel sediment are thickest over the northern half. RgQm represents ferruginous pedolith dominated by a collapsed megamottle horizon. Locations for Benchmarks 15 and 16 are indicated.

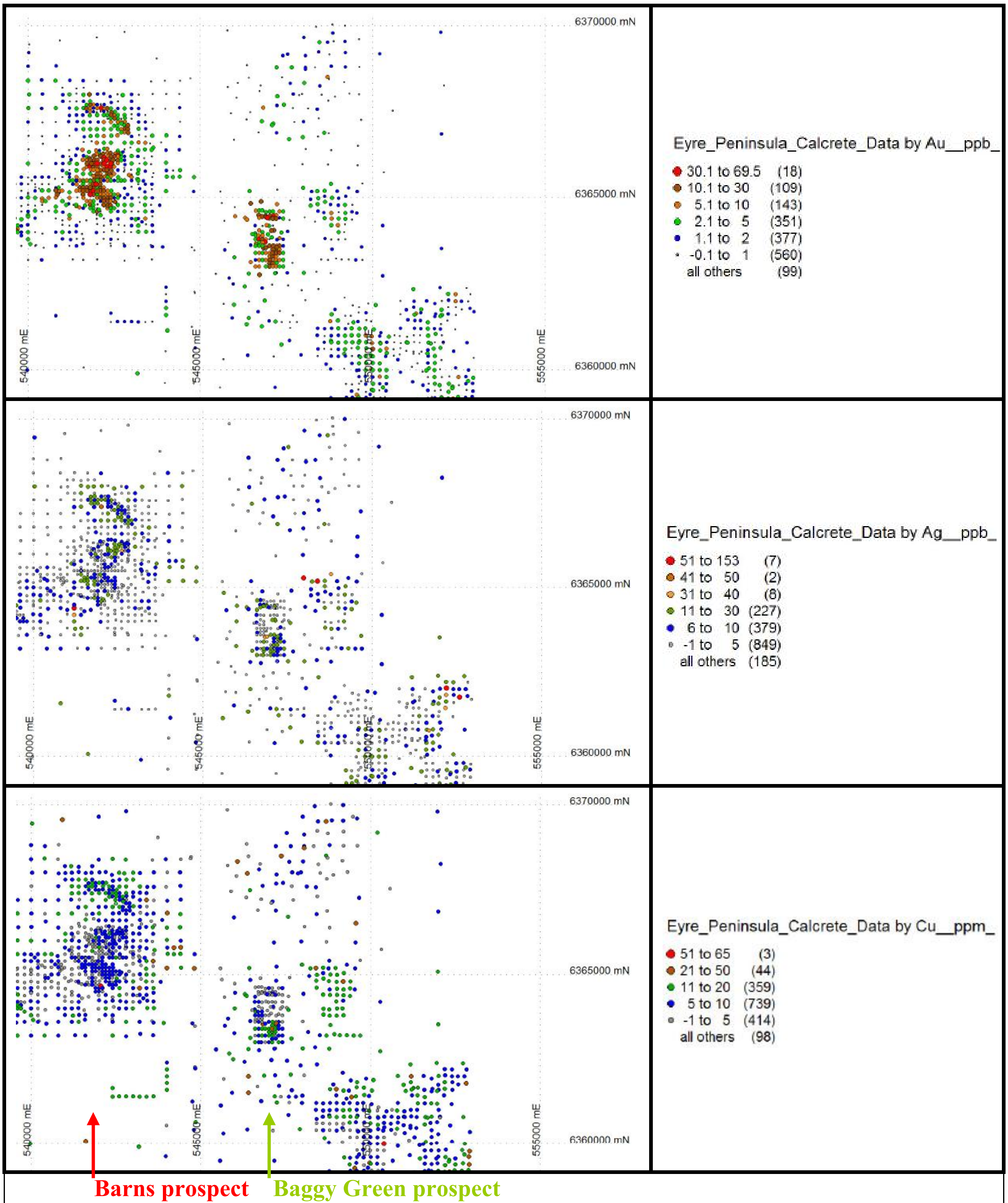


Figure 77: Regional calcrete assay data plots for Au, Ag and Cu over Barns and Baggy Green prospects (after Sheard, 2007b). RH column keys: bracketed numbers equate to number of samples in assay value range. Grid projection is AMG88. Original data supplied by Adelaide Resources Ltd.

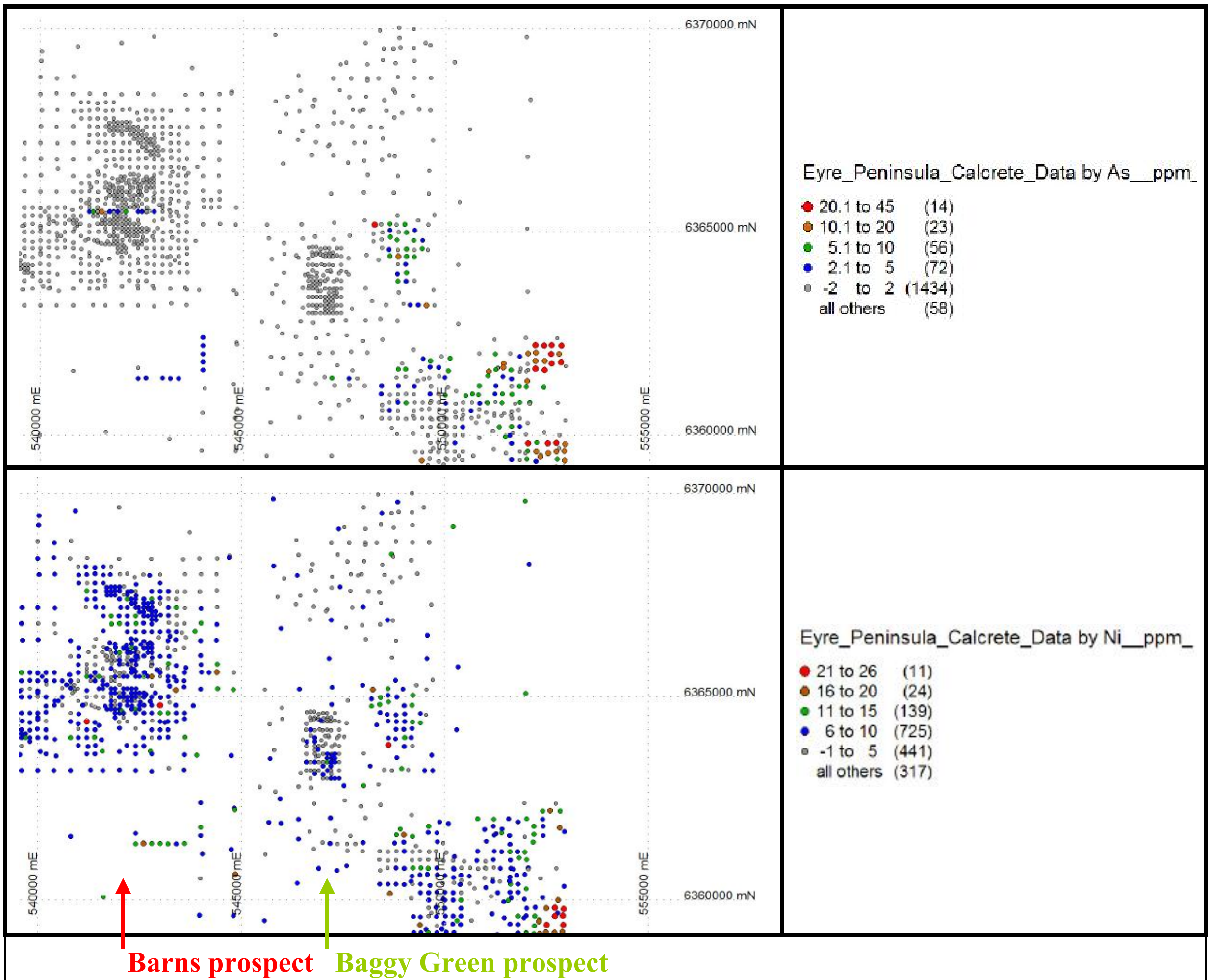


Figure 78: Regional calcrete assay data plots for As and Ni over Barns and Baggy Green prospects (after Sheard, 2007b). RH column keys: bracketed numbers equate to number of samples in assay value range. Grid projection is AMG88. Original data supplied by Adelaide Resources Ltd.

Benchmark 13: drillhole RCBN-87 (Barns gold prospect)

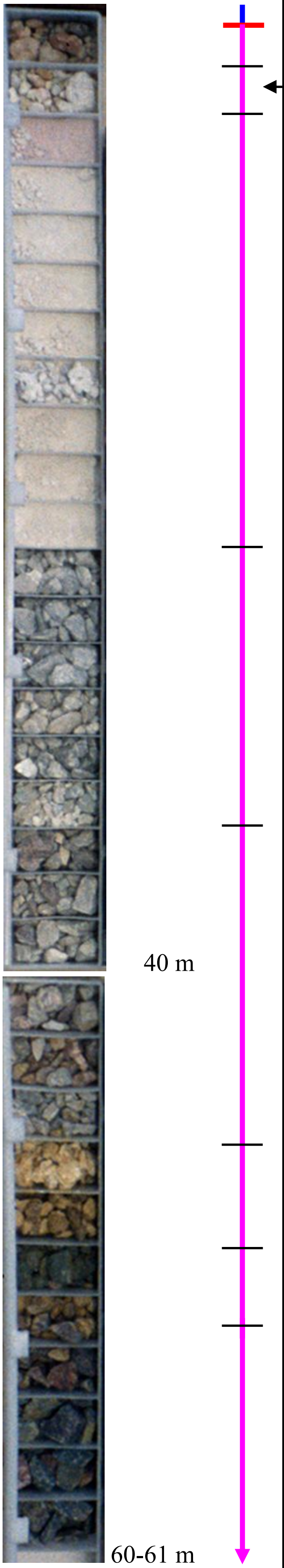
Quick reference items are set out in Table 32; detailed descriptions, figures and data tables follow on below. Barns gold prospect is ~360 km NW of Adelaide and ~25 km N of Wudinna on the YARDEA 1:250,000 map area of Eyre Peninsula. Access is via the unsealed Barns Road N of Wudinna (Figures 67-74). This Au anomaly is mostly on private farm land but partly extends into the Gawler Ranges National Park. Drilling for many of the holes on this prospect was vertical (RAB and RC methods), but some later RC and diamond coring was angled. A summary of this profile is provided in Table 33 and chiptray photograph with regolith zonation is in Figure 79. Regional calcrete geochemical data are presented in Figures 77, 78.

Table 32: Benchmark 13 reference data; drillhole RCBN-87 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 67-69.
Local-site location map	Figures 70, 73, 74.
GPS coordinates, attitude & elevation	RC drillhole RCBN-87: Zone 53, 542029 E, 6365771 N, GDA 94. **Attitude**: vertical. **AHD:** 129.99 m (Digital Terrain Model).
Site access, owner	Barns gold prospect is ~360 km NW of Adelaide, ~25 km N of Wudinna and ~100 km WNW of Kimba on the YARDEA 1:250,000 map area of Eyre Peninsula. Access is via the unsealed Barns Road N of Wudinna. Prospect is mostly on Private farm land and partly extends into the Gawler Ranges National Park.
Related drillholes	Adelaide Resources Ltd Barns prospect drillhole grid (300 holes).
Drill sample photo / log	Yes, Figure 79, Table 33.
Sample types	Drill chips in chiptrays.
Sample storage	Adelaide Resources Ltd, 69 King William Rd, UNLEY, SA.
Lithotypes	Weathered Tunkillia Suite granodiorite (gneiss).
Petrology	No.
Geochemistry	Yes, calcrete only (Figures 77, 78).
XRD mineralogy	No.
PIMA spectral data	No, but HyLogger data is available for nearby drillhole RCBN-126 (Keeling *et al*., 2004) with comparisons between drill chips & core.
Dating	Tunkillia Suite granodiorite (gneiss) at Little Pinbong Rockhole, U-Pb zircon age of 1669 ± 13 Ma (Fanning *et al*., 2007). Yellowish aeolian dunes, overlying Barns prospect, optical luminescence age 26,300 ± 1300 a (for dune core) & for upper profile 9,100 ± 1100 a (Lintern and Rhodes, 2005).
Target Elements	Au.
Potential Pathfinder Elements	Ag & Cu, ?As.
Useful sampling media	Calcrete.
Key reference sources	Drown (2002, 03), Sheard (2007a, b), Lintern (2004c, 05, 06), Lintern & Rhodes (2005), McEntegart & Schmidt-Mumm (2004).

Background

Drillhole RCBN-87 is selected to form this benchmark because it is within the defined gold mineralization, it has relatively thin transported regolith, while the weathered *in situ* regolith has a least eroded top and the profile is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 14 (within a palaeochannel) and the regolith cross-section Figure 74. The exploration grid drilling involved a combination of RAB with hammer, Aircore and RC methods. Follow-up diamond coring did not core through the regolith (transported regolith & weathered *in situ* regolith zones). Cuttings have been sampled from the drilled 2 m composites (not ideal for regolith investigations). This drillhole was not originally intended for use as a benchmark, it was later logged and interpreted as part of regional regolith studies by Sheard (2007a, b).



0-2 m	**Transported** (minor) + ***in situ***: thin sandy soil with pinkish calcrete + various Fe-rich lags as dark brown gravel + remnant partly silicified megamottled upper saprolite (brown + reddish + pale yellow). Compact to competent. Strong acid reaction. **Unconformity** <1 m.
2-4 m	***In situ***: pallid upper saprolite, partly silicified with thin silcrete bands developed in quartz grit, (pale pink to white); competent, indurated. No acid reaction.
4-22 m	Pallid upper saprolite, 4-6 m pale pink FeOx stained, kaolinite-rich, earthy to chalky; 6-22 m, white; compact to coherent.
22-34 m	Upper saprolite, kaolinite-rich + abundant quartzite (recrystallised granular, pale grey); coherent to competent.
34-46 m	Lower saprolite, >20% weathered, pink, grey, white, pale greenish grey, abundant quartz (recrystallised granular, pale grey) + some kaolinite, some relict K-feldspar; competent.
46-50 m	Saprolite, pallid, more highly weathered than interval above, kaolinite-rich; chalky to compact.
50-53 m	Saprock, 5-20% weathered, chloritic gneiss, FeOH stained, grey, olive-grey, yellow-brown, pale and dark green, + relict K-feldspar + quartz + goethite; coherent to competent.
53->61 m	Bedrock, <5% weathered, dark grey, dark olive-grey + pink + dark green, chlorite altered felsic gneiss, fine- to coarse-grained, quartz-rich + K feldspar + chlorite; competent.

Sample interval = 2 m except bottom chamber = 1 m

Regolith logged by M.J. Sheard

Figure 79: Benchmark 13, Barns gold prospect drillhole RCBN-87, chiptrays and regolith zonation (image extracted from Sheard, 2007b). Bedrock at 53 m, E.O.H. at 61 m.

Table 33: Summary log of Benchmark 13, drillhole RCBN-87 (Type 2, drill cuttings profile).

Drillhole: RCBN-87, Barns Au Prospect, Adelaide Resources Ltd. **Coords:** Zone 53, 542029 E, 6365771 N, GDA 94. **DTM Elevation:** 129.99 m. **Azimuth:** 360°, **Dip Angle:** -90°, **Drill Type:** Reverse Circulation.	
Depth (m)	**Description**
0-2	Mostly <u>*in situ*</u> with <u>minor transported</u> materials. Various Fe-rich lags as dark brown gravel + remnant partly <u>silicified megamottled upper saprolite</u> (brown + reddish + pale yellow)+ pinkish calcrete developed in thin sandy soil. Compact to competent. Strong acid reaction.
2-4	*In situ* materials. Pallid <u>upper saprolite</u>, partly silicified with thin silcrete bands developed in quartz grit, (pale pink to white), competent, indurated. No acid reaction.
4-6	*In situ*. Pallid <u>upper saprolite</u>, pale pink FeOx stained, kaolinite-rich, earthy to chalky.
6-22	*In situ*. Pallid <u>upper saprolite</u>, kaolinite-rich, compact to coherent.
22-34	*In situ*. Pallid <u>upper saprolite</u>, kaolinite-rich + abundant quartzite (recrystallised granular, pale grey), coherent to competent.
34-46	*In situ*. <u>Lower saprolite</u>, pink + grey + white + pale greenish grey, abundant quartz (recrystallised granular, pale grey) + some kaolinite, some relict K-feldspar, competent. >20% weathered.
46-50	*In situ*. Pallid <u>saprolite</u>, more highly weathered than interval above, kaolinite-rich, chalky to compact.
50-53	*In situ*. <u>Saprock</u>, weathered chloritic gneiss, FeOH stained, grey + olive-grey + yellow-brown + pale and dark green, chlorite + relict K-feldspar + quartz + goethite, coherent to competent. 5-20% weathered.
53-61	*In situ*. <u>Bedrock</u>, dark grey + dark olive-grey + pink + dark green, incipiently weathered chlorite altered felsic gneiss, fine- to coarse-grained, quartz-rich + K feldspar + chlorite, competent. <5% weathered.
E.O.H.	Regolith Logged by M.J. Sheard (PIRSA-GSB)

In situ Regolith

Gneissic bedrock was penetrated at 53 m and has chloritic alteration with abundant quartz (?veining). This rock is altered Tunkillia Suite orthogneiss and is within the defined mineralized part of this prospect. Saprock is typically thin (~3 m) and contains relict K-feldspar plus some goethitic staining. Saprolite is 48 m thick here (less than in some adjacent drillholes where it can be >70 m thick), and it follows descriptions for this prospect set out earlier. However, in Benchmark 13 it is more complex, in that a more highly weathered ~4 m thick interval exists below the lower saprolite (46-50 m). This may suggest a brittle fracture zone occurs through that interval, allowing meteoric water ingress to promote additional weathering (cuttings alone cannot resolve this observation). Pedolith is truncated by erosion here, what remains is a remnant collapsed megamottle horizon (ferruginous) with some silcrete and siliceous overprinting that extends into the upper saprolite. The detail is difficult to be certain about (cuttings alone don't provide large enough fragments for complex weathering fabrics and textures to be properly observed-described), (Sheard, 2007b).

Transported Regolith

Transported regolith here is minimal (<1 m) and consists chiefly of aeolian sand and ferruginous gravel lag incorporated into a sandy lithosol resting on the unconformity surface. This is in marked contrast to Benchmark 14.

Geochemistry

There is no public domain geochemistry available for this drillhole. More general comments on calcrete (soil hosted) elemental abundances and dispersion are set out earlier, (Figures 77, 78).

Benchmark 14: drillhole RHBN-188 (Barns gold prospect)

Quick reference items are set out in Table 34; detailed descriptions, figures and data tables follow on below. Barns gold prospect is ~360 km NW of Adelaide and ~25 km N of Wudinna on the YARDEA 1:250,000 map area of Eyre Peninsula. Access is via the unsealed Barns Road N of Wudinna (Figures 67-74). This Au anomaly is mostly on private farm land but partly extends into the Gawler Ranges National Park. Drilling for many of the holes on this prospect was vertical (RAB and RC methods), but some later RC and diamond coring was angled. A summary of this profile is provided in Table 35 and chiptray photograph with regolith zonation in Figure 80. Regional calcrete geochemical data are presented in Figures 77, 78.

Table 34: Benchmark 14 reference data; drillhole RHBN-188 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 67-69.
Local-site location map	Figures 70, 73, 74.
GPS coordinates, attitude & elevation	Drillhole RHBN-188: RAB Hammer 0-51 m + Aircore 51-60 m. Zone 53, 540717 E, 6365148 N, GDA 94. **Attitude**: vertical. **AHD:** 127.54 m (Digital Terrain Model).
Site access, owner	Barns gold prospect is ~360 km NW of Adelaide, ~25 km N of Wudinna and ~100 km WNW of Kimba on the YARDEA 1:250,000 map area of Eyre Peninsula. Access is via the unsealed Barns Road N of Wudinna. Prospect is mostly on Private farm land and partly extends into the Gawler Ranges National Park.
Related drillholes	Adelaide Resources Ltd Barns prospect drillhole grid (300 holes).
Drill sample photo / log	Yes, Figure 80, Table 35.
Sample types	Drill chips in chiptrays.
Sample storage	Adelaide Resources Ltd, 69 King William Rd, UNLEY, SA.
Lithotypes	Weathered Tunkillia Suite granodiorite (gneiss).
Petrology	No.
Geochemistry	Yes, calcrete only (Figures 77, 78).
XRD mineralogy	No.
PIMA spectral data	No.
Dating	Yes, for Tunkillia Suite granodiorite (gneiss) at nearby Little Pinbong Rockhole, U-Pb zircon age of 1669 ± 13 Ma (Fanning *et al*., 2007, pp. 131).
Target Elements	Au & ?U.
Potential Pathfinder Elements	Ag & Cu, ?As, ?Th.
Useful sampling media	Calcrete.
Key reference sources	Drown (2002, 2003), Sheard (2007a, b), Lintern (2004c, 2005, 2006), McEntegart and Schmidt-Mumm (2004).

Background

Drillhole RHBN-188 is selected to form this benchmark because it is away from the main Au mineralized area, it has a significant thickness of transported regolith, while the weathered *in situ* regolith is significantly eroded by palaeochannel activity; however, the overall profile remains relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 13 (in an area of thinly covered subcropping weathered basement) and the regolith cross-section Figure 74. The exploration grid drilling involved a combination of RAB with hammer, Aircore and RC methods. Follow-up diamond coring did not core through the regolith (transported + weathered *in situ* zones). Cuttings have been sampled from the drilled 2 m composites (not ideal for regolith investigations). This drillhole was not originally intended for use as a benchmark, it was later logged and interpreted as part of regional regolith studies by Sheard (2007a, b).

0-4 m **Transported**: yellowish aeolian quartz sand (fine- to medium-grained), frosted angular to rounded grains, loose to free running. Loow acid reaction.

4-16 m **Transported**: orange + brown + yellow-brown fluvial sand (palaeochannel), quartz dominant, angular to well rounded; 6-10 m is clayey sand to sandy clay + gypsum. 4-8 m mild to strong acid reaction.

16-18 m **Mixed Provenance**: **transported,** sand as in above interval + ***in situ***, pallid upper saprolite. Angular quartz gravel colluvium forms basal **unconformity**.

18-42 m ***In situ***: pallid upper saprolite, kaolinite dominant + quartz grit; chalky to earthy to coherent.

42-46 m Lower saprolite, >20% weathered, grey to pale greenish grey, clays + quartz grit; chalky to coherent.

46-48 m Transition interval (>20% to <10% weathered) lower saprolite – saprock: grey - greenish grey, clays + quartz grit + abundant vein quartz; compact to semi-competent.

48-54 m Saprock, 5-20% weathered, altered felsic gneiss, greys to olive-greys + browns, vein quartz at 48-52 m; semi-competent.

54->60 m Bedrock, <5% weathered, dark grey to grey + dark green-grey + pink, chlorite altered felsic gneiss, foliated, chlorite + quartz + K-feldspar + micas + sericite, coarse- to very coarse-grained, competent.

Sample interval = 2 m.

Regolith logged by M.J. Sheard

Figure 80: Benchmark 14, Barns gold prospect drillhole RHBN-188, chiptrays and regolith zonation (image extracted from Sheard, 2007b). Bedrock at 54 m, E.O.H. at 60 m.

Table 35: Summary log of Benchmark 14, drillhole RHBN-188 (Type 2, drill cuttings profile).

Drillhole: RHBN-188 / ACBN-188A, Barns Au Prospect, Adelaide Resources Ltd.
Coords: Zone 53, 540717 E, 6365148 N, GDA 94. **DTM Elevation:** 127.54 m.
Azimuth: 360°, **Dip Angle:** -90°, **Drill Type:** RAB Hammer 0-51 m / Aircore 51-60 m.

Depth (m)	Description
0-4	Transported materials. Yellowish aeolian quartz sand (fine- to medium-grained), frosted angular to rounded grains, loose to free running. Low acid reaction.
4-6	Transported materials. Yellow-brown sand, fine- to coarse-grained, poorly sorted, angular to rounded, has <2% clay fines, fluvial to colluvial sediment, earthy calcrete throughout, unconsolidated. Strong acid reaction.
6-8	Transported materials. Pale brownish clayey sand to sandy clay with specks of white clay + gypsum (quartz sand is fine- to very coarse-grained, poorly sorted), clasts are angular to subrounded, fluvial to colluvial sediment, unconsolidated. Mild to strong acid reaction.
8-10	Transported materials. Dark yellow-brown clayey quartz sand with clay-rich beds (fine- to medium-grained + some coarser clasts), poorly sorted, subrounded to rounded grains, fluvial sediment, unconsolidated. No acid reaction.
10-12	Transported materials. Dark orange to red-brown quartz sand, coarse-grained, well sorted, slightly clayey, clasts are subrounded to rounded, fluvial sediment, unconsolidated.
12-14	Transported materials. Pale yellow quartz sand (coarse-grained) + angular subrounded to rounded gravel, bimodal fluvial sediment, unconsolidated.
14-16	Transported materials. Pale orange quartz sand (coarse-grained), well sorted, clasts are subrounded to rounded, fluvial sediment, unconsolidated.
16-18	Mixed provenance materials. Transported: sand as in above interval + *in situ*: just penetrated pallid upper saprolite. Angular quartz gravel colluvium (fine-grained) may form the **unconformity** contact.
18-42	*In situ*. Pallid upper saprolite, kaolinite dominant + quartz grit, chalky to earthy to coherent.
42-46	*In situ*. Lower saprolite, grey to pale greenish grey, clays + quartz grit, chalky to coherent. >20% weathered.
46-48	*In situ*. Transition interval, lower saprolite to saprock, grey to greenish grey, clays + quartz grit + abundant vein quartz, remnant gneiss, compact to semi-competent. >20% to <10% weathered.
48-54	*In situ*. Saprock, altered felsic gneiss, greys to olive-greys to browns, vein quartz at 48-52 m, semi-competent. <20% to >5% weathered.
54-60	*In situ*. Bedrock, dark grey to grey + dark green-grey + pink, chlorite altered felsic gneiss, foliated, chlorite + quartz + K-feldspar + micas + sericite, coarse- to very coarse-grained, competent. <5% weathered.
E.O.H.	Regolith Logged by M.J. Sheard (PIRSA-GSB)

In situ Regolith

Gneissic bedrock was penetrated at 54 m and has chloritic alteration with abundant quartz (?veining) and K-feldspar + micas + sericite. This rock is altered Tunkillia Suite orthogneiss and is on the edge to or external to the defined mineralized part of this prospect. Saprock is ~8 m thick and is transitional to saprolite above. Saprolite has been reduced to 30 m here by the palaeochannel incision, the remainder follows descriptions for this prospect set out earlier. Pedolith has been totally removed by the palaeochannel erosion at this location. Two and a half kilometres further west this same palaeochannel complex has incised >35 m into the *in situ* weathered regolith (Sheard, 2007b).

Transported Regolith

Transported regolith here is moderate (>17 m) and consists of a 4 m thick aeolian sand layer followed by fluvial deposits (sand, clayey sand, sandy clay and fine gravel) of a significant palaeochannel system. Fluvial sand intervals here have oxidised hues (reds, browns, yellows) but in a number of drillhole profiles to the N and E there are intervals with reduced oxide hues (greys to near black). Those redox colours may be significant for sedimentary uranium exploration. Riverine erosion has significantly cut into the weathered basement profile and the valley infill is near complete to the point that the palaeochannel is difficult to discern from previous topographic mapping and more recently constructed digital elevation modelling (Sheard, 2007b). This regolith profile is in marked contrast to Benchmark 13.

Geochemistry

There is no public domain geochemistry available for this drillhole. More general comments on calcrete (soil hosted) elemental abundances and dispersion set out earlier (Figures 77, 78). As mentioned above, the large palaeochannel system (Narlaby-Yaninee) may host sedimentary roll-front U-REE as suggested by marked redox changes in sediment hues with channel depth (Sheard, 2007b).

Benchmark 15: drillhole WUD6-693 (Baggy Green gold prospect)

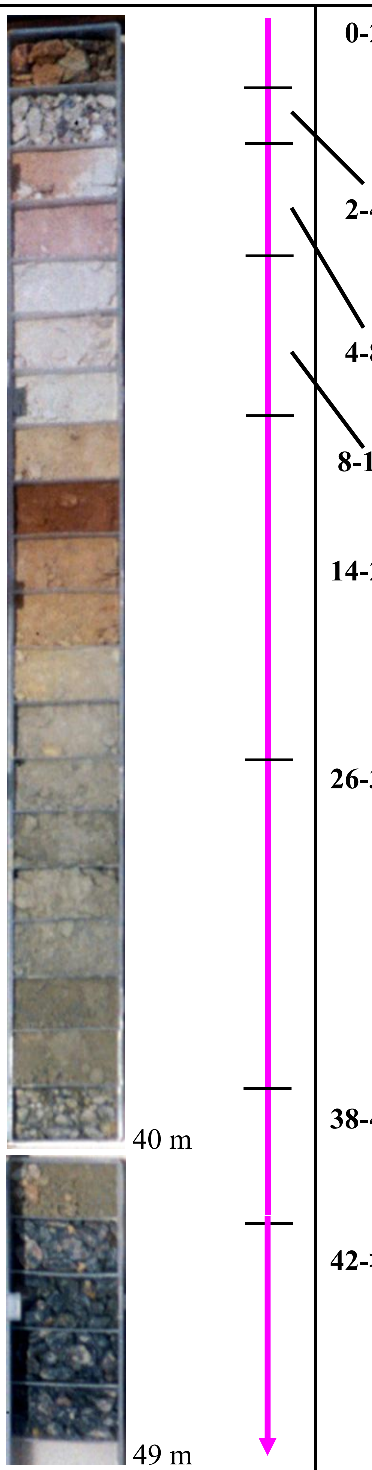
Quick reference items are set out in Table 36; detailed descriptions, figures and data tables follow on below. Barns gold prospect is ~360 km NW of Adelaide and ~25 km N of Wudinna on the YARDEA 1:250,000 map area of Eyre Peninsula. Access is via the unsealed Barns Road N of Wudinna (Figures 67-76). This Au anomaly is mostly on private farm land but partly extends into the Gawler Ranges National Park. Drilling for many of the holes on this prospect was vertical (RAB and RC methods), but some later RC and diamond coring was angled. A summary of this profile is provided in Table 37 and chiptray photograph with regolith zonation is in Figure 81. Regional calcrete geochemical data are presented in Figures 77, 78.

Table 36: Benchmark 15 reference data; drillhole WUD6-693 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 67-69.
Local-site location map	Figures 70, 75, 76.
GPS coordinates, attitude & elevation	Drillhole WUD6-693: RAB Hammer 0-49 m. Zone 53, 547030 E, 6363081 N, GDA 94. **Attitude**: vertical. **AHD:** 131.14 m (Digital Terrain Model).
Site access, owner	Baggy Green gold prospect is ~360 km NW of Adelaide, ~25 km N of Wudinna and ~100 km WNW of Kimba on the YARDEA 1:250,000 map area of Eyre Peninsula. Access is via the unsealed Bartley Road N of Wudinna and Park fire-access tracks. Prospect is totally within the Pinkawillinie Conservation Park.
Related drillholes	Adelaide Resources Ltd Barns prospect drillhole grid (300 holes).
Drill sample photo / log	Yes, Figure 81, Table 37.
Sample types	Drill chips in chiptrays.
Sample storage	Adelaide Resources Ltd, 69 King William Rd, UNLEY, SA.
Lithotypes	Weathered Tunkillia Suite granodiorite (gneiss).
Petrology	No.
Geochemistry	Yes, calcrete only (Figures 77, 78).
XRD mineralogy	No.
PIMA spectral data	No.
Dating	Yes, for Tunkillia Suite granodiorite (gneiss) at nearby Little Pinbong Rockhole, U-Pb zircon age of 1669 ± 13 Ma (Fanning *et al*., 2007, pp. 131).
Target Elements	Au.
Potential Pathfinder Elements	Ag & Cu, ?As.
Useful sampling media	Calcrete.
Key reference sources	Drown (2002, 2003), Adelaide Resources Ltd (2004), Sheard (2007a, b), Lintern (2004c, 2005, 2006), McEntegart and Schmidt-Mumm (2004).

Background

Drillhole WUD6-693 is selected to form this benchmark because it is within the main Au mineralized area, it has negligible transported regolith, and the weathered *in situ* regolith profile is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 16 (in an area of moderately thickly covered weathered basement) and the regolith cross-section Figure 76. The exploration grid drilling involved a combination of RAB with hammer, Aircore and RC methods. Follow-up diamond coring did not core through the regolith (transported & weathered *in situ* regolith zones). Cuttings have been sampled from the drilled 2 m composites (not ideal for regolith investigations). This drillhole was not originally intended for use as a benchmark, it was later logged and interpreted as part of regional regolith studies by Sheard (2007a, b).



0-2 m	*in situ*: calcrete cemented Fe-rich capping of collapsed megamottles and fragments of silicified pedolith-saprolite, brown + yellow-brown + pale yellow, competent to fragmental. Strong acid reaction.
2-4 m	Silicified upper saprolite (to silcrete in thin bands), Fe-mottles and stains, pallid grey + dark FeOH browns, kaolinite + QAZ cement + angular quartz grit. No acid reaction.
4-8 m	Megamottled upper saprolite, near white to pale brown to pale pink, kaolinite + fine-grained quartz grit, chalky to weakly coherent.
8-14 m	Pallid upper saprolite, near white to pale grey, soft to chalky and earthy, kaolinite + fine-grained quartz grit, chalky to weakly coherent.
14-26 m	Upper saprolite, weakly to strongly coloured, variably (FeOH) stained, weakly to moderately coherent, chalky in places, kaolinite-rich + fine-grained quartz grit.
26-38 m	Lower saprolite, >20% weathered, blotchy greys, kaolinite-rich, plastic (moist), coherent.
38-42 m	Saprock, 5-20% weathered, blotchy greys + browns and pinks, relict foliation and gneissic texture, competent, partly weathered felsic gneiss.
42->49 m	Bedrock, dark grey-green + white, chloritic felsic gneiss, coarse-grained, relict K-feldspar + quartz + chlorite + clays along fractures. <5 weathered.

Sample interval = 2 m except bottom chamber = 1 m

Regolith logged by M.J. Sheard

Figure 81: Benchmark 15, Baggy Green gold prospect drillhole WUD6-693, chiptrays and regolith zonation (image extracted from Sheard, 2007b). Bedrock at 42 m, E.O.H. at 49 m.

Table 37: Summary log of Benchmark 15 drillhole WUD6-693 (Type 2, drill cuttings profile).

Drillhole: WUD6-693, Baggy Green Au Prospect, Adelaide Resources Ltd. **Coords:** Zone 53, 547030 E, 6363081 N, GDA 94. **DTM Elevation:** 131.14 m. **Azimuth:** 360°, **Dip Angle:** -90°, **Drill Type:** RAB Hammer.	
Depth (m)	**Description**
0-2	*In situ* materials. Calcrete cemented Fe-rich capping of collapsed megamottles and fragments of silicified pedolith-saprolite, brown + yellow-brown + pale yellow, competent to fragmental. Strong acid reaction.
2-4	*In situ* materials. Silicified upper saprolite (to silcrete in thin bands), Fe-mottles and stains, pallid grey + dark FeOH browns, kaolinite + QAZ cement + angular quartz grit. No acid reaction.
4-8	*In situ*. Megamottled upper saprolite, near white to pale brown to pale pink, kaolinite + fine-grained quartz grit, chalky to weakly coherent.
8-14	*In situ*. Pallid upper saprolite, near white to pale grey, soft to chalky and earthy, kaolinite + fine-grained quartz grit, chalky to weakly coherent.
14-16	*In situ*. Upper saprolite, pale yellow, soft to chalky, kaolinite-rich + fine-grained quartz grit.
16-18	*In situ*. Upper saprolite, strongly coloured orange (FeOH), weakly coherent to chalky, kaolinite-rich + fine-grained quartz grit.
18-22	*In situ*. Upper saprolite, pale orange-brown, mildly coherent, kaolinite-rich + fine-grained quartz grit.
22-26	*In situ*. Upper saprolite, pallid: blotchy white and yellowish pale grey, mildly coherent, kaolinite-rich + fine-grained quartz grit.
26-38	*In situ*. Lower saprolite, blotchy greys, kaolinite-rich, plastic (moist), coherent. >20% weathered.
38-42	*In situ*. Saprock, blotchy greys + browns and pinks, relict foliation and gneissic texture, competent, partly weathered felsic gneiss. 5-20% weathered.
42-49	*In situ*. Bedrock, dark grey-green + white, chloritic felsic gneiss, coarse-grained, relict K-feldspar + quartz + chlorite + clays along fractures. <5 weathered.
E.O.H.	Regolith Logged by M.J. Sheard (PIRSA-GSB)

In situ Regolith

Gneissic bedrock was penetrated at 42 m, it has chloritic alteration, the rock is coarse-grained, with relict K-feldspar + chlorite + quartz and clay lined rock fractures. This rock is altered Tunkillia Suite orthogneiss and is within the defined mineralized part of this prospect. Saprock is ~4 m thick and has many of the bedrock properties but is more than just incipiently weathered. Saprolite is ~34 m thick at this site, is both pallid and variably coloured, with mottling near the top. This weathering zone generally follows descriptions for the prospect set out earlier. Pedolith is truncated by erosion here, what remains is a remnant collapsed megamottle horizon (ferruginous) with some silcrete and siliceous overprinting that extends into the upper saprolite. The detail is difficult to be certain about but some cuttings imply the silcrete is densely developed in thin bands (cuttings alone don't provide large enough fragments for complex weathering or cementation fabrics or textures to be properly observed-described), (Sheard, 2007b).

Transported Regolith

There is little to no transported cover recorded for this site (possibly a patchy sandy soil <100 mm thick derived from aeolian materials), (Sheard, 2007b). This regolith profile is in marked contrast to Benchmark 16.

Geochemistry

There is no public domain geochemistry available for this drillhole. More general comments on calcrete (soil hosted) elemental abundances and dispersion are set out earlier, (Figures 77-78), (Sheard, 2007b).

Benchmark 16: drillhole BGRC-1057 (Baggy Green gold prospect)

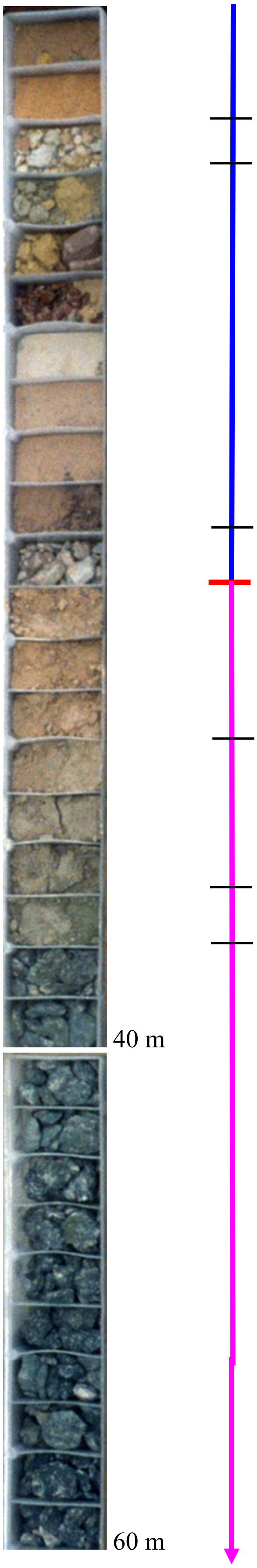
Quick reference items are set out in Table 38; detailed descriptions, figures and data tables follow on below. Barns gold prospect is ~360 km NW of Adelaide and ~25 km N of Wudinna on the YARDEA 1:250,000 map area of Eyre Peninsula. Access is via the unsealed Barns Road N of Wudinna (Figures 67-76). This Au anomaly is mostly on private farm land but partly extends into the Gawler Ranges National Park. Drilling for many of the holes on this prospect was vertical (RAB and RC methods), but some later RC and diamond coring was angled. A summary of this profile is provided in Table 39 and chiptray photograph with regolith zonation is in Figure 82. Regional calcrete geochemical data are presented in Figures 77, 78.

Table 38: Benchmark 16 reference data; drillhole BGRC-1057 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 67-69.
Local-site location map	Figures 70, 75, 76.
GPS coordinates, attitude & elevation	Drillhole BGRC-1057: Reverse Circulation, 0-196 m. Zone 53, 547513 E, 6364670N, GDA 94. **Azimuth:** 095.5^o, **Dip Angle:** -60^o, **AHD:** 120.00 m (Digital Terrain Model).
Site access, owner	Baggy Green gold prospect is ~360 km NW of Adelaide, ~25 km N of Wudinna and ~100 km WNW of Kimba on the YARDEA 1:250,000 map area of Eyre Peninsula. Access is via the unsealed Bartley Road N of Wudinna and Park fire-access tracks. Prospect is totally within the Pinkawillinie Conservation Park.
Related drillholes	Adelaide Resources Ltd Barns prospect drillhole grid (300 holes).
Drill sample photo / log	Yes, Figure 82, Table 39.
Sample types	Drill chips in chiptrays.
Sample storage	Adelaide Resources Ltd, 69 King William Rd, UNLEY, SA
Lithotypes	Weathered Tunkillia Suite granodiorite (gneiss).
Petrology	No.
Geochemistry	Yes, calcrete only (Figures 77, 78).
XRD mineralogy	No.
PIMA spectral data	No.
Dating	Yes, for Tunkillia Suite granodiorite (gneiss) at nearby Little Pinbong Rockhole, U-Pb zircon age of 1669 ± 13 Ma (Fanning *et al*., 2007, pp. 131).
Target Elements	Au.
Potential Pathfinder Elements	Ag & Cu, ?As.
Useful sampling media	Calcrete.
Key reference sources	Drown (2002, 2003), Adelaide Resources Ltd (2004), Sheard (2007a, b), Lintern (2004c, 2005, 2006), McEntegart and Schmidt-Mumm (2004).

Background

Drillhole BGRC-1057 is selected to form this benchmark because it is north of the main Au mineralized area, it has significant transported regolith (palaeochannel sediment), and the weathered *in situ* regolith profile is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 15 (in an area of outcropping weathered basement) and the regolith cross-section Figure 76. The exploration grid drilling involved a combination of RAB with hammer, Aircore and RC methods. Follow-up diamond coring did not core through the regolith (transported & weathered *in situ* regolith zones). Cuttings have been sampled from the drilled 2 m composites (not ideal for regolith investigations). This drillhole was not originally intended for use as a benchmark, it was later logged and interpreted as part of regional regolith studies by Sheard (2007a, b).



0-4 m **Transported**: yellowish quartz aeolian sand (fine- to medium-grained), frosted angular to rounded grains, loose to free running. No acid reaction.

4-6 m **Transported**: yellowish quartz aeolian sand (as above) + paler yellow quartz sand to grit (medium- to coarse-grained, subrounded to rounded) unconsolidated to weakly bound by pallid calcrete, fluvial sediment. Strong acid reaction.

6-20 m **Transported**: (6-9 m) yellowish clayey quartz sand to grit (medium- to coarse-grained, subrounded to rounded) weakly bound by ~5% clay. No acid reaction. (9-12 m) mottled clay + quartz sand to grit (as above) + rounded lithic gravel. (12-20 m) pale yellowish brown to dark brown quartz sand (fine-grained grading to coarser grained with depth, angular to well rounded), coherent, fluvial sediment.

20-22 m **Transported**: gravel, greyish quartz clasts (subrounded to well rounded, ~4->15 mm), no fines, Unconsolidated basal bed to palaeochannel valley, **unconformity** at 22 m.

22-28 m ***In situ***: upper saprolite, **truncated** profile, pale yellow-brown to variably pallid clay + fine-grained quartz grit, competent to coherent.

28-34 m Lower saprolite, >20% weathered, greenish grey to dark olive-grey, clay + degraded chlorite-rich material, coherent.

34-36 m Transition interval (>20% to <10% weathered) lower saprolite – saprock: dark olive-grey, chlorite + clays + quartz, partly weathered chloritic gneiss, competent.

36-196 m Bedrock, <5% weathered, (36-76 m) chloritic felsic gneiss, dark green-grey & olive-grey, fine- to very coarse-grained, chlorite + quartz + minor clays, competent. (76-196 m) variably chlorite altered felsic gneiss, dark grey to dark olive-grey to pink with pale grey, fine- to very coarse-grained, chlorite + quartz + pink K feldspar + opaques, very competent. Essentially unweathered.

Sample interval = 2 m, only first 2 of 5 chiptrays are imaged.

Regolith logged by M.J. Sheard

Figure 82: Benchmark 16, Baggy Green gold prospect drillhole BGRC-1057, chiptrays and regolith zonation (image extracted from Sheard, 2007b). Bedrock at 36 m, E.O.H. at 196 m.

Table 39: Summary log of Benchmark 16 drillhole BGRC-1057 (Type 2, drill cuttings profile).

Depth (m)	Description
Drillhole: BGRC-1057, Baggy Green Au Prospect, Adelaide Resources Ltd. **Coords:** Zone 53, 547513 E, 6364670N, GDA 94.. **DTM Elevation:** 120.0 m. **Azimuth:** 095.5^o, **Dip Angle:** -60^o, **Drill Type:** Reverse Circulation.	
0-4	Transported materials. Yellowish quartz aeolian sand (fine- to medium-grained), frosted angular to rounded grains, loose to free running. No acid reaction.
4-6	Transported materials. Yellowish quartz aeolian sand (as above) + paler yellow quartz sand to grit (medium- to coarse-grained, subrounded to rounded) unconsolidated to weakly bound by pallid calcrete, fluvial sediment. Strong acid reaction.
6-~9	Transported materials. Yellowish clayey quartz sand to grit (medium- to coarse-grained, subrounded to rounded) weakly bound by ~5% clay, fluvial sediment. No acid reaction.
~9-12	Transported materials. Mottled clay + quartz sand to grit (medium-grained, subrounded to angular) + lithic gravel (rounded, 3-10 mm) composed of Fe-pedolith or remnant megamottle clasts. Coherent, fluvial sediment. No acid reaction.
12-20	Transported materials. Pale yellowish brown to dark brown quartz sand (fine-grained grading to coarser grained with depth, angular to well rounded) fluvial, well to poorly sorted sediment, clayey in basal 2 m. Unconsolidated.
20-22	Transported materials. Fluvial basal gravel, greyish quartz clasts (subrounded to well rounded, ~4->15 mm), no fines, Unconsolidated palaeochannel basal bed, **unconformity**.
22-28	*In situ*. Upper saprolite, **Truncated** profile, pale yellow-brown to variably pallid clay + fine-grained quartz grit, competent to coherent.
28-34	*In situ*. Lower saprolite, greenish grey to dark olive-grey, clay + degraded chlorite-rich material, coherent. >20% weathered
34-36	*In situ*. Transitional interval lower saprolite to saprock, dark olive-grey, chlorite + clays + quartz, partly weathered chloritic gneiss, competent. ~10% to >20% weathered.
36-76	*In situ*. Bedrock, chloritic felsic gneiss, dark green-grey and olive-grey, fine- to very coarse-grained, chlorite + quartz + minor clays, competent. <5% weathered.
76-196	*In situ*. Bedrock, variably chlorite altered felsic gneiss, dark grey to dark olive-grey to pink with pale grey, fine- to very coarse-grained, chlorite + quartz + pink K feldspar + opaques, very competent. Essentially unweathered.
E.O.H.	**Note:** no depth correction for angled drilling has been made, to obtain true depths multiply by 0.86. Regolith Logged by M.J. Sheard (PIRSA-GSB)

In situ Regolith

Gneissic bedrock was penetrated at 36 m and has chloritic alteration with quartz and K-feldspar + micas. This rock is altered Tunkillia Suite orthogneiss and is N of the main mineralized part of this prospect. Saprock is thin and ill defined, being transitional to saprolite above. Saprolite has been reduced to ~13 m here by the palaeochannel incision, the remainder follows descriptions for this prospect set out earlier. Pedolith has been totally removed by the palaeochannel erosion at this location (Sheard, 2007b).

Transported Regolith

Transported regolith here is moderately thick (22 m) and consists of a >5 m thick aeolian sand layer followed by fluvial deposits (sand, clayey sand, sandy clay and fine gravel) of the Narlaby Palaeochannel system (underlies the Corrobinnie Depression). Fluvial sand intervals here have oxidised hues (browns, yellows) but in a number of adjacent drillhole profiles there are intervals with reduced oxide hues (greys to near black). Those redox colours may be significant for sedimentary uranium exploration. Riverine erosion has significantly cut into the weathered basement profile and the valley infill is near complete (Sheard, 2007b). This regolith profile is in marked contrast to Benchmark 15.

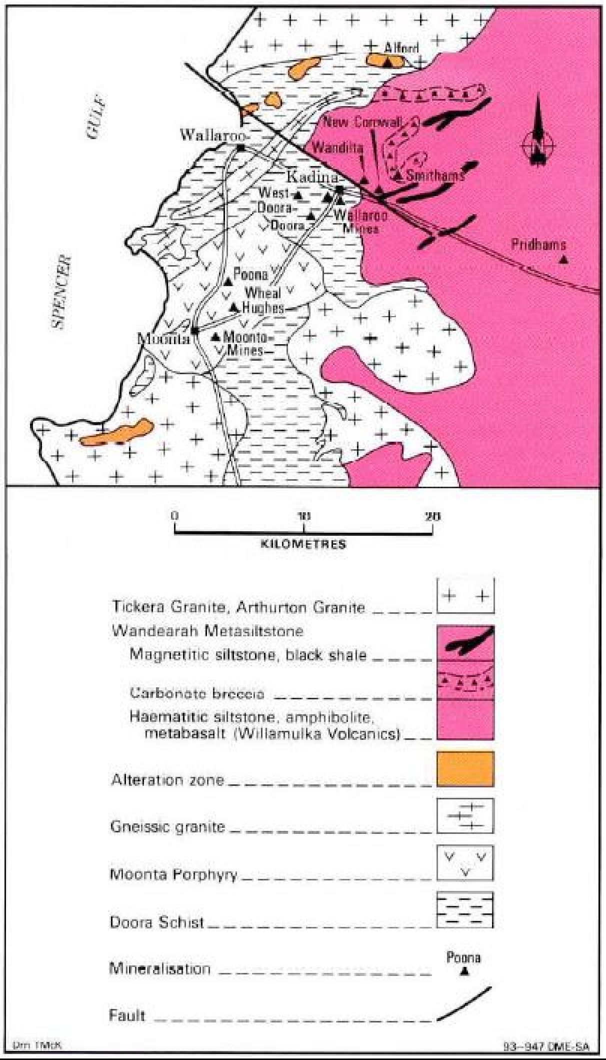
Geochemistry

There is no public domain geochemistry available for this drillhole. More general comments on calcrete (soil hosted) elemental abundances and dispersion are set out earlier (Figures 77, 78). As mentioned above, the large palaeochannel system (Narlaby-Yaninee) may host sedimentary roll-front U-REE as suggested by marked redox changes in sediment hues with channel depth (Sheard, 2007b).

Yorke Peninsula *(Moonta-Wallaroo Copper District)*

The Moonta-Wallaroo Copper District of northern Yorke Peninsula is approximately 120 km NW of Adelaide (Figure 1) and was an important source of copper between 1861-1923, producing over 350,000 t Cu and 2 t Au. Numerous but narrow, shear hosted Cu-sulphide lodes, are covered by 5-15 m of sedimentary regolith. Initial discovery came from recognition of secondary copper carbonates (malachite, azurite) or copper oxychloride (atacamite) in the spoil of wombat or bandicoot burrows by a shepherd named Patrick Ryan. Most mining took place adjacent to the town of Moonta but smaller scale shaft-pit-costean operations also occurred near Kadina ('Wallaroo Mines'; Figure 83).

Recent mining operations at Poona and Wheal Hughes (1988-92; Figure 84) followed a 30 year exploration history in the district by Western Mining Ltd, North Broken Hill Ltd and Broken Hill South Ltd. Copper sulphide lodes were located in 1985 using a large-loop (1 km) ground TEM survey with follow up 100 m coincident-loop SIROTEM surveys, and close-spaced drilling of conduction anomalies (Keeling and Hartley, 2005; Cornish and Drew, 1999; Parker, 1993; Both *et al*., 1993).



Location for Figures 83, 84.

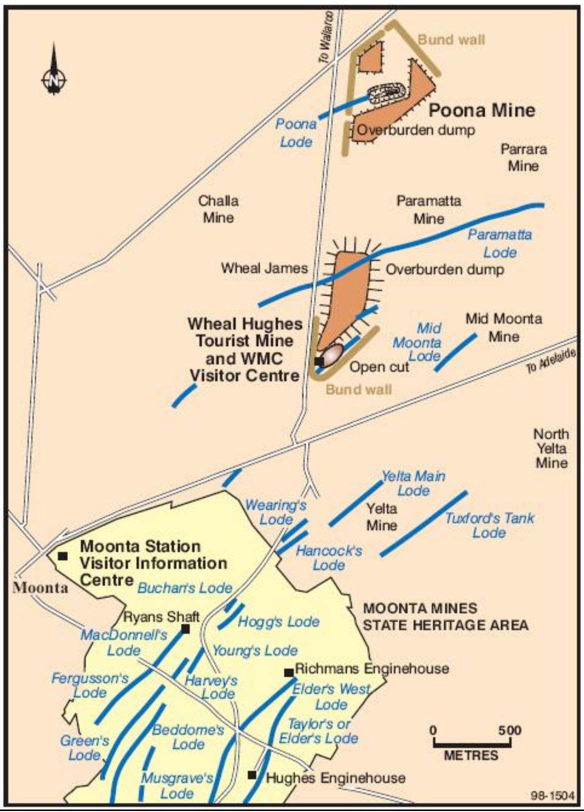


Figure 83: Proterozoic geology of the Moonta-Wallaroo area showing where historic and recent Cu-Au mining has taken place (Parker, 1993). Inset atop next Figure provides regional location.

Figure 84: Location of Cu-Au mines in the Moonta area, and the orientation of the numerous Cu-sulphide lodes (Cornish and Drew, 1999).

Climate in the Moonta-Wallaroo area is semi-arid, where annual rainfall is <400 mm and annual evaporation is ~2000 mm. This area has hot dry summers and cool moist winters (Griffin and McCaskill, 1986). The landscape is a gently undulating depositional plain with relict linear 'seif' dunes and loamy soils bearing widespread calcrete. Prior to 1860 this area was covered by open scrub and *Eucalyptus* mallee woodland, now mostly cleared for cereal cropping, leaving remnants along road corridors (Keeling and Hartley, 2005; Jack, 1917). The region is highly anomalous with respect to numerous metals (Cu, Au, Pb, Zn, Mo, Ni, Co, U and Ce (Conor, 1995).

Geological Setting

The Moonta mines, including Poona and Wheal Hughes, are all within Moonta Porphyry, a Palaeoproterozoic, foliated rhyolite to rhyodacite complex. Relict primary textures in the porphyry indicate a sequence of comagmatic ash-flow tuff and tuff breccia with intrusive microgranite (Lemar, 1975). The volcanics intercalate with Wallaroo Group metasediments, including Doora Member schist and calcsilicate which host the Wallaroo Cu deposits, 15 km NE of Moonta. The Palaeoproterozoic rocks were intruded at ~1580 Ma by Mesoproterozoic Hiltaba Suite granite, now regarded as the source of heat and fluid that mobilised metal ions to sites of deposition (Moonta Porphyry fractures) to form the Moonta Cu lodes (Conor, 2002).

The older Proterozoic basement is overlain by gently folded to flat-lying sediments that include platform marine deposits of Neoproterozoic Burra and Umberatana Groups, Cambrian Winulta Fm. and Kulpara Limestone, and Neogene Melton Limestone. Only remnants of these sediments are preserved in the NW Yorke Peninsula beneath Pliocene-Pleistocene terrestrial clay, younger calcareous dunes and loamy soils (Keeling and Hartley, 2005, Zang, 2003; Zang *et al*., 2006).

Regolith

Basement outcrop near Moonta is restricted to the coast around Moonta Bay, where weathered and mottled Hiltaba Suite granite is exposed on the beach platform in unconformable contact with silicified Cambrian Winulta Fm. (sandstone). Here cliff sections through Plio-Pleistocene clay and younger calcareous dunes are also visible. The coastal zone north of Moonta Bay includes modern beach and associated dune deposits with saline swamps and clayey alluvium in low lying back-barrier areas adjacent to the coast (Figure 85). Inland the undulating landscape of swale and plateau is covered by calcareous loamy soil that blankets NW-SE trending linear 'seif' dunes (calcareous to siliceous) and a variable thickness of Plio-Pleistocene clay (Hartley, 2000). Dating of alunite bands within the clays of previously assumed Pleistocene age, using K-Ar methods, has revealed them to be significantly older – Pliocene (J.L. Keeling, PIRSA Geological Survey, pers. comm. Nov. 2007).

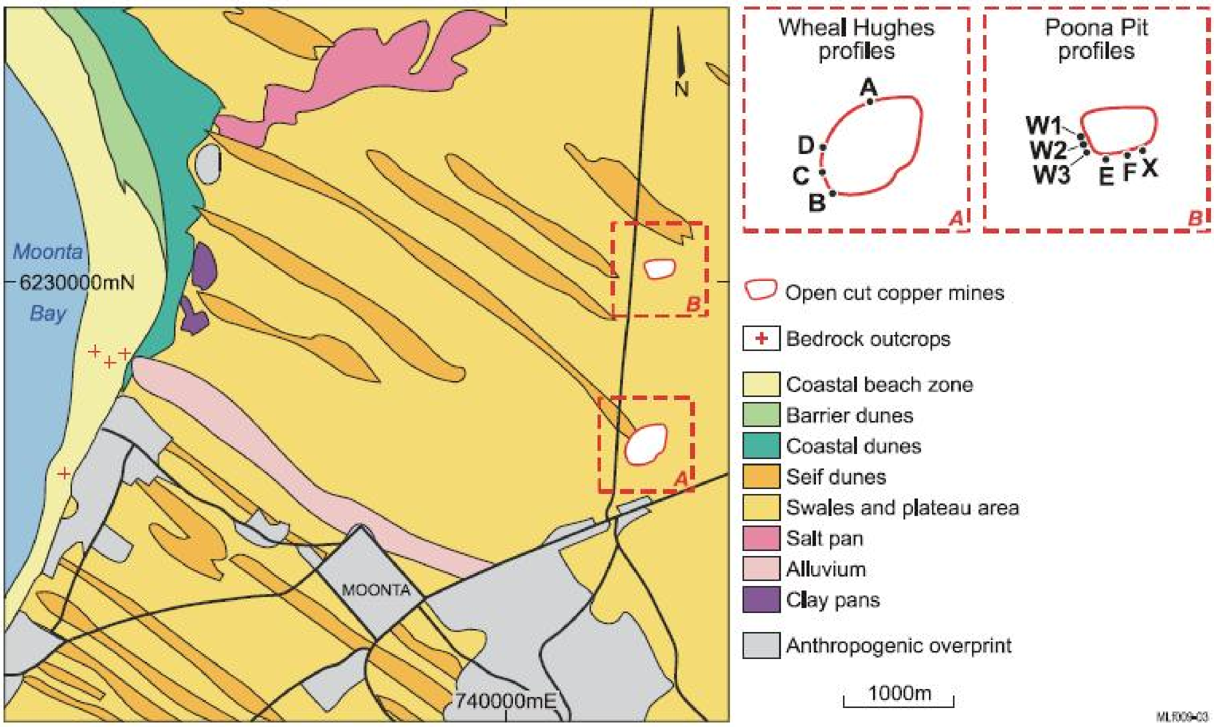


Figure 85: Moonta area regolith-landform map of Hartley (2000) with modifications by Lintern (2004b). Locations to Poona and Wheal Hughes Cu Mines and sampling profile sites are indicated. Compare with Figures 83, 84.

Poona & Wheal Hughes Copper-Gold Mines

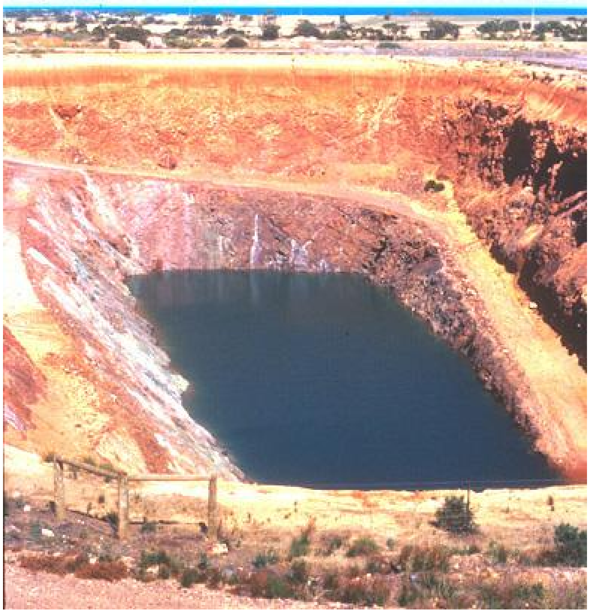


Plate 4: Poona Cu-Au Mine open cut pit, view is ~W towards the coast. The sulphide lode was located on the LHS wall, dipping ~50^o towards 40^o N. Underground workings have been flooded by groundwater pumped in from nearby Wheal Hughes Mine.

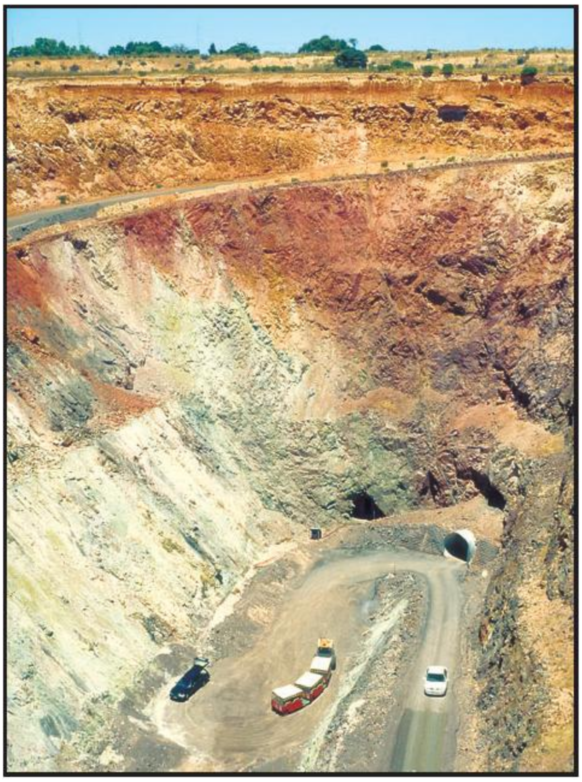


Plate 5: Wheal Hughes Cu-Au Mine open cut pit, view is ~SW. The Cu-Au lode is located within the dipping greenish area of the end wall. Underground workings now form an educational 'Tourist Mine'.

Background

Poona Mine (Plate 4) is 1.7 km N of Wheal Hughes Mine (Plate 5). Both are located 3-6 km NE of Moonta township on NW Yorke Peninsula (Figures 1, 83-85). They are currently used for a 'Tourist Mine' attraction run by the Copper Triangle District Council (Cornish and Drew, 1999). Regolith landform mapping and profile classification, with geochemical investigations were carried out during 1997-1999 as part of ongoing CRC LEME regolith studies (Hartley, 2000, 2004; Keeling *et al*, 2003; Keeling and Hartley, 2005).

Ore totalling 475,000 tonnes, averaging 4.0% Cu and 1.0 g/t Au, was mined from both Poona and Wheal Hughes Mines during 1988-1993 (Adelaide Resources NL, 1996).

Mineralization

As described earlier, these deposits were located using geophysical methods in the mid 1980's. However, the Poona deposit could just as easily have been located using Au-in-calcrete methods developed later for exploration by CSIRO (early 1990's). It has anomalous Cu in soil and calcrete (10->80 ppm) and Au (<3-10 ppb) (Hartley, 2000, 2004). Wheal Hughes deposit on the other hand has very low levels of surface Cu-Au anomalism and this difference has been the focus of recent regolith research (Keeling, 2004).

Poona Pit shape reflects the lenticular nature of the main lode, with offshoots of mineralization occurring in the hanging wall (Figure 86). Lodes plunge 22^o W, dip ~50^o towards 040^o and strike along 070^o. Mineralization is truncated to the WSW and ENE by steeply dipping faults striking ~032^o (Conor, 1996). Principal lode minerals include: chalcopyrite and pyrite with minor bornite, gold and native copper. Secondary minerals included: covellite, chalcocite, digenite and djurleite (Janz, 1990; Both *et al*., 1993). At Wheal Hughes pit, the mineralization is similar to Poona but has associated tourmaline. Lodes at Wheal Hughes are structurally similar to those at Poona, and are like wise structurally constrained. Wheal Hughes footwall and hanging wall lodes (~2-5 m wide) parallel each other and are joined by a 'middle' lode (Conor, 1996; Figure 87).

The wall rocks at both deposits show primary alteration associated with hydrothermal fluids, of Mg-chlorite and muscovite/phengite with coatings of secondary halloysite related to acid sulphate groundwater (Mauger *et al*., 1997; Keeling *et al*., 2003).

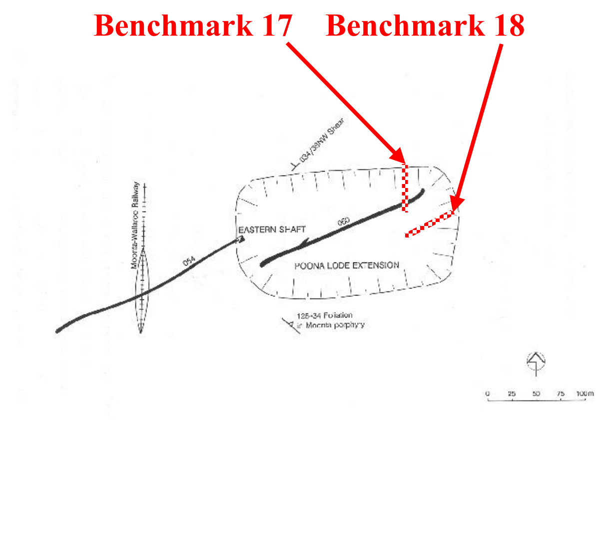


Figure 86: Diagrammatic representation of the mineralized lodes at Poona Mine, their parallel nature is typical of the Moonta area (after Janz, 1990). Benchmarks 17 & 18 locations are indicated. Scale bar is 100 m.

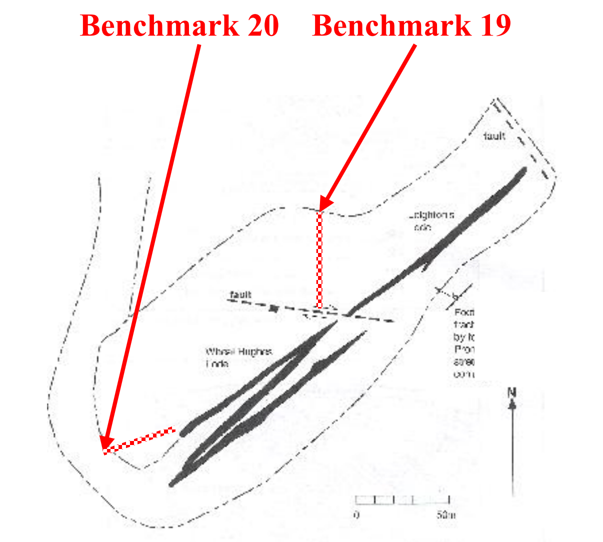


Figure 87: Diagrammatic representation of the mineralized lodes at Wheal Hughes Mine, their parallel nature is typical of the Moonta area (after Conor, 1996). Benchmarks 19 & 20 locations are indicated. Scale bar is 50 m.

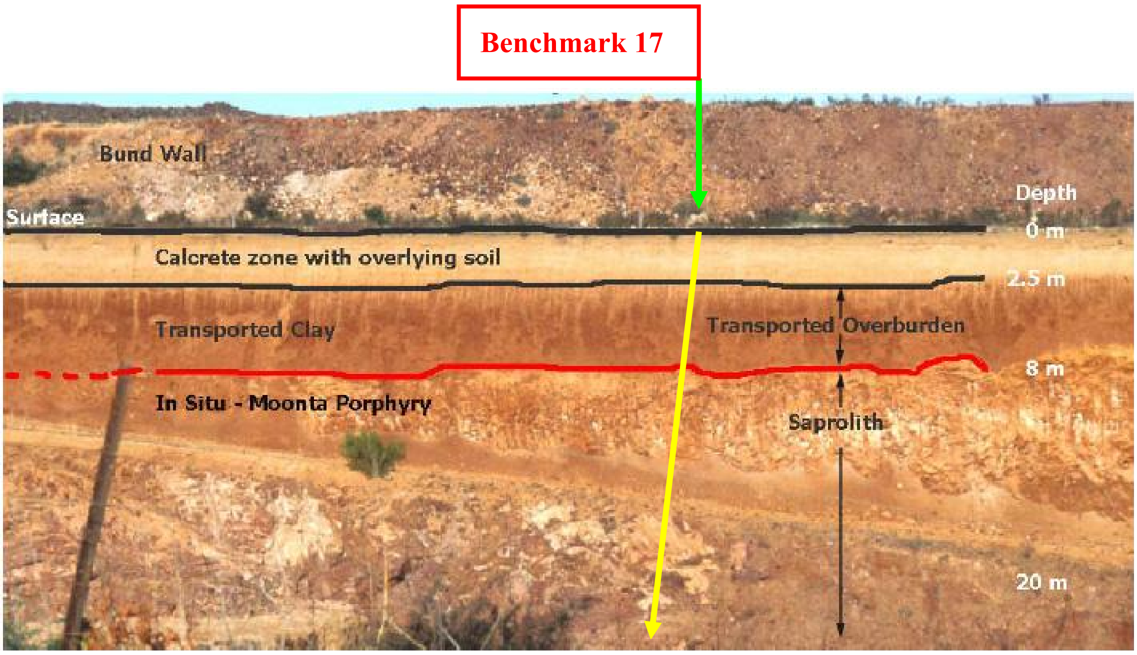


Figure 88: Poona Mine open cut pit, regolith profile exposed on the southern wall, haulage way is cut into saprolith. Regolith zonation is indicated, a red line marks the unconformity (Hartley, 2000). Benchmark 17 profile location is indicated (yellow line & red tag) and Benchmark 18 is out of frame on the far right.

In situ Regolith

Bedrock is Moonta Porphyry at both mines, and the open cut pits expose both altered and relatively fresh porphyry, generally reddish (Figure 88) but it can be grey to greenish where chemically altered. Rock fabric is strongly developed near the mineralized lodes. Saprolith ranges in thickness from <10->20 m and its upper third to half has red megamottles developed within a pallid saprolitic clay + quartz groundmass retaining a reasonable degree of rock competency. There is no pedolith preserved below transported regolith at either mine site. Pedolith was eroded prior to deposition of the Cambrian sandstone at Wheal Hughes and prior to deposition of the Cainozoic terrigenous sediment sequence at Poona. However, a remnant lag of Cainozoic silcreted Cambrian sandstone has been observed in the profile at Wheal Hughes, where fist sized clasts lie along the sandstone-Cainozoic clay unconformity

(Plate 6; Hartley, 2000). It therefore can be surmised that a pedolith profile containing silcrete horizon(s) did exist here at one time (similar to that still preserved in the sandstone along Moonta Bay).

Transported Regolith

Plate 6: Dark rinded lag clasts of silicified Cambrian sandstone from the unconformity contact with overlying Cainozoic clay, Wheal Hughes Mine, SW face (Hartley, 2000).

Plate 7: Fractured Cambrian sandstone at Wheal Hughes Mine, SW face adjacent to haulage way (Hartley, 2000).

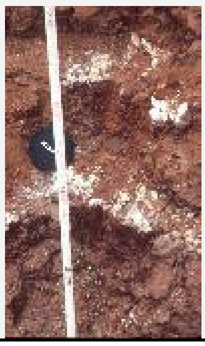


Plate 8: White alunite seams in transported Cainozoic red-brown clay at Poona Mine (Hartley, 2000).

The oldest transported component is Cambrian Winulta Fm. Sandstone exposed within the pit walls at Wheal Hughes Mine (Plate 7. This is a coarse-grained, cross-bedded, fractured and indurated rock containing angular quartz sand with minor K-feldspar grains (mostly altered to kaolinite). Pit wall exposures demonstrate but initially narrow channels incised into the Moonta Porphyry have been infilled and deposition expanded laterally to include much broader areas. Erosion has subsequently removed much of this sandstone but not before pedogenic silcrete horizons had developed within its exposed top (Plate 6). This erosional unconformity represents a long time where little or no deposition occurred in this area, and where the resultant regional landform is a low relief basement plateau thinly covered by Cainozoic sediment.

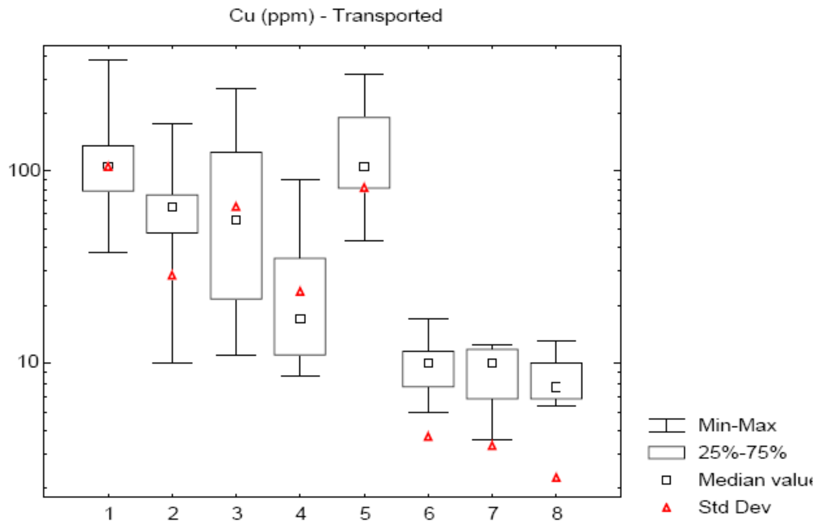
Overlying the main unconformity is a red-brown terrigenous sequence dominated by clay with lesser sand, granules and gravel. Deposition has occurred in alluvial fans, valley flat, playa lake and fluvial channel settings. These materials strongly resemble portions of the Pleistocene Ardrossan Clay (E side of Yorke Peninsula) and the more wide spread Pleistocene Hindmarsh Clay, and have been stratigraphically correlated with Hindmarsh Clay by Zang (2003) and Zang *et al*. (2006). Palaeomagnetic polarity studies by Pillans and Bourman (1996) have demonstrated the presence, within this sequence in the Moonta area, of the Brunhes-Matuyama 0.78 Ma magnetic reversal, consistent with Hindmarsh Clay examined elsewhere within St Vincent Basin. However, K-Ar dating of conspicuous but thin alunite seams (Plate 8) high in this sequence, at Poona Mine; has revealed Pliocene ages (2.09 ± 0.03 Ma & 2.14 ± 0.05 Ma; J.L. Keeling, PIRSA Geological Survey, pers. comm. Nov. 2007) well beyond those accepted to be from the oldest Hindmarsh Clay members (*i.e.* Pleistocene <1.6 Ma to > 0.35 Ma). Therefore this sequence is strictly not Hindmarsh Clay and its correlation with Ardrossan Clay may also be in doubt.

Overlying the red-brown clay sequence is a pale yellow-brown to pale orange sandy clay (<1-~2 m thick) with textural similarities to the Pooraka Fm of the Adelaide Plains. Sediment in this unit has a mixture of aeolian and fluvial provenance. Soil development is visible within the top ~200 mm, which is greyer and much more sandy. That sand may relate to the linear Pleistocene seif dunes of the area (swale sand).

Conspicuous calcrete has developed throughout the sandy clay and upper portions of the underlying red-brown clay sequence (refer to Figure 88 and Benchmark 17). This pale coloured zone contains pervasive silty, earthy, pisolitic to nodular, biscuity and aggregated cobble forms of calcrete – as a duricrust overprint. Calcite dominates the near surface calcrete horizons but this becomes progressively more dolomitic with profile depth (Hartley, 2000; Lintern, 2004b).

Geochemistry

All material from the mine pits including: soil, calcrete, transported clay, alunite seams and sandstone, have higher Cu concentrations than background samples (Figure 89), suggesting that these are related to the underlying mineralization. Profile data indicate that Cu abundances generally increase with depth through the calcrete zone and transported clay into the *in situ* (residual) regolith in the Poona Pit profiles, which suggests that the Cu in the transported regolith is related to the underlying mineralization. Maximum Cu concentrations occur at ~4 m within transported clay at Poona Pit (120-220 ppm) corresponding with a change in clay mineralogy from smectite to kaolinite (Figure 90a, b). Copper and Fe distributions are related throughout the profiles at both Pits and may be related to Cu^{2+} adsorption and incorporation into Fe-oxides and clay minerals (Figure 90c, d).



MINERALIZED MATERIAL
1 Soil –Pits (n=8)
2 Calcrete – Pits (n=89)
3 Clay – Pits (n=140)
4 Sandstone – Pits (n=11)
5 Alunite Seams – Pits (n=11)

NON-MINERALIZED MATERIAL
6 Coastal Transported Clay (n=9)
7 Coastal Alunite Seams (n=4)
8 Coastal Sand Dune (n=10)

Figure 89: Copper concentrations in different materials within transported regolith of the Moonta study area (Hartley, 2000). Note higher Cu concentrations in sample media from the mine pits (1-5), in comparison with the sample media from the coast, at least 2 km distant (6-8). Adapted from Hartley (2000) and Lintern (2004b).

Red-brown clay (previously equated with Hindmarsh Clay), hosts relatively soluble, secondary Cu mineralization as atacamite [$Cu_2Cl(OH)_3$] in geode forms and irregular crystalline masses up to ~350 kg, located above the Cu-sulphide lodes exploited by mining around Moonta in the late 19th and early 20th centuries (Jack, 1917; Keeling, 2004). A similar occurrence was observed for Poona Mine (Janz, 1990; Both *et al.*, 1993) but there was no such occurrence at Wheal Hughes Mine (Hartley, 2000; Keeling, 2004; Both *et al.*, 1993). Moreover, alunite seams (Plate 8), carrying elevated Cu and REE signatures, are also only found over the Cu-lodes at Poona Mine, but not at Wheal Huges (Hartley, 2000). Arguments had been made by Keeling (2004) for this difference being due to clay *versus* sand capillary-suction differences affecting the vertical migration of groundwater bearing Cu salts from the Cu-lodes into any overlying clays. It would now seem that in light of the alunite distribution, Pliocene dates and evidence from palaeo-sea levels, that a more plausible cause for atacamite and alunite developing within the red-brown transported clay sequence is 'earthquake pumping' of metal-bearing acid groundwater.

Material from the mine pits, in particular the soil, calcrete and alunite seams, contained higher concentrations of Au (>10 ppb for mine pit calcrete) than the transported clay and alunite seams collected from nearby coastal areas where the Au concentrations were generally below the detection limit (<0.10 ppb; Hartley, 2000; Lintern, 2004b).

High Au concentrations (up to 10 ppb) are present in the upper 2-2.5 m of regolith at Poona Mine, which corresponds to the calcrete horizon. Gold concentrations tend to reach their maximum just below the surface (*i.e.* 0.5 m depth) in those profiles, and peaks also occur at the boundary between calcrete and red-brown clay – some of which correlate with alunite seams. Gold concentrations at Wheal Hughes Mine are consistently lower (<3 ppb) in the calcrete horizon than is the case for Poona Mine. Gold concentrations within the transported clay at Wheal Hughes Mine are generally <1 ppb (Figure 90), (Hartley, 2000; Lintern, 2004b).

As with Cu, Au concentrations in the transported clay at Poona Mine consistently have maxima at the clay mineral change (depth of ~3.80 m). Gold and Ca generally behave similarly in all profiles at Poona Mine, however Au minima *versus* Ca minima are more erratic and seem to relate to calcrete morphology *i.e.* from nodular to predominantly pisolitic. For Wheal Hughes Mine the relationship between Au and Ca is less clear due to very low Au concentrations in near surface regolith (Figure 90), (Hartley, 2000; Lintern, 2004b).

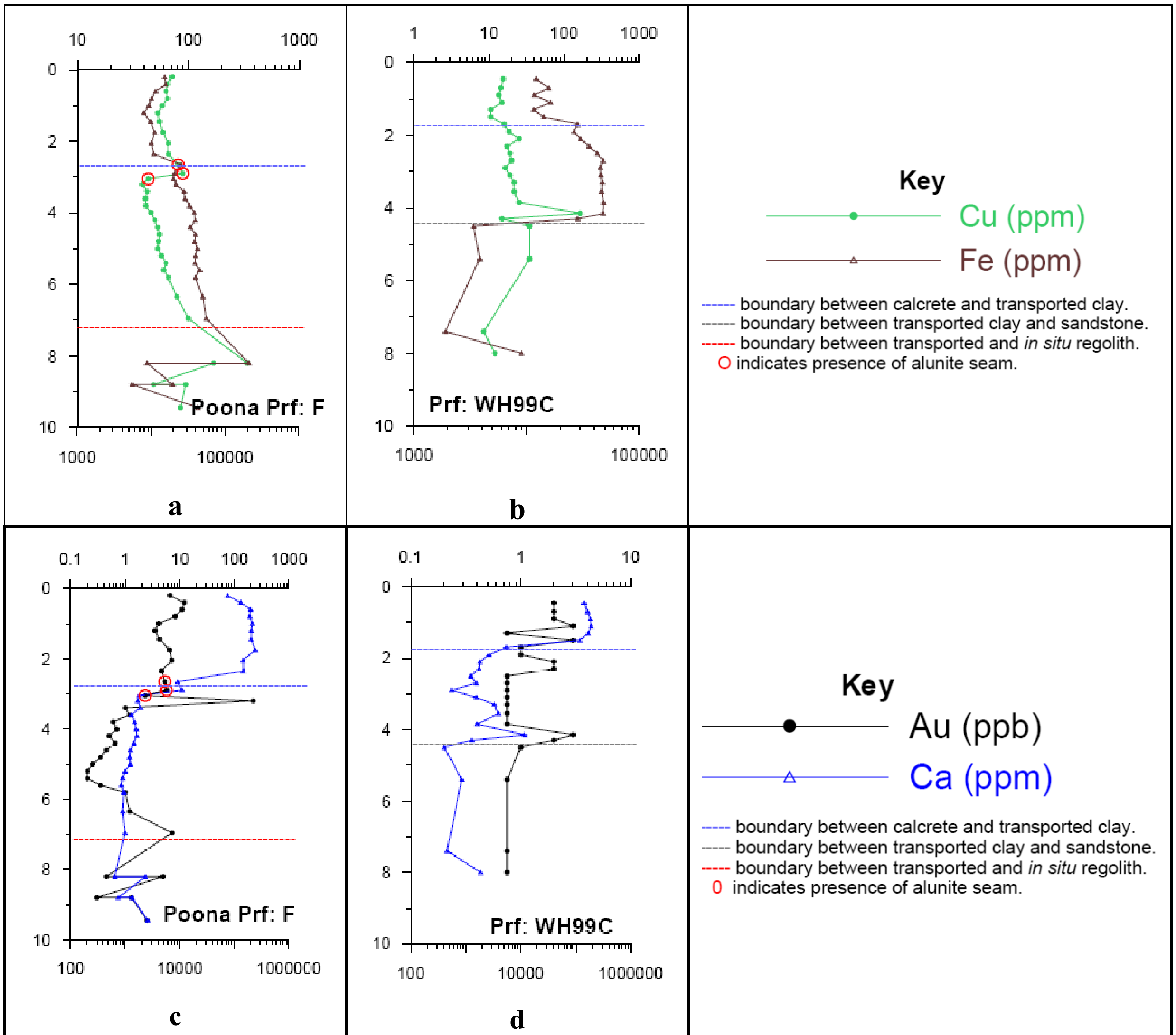


Figure 90: Down profile distributions of Cu *vs* Fe (plots a, b) and Au *vs* Ca (plots c, d) for selected profiles from Poona Mine (LHS) and Wheal Hughes Mine (centre), (after Hartley, 2000; Lintern, 2004b). Refer to Figure 85 for profile locations.

<u>Sample media</u>: a large selection of varied sample media were tested by Hartley (2000) and Mazzucchelli *et al*. (1980), their data along with calcrete data from Adelaide Resources Ltd, have been evaluated and adapted to compile the summary Table 40 for Moonta district sample media (Keeling and Hartley, 2005). Calcrete is the best near surface sample medium for Au and Cu in this region; alunite, if present, is another useful sample medium (Lintern, 2004b).

<u>Geochemical Conclusions</u>: The presence of 5-10 m of Cainozoic transported regolith conceals residual regolith at Moonta. However, geochemical signatures for Cu and Au are present within that transported regolith, those can lead to detection of underlying mineralization. Relatively high Cu and Au concentrations at the calcrete—transported clay boundary (commonly associated with alunite seams) are probably due to upward migration of acid–saline groundwater precipitating metals with the increasing pH near calcrete. Copper-Fe and Au-Ca are associated in the transported regolith, Au is especially concentrated in calcrete. These findings are similar to those of Mazzucchelli *et al*. (1980) for the area near Kadina, ~10 km N of Moonta; where the readily extractable Cu in transported regolith was

said to be due to continued upward migration of Cu in highly saline acidic groundwater, with some lateral dispersion occurring prior to fixation in the high pH calcrete horizon (Lintern, 2004b).

Table 40: Moonta district sample media summary tabulation (Keeling and Hartley, 2005). Data adapted from Hartley (2000) with background and dispersion estimates taking into account data in Mazzucchelli *et al*. (1980) and unpublished calcrete data from Adelaide Resources Ltd.

Sample Medium	Indicator Elements	Analytical Methods	Detection Limit (ppm)	Background (ppm)	Maximum anomaly (ppm)	Dispersion Distance (m)
Residual Regolith						
Weathered Bedrock	Cu Au	ICP-MS[1] ICP-MS[2]	0.5 0.0005	<50 <0.001	3500 0.070	20-50 N/A
Transported Regolith						
Pleistocene clay	Cu Au U	ICP-MS[1] ICP-MS[2] ICP-MS[1]	0.5 0.0005 0.02	10-20 <0.0005 5	260 0.0086 36	100 50-100 N/A
Alunite seam	Cu Au U	ICP-MS[1] ICP-MS[2] ICP-MS[1]	0.5 0.0005 0.02	<15 <0.001 10	270 0.005 36	distribution uncertain
Calcrete	Cu Au	ICP-MS[1] ICP-MS[2]	0.5 0.0005	<20 <0.002	210 0.012	100 50-100

[1] ICP-MS analysis of 0.25 gm samples after HF/HCl/HNO_3 digest.

[2] ICP-MS analysis of 0.25 gm samples after a 24 h cyanide digest.

Benchmark 17: Pit Profile E (Poona Cu-Au Mine)

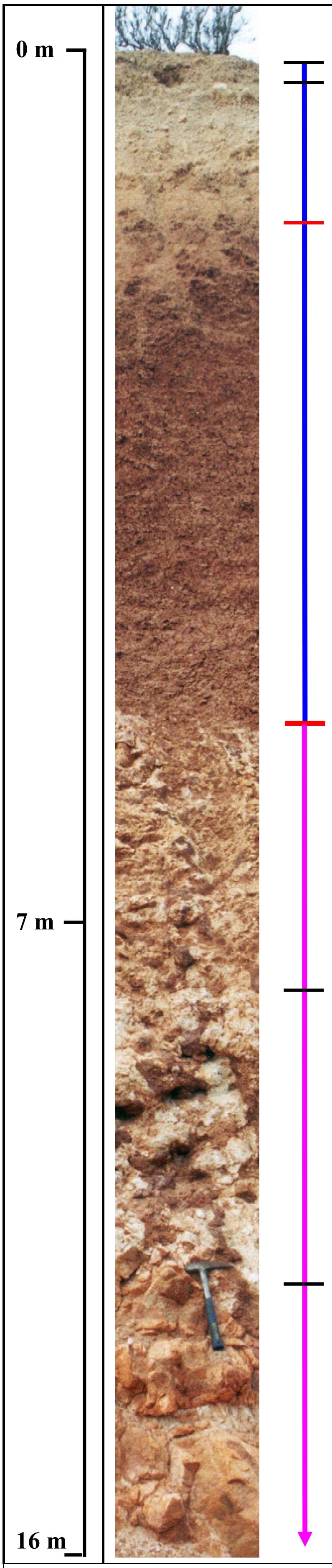
Quick reference items are set out in Table 41; detailed descriptions, figures and data tables follow on below. Poona Mine is ~120 km NW of Adelaide and ~6 km N of Moonta on the MAITLAND 1:250,000 map area of Yorke Peninsula. Access is via sealed roads N of Moonta (Figures 83-88). This mine open cut pit is on private land controlled by the Copper Triangle District Council. Regolith sampling utilised existing mine haulage way tracks and mine faces using ladders and abseil techniques for safe collecting. A summary of this profile is provided in Table 42 and photographs with regolith zonation are in Figures 88, 91, 92. Geochemical data are presented in Figures 89, 90, 95, 96.

Table 41: Benchmark 17 reference data; Pit Profile E, Poona Cu-Au Mine (Type 3, mine profile).

Items	Figures, Data, Sources
Regional location map	Figures 83-84.
Local-site location map	Figures 85, 86, 88.
GPS coordinates & elevation	Steep profile down Mine footwall Zone 53, 741481 E, 6230216 N, GDA 94. **AHD:** ~47 m (topographic map data).
Site access, owner	Mine is located just E of the sealed Moonta to Wallaroo road, N of Moonta. This mine open cut pit is on private land controlled by the Copper Triangle District Council. Permission to enter MUST be obtained from the Copper Triangle District Council and associated Tourist Mine operator.
Related profiles	APX, F, W1 to W3 of Hartley (2000).
Profile photo / log	Yes, Figures 88, 91, 92; Table 42.
Sample types	1-2 kg bags + chiptrays.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Sediments, weathered & fresh Moonta Porphyry.
Petrology	Yes, *c.f.* Janz (1990), Conor, (2002), Fanning *et al*. (2007).
Geochemistry	Yes, (Figures 89, 90, 95, 96), Table 40.
XRD mineralogy	Yes, (Figure 93).
PIMA spectral data	Yes, (Figure 94).
Dating	Yes, Moonta Porphyry, U-Pb zircon age of 1753 ± 8 Ma & 1748 ± 15 Ma (Fanning *et al*., 2007, pp. 102-104). Yes, alunite seams in transported clay at Poona Mine: 2.09 ± 0.03 Ma & 2.14 ± 0.05 Ma (J.L. Keeling, PIRSA Geological Survey, pers. comm. Nov. 2007)
Target Elements	Cu, Au.
Potential Pathfinder Elements	Cu, Au.
Useful sampling media	Calcrete, soil.
Key reference sources	Hartley (2000), Lintern (2004b), Keeling (2004), Mauger *et al*. (1997), Keeling *et al*. (2003), Keeling and Hartley (2005), Conor, (2002), Both *et al*. (1993), Janz (1990), Jack (1917).

Background

This pit face profile is selected to form benchmark 17 because it intersects the main Cu-Au mineralization, it has a moderate thickness of transported regolith, and the weathered *in situ* regolith profile is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 18. Regolith was sampled using the pit haulage road access, with a ladder + abseil methods to collect material safely from a measured profile. Samples of 1-2 kg were collected, these were studied and analysed as part of two CRC LEME – PIRSA sponsored undergraduate and Honours student projects spanning 1997-1999 (Hartley, 2000). This profile was not originally intended for use as a benchmark, it has been later re-logged and partly re-interpreted for this report by the author.



Ground surface. **Transported:** 0.00-5.65 m.

0-0.30 m soil, sandy to loamy, siliceous and highly calcareous,
some organic matter, 10YR 3/3. Aeolian sand.

0.30-2.10 m calcrete horizon, silty to loamy + earthy to pisolithic to nodular calcrete, loose to compact, 7.5YR 4/4 to 5YR 6/4 to 5YR 5/8, ? Pooraka Fm.

2.10 m **Unconformity # 2**

2.10-5.65 m **transported:** red-brown clay, sediment, massive, heavy clay, 2.5YR 4/6 to 4/8, 35->55% clay,
sandy
+ silty in some bands.

5.65 m **Unconformity # 1**

5.65-7.80 m ***in situ*:** megamottled pallid saprolite, clay + quartz grit, 2.5Y 7/2 & 10R 4/4. Highly weathered Moonta Porphyry.

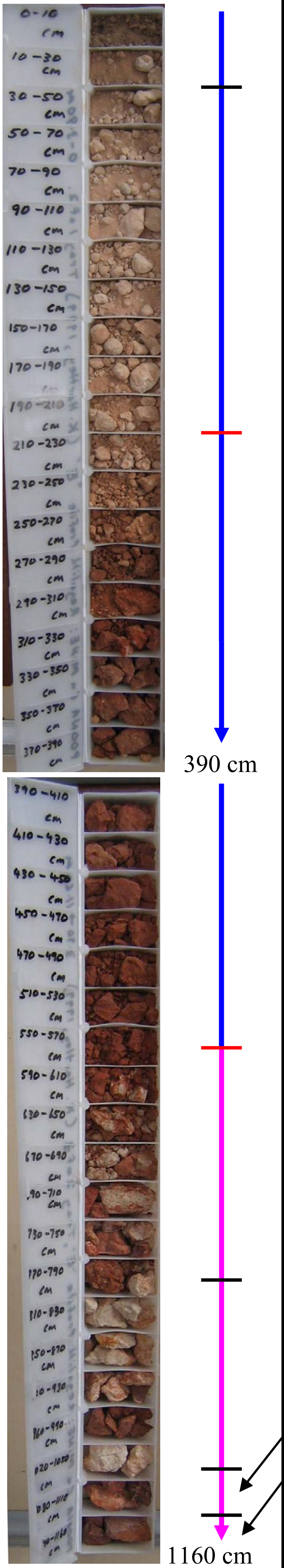
7.80-12.0 m pallid saprolite with variable staining by reddish FeOx, 5Y 7/2 + 10R 4/6. Weathered Moonta Porphyry.

12.00 m saprock, saprock + altered bedrock, alteration mostly by acid groundwater from Cu-sulphide lode oxidation, yellow-brown to reddish (2.5YR 4/6 + 10R 4/6). Moonta Porphyry.

For remainder of profile expression, as chiptrays, see Figure 92.

Logged by K. Hartley & M.J. Sheard

Figure 91: Benchmark 17, Poona Mine, regolith profile E (upper portion), image is angled up profile from haulage road, so vertical scale is not linear, hammer head at saprolith-bedrock join.



Ground surface. **Transported:** 0.00-5.65 m.

0-0.30 m soil, sandy to loamy, siliceous and highly calcareous, some organic matter, 10YR 3/3. Aeolian sand.

0.30-2.10 m calcrete horizon, silty to loamy + earthy to pisolithic to nodular calcrete, loose to compact, 7.5YR 4/4 to 5YR 6/4 to 5YR 5/8. ? = Pooraka Fm.

2.10 m **Unconformity # 2**

2.10-5.65 m **transported:** red-brown clay, sediment, massive, heavy clay, 2.5YR 4/6 to 4/8, 35->55% clay, sandy + silty in some bands.

5.65 m **Unconformity # 1**

5.65-7.80 m ***in situ*****:** megamottled pallid saprolite, clay + quartz grit, 2.5Y 7/2 & 10R 4/4. Highly weathered Moonta Porphyry.

7.80-10.35 m pallid saprolite with variable staining by reddish FeOx, 5Y 7/2 + 10R 4/6. Weathered Moonta Porphyry.

10.35- 10.95 m lower saprolite to saprock, yellow-brown to reddish.

>11 m bedrock + some saprock, Moonta Porphyry, brownish, 2.5YR 4/6 & 5YR 5/8.

Note: sampling is mostly in 30 cm intervals with similar sized gaps between in 2nd tray. Chiptrays compiled from 1-2 kg bagged samples. Logged by K. Hartley & M.J. Sheard.

Figure 92a: Benchmark 17, Poona Mine Profile E, top two chiptrays (0.0-11.6 m) see Figure 92b for remainder. Samples collected while sampler abseiled down the pit wall.

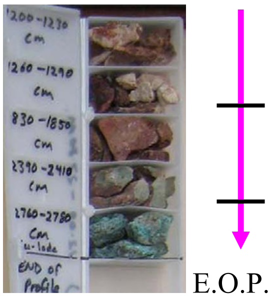
 E.O.P. at 2780 cm	**12.0->13 m** altered bedrock, dark brown to black, some clayey intervals. Altered Moonta Porphyry. **~18-24 m** bedrock, brown 2.5YR 4/6, Moonta Porphyry. Green secondary Cu staining along fractures (5G 6/2). **24->27.8 m** **copper lode**, green secondary Cu (5G 6/8, 5GY 6/6) and black chalcocite (N 1/-) + altered host rock. **Note:** irregular sampling. Chiptray compiled from 1-2 kg bagged samples. Logged by K. Hartley & M.J. Sheard.

Figure 92b: Benchmark 17 continued, Poona Mine Profile E bottom chiptray 12.0-27.8 m, see Figure 92a for top trays.

In situ Regolith

Moonta Porphyry bedrock is encountered at ~11 m, however, there is extant alteration, associated with fracturing between 12-13 m. Generally the bedrock is reddish to brownish with paler remnant feldspar phenocrysts on mm scales, this rock is quite competent. Copper mineralization extends from bedrock into the saprolite, in this profile only the secondary chalcocite (black) and atacamite/malachite (green) copper minerals were encountered (remnants left behind post mining). Saprock is relatively thin (<<0.5 m) and ill defined, being transitional to saprolite above. Saprolite has been reduced to ~5 m here by pre Pliocene erosion, its upper portions are strongly megamottled, the remainder follows descriptions for this prospect set out earlier and in Table 42. Any pedolith developed within weathered *in situ* basement has been totally removed by erosion at this location (Hartley, 2000).

Transported Regolith

Transported regolith here is moderate (5.65 m) and consists of ~0.3 m of aeolian sand and silt into which have developed a thin loamy soil and ubiquitous earthy to pisolitic calcrete to 2.1 m. Unconformably below this is a significantly older massive red-brown sedimentary clay sequence, with a medium to heavy texture and a thickness of ~3.5 m. There are some sandier intervals within this clay and its upper portions are variably calcrete impregnated. This sediment contained appreciable quantities of atacamite immediately above the copper lodes, forming nodules, irregular masses, aggregated crystals and individual translucent to transparent dark green crystals (typically of 2 x 2 x 20 mm size), (Janz, 1990; Both *et al*., 1993; Hartley, 2000). That style of post secondary mineralization was not encountered in this profile because the mine face angles away from the ore zone at that level. Furthermore, white alunite seams carrying high Cu and REE values also occur in this clay above the copper lodes and they were encountered in this and related nearby profiles, see Figure 93 (Hartley, 2000; Keeling, 2004, Lintern, 2004b; Mauger *et al*., 1997). Underlying this Cainozoic red-brown clay is a mildly irregular erosion surface (unconformity) where no other deposition remnants younger than Cambrian are known (see Benchmarks 19 & 20). This regolith profile has similarities and differences to and with Benchmark 18.

Mineralogy: XRD & PIMA

Calcrete zone XRD data reflect the dominantly quartz and calcite mineralogy of the upper part, with dolomite becoming more abundant with depth. The PIMA device was unable to adequately define the carbonate make up of this zone (Hartley, 2000; and Figures 93, 94).

Alunite seam XRD data indicate alunite and quartz dominating the mineralogy, with the clay fraction being either of smectite or kaolinite type (Hartley, 2000; and Figure 93). PIMA did detect alunite.

Transported clay XRD data demonstrate the presence of quartz and alunite in the majority of samples analysed. Clays present include: kaolinite, smectite or illite; but accessory minerals like rutile are only in trace amounts. PIMA spectra indicated the presence of interlayered smectite/kaolinite clays, where halloysite (hydrated kaolinite) is more common with depth and montmorillonite dominates the smectites near the basal zone (Hartley, 2000; and Figures 93, 94).

Moonta porphyry XRD data indicate the mineralogy is distinct from the transported regolith by being rich in microcline. PIMA detected halloysite in the upper pallid saprolite (Hartley, 2000; and Figure 93).

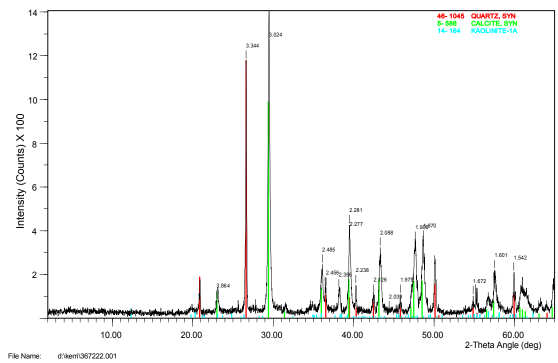
Table 42: Summary log of Benchmark 17, modified after Hartley (2000) with additional logging by M.J. Sheard (for 6.9-27.8 m).

Depth (cm)	Textural analysis	Munsell Colour	Clay %	Description: visual + microscope observations
0-10	loam, fine sandy	10YR 3/3	25	Predominantly rounded-subrounded quartz grains, clear, orange, milky, some with reddish coloured inclusions. Minor calcrete and lithics.
10-70	sandy clay loam	7.5YR 3.5/4 to 4/4	20-30	Predominantly nodular calcrete. Minor rounded-subrounded clear and milky quartz grains, with orange inclusions. Minor angular lithics.
70-150	fine sandy clay loam	7.5YR 5/4 + 6/6, 5YR 6/4	30-35	Predominantly nodular and pisolith calcrete, with some manganese coatings. Minor rounded and subrounded clear and milky quartz.
150-210	sandy clay	5YR 5/6 to 5/8	30-40	Predominantly calcrete pisoliths and nodules. Minor rounded-subrounded clear and milky quartz grains. Composite quartz-in-calcrete grains present.
210-250	light clay	5YR 6/6	35-40	Predominantly calcrete nodular. Minor rounded-subrounded clear and milky quartz grains, some with dark red or orange inclusions.
250-290	light medium-medium clay	2.5YR 4/6	40-55	Predominantly rounded-subrounded quartz grains, clear, orange, milky, some with red &/or orange coloured inclusions.
290-310	sandy clay	2.5YR 4/6	35-40	Predominantly rounded-subrounded quartz grains, clear, orange, milky, some with red &/or orange coloured inclusions.
310-350	light medium clay	2.5YR 4/6	40-45	Predominantly rounded-subrounded quartz grains, clear, orange, milky, some with red &/or orange coloured inclusions. Minor calcrete and dark lithics.
350-370	medium clay	2.5YR 4/8	45-55	Predominantly rounded-subrounded quartz grains, clear, orange, milky, some with red &/or orange coloured inclusions. Minor calcrete and dark lithics.
370-430	heavy clay	2.5YR 3/6	50^{+}	Predominantly clear, rounded-subrounded quartz grains some with dark/orange inclusions. Minor milky rounded-subrounded grains. Minor calcrete with manganese coating and dark angular grains.
450-530	medium clay	2.5YR 3/6	45-55	Predominantly clear, rounded-subrounded quartz grains some with dark/orange inclusions. Minor dark angular to subrounded lithics. Minor nodular calcrete.
530-565	heavy clay	2.5YR 4/7	50^{+}	Predominantly clear and milky, pink rounded-subrounded quartz grains some with dark/orange inclusions. Minor dark angular to subrounded lithics.

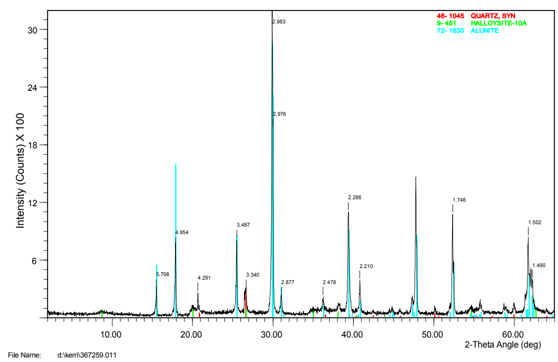
Cont

Table 42: Summary log of Benchmark 17, continued.

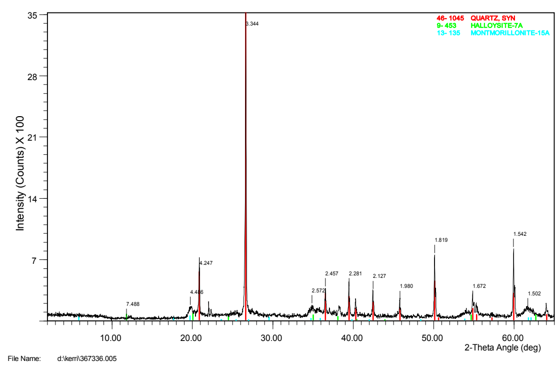
Depth (cm)	Textural analysis	Munsell Colour	Clay %	Description: visual + microscope observations
565-690	heavy clay	5Y 6/2 & 2.5YR 4/7, 4/8	50+	Predominantly rounded-subrounded clear, pink & milky quartz grains some with pinkish/dark orange/yellowish inclusions. Minor dark nodular grains & rounded-nodular calcrete. Minor bright white angular grains present. **Unconformity**. And megamottled pallid saprolite, highly weathered porphyry.
690-790	clay + quartz grit	5Y 6/2, 2.5Y 7/2, 5Y 7/2 + 10R 4/4 & 2.5R 4/4	50+	Megamottled pallid saprolite, highly weathered porphyry.
790-830	clay + quartz grit	5Y 6/2, 2.5Y 7/2, 5Y 7/2	50+	Pallid saprolite, highly weathered porphyry.
850-990	clay + quartz grit	2.5Y 7/2, 5Y 7/2 + 10R 4/6	50+	Pallid saprolite, red FeOx stained, highly weathered porphyry.
1035-1075	clay + quartz grit & relict rock	5YR 5/8 + 10R 4/6	~30	Lower saprolite to saprock, highly to partly weathered porphyry.
~1100-~1200	rock	2.5YR 4/6	<5	Bedrock, reddish-brown porphyry.
~1200-~1300	rock, weak	2.5Y 7/2, 10R 4/6, 2.5YR 4/6	>20	Altered porphyry, saprolith competency.
1830-2400	rock	2.5YR 4/6 + 5G 6/2	<5	Bedrock, reddish-brown porphyry + green secondary copper minerals staining fractures
~2400->2780	mineralization & rock	5G 6/8, 5GY 6/6 & N 1/-	NA	Copper Lode, green secondary Cu and black chalcocite + altered host rock



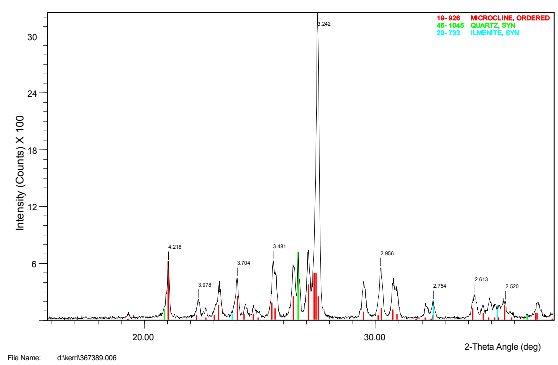
A (red = quartz, green = calcite, blue = kaolinite).



B (red = quartz, green = halloysite, blue = alunite)



C (red = quartz, green = halloysite, blue = smectite)



D (red = microcline, green = quartz, blue = ilmenite).

Figure 93: XRD plots, Benchmark 17; **A** calcrete zone at ~0.5 m, **B** alunite seam in transported red-brown clay at 2.30 m, **C** megamottled saprolite at 6.4 m, and **D** saprolitic Moonta Porphyry at 7.4 m.

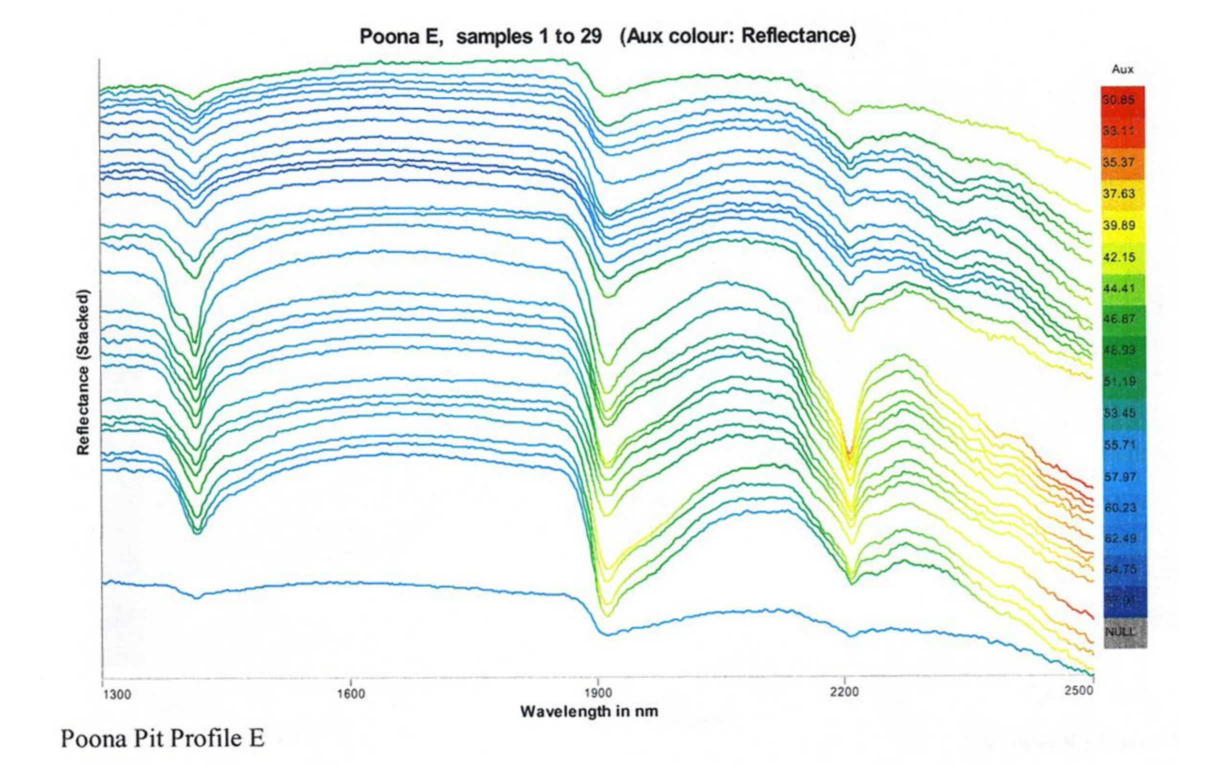


Figure 94: Down profile stacked PIMA spectra for Benchmark 17, 0-6.9 m. Note the shift in the clay water absorption feature approximately halfway down (right of centre); and the increasing FeOx adsorption feature with depth on the LHS (extracted from Hartley, 2000).

Geochemistry

Copper generally increases with depth through the calcrete zone into the transported clay and markedly increases within the weathered residual Moonta Porphyry (Figure 95), suggesting Cu in the transported regolith is related to the underlying mineralization. Peaks in Cu concentration, occur at the boundary between the calcrete zone and transported red-brown clay, and also near the base of that same clay (105 ppm). In nearby profiles, Cu peaks are related to alunite seams (*c.f.* Figure 90) but that situation is not as clear in this Benchmark (Profile E, Hartley, 2000).

Copper versus other elements: Cu distribution relates to that of Fe (and Zn) throughout the entire profile (Figures 95, 96). An inverse relationship between Cu and Au behaviour is evident within the upper metre of the calcrete zone at Poona Mine (Profiles E and F). However, in the lower part of the calcrete zone in the same profiles an increase of Cu concentration corresponds to an increase in Au values (Hartley, 2000).

Gold, high values (up to 10 ppb) are detected within the upper 2-2.5 m of regolith at Poona Mine (Figures 90, 95), which corresponds to the calcrete zone. Gold concentrations tend to reach their maxima just below the surface (<0.5 m), a smaller peak (~1 ppb) also occurs near the boundary between calcrete and the underlying red-brown clay (Hartley, 2000).

Gold versus other elements: Au and Ca generally behave similarly, however Au concentration lows at ~1-1.35 m (2.3 ppb) do not correspond to a decrease in Ca concentration. This change may reflect a change in calcrete morphology (predominantly nodular to pisolitic), (Hartley, 2000).

Alkaline earth elements (Figure 96): Ca, Mg and Sr generally behave similarly throughout the profile. Magnesium increases with depth within the calcrete zone; Ca, Mg and Sr have higher concentrations in the calcrete zone than in the underlying red-brown clay. Barium concentrations have an inverse relationship to the other alkaline earth elements, Ba is highest in the transported red-brown clay. Barium and K behave similarly in this profile and Ba is enriched within the alunite seams.

Rare earth elements (Figure 96): the REE behave the same throughout all profiles at Poona Mine. Peaks in concentration are associated with the calcrete zone boundary with the underlying red-brown clay, as well as within the alunite seams.

Down profile element abundance plots for ~50 elements are presented in Figure 96.

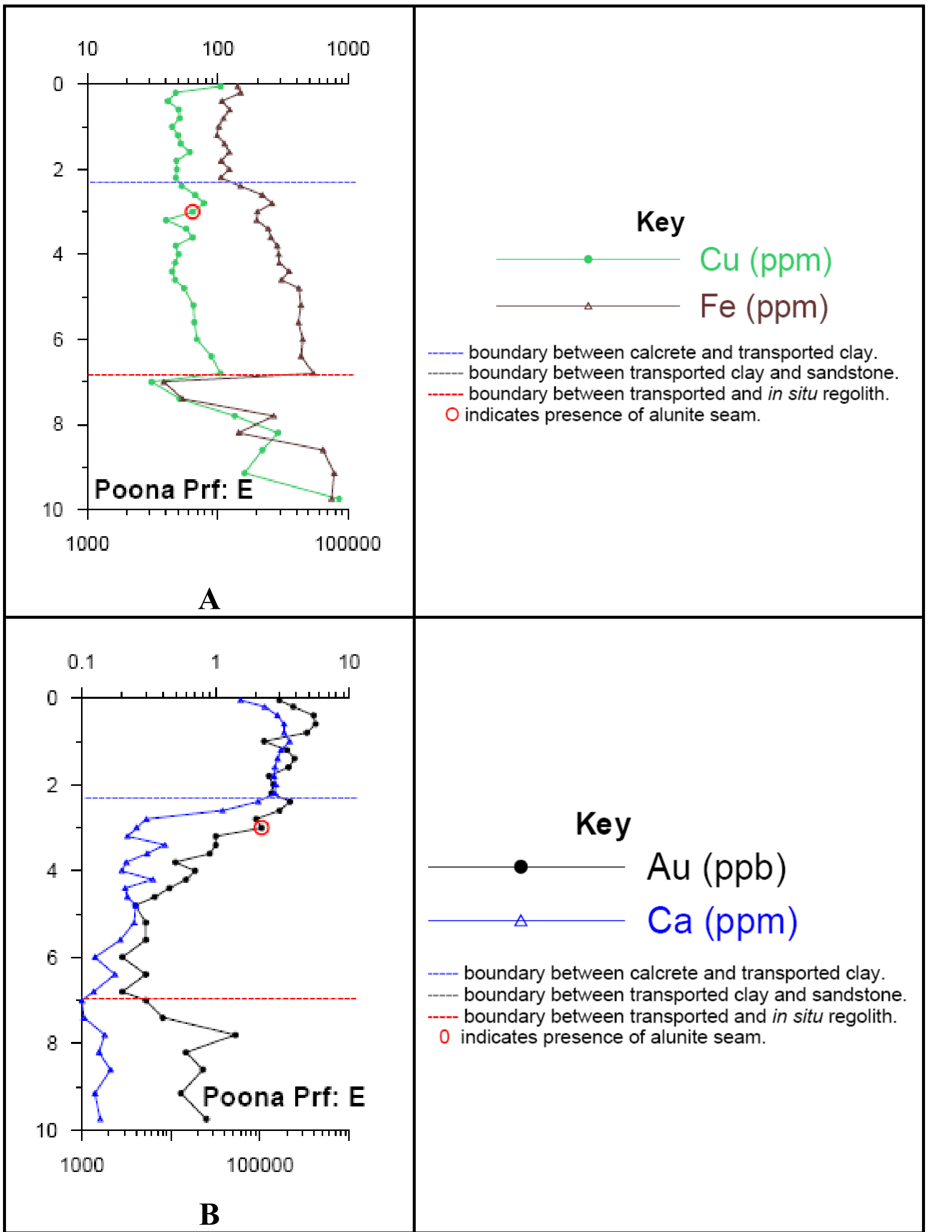


Figure 95: Benchmark 17 down profile distributions of Cu *vs* Fe (plot A) and Au *vs* Ca (plot B), (after Hartley, 2000; Lintern, 2004b). Refer to Figure 86 for profile location and compare with associated profiles in Figure 90.

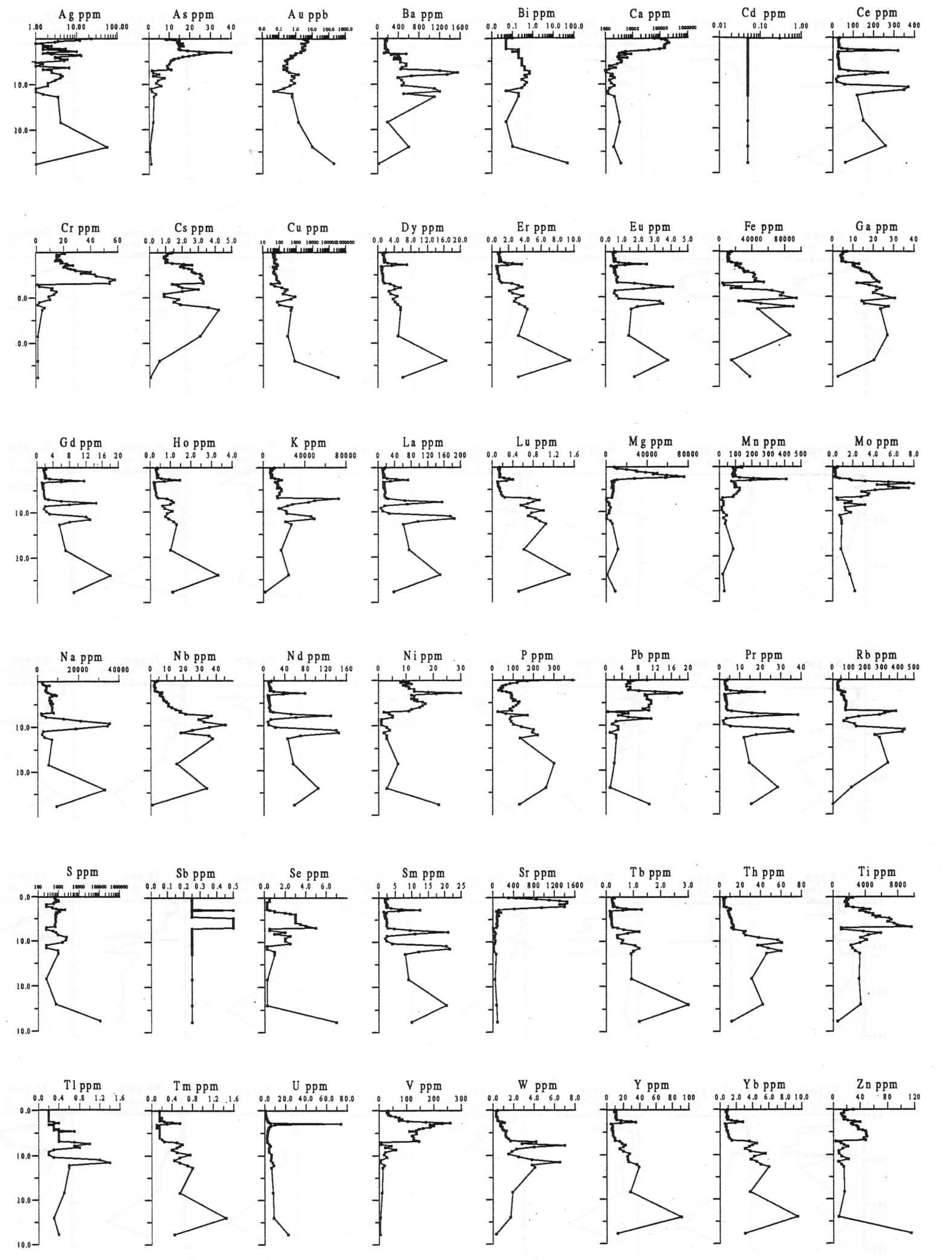


Figure 96: Benchmark 17, down profile plots for 48 selected elements (Hartley, 2000).
Note: depth values on the far left axis should be: 0, 10.0, 20.0 & 30.0 m.

Benchmark 18: Pit Profile W1 (Poona Cu-Au Mine)

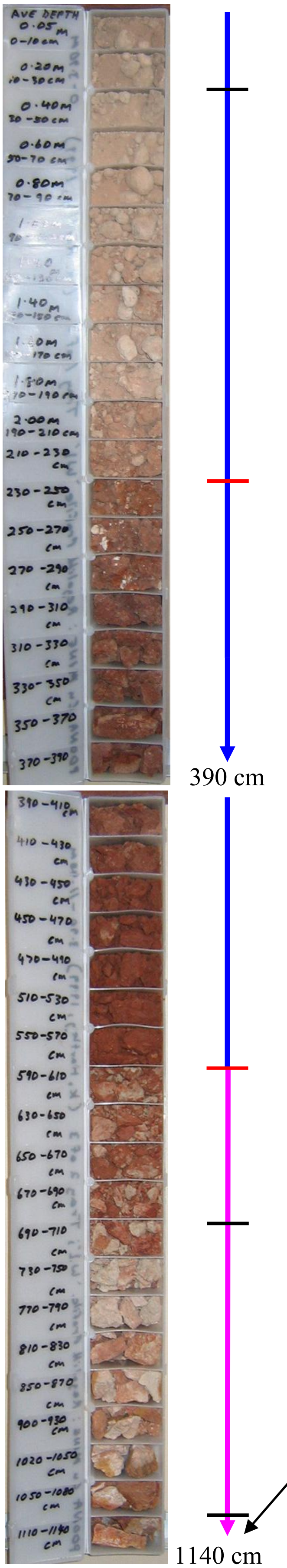
Quick reference items are set out in Table 43; detailed descriptions, figures and data tables follow on below. Poona Mine is ~120 km NW of Adelaide and ~6 km N of Moonta on the MAITLAND 1:250,000 map area of Yorke Peninsula. Access is via sealed roads N of Moonta (Figures 83-87). This mine open cut pit is on private land controlled by the Copper Triangle District Council. Regolith sampling utilised existing mine haulage way tracks and mine faces using ladders and abseil techniques for safe collecting. A summary of this profile is provided in Table 44 and chiptray photographs with regolith zonation are in Figure 97. Geochemical data are presented in Figures 89, 90, 99, 100.

Table 43: Benchmark 18 reference data; Pit Profile W1, Poona Cu-Au Mine (Type 3, mine profile).

Items	Figures, Data, Sources
Regional location map	Figures 83-85.
Local-site location map	Figure 87.
GPS coordinates & elevation	Steep profile down Mine footwall Zone 53, 741408 E, 6230206 N, GDA 94. **AHD:** ~47 m (topographic map data).
Site access, owner	Mine is located just E of the sealed Moonta to Wallaroo road, N of Moonta. This mine open cut pit is on private land controlled by the Copper Triangle District Council. Permission to enter MUST be obtained from the Copper Triangle District Council and associated Tourist Mine operator.
Related profiles	APX, E, F, W2, W3 of Hartley (2000).
Profile photo / log	Yes, Figures 97; Table 44.
Sample types	1-2 kg bags + chiptrays.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Sediments, weathered & fresh Moonta Porphyry.
Petrology	Yes, *c.f.* Janz (1990), Conor, (2002), Fanning *et al*. (2007).
Geochemistry	Yes, (Figures 89, 90, 99, 100), Table 40.
XRD mineralogy	Yes, (Figure 93) & Hartley (2000).
PIMA spectral data	Yes, (Figure 98).
Dating	Yes, Moonta Porphyry, U-Pb zircon age of 1753 ± 8 Ma & 1748 ± 15 Ma (Fanning *et al*., 2007, pp. 102-104). Yes, alunite seams in transported clay at Poona Mine: 2.09 ± 0.03 Ma & 2.14 ± 0.05 Ma (J.L. Keeling, PIRSA Geological Survey, pers. comm. Nov. 2007).
Target Elements	Cu, Au.
Potential Pathfinder Elements	Cu, Au.
Useful sampling media	Calcrete, soil.
Key reference sources	Hartley (2000), Lintern (2004b), Keeling (2004), Mauger *et al*. (1997), Keeling *et al*. (2003), Keeling and Hartley (2005), Conor, (2002), Both *et al*. (1993), Janz (1990), Jack (1917).

Background

This pit face profile is selected to form benchmark 18 because it just bypasses the main Cu-Au mineralization, it has a moderate thickness of transported regolith, and the weathered *in situ* regolith profile is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 17. Regolith was sampled using the pit haulage road access, with a ladder + abseil methods to collect material safely from a measured profile. Samples of 1-2 kg were collected, these were studied and analysed as part of two CRC LEME – PIRSA sponsored undergraduate and Honours student projects spanning 1997-1999 (Hartley, 2000). This profile was not originally intended for use as a benchmark, it has been later re-logged and partly re-interpreted for this report by the author.



Ground surface. **Transported:** 0.00-5.80 m.

0-0.30 m soil, sandy to loamy, siliceous and highly calcareous, 7.5YR 5/5. Aeolian.

0.30-2.10 m calcrete horizon, silty to loamy + earthy to pisolithic to nodular calcrete, loose to compact, 7.5YR 6/5 to 6/6. ? = Pooraka Fm.

2.10-2.30 Clay + sand & silt with nodular calcrete, . 7.5YR 6/6

2.30 m **Unconformity # 2**

2.30-5.80 m **transported:** medium – heavy red-brown clay, sediment, massive, 5YR 5/8 to 2.5YR 5/7, 40-55% clay.

5.80 m **Unconformity # 1**

5.80-6.90 m ***in situ*****:** megamottled pallid saprolite, clay + quartz grit, 5Y 6/3 & 2.5YR 5/6. Highly weathered Moonta Porphyry.

6.90-10.80 m pallid saprolite with remnant corestones of saprock also present, 5Y 6/3. Weathered Moonta Porphyry.

10.80- 11.40 m lower saprolite to saprock, yellow-brown to reddish.

Note: sampling is mostly in 30 cm intervals with similar sized gaps between in 2nd tray. Chiptrays compiled from 1-2 kg bagged samples.

Logged by K. Hartley & M.J. Sheard.

Figure 97a: Benchmark 18, Poona Mine Profile W1, top two chiptrays (0.0-11.4 m) see Figure 97b for remainder. Samples collected while sampler abseiled down the pit wall.

E.O.P. at 1800 cm

11.70-12.00 m Altered bedrock, browns, some clayey intervals. Altered Moonta Porphyry. Edge of mineralized lode.

12->18 m Bedrock, brownish porphyry, K-feldspar & quartz porphyroblasts + minor hydrothermal alteration minerals along fractures.

Note: irregular sampling. Chiptray compiled from 1-2 kg bagged samples.

Logged by K. Hartley & M.J. Sheard.

Figure 97b: Benchmark 18 continued, Poona Mine Profile W1 bottom chiptray 11.70-18.00 m, see Figure 97a for top trays.

In situ Regolith

Moonta Porphyry bedrock is encountered at 11.70 m, however, there is some alteration, associated with fracturing between ~11.7-12.0 m. Generally the bedrock is brownish to pinkish with remnant feldspar porphyroblasts on mm to cm scales, this rock is quite competent. Copper mineralization was not encountered by this profile, although it passes near the lode-associated alteration zone. Saprock is relatively thin (<<0.5 m) and ill defined, being transitional to saprolite above. Saprolite has been reduced to ~5.5 m here by pre Pliocene erosion, its upper portions are strongly megamottled, the remainder follows descriptions for this prospect set out earlier and in Table 44. Any pedolith developed within weathered *in situ* basement has been totally removed by erosion at this location (Hartley, 2000).

Transported Regolith

Transported regolith here is moderate (~5.8 m) and consists of ~0.3 m of aeolian sand and silt into which have developed a thin loamy soil and ubiquitous earthy to pisolitic calcrete to 2.3 m. Unconformably below this is a significantly older massive red-brown sedimentary clay sequence, with a medium to heavy texture and a thickness of ~3.5 m. There is some calcrete impregnation into this material. Furthermore, white alunite seams carrying high Cu and REE values also occur in this clay above the copper lodes and they were encountered in this and related nearby profiles, see Figure 93 (Hartley, 2000; Keeling, 2004, Lintern, 2004b; Mauger *et al.*, 1997). Underlying this Cainozoic red-brown clay is a mildly irregular erosion surface (unconformity) where no other deposition remnants younger than Cambrian are known in this area (see Benchmarks 19 & 20). This regolith profile has similarities and differences to and with Benchmark 17.

Mineralogy: XRD & PIMA

Calcrete zone XRD data reflect the dominantly quartz and calcite mineralogy of the upper part, with dolomite becoming more abundant with depth. The PIMA device was unable to adequately define the carbonate make up of this zone (Hartley, 2000; and Figures 93, 98).

Alunite seam XRD data indicate alunite and quartz dominating the mineralogy, with the clay fraction being either of smectite or kaolinite type (Hartley, 2000; and Figure 93). PIMA did detect alunite.

Transported clay XRD data demonstrate the presence of quartz and alunite in the majority of samples analysed. Clays present include: kaolinite, smectite or illite; but accessory minerals like rutile are only in trace amounts. PIMA spectra indicated the presence of interlayered smectite/kaolinite clays, where halloysite (hydrated kaolinite) is more common with depth and montmorillonite dominates the smectites near the basal zone (Hartley, 2000; and Figures 93, 98).

Moonta porphyry XRD data indicate it is rich in microcline, while the overlying transported regolith is not. PIMA detected halloysite in the upper pallid saprolite (Hartley, 2000; and Figure 93).

Table 44: Summary log of Benchmark 18, modified after Hartley (2000) with additional log detail by M.J. Sheard.

Depth (cm)	Textural analysis	Munsell Colour	Clay %	Description: visual + microscope observations
0-10	loam, fine sandy	7.5YR 5/5	<20	Predominantly loamy soil (siliceous) with calcrete nodules.
10-70	loam, fine sandy	7.5YR 5/5	<20	Predominantly nodular calcrete and loamy subsoil (siliceous).
70-90	loam + nodules	7.5YR 6/5	<20	Predominantly nodular and pisolith calcrete in a silty subsoil (siliceous).
90-210	sandy clay	7.5YR 6/5 to 6/6	<20	Predominantly calcrete pisoliths and nodules in a silty sandy unstructured matrix.
210-230	clay loam	7.5YR 6/6	~35	Clay + sand & silt with nodular calcrete.
230-270	medium clay	5YR 5/8	~45	Medium clay with some calcrete impregnations & pisoliths.
270-570	medium – heavy clay	2.5YR 5/7	40-55	Massive red-brown clay with rounded-subrounded quartz grains, clear, orange, milky, some with red &/or orange coloured inclusions.
570-590	-	-	-	**Unconformity** within this interval
590-690	medium – heavy clay & highly weathered rock	5Y 6/3 & 2.5YR 5/6	>45	Megamottled pallid upper saprolite, upper boundary with transported clay not easy to define by eye due to clay texture and reddish colour similarity. Gritty quartz also present.
690-1050	highly weathered rock	5Y 6/3	45^{+}	Pallid upper saprolite, kaolinite + quartz grit. Remnant corestones of saprock also present.
1050-1080	weathered rock	5Y 6/3 & 5YR 5/8	<30	Pallid upper saprolite, kaolinite + quartz grit with strongly coloured FeOH staining.
1110-1140	weathered rock	5YR 5/8 &5Y 6/3	>25 - <20	Lower saprolite to saprock, variably FeOH stained, fractured.
1170-1200	rock, altered	7.5YR 3/8	<20- <10	Weakly altered bedrock (porphyry) & minor saprock material in patches & facture linings; saprolith to rock competency.
1200->1800	clay + quartz grit	7.5YR 3/8	<5	Bedrock, brownish Moonta Porphyry, K-feldspar & quartz porphyroblasts + minor alteration minerals along fractures.

Geochemistry

Copper generally increases with depth through the calcrete zone into the transported clay and markedly increases within the weathered residual Moonta Porphyry (Figure 99), suggesting Cu in the transported regolith is related to the underlying mineralization. Peaks in Cu concentrations, occur at the boundary between the calcrete zone and transported red-brown clay, and also near the base of that same clay (120 ppm). In this and nearby profiles, Cu peaks are related to alunite seams (*c.f.* Figures 90, 100), (Hartley, 2000).

Copper versus other elements: Cu distribution relates to that of Fe (and Zn) throughout the entire profile (Figures 99, 100). An inverse relationship between Cu and Au behaviour is evident within the upper metre of the calcrete zone at Poona Mine (Profiles E and F but not in this profile). However, in the lower part of the calcrete zone in the same profiles an increase of Cu concentration corresponds to an increase in Au values (Hartley, 2000).

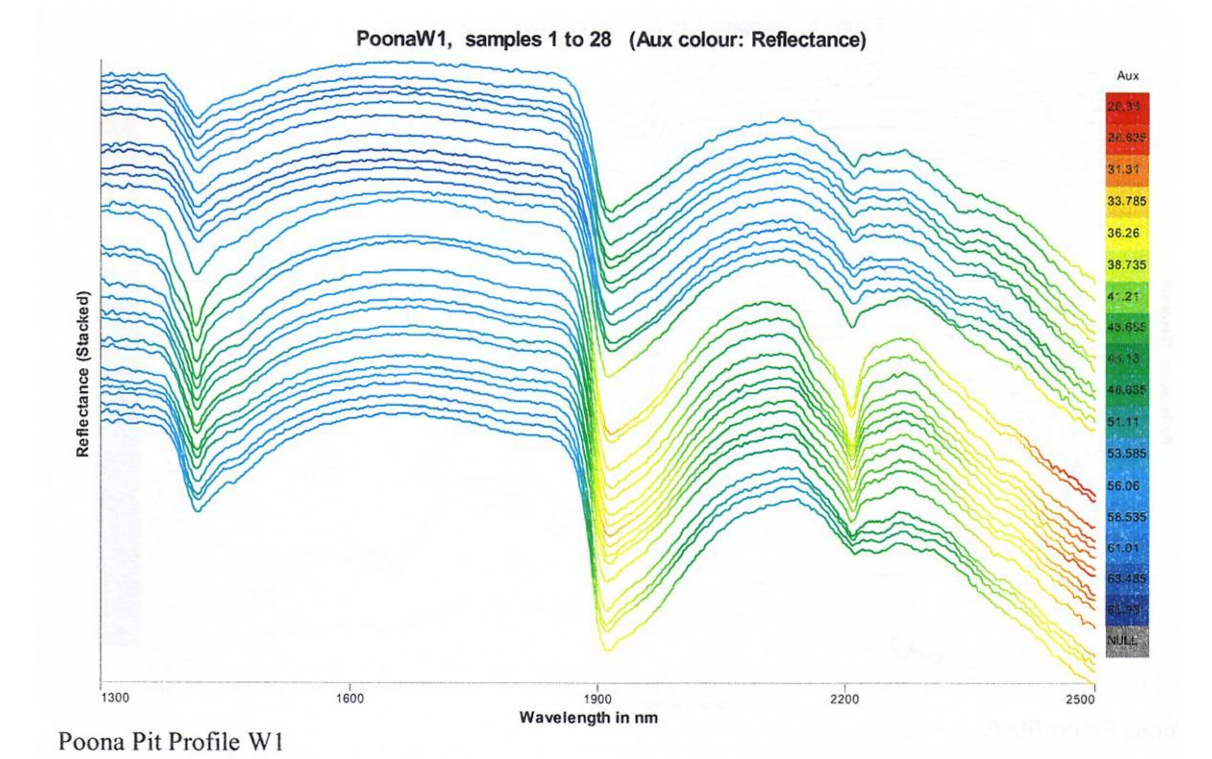


Figure 98: Down profile stacked PIMA spectra for Benchmark 18, 0-5.7 m. Note the near consistency with depth in the clay water absorption feature (right of centre); and similarly with the FeOx adsorption feature on the LHS (extracted from Hartley, 2000).

Gold, high values (up to 10 ppb) are detected within the upper 2-2.5 m of regolith at Poona Mine (Figures 90, 99), which corresponds to the calcrete zone. Gold concentrations tend to reach their maxima just below the surface (<0.5 m), a smaller peak (~1 ppb) also occurs near the boundary between calcrete and the underlying red-brown clay. High Au is also associated with alunite seams in this profile (Figures 99, 100), (Hartley, 2000)

Gold versus other elements: Au and Ca generally behave similarly, however Au concentration lows at ~1-1.35 m (2.3 ppb) do not correspond to a decrease in Ca concentration. This change may reflect a change in calcrete morphology (predominantly nodular to pisolitic), (Hartley, 2000).

Alkaline earth elements (Figure 100): Ca, Mg and Sr generally behave similarly throughout the profile. Magnesium increases with depth within the calcrete zone; Ca, Mg and Sr have higher concentrations in the calcrete zone than in the underlying red-brown clay. Barium concentrations have an inverse relationship to the other alkaline earth elements, Ba is highest in the transported red-brown clay. Barium and K behave similarly in this profile and Ba is enriched within the alunite seams.

Rare earth elements (Figure 100): the REE behave the same throughout all profiles at Poona Mine. Peaks in concentration are associated with the calcrete zone boundary with the underlying red-brown clay, as well as within the alunite seams.

Down profile element abundance plots for ~50 elements are presented in Figure 100.

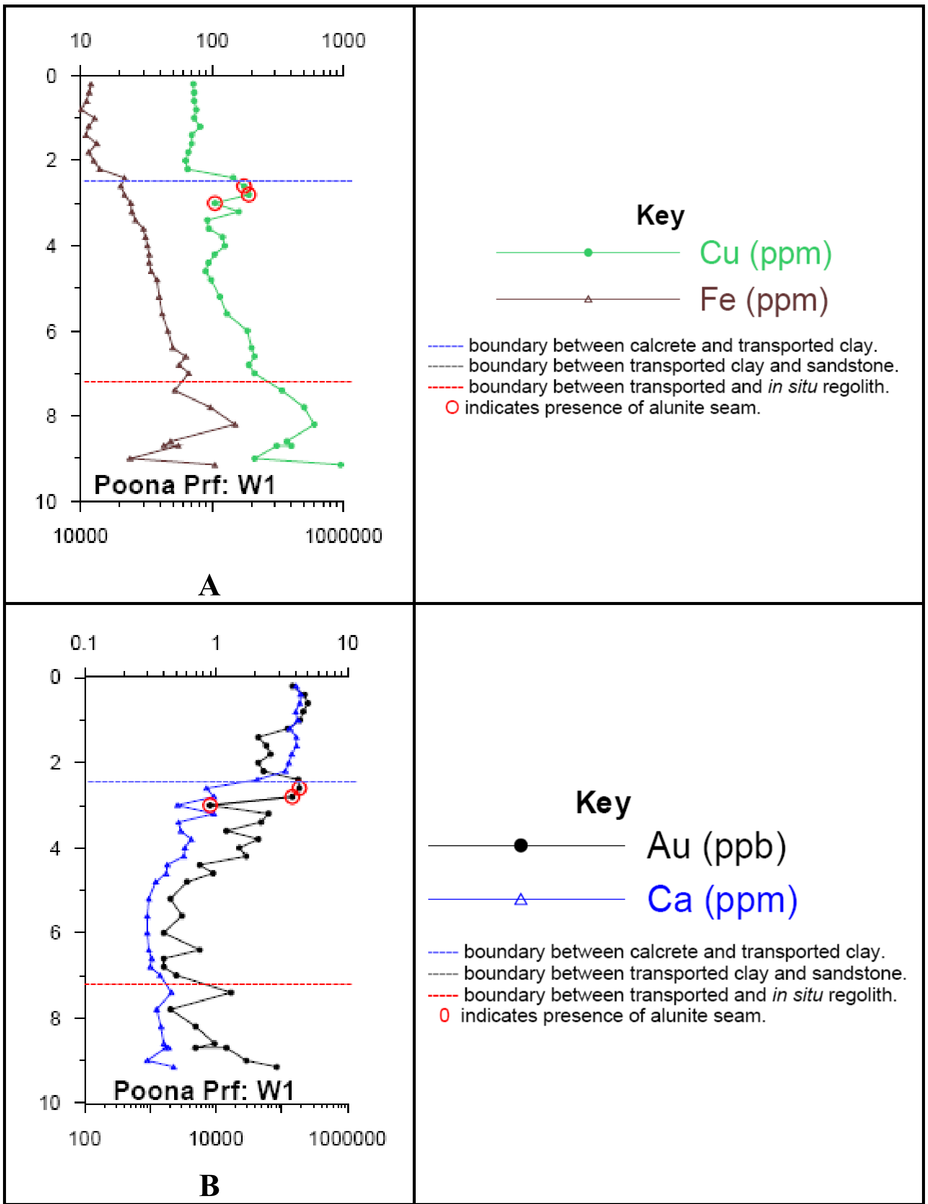


Figure 99: Benchmark 18 down profile distributions of Cu *vs* Fe (plot A) and Au *vs* Ca (plot B), (after Hartley, 2000; Lintern, 2004b). Refer to Figure 86 for profile location and compare with associated profiles in Figure 90.

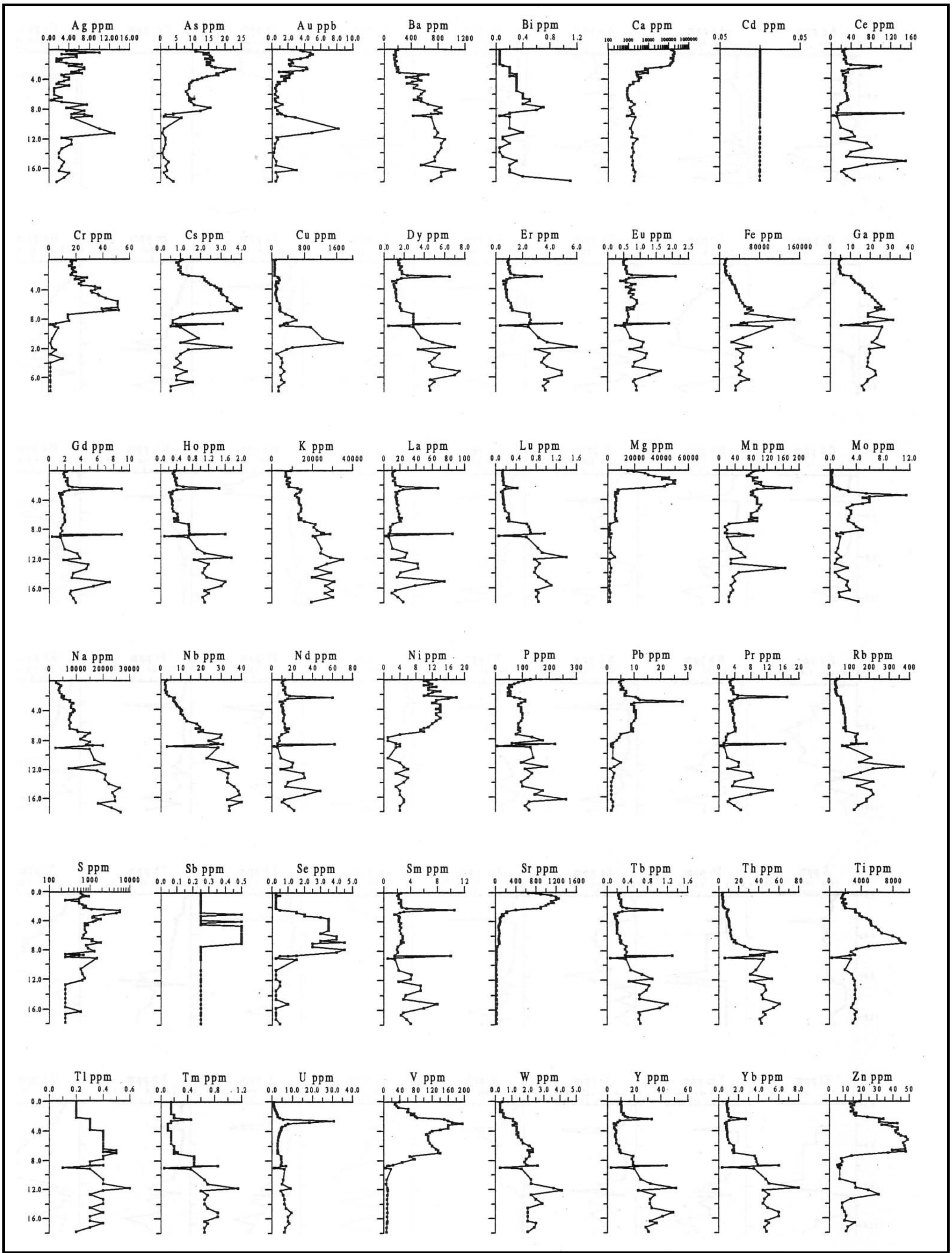


Figure 100: Benchmark 18, down profile plots for 48 selected elements (Hartley, 2000).

Benchmark 19: Pit Profile WH99A (Wheal Hughes Cu-Au Mine)

Quick reference items are set out in Table 45; detailed descriptions, figures and data tables follow on below. Wheal Hughes Mine is ~120 km NW of Adelaide and ~5 km N of Moonta on the MAITLAND 1:250,000 map area of Yorke Peninsula. Access is via sealed roads N of Moonta (Figures 83-87). This mine open cut pit is on private land controlled by the Copper Triangle District Council. It is utilised as an educational tourist mine by the Copper Triangle District Council. Regolith sampling utilised existing mine haulage way tracks and mine faces, where ladders and abseil techniques were employed for safe collecting. A summary of this profile is provided in Table 46 and a chiptray photograph with regolith zonation is in Figure 101. Geochemical data are presented in Figures 89, 90, 103, 104.

Table 45: Benchmark 19 reference data; Pit Profile WH99A, Wheal Hughes Cu-Au Mine (Type 3, mine profile).

Items	Figures, Data, Sources
Regional location map	Figures 83-84.
Local-site location map	Figures 85, 87.
GPS coordinates & elevation	Steep profile down Mine footwall Zone 53, 741313 E, 6228671 N, GDA 94. **AHD:** ~48 m (topographic map data).
Site access, owner	Mine is located just E of the sealed Moonta to Wallaroo road, N of Moonta. This mine open cut pit is on private land controlled by the Copper Triangle District Council. Permission to enter MUST be obtained from the Copper Triangle District Council and associated Tourist Mine operator.
Related profiles	WH99A, B, C & D of Hartley (2000).
Profile photo / log	Yes, Figure 101; Table 46.
Sample types	1-2 kg bags + chiptray.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Sediments, weathered & fresh Moonta Porphyry.
Petrology	Yes, *c.f.* Janz (1990), Conor, (2002), Fanning *et al*. (2007).
Geochemistry	Yes, (Figures 89, 90, 103, 104), Table 40.
XRD mineralogy	No, refer to Benchmark 20 & Hartley (2000).
PIMA spectral data	Yes, (Figure 102).
Dating	Yes, Moonta Porphyry, U-Pb zircon age of 1753 ± 8 Ma & 1748 ± 15 Ma (Fanning *et al*., 2007, pp. 102-104).
Target Elements	Cu, Au.
Potential Pathfinder Elements	Cu, Au.
Useful sampling media	Calcrete, soil.
Key reference sources	Hartley (2000), Lintern (2004b), Keeling (2004), Mauger *et al*. (1997), Keeling *et al*. (2003), Keeling and Hartley (2005), Conor, (2002), Both *et al*. (1993), Jack (1917).

Background

This pit face profile is selected to form benchmark 19 because it intersects the Cambrian Sandstone and it is near the main Cu-Au mineralization. This profile has a moderate thickness of transported regolith, and the weathered *in situ* regolith profile is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 20. Regolith was sampled using the pit haulage road access, with a ladder + abseil methods to collect material safely from a measured profile. Samples of 1-2 kg were collected, these were studied and analysed as part of a CRC LEME – PIRSA sponsored Honours student project in 1999 (Hartley, 2000). This profile was not originally intended for use as a benchmark, it has been later re-logged and partly re-interpreted for this report by the author.

End of profile at 1130 cm

Ground surface. **Transported:** 0.00-~5.50 m.

0-0.50 m soil + subsoil sandy to medium clay + hardpan calcrete, 2.5YR 4/8 to 5YR 5/8. Pooraka Fm. equivalent.

0.50 m **Unconformity # 2**

0.50-2.30 m **transported:** heavy red-brown clay, sediment, massive, 2.5YR 4/6, 50^{+}% clay.

2.30-~5.50 m **transported:** sandstone, fluvial sediment, cross-bedded to massive, medium-grained quartz + k-feldspar, 2.5YR 6/4 to N 6/-. Winulta Fm.

1.50-1.70 m Sandy interval within clay, medium-grained (fluvial) with a 5-15% clay binder, 2.5YR 4/6 & 7.5YR 5/8.

~5.50 m **Unconformity # 1**

~5.50-9.10 m ***in situ*****:** pallid to weakly mega mottled saprolite, clay + quartz grit, 2.5Y 6/2 & 2.5YR 6/4. Highly weathered Moonta Porphyry.

9.50-9.70 m Saprock to bedrock, 2.5Y 5/4. Weathered Moonta Porphyry.

9.70->11.40 m Bedrock, reddish, 10R 5/4, Moonta Porphyry.

Note: sampling is mostly in 10-30 cm intervals to ~4 but is more irregular below that depth. Chiptray compiled from 1-2 kg bagged samples.

Logged by K. Hartley & M.J. Sheard.

Figure 101: Benchmark 19, Wheal Hughes Mine Profile WH99A, chiptray (0.0-11.3 m). Samples collected while sampler abseiled down the pit wall.

In situ Regolith

Moonta Porphyry bedrock is encountered at ~9.60 m, Generally the bedrock is brownish to pinkish with remnant feldspar porphyroblasts on mm to cm scales, this rock is quite competent. Copper mineralization was not encountered by this profile, it is ~NW of the main lodes but still has appreciable Cu concentrations below 9.75 m. Saprock is relatively thin (<<0.5 m) and ill defined, being transitional to saprolite above. Saprolite has been reduced to <4 m here by fluvial erosion during the Cambrian, its upper portions are weakly megamottled, the remainder follows descriptions for this prospect set out earlier and in Table 46. Any pedolith developed within weathered *in situ* basement has been totally removed by erosion at this location (Hartley, 2000).

Transported Regolith

Transported regolith here is moderate (~5.5 m) and consists of ~0.3 m of sandy clay to light clay into which has developed a thin soil and hardpan and earthy to pisolitic calcrete. Unconformably below this is a significantly older massive red-brown sedimentary clay sequence, with a medium to heavy texture and a thickness of ~1.8 m. There is one interval of fluvial sand between 1.5-1.7 m depth and some calcrete impregnation into this material. Underlying this Cainozoic red-brown clay is a fluvial quartz sandstone, with siliceous cement, of the Winulta Fm., and mostly restricted to infill of a palaeochannel incised into the weathered Moonta Porphyry. This is a medium- to coarse-grained feldspathic sandstone where the k-feldspar grains (Moonta Porphyry derived) are altered to kaolinite. The upper surface of this rock has been silcreted but that horizon is now eroded, leaving only a silcrete lag on the rock's upper surface (Plates 6, 7). Immediately below the Winulta Fm. sandstone is the major unconformity (a mildly irregular surface) with weathered *in situ* Moonta Porphyry. This regolith profile has similarities and differences to and with Benchmark 20.

Mineralogy: PIMA

The PIMA device was unable to adequately define the carbonate make up of this zone (Hartley, 2000; and Figures 102).

PIMA spectra indicated an inverse situation regarding clay mineralogy than applies in the nearby Poona Mine. At Wheal Hughes the transported red-brown clay has interlayered smectitic/kaolinitic clays, however, montmorillonite dominates the smectites in the upper portion while halloysite (hydrated kaolinite) dominates clay near the base (Hartley, 2000; and Figures 102).

Moonta porphyry; PIMA spectra detected well crystalline kaolinite in the upper pallid saprolite (Hartley, 2000; and Figure 102).

Refer to Benchmark 20 for XRD mineralogy, samples from Benchmark 19 were not XRD analysed.

Table 46: Summary log of Benchmark 19, modified after Hartley (2000) with additional log detail by M.J. Sheard.

Depth (cm)	Textural analysis	Munsell Colour	Clay %	Description: visual + microscope observations
0-10	sandy clay	5YR 4/4	35-40	Soil + hardpan calcrete.
10-30	light medium clay	7.5YR 5/4	40-45	Subsoil clay & calcrete.
30-50	medium clay	5YR 5/8	45-55	Subsoil clay, Pooraka Fm. equivalent.
50-70	heavy clay	2.5YR 4/6	50^+	Plio-Pleistocene clay, transported, massive
70-90	heavy clay	2.5YR 4/6	50^+	Plio-Pleistocene clay, transported, massive
90-110	heavy clay	2.5YR 4/6	50^+	Plio-Pleistocene clay, transported, massive
110-130	heavy clay	2.5YR 4/6	50^+	Plio-Pleistocene clay, transported, massive
130-150	heavy clay	2.5YR 4/6	50^+	Plio-Pleistocene clay, transported, massive
150-170	heavy clay	2.5YR 4/6 & 7.5YR 5/8	50^+	Plio-Pleistocene clay, transported, massive + sand, medium-grained (fluvial) with a 5-15% clay binder.
170-190	heavy clay	2.5YR 4/6	50^+	Plio-Pleistocene clay, transported, massive
210-230	heavy clay	2.5YR 4/6	50^+	Plio-Pleistocene clay, transported, massive
230-510	rock	2.5YR 6/4 to N 6/-	N/A	Fluvial channel infill, cross-bedded to massive, medium-grained quartz + K-feldspar sandstone. Winulta Fm, Cambrian.
~550	-	-	-	**Unconformity**

Cont.

Table 46: Summary log of Benchmark 19 continued.

Depth (cm)	Textural analysis	Munsell Colour	Clay %	Description: visual + microscope observations
680-710	light clay, highly weathered rock	2.5YR 6/2	35-40	Upper saprolite, pallid, highly weathered Moonta Porphyry
880-910	gritty clay, weathered rock	2.5YR 6/2 & 2.5YR 6/4	35-40	Saprolite, pallid to weakly mottled, highly weathered Moonta Porphyry.
950-970	partly weathered rock	2.5YR 5/4	>20-<5	Saprock to bedrock, partly weathered Moonta Porphyry.
1095->1130	rock	10R 5/4	<5	Bedrock, Moonta Porphyry, light reddish brown, fine-grained matrix + mm-cm sized porphyroblasts.

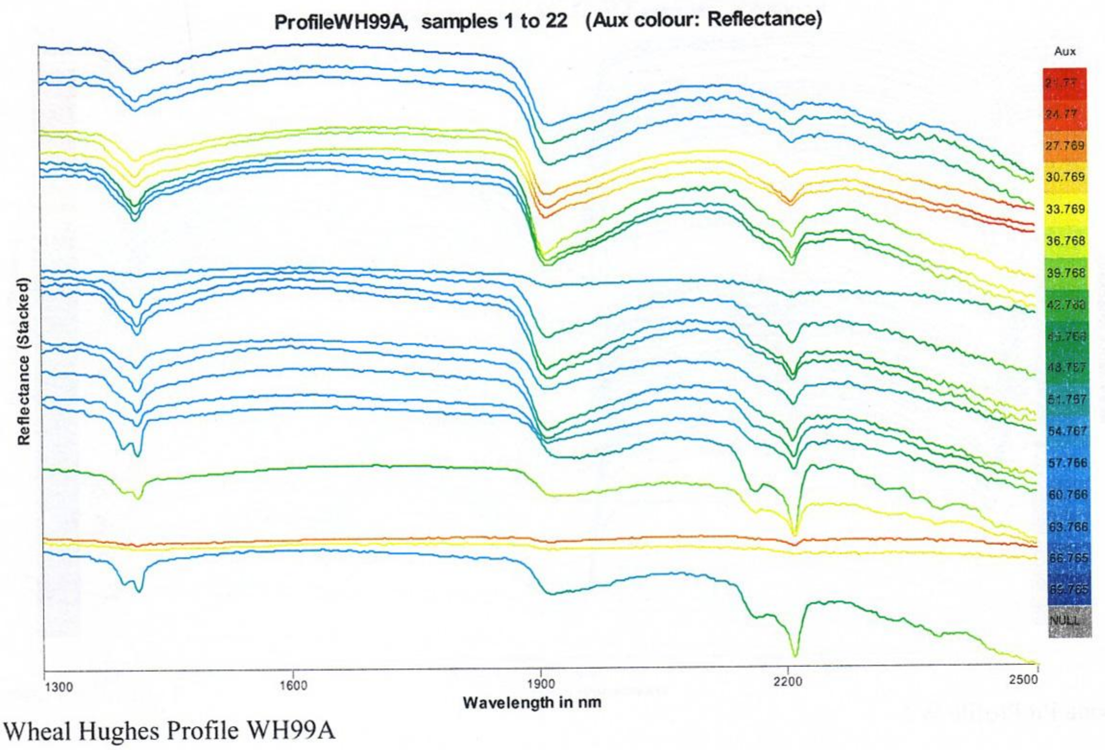


Figure 102: Down profile stacked PIMA spectra for Benchmark 19, 0-11.15 m. Note the progressive change in the clay water absorption feature (right of centre) with depth until the unconformity; and similarly with the FeOx adsorption feature on the LHS (extracted from Hartley, 2000).

Geochemistry

Copper generally increases with depth through the calcrete zone into the transported clay, it is present but in low values within the Winulta Fm. sandstone, and markedly increases within the weathered residual Moonta Porphyry (Figure 103), suggesting Cu in the transported regolith is related to the underlying mineralization. Peaks in Cu concentration, occur at the boundary between the transported red-brown clay and the weathered residual Moonta Porphyry (165 ppm in the nearby WH99C profile and 38 ppm in the nearby WH99D profile, both are over the Cu lodes; *c.f.* Figures 90, 103), (Hartley, 2000).

Copper versus other elements: Cu distribution relates to that of Fe (and Zn) throughout the entire profile (Figures 103, 104). The relationship between Cu and Au behaviour is complicated by the low Au values and the detection limit being reached by many samples. Moreover, Au was so low at the surface as to also be below detection limit in a number of samples. In the lower part of the calcrete zone in the same profiles an increase of Cu concentration corresponds to an increase in Au values (Hartley, 2000).

Gold values at the surface and in the deeper transported regolith are an order of magnitude lower at Wheal Hughes Mine than at Poona Mine (many samples were <1 ppb, detection limit of 1 ppb was used, peak Au is <3 ppb) (Figures 103). Gold concentrations tend to reach their maxima just below the surface (<0.5 m), a smaller peak (~1 ppb) also occurs near the boundary between calcrete and the underlying red-brown clay (Figure 103), (Hartley, 2000).

Gold versus other elements: Au and Ca generally behave similarly, however the much lower Au concentrations approaching or beyond detection limit at Wheal Hughes create noise that makes any low level signal difficult to analyse (Figure 103), (Hartley, 2000).

Alkaline earth elements (Figure 104): Ca, Mg and Sr generally behave similarly throughout the profile. Magnesium increases with depth within the calcrete zone (quite marked at Wheal Hughes); Ca, Mg and Sr have higher concentrations in the calcrete zone than in the underlying red-brown clay. Barium concentrations have an inverse relationship to the other alkaline earth elements, Ba is highest in the transported red-brown clay. Barium does not correlate with K in any of the transported regolith components at Wheal Hughes

Rare earth elements (Figure 104): the REE are much lower in concentration than at Poona Mine, they are associated with the calcrete zone boundary and with the underlying red-brown clay.

Down profile element abundance plots for ~50 elements are presented in Figure 104.

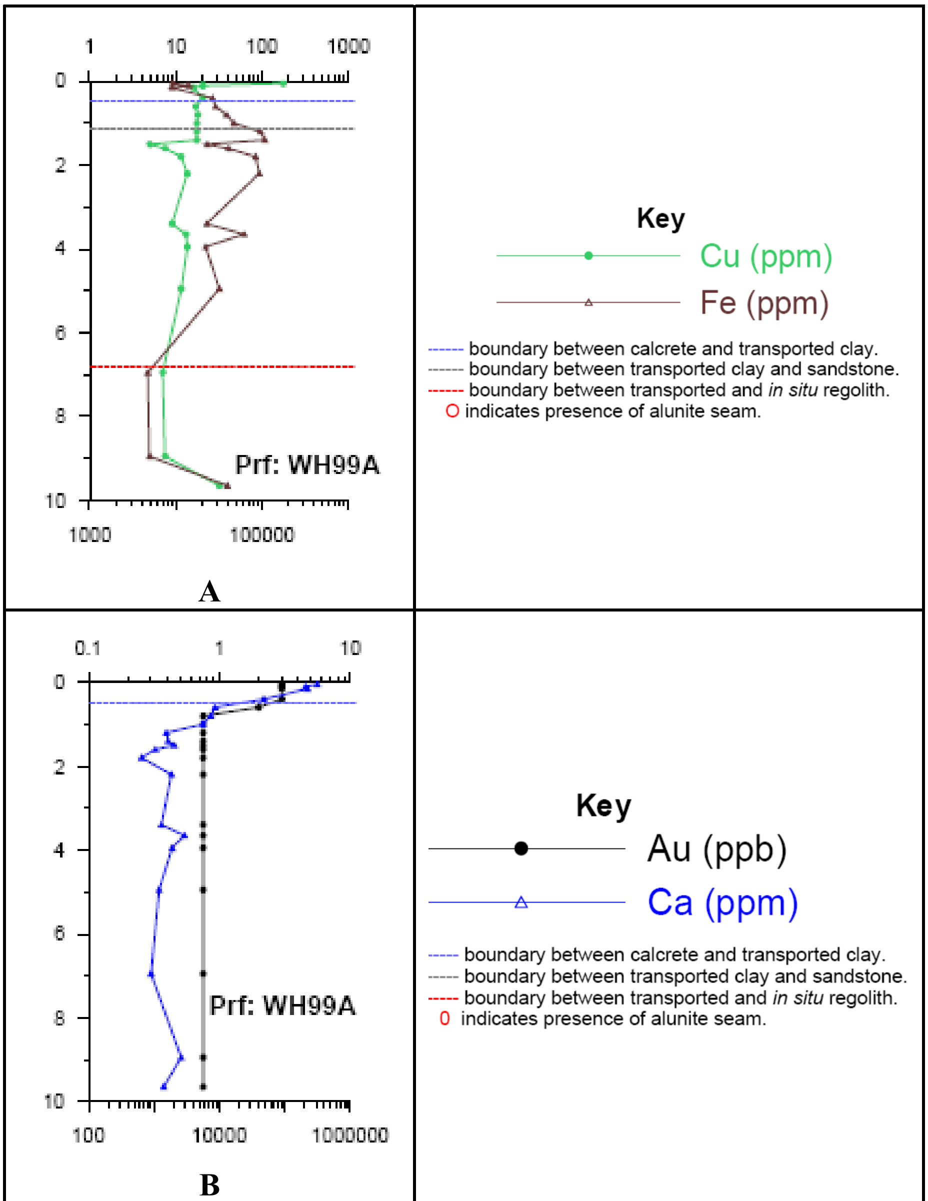


Figure 103: Benchmark 19 down profile distributions of Cu *vs* Fe (plot A) and Au *vs* Ca (plot B), (after Hartley, 2000; Lintern, 2004b). Refer to Figure 87 for profile location and compare with associated profiles in Figure 90.

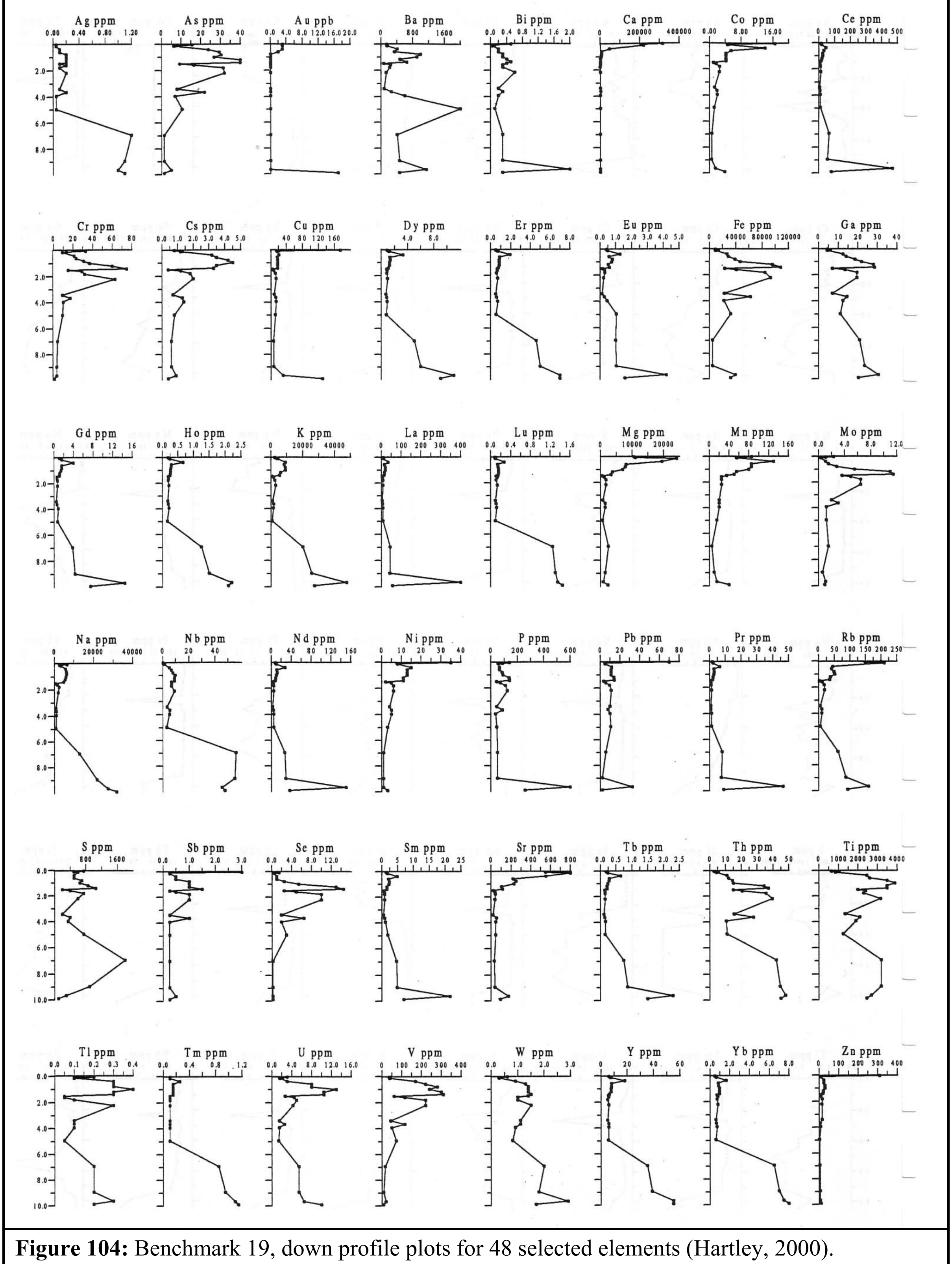


Figure 104: Benchmark 19, down profile plots for 48 selected elements (Hartley, 2000).

Benchmark 20: Pit Profile WH99B (Wheal Hughes Cu-Au Mine)

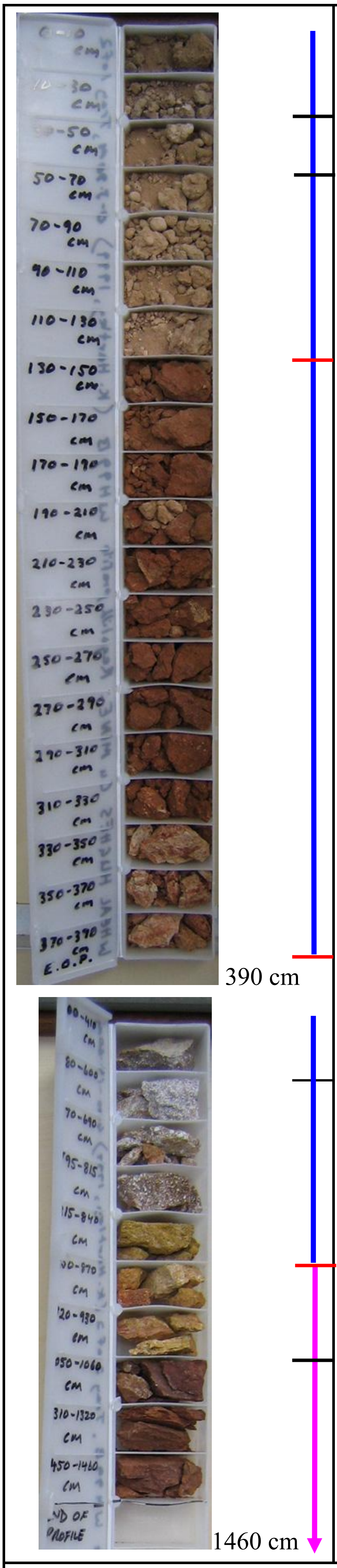
Quick reference items are set out in Table 47; detailed descriptions, figures and data tables follow on below. Wheal Hughes Mine is ~120 km NW of Adelaide and ~5 km N of Moonta on the MAITLAND 1:250,000 map area of Yorke Peninsula. Access is via sealed roads N of Moonta (Figures 83-87). This mine open cut pit is on private land controlled by the Copper Triangle District Council. It is utilised as an educational tourist mine by the Copper Triangle District Council. Regolith sampling utilised existing mine haulage way tracks and mine faces, where ladders and abseil techniques were employed for safe collecting. A summary of this profile is provided in Table 48 and a chiptray photograph with regolith zonation is in Figure 105. Geochemical data are presented in Figures 89, 90, 108, 109.

Table 47: Benchmark 20 reference data; Pit Profile WH99B, Wheal Hughes Cu-Au Mine (Type 3, mine profile).

Items	Figures, Data, Sources
Regional location map	Figures 83-84.
Local-site location map	Figures 85, 87.
GPS coordinates & elevation	Steep profile down Mine footwall Zone 53, 741268 E, 6228460 N, GDA 94. **AHD:** ~48 m (topographic map data).
Site access, owner	Mine is located just E of the sealed Moonta to Wallaroo road, N of Moonta. This mine open cut pit is on private land controlled by the Copper Triangle District Council. Permission to enter MUST be obtained from the Copper Triangle District Council and associated Tourist Mine operator.
Related profiles	WH99A, C & D of Hartley (2000).
Profile photo / log	Yes, Figure 105; Table 48.
Sample types	1-2 kg bags + chiptray.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Sediments, weathered & fresh Moonta Porphyry.
Petrology	Yes, *c.f.* Janz (1990), Conor, (2002), Fanning *et al*. (2007).
Geochemistry	Yes, (Figures 89, 90, 108, 109), Table 40.
XRD mineralogy	Yes, (Figure 106).
PIMA spectral data	Yes, (Figure 107).
Dating	Yes, Moonta Porphyry, U-Pb zircon age of 1753 ± 8 Ma & 1748 ± 15 Ma (Fanning *et al*., 2007, pp. 102-104).
Target Elements	Cu, Au.
Potential Pathfinder Elements	Cu, Au.
Useful sampling media	Calcrete, soil.
Key reference sources	Hartley (2000), Lintern (2004b), Keeling (2004), Mauger *et al*. (1997), Keeling *et al*. (2003), Keeling and Hartley (2005), Conor, (2002), Both *et al*. (1993), Jack (1917).

Background

This pit face profile is selected to form benchmark 20 because it intersects the thickest segment of Cambrian sandstone and it is near the main Cu-Au mineralization. This profile has a moderate thickness of transported regolith, and the weathered *in situ* regolith profile is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 19. Regolith was sampled using the pit haulage road access, with a ladder + abseil methods to collect material safely from a measured profile. Samples of 1-2 kg were collected, these were studied and analysed as part of a CRC LEME – PIRSA sponsored Honours student project in 1999 (Hartley, 2000). This profile was not originally intended for use as a benchmark, it has been later re-logged and partly re-interpreted for this report by the author.



Ground surface. **Transported:** 0.00-~8.40 m.

0-0.30 m soil + subsoil sandy clay + calcrete, 7.5YR 4/4.

0.30-0.50 m Subsoil sandy clay loam, + calcrete, 7.5YR 5/4, Pooraka Fm. equivalent.

0.50-1.30 m **transported:** Calcrete horizon (earthy to pisolitic to nodular) developed in Pooraka Fm. equivalent, 7.5YR 6/4.

1.30 m **Unconformity # 3**

1.30-3.95 m **transported:** Red-brown clay, transported, massive, mottled towards the base, 5YR 4/6 to 2.5YR 4/6 to 5YR 5/6, Plio-Pleistocene.

3.95 m **Unconformity # 2**

4.00-8.40 m **transported:** sandstone, fluvial sediment, cross-bedded to massive, medium-grained quartz + k-feldspar, N 6/- to 2.5YR 6/4 to 10YR 6/7. Winulta Fm.

8.40 m **Unconformity # 1**

8.40-9.30 m ***in situ*****:** pale yellowish saprolite, clay + quartz grit, 7.5YR 6/8. Highly weathered Moonta Porphyry.

9.30->14.60 m Bedrock, reddish, 10R 4/4, Moonta Porphyry. Saprock in bedrock interval between 13.10-13.20 m, 2.5YR 6/4 to 10R 4/4

Note: sampling is mostly in 10-30 cm intervals to ~4 but is more irregular below that depth. Chiptray compiled from 1-2 kg bagged samples.

Logged by K. Hartley & M.J. Sheard.

Figure 105: Benchmark 20, Wheal Hughes Mine Profile WH99B, chiptrays (0.0-14.6 m). Samples collected while sampler abseiled down the pit wall.

In situ Regolith

Moonta Porphyry bedrock is encountered at ~9.30 m, Generally the bedrock is reddish with feldspar porphyroblasts on mm to cm scales, this rock is quite competent. Visible Cu mineralization was not encountered by this profile, it is just W of the main lodes but still has appreciable Cu concentrations below 9.0 m. Saprock is relatively thin (<0.5 m) and ill defined, being transitional to saprolite above. Saprolite has been reduced to <1 m here by a fluvial channel during the Cambrian. The saprolite upper portions are pale hued and follows descriptions for this prospect set out earlier and in Table 48. Any pedolith developed within weathered *in situ* basement has been totally removed by erosion at this location (Hartley, 2000).

Transported Regolith

Transported regolith here is at its thickest for this mine exposure (8.4 m) and consists of ~0.3 m of sandy clay into which has developed a thin soil and earthy to pisolitic calcrete. Underlying this is a sandy clay loam to silty clay of the Pooraka Fm. into which earthy to nodular calcrete has developed. Unconformably below this is a significantly older massive red-brown sedimentary clay sequence, with a medium to heavy texture and a thickness of 2.85 m. Underlying this Cainozoic red-brown clay is a fluvial quartz sandstone, with siliceous cement, of the Winulta Fm., forming a palaeochannel incised 4.45 m into the weathered Moonta Porphyry. This is a medium- to coarse-grained feldspathic sandstone where the k-feldspar grains (Moonta Porphyry derived) are altered to kaolinite. The upper surface of this rock has been silcreted but that horizon is now eroded, leaving only a silcrete lag on the rock's upper surface (Plates 6, 7). Immediately below the Winulta Fm. sandstone is the major unconformity with weathered *in situ* Moonta Porphyry. This regolith profile has similarities and differences to and with Benchmark 19.

Table 48: Summary log of Benchmark 20, modified after Hartley (2000) with additional log detail by M.J. Sheard.

Depth (cm)	Textural analysis	Munsell Colour	Clay %	Description: visual + microscope observations
0-10	sandy clay	7.5YR 4/2	35-40	Soil + calcrete.
10-30	sandy clay	7.5YR 4/4	35-40	Subsoil & calcrete.
30-50	sandy clay loam	7.5YR 5/4	20-30	Subsoil, Pooraka Fm. equivalent.
50-110	silty clay	7.5YR 6/4	35-40	Calcrete horizon (earthy to pisolitic to nodular) in Pooraka Fm. equivalent.
110-130	light clay	5YR 6/6	35-40	Transitional zone to clay below, ?Pooraka Fm. equivalent.
130-170	medium clay	5YR 4/6	45-55	Plio-Pleistocene clay, transported, massive.
170-250	heavy clay	2.5YR 4/6	50^{+}	Plio-Pleistocene clay, transported, massive.
250-330	medium clay	2.5YR 4/6	50^{+}	Plio-Pleistocene clay, transported, massive.
330-395	medium clay	5YR 5/6	50^{+}	Plio-Pleistocene clay, transported, massive, mottled.
395	-	-	-	**Unconformity**
395-685	rock	N 6/-	N/A	Fluvial channel infill, cross-bedded to massive, medium-grained quartz + K-feldspar sandstone, greyish. Winulta Fm, Cambrian.
685-840	rock	2.5YR 6/4 to 10YR 6/7	N/A	Fluvial channel infill, cross-bedded to massive, medium-grained quartz + K-feldspar sandstone, pinkish to yellowish. Winulta Fm, Cambrian.
~840	-	-	-	**Unconformity**
840-930	light clay, highly weathered rock	7.5YR 6/8	35-40	Saprolite, pale coloured, highly weathered Moonta Porphyry
930-1050	weathered rock	7.5YR 6/8 to 2.5YR 6/4	~20-<5	Saprock to bedrock, partly weathered Moonta Porphyry. (not sampled).

Cont.

Table 48: Summary log of Benchmark 20 continued.

Depth (cm)	Textural analysis	Munsell Colour	Clay %	Description: visual + microscope observations
1050-1060	rock	10R 4/4	<5	Bedrock, Moonta Porphyry, light reddish brown, fine-grained matrix + mm-cm sized porphyroblasts.
1310-1320	partly weathered rock	2.5YR 6/4 to 10R 4/4	~20-<5	Saprock to bedrock, partly weathered Moonta Porphyry, ?fracture zone.
1450->1460	rock	10R 4/4	<5	Bedrock, Moonta Porphyry, light reddish brown, fine-grained matrix + mm-cm sized porphyroblasts.

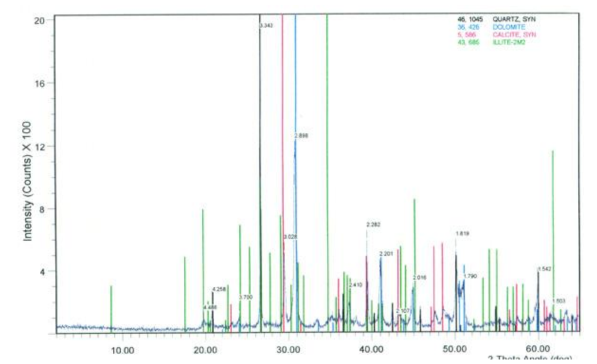
Mineralogy: XRD & PIMA

XRD analysis of samples from this particular profile was not attempted by Hartley (2000) however, an adjacent stratigraphically similar profile (WH99C, ~90 m NW of WH99B) does have three analyses, all within transported regolith; they are presumed to represent those from similar depths in this Benchmark.

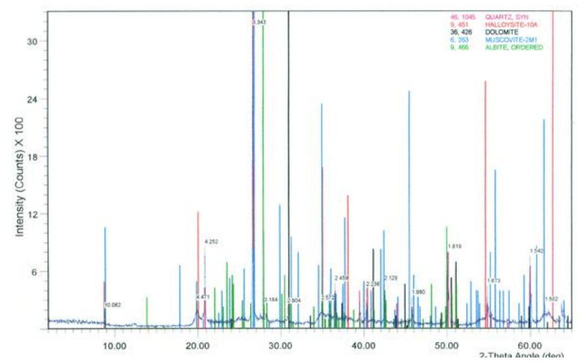
The PIMA device was unable to adequately define the carbonate make up of this zone. Calcrete zone XRD data reflect the dominantly quartz and calcite mineralogy of the upper part, with dolomite becoming more abundant with depth (Hartley, 2000; and Figures 106, 107).

Transported clay XRD data demonstrate the presence of quartz in the majority of samples analysed but also some muscovite and microcline (unweathered ?colluvial grains). Clays present include: kaolinite, smectite or illite; but accessory minerals like rutile are only in trace amounts. PIMA spectra indicated the presence of interlayered smectite/kaolinite clays, where montmorillonite is more common near the top, while halloysite (hydrated kaolinite) dominates near the base. This is the inverse of the Poona Mine profile examples (Hartley, 2000; and Figures 106, 107).

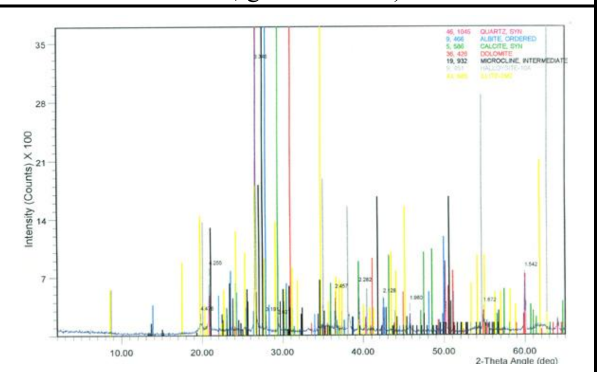
Moonta porphyry, XRD was not applied to the weathered *in situ* regolith (residual) at this end of the Wheal Hughes Mine. PIMA detected montmorillonite in the upper pallid saprolite (Hartley, 2000; and Figure 107).



A (black = quartz, blue = dolomite, pink = calcite, green = illite).



B (pink = quartz, red = halloysite, black = dolomite, blue = muscovite, green = albite).



C (pink = quartz, blue = albite, green = calcite, red = dolomite, black = microcline, grey = halloysite, yellow = illite).

Figure 106: XRD plots, Benchmark 20;

<u>A</u> calcrete zone at 1.50 m,

<u>B</u> transported red-brown clay at 1.70 m, and

<u>C</u> transported red-brown clay at 4.15 m.

Note: these samples actually come from the adjoining profile (WH99C) but are presumed to represent profile WH99B.

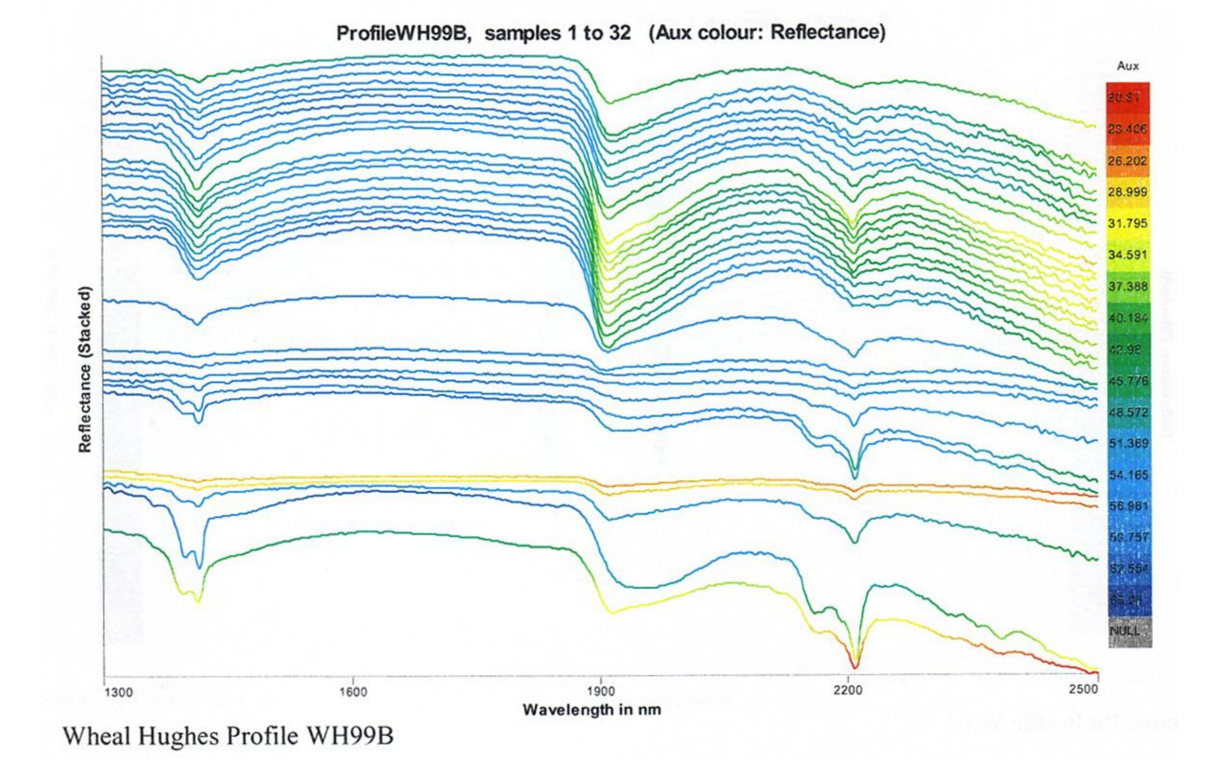


Figure 107: Down profile stacked PIMA spectra for Benchmark 20, 0-14.55 m. Note the consistency in the clay water absorption feature (right of centre) with depth until the unconformity; and a less consistent FeOx adsorption feature with depth on the LHS (extracted from Hartley, 2000).

Geochemistry

Copper concentrations in this profile, through the calcrete zone are variable and remain so throughout the transported clay, it is present in similarly low values within the Winulta Fm. sandstone until near the unconformity. Copper then markedly increases within the weathered residual Moonta Porphyry (Figure 108), suggesting Cu in the transported regolith is related to the underlying mineralization. Small peaks in Cu concentrations, occur at the boundary between the transported red-brown clay and the Winulta Fm. sandstone, and between it and the weathered residual Moonta Porphyry (165 ppm in the nearby WH99C profile and 38 ppm in the nearby WH99D profile, both are over the Cu lodes; *c.f.* Figures 90, 103), (Hartley, 2000).

Copper versus other elements: Cu distribution relates to that of Fe (and Zn) throughout the entire profile (Figures 108, 109). The relationship between Cu and Au behaviour is complicated by the low Au values and the detection limit being reached by many samples. Moreover, Au was so low at the surface as to also be below detection limit in a number of samples. In the lower part of the calcrete zone in the same profiles an increase of Cu concentration corresponds to an increase in Au values (Hartley, 2000).

Gold values at the surface and in the deeper transported regolith are an order of magnitude lower at Wheal Hughes Mine than at Poona Mine (many samples were <1 ppb, detection limit of 1 ppb was used, peak Au is <3 ppb). Gold concentrations tend to reach their maxima just below the surface (<0.5 m), a smaller peak (~1 ppb) also occurs near the boundary between calcrete and the underlying red-brown clay (Figure 108), (Hartley, 2000).

Gold versus other elements: Au and Ca generally behave similarly, however the much lower Au concentrations approaching or beyond detection limit at Wheal Hughes create noise that makes any low level signal difficult to analyse (Figure 108), (Hartley, 2000).

Alkaline earth elements (Figure 109): Ca, Mg and Sr generally behave similarly throughout the profile. Magnesium increases with depth within the calcrete zone (quite marked at Wheal Hughes); Ca, Mg and Sr have higher concentrations in the calcrete zone than in the underlying red-brown clay. Barium concentrations have an inverse relationship to the other alkaline earth elements, Ba is highest in the transported red-brown clay. Barium does not correlate with K in any of the transported regolith components at Wheal Hughes

Rare earth elements (Figure 109): the REE are much lower in concentration than at Poona Mine, they are associated with the calcrete zone boundary and with the underlying red-brown clay.

Down profile element abundance plots for ~50 elements are presented in Figure 109.

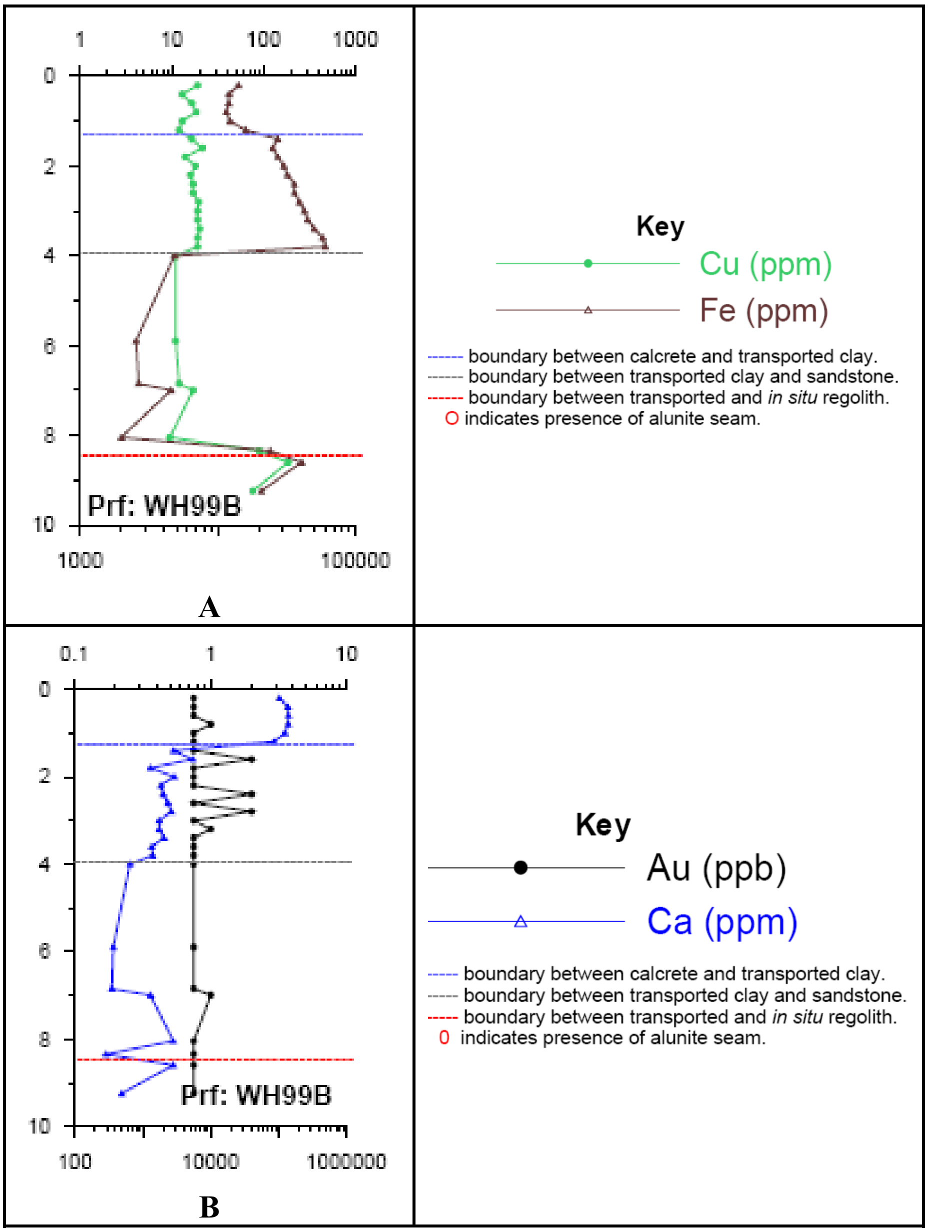


Figure 108: Benchmark 20 down profile distributions of Cu *vs* Fe (plot A) and Au *vs* Ca (plot B), (after Hartley, 2000; Lintern, 2004b). Refer to Figure 87 for profile location and compare with associated profiles in Figure 90.

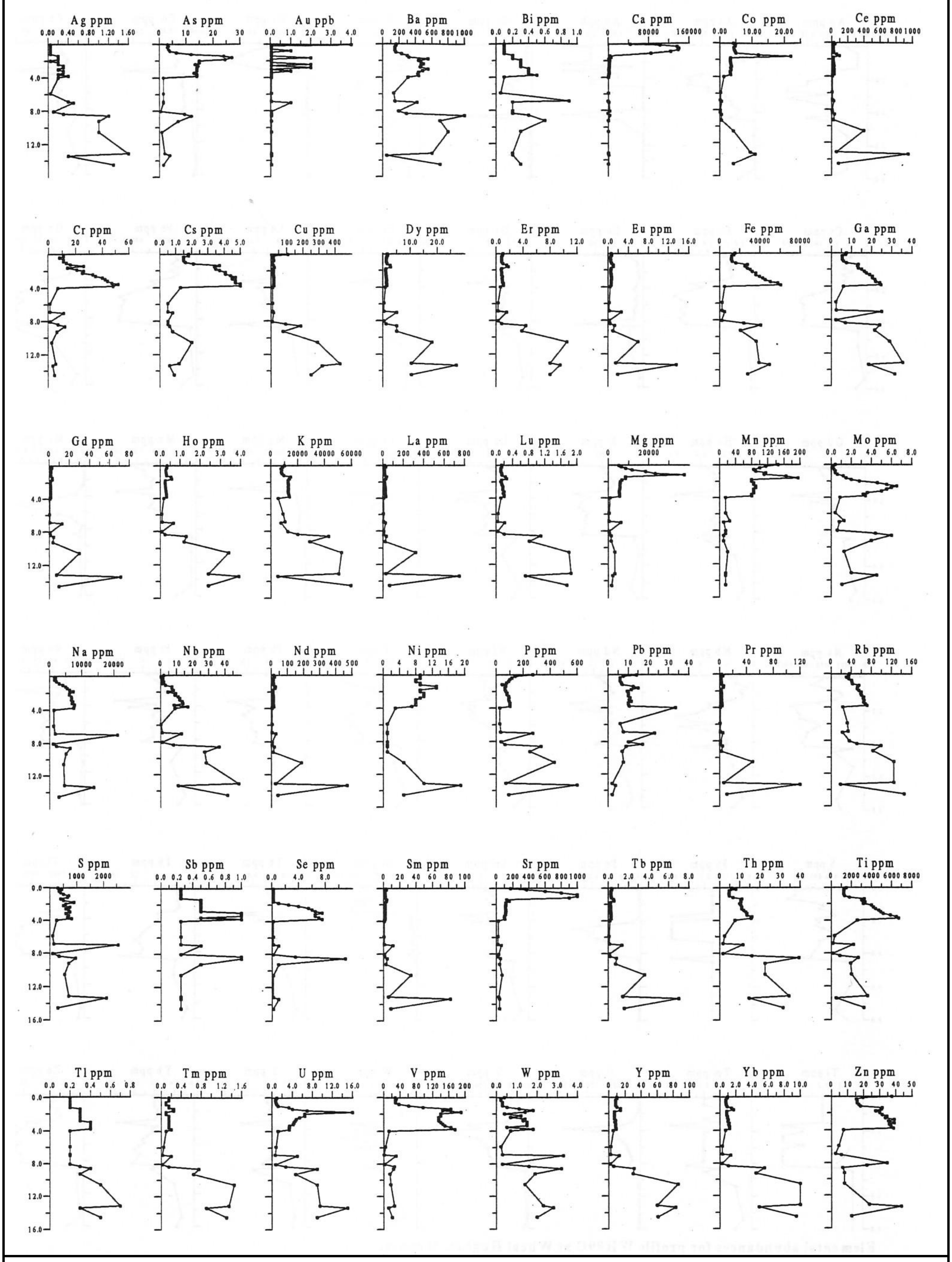


Figure 109: Benchmark 20, down profile plots for 48 selected elements (Hartley, 2000).

REFERENCES

Adelaide Resources Ltd, 2003. Industry News – Adelaide Resources. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 31:25.

Adelaide Resources Ltd, 2004. Industry News – Adelaide Resources. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 33:19.

Adelaide Resources NL, 1996. *Adelaide Resources Prospectus*. Adelaide Resources NL, Unley South Australia.

Anand, R.R., 2005. Weathering history, landscape evolution and implications for exploration. *In*: Anand, R.R. and de Broekert, P. (editors), 2005. *Regolith landscape evolution across Australia. A compilation of regolith landscape case studies with regolith landscape evolution models*. CRC LEME, Perth, Western Australia, pp. 2-40. ISBN: 1 921039 30 2.

Anand, R.R. and Paine, M., 2002. Regolith geology of the Yilgarn Craton, Western Australia: implications for exploration. *Australian Journal of Earth Sciences*, 49:4-162.

Baker, A.K.M., 1999. Metal geochemistry of regolith in the Mount Lofty Ranges and associated alluvial fans of the Adelaide Plains. [Glen Osmond Ag-Pb Deposits]. The University of Adelaide. Honours Degree of Bachelor of Science Research Thesis (unpublished).

Blissett, H., 1980a. CHILDARA, South Australia, sheet SH53-14. *South Australia. Geological Survey. 1:250 000 Series — Explanatory Notes*.

Blissett, H., 1980b. CHILDARA, South Australia, sheet SH53-14. *South Australia. Geological Survey. Geological Atlas 1:250 000 Series – Explanatory Notes*.

Blissett, A.H., Parker, A.J. and Crooks, A.F. (Compilers), 1988a. YARDEA map sheet. *South Australia. Geological Survey. Geological Atlas 1:250 000 Series,* sheet SI53-3.

Blissett, A.H., Parker, A.J. and Crooks, A.F. (Compilers), 1988b. Cacuppa map sheet. *South Australia. Geological Survey. Geological Atlas 1:100 000 Series, sheet 6032, SA_GEOLOGY/Geodetail. Preliminary geological map (2004)*. Primary Industries and Resources, South Australia. Spatial Information / Adelaide, SA.

Blissett, A.H., Parker, A.J. and Crooks, A.F. (Compilers), 1988c. Minnipa map sheet. *South Australia. Geological Survey. Geological Atlas 1:100 000 Series, sheet 5932, SA_GEOLOGY/Geodetail. Preliminary geological map (2004)*. Primary Industries and Resources, South Australia. Spatial Information / Adelaide, SA.

Both, R.A., Hafer, M.R., Mendis, D.P.J. and Kelly B.T., 1993. The Moonta copper deposits, South Australia: geology and ore genesis of the Poona and Wheal Hughes ore bodies. *In*: Fenoll Hach-Alf, P., Torres-Ruiz, J. and Gervilla, F. (editors). *Current Research in Geology Applied to Ore Deposits*, 49-52.

Brown, H.Y.L., 1908. *Record of the Mines of South Australia*. Fourth Edition. Government Printer, Adelaide, 381 p.

Carragher, A., 1999. The use of partial extractions for exploration [Windabout Cu-Co prospect, N of Mt Gunson, South Australia]. The University of Adelaide. Honours Degree of Bachelor of Science Research Thesis (unpublished).

Circosta, G. and Gum, J., 1989. Geological investigation. Mining Leases 5342 and 5361, Earea Dam, South Australia. Report by Tarcoola Gold Limited. *In*: *Primary Industries and Resources South Australia. Open File Envelope*, 8062, (unpaginated, unpublished).

Conor, C.H.H., 1995. Moonta – Wallaroo Region. An interpretation of the geology of the Maitland and Wallaroo 1:100 000 sheet areas. *South Australia. Mines and Energy Department. Open File Envelope*, 8886, (unpublished).

Conor, C.H.H., 1996. *Moonta – Wallaroo Cu-Au Province Excursion Guidebook*. South Australia. Mines and Energy Department. Adelaide, (unpublished).

Conor, C.H.H., 2002. The Palaeo-Mesoproterozoic geology of northern Yorke Peninsula, South Australia: Hiltaba Suite-related alteration and mineralization of the Moonta-Wallaroo Cu-Au district. *South Australia. Department of Primary Industries and Resources. Report Book*, 2002/007, (unpublished).

Cornish, D. and Drew, G., 1999. Wheal Hughes Tourist Mine. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 12:26-27.

Crettenden, P.P. and Fradd, W.P., 1992. Geological and Historical Review of the Earea Dam Goldfield. *South Australia. Department of Mines and Energy. Mines and Energy Review*, 158:81-83.

Daly, S.J. and Fanning, C.M., 1993. Chapter 3, Archaean. *In*: Drexel, J.R., Preiss, W.V. and Parker, A.J. (editors), 1993. The Geology of South Australia. Volume 1, The Precambrian. *South Australia. Geological Survey. Bulletin,* 54. ISBN: 0 7308 4146 4.

Daly, S.J. and van der Stelt, B., 1992. Archaean metabasic diamond drilling project (Northwest Gawler Craton Drilling Investigations 1991; Data Package Part B). *South Australia. Department of Mines and Energy. Confidential Envelope*, 8541, (unpublished).

Davies, M.B., 2002a. Harris Greenstone Domain Bedrock Drilling, May–August 2001. *South Australia. Department of Primary Industries and Resources. Report Book*, 2002/11, (unpublished).

Davies, M.B., 2002b. Harris 'Greenstone' Domain bedrock drilling Phase 2: June–August 2002. *South Australia. Department of Primary Industries and Resources. Report Book*, 2002/29, (unpublished).

Drexel, J.F. and Preiss, W.V. (editors), 1995. The Geology of South Australia. Volume 2, The Phanerozoic. *South Australia. Geological Survey. Bulletin*, 54. ISBN: 0 7308 0621 9.

Drexel, J.F., Preiss, W.V. and Parker, A.J., (editors), 1993. The geology of South Australia, Volume 1, The Precambrian. *South Australia. Geological Survey. Bulletin*, 54. ISBN: 0 7308 4146 4.

Drown, C.G., 2002. Barns Gold Project, Eyre Peninsula, South Australia. *In*: Ferris, G.M. (Compiler), 2002. Gawler Craton 2002: state of play. *South Australia. Department of Primary Industries and Resources. Mineral Exploration Data Package*, 10.

Drown, C.G., 2003. The Barns Gold Project – discovery in an emerging district. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 28:4-9.

Eggleton, R.A. (editor), 2001. *The Regolith Glossary: surficial geology, soils and landscapes*. Cooperative Research Centre for Landscape Evolution and Mineral Exploration. ISBN 0 7315 3343 7.

Fairclough, M.C. and Schwarz, M.P. (editors), 2003. Gawler Craton 2003: State of Play. The Excursion. *South Australia. Department of Primary Industries and Resources. Report Book*, 2003/17.

Fanning, C.M., 1997. Geochronological synthesis of South Australia. Part II: The Gawler Craton, South Australia. South Australia. Department of Mines and Energy. Open File Envelope, 8918 (unpublished).

Fanning, C.M., 2002. Geochronology and isotope geochemistry of crust forming events, and timing of orogenic events in the Gawler Craton. *In*: *Gawler Craton 2002: State of Play*. Office of Minerals and Energy Resources. South Australia. Department of Primary Industries and Resources. Workshop Proceedings CD-ROM.

Fanning, C.M., Reid, A.J and Teale, G.S., 2007. A geochronological framework for the Gawler Craton, South Australia. *South Australia. Geological Survey. Bulletin*, 55.

Ferris, G.M., and Fairclough, M.C., (in prep.). CHILDARA map sheet (2nd Edition). *South Australia. Geological Survey. Geological Atlas 1:250 000 Series*, sheet SH53-14.

Ferris, G.M. , and Fairclough, M.C., 2007. CHILDARA, South Australia, sheet SH53-14 (2nd Edition). Geological Atlas 1:250 000 Series – Explanatory Notes. *Primary Industries and Resources of South Australia. Office of Mineral and Energy Resources. Report Book*, 2007/01.

Ferris, G.M. and Schwarz, M.,2003. Proterozoic gold province of the central Gawler Craton. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 30:4-12.

Gibbons, L.K, 1997. Regolith study of the Old Well gold prospect, Tarcoola District, Gawler Craton. *University of Adelaide. Department of Geology and Geophysics. BSc Honours Thesis*, (unpublished).

Gibbons, L. and Lintern, M.J., 1998. Regolith geology and geochemistry at Old Well Au prospect, Gawler Craton, South Australia. Regolith '98: Australian Regolith & Mineral Exploration. "New Approaches to an old Continent". *3rd Australian Regolith Conference, Kalgoorlie, Western Australia, May 1998. Program and Abstracts. Cooperative Research Centre for Landscape Environments and Mineral Exploration, Perth, Western Australia*. ISBN: 0 9586857 3 8. p. 42.

Griffin, T. and McCaskill, M. (editors), 1986. *Atlas of South Australia*. South Australian Government Printing Division and Wakefield Press on behalf of the South Australian Jubilee 150 Board, Adelaide. pp. 50-51. ISBN: 0 7243 4688 0.

Guedria, A., Trichet, J. and Wilhelm, E., 1989. Behaviour of lead and zinc in calcrete-bearing soils around Bou Grine, Tunisia – its application to geochemical exploration. *Journal of Geochemical Exploration*, 32:117-132.

Hartley, K-L., 2000. Regolith studies of the Moonta Copper Mines Yorke Peninsula, South Australia. University of Melbourne. School of Earth Sciences. Honours Degree of Bachelor of Science Research Thesis, (unpublished).

Hartley, K-L., 2004. Moonta. *In*: Lintern, M.J. (Compiler), 2004. The South Australian Regolith Project Final Report – Summary and Synthesis. *Cooperative Research Centre for Landscape Environments and Mineral Exploration. Open File Report*, 156. ISBN: 0 643 06852 X. pp. 95-101.

Helix Resources, 2004. Industry News – advanced prospects and exploration projects: Tunkillia prospect. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 34:18-19.

Hoatson, D.M., Direen, N.G., Whitaker, A.J., Lane, R.J.L., Daly, S.J., Schwarz, M.P. and Davies, M.B., 2002. Geophysical Interpretation of the Harris Greenstone Belt, Gawler Craton, South Australia. *Preliminary Edition Map 1:250,000 scale. Geoscience Australia. Canberra*.

Hou, B., 2004. Palaeochannel studies related to the Harris Greenstone Belt, Gawler Craton, South Australia [Kingoonya Palaeochannel Project]. *Primary Industries and Resources of South Australia. Office of Mineral and Energy Resources. Report Book*, 2004/01.

Jack, R.L., 1917. The Geology of the Moonta and Wallaroo Mining District. *South Australia. Geological Survey. Bulletin*, 6:9-16.

Janz, J., 1990. The mineralogy and paragenesis of the Poona Mine copper deposit. Flinders University. School of Earth Science. Honours Degree of Bachelor of Science Research Thesis, (unpublished).

Keeling, J.L., 2004. Metal ion dispersal through transported cover at Moonta, South Australia. *In*: Roach, I.C. (editor), 2004. Regolith 2004. *Cooperative Research Centre for Landscape Environments and Mineral Exploration. Proceedings of the CRC LEME Regional Regolith Symposia 2004*. CRC LEME, Perth WA. pp. 161-165. ISBN: 0 9756895 0 9.

Keeling, J.L. and Hartley, K.L., 2005. Poona and Wheal Hughes Cu deposits, Moonta, SA. *In*: Butt, C.R.M., Robertson, I.D.M., Scott, K.M. and Cornelius, M., 2005. *Regolith Expression of Australian Ore Systems. A compilation of exploration case histories with conceptual dispersion, process and exploration models*. CRC LEME, Perth, Western Australia, pp. 383-385. ISBN: 1 921039 28 0.

Keeling, J., Mauger, A. and Huntington, J., 2004. Spectral core logger update – preliminary results from the Barns gold prospect. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 33,32-36

Keeling, J.L., Mauger, A.J., Scott, K.M. and Hartley, K., 2003. Alteration mineralogy and acid sulphate weathering at Moonta copper mines. *In*: Roach, I.C. (editor), 2003. Advances in Regolith. *Proceedings of the CRC LEME Regional Regolith Symposia 2003*. ISBN: 0 7315 5221 0. pp. 230-233.

Kelly, K.L. and Judd, D.R., 1976. *Color – Universal Language and Dictionary of Names*. National Bureau of Standards, United States Commerce Department, Washington, D.C.

Leduc, C., 1986. Prospection geochimique de mineralisations de converture en milieu carbonate sons climat semi-aride: resultans d'une etude d'orientation de Zn-Pb de Bou Grine (Atlas tunisien). *Chronique Des Mines Et De La Recherche Miniere*, 482:33-37.

Lemar, R.C., 1975. The origin of the Moonta Porphyry. South Australian Institute of Technology. School of Applied Geology. Graduate Diploma Project Thesis, (unpublished).

Lane, R. and Worrall, L., 2002. *Gawler Craton Mineral Promotion Project: Interpretation of airborne electromagnetic data. Summary Report on the Tunkillia Workshop*. Geoscience Australia, Canberra. Workshop Report (Open File as of Jan. 2006).

Lintern, M.J., 2004a. Preliminary regolith studies at Earea Dam gold prospect, Gawler Craton, South Australia. *Cooperative Research Centre for Landscape Environments and Mineral Exploration. Open File Report*, 153. ISBN: 0 643 06851 1.

Lintern, M.J. (Compiler), 2004b. The South Australian Regolith Project Final Report – Summary and Synthesis. *Cooperative Research Centre for Landscape Environments and Mineral Exploration. Open File Report*, 156. ISBN: 0 643 06852 X.

Lintern, M.J., 2004c. Preliminary biogeochemical studies at Barns gold prospect, Gawler Craton, South Australia. *Cooperative Research Centre for Landscape Environments and Mineral Exploration. Open File Report*, 168. ISBN: 0 643 09140 8.

Lintern, M.J., 2005. Biogeochemical anomalies at Barns gold prospect, Eyre Peninsula, South Australia. *In*: Roach, I.C., (editor). Regolith 2005 Ten Years of CRC LEME. *Cooperative Research Centre for Landscape Environments and Mineral Exploration. Proceedings of the CRC LEME Regional Regolith Symposia 2005, 195-196*. ISBN: 0-9756895-2-5.

Lintern, M.J., 2006. There's gold in them thar *sand* hills! *In*: Fitzpatrick, R.W. and Shand, P., (editors). Regolith 2006 Consolidation and dispersion of ideas. *Cooperative Research Centre for Landscape Environments and Mineral Exploration. Proceedings of the CRC LEME Regolith Symposium, November 2006, 215-216*. ISBN: 1-921039-47-7.

Lintern, M.J. and Rhodes, E., 2005. The dual role of vegetation in anomaly formation at Barns Gold Prospect, Eyre Peninsula, South Australia. 22nd International Geochemical Exploration Symposium, Perth, Western Australia. Abstract Volume, p72. ISBN: 1 86308 119 4.

Lintern, M.J. and Sheard, M.J., 1999. Regolith studies related to the Challenger Gold Deposit, Gawler Craton, South Australia. *Cooperative Research Centre for Landscape Evolution and Mineral Exploration. Open File Report*, 78 / *Primary Industries and Resources of South Australia. Office of Mineral and Energy Resources. Report Book*, 1998/10. ISBN v1: 0 643 06477 X v2: 0 643 06478 8 set: 0 643 06479 6.

Lintern, M.J., Sheard, M.J. and Gouthas, G., 2000. Regolith studies related to the Birthday Gold Prospect, Gawler Craton, South Australia. Co published as *CRC LEME Open File Report* 79 / *PIRSA Minerals and Energy Resources, South Australia. Report Book*, 2000/003. ISBN: 0 643 06480 X.

Lintern, M.J., Sheard, M.J. and Gouthas, G., 2006. Regolith studies at the Boomerang Gold Prospect, central Gawler Craton, South Australia. Co published as *CRC LEME Open File Report* 203 / *PIRSA Minerals and Energy Resources, South Australia. Report Book*, 2006/009 / *CSIRO Exploration and Mining Report* P2006/373. ISBN: 1 921039 43 4.

Lintern, M.J., Sheard, M.J. and Gray, G., 2007. Geochemical studies of the regolith at the Mt Gunson Copper Deposits, Stuart Shelf, South Australia. *CRC LEME Open File Report* 216. ISBN: 1 921039 61 2.

Mason, D.R. and Mason, J.E., 1998. A Petrographic study of Regolith Samples from the Challenger Project [Gawler Craton, South Australia]. For Mines and Energy, South Australia & CRC LEME. *Mason Geoscience Pty Ltd. Report*, 2413, (unpublished).

Mauger, A.J., Keeling, J.L., Luong, I. and Scott, K.M., 1997. Poona Copper Mine, Moonta South Australia: investigation of alteration mineralogy using short wave infrared analysis. *South Australia. Mines and Energy Department. Report Book*, 1997/51, (unpublished).

Mazzucchelli, R.H., Chapple, B.E.E. and Lynch, J.E., 1980. Northern Yorke Peninsula Cu. Gawler Block, S.A. *In*: Butt, C.R.M. and Smith, R.E. (editors), 1980. Conceptual models in exploration geochemistry – Australia. *Journal of Geochemical Exploration*, 12:203-207.

McEntegart, L.B. and Schmidt-Mumm, A., 2004. Gold mobility within dune systems on the Barns prospect, Wudinna, South Australia: a partial extraction approach. *In*: Rocah, I.C. (editor). *Cooperative Research Centre for Landscape Environments and Mineral Exploration. Abstracts of the CRC LEME Regional Regolith Symposia 2004*, pp. 235-340. ISBN: 0-9756895-0-9.

Munsell Color, 1975. *Munsell Soil Color Charts*. Munsell Color, Baltimore, Maryland, United States of America.

Northcote, K.H., 1979. *A Factual Key for the Recognition of Australian Soils*. Fourth Edition, Rellim Technical Publications, Adelaide, South Australia. ISBN: 0 9599989 0 X.

Northcote, K.H. and Skene, J.K.M., 1972. Australian Soils with Saline and Sodic Properties. *CSIRO. Melbourne, Australia. Soil Publication*, 27. ISBN: 0 643 00008 9.

Northcote, K.H., Hubble, G.D., Isbell, R.F., Thompson, C.H. and Bettenay, E., 1975. *A description of Australian Soils + Soil Map of Australia* (1:5,000,000). Commonwealth Scientific & Industrial Research Organisation, Australia. ISBN: 0 643 00139 5.

Northcote, K.H., with Beckmann, G.G., Bettenay, E., Churchward, H.M., Van Dijk, D.C., Dimmock, G.M., Hubble, G.D., Isbell, R.F., McArthur, W.M., Murtha, G.G., Nicolls, K.D., Paton, T.R., Thompson, C.H., Webb, A.A. and Wright, M.J., (1960-68). *Atlas of Australian Soils, Sheets 1 to 10. With explanatory data*. CSIRO Australia and Melbourne University Press, Melbourne.

Parker, A.J. (Compiler), 1993. Palaeoproterozoic. *In*: Drexel, J.F., Preiss, W.V. and Parker, A.J., (editors), 1993. The geology of South Australia, Volume 1, The Precambrian. *South Australia. Geological Survey. Bulletin*, 54. ISBN: 0 7308 4146 4. pp. 51-104.

Parker, A.J. and Flint, R.B., 2005. YARDEA, South Australia, sheet SI53-3. *South Australia. Geological Survey. Geological Atlas 1:250 000 Series – Explanatory Notes*. ISBN: 0 7590 1366 7.

Parker, A.J., Fanning, C.M. and Flint, R.B., 1985. 2: Geology. In: Twidale, C.R., Tyler, M.J. and Davies, M. (editors), 1985. Natural History of Eyre Peninsula. *Royal Society of South Australia. Occasional Publication*, 4, pp. 21-45. ISBN 0 9596627 3 1.

Pillans, B. and Bourman, R., 1996. The Brunhes/Matuyama Polarity Transition (0.78 Ma) as a chronostratigraphic marker in Australian regolith studies. *AGSO Journal of Australian Geology and Geophysics*, 16:289-294.

Pontual, S., Merry, N. and Gamson, P., 1997. *Spectral Interpretation Field Manual. Spectral Analysis Guides for Mineral Exploration. G-Mex version 1.0 Volumes 1-8*. Ausspec International Pty Ltd.

RASC, 1986. CHILDARA, SH 53-14, 1:250,000 scale topographic-cadastral map. *Royal Australian Survey Corps. Joint Operations Graphic*. Series 1501, sheet SH 53-14, Edition 1.

Robertson, I.D.M. and Butt, C.R.M., 1997. Atlas of Weathered Rocks. *Cooperative Research Centre for Landscape Evolution and Mineral Exploration. Open File Report*, 1 / *CSIRO Division of Exploration Geoscience. Report*, 390, first revision. ISBN: 0 958 68572 X.

Robertson, I.D.M., Koning, A.E., Anand, R.R. and Butt C.R.M. 1996. Atlas of transported overburden. *CSIRO Exploration and Mining Restricted Report 296R. 122p. (Reissued as Open File Report 87, CRC LEME, Perth, 2001)*. ISBN: 0 643 06483 4.

Rod, E, 1974. Misrepresentations by indiscriminate use of vertical exaggeration in geological sections. *Geological Society of Australia. Journal*, 21:203-208.

Schwarz, M., Morris, B., Sheard, M., Ferris, G., Daly, S. and Davies, M., 2002. Gawler Craton. *In*: Heithersay, P.S., Drexel, J.F., Hibburt, J.E. and Thomas, C.A. (editors), 2002. *South Australian mineral explorers guide*. Draft edition. Office of Minerals and Energy Resources. South Australian Department of Primary Industries and Resources, Adelaide, CD, Ch. 4.

Sheard, M.J., 1996. Technical Report Release: "Soils stratigraphy and engineering geology of near surface materials of the Adelaide Plains." *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 2:35-38.

Sheard, M.J., 2007a. Wudinna north area Regolith Landform Maps A & B. *South Australia. Geological Survey. Special Map 1:20 000 scale, SA_GEOLOGY/Geodetail, Preliminary digital map (June 2007)*. PIRSA Spatial Information / Adelaide, SA.

Sheard, M.J., 2007b. Regolith characterisation as an aid to mineral exploration in the Wudinna North Area, Central Gawler Province, South Australia. Co released as *CRC for Landscape Environment and Mineral Exploration. Open File Report*, 232 / *Primary Industries & Resources, South Australia. Report Book*, 2007/14. ISBN: 1 921039 81 9.

Sheard, M.J. and Bowman, G.M., 1996. Soils stratigraphy and engineering geology of near surface materials of the Adelaide Plains. *South Australia. Department of Mines and Energy. Report Book*, 94/9.

Sheard, M.J. and Robertson, I.D.M., 2003. Lake Harris Regolith Landform Map. *South Australia. Geological Survey. Special Map 1:10 000 scale. SA_GEOLOGY/Geodetail. Preliminary digital map (27th June 2003)*. PIRSA Spatial Information, Adelaide, SA.

Sheard, M.J. and Robertson, I.D.M., 2004. Regolith Characterisation and Geochemistry as an Aid to Mineral Exploration in the Harris Greenstone Belt, Central Gawler Craton, South Australia. *Cooperative Research Centre for Landscape Environments and Mineral Exploration. Open File Report*, 155 / *Primary Industries and Resources of South Australia. Office of Mineral and Energy Resources. Report Book*, 2003/10 / *CSIRO Exploration and Mining. Report*, 1165F. ISBN: v1: 0 643 06855 4 v2: 0 643 06856 2 set: 0 643 06857 0.

Sheard, M.J., Lintern, M.J., Prescott, J.R. and Huntley, D.J., 2006. Great Victoria Desert: new dates for South Australia's ?oldest desert dune system? *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 42:15-26.

Sheard, M., Robertson, I., Zang, W., Daly, S. and Davies, M., 2003. Stop 5.1.1: Ferruginised and silicified Archaean Lake Harris Komatiite intruded by Glenloth Granite. And, Stop 5.1.2.R: Weathered Glenloth Granite, lake shoreline escarpment. *In:* Fairclough, M.C. and Schwarz, M.P. (editors), 2003. Gawler Craton 2003: State of Play. The Excursion. *South Australia. Department of Primary Industries and Resources. Report Book*, 2003/17.

Stace, H.C.T., Hubble, G.D., Brewer, R., Northcote, K.H., Sleeman, J.R., Mullahy, M.J. and Hallsworth, E.G., 1968. *A handbook of Australian Soils*. Rellim Technical Publications, Adelaide.

Swain, G., Woodhouse, A., Hand, M., Barovich, K., Schwarz, M. and Fanning, C.M., 2005. Provenance and tectonic development of the late Archaean Gawler Craton, Australia: U–Pb zircon, geochemical and Sm–Nd isotopic implications. *Precambrian Research*, 141:106-136.

Taylor, G and Eggleton, R.A., 2001. *Regolith geology and geomorphology*. John Wiley & sons, Ltd, Chichester, 375 p.

Thomas, M. (Compiler), 2004. Central Gawler Gold – Data Catalogue. Co-published by *Primary Industries & Resources South Australia. Report Book*, 2004/004 / *Cooperative Research Centre for Landscape Environment and Mineral Exploration. Open File Report*, 202. ISBN: 1 921039 426 .

Twidale, C.R. and Campbell, E.M., 1985. The form of the land surface. *In*: Twidale, C.R., Tyler, M.J. and Davies, M. (editors), 1985. Natural History of Eyre Peninsula. *Royal Society of South Australia. Occasional Publication*, 4, pp. 57-76. ISBN 0 9596627 3 1.

Zang, W-l. (Compiler), 2003. MAITLAND Special map sheet. *South Australia. Geological Survey. Geological Atlas 1:250 000 Series,* sheet SI53-12 & portion SI53-16.

Zang, W-l., Cowley, W.M. and Fairclough, M., 2006. MAITLAND Special, South Australia, sheet SI53-12 & portion SI53-16. *South Australia. Geological Survey. Geological Atlas 1:250 000 Series – Explanatory Notes*. ISBN: 0 7590 1380 2.

•——oo0oo——•

REGOLITH BENCHMARK ATLAS, GAWLER CRATON, SOUTH AUSTRALIA

Complied by M.J. Sheard

CRC LEME Openfile Report 210
Volume 2

June 2008

(PIRSA-Minerals and Energy Resources Group,
South Australia, Report Book, 2008/07)

CRC LEME is an incorporated joint venture between CSIRO-Exploration & Mining, and Land & Water, The Australian National University, Curtin University of Technology, University of Adelaide, Geoscience Australia, Primary Industries & Resources SA, NSW Department of Mineral Resources and the Minerals Council of Australia.

Headquarters: CRC LEME, C/o CSIRO-Exploration and Mining, PO Box 1130, BENTLEY WA 6102, Australia.

This report presents outcomes of a CRC LEME project involving the Department of Primary Industries and Resources, Adelaide, South Australia (PIRSA) that commenced in mid 2006 and continued until late 2007. There were no confidentiality agreements entered into regarding any aspects of this project or covering any primary data and images or derived data and images obtained during the execution of this project. All contents, data and samples associated with this report are open file items. All reference materials (regolith samples, thin and polished sections) have been retained by PIRSA at their Drill Core Storage Facility, 23 Conyngham St, Glenside, South Australia, 5065. Those materials can be viewed without restriction by prior arrangements with the Drill Core Storage Facility Manager [ph: (08) 8379 9574 ; Fax: (08) 8338 1925].

Electronic copies of the publication in PDF format can be downloaded from the CRC LEME website: http://crcleme.org.au/Pubs/OFRSindex.html. Information on this or other CRC LEME publications can be obtained from http://crcleme.org.au
Hard copies will be retained in the Australian National Library, the J. S. Battye Library of West Australian History, and the CSIRO Library at the Australian Resources Research Centre, Kensington, Western Australia.

Reference:
Sheard, M.J., 2008. Regolith Benchmark Atlas, Gawler Craton, South Australia. *CRC LEME Open File Report 210. PIRSA Report Book 2008/07*, Volume 2 154 pages.

Keywords
1. Regolith – South Australia. 2. Benchmarks – South Australia. 3. Central Gawler Gold Province – South Australia. 4. Christie Domain – South Australia. 5. Harris Domain – South Australia. 6. Nuyts Domain – South Australia.

ISSN: 1329-4768
ISBN: 1 921039 54X

Address and Affiliations of the Author:
M.J. Sheard
Principal Geologist
Cooperative Research Centre for Landscape Environments and Mineral Exploration,
C/- PIRSA, Minerals & Energy Resources Group, Geological Survey Branch,
GPO Box 1671, ADELAIDE SA 5001, Australia

Published by: CRC LEME, c/o CSIRO Exploration and Mining, PO Box 1130, Bentley, Western Australia 6102

Contents Page

Figure Listing ____ III
Table Listing ____ VI
Plate Listing ____ VII
Introductory Comments ____ 1
BENCHMARKS ____ 3
Christie Domain ____ 3
Christie Gneiss ____ 3
Challenger Gold Deposit ____ 5
Background ____ 5
Geology and Mineralization ____ 7
Regolith Studies ____ 8
***In situ* Regolith** ____ 9
Calcrete ____ 9
Transported Regolith ____ 9
Regolith Exposure ____ 10
Geochemical expression ____ 16
Benchmark 21 composite; drillholes 95CHAR312 + GC128 ____ 20
Background ____ 22
***In situ* Regolith** ____ 23
Transported Regolith ____ 24
Geochemistry ____ 24
Benchmark 22 composite, drillholes 95CHAR115, GC121 & Pit GCP121 ____ 26
Background ____ 28
***In situ* Regolith** ____ 33
Transported Regolith ____ 33
Geochemistry ____ 33
Benchmark 23 composite, drillholes 95CHAR558, GC100 & Pit GCP100 ____ 36
Background ____ 38
***In situ* Regolith** ____ 44
Transported Regolith ____ 44
Geochemistry ____ 45
Jumbuck gold prospect ____ 48
Background ____ 48
***In situ* Regolith** ____ 48
Transported Regolith ____ 50
Geochemical expression ____ 53
Benchmark 24, drillhole 97JBAR054 ____ 55
Background ____ 55
***In situ* Regolith** ____ 57
Transported Regolith ____ 57
Geochemistry ____ 58
Benchmark 25, drillhole 97JBAR064 ____ 63
Background ____ 63
***In situ* Regolith** ____ 65
Transported Regolith ____ 65
Geochemistry ____ 66
Golf Bore gold prospect ____ 67
Background ____ 67
***In situ* Regolith** ____ 68
Transported Regolith ____ 69
Geochemical expression ____ 69
Benchmark 26, drillhole 96GBAR093 ____ 73
Background ____ 73
***In situ* Regolith** ____ 75
Transported Regolith ____ 75
Geochemistry ____ 76

Cont.

<u>Benchmark 27</u>, drillhole 96GBAR249 ____ **81**
Background ____ **81**
***In situ* Regolith** ____ **83**
Transported Regolith ____ **83**
Geochemistry ____ **83**
South Hilga gold prospect ____ **85**
Background ____ **85**
***In situ* Regolith** ____ **86**
Transported Regolith ____ **86**
PIMA Mineralogy ____ **86**
Geochemical expression ____ **89**
<u>Benchmark 28</u>, drillhole MHP080b ____ **92**
Background ____ **92**
***In situ* Regolith** ____ **94**
Transported Regolith ____ **94**
Geochemistry ____ **94**
<u>Benchmark 29</u>, drillhole 96SHAR154 ____ **99**
Background ____ **99**
***In situ* Regolith** ____ **101**
Transported Regolith ____ **101**
Geochemistry ____ **101**
Monsoon gold prospect ____ **102**
Background ____ **102**
***In situ* Regolith** ____ **103**
Transported Regolith ____ **103**
PIMA Mineralogy ____ **106**
Geochemical expression ____ **106**
<u>Benchmark 30</u>, drillhole 97MNAR105 ____ **109**
Background ____ **109**
***In situ* Regolith** ____ **111**
Transported Regolith ____ **111**
Geochemistry ____ **111**
<u>Benchmark 31</u>, drillhole 97MNAR049 ____ **117**
Background ____ 117
***In situ* Regolith** ____ **119**
Transported Regolith ____ **119**
Geochemistry ____ **119**
Edoldeh Tank (ET) gold prospect ____ **120**
Background ____ **120**
***In situ* Regolith** ____ **123**
Transported Regolith ____ **125**
PIMA Mineralogy ____ **126**
Geochemical expression ____ **126**
<u>Benchmark 32</u>, drillhole 96ETAR187 ____ **133**
Background ____ **133**
***In situ* Regolith** ____ **135**
Transported Regolith ____ **135**
Geochemistry ____ **136**
<u>Benchmark 33</u>, drillhole 96ETAR193 ____ **138**
Background ____ **138**
***In situ* Regolith** ____ **140**
Transported Regolith ____ **141**
Geochemistry ____ **141**
REFERENCES ____ **142**

Volume 2 Figures **Page**

1 (Repeated from Volume 1) Generalised Regolith Terminology after Robertson and Butt (1997) modified slightly to better represent South Australian regolith ______________ **1**
110 Gawler Craton, Christie Domain Benchmarks 21-33 ________________________________ **2**
111 Colour contoured Au-in-calcrete geochemical anomalism on prospects held by the Gawler Joint Venture (Dominion Mining Ltd & Resolute Resources Ltd), including the Challenger Gold Deposit. Western Gawler Craton regional roads, rail and towns are also marked _____ **5**
112 Gold in calcrete geochemical anomalies and significant prospects held by the Gawler Joint Venture (Dominion Mining Ltd & Resolute Resources Ltd), including Challenger Gold Deposit. Drill tested Au values are also indicated (GJV, 1998) _______________________ **6**
113 Challenger Gold Deposit in plan, showing the surficial Au-in-calcrete anomaly (max. regional grid sample value is indicated), subsurface mineralization (as defined by RAB drilling), ore shoots (as defined by RC drilling), and the regolith sampling drill line of Lintern and Sheard (1998, 1999a) ____ **6**
114 Challenger Gold Mine in long section, displaying four northerly plunging mineralized lodes, M1, M2 and two others (unlabeled). The open cut pit in outline and the first stage underground access decline with sublevel workings are indicated. Angled diamond drillholes (black lines) have provided pre-mining strategic data (Poustie *et al*., 2002) ______ **7**
115 Challenger Gold Deposit: projected 'M' folding along the M1 lode, with the actual intersections by deep drill coring (~600 m below ground level), indicating the quite variable high grade gold distribution (Poustie, 2006) ______________________________ **7**
116 Lag distribution plan of Povey (1999) displaying a 3 x 3 km area centred on the Challenger Gold Deposit. The unconformity (as defined by drilling) is indicated by the thick black line. Lag distribution, via surface visual appraisal mapping, is coloured, while contours display laboratory work involving sample weights _________________________________ **8**
117 Regolith line cross-section at Challenger, the position is indicated with a grey line on Figure 113 (Lintern and Sheard, 1999a). RAB drilling was carried out by the Gawler Joint Venture partners to define mineralization below the surficial Au-in-calcrete geochemical anomaly. Benchmarks 21-23 locations are indicated ___________________ **10**
118 Major stages of profile weathering in strategic core segments from geotechnical drillhole 97CHDH1361-A. LHS displays cut core faces and RHS displays thin-section photomicrographs. Simplified petrographic explanations are after Mason and Mason (1998) ____ **10-11**
119 A grab sample extracted from Challenger Regolith Pit GCP 122 of Lintern and Sheard (1999b) with simplified petrography. Sample #: R214050, thin-section #: R214050 _____ **13**
120 Challenger Gold Mine eastern face (main pit), as exposed in September 2003. Major regolith zones are indicated in the RHS column _________________________________ **14**
121 Section along the regolith line of Figure 117 but displaying only upper regolith (0-6 m) at Challenger (Lintern and Sheard, 1998). Section position is marked as the grey Regolith Line on Figure 113. Benchmarks 21-23 are indicated ____________________________ **15**
122 Elevation model of the AEM basal conductor surrounding the Challenger Gold Deposit. Hatched area indicates location of the lag distribution plan of Figure 116 (Lintern, 2004b). Note the two deep palaeovalleys to the west of the hatched area ____________________ **16**
123 Elemental distribution plots for different regolith materials and 'Blue Bush' (*Maireana sedifolia*) as exemplified by: (a) S (%), (b) K (%), (c) Ce (ppm) and (d) Au (ppb). LHS of each profile is at the NW end of the NW-SE oriented Regolith Line on Figure 113 (Lintern and Sheard, 1999a) ____ **17**
124 Concentration *vs* depth for Au and Ca within the Challenger regolith–soil pits of Lintern and Sheard (1999a, b; Lintern 2004b). All pits except Pit A are located along the Regolith Line indicated on Figure 113 and the pit numbers correspond to drillhole numbers displayed in Figure 123 ____ **18**
125 3D modelling of Au distribution at Challenger using a 70 ppb cut off, showing the top of the supergene Au enrichment zone at the completely- to highly-weathered interface _____ **19**
126 **Benchmark 21** chiptray photo and regolith log to RAB drillhole 95CHAR312. Drilling terminated in saprock near its upper boundary with lower saprolite __________________ **21**

127 Elemental abundances *vs* depth (m) for Benchmark 21, RC drillhole GC128, Challenger Gold Deposit (Lintern and Sheard, 1999b) **25**
128 **Benchmark 22** chiptray photo and regolith log to RAB drillhole 95CHAR115. Drilling depth was to 48 m but chiptray samples stop at 39 m (in saprock) **27**
129 **Benchmark 22** continued, composite profile to Challenger regolith pit GCP121 (Lintern and Sheard, 1999b). Data from laboratory, microscope & in-field logging are included **30**
130 Elemental abundances *vs* depth (m) for Benchmark 22, RC drillhole GC121, Challenger Gold Deposit (Lintern and Sheard, 1999b) **34**
131 Elemental distributions *vs* depth (m) for Benchmark 22, Regolith Pit GCP121, Challenger Gold Deposit (Lintern and Sheard, 1999b) **35**
132 **Benchmark 23** chiptray photo and regolith log to RAB drillhole 95CHAR558. Drilling depth was to 41 m but chiptray samples stop at 40 m (in saprock) **37**
133 **Benchmark 23** continued, composite profile to Challenger regolith pit GCP100 (Lintern and Sheard, 1999b) **40**
134 Elemental abundances *vs* depth (m) for Benchmark 23, RC drillhole GC100, Challenger Gold Deposit (Lintern and Sheard, 1999b) **46**
135 Elemental distributions *vs* depth (m) for Benchmark 23, RC Regolith Pit GCP100, Challenger Gold Deposit (Lintern and Sheard, 1999b) **47**
136 Locations marked on the 1:250,000 scale geology for five prospects where benchmark sites are described herein (map coordinates are in AMG66 projection) **49**
137 Jumbuck gold prospect in 3D, showing Au-in-calcrete anomaly draped over the local DEM and indicating the regolith (sampling) line. Exposed “wireframe” grid indicates data below 1 ppb (Lintern *et al*., 2002) **50**
138 Jumbuck gold prospect, full regolith section along line displayed in Figure 137 (Lintern *et al*., 2002). Benchmarks 24 and 25 are indicated **51**
139 Jumbuck gold prospect, upper regolith section along line displayed in Figures 137, 138 (Lintern *et al*., 2002). Benchmarks 24 and 25 are indicated **52**
140 Jumbuck gold prospect regolith section, regolith architecture and Au geochemical expression (*c.f.* Figures 137-139), (Lintern, 2004b). Benchmarks 24 and 25 indicated **54**
141 **Benchmark 24**, Jumbuck gold prospect drillhole 97JBAR054, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002) **56**
142 Jumbuck gold prospect regolith section, regolith architecture and Ag geochemical expression (*c.f.* Figures 140, 143-145). Lintern *et al*. (2002) **59**
143 Jumbuck gold prospect regolith section, regolith architecture and Bi geochemical expression (*c.f.* Figures 140, 142, 144, 145). Lintern *et al*., (2002) **60**
144 Jumbuck gold prospect regolith section, regolith architecture and U geochemical expression (*c.f.* Figures 140, 142, 143, 145). Lintern *et al*., (2002) **61**
145 Jumbuck gold prospect regolith section, regolith architecture and Zn geochemical expression (*c.f.* Figures 140, 142-144). Lintern *et al*., (2002) **62**
146 **Benchmark 25**, Jumbuck gold prospect drillhole 97JBAR064, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002) **64**
147 Golf Bore prospect in plan, showing Au-in-calcrete anomaly. Black dots are sample points, black line is the Regolith sampling section of Lintern *et al*. (2002) and Figures 148, 149 **67**
148 Golf Bore gold prospect, full regolith section along line displayed in Figure 147 (Lintern *et al*., 2002). Benchmarks 26 and 27 are indicated **70**
149 Golf Bore gold prospect, upper regolith section along line displayed in Figure 147 (Lintern *et al*., 2002). Benchmarks 26 and 27 are indicated **71**
150 Golf Bore gold prospect regolith section, regolith architecture and Au geochemical expression (*c.f.* Figures 147-149), (Lintern, 2004b). Benchmarks 26 and 27 indicated **72**
151 **Benchmark 26**, Golf Bore gold prospect drillhole 96GBAR093, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002) **74**
152 Golf Bore gold prospect regolith section, regolith architecture and As geochemical expression (*c.f.* Figures 150, 153-155). Lintern *et al*. (2002) **77**
153 Golf Bore gold prospect regolith section, regolith architecture and Ca geochemistry (calcrete + gypsum; *c.f.* Figures 150, 152, 154, 155). Lintern *et al*. (2002) **78**

154 Golf Bore gold prospect regolith section, regolith architecture and S geochemistry (gypsum; *c.f.* Figures 150, 152, 153, 155). Lintern *et al.* (2002) **79**
155 Golf Bore gold prospect regolith section, regolith architecture and W geochemistry (*c.f.* Figures 150, 152-154). Lintern *et al.* (2002) **80**
156 **Benchmark 27**, Golf Bore gold prospect drillhole 96GBAR249, chiptray and regolith zonation (image extracted from Lintern *et al.*, 2002) **82**
157 Golf Bore gold prospect. Distribution of Au (numerical data in ppb) and Ca (circular symbols) in the upper regolith section. Calcium is present principally as calcrete and gypsum **84**
158 South Hilga gold prospect in plan, showing Au-in-calcrete anomaly. Black dots are sample points; black line is the Regolith Line of Lintern *et al.* (2002) **85**
159 South Hilga gold prospect, full regolith section along line displayed in Figure 158 (Lintern *et al.*, 2002). Benchmarks 28 and 29 are indicated **87**
160 South Hilga gold prospect, upper regolith section along line displayed in Figure 158 (Lintern *et al.*, 2002). Benchmarks 28 and 29 are indicated **88**
161 South Hilga gold prospect, scatter plots for selected elements. Box symbols indicate samples with the higher Au concentrations. Plot a: Fe *v* Mg. Note the cluster of high Fe and relatively low Mg (lower right) indicating highly ferruginous saprolite (derived from a mafic parent). Plot b: Fe *v* As. Some pathfinders, e.g. As, are adsorbed by Fe oxyhydroxides (goethite), (Lintern *et al.*, 2002) **89**
162 South Hilga gold prospect, regolith section, regolith architecture and Au geochemical expression (*c.f.* Figures 159, 160), (Lintern, 2004b). Benchmarks 28 and 29 indicated **91**
163 **Benchmark 28**, South Hilga gold prospect drillhole MHP080b, chiptray and regolith zonation (image extracted from Lintern *et al.*, 2002) **93**
164 South Hilga gold prospect regolith section, regolith architecture & As geochemistry (*c.f.* Figures 165-167). Lintern *et al.* (2002). Benchmarks 28, 29 are indicated **95**
165 South Hilga gold prospect regolith section, regolith architecture & Cu geochemistry (*c.f.* Figures 164, 166, 167). Lintern *et al.* (2002). Benchmarks 28, 29 are indicated **96**
166 South Hilga gold prospect regolith section, regolith architecture & Fe geochemistry (*c.f.* Figures 164, 165, 167). Lintern *et al.* (2002). Benchmarks 28, 29 are indicated **97**
167 South Hilga gold prospect regolith section, regolith architecture & Zn geochemistry (*c.f.* Figures 164-166). Lintern *et al.* (2002). Benchmarks 28, 29 indicated **98**
168 **Benchmark 29**, South Hilga gold prospect drillhole 96SHAR154, chiptray and regolith zonation (image extracted from Lintern *et al.*, 2002) **100**
169 Monsoon gold prospect in plan, showing Au-in-calcrete anomaly. Black dots are sample points; black line is the Regolith Line of Lintern *et al.* (2002) **102**
170 Monsoon gold prospect, full regolith section along line displayed in Figure 169 (Lintern *et al.*, 2002). Benchmarks 30 and 31 are indicated **104**
171 Monsoon gold prospect, upper regolith section along line displayed in Figure 169 (Lintern *et al.*, 2002). Benchmarks 30 and 31 are indicated **105**
172 Monsoon gold prospect, scatter plots for selected elements. Plot a. Ca *v* Au; large box symbols indicate highly calcareous surficial samples showing strong association between Ca and Au. Plot b. Fe *v* S; large box symbols in top right of plot indicate samples with high Au contents **107**
173 Monsoon gold prospect, regolith section, regolith architecture and Au geochemical expression (*c.f.* Figures 170, 171), (Lintern, 2004b). Benchmarks 30 and 31 indicated **108**
174 **Benchmark 30**, Monsoon gold prospect drillhole 97MNAR105, chiptray and regolith zonation (image extracted from Lintern *et al.*, 2002). **110**
175 Monsoon gold prospect, distribution of Au (numerical data in ppb) and Ca (circular symbols) in the upper regolith. Calcium is present principally as calcrete but some gypsum is also present (*c.f.* S plot in Figure 178) **112**
176 Monsoon gold prospect regolith section, regolith architecture & Bi geochemistry (*c.f.* Figures 177-179). Lintern *et al.* (2002). Benchmarks 30, 31 indicated **113**
177 Monsoon gold prospect regolith section, regolith architecture & Ni geochemistry (*c.f.* Figures 176, 178, 179). Lintern *et al.* (2002). Benchmarks 30, 31 are indicated **114**
178 Monsoon gold prospect regolith section, regolith architecture & S geochemistry (*c.f.* Figures 176, 177, 179). Lintern *et al.* (2002). Benchmarks 30, 31 are indicated **115**

179 Monsoon gold prospect regolith section, regolith architecture & V geochemistry (*c.f.* Figures 176-178). Lintern *et al*. (2002). Benchmarks 30, 31 are indicated **116**
180 **Benchmark 31**, Monsoon gold prospect drillhole 97MNAR049, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002) **118**
181 ET gold prospect (boxed) and drill lines in relation to Mt Christie, local roads and tracks, and regional geology (BARTON 250k sheet), (Lintern *et al*., 2003) **120**
182 ET gold prospect showing Au-in-calcrete anomaly and drilled regolith study line overlaid on the DEM. Viewed from the east (Lintern *et al*., 2002) **121**
183 ET gold prospect DEM, derived from aerial photographs. It displays the westerly high ground and associated ridge trending SW. Drillholes are marked by red dots. (Lintern *et al*., 2003) **122**
184 ET gold prospect, isopachs to transported cover. Comparison with the DEM (Figure 183) reveals that the sediments are infilling a palaeolandscape and that there is no significant topographic inversion. Sediment thins over the palaeo-ridgeline and most of the drillholes are sited within the area enclosed by the 4.5 m isopach (Lintern *et al*., 2003) **122**
185 ET gold prospect, a 3D perspective view of colour composite image of HYMAP endmembers 6:5:4, overlaid on the TOPSAR DEM and viewed from the E, looking W across a 2.5 km swath of the prospect (Tapley and Cornelius, 2003) **123**
186 ET gold prospect. Munsell Colours (dominant) for samples from 200 RAB drillholes. Drillholes have been plotted in 3D using small circles for each 2 m sample where the assigned Munsell colour has been converted from its original notational form to an equivalent digital RGB form. Two contrasting backdrops amply highlight the pallid zones, mafic lithotypes and weathering variation across this area (Lintern *et al*., 2003) **124**
187 ET gold prospect, full depth section along the study line (340200 m E local grid) displayed on Figure 182 (Lintern *et al*., 2002). Benchmarks 32 and 33 are indicated **127**
188 ET gold prospect, upper regolith section along study line (340200 m E local grid) displayed in Figures 182, 187 (Lintern *et al*., 2002). Benchmarks 32 and 33 are indicated **128**
189 ET gold prospect, scatter plots (logarithmic axies) for: a) Ca *v* Au, and b) Fe *v* Ga **129**
190 ET gold prospect, regolith section, regolith architecture and Au geochemical expression (*c.f.* Figures 187, 188, 193), (Lintern, 2004b). Benchmarks 32 and 33 are indicated **130**
191 Gold-in-calcrete anomaly in transported regolith over mineralization along the southern portion of drilled section 339000 m E (local grid). Chiptray photos are behind the down hole Au traces, they display regolith colours (Lintern *et al*., 2003, 2004) **132**
192 **Benchmark 32**, ET gold prospect drillhole 96ETAR187, chiptray and regolith zonation **134**
193 ET gold prospect, geochemical expression along drill line 340200 m E (AMG grid) for selected elements Ag, As, Cu, Fe & Ni (Lintern *et al*., 2003). Benchmarks 32 and 33 are indicated in top panels. Compare these with Au plot in Figure 190 **136**
194 ET gold prospect, relationships between Au, Ca & Mg *versus* depth (0-12 m) for Benchmark 32 (Lintern *et al*., 2003). **137**
195 **Benchmark 33**, ET gold prospect drillhole 96ETAR193, chiptray and regolith zonation. In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehabilitation work **139**
196 ET gold prospect, relationships between Au, Ca & Mg *versus* depth (0-12 m) for Benchmark 33 (Lintern *et al*., 2003) **141**

Volume 2 Tables

1 (Repeated from Volume 1) Benchmark data that will be displayed where available **3**
49 Anomalous concentrations of elements over the 3 zones of mineralization in different materials and vegetation at Challenger (from Lintern and Sheard, 1999b) **19**
50 **Benchmark 21** reference data; composite of drillholes 95CHAR312 & GC128 (Type 2, drill cuttings profile) **20**
51 Benchmark 21 composite (continued) regolith log to RC drillhole GC128 (Lintern and Sheard, 1999b) **23**

52 **Benchmark 22** reference data; composite of drillholes 95CHAR115 & GC121 (Type 2, drill cuttings profiles) + regolith pit GCP121 (Type 3, excavation) ____ **26**
53 Benchmark 22 composite (continued) regolith log to RC drillhole GC121 (Lintern and Sheard, 1999b)____ **28-29**
54 Benchmark 22 composite (continued) regolith profile in-field log, sampling points and sample numbers to excavation GCP121 (pit size 12 x 6 x 3 m) ____ **31**
55 **Benchmark 23** reference data; composite of drillholes 95CHAR558 & GC100 (Type 2, drill cuttings profiles) + regolith pit GCP100 (Type 3, excavation) ____ **36**
56 Benchmark 23 composite (continued) regolith log to RC drillhole GC100 (after Lintern and Sheard 1999b) ____ **39**
57 Benchmark 23 composite (continued) regolith profile in-field log, sampling points and sample numbers to excavation GCP100 (pit size 12 x 8 x 3 m) ____ **41-42**
58 Jumbuck gold prospect, highest Au concentrations and other anomalous drillhole intervals (Lintern, 2004b) ____ **53**
59 **Benchmark 24** reference data; drillhole 97JBAR054 (Type 2, drill cuttings profile) ____ **55**
60 Benchmark 24, regolith log to RAB drillhole 97JBAR054 (after Lintern *et al*., 2002) ____ **57**
61 **Benchmark 25** reference data; drillhole 97JBAR064 (Type 2, drill cuttings profile) ____ **63**
62 Benchmark 25, regolith log to RAB drillhole 97JBAR064 (after Lintern *et al*., 2002) ____ **65**
63 Golf Bore gold prospect, the association between major and trace elements (after Lintern, 2004b) ____ **69**
64 Golf Bore gold prospect, highest Au concentrations and other anomalous drillhole intervals (Lintern, 2004b) ____ **69**
65 **Benchmark 26** reference data; drillhole 96GBAR093 (Type 2, drill cuttings profile) ____ **73**
66 Benchmark 26, regolith log to RC drillhole 96GBAR093 (after Lintern *et al*., 2002) ____ **75**
67 **Benchmark 27** reference data; drillhole 96GBAR249 (Type 2, drill cuttings profile) ____ **81**
68 Benchmark 27, regolith log to RAB drillhole 96GBAR249 (after Lintern *et al*., 2002) ____ **83**
69 South Hilga gold prospect, highest Au concentrations and other anomalous drillhole intervals (Lintern, 2004b) ____ **90**
70 **Benchmark 28** reference data; drillhole MHP080b (Type 2, drill cuttings profile) ____ **92**
71 Benchmark 28, regolith log to Rotary drillhole MHP080b (after Lintern *et al*., 2002) ____ **94**
72 **Benchmark 29** reference data; drillhole 96SHAR154 (Type 2, drill cuttings profile) ____ **99**
73 Benchmark 29, regolith log to RAB drillhole 96SHAR154 (after Lintern *et al*., 2002) ____ **101**
74 Monsoon gold prospect, highest Au concentrations and other anomalous drillhole intervals (Lintern, 2004b) ____ **106**
75 **Benchmark 30** reference data; drillhole 97MNAR105 (Type 2, drill cuttings profile) ____ **109**
76 Benchmark 30, regolith log to RAB drillhole 97MNAR105 (after Lintern *et al*., 2002) ____ **111**
77 **Benchmark 31** reference data; drillhole 97MNAR049 (Type 2, drill cuttings profile) ____ **117**
78 Benchmark 31, regolith log to RAB drillhole 97MNAR049 (after Lintern *et al*., 2002) ____ **119**
79 ET gold prospect, highest Au concentrations and other anomalous drillhole intervals for drilled section 340200 m E (local grid) ____ **129**
80 **Benchmark 32** reference data; drillhole 96ETAR187 (Type 2, drill cuttings profile) ____ **133**
81 Benchmark 32, regolith log to RAB drillhole 96ETAR187 (after Lintern *et al*., 2002, 2003) ____ **135**
82 **Benchmark 33** reference data; drillhole 96ETAR193 (Type 2, drill cuttings profile) ____ **138**
83 Benchmark 33, regolith log to RAB drillhole 96ETAR193 (after Lintern *et al*., 2002, 2003) ____ **140**

Volume 2 Plates

9 Christie Gneiss bedrock (wet), collected from the open cut at Challenger Gold Mine, ~100 m below ground level. Note the banding; the bluish quartz, cordierite and feldspar + dark pink coarse-grained garnets. The black bands contain abundant biotite, amphibole and pyroxene ____ **8**
10 Challenger Gold Deposit regolith. Thin-section view (reflected plane polarised light) of silicified-ferruginous graphite-bearing saprolite (lag sample of Lintern and Sheard, 1999b). Sample #: R214180, thin-section #: R214180 ____ **13**
11 Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP 100 of Lintern and Sheard (1999b). A porcellanite-silcrete-ferruginous claycrete-breccia, cemented by later calcrete and minor hyaline silica. Sample #: R367482 ____ **13**

12 Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP 100 of Lintern and Sheard (1999b). Brecciated porcellanite in a matrix supported framework of grey silcrete. Material resembles a debris flow deposit. Sample #: R214153 ________________ **13**
13 Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP 106 of Lintern and Sheard (1999b). Brecciated porcelanitic (+ grey potch opal cores) and kaolinite rich saprolite in a matrix supported framework of brown ferruginous calcrete and quartz grit. Material resembles an expanded talus deposit. Sample #: R214137 ___________________ **14**
14 Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP 110 of Lintern and Sheard (1999b). Colourful, complexly laminated calcrete containing: ferruginous lithic fragments/cement (claycrete 20%, silcrete <1%) + quartz grains (5%) + calcrete cement (70%) + dolomite (<1%) + opaline silica (~2%) + voids (~3%). Sample #: R214109 ______ **14**
15 The initial 296 ppb Au calcrete sample site at the Challenger prospect (at the pink pin flag, after Edgecombe, 1997). Note the sparse low vegetation and abundant surface lag that includes calcrete, silcrete, siliceous-ferruginous saprolite, ferruginous granules and exotic rounded pebbles ____ **14**
16 **Benchmark 21** composite (continued), chiptray samples to RC drillhole GC128 (0-6 m). LHS displays unprocessed samples; RHS displays washed samples, where clay and silt have been removed ____ **22**
17 **Benchmark 22** composite (continued), chiptray samples to RC drillhole GC121 (0-6 m). LHS displays unprocessed samples; RHS displays washed samples, where clay and silt have been removed. Granular residue becomes less abundant with depth below 3 m. Sample interval was one metre ____ **28**
18 Pit GCP121, wide angle view, SE face with logged and sampled profile marked by measuring tape (Lintern and Sheard, 1999b). *(photo 45481)* __________________________ **32**
19 Pit GCP121, SE face, top metre (red mark at 1 m) with central logged and sampled profile marked by measuring tape (Lintern and Sheard, 1999b). *(photo 45482)* _________________ **32**
20 Pit GCP121, SE face, ~1-2 m (red marks at 1 and 2 m) with central logged and sampled profile marked by measuring tape (Lintern and Sheard, 1999b). *(photo 45483)* ___________ **32**
21 Pit GCP121, SE face, ~2.5-3 m (red marks at 2 m) with central logged and sampled profile marked by measuring tape (Lintern and Sheard, 1999b). *(photo 45484)* _________________ **32**
22 Pit GCP121, saprolite from 1.7-1.8 m, fine pallid kaolinite with ovoid and diffuse yellow-brown to dark brown ferruginous patches. Black rectangle marks location of thin-section in Plate 23 opposite. Sample R214079. *(photo 45599)* ______________________________ **32**
23 Pit GCP121, sample R214079, in transmitted plane polarised light. Saprolite with relict metamorphic quartz (colourless), K-feldspar (colourless, slightly turbid & cleaved), + alteration clay (pale yellow) and goethite (dark brown after altered biotite flakes. View 1.5 x 2.5 mm (Mason and Mason, 1998). *(photo 45865)* ______________________________ **32**
24 **Benchmark 23** composite (continued), chiptray samples to RC drillhole GC100 (0-6 m). LHS displays unprocessed samples; RHS displays washed samples, where clay and silt have been removed. Granular residue becomes less abundant with depth below 3 m. Sample interval was one metre ____ **38**
25 Pit GCP100, view of the bouldery grey billy silcrete on the SE side of the pit, in marked contrast to the laminar calcrete-silcrete breccia on the N and W sides of the pit. View from atop the sampled profile (Lintern and Sheard, 1999b). *(photo 45508)* ______________ **42**
26 Pit GCP100, wide angle view, NW face with logged and sampled profile marked by measuring tape (Lintern and Sheard, 1999b). *(photo 45504)* __________________________ **42**
27 Pit GCP100, NW face, top metre (red mark at 1 m) central logged profile indicated by tape (Lintern and Sheard, 1999b). *(photo 45505)* ________________________________ **42**
28 Pit GCP100, NW face, top 1-2 m (red mark at 1 m) central logged profile indicated by tape (Lintern and Sheard, 1999b). *(photo 45506)* ________________________________ **42**
29 Pit GCP100, NW face, 1.5-2.75 m (red mark at 2 m) central logged profile indicated by measuring tape (Lintern and Sheard, 1999b). Silcrete is more bouldery-concretionary between 1.85-2.15 m. *(photo 45507)* ______________________________________ **43**
30 Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP100 of Lintern and Sheard (1999b). Silcrete (grey billy) composed of small translucent grey quartz grains distributed uniformly through a pale cream-grey matrix. Sample R213794, *(photo 45537)* __ **43**

31 Sample R213794, in transmitted plane polarised light. Rounded and angular quartz fragments (colourless) lie in a cryptocrystalline siliceous cement pervaded by submicron dusty material (possibly leucoxene). Silicified sediment with colluvial and alluvial grains. View 1.5 x 2.5 mm (Mason and Mason, 1998). *(photo 45837)* ________ **43**

32 Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP100 of Lintern and Sheard (1999b). Calcrete bearing Fe-stained lithic fragments in a fine-grained pink-cream matrix. A 1 cm thick irregular band without Fe-lithic fragments defines layering. Sample R367480, *(photo 45524)* ________ **43**

33 Sample R367480, in transmitted plane polarised light. Large Fe-fragment (lower right) lies in a matrix of quartz particles (colourless) & cryptocrystalline-microcrystalline calcite (lower left), + overgrowths of colloform opaline silica (colourless) and microcrystalline calcite (pale brown). View 1.5 x 2.5 mm (Mason and Mason, 1998). *(photo 45885)* ________ **43**

34 ET gold prospect, dune sand-soil pit (~1 m deep) exposing a sheet calcrete B_{Ca} horizon (>50 cm thick) into which pipe karst has developed. Soil water dissolution and perhaps the activity of tree roots on the $CaCO_3$ have yielded this solution feature (Lintern *et al*., 2003) ________ **126**

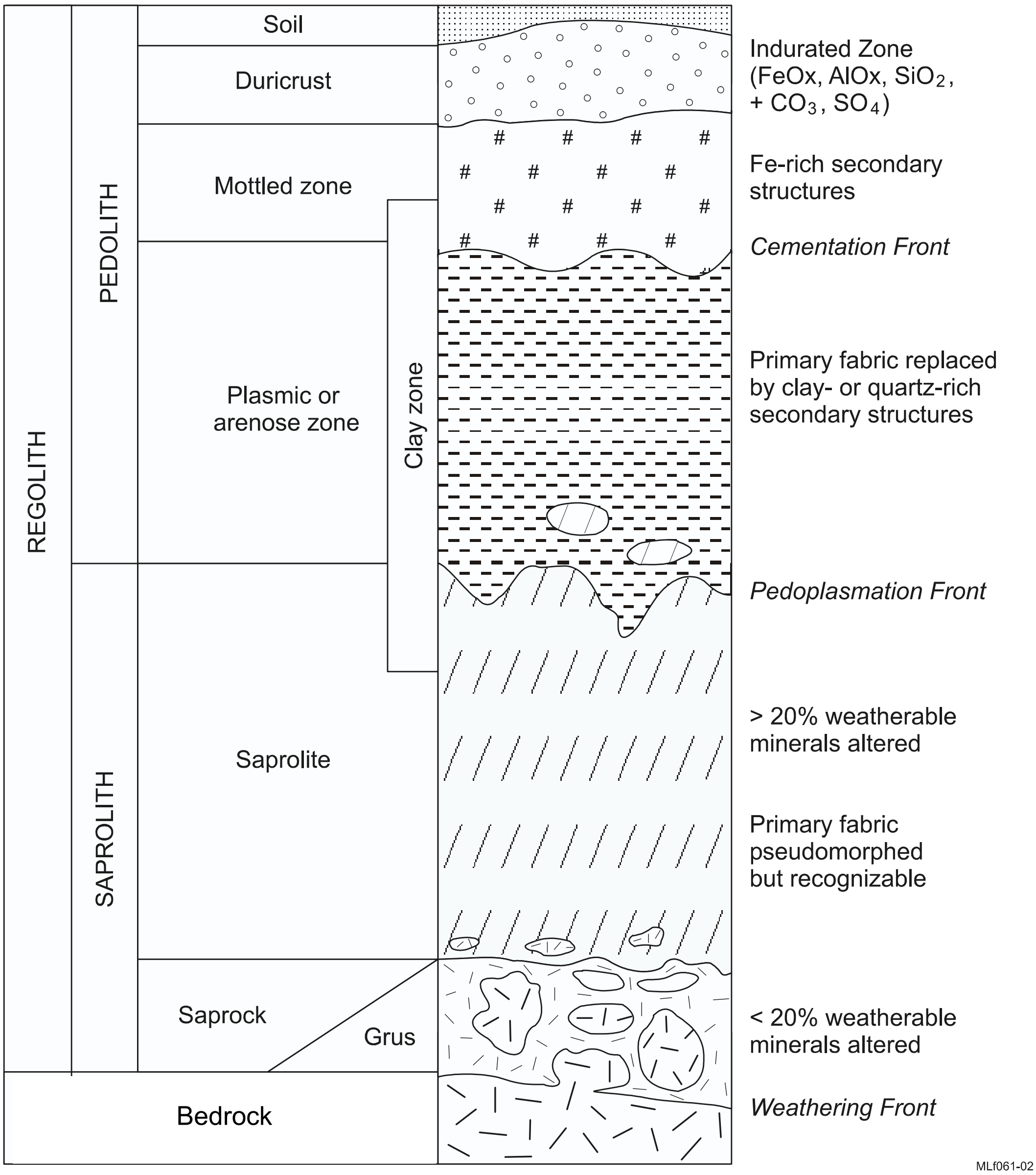
•——oo0oo——•

REGOLITH BENCHMARK ATLAS, GAWLER CRATON, SOUTH AUSTRALIA – Volume 2

Introductory Comments

A detailed introduction to Benchmarking is provided in Volume 1, covering the following: Benchmark Types, Methods, Regolith Profile Terminology, and Benchmarks 1 to 20, located within the Harris Domain, Central Gawler Gold Province and Yorke Peninsula. Volume 2 includes 13 Benchmarks dominantly located within the Archaean Christie Domain, these are drawn from CRC LEME & PIRSA regolith investigations, and a series of university Honours theses covering prospect scale regolith studies. The case history extracts presented herein are drawn from work done during 1997-2006.

To assist the user of this Volume, as a stand-alone reference, the Regolith Terminology chart from Volume 1 is reproduced below (Figure 1). A regional location plan for the Benchmarks contained herein follows as Figure 110.



(Adapted from: CRC LEME - Atlas of Weathered Rocks 1997, Open File Report 1; CSIRO Division of Exploration Geoscience, Report 390, 1st Revision.)

Figure 1: Generalised Regolith Terminology after Robertson and Butt (1997) modified slightly to better represent South Australian regolith. Weathering can affect both crystalline basement and overlying sedimentary cover, but erosion may also truncate portions of that weathering profile. In numerous areas, the weathering profile may be repeated more than once – especially within sedimentary basins. (duplicated from Vol. 1).

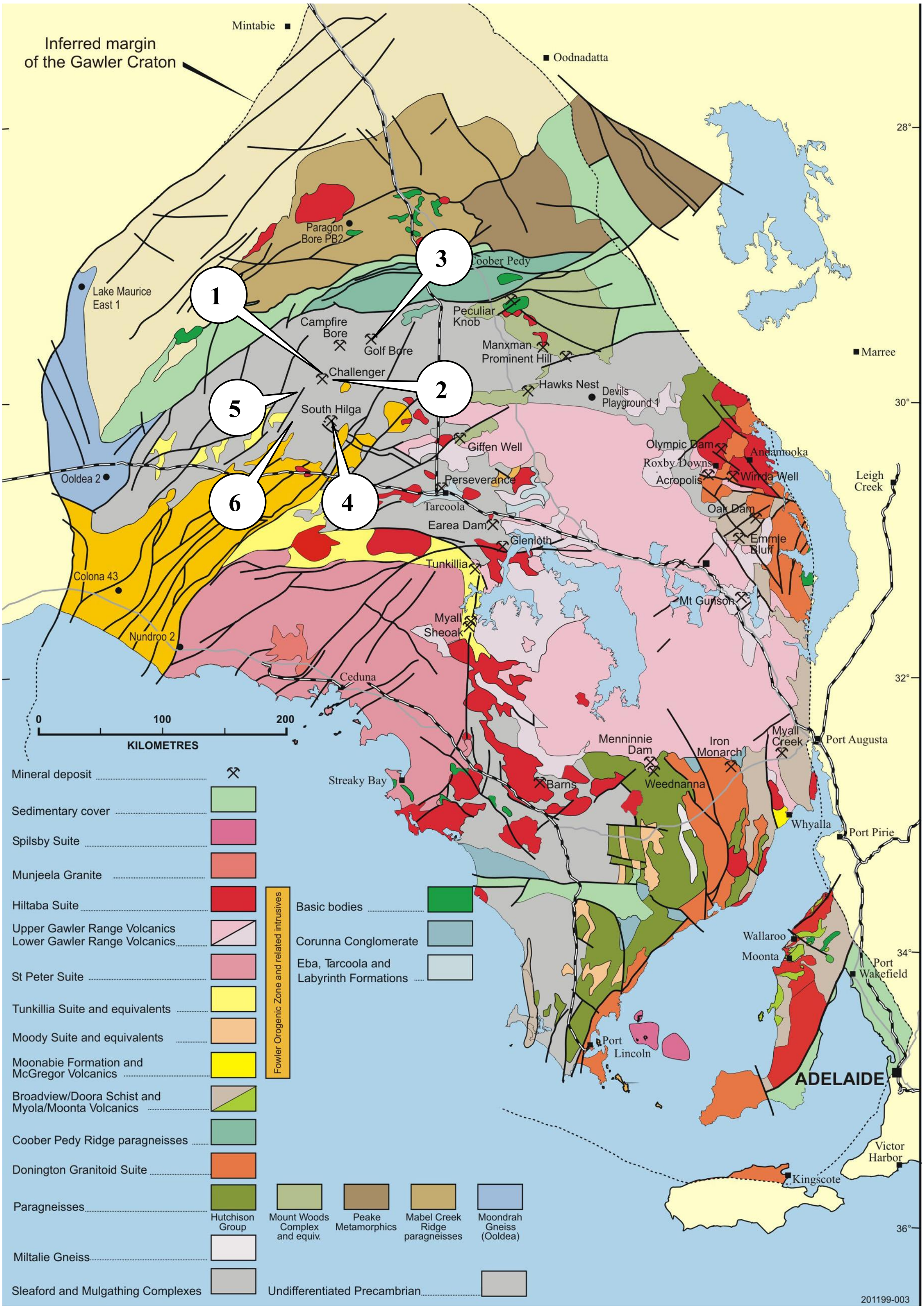


Figure 110: Gawler Craton, Christie Domain Benchmarks 21-33, CRC LEME + PIRSA 1996-2004:
1. 21-23 Challenger Gold Deposit, **2.** 24, 25 Jumbuck gold prospect,
3. 26, 27 Golf Bore gold prospect, **4.** 28, 29 South Hilga gold prospect,
5. 30, 31 Monsoon gold prospect, and **6.** 32, 33 ET gold prospect.

BENCHMARKS

Benchmark profile details are drawn from many sources, where uniformity of presentation and data between sources were not consistent. Ideal formats would include the items as set out in Table 1, however, not every site will necessarily have data or those particular items for each indicated level because benchmarking was not the original investigative focus. New photography was taken where samples or sites were amenable and additional data drawn from other sources, to infill any serious information gaps.

Table 1: Benchmark data that will be displayed where available.

#	Type 1 (natural outcrop)	Type 2 (drilled profiles)	Type 3 (excavations)
1	Regional location map	Regional location map	Regional location map
2	Local-site location map	Local-site location map	Local-site location map
3	GPS coordinates & elevation	GPS coordinates, attitude & elevation	GPS coordinates & elevation
4	Site access, owner	Site access, owner	Site access, owner
5	Related sites	Related drillholes	Related excavations
6	Profile photos + logs	Drill sample photos + logs	Excavation photos + logs
7	Sample storage location	Sample storage location	Sample storage location
8	Lithotypes	Lithotypes	Lithotypes
9	Petrology (if available)	Petrology (if available)	Petrology (if available)
10	Geochemistry (if available)	Geochemistry (if available)	Geochemistry (if available)
11	XRD data (if available)	XRD data (if available)	XRD data (if available)
12	PIMA data (if available)	PIMA data (if available)	PIMA data (if available)
13	Dating (if available)	Dating (if available)	Dating (if available)
14	Target elements	Target elements	Target elements
15	Potential Pathfinder Elements	Potential Pathfinder Elements	Potential Pathfinder Elements
16	Useful sampling media	Useful sampling media	Useful sampling media
17	Key reference sources	Key reference sources	Key reference sources

Christie Domain

The original Christie Sub-domain of Parker (1990) has been subsequently subdivided to exclude the Fowler Domain (Fowler Orogenic Zone), the Coober Pedy Domain and the Mount Woods Domain. The Christie Domain comprises Archaean to earliest Palaeoproterozoic rocks (original bedrock) onto which younger units were deposited and/or incorporated (Daly and Fanning, 1993; Teasdale, 1997). Major rock units include low magnetic intensity Mulgathing Complex paragneiss (e.g. host of the Challenger Gold Deposit) interlayered with, linear high magnetic zones of banded iron formation and ultramafic rocks, including peridotite, and intruded by highly magnetic ~1690-1670 Ma intrusives. The western boundary is the Karari Fault Zone and the eastern boundary is the Coorabie and Tallacootra Shear Zones (Figure 110; Fairclough and Schwarz, 2003; Daly and Fanning, 1993).

Christie Gneiss

The Christie Gneiss – paragneiss Type Locality includes the following sites and cores: the Mt Christie banded iron formation outcrop (TARCOOLA 1:250,000 & 5637 1:100,000 map sheets; Zone 53, 357200 m E, 6646450 m N) plus three short (angled) diamond drill holes intersecting the Mt Christie sequence at depth, and gneisses exposed at Christie Corner (356800 m E, 6644700 m N; 1.9 km SSW of Mt Christie. Daly and Fanning, 1993; Daly, 2003). These granulite facies metasediments are currently considered probable correlatives of the Carnot Gneiss partly exposed along the coast in the southern Gawler Craton, with both sequences undergoing granulite facies metamorphism at ~2440 Ma (Fanning *et al*., 2007). More recent work on the Harris Domain (see Vol 1) in the central Gawler Craton, indicates possible equivalents to the Christie Gneiss, intercalated with the greenstones and basalts, to be coeval (extrusion age 2510 Ma; Fanning, 2002). Detrital zircon geochronology on the nearby sediments at Kenella indicate ages of 2560 Ma, 2680 Ma and 2760 Ma (Swain, 2002).

Well exposed Christie Gneiss at Christie Corner reveals north trending gneissic banding, with coarse pegmatitic quartz, K-feldspar ± cordierite and garnet interlayered with finer darker layers of plagioclase, hypersthene (partly regressed to biotite during the Kimban Orogeny) diopside (partly regressed to hornblende) and quartz. The characteristic coarse garnets (purple-maroon) are partially regressed to chlorite and when weathered consist of iron oxides (expressed as brown mottles in pallid saprolite; Lintern and Sheard, 1999a). The pegmatitic layers are considered to have developed during peak metamorphism from a layered sedimentary sequence (Daly, 2003).

Christie Gneiss metasediments were isoclinally folded during the Sleafordian Orogeny. Small-scale isoclinal SD_2 folds are common. More open small-scale M-shaped folds (N closure) are considered associated with the later SD_3 folding, contemporaneous with the more open gently northerly plunging Mulgathing Antiform. Christie Corner outcrop is interpreted as part of a western limb to the Mulgathing Antiform. Boudins of metabasic rock (presumed basalt) also occur in the Christie Gneiss at this locality (N side) where small-scale SD_3 folding can also be observed. Small-scale Palaeoproterozoic shearing (trending ~NE) rotating Archaean layering to the NE occurs here too (Daly and Fanning, 1993; Daly, 2003).

Banded iron formation and interlayered aluminous metasediments at Mt Christie are interpreted as forming part of the western limb to the Mulgathing Antiform. Folding within the banded iron formation includes both isoclinal SD_2 and more open SD_3 folds which are coaxial at this location. The subhorizontal axies plunge more steeply on the northern and southern parts of the main outcrop due to inferred Proterozoic shearing. In the late 1960's the South Australian Geological Survey sponsored angled drilling at three sites through (below) the Mt Christie outcrop, each drillhole provided HQ cores from surface to fresh rock (PIRSA Mt Christie drillcores CD 1-3). Core exposes finely banded iron formation, oxidised–extremely weathered at the surface, it comprises: quartz, magnetite, diopside and hypersthene. Thin inter-layers of feldspar and carbonate with accessory garnet, clinopyroxene and olivine also occur. The banded iron formation is structurally overlain by banded coarse-grained quartz, plagioclase, K-feldspar, cordierite, garnet gneiss. Garnet-rich and cordierite-rich metasediments (seen only within the drill core) are identical to gneissic rocks hosting the Challenger Gold Deposit (Plate 9). Retrogression, presumed to be the result of Kimban Orogeny deformation (dated at the Challenger Gold Deposit as ~1710 Ma; Fanning, 2002), has partially altered the granulite facies orthopyroxene (to biotite) clinopyroxene (to amphibole) and cordierite (to sillimanite) (Daly and Fanning, 1993; Daly, 2003). Additional U-Pb zircon dating for this rock sequence is available in Fanning *et al*. (2007).

The Mt Christie drillcores CD 1-3 are not discussed further as benchmarks herein, however, they do provide additional visual access to the natural exposures of that area, and well present the weathering zone not seen in the local area outcrop.

Challenger Gold Deposit

Background

The Challenger Gold Mine is located in the Western Gawler Craton 750 km NW of Adelaide and 140 km NW of Tarcoola (Figures 110, 111). This deposit was discovered in 1995 using broad spaced (1.6 km grid) calcrete sampling and Au analysis (local maximum of 180 ppb Au), followed by in-fill calcrete sampling, where the anomaly gave a peak calcrete-Au value of 620 ppb (Lintern, 2004b; GJV, 1998; Edgecombe, 1997; Figures 111-113). Subsurface mineralization was defined by RAB and RC drilling during 1995-97, diamond coring in 1996-97 provided structural and more specific assay data. Gold production commenced in late 2002, initially from an open-cut pit, followed by underground mining operations. Those commenced late in 2004, where a spiral decline and stopes continued mining of the NE plunging loads below where the open-cut operations ceased. Production of gold from the underground workings began in 2005. The open cut mine produced 120,000 oz Au, and the underground operations have produced 190,000 oz Au (to late Nov. 2006). Reserves of 270,000 oz have been announced with another 410,000 oz Au projected as an in-ground resource from drilling and mine forward developments (Poustie *et al*., 2002; Poustie, 2006). Dominion Mining announced to the ASX in late July 2007 that Challenger Gold Deposit has current reserves standing at 2.2 million tonnes at 7.2 grams per tonne Au for 512,000 oz. This places the pre-mined Deposit size at equal to or more than 1.1 M oz.

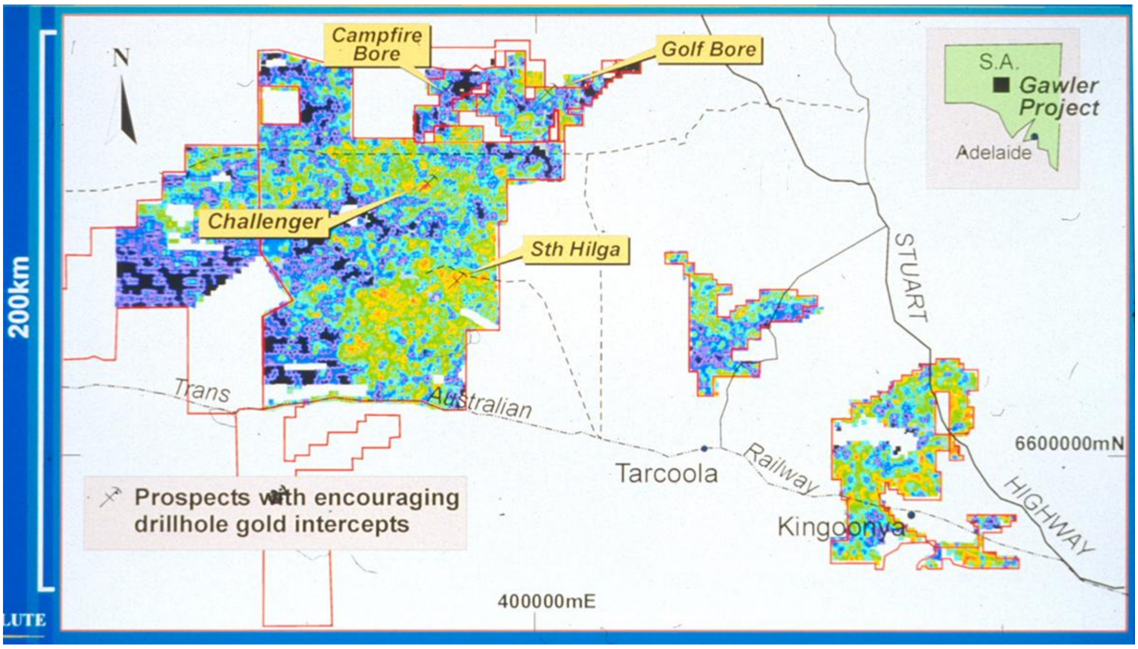


Figure 111: Colour contoured Au-in-calcrete geochemical anomalism on prospects held by the Gawler Joint Venture (Dominion Mining Ltd & Resolute Resources Ltd), including the Challenger Gold Deposit. Western Gawler Craton regional roads, rail and towns are also marked. Image courtesy of Resolute Resources Ltd.

The deposit is located beneath an expansive plain of several tens of kilometres square, with generally low relief (<50 m) consisting of: sparse longitudinal sand dunes, various terrigenous and marine sediments, occasional eroding escarpments in deeply weathered crystalline basement, and rare silcrete armoured remnant low rises of deeply weathered Christie Gneiss. Locally the Challenger Gold Deposit cropped out on the flanks of a low rise about two kilometres east of a poorly defined ephemeral drainage. There was no obvious active drainage within the outcrop-subcrop area, although in the subsurface there is evidence for small (<1 m) to wide (>1000 m) palaeochannels, the largest now provides groundwater to the Challenger Gold Mine (see later sections). Regional climate is arid with rainfall of about 150 mm per annum, falling mostly in the winter. Vegetation has been affected by grazing and consists of scattered open low woodland of *Acacia*, *Eremophila* and *Casuarina* spp. (up to 4 m in height) with an understory of shrubby genera (1-2 m in height), the most significant being 'Pearl Blue Bush' *Maireana sedifolia* (Lintern and Sheard, 1999; Lintern, 2004b).

Figure 112: Gold in calcrete geochemical anomalies and significant prospects held by the Gawler Joint Venture (Dominion Mining Ltd & Resolute Resources Ltd), including Challenger Gold Deposit. Drill tested Au values are also indicated (GJV, 1998).

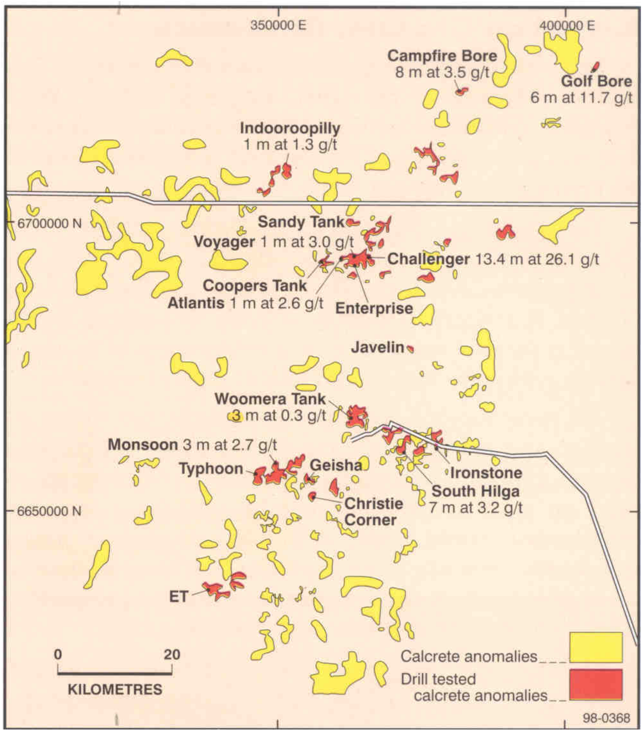
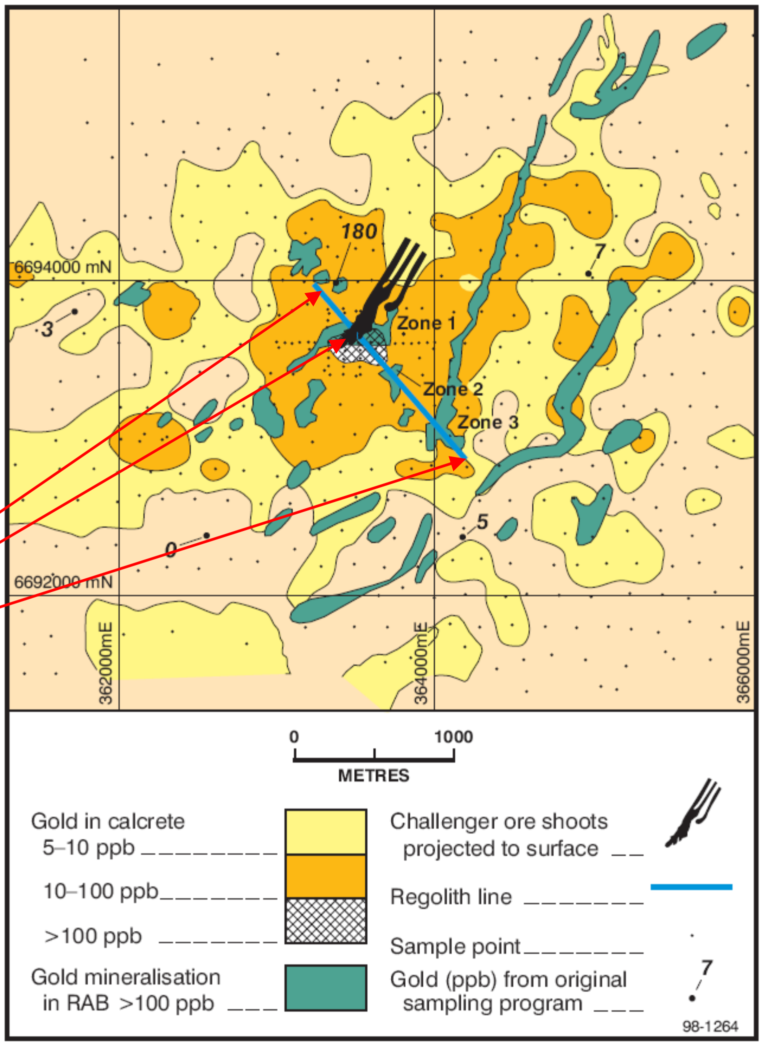


Figure 113: Challenger Gold Deposit in plan, showing the surficial Au-in-calcrete anomaly (max. regional grid sample value is indicated), subsurface mineralization (as defined by RAB drilling), ore shoots (as defined by RC drilling), and the regolith sampling drill line of Lintern and Sheard, 1998, 1999a. Some data derived from the Gawler Joint Venture partners.

Benchmark locations are shown.

Benchmarks:
21
22
23



Geology and Mineralization

The Challenger lode systems are contained within the Archaean metasedimentary Christie Gneiss, where the local lithology is a feldspar-quartz-cordierite-garnet-biotite gneiss (Poustie *et al*., 2002). Geochronology indicates peak metamorphism of the host rock at ~2440 Ma. Monazite intergrown with gold gives a similar age (Fanning, 2002). Work by Tomkins and Mavrogenes (2002) indicates that the gold was present within the sedimentary pile prior to metamorphism and was concentrated during peak metamorphism. Later heating and possible gold remobilisation, recorded by growth of monazite rims, occurred at ~1710 Ma.

The high grade coarse-grained Au mineralization occurs within and adjacent to coarse-grained quartz, feldspar, garnet and biotite-bearing veins, and is associated with minor disseminations of arsenopyrite, loellingite ($FeAs_2$) and pyrrhotite. Bluish quartz, bluish feldspar and greyish cordierite porphyroblasts can attain dimensions of many centimetres in some mineralization associated gneissic bands (Plate 9). Bismuth minerals, tellurides, chalcopyrite, pentlandite, sphalerite and graphite are also present in small amounts (Poustie *et al*., 2002; Lintern and Sheard, 1999b; Mason and Mason, 1998; Bonwick, 1997).

Mineralization occurs within structurally controlled shoots which plunge ~30^o towards 055^o local grid Figures 114, 115). The internal vein geometry is oblique to the plunge azimuth of the shoots. Mineralized veins have short strike lengths but are very consistent and are elongated down plunge. This consistency is supported by the fact that every drill section has intersected the mineralization over a down plunge distance of more than 800 m (Poustie *et al*., 2002; Poustie, 2006).

Figure 114: Challenger Gold Mine in long section, displaying four NE plunging mineralized lodes, M1, M2 and two others (unlabeled). The main pit in outline and the first stage underground access decline with sublevel workings are indicated. Angled diamond drillholes (black lines) have provided pre-mining strategic data (Poustie *et al*., 2002).

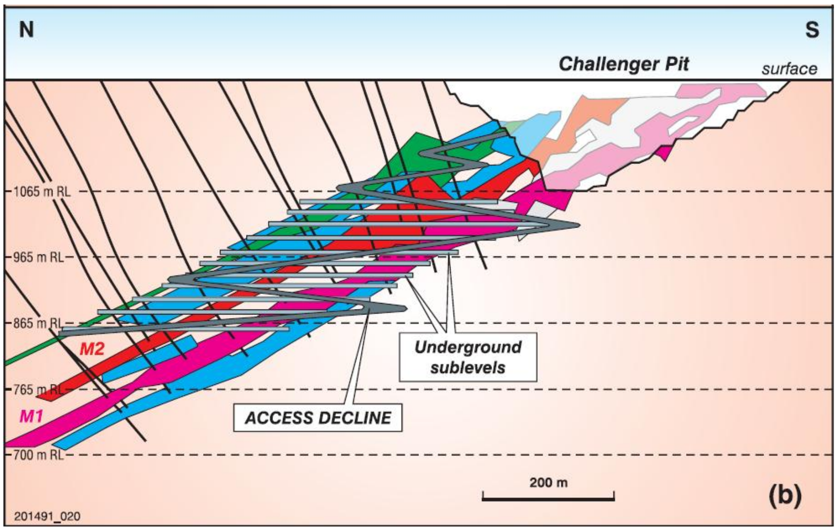


Figure 115: Challenger Gold Deposit: projected 'M' folding along the M1 lode, with the actual intersections by deep drill coring (~600 m below ground level), indicating a very persistent structural trend within which a quite variable high grade gold distribution occurs (Poustie, 2006).

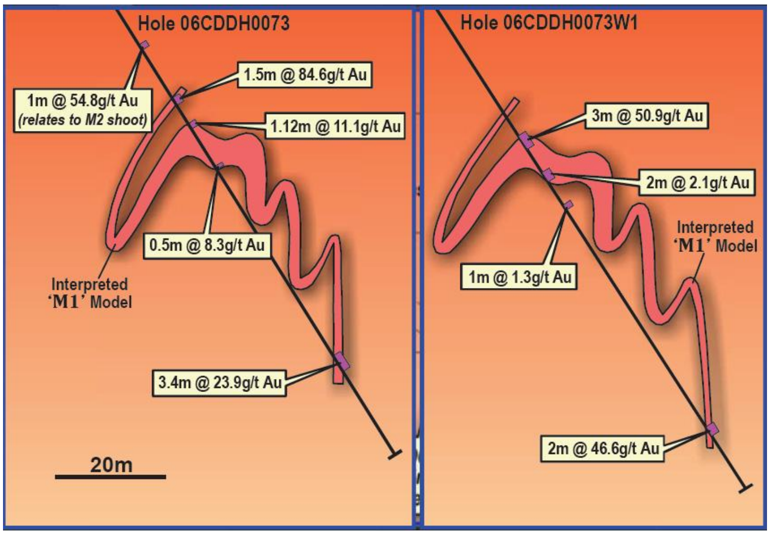


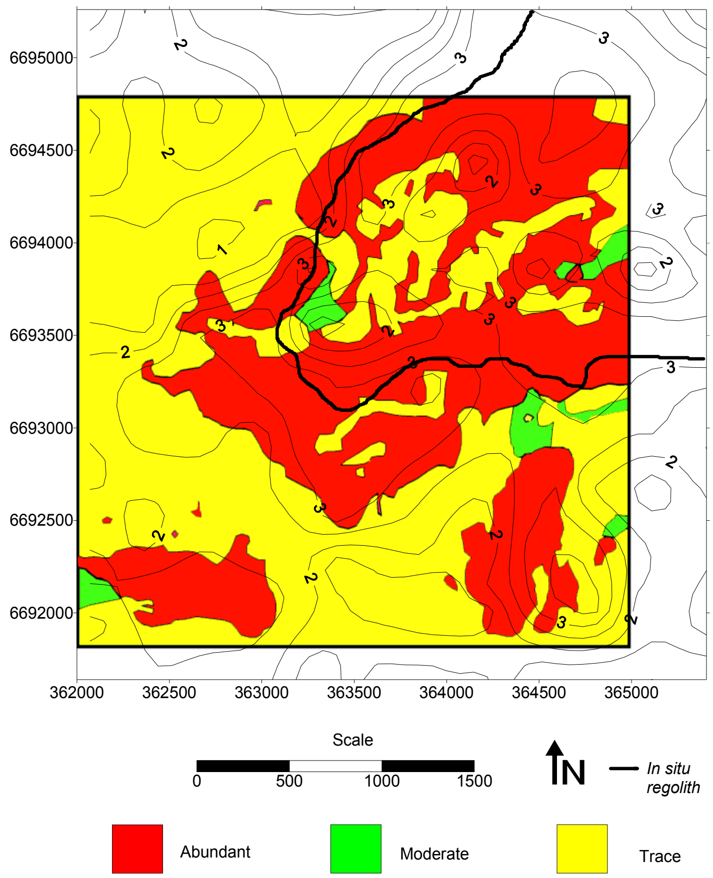
Plate 9: Christie Gneiss bedrock (wet), collected from the main pit at Challenger Gold Mine, ~100 m below ground level. Note the banding; the bluish quartz, cordierite and feldspar + dark pink coarse-grained garnets. The black bands contain abundant biotite, amphibole and pyroxene.

Regolith Studies

Regolith studies at the Challenger Gold Deposit were undertaken by CRC LEME, PIRSA and two university Honours students, and as a result, a more detailed understanding of the regolith landforms, distributions of materials and geochemistry was made possible (Lintern and Sheard, 1998, 1999a, b; Povey, 1999, van der Wielen, 1999; Lintern, 2004b). Several regolith landform maps were compiled for the area including 1:100,000, 1:50,000 (Craig and Wilford, 1997a, b; Wilford *et al*., 2001) and a 3 x 3 km 1:5,000 detailed map (Povey, 1999).

Figure 116: Lag distribution plan of Povey (1999) displaying a 3 x 3 km area centred on the Challenger Gold Deposit. The unconformity (as defined by drilling) is indicated by the thick black line. Lag distribution, via surface visual appraisal mapping, is coloured, while contours display laboratory work involving sample weights.

Lag dispersal away from the unconformity has been strongly influenced by the very low topographic relief. Two red areas, south of and well away from the unconformity, represent fluvially transported ferruginous granule lags derived from a ferruginous pisolith-rich duricrust (Craig and Wilford, 1997b; Povey, 1999; Wilford *et al*., 2001; Lintern, 2004b).



In situ Regolith

In situ regolith (weathered basement) occurs principally in the area central to the Challenger Au-in-calcrete anomaly displayed in Figure 113, where an outcrop-subcrop tongue (closing towards ~SW) of weathered *in situ* regolith is surrounded by transported regolith (sediments). That is, the major unconformity (transported on *in situ* regolith), as defined by drilling, could also roughly be defined at the surface by examining lag distributions and shallow soil pit profiles (Figure 116; Povey, 1999; Lintern, 2004b). Full-section regolith (Figure 117), constructed from re-logged exploration RAB drill cuttings, reveals moderately deep weathering in Christie Gneiss, yielding a generally pale coloured (typically yellowish and reddish) clay-rich saprolite. Its mineralogy is predominantly kaolinite, with less illite and smectite, plus residual quartz as grains and veins (Figure 118-120).

The lower regolith consists of either (i) mottled clay, overlying variably coloured clay (and partly ferruginous saprock fragments and/or corestones) with abundant quartz, grading to less weathered rock and abundant quartz with depth, or (ii) as above but with mottled clay absent. The boundary between highly weathered, mostly clay-rich saprolite, and moderately weathered saprolite-saprock containing appreciable quantities of saprock (partially weathered gneiss) is variable but lies between 20 to 40 m (Figure 118). Primary gneissic fabric is preserved within saprolite even to within <3 m of the surface (Figures 118G, H & 119) indicating that weathering has been essentially isovolumetric – at least below the silcrete horizon. Other relict minerals encountered within the weathering profile include occasional biotite (as inclusions within quartz) garnet and graphite (Figure 118, Plate 10).

The upper regolith (0-6 m) is more complex, consisting in the lower half (~6-3 m) of pallid saprolite overprinted and coloured by iron and manganese oxides and/or sesquioxides, while the upper half (~3-0 m) is pedolith. The upper few metres of pedolith is variably cemented by silica (silcrete ± hyaline opal ± potch opal), along with calcrete and gypsum (Figures 118, 121). Some pedogenic silcrete displays features consistent with surficial physical disruption and dislodgement, to form locally derived slope talus breccias and/or debris flow deposits (pedolith; Plates 11-13) later recemented by secondary or tertiary silica. These breccias can contain resistate mineral grains that have low to moderate rounding due to short distance transport; some clasts have been incorporated deeper into the profile via coeval surface shrinkage cracks. Any original ferruginous pedolith has been stripped from the outcropping relict profile (it was still within an erosional regime prior to mining) – possibly by similar processes that formed the talus breccias and now typically bearing potch opal blebs-lenses, fragments and veins (Lintern and Sheard, 1998, 1999b; Mason and Mason, 1998).

Calcrete

Calcrete in this area is highly variable and ranges from massive to laminar to nodular and to earthy types, where the more indurated forms occur on saprolite or within palaeochannel fluvial sands. At some locations laminar calcrete has a very complex internal structure and mineralogy (Plate 14). Calcrete cements have invaded 1-3 m into the upper regolith (Figure 121) to infill voids, fractures and commonly yielding a significant expansion of the profile – typically forming jig-saw-fit textures and complex profiles (Plate 13).

Transported Regolith

Transported regolith includes fluvial sediments in palaeochannels to the W and E of the mineralization (Figure 117, 122). Those sediments include clay ± silt ± sand in variable thicknesses and mixtures. The largest palaeochannel, west of the Deposit, in a northerly draining palaeovalley (infilled to >150 m) now supples the Challenger Mine and Processing Plant with groundwater. Upper portions of those sediments have been both silcreted and calcreted (Figure 121). Aeolian sand, as minor dunes (<2 m thick) and thin interdune sheet deposits, partly covered the area around the weathered *in situ* regolith outcrop. Nodular to earthy pedogenic calcrete was observed to occur in those sands at depths of 20-30 cm. Colluvium, including a variety of lags, forms a minor (<25 cm thick) transported component to this relatively flat landscape (Plate 15).

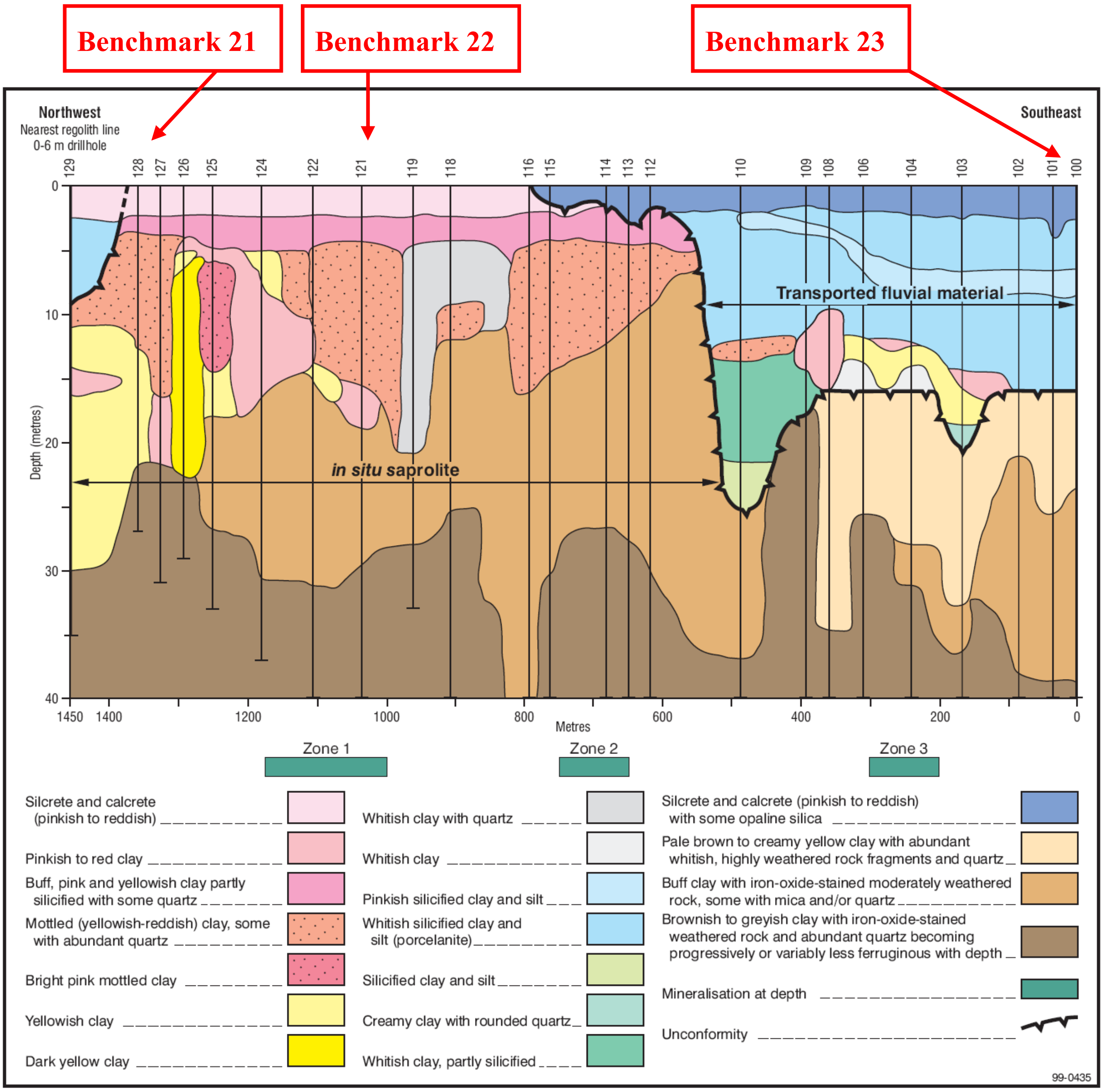


Figure 117: Regolith Line cross-section at Challenger, the position on Figure 113 is indicated with a grey line (Lintern and Sheard, 1999a). Benchmarks 21-23 locations are indicated. RAB drilling was carried out by the Gawler Joint Venture partners to define mineralization below the surficial Au-in-calcrete geochemical anomaly. Gold mineralized zones are marked by dark green horizontal bars below the x-section. Chiptray samples are lodged with PIRSA's Drillcore Storage Facility.

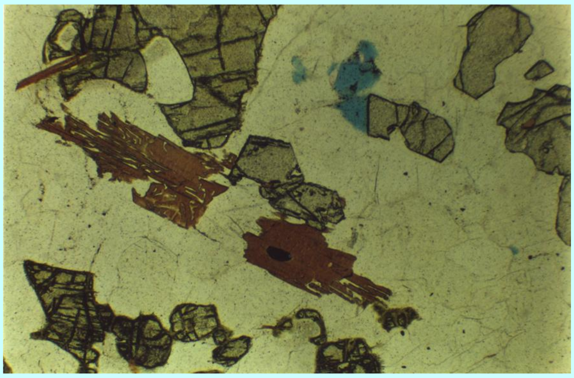
Regolith Exposure

An overview of the regolith profile, as exposed by mining within the main pit, is displayed in Figure 120 where regolith weathering zonation is also indicated. Subsequent mining has deepened the main pit to ~125 m below ground level, where an underground decline and stope mining operations have taken over. Due to the effects of continued mining and ongoing haulage ramp maintenance–use, the inclusion herein of Challenger Gold Mine's current pit faces as regolith benchmarks wasn't practical. However, the main pit wall exposures do provide an excellent regolith overview that can be safely observed from several surface vantage points and more closely by prior arrangement with the mine management. Those deep sections offer the best local 3D regolith exposures in this region, so typified by terrain of low relief with ubiquitous cover.

Explanations to Figure 118 on next page (petrography to segments of geotechnical drillhole 97CHDH1361-A).

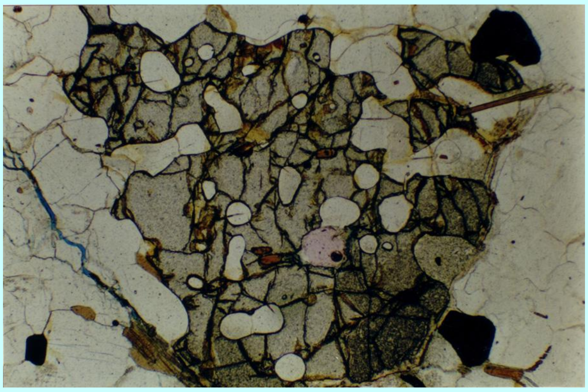
A: Christie Gneiss, bedrock (¼ HQ core) at 40.43-40.51 m, top is on LHS. A medium- to coarse-grained gneiss with rounded pink garnet aggregates scattered through a pale to medium grey crystalline matrix. Sample #: R367483.	**B:** Thin-section view (transmitted plane polarised light) of fresh felsic gneiss with biotite (brown), orthopyroxene (dull grey, cleaved, bottom & top left), garnet (high relief, uncleaved, top right), felsic minerals (plagioclase, K-feldspar & cordierite) and quartz. Field of view 1.5 x 2.5 mm. Sample #: R367483, thin-section #: C69890.
C: Christie Gneiss, saprock (½ HQ core) at 26.62-26.72 m, top is on LHS. Weathered medium-grained felsic crystalline rock with large spongy reddish garnet porphyroblasts (partly reddened by weathering) in a dull grey felsic matrix with tiny dark flecks (biotite). Scattered throughout are small pale cream alteration patches (clay after cordierite). Sample #: R367484.	**D:** Thin-section view (transmitted plane polarised light) of partly weathered gneiss. Thin trails of dark iron oxide (goethitic) have developed along micro-cracks in a large garnet poikiloblast (high relief, pale grey), other minerals remain fresh (except for complete alteration of cordierite and orthopyroxene, not shown). Field of view 1.5 x 2.5 mm. Sample #: R367484, thin-section #: C69891.
E: Christie Gneiss, lower saprolite (½ HQ core) at ~20 m, top is on LHS. Very weathered felsic crystalline rock in which abundant medium-grained felsic grains have suffered pervasive weathering to a cream colour with diffuse pale orange to pink ferruginous discolouration. Centimetre-sized mottle-like dark brown patches are irregularly scattered through the rock. Sample #: R367485.	**F:** Thin-section view (transmitted plane polarised light) of severely weathered gneiss. A large garnet poikiloblast has suffered complete replacement by goethite (dense dark red-brown) and clays (not readily seen at this magnification). Note the characteristically round shape of the unaltered quartz inclusions in the relict garnet poikiloblast site. *C.f.* with less weathered garnets shown above from fresher rock. Field of view 1.5 x 2.5 mm. Sample #: R367485, thin-section #: C69892.
G: Christie Gneiss, upper saprolite (¼ HQ core) at 4.77-4.85 m, top is on LHS. Extremely weathered felsic crystalline rock composed of fine-grained soft cream clay through which are scattered indistinct ovoid white patches. A precursor foliation is defined by relict translucent grey quartz grains, which tend to be aligned in thin quartz-rich lamina. Sample #: R367486.	**H:** Thin-section view (transmitted light, cross polarisers) of extremely weathered felsic gneiss as saprolite. Image reveals tiny biotite flakes (centre, bright colours) these are preserved as inclusions within relict quartz grains (white to grey). Elsewhere, kaolinite clay (dark) forms a microcrystalline massive replacement mat. Field of view 1.5 x 2.5 mm. Sample #: R367486, thin-section #: C69893.

A *(photo 45689)*.

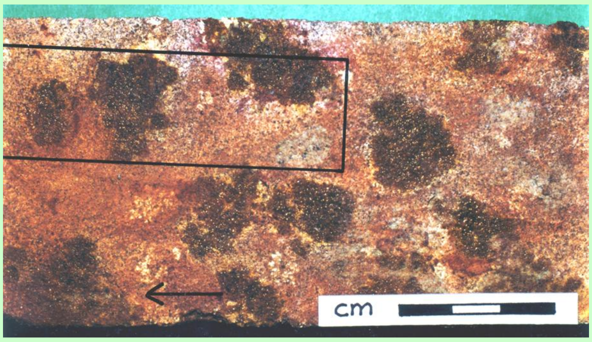


B *(photo 45889)*.

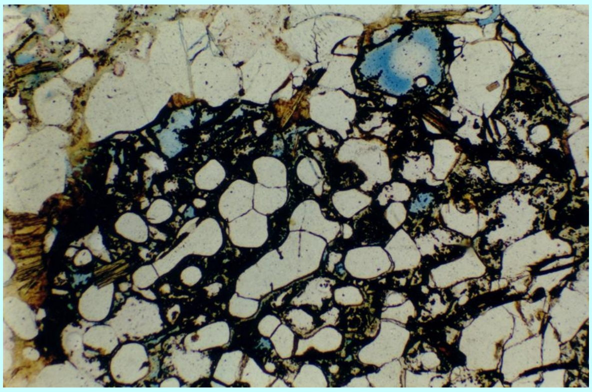
C *(photo 45690)*.



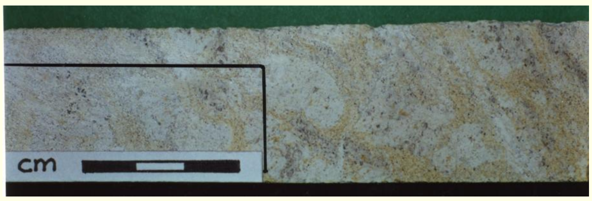
D *(photo 45890)*.



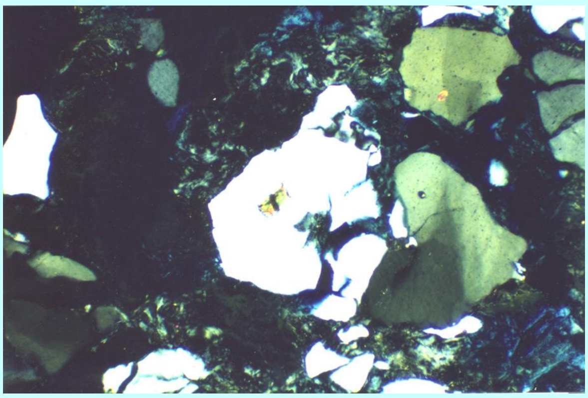
E *(photo 45691)*.



F *(photo 45891)*.

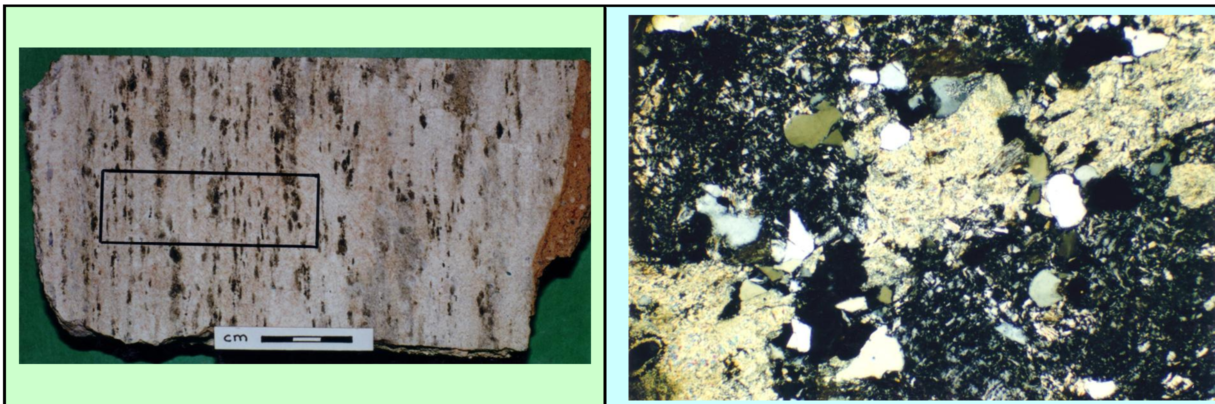


G *(photo 45694)*.



H *(photo 45892)*.

Figure 118: Major stages of profile weathering in strategic core segments from geotechnical drillhole 97CHDH1361-A (Zone 53, 365892E, 6694533N). LHS displays cut core faces and RHS displays thin-section photomicrographs. Simplified petrographic explanations are on the previous page (after Mason and Mason, 1998). Black rectangles marked on cut faces indicate thin-section placement.



A *(photo 45625)* **B** *(photo 45857)*

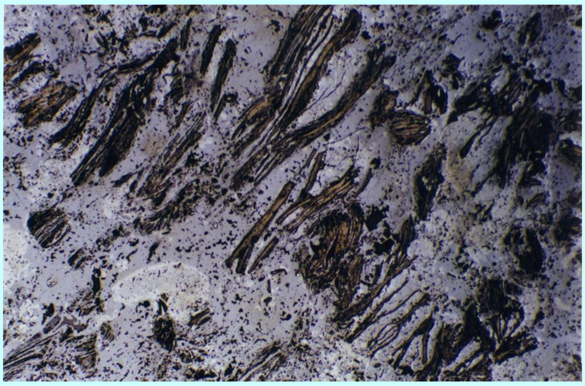
Figure 119: A grab sample extracted from Challenger Regolith Pit GCP 122 of Lintern and Sheard (1999b). Sample #: R214050, thin-section #: R214050.

A: Sawn face of pervasively altered clay-rich saprolite (after gneiss) is composed of abundant fine-grained massive white clay (mostly kaolinite) through which are distributed darker waxy greenish grey rods that define a strong lineation in the precursor metamorphic rock. Black rectangle, left of centre, indicates thin-section placement. Sample #: R214050.

B: Thin-section view (transmitted light, cross polarisers). Fine-grained massive sericite (larger pale yellow areas) has replaced a lineated aggregate (oriented NE-SW) of a metamorphic mineral (?cordierite). Fine-grained microcrystalline clay (kaolinite, dark grey) is abundant. Minor relict metamorphic quartz is preserved. Field of view 1.5 x 2.5 mm.

Plate 10: Challenger Gold Deposit regolith. Thin-section view (reflected plane polarised light) of silicified-ferruginous graphite-bearing saprolite (lag sample collected above mineralized zone 1). Imaged area: schistose rock with aligned flakes of relict metamorphic graphite (oriented NE-SW) that lie in a fine-grained matrix of goethite (medium grey). Field of view 1.5 x 2.5 mm (Lintern and Sheard, 1999b; Mason and Mason, 1998).

Sample #: R214180, thin-section #: R214180.



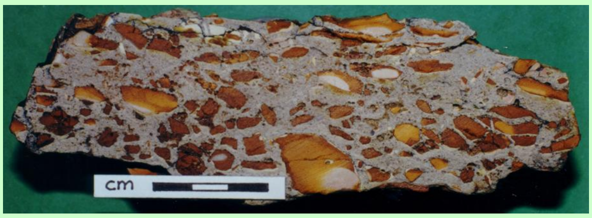
(photo 45878)

Plate 11: Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP 100 of Lintern and Sheard (1999b). A porcellanite-silcrete-ferruginous claycrete-breccia, cemented by later calcrete and minor hyaline silica. Large clasts are subangular to subrounded, are polymict and resemble a talus deposit.

Sample #: R367482.

(photo 45526)

Plate 12: Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP 100 of Lintern and Sheard (1999b). Brecciated porcellanite in a matrix supported framework of grey silcrete. Clasts are subangular-subrounded. Material resembles a debris flow deposit where the clay fines have later been totally replaced by silica. Sample #: R214153.



(photo 45521)

Plate 13: Challenger Gold Deposit, a slabbed sample from Regolith Pit GCP 106 of Lintern and Sheard (1999b). Brecciated porcelanite (+ grey potch opal cores) + kaolinite-rich saprolite in matrix supported framework of brown ferruginous calcrete + quartz grit. Subangular-subrounded clasts as an expanded talus deposit (original fines + voids have been totally replaced-infilled by iron sesquioxide stained calcrete). Sample #: R214137.

(photo 45556)

Plate 14: Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP 110 of Lintern and Sheard (1999b). Colourful, complexly laminated calcrete containing: ferruginous lithic fragments and/or cement (claycrete 20%, silcrete <1%) + quartz grains (5%) + calcrete cement (70%) + dolomite (<1%) + opaline silica (~2%) + remnant voids (~3%).
Sample #: R214109. *(photo 45566)*.

Plate 15: The initial 296 ppb Au calcrete sample site at the Challenger prospect (at the pink pin flag; after Edgecombe, 1997). Note the sparse low vegetation and abundant surface lag that includes calcrete, silcrete, siliceous-ferruginous saprolite, ferruginous granules and exotic rounded pebbles. *(photo 44292)*.

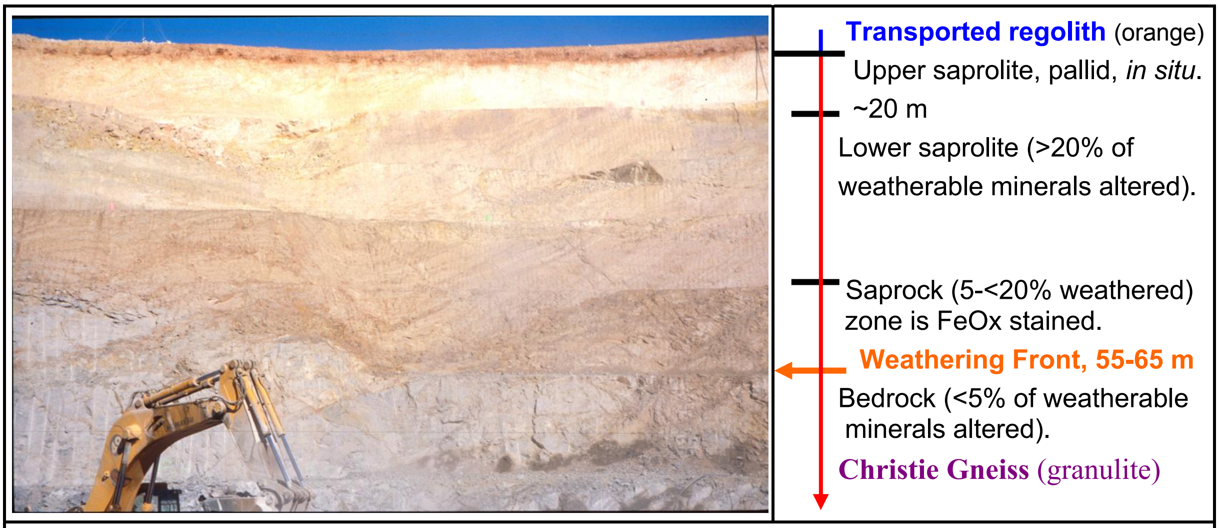


Figure 120: Challenger Gold Mine eastern face (main pit), as exposed in September 2003. Major regolith zones are indicated in the RHS column. Note the >10-20 m irregularities in the Weathering Front and the lower saprolite–saprock boundary. Pit base was at ~100 m below ground level at this stage of development. Ore loads plunge at ~ 30° to the LHS but never extended laterally into the eastern face portion imaged here.

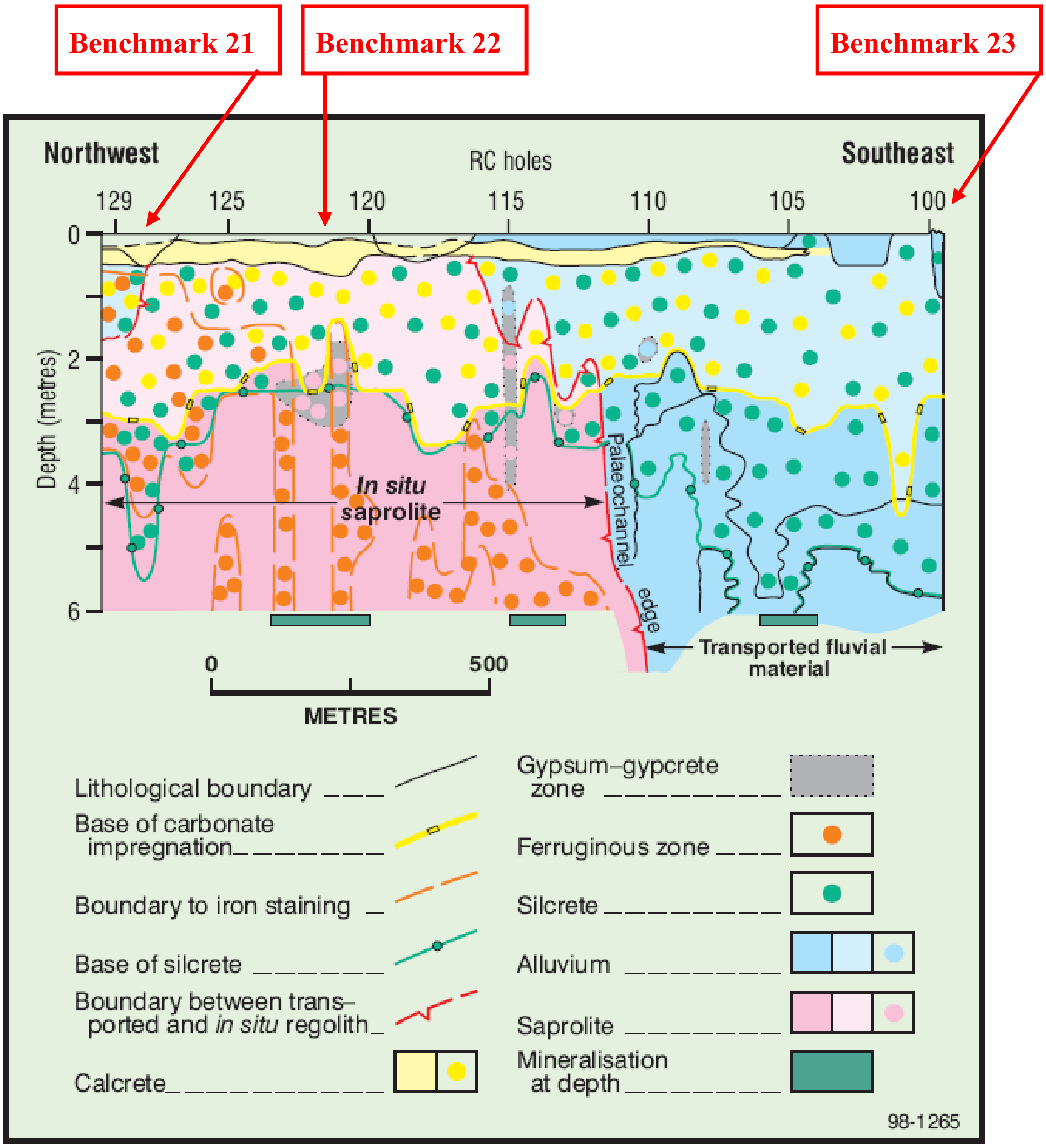


Figure 121: Section along the regolith line of Figure 117 but displaying only upper regolith (0-6 m) at Challenger. Section position is marked as the grey Regolith Line on Figure 113. RC drillholes used for this more detailed interpretation were placed as close as practical to existing company exploration drillholes along the same alignment. Benchmarks 21-23 are indicated. Pink colours represent weathered *in situ* regolith, blues represent transported regolith, separated by a red unconformity line (Lintern and Sheard, 1998). Significant overprinting by ferruginous + siliceous + calcareous + gypseous cements and duricrusts have complicated this near surface weathered profile. Deeper mineralized zones of significance are indicated by the grey horizontal bars immediately below the x-section. Chiptray samples to all 30 (0-6 m) drillholes are lodged with PIRSA's Drillcore Storage Facility.

b

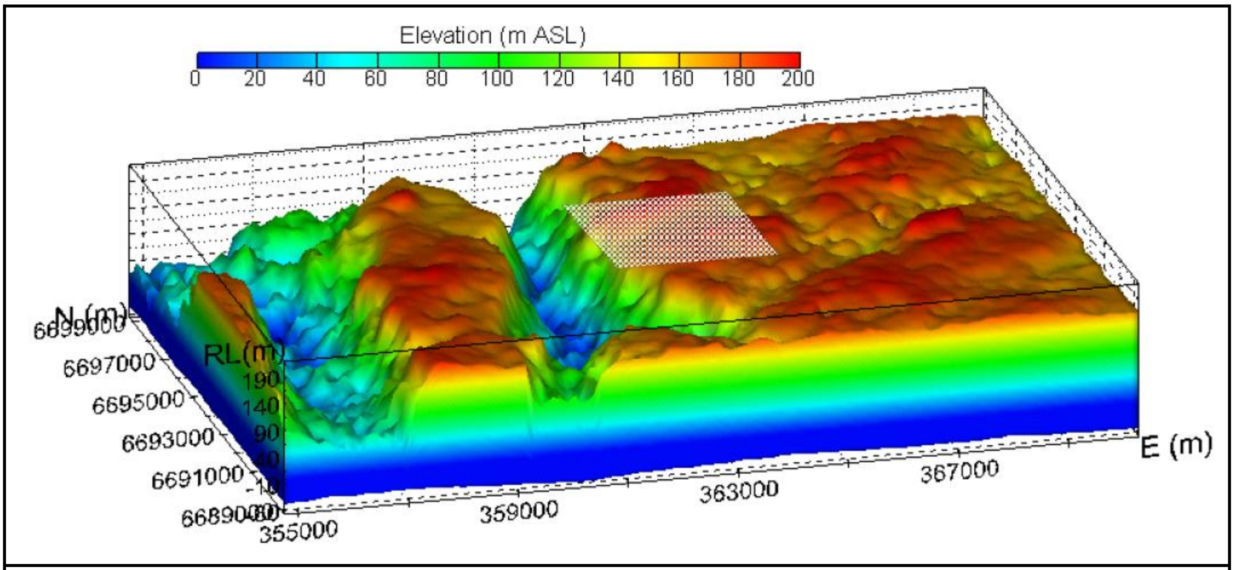


Figure 122: Elevation model of the AEM basal conductor surrounding the Challenger Gold Deposit. Hatched area indicates location of the lag distribution plan of Figure 116 (Lintern, 2004b). Note the two deep palaeovalleys to the west of the hatched area. Grid coordinates are in AGD84 projection.

Geochemical expression

Detailed geochemical analysis was carried out in 1997 by Lintern and Sheard (1999a, b) along a 1.6 km line encompassing both company exploration drillholes (0-<60 m) and purpose drilled RC holes (0-6 m). Subsequently, a series of eight ~12 x 6 x 3 m regolith pits were excavated, along the same alignment at strategic sites, to enable additional detailed regolith and geochemical examination. During 1999, 3D regolith and geochemical dispersion modelling was carried out by van der Wielen (1999) over a 3 x 3 km area, using available company exploration drill samples and assays, along with additional strategic assays. At the same time, and over the same 3 x 3 km area, a geochemical survey, using a 100 m sample grid, provided more detailed information on subtle differences in Au distribution for calcrete, soil and two forms of lag (Povey, 1999).

The Au in calcrete and soil showed similar distributions but soil Au concentrations were much lower. The calcrete data appear to indicate Zone 1 (see Figure 113) mineralization better than does soil data but this may also be a sampling artefact, where more calcrete samples were available. Some lag over mineralization was also anomalous. Geochemical data from the initial regolith investigations of Lintern and Sheard (1998, 1999b) are shown in Figure 123.

Gold concentrations in surficial calcrete reach a maximum of 2390 ppb over Zone 1; this particularly high concentration was due to coarse Au, derived from the subcropping gold-bearing quartz veins being incorporated into the calcrete. Anomalous values (>10 ppb) extend for about 500 m over Zone 1 mineralization, and about 200 m over Zone 2 (maximum of 52 ppb); but no Au or other pathfinder element anomalism was detected in surficial calcrete over the buried Zone 3 mineralization (Figure 113). For other elements, the response over Zone 1 was more subdued and erratic with As and Cu, and, possibly, Ce, Cr, Fe, K, Mg, Rb, S, Th, and V exhibiting one- or two-point anomalies. A response was not detected over Zone 2 mineralization except perhaps for Cu and Zn. Some smoothing of the data was achieved after normalising the chalcophile elements with respect to Fe.

Gold abundances in regolith and soil pit profiles are extremely variable but there appears to be a general association between Au and Ca (Figure 124). The highest Au concentration (~100 ppm) was recorded at 2.0 m in regolith pit GCP122, immediately over Zone 1, although the concomitant Au concentrations for the soil was only 250 ppb. For adjacent profiles from the same pit, located within 5 m of each other, the near surface sample concentrations of 35, 250, 380 and 900 ppb Au were recorded. These indicate the extreme variability close to mineralization where there is probably detrital Au present. The high Ca concentrations (15%) at the base of pit GCP122 is almost entirely due to the presence of gypsum; the Au concentration there is 760 ppb. Interestingly, Au concentrations in the order of 20-30 ppb in regolith pit GCP106 (within fluvial sediment over Zone 3 mineralization) are relatively higher than in the adjacent pits GCP110 and GCP100 (within fluvial sediment but no underlying mineralization) suggesting the possibility of Au enrichment related to mineralization further away (perhaps from upstream subcrop).

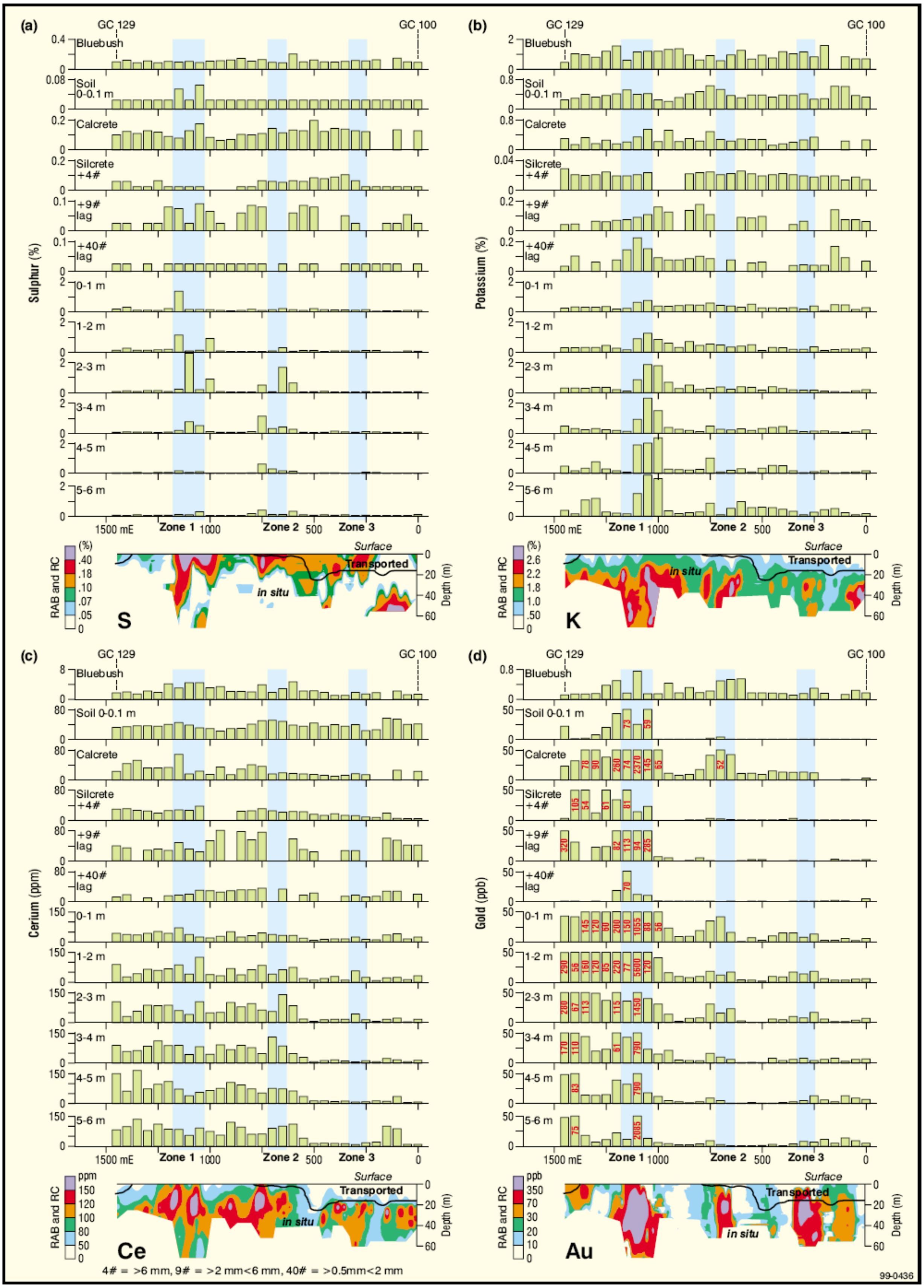


Figure 123: Elemental distribution plots for different regolith materials and 'Blue Bush' (*Maireana sedifolia*) as exemplified by: (a) S (%), (b) K (%), (c) Ce (ppm) and (d) Au (ppb). LHS of each profile is at the NW end of the NW-SE oriented Regolith Line on Figure 113 (Lintern and Sheard, 1999a).

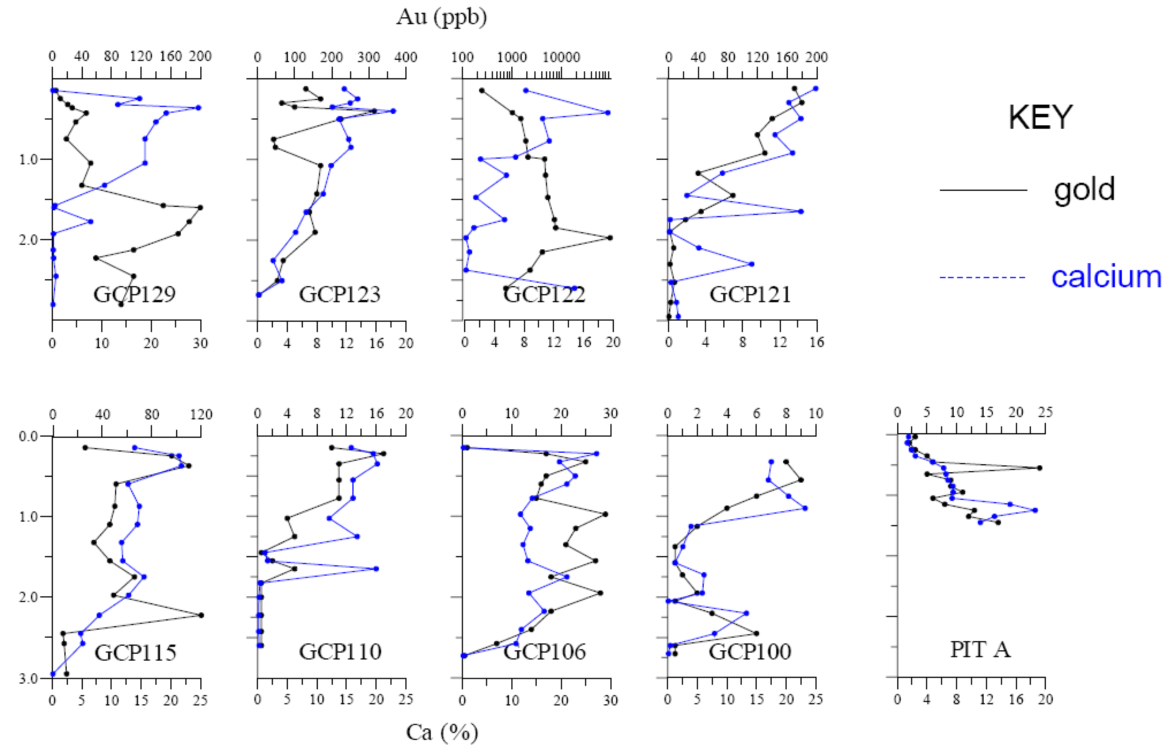


Figure 124: Concentration *vs* depth for Au and Ca within the Challenger regolith–soil pits of Lintern and Sheard (1999a, b; Lintern 2004b). All pits except Pit A are located along the Regolith Line indicated on Figure 113 and the pit numbers correspond to drillhole numbers displayed in Figure 123.

<u>Geochemistry in summary</u>: whereas it appears that near outcropping mineralization can be relatively easily detected using a variety of elements and sample media, the outlook for exploring in transported cover in the Challenger area is less certain. Further investigations would be required over Zone 3 mineralization, located under ~20 m of palaeovalley sediments, to test whether locally anomalous concentrations of Au, Bi, W, Mo and Fe normalised elements (*i.e.* Cu and As), detected in the upper regolith drill cuttings and in regolith pits GCP106, are related to underlying mineralization or some other factor.

Calcrete is ubiquitous and is recommended as the best sample medium for detecting Au mineralization in the weathered *in situ* regolith, providing broad high contrast anomalies for several elements, in particular, Au, and to a lesser extent, As and Cu.

The Challenger studies indicate that elements in the regolith, other than Au, associated with mineralization, fall into two broad groups: sulphide-related (Ag, As, Bi, Cd, Cr, Cu, Fe, Mo, S, Se, Zn and possibly W; and alteration-related (Ba, Cs, K, Rb, Tl). The specific use of these elements and others as pathfinders depends on sample medium to be used and the regolith setting. Elements that appeared to be present in anomalous concentrations in regolith materials, specifically over the three mineralized zones are summarised in Table 49.

<u>Challenger 3D modelling and geochemistry studies</u> incorporated surface and subsurface regolith detail extracted from company drill samples which were integrated with company logging and assay, and some new assays (van der Wielen, 1999; Lintern, 2004b). They have differentiated the following units: (i) transported overburden (thin hardpan overlying a silt horizon, commonly 10-20 m thick, with gravels at the base; (ii) residuum – highly to weakly weathered; (iii) rock, unweathered apart from limonite staining of cracks; and (iv) bedrock. Both Zone 1 (main Challenger ore lodes) and Zone 2 mineralization show Au depletion at the completely- to highly-weathered interface (Figure 125). At Zone 1 this depletion is incomplete and residual Au is maintained at the surface, albeit at lower concentrations; whereas at Zone 2 the depletion is complete (Lintern, 2004b). A significant proportion of the Au in Zone 1 is hosted within quartz veins (Poustie *et al.*, 2002, Poustie, 2006) and therefore has been substantially protected from weathering processes and metallic dissolution-remobilisation, this may account for the persistence of Au to surface as the residual <u>chimney effect</u> revealed in Figure 125.

Table 49: Anomalous concentrations of elements over the 3 zones of mineralization in different materials and vegetation at Challenger (from Lintern and Sheard, 1999b).

Regolith line component	Zone 1 (*in situ*)	Zone 2 (*in situ*)	Zone 3 (transported)
Lower regolith	**Au Ag As Bi Cd Cr Cs** Cu **K Mo** Rb S **Se Tl W** Zn	**Au Ag As Bi** Cd Cr Cu **K Mo Rb S Tl** Fe Zn	**Au** Ag **As** K Mo Rb W
Upper regolith (0–6 m)	**Au As** Bi Ba *Cd* **Cr** Cs **Cu Fe K Mo Rb S Se Tl** V Zn	**Au As Cr Cu Fe Mo S Se V** Zn	As* Cu* Mo W (possibly Au)
Silcrete	**Au** *As Ag* Bi Cd Tl *Th* Fe *W*	Au Cd **Cu**	
Calcrete	**Au As** Ba Cr Ce **Cu** Fe K Mg Rb S Th V	**Au** Cu Zn	
Ferricrete**	Au As Cr Cu Mo Se		
Lag	**Au As Cu K Na Rb W**	Bi Cu	
Soil	**Au** Ag As **Cu** Na *Mo* P S Se *W*	Au K Mo Na W	
Vegetation	**Au As** Cr **W**	**Au**	

Cu*, As* - anomalous once normalized with respect to Fe
Ferricrete** - not systematically collected since it does not comprise a major surface component.
Bold - strongly anomalous and/or showing more than a single peak maximum.
Italics - having a broad anomaly in the western end of the regolith line without being specifically associated with Zone 1 mineralization.
Underlined – element not associated with mineralization but, nevertheless, anomalous.

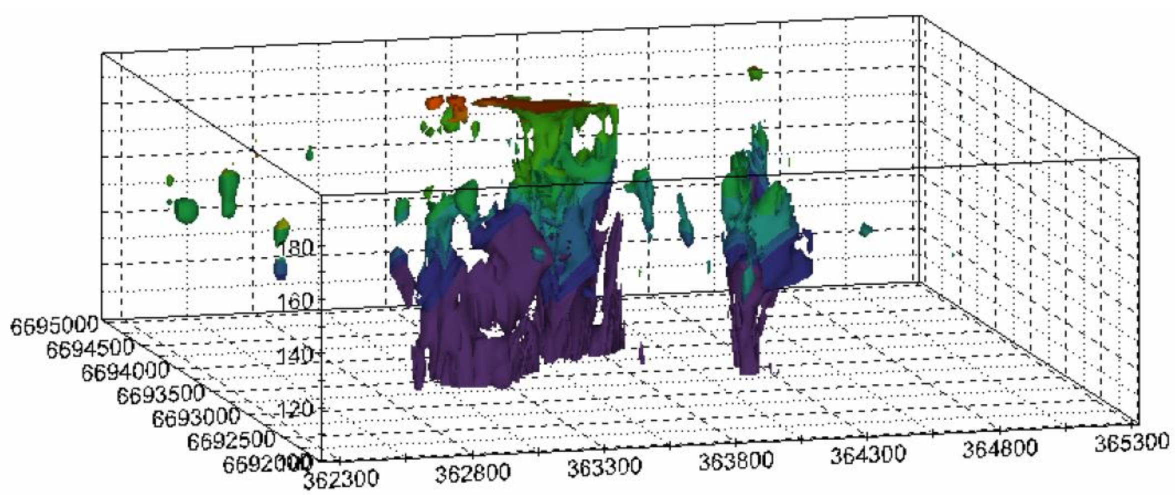


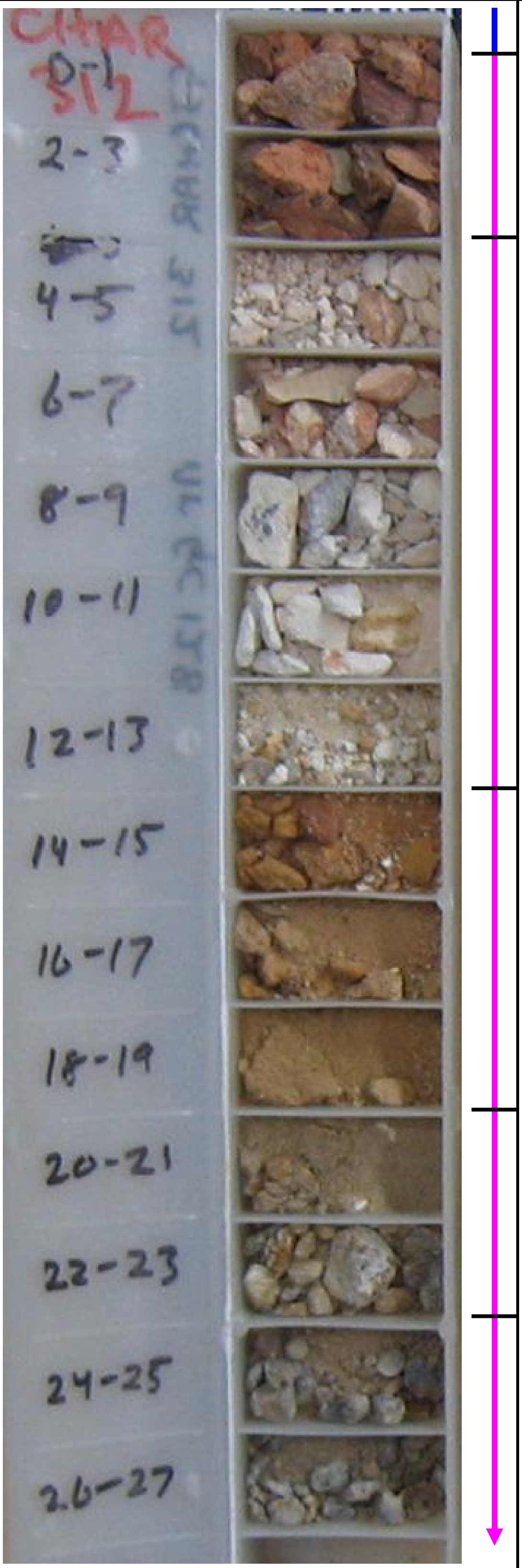
Figure 125: 3D modelling of Au distribution at Challenger using a 70 ppb cut off, showing the top of the supergene Au enrichment zone at the completely- to highly-weathered interface.
Key: purple = bedrock, blue = limonite stained bedrock, light blue = weakly weathered (saprock), aqua = moderately weathered (lower saprolite), dark green = highly weathered (upper saprolite), green = completely weathered (pallid saprolite), yellow/orange/red = transported units (after Lintern, 2004b). Grid coordinates are in AGD84 projection.

Benchmark 21 composite: drillholes 95CHAR312 + GC128

Quick reference items are set out in Table 50; detailed descriptions, figures and data tables follow on below. Sites were about one kilometre N from the original unsealed road between Commonwealth Hill to Mobella Pastoral Station Homesteads (Figures 110-113). Drilling for these holes was vertical, of RAB and RC type, and to the west of the established gold lodes mineralization. A summary of these profiles is provided in Figure 126, Plate 16 and Table 51. Geochemical data are presented in Figures 123-125, 127 plus Table 49.

Table 50: Benchmark 21 reference data; composite of drillholes 95CHAR312 & GC128 (Type 2, drill cuttings profiles).

Items	Figures, Data, Sources
Regional location map	Figures 110-111.
Local-site location map	Figure 113.
GPS coordinates, attitude & elevation	• RAB drillhole 95CHAR312: Zone 53, 363335 E, 6694008 N, GDA 94. Vertical. **AHD:** ~200 m (estimated from map data). • RC drillhole GC128: Zone 53, 363371 E, 6694003 N, GDA 94. Vertical. . **AHD:** ~200 m (estimated from map data).
Site access, owner	About 1 km N of the track between Commonwealth Hill and Mobella Pastoral Station Homesteads, on E end of Mobella Pastoral Lease. Site Lease holders: Mobella Pastoral Station & Dominion Mining NL.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photos + logs	Yes, Figure 126, Plate 16 and Table 51.
Sample types	Drill chips, chiptrays & ~1 kg bags for RC drillhole GC128.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	No.
Geochemistry	Yes, Figures 123-125, 127 and Table 49.
XRD mineralogy	No.
PIMA spectral data	Not for this drillhole but many others have data available (van der Wielen, 1999). Analytical Spectral Detection (ASD, an advanced PIMA) was carried out on all available drilled samples within ~2 km radius of the Challenger Mine in 2003; however, that data remains restricted access (Gray & Lintern, 2004; Lintern, 2004b; Figure 125).
Dating	Yes, for Christie Gneiss bedrock, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	Complex & sample media dependent, refer to Table 49.
Useful sampling media	Calcrete, soil, vegetation, silcrete.
Key reference sources	Lintern and Sheard (1999a, b); Lintern and Sheard (1998); Povey (1999); van der Wielen (1999); Poustie *et al.* (2002); Lintern (2004b); Poustie (2006); Edgecombe (1997).



0-2 m Soil not recovered (**minor transported**). Pink to orange massive-laminar calcrete entrapping lithic grit, + also present are lags + ***in situ*** silicified saprolite + ferruginous saprolite + red to brown ?mottled saprolite.

2-3 m silicified upper saprolite, pale greenish grey + grey vein quartz + fracture in-fill calcrete (pale pink).

4-13 m upper saprolite, pallid, kaolinite-rich + grey quartz grit + bluish grey vein quartz.

13-19 m lower saprolite, pate yellow-brown, clay-rich with scattered brown FeOH cemented segregations + grey quartz grit.

19-23 m lower saprolite, grey-brown to greyish olive-brown, clayey with relict harder material + grey quartz grit.

23-<27 m lower saprolite to saprock, grey-brown to greyish olive-brown, clays + relict less weathered foliated rock + grey vein quartz.

>27 m saprock, greyish olive-brown, clay + relict partially weathered foliated rock + grey vein quartz, more competent than above interval.

EOH Regolith logged by M.J. Sheard

Figure 126: Benchmark 21 chiptray photo and regolith log to RAB drillhole 95CHAR312. Drilling depth was <28 m and terminated in saprock near its upper boundary with lower saprolite.

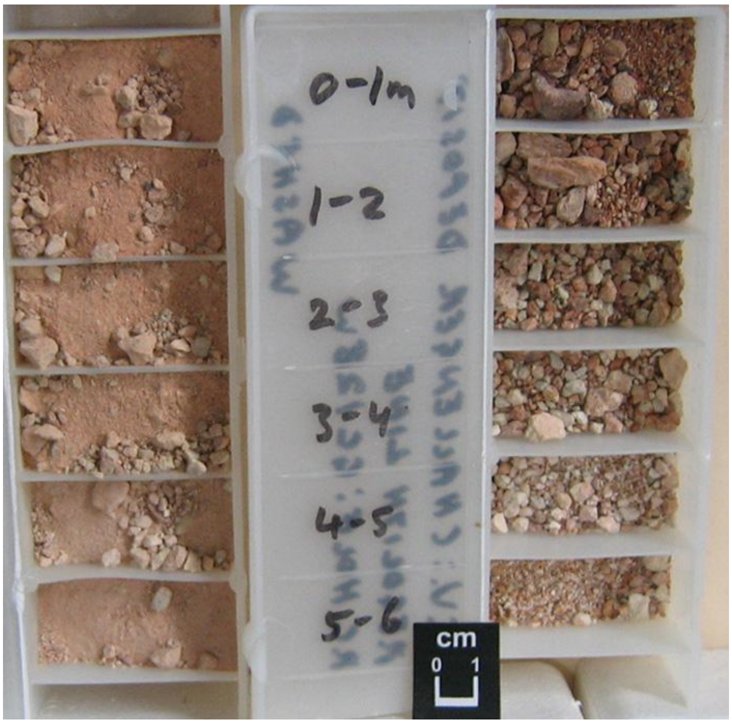


Plate 16: Benchmark 21 composite (continued), chiptray samples to RC drillhole GC128 (0-6 m).

LHS displays unprocessed samples.

RHS displays washed samples, where clay and silt have been removed. Granular residue becomes less abundant with depth below 3 m.

Sample interval was one metre.

See Table 51 for log.

Background

Drillholes 95CHAR312 and GC128 have been selected to form this composite benchmark because their adjacent sites are away from the major Au mineralization, these sites have minimal transported cover and the weathered *in situ* regolith is relatively straight forward regarding its interpretation. Comparisons are provided through composite Benchmarks 22 and 23. From mid 2002 all of these sites were rehabilitated or covered by the Challenger Gold Mine developments, Processing Plant and associated facilities. The initial phase of exploration grid drilling at Challenger during 1995 involved RAB methods (mostly without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore those drillholes typically end in saprock or lower saprolite rather than within bedrock (fresh gneiss). Cuttings were sampled either on alternate metre intervals or as 2 m composites (not ideal for regolith investigations). Later drilling phases employed hammer assisted RAB and/or RC, and targeted diamond coring methods to obtain better sample control and bedrock structural representation.

The initial phase of exploration grid drilling at Challenger during 1995 involved RAB methods (mostly without hammer) and therefore drillholes commonly terminated at or near blade refusal. Therefore those drillholes typically end in saprock or lower saprolite rather than within fresh gneiss. Cuttings were sampled either on alternate metre intervals or as 2 m composites (not ideal for regolith investigations). Later drilling phases employed hammer assisted RAB and/or RC, and targeted diamond coring methods to obtain better sample control, geotechnical appraisal of weathered rock competency, and bedrock structural representation.

Table 51: Benchmark 21 composite (continued) regolith log to RC drillhole GC128 (Lintern and Sheard, 1999b).

Drillhole: GC128, Reverse Circulation, vertical.
Location: Zone 53, 363371 E, 6694003 N, GDA 94
Site: W. side of *Mt Challenger* on E. side of low reddish dune with quite a lot of gibber deriving from *Mt Challenger.*
Vegetation: Acacia-dominated open woodland.
Soil: sand, moderate reddish brown (wet) (10R 4/5).
Calcrete: nodular aggregates to platy to massive on silcrete, at ~25-50 cm.
Logged by: M.J. Sheard.

Sample #	Depth	Description
GC128A	0-1 m	UNWASHED: light red - brown (dry) crushed calcrete (cream – white, dry) and silcrete fragments, sandy and gravelly, strong carbonate acid reaction; texture – sand and rock fragments, brownish orange (wet, 5YR 5/7). WASHED: orange stained frosted quartz sand (fine-medium) ~10%, calcrete ~50% – pale and red-brown to reddish and cream, silcrete 30% – greys, browns and reds, some potch opal and porcelanitic forms – all with quartz fragments within – some of these contain black grain inclusions, quartz ~10% - bluish-grey-milky (<1 to 3 mm). Saprolitic.
GC128B	1-2 m	UNWASHED: orange brown (d) as above; texture – rock fragments and fines, brownish orange (w) (5YR 5/7). WASHED: as above.
GC128C	2-3 m	UNWASHED: pale orange (d) as per 1-2 m; texture – rock fragments and fines, light brown (w) (7.5YR 5/6). WASHED: as above, with more silicified kaolinitic relict gneiss, grey and pale brown hyaline silica chips common, Mn oxide as dendrites, coatings and inclusions.
GC128D	3-4 m	UNWASHED: as per 2-3m, moderate carbonate acid response; texture – rock fragments and fines, light brown (w) (7.5YR 6/5). WASHED: as per 2-3 m.
GC128E	4-5 m	UNWASHED: pale yellow brown (d), clayey sand, silicified claystone fragments, moderate carbonate acid reaction; texture – clayey grit, light brown (w) (7.5YR 5.5/5). WASHED: mostly pale coloured and cream silicified kaolinitic relict gneiss, white to cream hyaline silica coatings and chips, quartz as above. Saprolite.
GC128F	5-6 m	UNWASHED: pale pink brown (d) sandy loam with claystone fragments as per 4-5 m, moderate to weak acid response; texture – clayey grit, light brown (w) (7.5YR 6/4). WASHED: much less grainy matter, silicified saprolite as above with some pink and yellowish Fe-staining and coatings. Saprolite.

In situ Regolith

Bedrock (fresh Christie Gneiss, <5% weathered) was not penetrated in drillhole 95CHAR312 and the Weathering Front is presumed to be below ~35 m (Figure 126) based on evidence from adjacent drillholes. Examples of Christie Gneiss bedrock are provided earlier (Plate 9, Figure 118).

Saprock (>5-<20% weathered) was only just penetrated, near its upper boundary with lower saprolite. Here all biotite is altering to chlorite; pyroxene and amphiboles are partially altering to clay ± goethite ± chlorite; while feldspars and cordierite are partly altering to clay and sericite. Saprock at this site is moderately competent and may display considerable yellowing or brown staining by FeOH distributed along fractures and intergrain boundaries. Clays are present within altering minerals and/or as fracture infill.

Lower saprolite (>20% weathered) is characterised by a reduced competency + yellow-brown colours overprinting greys and olive-greys; clay is commonly more abundant; FeOH segregations and/or cementation is present; abundant quartz grit and vein quartz are also evident.

Upper saprolite (>50% weathered) is typically strongly leached, exhibits either pallid or subdued hues and is generally chalky (kaolinite-rich + quartz grit; low competency material). This sub-zone may also exhibit FeOx/FeOH mottling or staining in a variety of colours (red-brown-yellow) and the relict quartz (grit + veins) is more visually obvious (Lintern and Sheard, 1999b).

Regolith drillhole GC128 (drilled with RC method) provides more detailed information on the 0-6 m interval within upper saprolite. Sampling involved 1 m composites that were logged in both the raw and washed states (Plate 16, Table 51). This 6 m interval is complex due to an advanced state of *in situ* weathering and the intensity of overprinting by siliceous, calcareous and ferruginous cements to form a significantly indurated duricrust (~3-5 m thick: silcrete + calcrete). Some profile collapse, repeated erosive episodes and the incorporation of surface lags and/or finer sediments into the upper 1-3 m profile, have combined to further complicate near surface regolith. Any original ferruginous pedolith (± Fe-pisolith horizon) was stripped prior to silcrete duricrust development. Some evidence for it once having been present was observed at nearby and more distal sites (transported Fe-pisoliths, Fe-pisoliths incorporated into silcreted sediments; Craig and Wilford, 1997b; Mason and Mason, 1998; Lintern and Sheard, 1999b; van der Wielen, 1999; Wilford *et al*., 2001). Exactly how much of the upper saprolite has been eroded away or reduced by fines removal is not clear but it may include ~3-5 m of section. Calcrete forms a massive to laminar coating (~20-150 mm thick, very indurated) on the silcrete duricrust at the soil-rock or sand-rock interface, but it also invades the silcrete along fractures and partings where it has gradually jacked apart the silcrete to form a jig-saw-fit assemblage.

Transported Regolith

Transported regolith was relatively thin (~1 m), consisting of orange aeolian dune sand (30-<50 cm; edge of a low dune), mostly loose and free running, quartz dominant, containing nodular to earthy calcrete in mid profile. Underlying the sand was a thin wedge (<50 cm thick) of fluvial sediment, thickening to the NW towards drillhole GC129 and regolith pit GCP129 (refer to detail in Figure 6 of Lintern and Sheard, 1999b). Calcrete, silcrete (including hyaline and potch opal) and FeOH have overprinted this sediment wedge and partially disguised the underlying unconformity. Some colluvium is included within the silcrete horizon (pedolith including: slope talus, ± debris flows, ± short transport distance sediment, ± pedogenic brecciation).

Geochemistry

Detailed geochemical analysis of the 0-6 m samples using a 50 element assay package is available in Lintern and Sheard (1999b). An extract of that work is provided below. Down profile elemental abundance plots are set out in Figure 127. Gold is present within the <1 m of transported sediment at 40-60 ppb but Au and Ca aren't particularly well associated here nor at depth, suggesting that Au is not related to calcrete presence or absence. Neither is Au particularly associated with As, Bi, Fe or Mn, indicating that Au may be dominantly in a micro-nuggetty form (peak abundance 110 ppb Au at ~3.5-4 m) and either within quartz veins (weathering-alteration protection) or shedding there from. It is worth noting though, that this site was well away from the recognised main Au mineralization. High S within the upper 3 m is most likely entirely due to the presence of gypsum. A more general account of the broader geochemistry is provided earlier in the Challenger Gold Deposit summary under Geochemistry and includes Figures 123-125 plus Table 49.

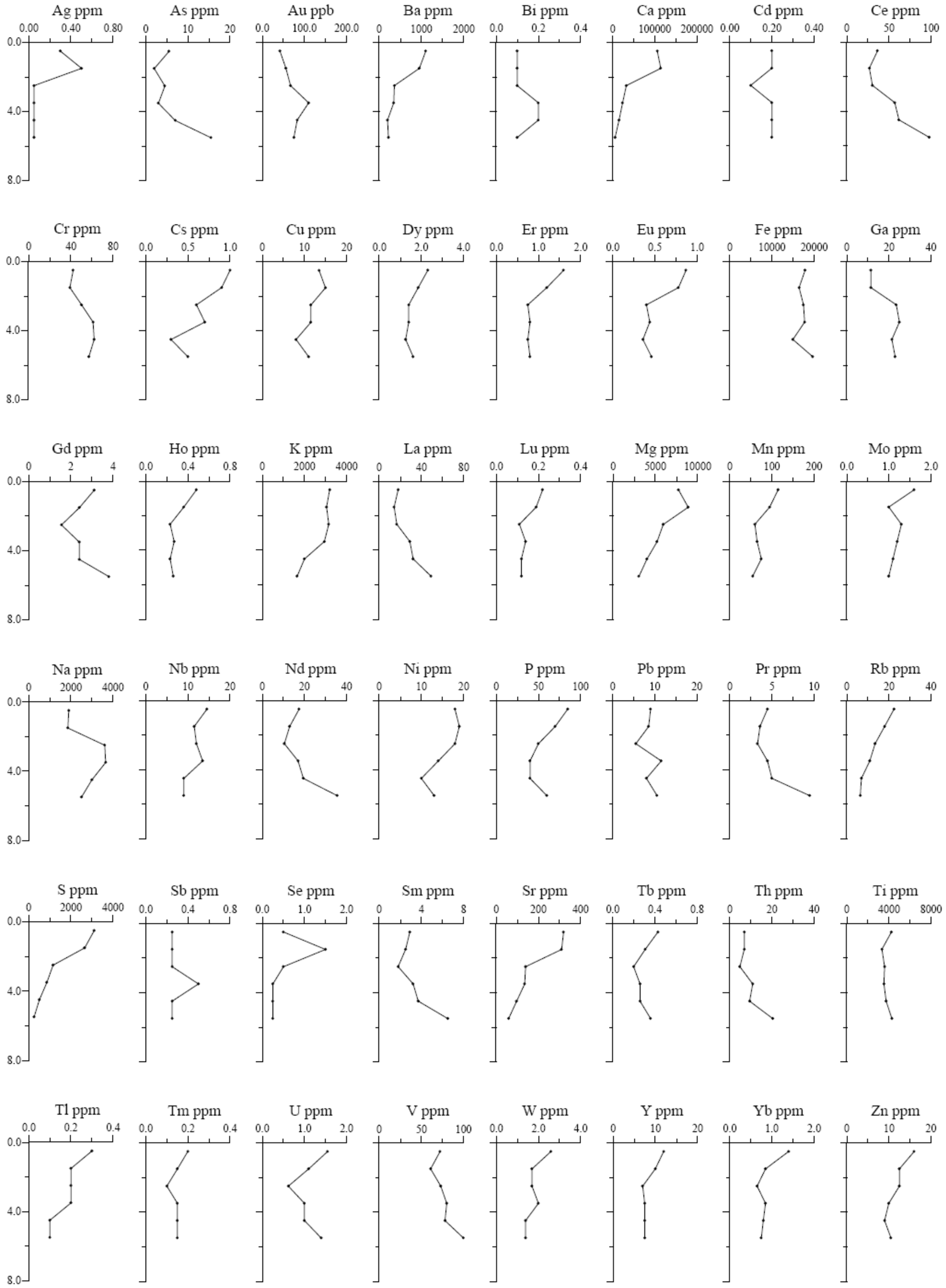


Figure 127: Elemental abundances *vs* depth (m) for Benchmark 21, RC drillhole GC128, Challenger Gold Deposit (Lintern and Sheard, 1999b).

Benchmark 22 (composite): drillholes 95CHAR115 + GC121 + regolith pit GCP121

Quick reference items are set out in Table 52; detailed descriptions, figures and data tables follow on below. Sites were about one kilometre N from the original unsealed road between Commonwealth Hill to Mobella Pastoral Station Homesteads Figures 110-113. Drilling for these holes was vertical, of RAB and RC type, and immediately over the established gold lodes mineralization. A summary of these profiles is provided in Figure 128, Plates 17-23 and Tables 53, 54. Geochemical data are presented in Figures 123-125, 130, 131 plus Table 49.

Table 52: Benchmark 22 reference data; composite of drillholes 95CHAR115 & GC 121 (Type 2, drill cuttings profiles) + regolith pit GCP121 (Type 3, excavation).

Items	Figures, Data, Sources
Regional location map	Figures 110-112.
Local-site location map	Figure 113.
GPS coordinates, attitude & elevation.	• RAB drillhole 95CHAR115: Zone 53, 363622 E, 6693740 N, GDA 94. Vertical. **AHD:** ~208 m (estimated from map data). • RC drillhole GC121: Zone 53, 363619 E, 6693752 N, GDA 94. Vertical. **AHD:** ~208 m (estimated from map data). • Regolith pit GCP121: Zone 53, 363619 E, 6693752 N, GDA 94
Site access, owner	About 1 km N of the track between Commonwealth Hill and Mobella Pastoral Station Homesteads, on E end of Mobella Pastoral Lease. Site Lease holders: Mobella Pastoral Station & Dominion Mining NL.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill / Pit sample photos + logs	Yes, Figures 128, 129, Plates 17-23 and Tables 53, 54.
Sample types	Drill chips, chiptrays & ~1 kg bags for RC drillhole GC121, ~1 kg bags and numerous 0.5->5 kg blocks for Regolith Pit GCP121.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Yes, for regolith pit samples, Plates 22, 23. See also Challenger Regolith section above, Figure 118, and Mason and Mason (1998).
Geochemistry	Yes, Figures 123-125, 130, 131 and Table 49.
XRD mineralogy	No.
PIMA spectral data	Not for this drillhole but many others have data available (van der Wielen, 1999). Analytical Spectral Detection (ASD, an advanced PIMA) was carried out on all available drilled samples within ~3 km radius of the Challenger Mine in 2003; however, that data remains restricted access (Gray & Lintern, 2004; Lintern, 2004b; Figure 125).
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	Complex & sample media dependent, refer to Table 49.
Useful sampling media	Calcrete, soil, vegetation, silcrete.
Key reference sources	Lintern and Sheard (1999a, b); Lintern and Sheard (1998); Povey (1999); van der Wielen (1999); Poustie *et al*. (2002); Lintern (2004b); Poustie (2006); Edgecombe (1997).

0-1 m *In situ* cream to pink-orange massive-laminar calcrete entrapping lithic grit, + *in situ* grey vein quartz + silicified saprolite (pallid).

1-3 m silicified upper saprolite, pink + minor calcrete + pallid saprolite.

3-17 m upper saprolite, pallid, kaolinite-rich + grey quartz grit + grey vein quartz + yellow-brown FeOH mottling and staining (4-5 m).

17-30 m lower saprolite, pate yellow-brown to yellow-brown, clay-rich + dark yellow-brown FeOH cemented segregations + grey quartz grit + some bluish grey vein quartz.

30-39 m lower saprolite to saprock, pale yellow-brown to reddish grey to grey, clayey + abundant grey and bluish grey vein quartz.

39-48 m saprock, greyish, partially weathered gneiss + abundant grey vein quartz, more competent than above interval, weathering becomes less with depth.

EOH

Regolith logged by M.J. Sheard

Figure 128: Benchmark 22 chiptray photo and regolith log to RAB drillhole 95CHAR115. Drilling depth was to 48 m but chiptray samples stop at 39 m (in saprock).

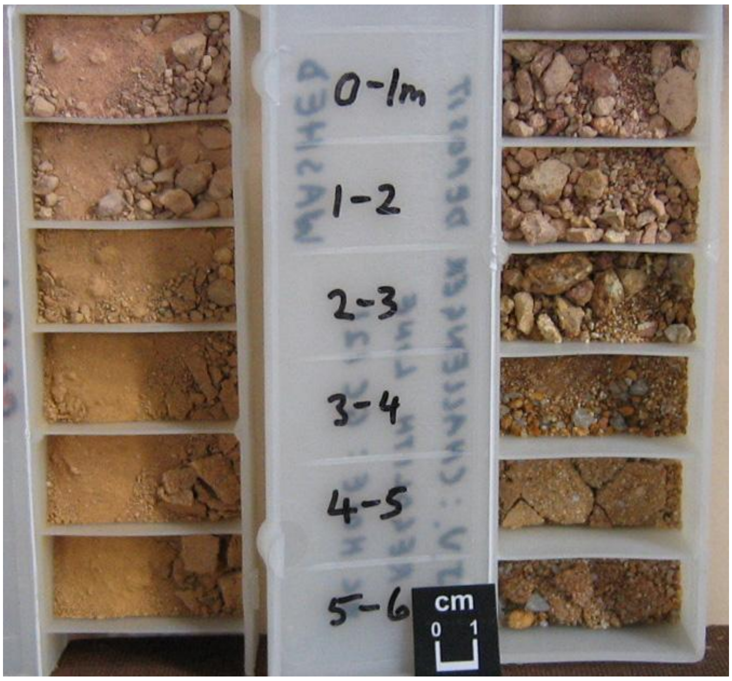


Plate 17: Benchmark 22 composite (continued), chiptray samples to RC drillhole GC121 (0-6 m).

LHS displays unprocessed samples.

LHS displays washed samples, where clay and silt have been removed. Granular residue becomes less abundant with depth below 3 m.

Sample interval was one metre.

See Table 53 for log.

Background

Drillholes 95CHAR115 and GC121 and regolith Pit GCP121 have been selected to form this composite benchmark because their adjacent sites overlie the major Au mineralization. These sites have very little transported cover and the weathered *in situ* regolith is relatively straight forward regarding its interpretation. Comparisons are provided through composite Benchmarks 21 and 23. From mid 2002 all of these sites were rehabilitated or covered by the Challenger Gold Mine developments, Processing Plant and associated facilities. The initial phase of exploration grid drilling at Challenger during 1995 involved RAB methods (mostly without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore those drillholes typically end in saprock or lower saprolite rather than within bedrock (fresh gneiss). Cuttings were sampled either on alternate metre intervals or as 2 m composites (not ideal for regolith investigations). Later drilling phases employed hammer assisted RAB and/or RC, and targeted diamond coring methods to obtain better sample control and bedrock structural representation.

Excavation of eight strategically sited pits (12 x 6 x 3 m) cut using explosives and a bulldozer, into the indurated upper regolith provided ready access for detailed sampling (assay, petrology, XRD, PIMA, etc) and offered a valuable 3D exposure of regolith development and irregularities.

Table 53: Benchmark 22 composite (continued) regolith log to RC drillhole GC121 (Lintern and Sheard, 1999b).

Drillhole: GC121, Reverse Circulation, vertical.
Location: Zone 53, 363619 E, 6693752 N, GDA 94
Site: Lower eastern flank of *Mt Challenger*, flat sandy site with scattered small gibber of exotics, silcrete and quartz. Gravel – pebbles, reddish sand.
Vegetation: shrubland.
Soil: sandy loam, light brown (wet) (5YR 6/6).
Calcrete: massive to laminar, at ~15-20 cm.
Logged by: M.J. Sheard.

Sample #	Depth	Description
GC121A	0-1 m	UNWASHED: dark pink (dry) sand, calcrete plate fragments, strong carbonate acid reaction; texture – sand and rock fragments, strong brown (wet) (7.5YR 4/6). WASHED: creamy grey and brown platy calcrete fragments enclosing grey-milky-bluish angular quartz fragments with chlorite inclusions, reddish and grey silcrete enclosing white quartz grains, loose quartz grains – angular to subrounded – similar to the cemented grains, rare rounded black Fe oxide granules. Saprolitic.
GC121B	1-2 m	UNWASHED: yellow (d) sand and rock fragments, many calcrete fragments, strong carbonate acid reaction; texture – rock fragments and fines, light brown (w) (7.5YR 5/6). WASHED: as above, with no Fe granules, more quartz fragments – clear and grey.
GC121C	2-3 m	UNWASHED: strong yellow (d) rock chips and fines, many grey shale and quartzite fragments with ferruginous nodules, no carbonate acid reaction; texture - rock fragments and fines, strong yellowish brown (w) (10YR 5/8). WASHED: yellow-brown to brown calcrete fragments (5%), yellowish brown - yellowish grey silcrete fragments (~60%), conspicuous angular quartz fragments and grains (1-5 mm) - grey-clear-milky and mostly bluish – some to 10 mm, some quartz with black equant grain inclusions <0.1 mm (?magnetite or ilmenite). Saprolitic.
GC121D	3-4 m	UNWASHED: pale yellow (d) clay with some fragments of yellow and cream shale siltstone, weak carbonate acid reaction; texture - gritty light clay, light yellowish brown (w) (10YR 6/6). WASHED: small quantity of grainy matter, small (<2 mm) fragments of silcrete as per 2-3 m, abundant quartz – angular fragments – cream-milky-grey-bluish, bluish quartz with black equant grain inclusions <0.1 mm (?magnetite or ilmenite), kaolinite grains and fragments. Saprolitic.
GC121E	4-5 m	UNWASHED: yellow (d) clay, small shale and quartz fragments, no carbonate acid reaction; texture – gritty light clay, moderate orange yellow (w) (7.5YR 6.5/8). WASHED: quartz sand (fine-coarse) as above, mostly sub-mm grit, bluish quartz fragments 1-3 mm. Saprolitic.
GC121F	5-6 m	UNWASHED: yellow (d) clay, yellow, grey and white shale fragments and thin quartz vein fragments, no carbonate acid reaction; texture – light clay, dark orange yellow (w) (10YR 6/8). WASHED: as per 4-5 m, with higher % of coarse bluish grit, ~30% of washed sample is yellowish Fe-stained psammite and claystone. Saprolitic.

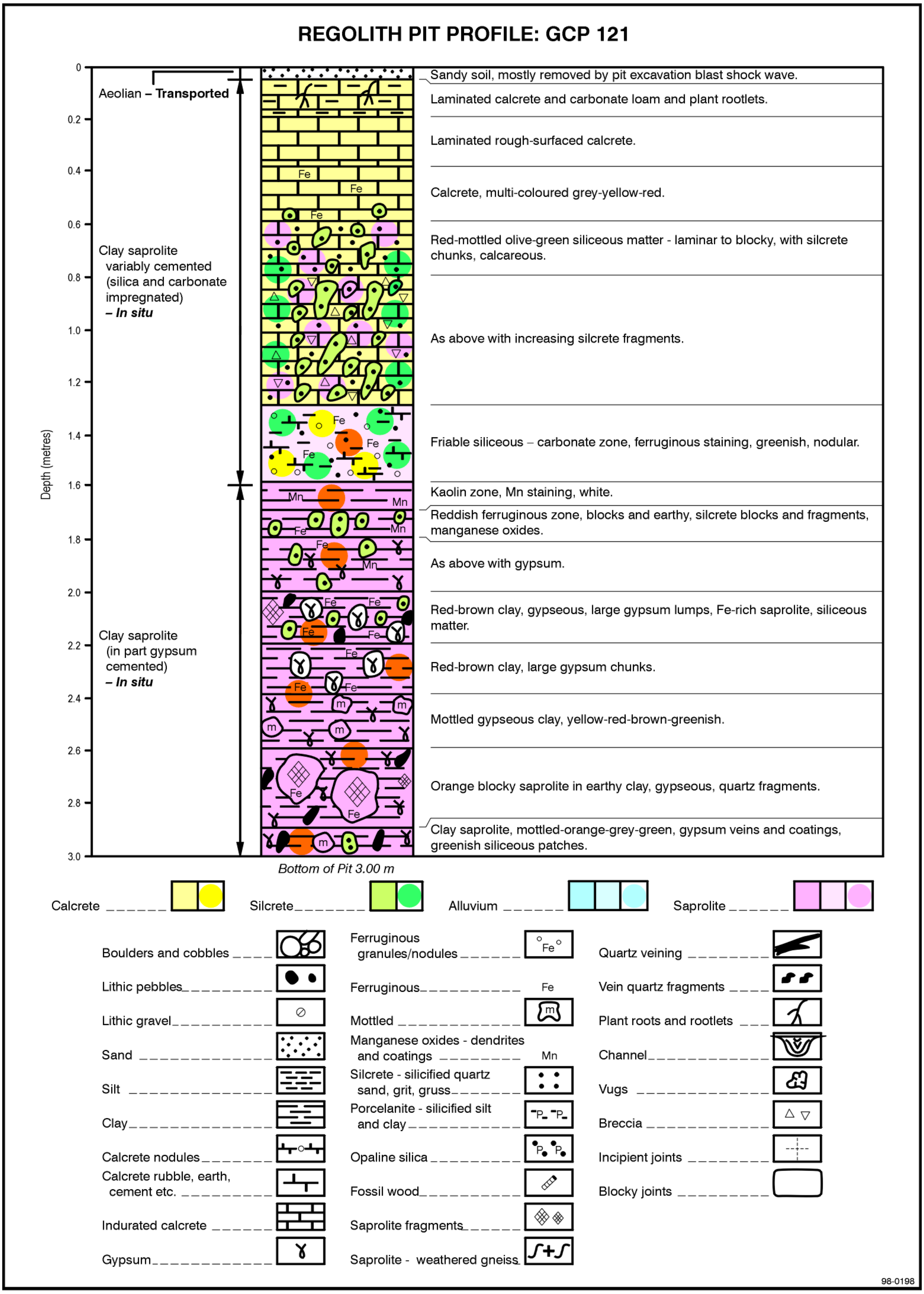


Figure 129: Benchmark 22 continued, composite profile to Challenger regolith pit GCP121 (Lintern and Sheard, 1999b). Data from laboratory, microscope and in-field logging are included.

Table 54: Benchmark 22 composite (continued) regolith profile in-field log, sampling points and sample numbers to excavation GCP121 (pit size 12 x 6 x 3 m).

Pit: GCP121	Profile of SE face, centre (Excavated by blasting and bulldozing).
Location	Zone 53, 363619 E, 6693752 N, GDA 94. Nearest Regolith RC Hole: GC121.
Site	Eastern side of a vegetation denuded area E of *Mt Challenger;* flat sandy (reddish) with scattered small gibber (gravel to pebbles) of exotic lithic, silcrete and quartz clasts. Sandy soil removed by pit excavation blasting and exploration vehicular traffic.
Logged by:	M.J. Sheard (PIRSA) & M.J. Lintern (CSIRO-E&M).
Photographic images (PIRSA).	(45481 to 45484, 45599, 45865) Plates 18-23.

Sample #	Depth (cm)	Description
GCP121-1	5-20	Laminar calcrete with fine plant rootlets and calcareous loam. Sample: R214071.
GCP121-2	20-40	Laminar calcrete – rough surfaced. Sample: R214072.
GCP121-3	40-60	Calcrete – greys, zone is multi-coloured in pastel shades of red and yellow. Sample: R214073.
GCP121-4	60-80	Red-mottled olive-green laminar to blocky material, calcareous, with silcrete chunks. Sample: R214074.
GCP121-5	80-105	As per 60-80 cm. Sample: R214075.
GCP121-6	105-130	As per 60-80 cm. Sample: R214076.
GCP121-7	130-160	Friable siliceous and calcareous zone with greenish colour and Fe-staining and nodules of unknown mineral within. Sample: R214077.
GCP121-8	160-170	White zone – marker band right around pit, possibly kaolinite, some Mn oxide staining. Sample: R214078.
GCP121-9	170-180	Reddish FeOx zone below white zone, blocks of earthy material, olive silcrete and blocky to platy mineral with Mn oxide coatings. Sample: R214079.
GCP121-10	180-200	As above with gypsum. Sample: R214080.
GCP121-11	200-220	Gypsum pieces up to 10 cm in a red-brown clay, Fe-rich saprolite and nodules, lumps of siliceous matter. Sample: R214081.
GCP121-12	220-240	Gypseous chunks in a red-brown clay. Sample: R214082.
GCP121-13	240-260	Mottled gypseous yellow clay, mottling - red-brown and greenish. Sample: R214083.
GCP121-14	260-290	Clay saprolite, gypseous and intensely mottled – orange and grey-green, gypsum fine to medium well crystallised coatings and veins, siliceous patches – greenish. Sample: R214084.
GCP121-15	290-300	Orange saprolite with greenish grey blotches, gypseous, quartz, clay, Ferruginous earthy material surrounding blocks, small crystals of dark red vitreous mineral (?rutile). Sample: R214085.

	
Plate 18: Pit GCP121, wide angle view, SE face with logged and sampled profile marked by measuring tape (Lintern and Sheard, 1999b). *(photo 45481)*.	**Plate 19:** Pit GCP121, SE face, top metre (red mark at 1 m) with central logged and sampled profile marked by measuring tape (Lintern and Sheard, 1999b). *(photo 45482)*.

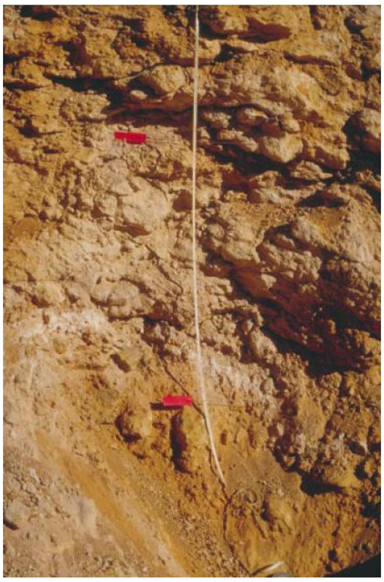
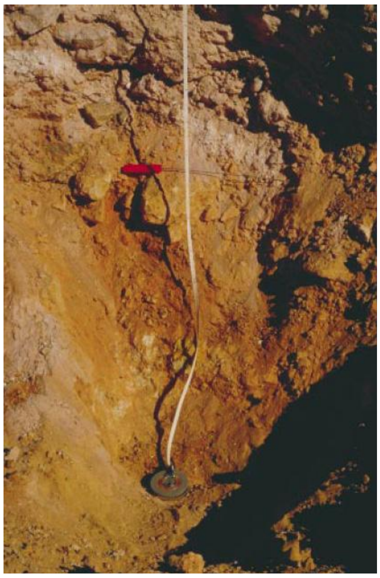

	

Plate 20: Pit GCP121, SE face, ~1-2 m (red marks at 1 and 2 m) with central logged and sampled profile marked by measuring tape (Lintern and Sheard, 1999b). *(photo 45483)*.	**Plate 21:** Pit GCP121, SE face, ~2.5-3 m (red marks at 2 m) with central logged and sampled profile marked by measuring tape (Lintern and Sheard, 1999b). *(photo 45484)*.

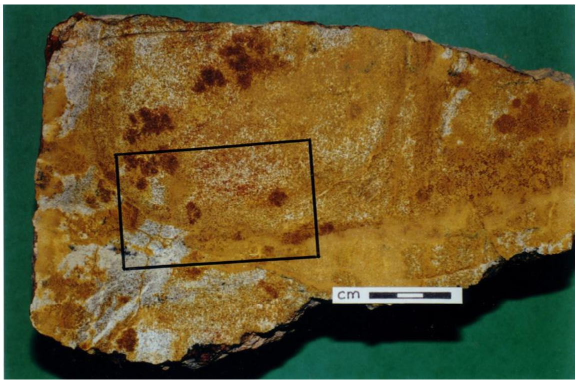
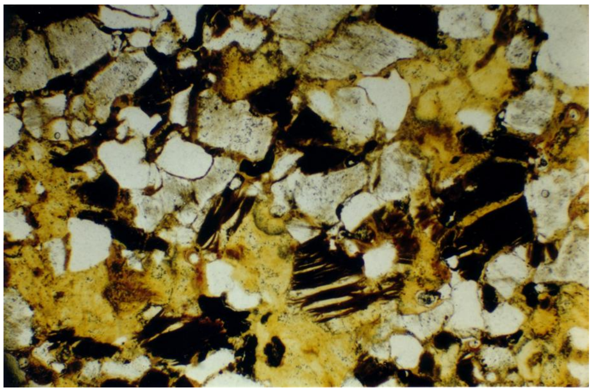

	

Plate 22: Pit GCP121, saprolite from 1.7-1.8 m, fine pallid kaolinite with ovoid and diffuse yellow-brown to dark brown ferruginous patches. Black rectangle marks location of thin-section in Plate 23 opposite. Sample R214079. *(photo 45599)*.	**Plate 23:** Pit GCP121, sample R214079, in transmitted plane polarised light. Saprolite with relict metamorphic quartz (colourless), K-feldspar (colourless, slightly turbid & cleaved), + alteration clay (pale yellow) and goethite (dark brown after altered biotite flakes. View 1.5 x 2.5 mm (Mason and Mason, 1998). *(photo 45865)*.

In situ Regolith

Bedrock (fresh Christie Gneiss, <5% weathered) was not penetrated in drillhole 95CHAR115 and the Weathering Front is presumed to be below ~50 m based on evidence from adjacent drillholes. Examples of Christie Gneiss bedrock are provided earlier (Plate 9, Figure 118) from a cored geotechnical drillhole located reasonably close to this site.

Saprock (>5-<20% weathered) was penetrated but its lower boundary was not encountered. All biotite is altering to chlorite; pyroxene and amphiboles are partially altering to clay ± goethite ± chlorite ; while feldspars and cordierite are partially altering to clay and sericite. Saprock at this site is moderately competent and may display considerable yellowing or brown staining by FeOH distributed along fractures and intergrain boundaries. Clays are present within altering minerals and/or as fracture infill (Figure 128).

Lower saprolite (>20% weathered) is characterised by a reduced competency + yellow-brown colours; clay is commonly more abundant; dark yellow-brown FeOH segregations and/or cementation is present; quartz grit and some vein quartz also occur (Figure 128).

Upper saprolite (>50% weathered) is typically strongly leached, exhibits either pallid or subdued hues and is generally chalky (kaolinite-rich + quartz grit; low competency material). This sub-zone may also exhibit FeOx/FeOH mottling or staining in a variety of colours (red-brown-yellow) and the relict quartz (grit + veins) is more visually obvious (Lintern and Sheard, 1999b) (Figures 128, 129; Plate 17, Tables 53, 54).

Regolith drillhole GC121 (drilled with RC method) and pit excavation GCP121 provide far more detailed information on the 0-6 m and 0-3 m intervals (respectively) within upper saprolite. Drill sampling involved 1 m composites that were logged in both the raw and washed states (Plate 17, Table 53); while the pit sampling involved bulks and blocks (at 10-30 cm intervals) removed from one or more selected vertical profiles (Plates 18-23, Figure 129, Table 54). The 6 m drilled interval is complex due to an advanced state of *in situ* weathering and the intensity of overprinting by siliceous, calcareous and ferruginous cements that form a significantly indurated duricrust (~2-3 m thick: calcrete + silcrete overlying gypsum). Excavation GCP121 provided further detail in 3D that drill cuttings cannot and allowed the collection of bulk samples for petrography and more detailed assay. Relict metamorphic fabric is retained in upper saprolite even to within <2 m of the surface (Plates 22, 23, Figure 119). Some profile collapse, repeated erosive episodes and the incorporation of surface lags and/or finer sediments into the upper 1-3 m profile, have combined to further complicate near surface regolith. Any original *in situ* developed ferruginous pedolith (± Fe-pisolith horizon) was stripped prior to silcrete duricrust development. Some evidence for it once having been present was observed as ferruginous granules within the calcrete capping (lags) and at nearby to more distal sites (transported Fe-pisoliths, Fe-pisoliths incorporated into silcreted sediments; Craig and Wilford, 1997b; Mason and Mason, 1998; Lintern and Sheard, 1999b; van der Wielen, 1999; Wilford *et al*., 2001). Exactly how much of the upper saprolite has been eroded away or reduced by fines removal is not clear but it may include ~3->5 m of section. Calcrete forms a massive to laminar coating (~20-150 mm thick, very indurated) on the silcrete duricrust at the soil-rock interface, but it also invades the silcrete along fractures and partings where it has gradually jacked apart the silcrete to form a jig-saw-fit assemblage.

Transported Regolith

Transported regolith was very thin (<0.1 m), consisting of an eroding-deflating soil that included quartz dominant aeolian dune sand as a major component. Over grazing by animals plus the vehicle traffic associated with exploration work around this site, where thin soil overlay hard rock, have exacerbated soil erosion locally. The remnant soil and the underlying massive calcrete both contained lags of small ferruginous granules, larger silcrete clasts (ferruginous and grey billy types) and well rounded exotic clasts (Lintern and Sheard, 1999b). Some colluvium is included within the silcrete horizon (pedolith including: slope talus, ± debris flows, ± short transport distance sediment, ± pedogenic brecciation).

Geochemistry

Detailed geochemical analysis of the 0-6 m samples using a 50 element assay package is available in Lintern and Sheard (1999b). An extract of that work is provided below. Down profile elemental abundance plots are set out in Figures 130, 131. Gold is present throughout the upper ~3 m regolith (180-<5 ppb), where Au and Ca abundances are synchronously varying, suggesting that Au is associated with calcrete (see Figure 124 and compare results across all pits). However, Au only appears to be loosely associated with As, Bi, Fe and Mn, indicating that some Au may be in a micro-nuggetty form while the remainder is in a more soluble form. High S within the upper 3 m is most likely entirely due to the presence of gypsum, which here and in adjacent pits seems more likely to have derived from the *in situ* weathering of sulphides (Lintern *et al*., 2006). A general account of the broader geochemistry is provided earlier in the Challenger Gold Deposit summary under Geochemistry and includes Figures 123-124 plus Table 49.

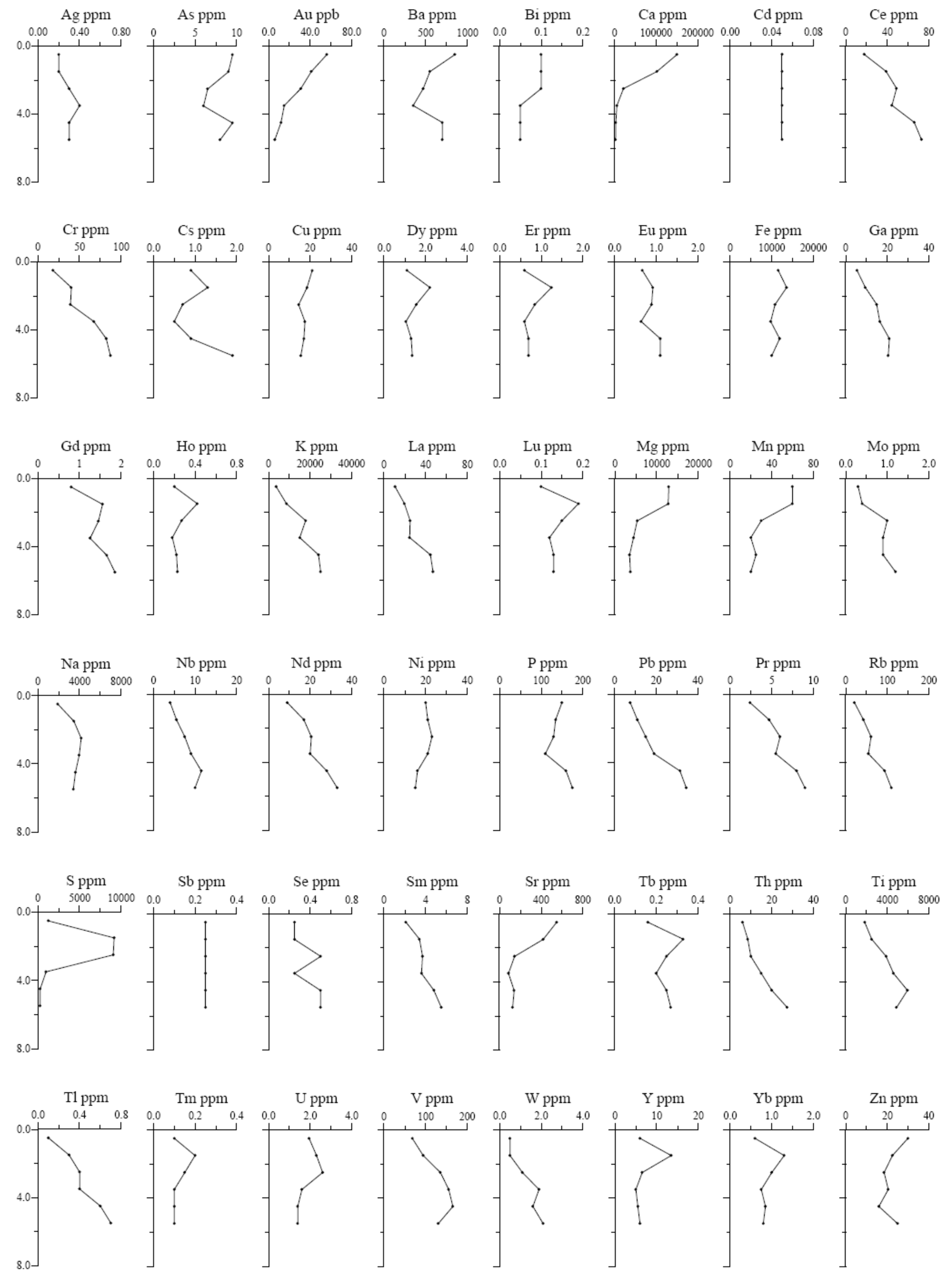


Figure 130: Elemental abundances *vs* depth (m) for Benchmark 22, RC drillhole GC121, Challenger Gold Deposit (Lintern and Sheard, 1999b).

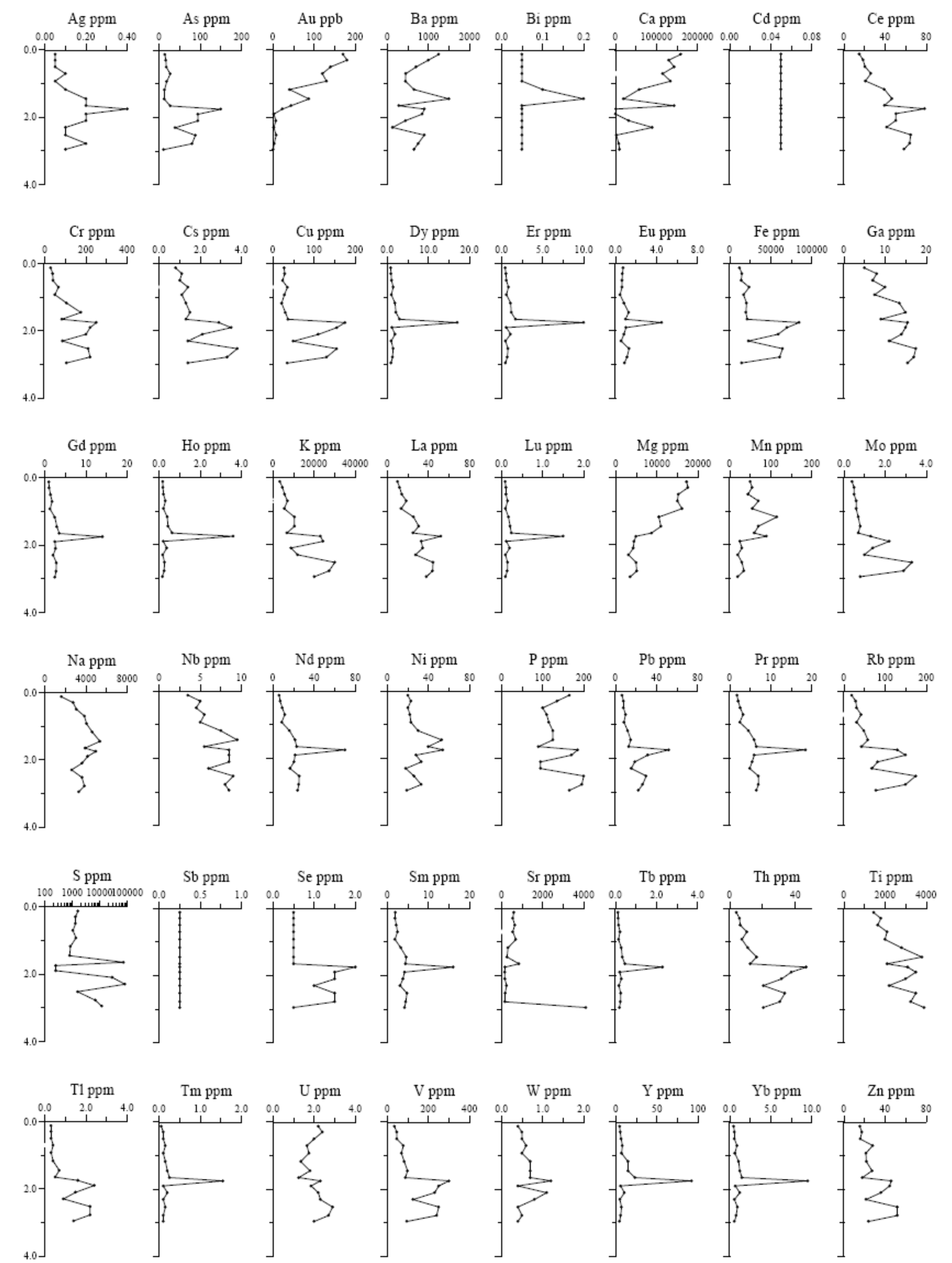


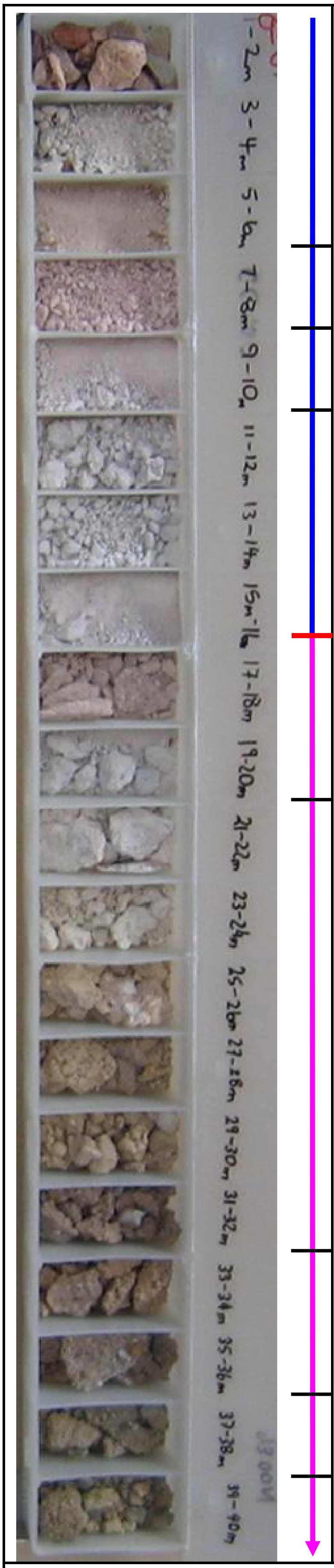
Figure 131: Elemental distributions *vs* depth (m) for Benchmark 22, Regolith Pit GCP121, Challenger Gold Deposit (Lintern and Sheard, 1999b). There is a strong correlation between Fe and numerous other elements (e.g. Bi, Cr, Cs, Cu, Mo, Nd, Pb, Sm, Th, Tl, V, Y, Zn & some REE) at ~1.7 m. An iron-rich halo surrounds weathered mineralization in the upper saprolite and is intersected at this depth, it is likely that this Fe (goethite ± hematite) may have scavenged other metallic ions (*c.f.* Figure 121. This effect is not seen at Benchmarks 21 or 23.

Benchmark 23 (composite): drillholes 95CHAR558 + GC100 + regolith pit GCP100

Quick reference items are set out in Table 55; detailed descriptions, figures and data tables follow on below. Sites were about one kilometre N from the original unsealed road between Commonwealth Hill to Mobella Pastoral Station Homesteads (Figures 110-113). Drilling for these holes was vertical, of RAB and RC type, they are to the E of the established gold lodes mineralization and intersected ~15 m of transported cover. A summary of these profiles is provided in Tables 56, 57 and chiptray photographs are in Figure 132 and Plates 24-33. Geochemical data are presented in Figures 123-125, 134, 135.

Table 55: Benchmark 23 reference data; composite of drillholes 95CHAR558 & GC100 (Type 2, drill cuttings profiles) + regolith pit GCP100 (Type 3, excavation).

Items	Figures, Data, Sources
Regional location map	Figures 110-112.
Local-site location map	Figure 113.
GPS coordinates, attitude & elevation.	• RAB drillhole 95CHAR558: Zone 53, 364342 E, 6693024 N, GDA 94. Vertical. AHD: ~200 m (estimated from map data). • RC drillhole GC100: Zone 53, 364315 E, 6693033 N, GDA 94. Vertical. AHD: ~200 m (estimated from map data). • Regolith pit GCP100: Zone 53, 364315 E, 6693033 N, GDA 94
Site access, owner	About 1 km N of the track between Commonwealth Hill and Mobella Pastoral Station Homesteads, on E end of Mobella Pastoral Lease. Site Lease holders: Mobella Pastoral Station & Dominion Mining NL.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photos + logs	Yes, Figures 132, 133, Plates 24-33 and Tables 56, 57.
Sample types	Drill chips, chiptrays & ~1 kg bags for RC drillhole GC100, ~1 kg bags and numerous 0.5->5 kg blocks for Regolith Pit GCP100.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Yes, for regolith pit samples, Plates 30-33, Table 57. See also Challenger Regolith section above, Figure 118, and Mason and Mason (1998).
Geochemistry	Yes, Figures 134, 135 and Table 49.
XRD mineralogy	No.
PIMA spectral data	Not for this drillhole but many others have data available (van der Wielen, 1999). Analytical Spectral Detection (ASD, an advanced PIMA) was carried out on all available drilled samples within ~3 km radius of the Challenger Mine in 2003; however, that data remains restricted access (Gray & Lintern, 2004; Lintern, 2004b; Figure 125).
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002). Regolith date: petrified wood in palaeochannel fluvial sediment, latest Eocene to latest Miocene (Rowett, 1997).
Target elements	Au.
Potential Pathfinder Elements	Complex & sample media dependent, refer to Table 49.
Useful sampling media	Calcrete, soil, vegetation, silcrete.
Key reference sources	Lintern and Sheard (1999a, b); Lintern and Sheard (1998); Povey (1999); van der Wielen (1999); Poustie *et al*. (2002); Lintern (2004b); Poustie (2006); Edgecombe (1997).



0-2 m	**Transported:** No soil recovery, silicified fluvial sands (grey billy silcrete, cream, & porous red FeOx-stained form) sand is poorly sorted quartz, angular-rounded, fine- to medium-grained. No calcrete recovered / noted.
2-6 m	silicified fluvial sand (grey billy silcrete, grey & cream) sand is poorly sorted quartz, angular-rounded, fine- to medium-grained. Porcelanite (cream, grey & yellowish) + yellow potch opal also present.
6-8 m	Pink uniform clay to claystone, fluvial deposit.
8-10 m	Pallid uniform clay to claystone, fluvial deposit.
10-15 m	Fluvial sand, fine- to medium-grained quartz + fines (clay + silt) poorly sorted, may be bedded.
15-16 m	Fluvial sand and gravel, fine- to medium-grained quartz sand + fine-grained gravel (includes <3% lithics as gneiss & multi-grained metamorphic quartz aggregates) poorly sorted + ~40% fines (clay, silt + fine quartz grit). Channel basal sand-gravel. **Unconformity** in interval.
16-20 m	***In situ*:** upper saprolite, pallid to pinkish, kaolinite (>60%) + grey quartz grit + white & grey & bluish grey vein quartz +lithics (felsic gneiss & pink K-feldspar as quartz vein inclusions).
20-31 m	upper saprolite, pallid, kaolinite-rich + vein quartz & quartz grit + minute relict red garnet grains + lithic corestone remnants (garnet gneiss, K-feldspar).
31-37 m	lower saprolite, pale brown-grey to yellow-grey, clayey + quartz grit, relict foliation preserved in weathered rock.
37-38 m	lower saprolite to saprock, yellowish khaki, variably weathered gneiss + fresher corestones of felsic gneiss.
38-41 m	saprock, khaki, partly weathered gneiss + corestones of felsic gneiss (chloritic biotite-quartz-k-spar-garnet) **EOH**. Regolith logged by M.J. Sheard

Figure 132: Benchmark 23 chiptray photo and regolith log to RAB drillhole 95CHAR558. Drilling depth was to 41 m but chiptray samples stop at 40 m (in saprock).

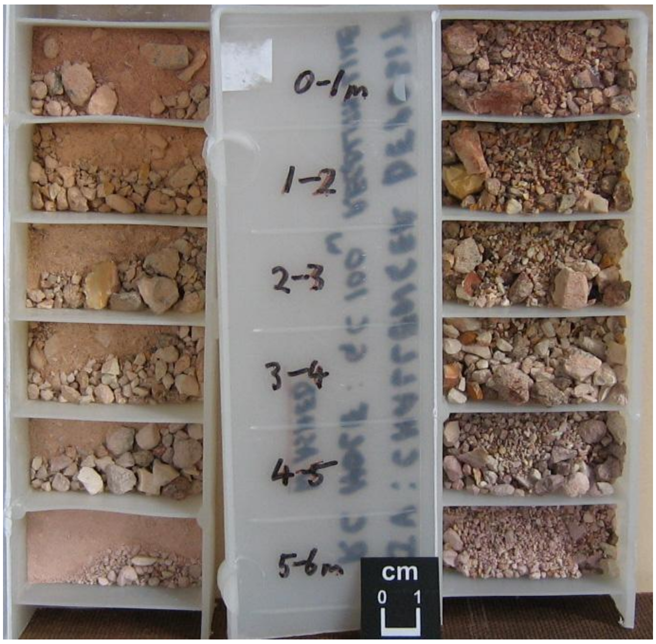


Plate 24: Benchmark 23 composite (continued), chiptray samples to RC drillhole GC100 (0-6 m).

LHS displays unprocessed samples.

RHS displays washed samples, where clay and silt have been removed. Granular residue becomes less abundant with depth below 3 m.

Sample interval was one metre.

See Table 56 for log.

Background

Drillholes 95CHAR558 and GC100 and Pit GCP100 have been selected to form this composite benchmark because their adjacent sites occur within a significant palaeochannel tributary away from the major Au mineralization, these sites have significant transported cover, while the weathered *in situ* regolith is relatively straight forward regarding its interpretation. Comparisons are provided through composite Benchmarks 21 and 22. From mid 2002 all of these sites were removed or covered by the Challenger Gold Mine developments, Processing Plant and associated facilities. The initial phase of exploration grid drilling at Challenger during 1995 involved RAB methods (mostly without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes typically end in saprock or lower saprolite rather than within fresh gneiss. Cuttings were sampled either on alternate metre intervals or as 2 m composites (not ideal for regolith investigations). Later drilling phases employed hammer assisted RAB and/or RC, and targeted diamond coring methods to obtain better sample control and bedrock structural representation.

Excavation of eight strategically sited pits (12 x 6 x 3 m) cut using explosives and a bulldozer, into the indurated upper regolith provided ready access for detailed sampling (assay, petrology, XRD, PIMA, etc) and offered a valuable 3D exposure of regolith development and irregularities.

Table 56: Benchmark 23 composite (continued) regolith log to RC drillhole GC100 (after Lintern and Sheard 1999b).

Drillhole: GC100, Reverse Circulation, vertical.
Location: Zone 53, 364315 E, 6693033 N, GDA 94
Site: within silcrete outcrop area on a slight rise on otherwise flat ground. Silcrete is massive to vuggy with quartz clasts, x-bedded sandstone and ferruginous stains along fractures. Outcrop is bouldery. Fluvial sedimentary structures are preserved in the silcrete. Potch opal veins, stringers and blebs are also observable in outcrop. Opalised and silicified wood fragments noted in silicified sediments or as loose float on the surface.
Vegetation: shrubland.
Soil: clayey sand, moderate reddish brown (wet) (2.5YR 4/5); as discontinuous patches within silcrete outcrop.
Calcrete: not at surface, thin plates and slabs coating silcrete below soil at ~25-30 cm.
Logged by: M.J. Sheard.

Sample #	Depth	Description
GC100A	0-1 m	UNWASHED: cuttings and fines, pale pink (dry), strongly calcareous silcrete, calcrete with some of the reddish sandy soil included, strong carbonate acid reaction; texture – gritty sand and rock fragments, light brown (wet) (5YR 6/6). WASHED: fragments of calcrete, silcrete and calcrete coating silcrete, creamy quartz fragments, Fe oxides as orange-brown coatings on silcrete.
GC100B	1-2 m	UNWASHED: cuttings and fines, pale grey (d) silcrete, many angular broken fragments, calcareous, pale pinkish (d), moderate to strong carbonate acid reaction; texture – rock fragments, brownish orange (w) (5YR 5/8). WASHED: cuttings of brown, grey and buff coloured silcrete, and cream, yellow, orange and grey potch opal and porcelanite, very calcareous, Fe oxides as above.
GC100C	2-3 m	UNWASHED: as above, silcrete – very fine grained sand within each fragment, strong carbonate acid reaction; texture as above, colour – light yellowish brown (w) (7.5YR. 7/5). WASHED: as per 1-2 m.
GC100D	3-4 m	UNWASHED: cuttings and fines, creamy-grey, calcareous silcrete, mostly finer fragments (<3 mm), moderate carbonate acid reaction; colour – moderate yellowish pink (w) (5YR 7/4). WASHED: creamy silcrete and porcelanite fragments.
GC100E	4-5 m	UNWASHED: cuttings and fines, creamy grey (d), slightly clayey gritty material, contains clasts of silcrete as both large (5-10 mm) and smaller sand-sized fragments no carbonate acid reaction; texture – rock fragments, light yellowish brown (w) (7.5YR 7/4). WASHED: silcrete and porcelanite as above plus purple to pink silicified claystone.
GC100F	5-6 m	UNWASHED: cuttings and fines, pale pink (d) clay with some angular grit, no carbonate acid reaction; texture – sticky gritty loam to gritty medium clay, greyish yellowish pink (w) (2.5YR 7/2.). WASHED: pink to purple clay and claystone with some contamination from above of silcrete and potch opal fragments.

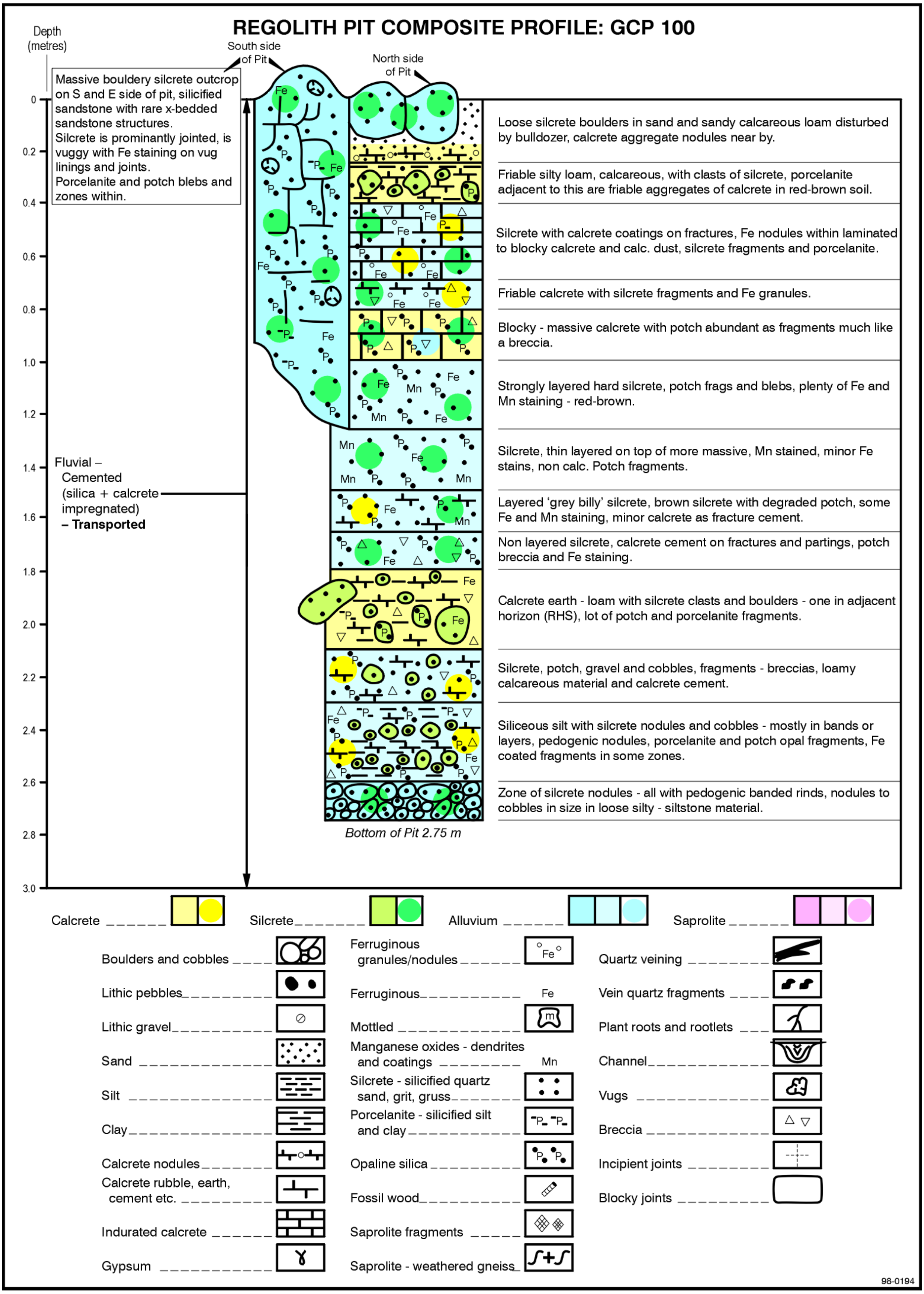


Figure 133: Benchmark 23 continued, composite profile to Challenger regolith pit GCP100 (Lintern and Sheard, 1999b).

Table 57: Benchmark 23 composite (continued) regolith profile in-field log, sampling points and sample numbers to excavation GCP100 (pit size 12 x 6 x 3 m).

Pit: GCP100	Regolith Profile on NW face, centre (excavated by blasting and bulldozing).
Location:	Zone 53, 364315 E, 6693033 N, GDA 94 Nearest Regolith RC Hole: GC100.
Site:	Bouldery silcrete outcrop area with thin patchy reddish sandy soil and sparse shrubby vegetation. Pit excavation too difficult for bulldozer at hand, pit messed up in process. The most accessible face (northern) was not typical of the pit S side – this consisted of massive to bouldery pedogenic "grey billy" silcrete with a sporadic thick massive calcrete capping. That silcrete was vuggy with Fe-staining on fractures and vugh linings, and ferruginous granules within.
Logged by:	M.J. Sheard (PIRSA) & M.J. Lintern (CSIRO-E&M).
Photographic images (PIRSA)	(45504 to 45508) Plates 25-33

Sample #	**Depth (cm)**	**Description**
GCP100-1	25-40	NOTE: top soil (0-25 cm) disturbed by blasting and pit excavation. Friable calcareous silty loam soil (B horizon) with clasts of calcrete, silcrete, porcelanite and potch opal. Adjacent to sample line are friable aggregates of calcrete in a red-brown sandy soil. Sample: R214139.
GCP100-2	40-70	Silcrete with calcrete coatings and dust with Fe granules (to 3 mm) and nodules within, laminated to blocky calcrete with silcrete and porcelanite fragments. Sample: R214140.
GCP100-3	70-80	Calcrete – friable with small fragments (to 20 mm) of silcrete and Fe granules. Sample: R214141.
GCP100-4	80-100	Blocky to massive calcrete with abundant potch opal as fragments and ?breccia clasts . Sample: R214142.
GCP100-5	100-125	Beginning of a strongly layered zone – non calcareous, siliceous with fragments of silcrete and potch opal – with silica cement containing much Fe- and Mn-staining, distinctly layered, it forms the top of this zone. Quite a reddish brown horizon with layers on a cm scale. Sample: R214143.
GCP100-6	125-150	Siliceous, thin layers over larger block silcrete, Mn-stained, minor Fe-staining, some potch opal fragments, non calcareous. Sample: R214144.
GCP100-7	150-165	Silcrete, layered "grey billy" and brown forms with ?weathered potch (dull), some Mn- and Fe-staining, with minor calcrete cement. Sample: R214145.
GCP100-8	165-180	Base of layered zone, various silcretes as layers, potch opal breccias and Fe-staining, with calcrete cement and coatings. Sample: R214146.
GCP100-9	180-210	Calcareous loam with silcrete boulder ("grey billy") in an adjacent horizon, silcrete nodules and fragments with plenty of potch opal and porcelanite bands and fragments. A band within calcareous earth of Fe-stained silcrete. Large silcrete block (Sub-sample A). Samples: (9) R214147, (9A) R214148.
GCP100-10	210-230	Calcrete cemented silcrete, potch opal, gravels and cobbles of the same, matrix is calcareous loamy material. Silcrete is pedogenic. Sample: R214149.
GCP100-11	230-260	Silcrete with bands of potch opal – yellow and grey, basal horizon of silcrete cobble, pebble and gravel sized concretions—nodules in a matrix of calcareous silty loam. Ferruginous coated silcrete fragments in indurated calcrete. Sample: R214150.
GCP100-12 **Cont. below**	260-275	silcrete as rounded nodules 2-15 cm diameter (single small boulder as sub-sample 12A), bands and nodules of yellow to grey potch opal in a siliceous dust or earth (?calcareous). Samples: R214151, (12A) R214152 and R367478.

GCP100-grab	pit spoil pile	Vitreous potch opal, mostly yellow creamy, some has reddish Fe-coating. Sample: R214153.
GCP100-grab	pit spoil pile	Greenish grey silcrete with Fe-granules and angular gravel encapsulates, partly calcreted. Sample: R214154.
GCP100-grab	pit spoil pile	Grey billy massive silcrete – silicified sandstone, from near the surface. Sample: R214155.
GCP100-grab	pit spoil pile	Pure potch opal – yellow and cream and grey with no other adhering matter (curiosity assay). Sample: R214156.
GCP100 -grab m	pit spoil pile	Potch opal-calcrete breccia. Sample: R367479.
GCP100 -grab f	pit spoil pile	Ferruginous granules in calcrete. Sample: R367480.
GCP100 -grab j	pit spoil pile	Porcelanite chunk with potch opal core. Sample: R367481.
GCP100 -grab h	pit spoil pile	polymict breccia – silcrete-porcelanite-potch-ferricrete-calcrete. Sample: R367482.

Plate 25: Pit GCP100, view of the bouldery grey billy silcrete on the SE side of the pit, in marked contrast to the laminar calcrete-silcrete breccia on the N and W sides of the pit. View from atop the sampled profile (Lintern and Sheard, 1999b). *(photo 45508)*.

Plate 26: Pit GCP100, wide angle view, NW face with logged and sampled profile marked by measuring tape (Lintern and Sheard, 1999b). *(photo 45504)*.

Plate 27: Pit GCP100, NW face, top metre (red mark at 1 m) central logged profile indicated by tape (Lintern and Sheard, 1999b). *(photo 45505)*.

Plate 28: Pit GCP100, NW face, top 1-2 m (red mark at 1 m) central logged profile indicated by tape (Lintern and Sheard, 1999b). *(photo 45506)*.

Plate 29: Pit GCP100, NW face, 1.5-2.75 m (red mark at 2 m) central logged profile indicated by measuring tape (Lintern and Sheard, 1999b). Silcrete is more bouldery-concretionary between 1.85-2.15 m. *(photo 45507).*

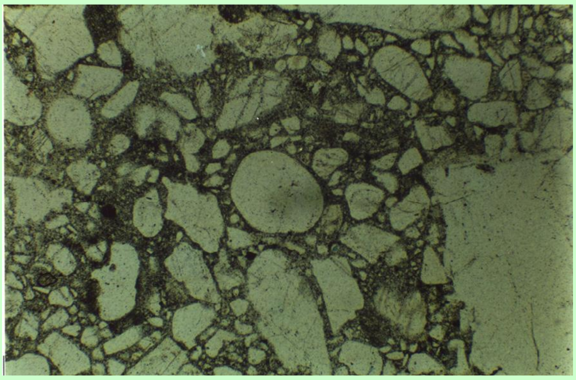


Plate 30: Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP100 of Lintern and Sheard (1999b). Silcrete (grey billy) composed of small translucent grey quartz grains distributed uniformly through a pale cream-grey matrix. (see Plate 31 for petrography). Sample R213794, *(photo 45537).*

Plate 31: sample R213794, in transmitted plane polarised light. Rounded and angular quartz fragments (colourless) lie in a cryptocrystalline siliceous cement pervaded by submicron dusty material (possibly leucoxene). Silicified sediment with colluvial and alluvial grains. View 1.5 x 2.5 mm (Mason and Mason, 1998). *(photo 45837).*

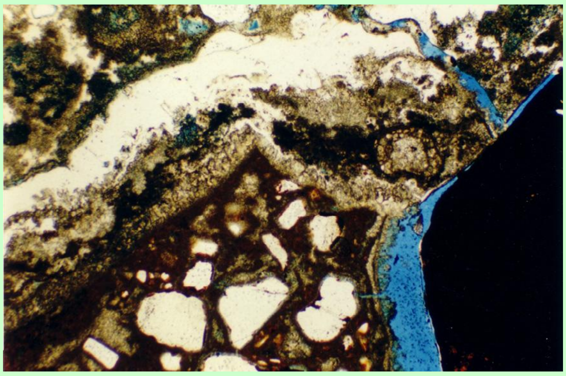


Plate 32: Challenger Gold Deposit regolith, slabbed sample from Regolith Pit GCP100 of Lintern and Sheard (1999b). Calcrete bearing Fe-stained lithic fragments in a fine-grained pink-cream matrix. A 1 cm thick irregular band without Fe-lithic fragments defines layering. (see Plate 33 for petrography). Sample R367480, *(photo 45524).*

Plate 33: sample R367480, in transmitted plane polarised light. Large Fe-fragment (lower right) lies in a matrix of quartz particles (colourless) & cryptocrystalline-microcrystalline calcite (lower left), + overgrowths of colloform opaline silica (colourless) and microcrystalline calcite (pale brown). View 1.5 x 2.5 mm (Mason and Mason, 1998). *(photo 45885).*

In situ Regolith

Bedrock (Christie Gneiss, <5% weathered) was not penetrated in drillhole 95CHAR558 and the Weathering Front is presumed to be below ~50 m based on evidence from adjacent drillholes. Examples of Christie Gneiss bedrock are provided earlier (Plate 9, Figure 118) from a cored geotechnical drillhole located reasonably close to Benchmark 22.

Saprock (>5-<20% weathered) was penetrated but its lower boundary was not encountered. All biotite is altering to chlorite; pyroxene and amphiboles are partially altering to clay ± goethite ± chlorite ; while feldspars and cordierite are partially altering to clay and sericite. Saprock at this site is moderately competent, is mostly khaki-grey but may display considerable yellowing or brown staining by FeOH distributed along fractures and intergrain boundaries (Figure 132). Clays are present within altering minerals and/or as fracture infill.

Lower saprolite (>20% weathered) is characterised by a reduced competency + yellow-brown to yellowish grey colours; clay is commonly more abundant; darker yellow-brown FeOH segregations are present; quartz grit and some vein quartz also occur (Figure 132).

Upper saprolite (>50% weathered) is typically strongly leached, exhibits either pallid or subdued hues and is generally chalky (kaolinite-rich + quartz grit; low competency material). This sub-zone may also exhibit FeOx/FeOH mottling or staining in a variety of colours (red-brown-yellow) and the relict quartz (grit + veins) is more visually obvious (Lintern and Sheard, 1999b). Some small red garnets (<1 mm) were encountered and unlike the larger garnets, have survived weathering alteration to ~22 m below the surface. Palaeovalley incision-erosion into the upper saprolite has truncated possibly half of its original thickness (Figures 122, 132).

Transported Regolith

Transported regolith formed a substantial cover sequence at these sites (Lintern and Sheard, 1999b). Regolith drillhole GC100 (drilled with RC method) and pit excavation GCP100 provide detailed information on the 0-6 m and 0-3 m intervals (respectively) within totally transported materials. Drill sampling involved 1 m composites that were logged in both the raw and washed states (Plate 24, Table 56); while the pit sampling involved bulks and blocks (at 10-30 cm intervals) removed from a selected vertical profile (Plates 25-33, Figure 133, Table 57). The 6 m drilled interval is complex due to the intensity of overprinting by siliceous and calcareous cements that form a significantly indurated duricrust (5->6 m thick: silcrete + calcrete). Excavation GCP100 provided further detail in 3D that drill cuttings cannot and allowed the collection of bulk samples for petrography and more detailed assay. Outcrop at the regolith pit location consisted of scattered low domes and boulders of massive grey billy silcrete protruding orange sand and thin soil. Some silcrete exhibited overgrowth lamellae and preserved sedimentary structures (cross-bedded sands, graded bedding), veins and blebs of yellow potch opal, and fragments of dark grey-brown petrified wood (Plates 11,12, 25-31).

However, pit excavation revealed that the massive dense silcrete was patchy and irregularly developed in amongst less densely massive silcrete-calcrete duricrust (Figure 133, Plates 25-29). The siliceous duricrust overprints fluvial quartz sand containing some layers of colluvial quartz grit (both being fine- to coarse-grained, clasts range from well rounded to angular, Plate 30). Beds of >300 mm to lamellae of <2 mm occur throughout and were best preserved in the larger blocks-boulders of massive grey billy silcrete.

Repeated erosive episodes and the incorporation of surface clasts into the upper 1-2 m profile, have combined to form complicated breccia beds within the upper transported regolith here (Plate 12). These indicate surface erosive-colluvial and pedogenic processes, yielding slope talus and debris flow deposits. Subsequent pedogenic silica and carbonate solutions have cemented those breccias and colluvium with hyaline opal and calcrete.

Calcrete forms occasional massive coatings on the silcrete duricrust but also substantially invades the silcreted sandstone along joints, bedding partings and infills remnant voids (clay ball and wood moulds). On one side of regolith Pit GCP100, calcrete has gradually jacked apart the silcrete to form a jig-saw-fit assemblage while on the other side it has only invaded between silcrete boulders or remains as a surface capping below thin sandy soil, sometimes the calcrete encloses lithic lags derived from up slope (Plates 32, 33).

Geochemistry

Detailed geochemical analysis of the 0-6 m samples using a 50 element assay package is available in Lintern and Sheard (1999b). An extract of that work is provided below. Down profile elemental abundance plots are set out in Figures 134, 135. Gold is at very low levels in the upper ~3 m regolith (<9 ppb) where there is ~15 m of transported cover and the nearest Au mineralization being ~200 m NW. Gold and Ca abundances are well correlated (see Figure 124 to compare across all pits). However, Au only appears to be poorly associated with As, Bi, Fe and Mn. High S within the upper 3 m is most likely due to the presence of gypsum (presence logged in cuttings), which in adjacent pits seems more likely to have derived from the *in situ* weathering of sulphides (Lintern *et al*., 2006). A more general account of the broader geochemistry is provided earlier in the Challenger Gold Deposit summary under Geochemistry and includes Figures 123-125 plus Table 49.

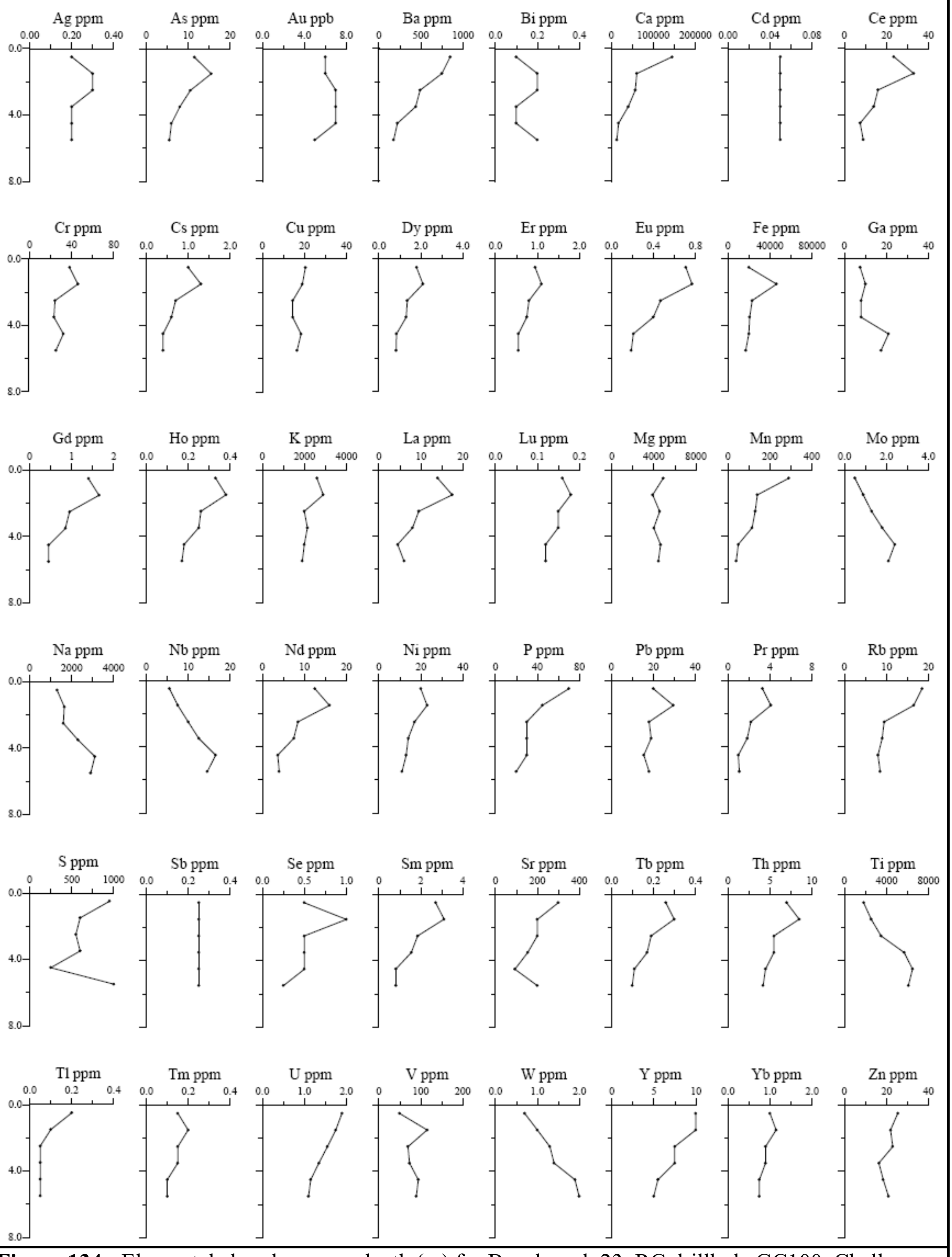


Figure 134: Elemental abundances *vs* depth (m) for Benchmark 23, RC drillhole GC100, Challenger Gold Deposit (Lintern and Sheard, 1999b).

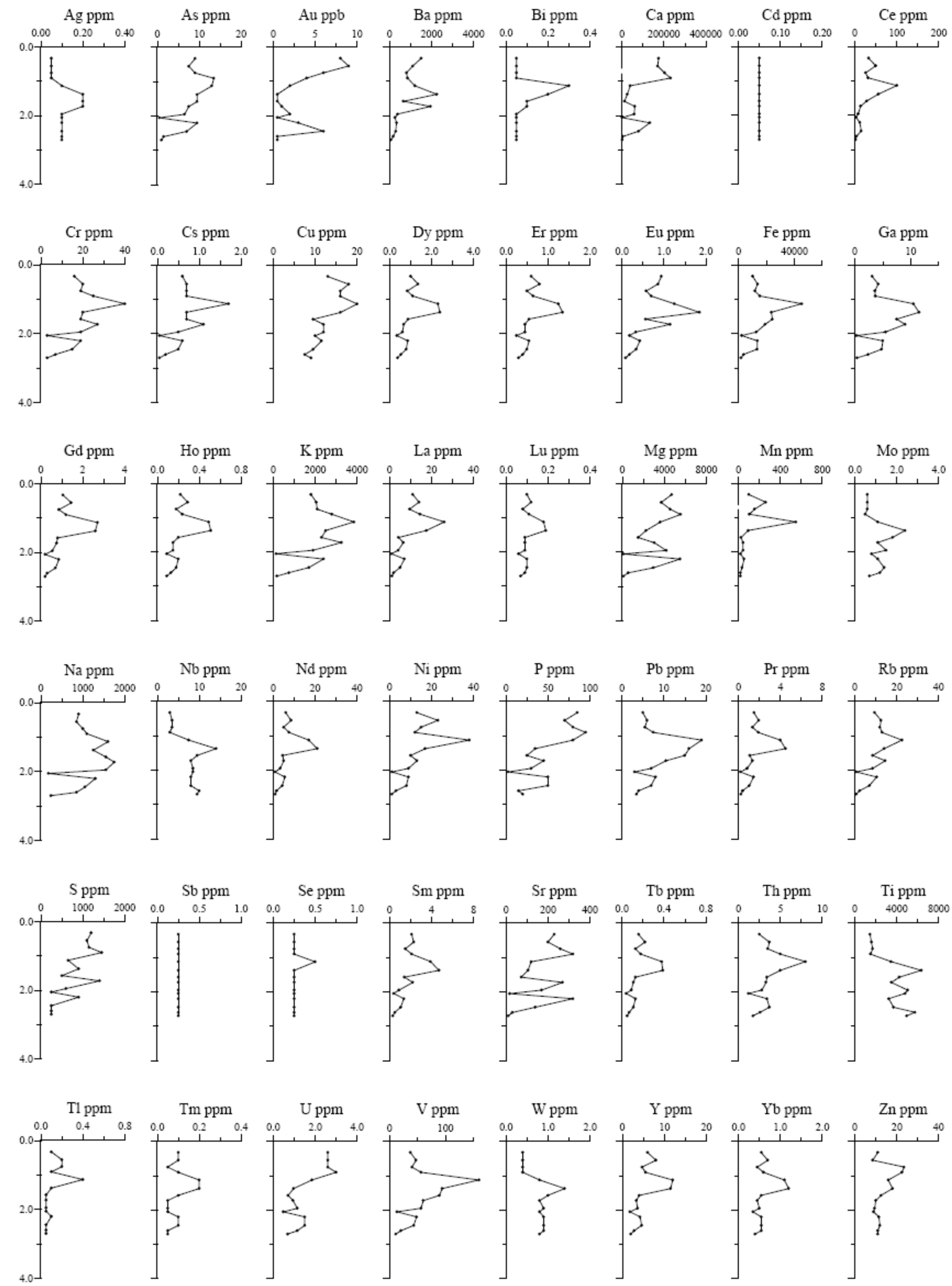


Figure 135: Elemental distributions *vs* depth (m) for Benchmark 23, RC Regolith Pit GCP100, Challenger Gold Deposit (Lintern and Sheard, 1999b).

Jumbuck gold prospect

Background

The Jumbuck gold prospect lies about 40 km W of Commonwealth Hill Pastoral Station Homestead, about 5 km E of the Challenger Gold Mine and ~140 km NW of Tarcoola (Figure 136). The prospect covers undulating terrain in an area occupied by ~E-W trending orange longitudinal dunes of Pleistocene age that form an easterly outlier of the Great Victoria Desert. Dunes cover a substrate of deeply weathered and silcrete capped Archaean Christie Gneiss with a variety of overlying sediments. In part, the dunes infill basement depressions with up to 6 m of sand ± other sedimentary deposits. Vegetation has stabilised the dunes and includes deep rooted woodland (*Eucalyptus* and *Acacia*), numerous woody shrubs (e.g. *Acacia, Eremophila* and *Maireana*) and various ground cover plants (e.g. *Ptilotus, Eragrostis, Sclerolaena* and *Thyridolepis*) (after Lintern *et al*., 2002).

Jumbuck prospect formed part of the larger Gawler Joint Venture tenement coverage, occupying most of the area in Figure 136. The Jumbuck Au anomaly was discovered in 1995 using regional Au-in-calcrete methods (anomaly area ~2 x 3 km at >3 ppb Au). It was drilled early in 1997, but assays soon indicated that mineralization is weak despite the anomaly size. Regolith investigations by Lintern *et al.* (2002) began in 1998 as part of a broader regional study examining Au-in-calcrete anomalism. A series of ~EW trending company RAB drill-lines provided samples for regolith logging, characterisation, and analysis. Field inspection of drill spoil piles aided selection of a suitable study line of drillholes (local grid 6690400 N AMG66 [= 6690571 N GDA94]). Figure 137 indicates the location of that regolith study line in relation to the topography and Au-in-calcrete anomaly.

In situ Regolith

<u>Bedrock</u> (<5% weathered) was not penetrated by any of the exploration drilling on this prospect, however, remnant corestone fragments in saprock indicate bedrock to be a biotite-rich (?mafic) form of Christie Gneiss.

<u>Saprock</u> (>5% to <20% weathered) was penetrated by most drilling (Figure 138), it is generally complexly weathered and its boundary with lower saprolite is not easy to define from cuttings (possibly a gradational interval). It consists of a strongly foliated mafic to biotite-rich gneiss, and is commonly grey to dark grey in colour, and possibly dark brown at one drill site (FeOH staining after weathered chlorite). Thickness is indeterminate because its base was not intersected, however, it is likely to be in the range 5->10 m.

<u>Saprolite</u> (>20% weathered) is quite a complex weathering zone at Jumbuck (Figures 138, 139), lower saprolite was more uniform of colour and is less weathered than upper saprolite. Lower saprolite is typically greyish, but also brownish to olive or mixtures of those near more mafic bands, and there are intervals at depth where extremely weathered rock is surrounded by much less weathered rock. Remnant biotite and chlorite plus abundant clay and quartz grit are typical components. Upper saprolite is highly variable of colour (pallid, pink, yellow, brown and olive-brown), is of variable competency, and in places has FeOx-FeOH segregations and/or ?mottles, and/or fracture staining. Kaolinite plus quartz grit are the dominant mineral assemblage. As a whole, saprolite is at least 30 m thick and may exceed 55 m.

<u>Pedolith</u> along the entire regolith section (Figures 138, 139) is intensely silicified and is partly enclosed by a silcrete horizon that commonly extends up into the overlying sediments, where the weathered *in situ* pedolith top is an erosional unconformity located wholly within that silcrete (best seen in outcrop but can be located with PIMA and a formula for determining the "kaolin crystallinity index" or KCI, refer to Lintern *et al*., 2002). Pedolith nearer its base is less silicified and in places retains a clay-rich texture. At one location drilling revealed a relict ferruginous-siliceous granule horizon (granules not cemented together, pale brown to pale khaki-brown) within the silcrete horizon and presumed to be part of the pedolith (requires drill core to elaborate further upon). Those granules-pisoliths (5-11 mm) retained intact cutans and so are more likely to be *in situ* rather than transported.

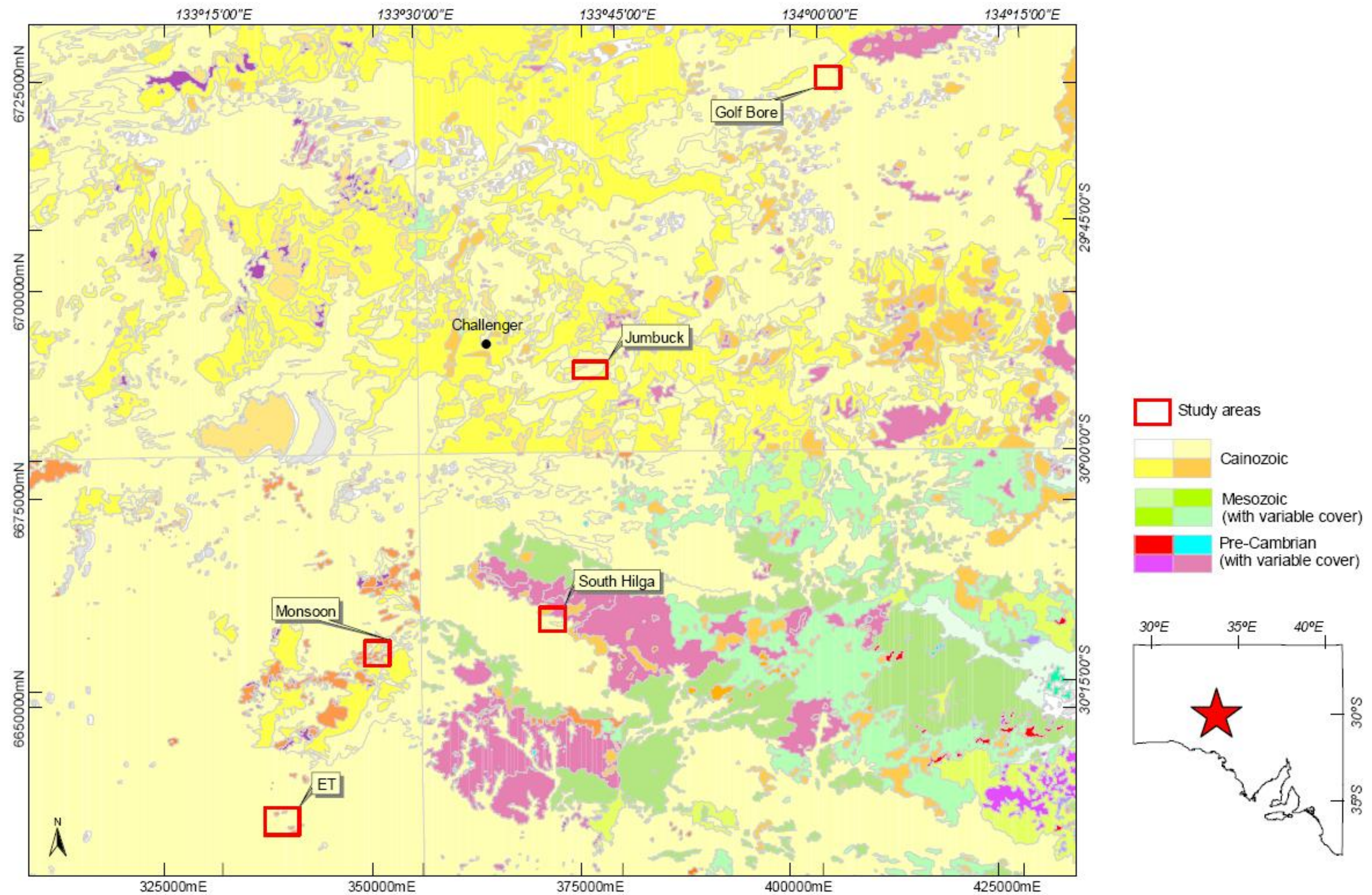


Figure 136: Locations marked on the 1:250,000 scale geology for five prospects where benchmark sites are described herein (map coordinates are in AMG66 projection). For geology interpretive key refer to the geological map sheets BARTON & TARCOOLA (1:250,000 scale).

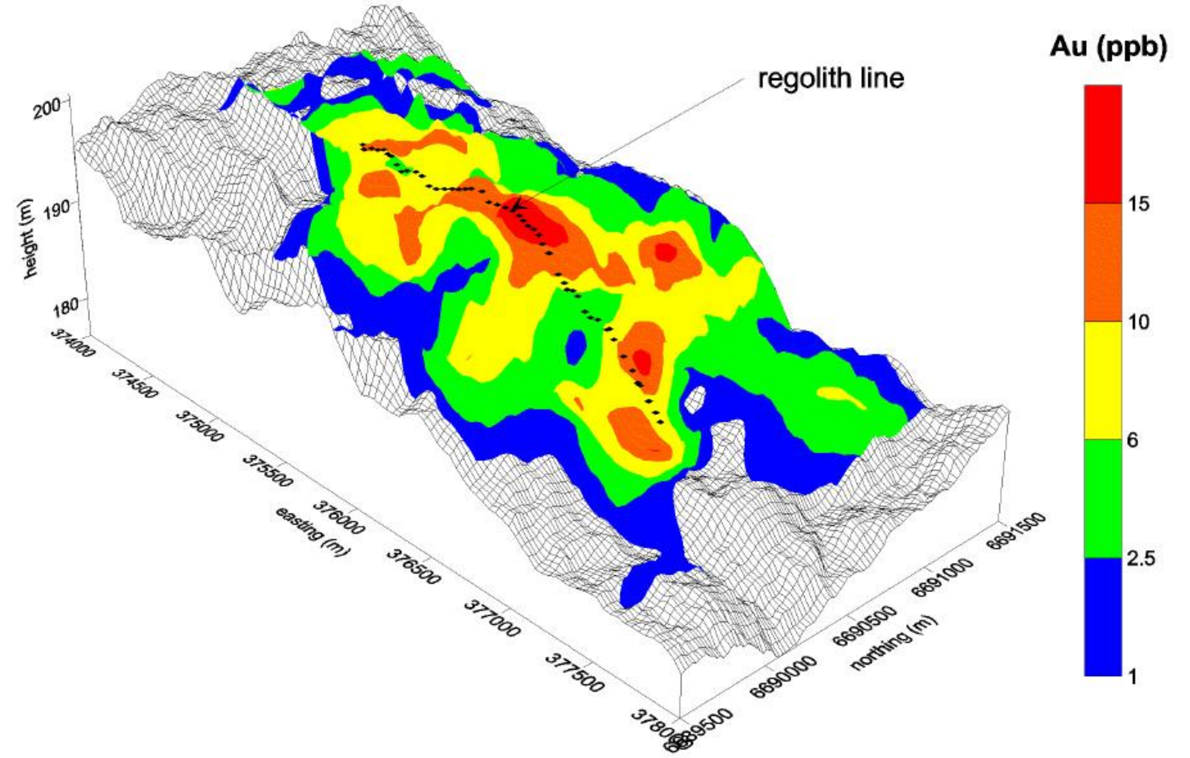


Figure 137: Jumbuck gold prospect in 3D, showing Au-in-calcrete anomaly draped over the local DEM and indicating the regolith (sampling) line. Exposed "wireframe" grid indicates data below 1 ppb. View from SE. Original data supplied from the Gawler Joint Venture (Lintern *et al*., 2002).

Transported Regolith

Positioning the unconformity was difficult at Jumbuck due to its loci being mostly within the silcrete horizon. In-field and microscopic examinations were compared with PIMA derived kaolinite crystallinity indices (KCI). However, the paucity of kaolinite remaining within silcrete and the presence of interfering smectite made use of KCI problematic (see the red line on Figures 138, 139).

<u>Fluvial sediment</u>, composed of clay and sandy silt that infills a 5 m deep by >250 m wide channel, running roughly orthogonal to the section (Figures 138, 139). This sediment is silcreted near its top.

<u>Red-brown hardpan</u>, forms a distinctive strongly coloured but discontinuous horizon above the silcrete (Figures 138, 139). Composed of clay plus quartz clasts (angular to subrounded) in a matrix supported framework, this colluvial unit is typically partly cemented with silica (hyaline opal) and possibly other cements (FeOH, gypsum, calcite) to form an indurated strongly coloured horizon. Here it is discontinuous but elsewhere it forms a more useful laterally extensive marker bed. Red-brown hardpan also possibly interdigitates with another clay-rich, multicoloured unit of uncertain affinity.

<u>Aeolian dune sand</u>, orange, siliceous, is generally free-running except where cemented by calcrete. Sand grains are frosted, rounded to subangular, and of medium-grain size (uniformly sorted), they are coated with a thin ferruginous skin and elsewhere have been dated by optical methods to age range from ~250 ka to <20 ka (Sheard *et al*., 2006). There is no illuviated clay or silt within the dunes (Figures 138, 139)

<u>Calcrete</u> occurs as pisoliths, nodules and earthy forms within the dunes, while it occurs as indurated laminar to more massive forms on outcropping silcrete. Within the dunes, calcrete has developed at more than one level (Figure 139) but when initially sampled by explorationists it is the uppermost level that would have been taken for assay.

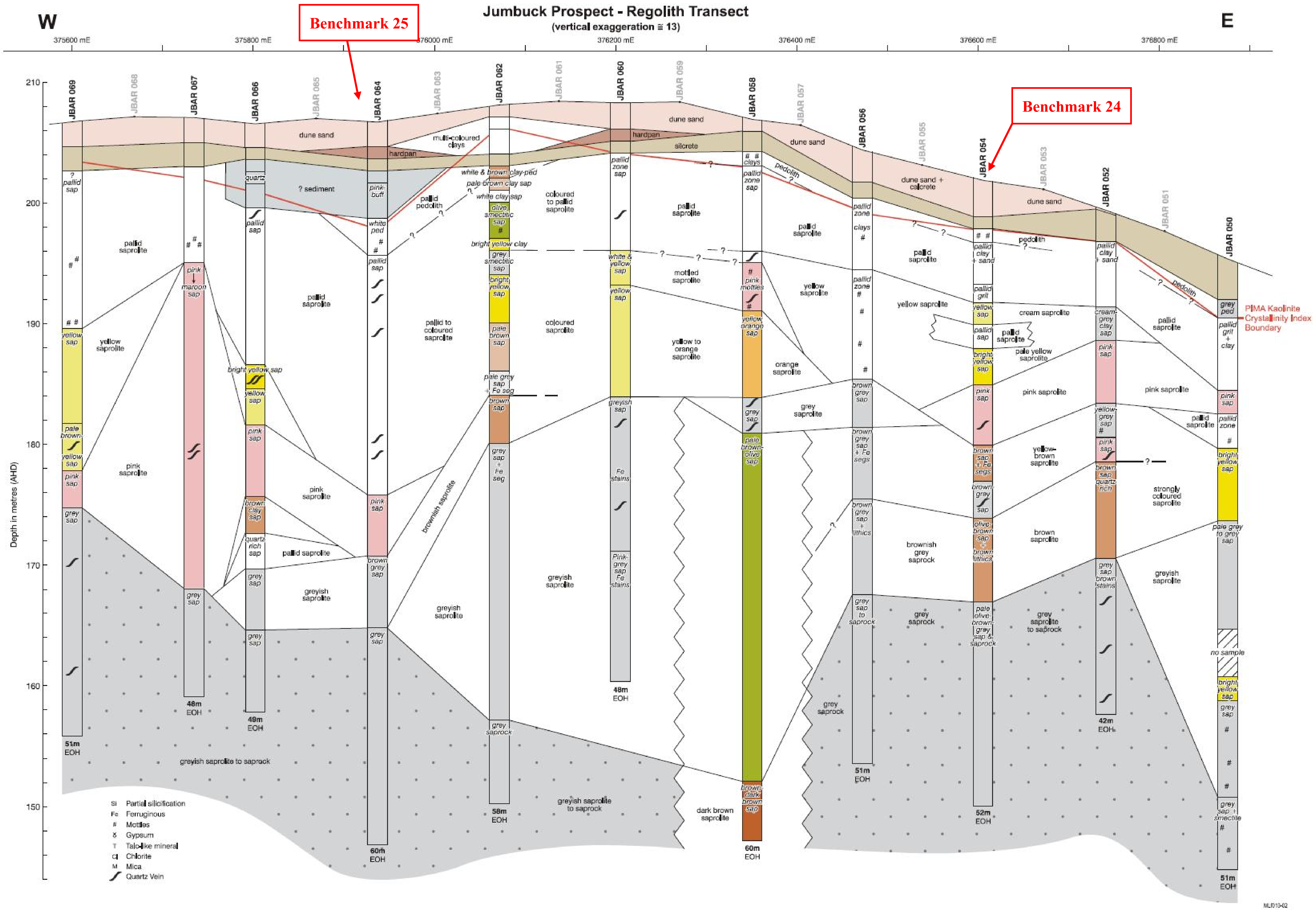


Figure 138: Jumbuck gold prospect, full regolith section along line displayed in Figure 137 (Lintern *et al.*, 2002). Benchmarks 24 and 25 are indicated.

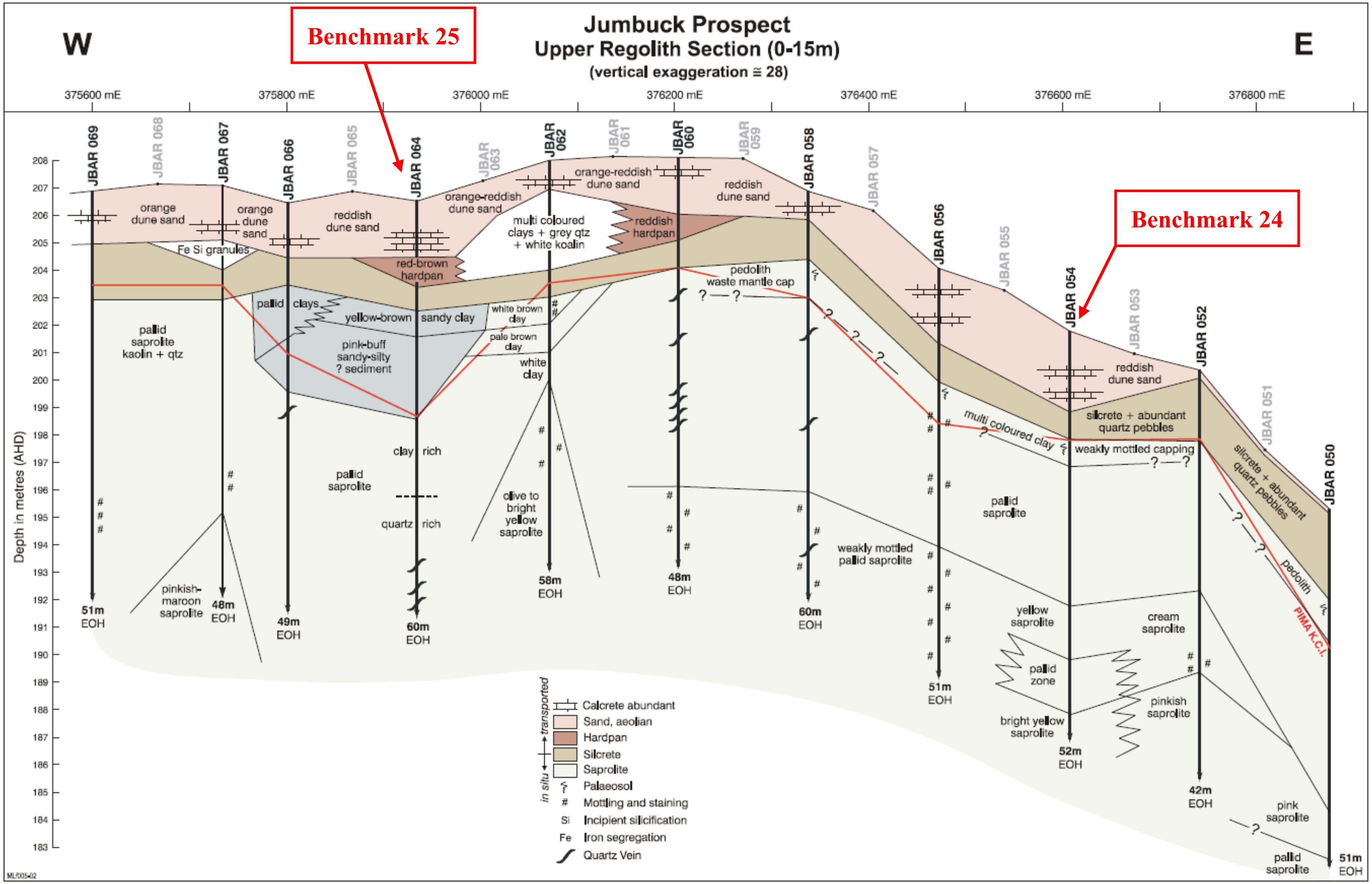


Figure 139: Jumbuck gold prospect, upper regolith section along line displayed in Figure 137 (Lintern *et al.*, 2002). Benchmarks 24 and 25 are indicated.

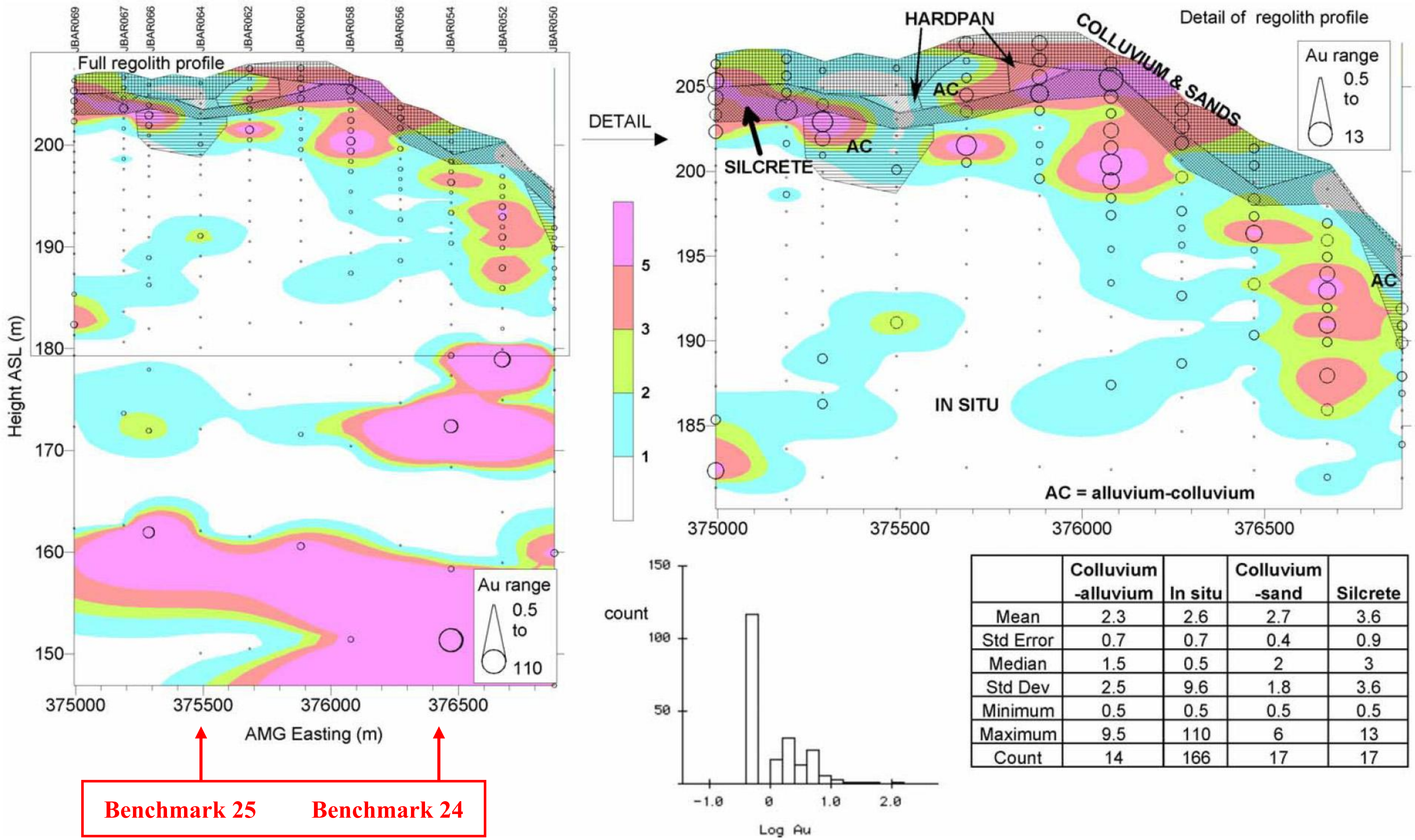
Geochemical expression

The anomaly in calcrete has a maximum of 20 ppb (Figure 137). Significant Au concentrations in the regolith are listed in Table 58. Gold concentrations above background (>1 ppb) were measured in both the transported cover and upper *in situ* weathered regolith at Jumbuck (Figure 140). The eastern part of the regolith section has higher concentrations of Au (13 ppb) in the upper regolith and this corresponds with higher Au concentrations (110 ppb) found in the deeper regolith in drillhole 97JBAR054 (Benchmark 24). For the upper regolith, the highest Au concentration (13 ppb) is found in a calcrete-silcrete sample towards the centre of the section and on the edge of the slope. Lower but still elevated Au concentrations were found sporadically in surficial calcrete developed in colluvium and sand (1-6 ppb). Iron is correlated with As, Co, Cr, Cu, Ni, V and Zn, and moderately with Mg, although the low K concentrations suggest a lack of sericitic alteration (Lintern *et al*., 2002). Left of centre section, at drillhole 97JBAR062 occurs a mafic-enriched basement intersection that has much higher values of As, Co, Cr, Cu, Fe, Mg, Ni, Ti, V, Zn, and REE than do most of the other drillholes, including another mafic intersection in drillhole 97JBAR058 (see Benchmark 24 geochemistry section).

Table 58: Jumbuck gold prospect, highest Au concentrations and other anomalous drillhole intervals (Lintern, 2004b).

Drillhole	Interval (m)	Analyses (ppm unless stated)	Regolith type
97JBAR054	50-51	Au 110 ppb	saprock
97JBAR054	29-30	Au 32 ppb	saprolite
97JBAR052	20-21	Au 44 ppb	saprolite
97JBAR066	44-45	Au 21 ppb	saprolite
97JBAR062	15-16	Au <1 ppb Cu 250, Zn 270	saprolite
97JBAR062	11-12	Au <1 ppb Cu 220, As 33, Zn 290	saprolite

In Summary: Jumbuck is a good example of a prospect characterised by a spatially large, but weak, Au-in-calcrete anomaly overlying low grade mineralization. Maximum Au concentration in calcrete is 20 ppb, and the >3 ppb Au contour spreads over an area of 2 x 3 km. Calcrete is associated with aeolian dune sand and a relict silcrete outcrop forming a palaeo-breakaway (now partly obscured by the dune sand cover).



	Colluvium -alluvium	In situ	Colluvium -sand	Silcrete
Mean	2.3	2.6	2.7	3.6
Std Error	0.7	0.7	0.4	0.9
Median	1.5	0.5	2	3
Std Dev	2.5	9.6	1.8	3.6
Minimum	0.5	0.5	0.5	0.5
Maximum	9.5	110	6	13
Count	14	166	17	17

Figure 140: Jumbuck gold prospect regolith section, regolith architecture and Au geochemical expression (*c.f.* Figures 93-95). All data are in ppb (Lintern, 2004b). Benchmarks 24 and 25 are indicated.

Benchmark 24: drillhole 97JBAR054

Quick reference items are set out in Table 59; detailed descriptions, figures and data tables follow on below. Jumbuck prospect is ~3 km SE of Jumbuck Outstation on Commonwealth Hill Pastoral Station. Sites were about 2 kilometres S of the original unsealed road between Commonwealth Hill to Mobella Pastoral Station Homesteads, and via station-mineral exploration dirt tracks (Figures 110-112, 136, 137). Drilling for these holes was vertical, and of RAB type. A summary of this profile is provided in Table 60 and chiptray photograph with regolith zonation is in Figure 141. Geochemical data are presented in Figures 140, 142-145 and Table 58.

Table 59: Benchmark 24 reference data; drillhole 97JBAR054 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 110-112, 136.
Local-site location map	Figures 137-139.
GPS coordinates, attitude & elevation	RAB drillhole 97JBAR054: Zone 53, 376599 E, 6690643 N, GDA 94. Vertical. **AHD:** 201.853 m (differential GPS data).
Site access, owner	About 3 km SE of Jumbuck Outstation on the Commonwealth Hill Pastoral Lease, and ~5 km E of the Challenger Gold Mine. Site Lease holder: Commonwealth Hill Pastoral Station.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photo / log	Yes, Figure 141, Table 60.
Sample types	Drill chips in chiptrays + ~1 kg bags.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Not from thin-sections, only from binocular microscope observations.
Geochemistry	Yes, Figures 140, 142-145 and Table 58.
XRD mineralogy	No.
PIMA spectral data	Yes, unpublished data only, used by Lintern *et al*. (2002) to produce kaolinite crystallinity indices for unconformity picks.
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	Ag, Bi, ?Cu, Zn.
Useful sampling media	Calcrete, silcrete.
Key reference sources	Lintern *et al*. (2002); Lintern (2004b).

Background

Drillhole 97JBAR054 is selected to form this benchmark because it has the most significant Au mineralization, and it has relatively thin transported cover, while the weathered *in situ* regolith is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 25 and the regolith cross-sections of Figures 138, 139. The exploration grid drilling involved RAB methods (mostly without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes typically end in saprock or lower saprolite rather than within fresh gneiss. Cuttings were sampled from the drilled 1-2 m composites (not ideal for regolith investigations). These drillholes were not originally intended for use as benchmarks, they were later sampled and analysed as part of regional regolith and chemical dispersion studies (Lintern *et al*., 2002, 2003).

0-3 m **Transported**: dune sand, aeolian, orange, siliceous uniformly sorted fine to medium sand grains, + earthy carbonate 1-2 m, + nodular calcrete 2-3 m.

3-4 m **Mixed provenance**: silcrete, greyish to yellowish, cements coarse-grained alluvial quartz in some drill chips and angular quartz grit in others. **Unconformity** >3 m.

4-18 m ***In situ***: upper saprolite (?+ remnant pedolith), pallid, kaolinite-rich + quartz grit, 4-5 m has red + yellow staining and/or mottling, 9-10 m is yellow throughout, occasional vein quartz.

18-33 m Saprolite, pinkish to brownish hued, clay-rich + quartz grit, occasional quartz veins. Greyish interval 25-28 m, FeOH staining of saprolite either side of grey interval.

33-35 m Lower saprolite, olive-brown, clayey + quartz grit.

35-52 m Saprock-lower saprolite, pale olive-brown to greyish, more competent than above, irregularly weathered.

NOTE: bedrock not penetrated. E.O.H. at 52 m.

Regolith logged by M.J. Sheard

Figure 141: Benchmark 24, Jumbuck gold prospect drillhole 97JBAR054, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002). Drilling penetrated to 52 m but regolith chiptray sampling stopped at 44 m. In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehab. work.

Table 60: Benchmark 24 regolith log to RAB drillhole 97JBAR054 (after Lintern *et al*., 2002).

Hole: 97JBAR054. **Regolith Line**, Jumbuck gold prospect. Regolith descriptions (combined in-field + laboratory observations).

Location: Zone 53, 376599 E, 6690643 N, GDA 94. **AHD:** 201.833 m (differential GPS data)

Site: gently sloping ground on reddish sand dune, vegetated.

Vegetation: *Acacia aneura* as Tall Open Shrubland over *Senna artemisioides* sub sp. *petiolaris* + Open Shrubland over *Ptilotus obovatus* and *Maireana georgei* + Low Shrubland over *Eragrostis eriopoda* + Very Open Grassland (Botanical log by S. Lintern).

Soil: Um (sand, loose, medium grained throughout).

Calcrete: nodular.

Logged by: M.J. Sheard, 1999.

Depth (m)	Description of RAB cuttings
0-1	Reddish siliceous dune sand with podsol horizonation developed, loose, medium-grained sand, frosted sub-rounded grains.
1-2	Pale red siliceous dune sand as above + earthy carbonate.
2-3	Pale red siliceous dune sand as above + nodular calcrete.
3-4	Greyish to yellowish silcrete encapsulating rounded fluvial coarse-grained sand + rounded quartz pebbles (20-40 mm) + angular quartz grit. Unconformity within this interval.
4-5	?Pedolith – Saprolite, white, red and yellow clay, kaolinite + fine- to medium-grained quartz grit (+ pebble & gravel contamination from above interval).
5-9	Pallid saprolite, white to grey kaolinite + angular quartz grit (+ contamination from above intervals).
9-10	Pallid saprolite, kaolinite-rich + angular quartz grit.
10-12	Saprolite, yellowish, kaolinite-rich + angular quartz grit.
12-14	Pallid saprolite, greenish tinted, kaolinite-rich + angular quartz grit.
14-17	Saprolite, bright yellow to pale yellow, kaolinite + angular quartz grit.
17-22	Saprolite, pinkish, clay-rich + vein quartz at 20 m.
22-25	Saprolite, brown, Fe-stained, + yellow-brown cemented segregations.
25-28	Saprolite, brownish grey, clay-rich + vein quartz at 26 m.
28-33	Saprolite, brownish grey to olive-brown, clay + quartz grit.
33-35	Lower saprolite, olive-brown, clayey + quartz grit + dark brown lithic fragments (gneissic remnants).
35-52	Lower saprolite + Saprock (?corestones or irregularly weathered), pale olive-brown to greyish, mostly more competent than above interval. Greyish gneissic remnants.
E.O.H.	

In situ Regolith

Bedrock wasn't penetrated by any drillholes on this prospect, but remnant corestones within the saprock indicate it is typical of the Christie Gneiss. Generally saprolite and most of the weathered *in situ* regolith at this site follows descriptions for this prospect set out earlier. However, pedolith appears to be severely truncated here, probably by erosion (the site is on a buried escarpment where the silcrete roughly follows that palaeotopography). What remaining pedolith there is, is partly encapsulated by the silcrete horizon, and the remainder is difficult to be certain about (cuttings alone don't provide large enough fragments for complex weathering fabrics to be properly observed-described).

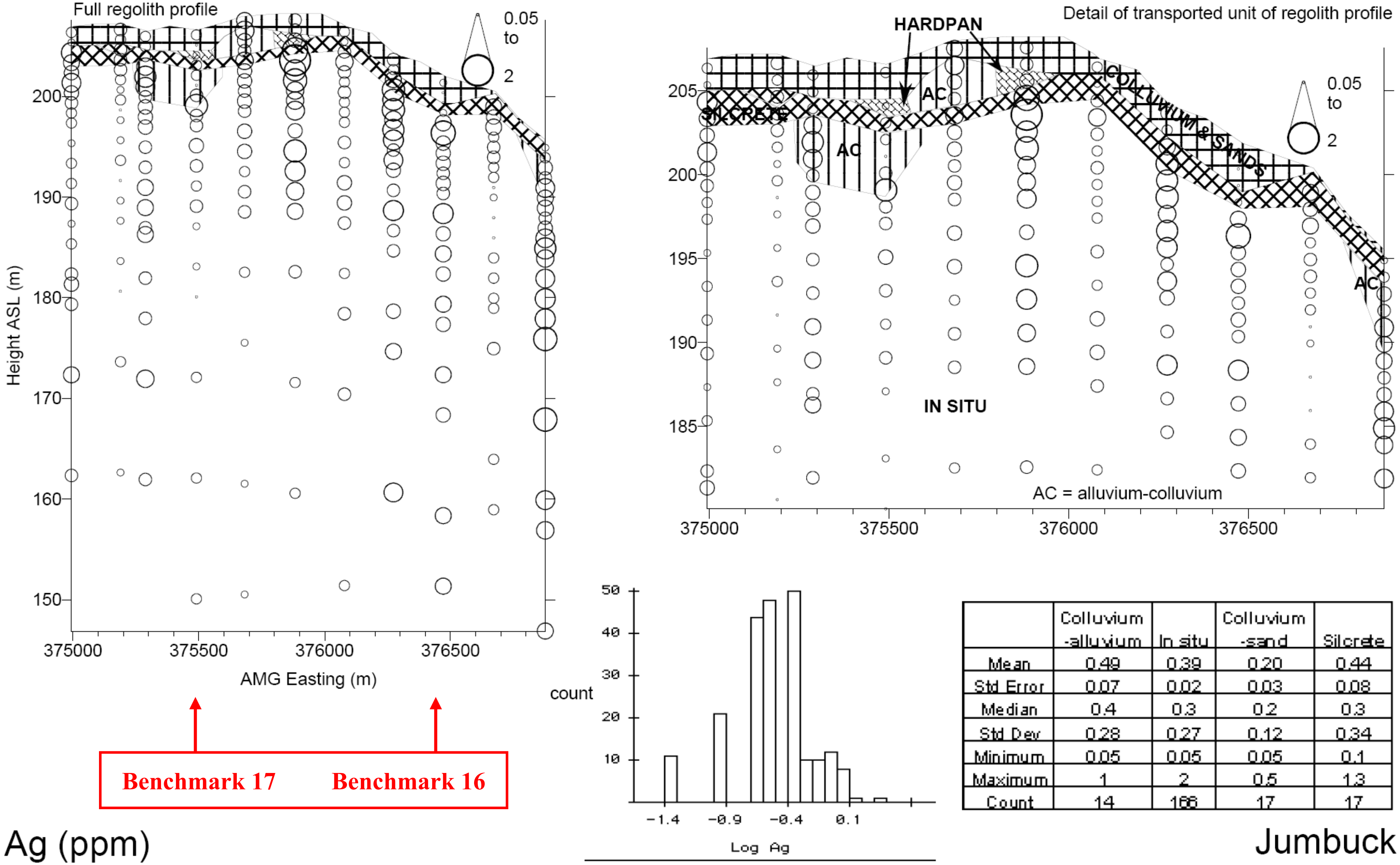
Transported Regolith

Aeolian dune sand forms the primary transported cover (3 m thick) with an additional <1 m of primarily fluvial sediment (sand + gravel + pebbles +?colluvium) encapsulated by the silcrete duricrust. That silcrete possibly forms a major barrier or impediment to the upward migration of weathering associated solutions derived from buried mineralization.

It is worth noting here that well rounded fluvial pebbles were shaken loose during drilling, from the silcrete and associated overlying sediments, and similarly for nodular calcrete in the dune sands. These together formed significant down-hole contaminants in the RAB samples (to sample depths of ~30 m) and could mislead unwary sample loggers.

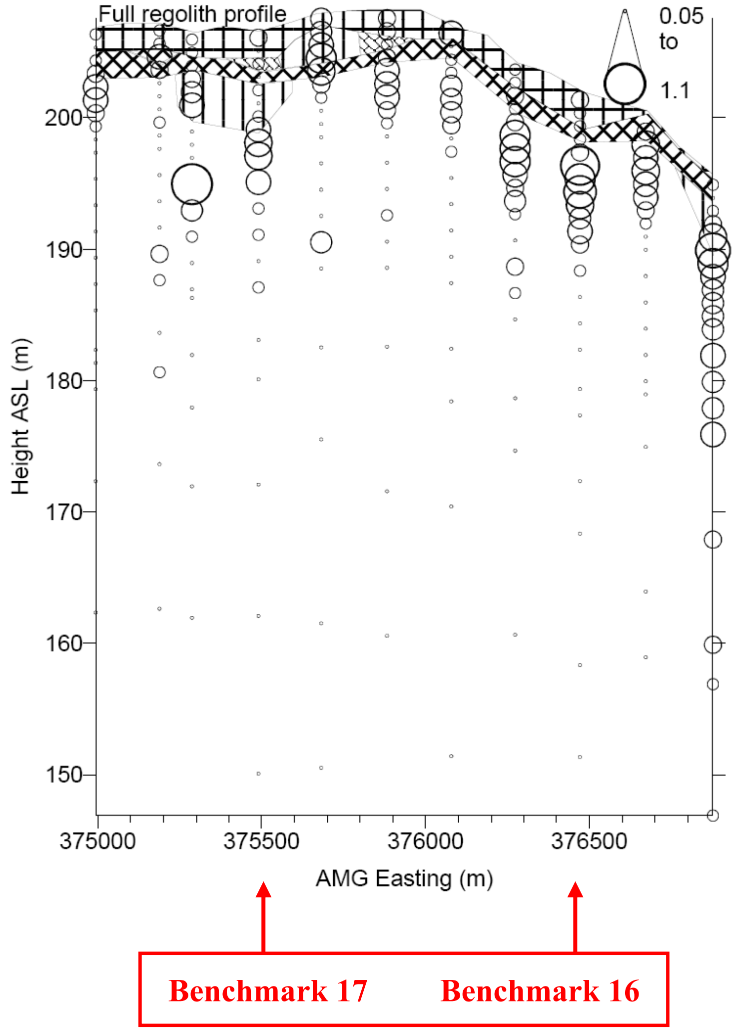
Geochemistry

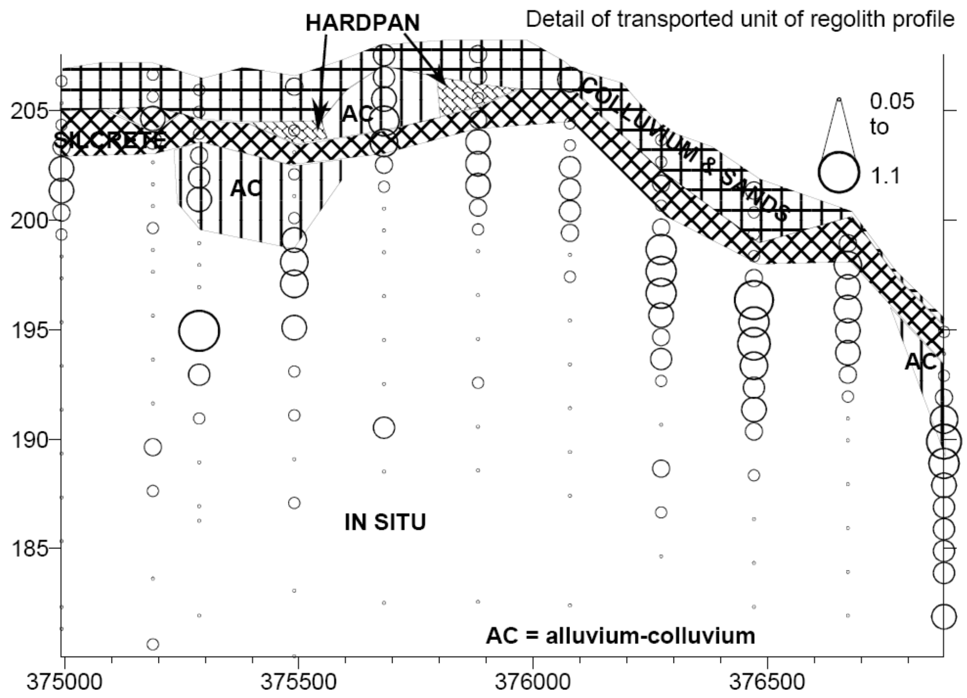
Significant Au concentrations in the regolith are listed in Table 58. Gold concentrations above background (>1 ppb) were measured in both the transported cover and upper weathered *in situ* regolith at Jumbuck (Figure 140). Benchmark 24 (drillhole 97JBAR054) has the highest Au concentrations (13 ppb) in the upper regolith and this corresponds with higher Au concentrations (110 ppb) found in the deeper regolith. Near surface, the highest Au concentration was located in a calcrete-silcrete sample towards the centre of the section and on the edge of the slope. More general comments on associated elemental abundances and dispersion are made under the Jumbuck gold prospect heading. A 51 element assay package was applied to all samples and Lintern *et al*. (2002) have plotted elemental abundances for all of those on a cross-sectional backdrop. From those abundance plots a selected set, including Ag, Bi, U and Zn, appear in Figures 142-145.

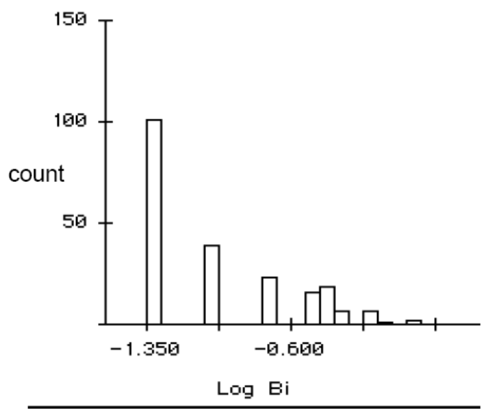


	Colluvium -alluvium	In situ	Colluvium -sand	Silcrete
Mean	0.49	0.39	0.20	0.44
Std Error	0.07	0.02	0.03	0.08
Median	0.4	0.3	0.2	0.3
Std Dev	0.28	0.27	0.12	0.34
Minimum	0.05	0.05	0.05	0.1
Maximum	1	2	0.5	1.3
Count	14	166	17	17

Figure 142: Jumbuck gold prospect regolith section, regolith architecture and Ag geochemical expression (*c.f.* Figures 140, 143-145). Lintern *et al*. (2002).





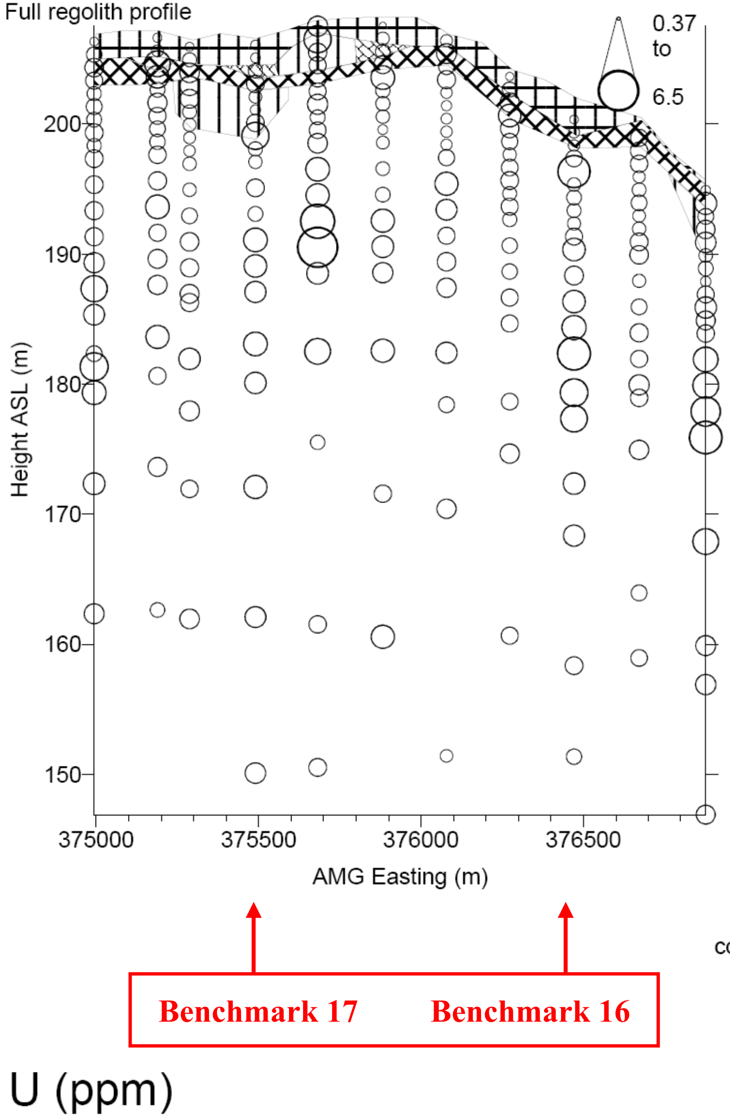


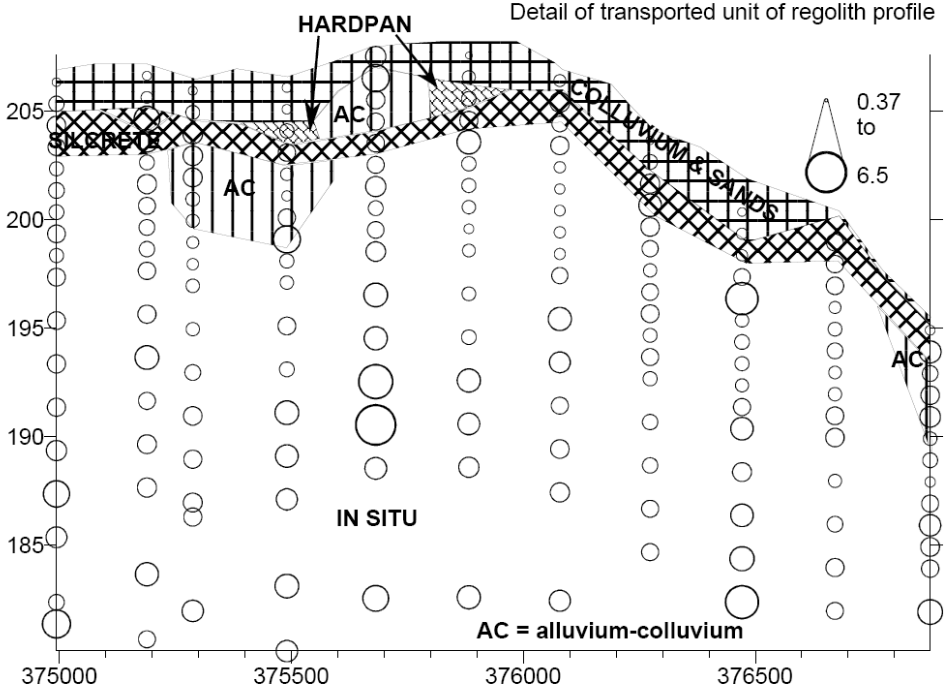
	Colluvium -alluvium	In situ	Colluvium -sand	Silcrete
Mean	0.26	0.16	0.15	0.19
Std Error	0.05	0.01	0.02	0.04
Median	0.25	0.05	0.1	0.1
Std Dev	0.18	0.19	0.09	0.15
Minimum	0.05	0.05	0.05	0.05
Maximum	0.6	1.1	0.4	0.5
Count	14	166	17	17

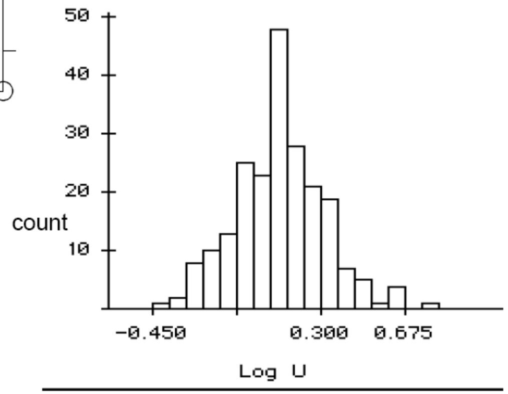
Bi (ppm)

Jumbuck

Figure 143: Jumbuck gold prospect regolith section, regolith architecture and Bi geochemical expression (*c.f.* Figures 140, 142, 144, 145). Lintern *et al*., (2002).



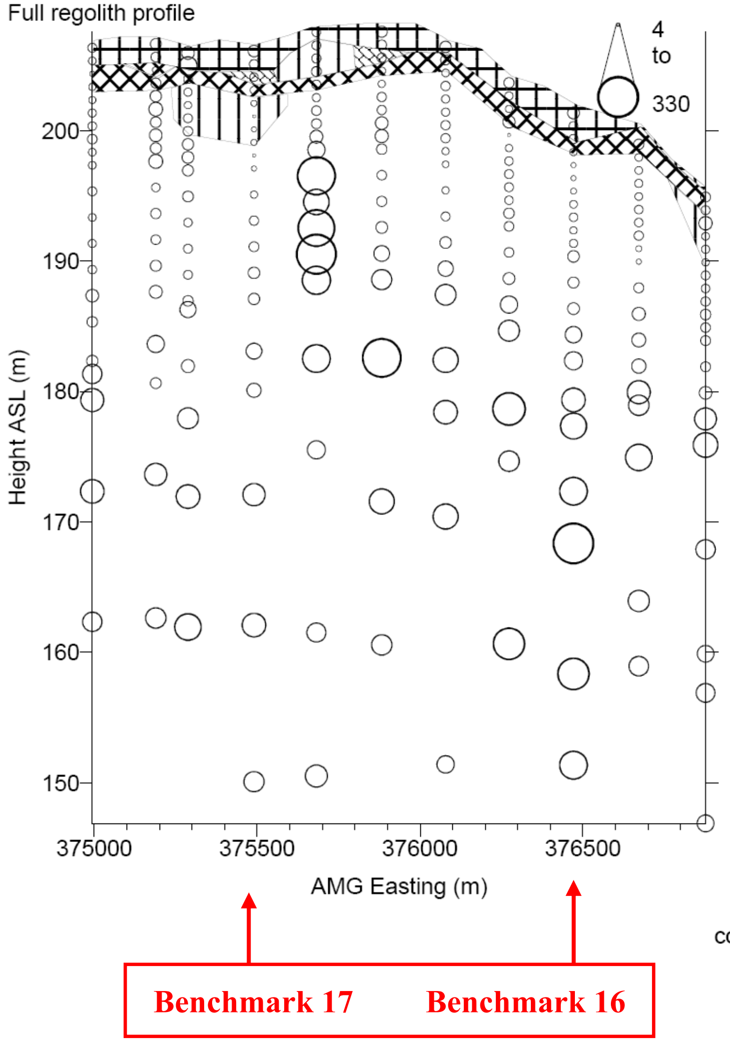


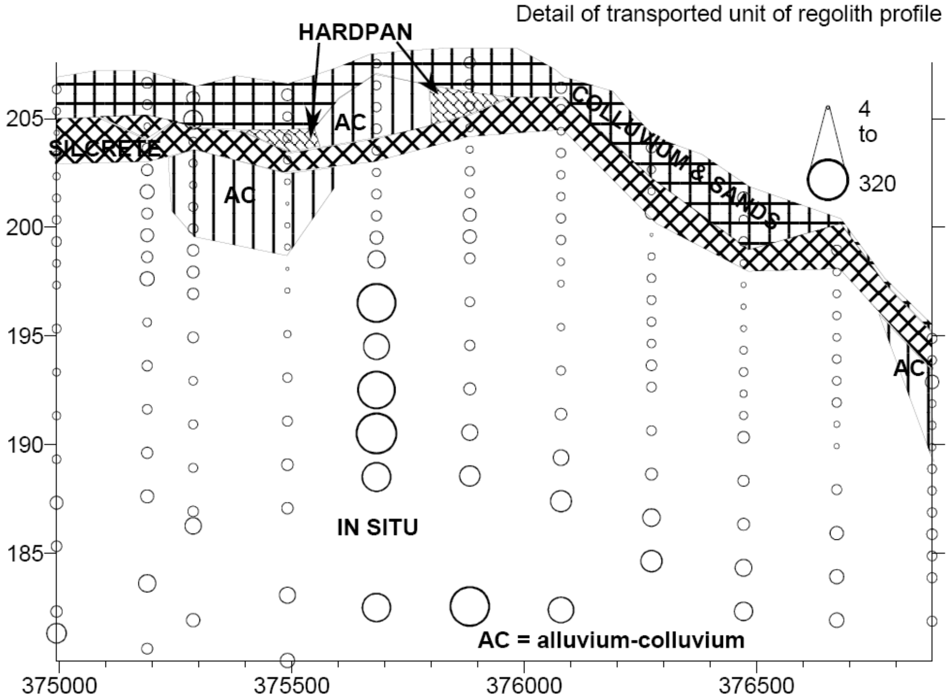


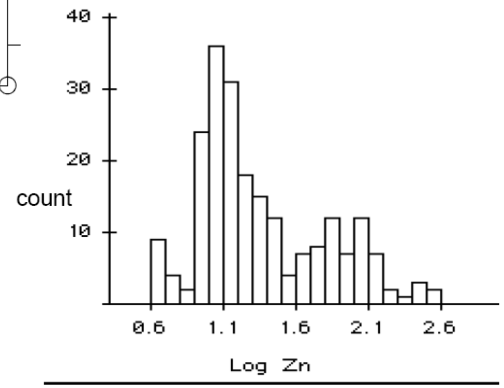
	Colluvium -alluvium	In situ	Colluvium -sand	Silcrete
Mean	1.5	1.5	0.7	1.5
Std Error	0.2	0.1	0.1	0.1
Median	1.4	1.4	0.6	1.4
Std Dev	0.7	0.8	0.3	0.5
Minimum	0.6	0.6	0.4	0.6
Maximum	3	6.5	1.7	2.7
Count	14	166	17	17

Jumbuck

Figure 144: Jumbuck gold prospect regolith section, regolith architecture and U geochemical expression (*c.f.* Figures 140, 142, 143, 145). Lintern *et al*., (2002).







	Colluvium -alluvium	In situ	Colluvium -sand	Silcrete
Mean	11	49	18	11
Std Error	2	5	3	1
Median	10	20	14	9
Std Dev	6	63	12	5
Minimum	4	4	9	5
Maximum	29	330	61	24
Count	14	166	17	17

Zn (ppm)

Jumbuck

Figure 145: Jumbuck gold prospect regolith section, regolith architecture and Zn geochemical expression (*c.f.* Figures 140, 142-144). Lintern *et al.*, (2002).

Benchmark 25: drillhole 97JBAR064

Quick reference items are set out in Table 61; detailed descriptions, figures and data tables follow on below. Jumbuck prospect is ~3 km SE of Jumbuck Outstation on Commonwealth Hill Pastoral Station. Sites were about 2 kilometres S of the original unsealed road between Commonwealth Hill to Mobella Pastoral Station Homesteads, and via station-mineral exploration dirt tracks (Figures 110-112, 136, 137). Drilling for these holes was vertical, and of RAB type. A summary of this profile is provided in Table 62 and chiptray photograph with regolith zonation is in Figure 146. Geochemical data are presented in Figures 140, 142-145 and Table 58.

Table 61: Benchmark 25 reference data; drillhole 97JBAR064 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 110-112, 136.
Local-site location map	Figures 137-139.
GPS coordinates, attitude & elevation	RAB drillhole 97JBAR064: Zone 53, 375619 E, 6690615 N, GDA 94. Vertical. **AHD:** 206.593 m (differential GPS data).
Site access, owner	About 3 km SE of Jumbuck Outstation on the Commonwealth Hill Pastoral Lease, and ~5 km E of the Challenger Gold Mine. Site Lease holder: Commonwealth Hill Pastoral Station.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photo / log	Yes, Figure 146, Table 62.
Sample types	Drill chips in chiptrays + ~1 kg bags.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Not from thin-sections, only from binocular microscope observations.
Geochemistry	Yes, Figures 140, 142-145 and Table 58.
XRD mineralogy	No.
PIMA spectral data	Yes, unpublished data only, used by Lintern *et al*. (2002) to produce kaolinite crystallinity indices for unconformity picks.
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	Ag, Bi, ?Cu, Zn.
Useful sampling media	Calcrete, silcrete.
Key reference sources	Lintern *et al*. (2002); Lintern (2004b).

Background

Drillhole 97JBAR064 is selected to form this benchmark because it intersects the thickest transported cover, while the weathered *in situ* regolith is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 24 and the regolith cross-sections of Figures 138, 139. The exploration grid drilling involved RAB methods (mostly without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes typically end in saprock or lower saprolite rather than within fresh gneiss. Cuttings were sampled from the drilled 1-2 m composites (not ideal for regolith investigations). These drillholes were not originally intended for use as benchmarks, they were later sampled and analysed as part of regional regolith and chemical dispersion studies (Lintern *et al*., 2002, 2003).

0-2 m **Transported**: dune sand, aeolian, orange, siliceous uniformly sorted fine to medium sand grains, + earthy carbonate 1-2 m, + nodular calcrete 2-3 m.

2-3 m **Transported**: red-brown hardpan, clay-rich, cemented colluvial.

~3-~4 m **Duricrust**, silcrete developed in fluvial sands, brown to yellowish, cemented coarse-grained rounded to subrounded to subangular quartz grains.

~4-5 m **Transported**: yellow to reddish sandy clay + rounded sand grains.

5-8 m **Transported**: pale pink to buff coloured fluvial sand + silt & clay.

8 m **Unconformity**

8-11 m ***In situ***: ?remnant pedolith, plasmic (clay-rich), yellow flecked & stained.

11-31 m Upper saprolite, pallid, kaolinite-rich + quartz grit, bluish vein quartz at 13-15 + 17-18 + 26-28 m.

31-36 m Saprolite, pinkish grey to creamy mottled interval, clay-rich.

36-60 m Lower saprolite-Saprock, irregularly weathered, greyish with some pink staining, red staining at 55, 57, & 60 m; more competent than above interval. Greyish gneissic remnants (corestones).

NOTE: bedrock not penetrated. E.O.H. at 60 m.

Regolith logged by M.J. Sheard

Figure 146: Benchmark 25, Jumbuck gold prospect drillhole 97JBAR064, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002). Drilling penetrated to 60 m but regolith chiptray sampling stopped at 57 m. In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehab. work.

Table 62: Benchmark 25 regolith log to RAB drillhole 97JBAR064 (after Lintern *et al*., 2002).

Hole: 97JBAR064. **Regolith Line**, Jumbuck gold prospect. Regolith descriptions (combined in-field + laboratory observations).

Location: Zone 53, 375619 E, 6690615 N, GDA 94. **AHD:** 206.593 m (differential GPS data)

Site: near flat area on reddish sand dune, vegetated.

Vegetation: *Acacia aneura* as Tall Open Shrubland over *Acacia aneura* Open Shrubland over *Ptilotus obovatus* and *Maireana georgei* + Low Shrubland over *Eragrostis eriopoda* + Very Open Grassland (Botanical log by S. Lintern).

Soil: Um (sand, loose, medium grained throughout).

Calcrete: nodular.

Logged by: M.J. Sheard, 1999.

Depth (m)	Description of RAB cuttings
0-1	Reddish siliceous dune sand with podsol horizonation developed, loose, medium-grained sand, frosted sub-rounded grains + some earthy carbonate.
1-2	Pale red siliceous dune sand as above + ubiquitous nodular calcrete.
2-~3	Red-brown hardpan, non calcareous but peds and clods are carbonate dusted, ferruginous.
~3-~4	Hardpan as above + brown to yellowish silcrete encapsulating rounded fluvial coarse-grained sand + rounded quartz pebbles (20-40 mm) + angular quartz grit.
~4-5	Yellow to reddish sandy clay with rounded sand grains, fluvial deposit.
5-8	Pale pink to very pale yellow-brown sand + silt + kaolinite. Unconformity at ~8 m.
8-11	Pallid saprolite, kaolinite-rich, yellow staining & flecks, very little quartz grit.
11-31	Pallid saprolite, as above but with more quartz grit, abundant bluish vein quartz at 13-15 m + 17-18 m + 26-28 m.
31-36	Saprolite, pinkish grey to creamy mottled interval, clay-rich.
36-42	Lower saprolite, brownish grey + yellow mottles, becomes pale olive-grey with depth, more competent than above interval.
42->60	Lower saprolite to Saprock (?corestones or irregularly weathered), greyish with some pink staining, red staining at 55, 57, & 60 m; more competent than above interval. Greyish gneissic remnants.
E.O.H.	

In situ Regolith

Bedrock wasn't penetrated by any drillholes on this prospect, but remnant corestones within the saprock indicate it is typical of the Christie Gneiss. Generally saprolite and most of the weathered *in situ* regolith at this site follows descriptions for this prospect set out earlier. However, pedolith appears to be severely truncated by a fluvial channel development. What little pedolith remains is difficult to be certain about regarding pedogenic fabrics and mottling (cuttings alone don't provide large enough fragments for complex weathering fabrics to be properly observed-described).

Transported Regolith

Aeolian dune sand forms the upper most transported cover unit (2 m thick) with an additional ~1 m of primarily colluvial sediment forming a distinctive red-brown hardpan horizon below. Underlying the hardpan is a silcrete duricrust (~1 m thick) cementing fluvial sediment. That silcrete possibly forms a major barrier or impediment to the upward migration of weathering associated solutions derived from buried mineralization. Underneath the silcrete duricrust, more fluvial material occurs (sand + silt + clay, ~4 m thick, containing well rounded to subangular grains) as infill to a section cross-cutting fluvial channel (Figures 138, 139). Together these transported units form an 8 m covering on the weathered basement

It is worth noting here that well rounded fluvial granules were shaken loose during drilling, from the silcrete and associated overlying sediments, and similarly for nodular calcrete in the dune sands. These together formed a significant down-hole contaminant component in the RAB samples (to sample depths of ~30 m) and could mislead unwary sample loggers.

Geochemistry

Significant Au concentrations in the regolith are listed in Table 58. Gold concentrations above background (>1 ppb) were measured in both the transported cover and upper weathered *in situ* regolith at Jumbuck (Figure 140). Benchmark 25 has low order Au concentrations. Especially through the transported cover Near surface, the highest Au concentration was located in a calcrete-silcrete sample towards the centre of the section and on the edge of the slope. More general comments on associated elemental abundances and dispersion are made under the Jumbuck gold prospect heading. A 51 element assay package was applied to all samples and Lintern *et al*. (2002) have plotted elemental abundances for all of those on a cross-sectional backdrop. From those abundance plots a selected set, including Ag, Bi, U and Zn, appear in Figures 142-145.

Golf Bore gold prospect

Background

The Golf Bore gold prospect lies about 36 km NE of the Challenger Gold Mine (Figure 136) and can be accessed via a pastoral lease track running NW to Sandstone Bore from Commonwealth Hill Pastoral Station Homestead. The prospect covers undulating terrain in an area occupied by isolated W trending orange longitudinal dunes of Pleistocene age that form an easterly outlier of the Great Victoria Desert. Dunes cover a substrate of deeply weathered and silcrete capped Archaean Christie Gneiss with a variety of overlying sediments. Basement depressions have been infilled with up to 6 m of sediment. A silcrete duricrust has cemented both weathered *in situ* basement and overlying colluvium-alluvium into a single horizon that has been partly truncated by erosion on one side of a minor palaeochannel. This terrain supports open woodland vegetation (*Eucalyptus* and *Acacia*), numerous woody shrubs (e.g. *Acacia, Eremophila* and *Maireana*) and other plants (*Ptilotus, Eragrostis* and *Atriplex*) (after Lintern *et al*., 2002).

Golf Bore prospect formed part of the larger Gawler Joint Venture tenement coverage, occupying most of the area in Figure 136. This Au anomaly was discovered in 1995 using regional Au-in-calcrete methods (a complex anomaly, with ~NE-SW trend, and has a maximum of 260 ppb Au; Figure 147). It was drilled in 1996, mineralization appears to be restricted to a narrow corridor running diagonally across the prospect, where a resource of 0.72 million tonnes grading 3.29 g/t for 76,814 ounces of Au has been reported (Dominion Mining NL data).

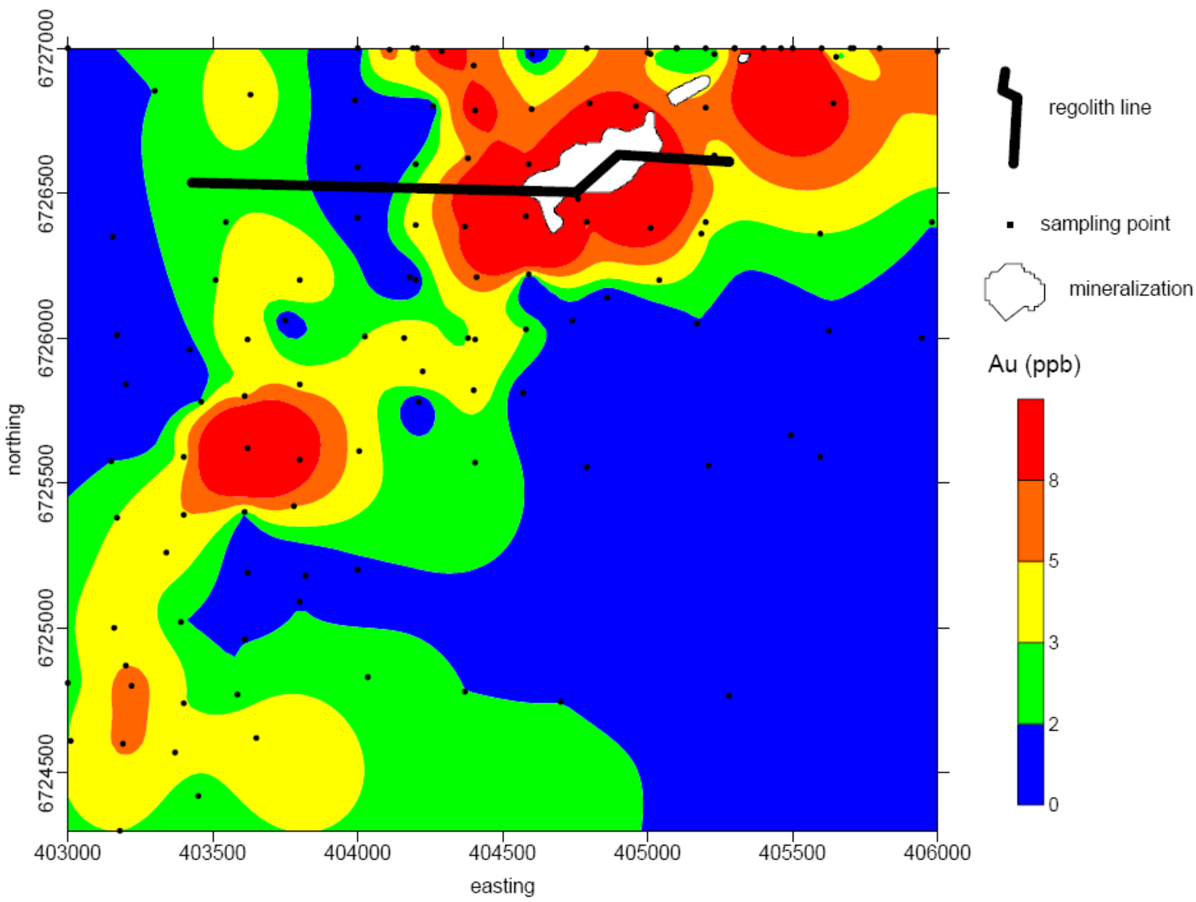


Figure 147: Golf Bore prospect in plan, showing Au-in-calcrete anomaly. Black dots are sample points, black line is the Regolith sampling section of Lintern *et al*. (2002) and Figures 148, 149. No detailed DEM is available for this area. Original data supplied by the Gawler Joint Venture. **Note**: grid coordinates are in AGD66 projection.

Regolith investigations by Lintern *et al*. (2002) began in 1998 as part of a broader regional study examining Au-in-calcrete anomalism. A series of ~EW trending company RAB and RC drillhole lines provided samples for regolith logging, characterisation, and analysis. Field inspection of drillhole spoil piles aided selection of two suitable study lines (local grid 6726500 N and 6726600 N AGD66 [respectively: 6726672 N & 6726772 N GDA94] Figure 147), joined as a single section to investigate the surface geochemical anomalism and mineralization identified by drilling.

In situ Regolith

Bedrock (<5% weathered) was not penetrated by any of the exploration drilling on this prospect, however, remnant corestone fragments in saprock indicate bedrock to be a dark grey quartz-feldspar-biotite-muscovite gneissic granulite of fine- to medium-grain size (Christie Gneiss, Archaean). A more mafic character is expected in drillholes 96GBAR093-96GBAR028 due to the presence of ubiquitous chlorite in the overlying saprock and lower saprolite (Figures 148, 149).

Saprock (>5% to <20% weathered) was penetrated by most drilling (Figures 148, 149), it is generally complexly weathered but its boundary with lower saprolite is not easy to define from cuttings (possibly a gradational interval). It consists of a strongly foliated mafic (chloritic) to biotite-muscovite-rich gneiss, and is commonly coloured grey to greenish grey to near black. Thickness is indeterminate because its base was not intersected, however, it is likely to be in the range 10->20 m.

Saprolite (>20% weathered) is quite a complex weathering zone at Golf Bore (Figures 148, 149), lower saprolite was more uniform of colour and is less weathered than upper saprolite. Lower saprolite is typically greyish to olive-grey or dark green near more mafic lithotypes, and there are intervals at depth where extremely weathered rock is surrounded by much less weathered rock (? faults or shear zones). Remnant biotite and chlorite, plus abundant clay and quartz grit, with some talc are typical components. Upper saprolite is highly variable of colour (pallid, pale to strong yellow, greenish and pink), is of variable competency, and in places has FeOx-FeOH ?mottles and/or fracture staining. Kaolinite plus quartz grit ± chlorite ± sericite are the dominant mineral assemblage. As a whole, saprolite ranges from ~33 to >50 m thick.

Pedolith was difficult to recognise from cuttings because much of the indicator pedogenic fabric is not retained by such small fragments. Along most of the regolith section (Figures 148, 149) pedolith is in-part silicified and/or capped by silcrete. That duricrust commonly extends up into the overlying fluvial sediments, where the pedolith top forms an unconformity located wholly within that silcrete (best seen in outcrop but can be located with PIMA and a formula for determining the "kaolin crystallinity index" or KCI; refer to Lintern *et al*., 2002). Pedolith nearer its base is mostly unsilicified where it retains a clay-rich texture, some FeOH/FeOx staining or mottling is also evident. A thickness range of <1 to >4 m was observed.

Transported Regolith

Positioning the unconformity was difficult at Golf Bore due to its loci being either totally within the silcrete horizon or just below it. Microscopic examinations were checked against the PIMA derived kaolinite crystallinity indices (KCI) but there were some conflicting outcomes due to the paucity of kaolinite remaining within silcrete and the presence of interfering smectite making utility of KCI's problematic (see location of red line on Figures 148, 149). Examining numerous eroding silcrete outcrops on the prospect provided valuable clues on just where the unconformity most likely occurs.

Fluvial sediment, is composed of alluvial sand ± gravel ± pebble-cobble beds in thin sheets (<1-<3 m thick) and these are all totally contained within the silcrete horizon. Clasts are well rounded, although not all have a high degree of sphericity, they are dominantly varieties of quartz with few to no lithics – indicating a relatively mature sediment derived from a well weathered terrain.

Silcrete, is thickest (2 m) at either end of the section and is thinnest (<1 m) to absent below the channel. As stated earlier, the silcrete contains both transported alluvium and silicified residual pedolith-saprolith where angular quartz grit dominates, along with some relict graphite grains. Part of the silcrete horizon may have been removed by erosion within the channel, and where outcropping it mostly displays an erosion truncated profile.

Red-brown hardpan, forms a distinctive strongly coloured colluvial-alluvial unit, infilling a palaeochannel above the silcrete (Figures 148, 149). Composed dominantly of clay with less quartz clasts (angular to subrounded) in a matrix supported framework, this colluvial-alluvial unit is typically partly bound by brown to black FeOx-MnOx cements ± hyaline silica to form an indurated horizon. Here it is restricted to the palaeochannel, elsewhere it forms a more extensive and useful marker bed.

Aeolian dune sand, orange, siliceous, is generally free-running except where cemented by calcrete. Sand grains are frosted, rounded to subangular, and of medium-grain size (uniformly sorted), grains are coated with a thin ferruginous skin and elsewhere have been dated by optical methods to age range from

~250 ka to <20 ka (Sheard *et al*., 2006). There is no illuviated clay or silt within these sands (Figures 148, 149)

Gypsum, dominantly very crystalline, occurs across the section, within and/or below the siliceous horizon, the pedolith and upper saprolite. It forms another indurated zone where interlocking pencil sized colourless to honey coloured crystals abound. Gypsum may comprise ~20-40 % of this zone, ranging from <1 to ~3 m thick (thickest below the palaeochannel, Figure 149), it therefore potentially dilutes any host materials and remnant geochemical signatures.

Calcrete, pale hues, occurs across the upper regolith within the dune sand, coating exposed silcrete and within thin soils. Nodules are dominant within the dunes but earthy powders and coatings occur on or within the upper hardpan, with laminated coatings to fracture infill on silcrete. Within the dunes, calcrete has developed at more than one level (Figure 149) but when initially sampled by explorationists it is the uppermost level that would have been taken for assay.

Geochemical expression

Gold concentrations in calcrete (n=6) sampled from above mineralization have a mean concentration of 20 ppb against a background of about 3 ppb (n=8) (Figure 150). Calcrete over the mineralization zone has developed in about 2 m of colluvium over silcrete (non-calcareous) also containing elevated Au concentrations similar to those within the calcrete. The highest Au concentrations (85 ppb) are in silicified saprolite immediately beneath a Au- and Ca-rich silcreted horizon indicating a possible origin for the Au anomaly. Unfortunately, the corresponding colluvium and sand above these materials was not sampled due to poor drill spoil condition, so it was not possible to establish whether the Au anomaly is continuous to the surface. The effect of gypsum on the distribution of Au is unclear here but elsewhere gypsum dilutes the Au geochemical signal (see Volume 1, Boomerang gold prospect). Gold concentrations in the gypseous zone are not anomalous (<10 ppb) and they appear to be slightly diluted relative to the surface (Lintern *et al*., 2002, Lintern 2004b).

Gold is weakly correlated with As, Mn, and W in drill cuttings. Some of the more significant correlations between major and trace elements are available in Table 63, Selected drillhole intervals with elevated Au and basemetal concentrations are summarised in Table 64.

Saprolite and saprock are relatively rich in Fe, Mg, As, Co, Cr, Cs, Mn, Ni and Zn, derived from cordierite, garnet, feldspar, muscovite (sericite) and biotite in the bedrock. Higher in the profile, these minerals have largely weathered to kaolinite, with a subsequent depletion of chalcophile and siderophile elements. However, the upper regolith still retains the elemental signatures noted at depth, though at a lower concentration.

Table 63: Golf Bore gold prospect, the association between major and trace elements (Lintern 2004b).

Major element	Trace element association	Interpretation
Ca	S and Sr	gypsum, calcrete.
K	Ba, Cs, Rb, Tl and (mainly) light REE	white micas and feldspars.
Mg	Co, Cu, Cs, Fe, Mn and Zn	adsorption by Fe oxides and/or original mafic composition.
Ti	Th, Nb, and U	similar ionic radii (Nb).

Table 64: Golf Bore gold prospect, highest Au concentrations and other anomalous drillhole intervals (Lintern 2004b).

Drillhole	Interval (m)	Analyses (ppm except Au)	Regolith zone
96GBAR102	22-23	Au 85 ppb, As 145	saprolite
96GBAR93	46-47	Au 284 ppb, As 120	saprolite
96GBAR93	35-36	Au 483 ppb	saprolite
96GBAR249	19-20	Au 5 ppb, Cu 420, As 100	saprolite
96ORAR10	25-26	Au 2 ppb, Cu 600	saprolite

In Summary: the Golf Bore gold prospect case study outlined above indicates that elevated Au concentrations in calcrete can be detected in thin (<6 m) transported cover over mineralization. Gold also occurs in silcrete developed over mineralization (as was also demonstrated at the Challenger Gold Deposit) and may argue for a localised river bank origin for the Au in transported cover. The effect of gypsum on Au concentrations is unclear – not notably diluted nor enhanced (after Lintern 2004b).

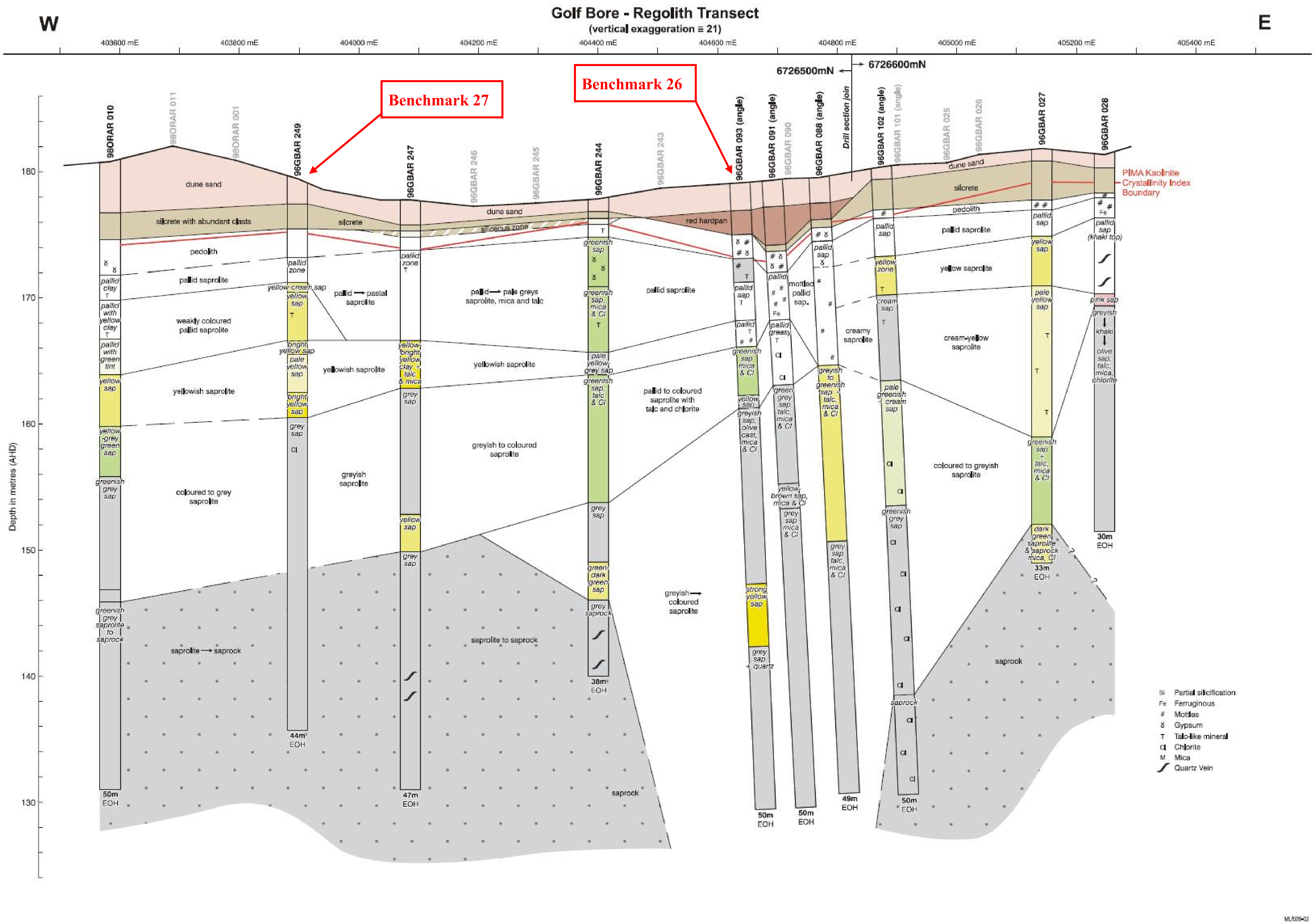


Figure 148: Golf Bore gold prospect, full regolith section along line displayed in Figure 147 (Lintern *et al.*, 2002). Benchmarks 26 and 27 are indicated.

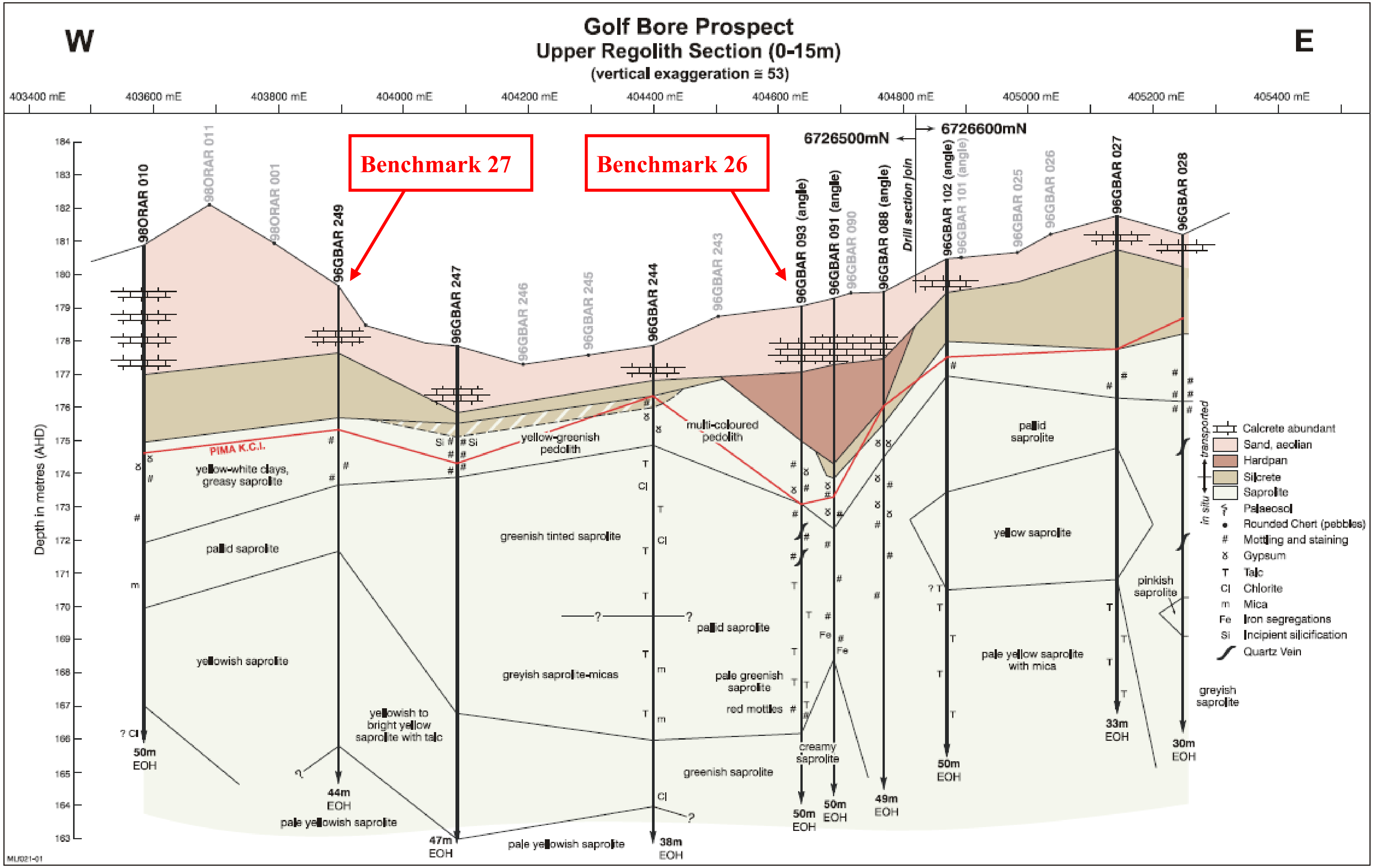
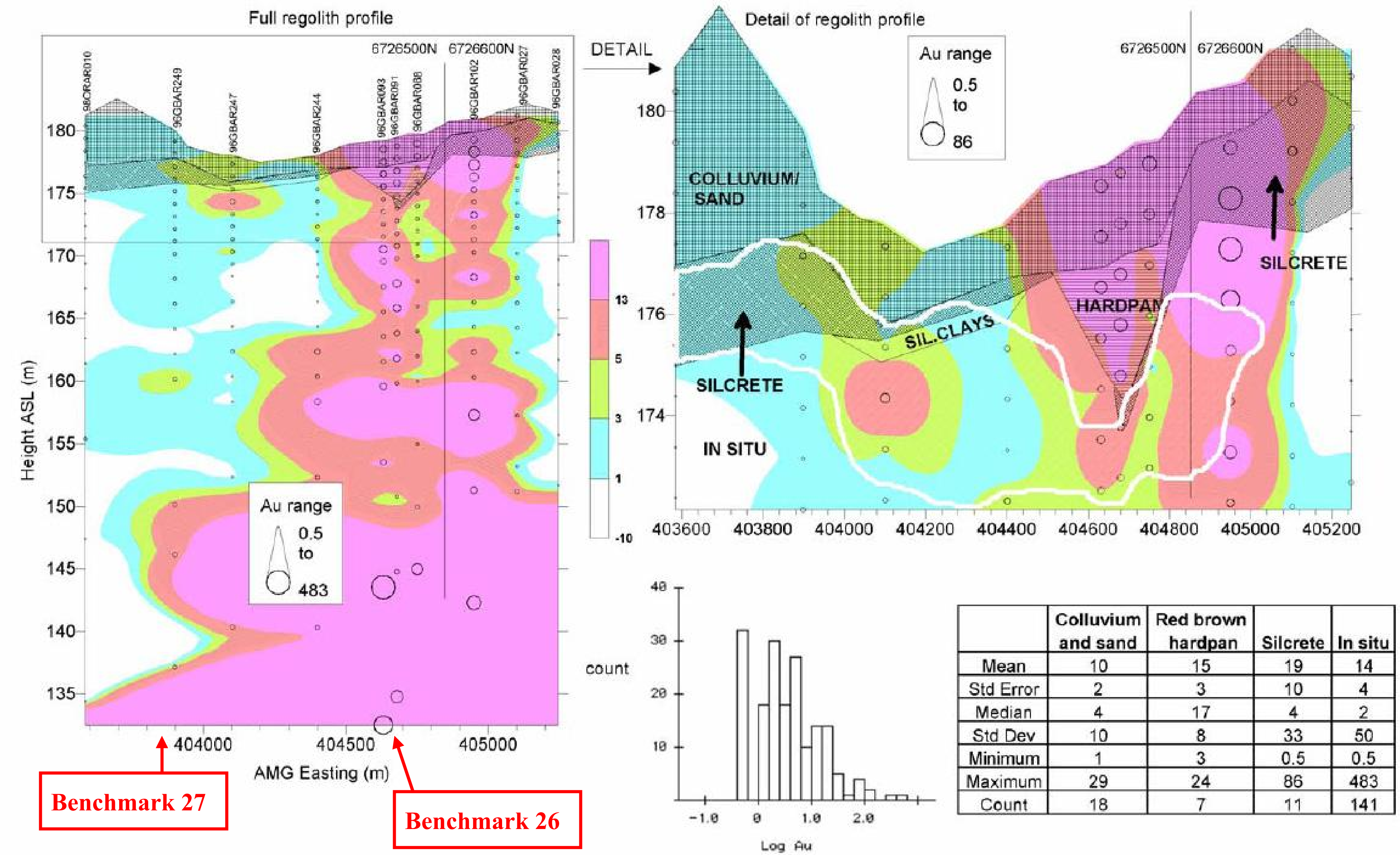


Figure 149: Golf Bore gold prospect, upper regolith section along line displayed in Figure 147 (Lintern *et al*., 2002). Benchmarks 26 and 27 are indicated.



	Colluvium and sand	Red brown hardpan	Silcrete	In situ
Mean	10	15	19	14
Std Error	2	3	10	4
Median	4	17	4	2
Std Dev	10	8	33	50
Minimum	1	3	0.5	0.5
Maximum	29	24	86	483
Count	18	7	11	141

Figure 150: Golf Bore gold prospect regolith section, regolith architecture and Au geochemical expression (*c.f.* Figures 147-149). All data are in ppb (Lintern, 2004b). Benchmarks 26 and 27 are indicated.

Benchmark 26: drillhole 96GBAR093

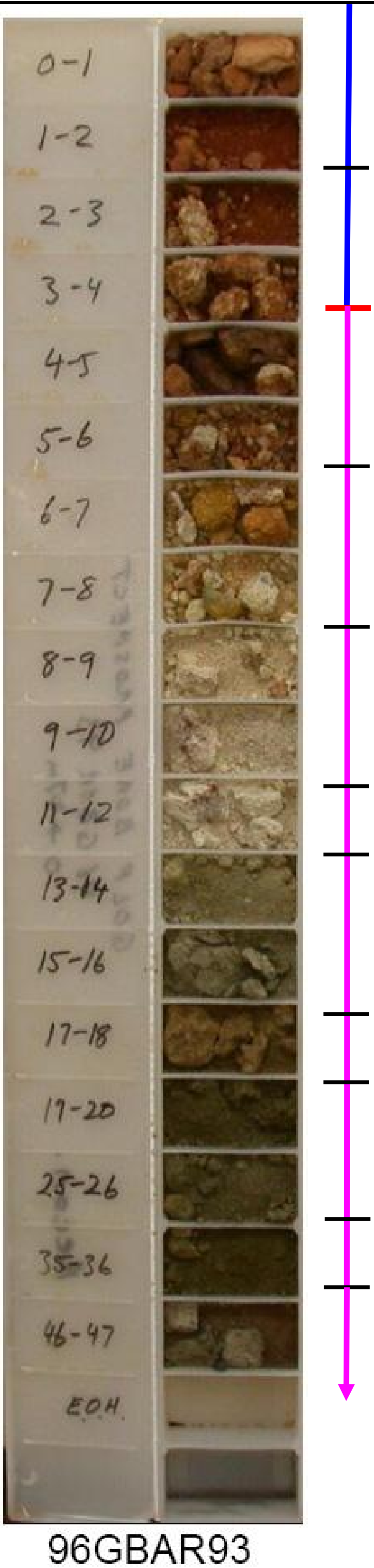
Quick reference items are set out in Table 65; detailed descriptions, figures and data tables follow on below. Golf Bore prospect lies about 36 km NE of the Challenger Gold Mine and can be accessed via a pastoral lease track running NW to Sandstone Bore from Commonwealth Hill Pastoral Station Homestead (Figures 110-112 136, 147). Drilling for this RC hole was angular (60^o dip → 090^o) while all RAB holes were vertical. A summary of this profile is provided in Table 66 and chiptray photograph with regolith zonation is in Figure 151. Geochemical data are presented in Figures 150, 152-155 and Tables 63, 64.

Table 65: Benchmark 26 reference data; drillhole 96GBAR093 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 110-112, 136.
Local-site location map	Figures 147-149.
GPS coordinates, attitude & elevation	RC drillhole 96GBAR093: Zone 53, 404759 E, 6726683 N, GDA 94. **Attitude**: 60^o dip → 090^o. **AHD:** 179.026 m (differential GPS data).
Site access, owner	About 36 km NE of the Challenger Gold Mine (Figure 136) and can be accessed via a pastoral lease track running NW to Sandstone Bore from Commonwealth Hill Pastoral Station Homestead. Site Lease holder: Commonwealth Hill Pastoral Station.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photo / log	Yes, Figure 151, Table 66.
Sample types	Drill chips in chiptrays + ~1 kg bags
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Not from thin-sections, only from binocular microscope observations.
Geochemistry	Yes, Figures 150, 152-155 and Tables 63, 64.
XRD mineralogy	No.
PIMA spectral data	Yes, unpublished data only, used by Lintern *et al*. (2002) to produce kaolinite crystallinity indices for unconformity picks.
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	As, ?W.
Useful sampling media	Calcrete, alluvium-colluvium & silcrete.
Key reference sources	Lintern *et al*. (2002); Lintern (2004b).

Background

Drillhole 96JGAR093 is selected to form this benchmark because it intersects a thick segment of palaeochannel sediment and other transported cover, while the weathered *in situ* regolith is relatively straight forward regarding its interpretation. This drillhole also contains some high Au concentrations and so do the overlying transported cover units. A comparison is provided through Benchmark 27 and the regolith cross-sections of Figures 148, 149. Exploration grid drilling on this prospect mostly involved RAB methods (typically without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes terminated in saprock or lower saprolite rather than within fresh gneiss. Moreover, the same is true for all infill RC drilling, in that those mineralization targeting drillholes also terminated in saprolite-saprock due to the weathering front dropping well below 55 m around mineralization. Cuttings were sampled from the drilled 1-2 m composites (not ideal for regolith investigations). These drillholes were not originally intended for use as benchmarks; they were later sampled and analysed as part of regional regolith and chemical dispersion studies (Lintern *et al*., 2002, 2003).



0-2 m	**Transported**: aeolian sand, orange, siliceous uniformly sorted fine to medium sand grains, + nodular calcrete.
2-<4 m	**Transported**: red hardpan, clay-rich + rounded gravel and pebbles, cemented colluvial-alluvial.
4 m	**Unconformity**
<4-6 m	***In situ***: remnant pedolith (waste mantle) plasmic (clay-rich), multicoloured + abundant crystalline gypsum.
6-8 m	Pallid saprolite, bright yellow mottles/stains, abundant grey vein quartz {+ down hole contamination from hardpan as water worn gravel & pebbles].
8-11 m	Pallid saprolite, greasy feel (? talc) + kaolinite & quartz grit.
11-13 m	Upper saprolite, greenish tint, kaolinite + talc + quartz, red mottling at 12-13 m.
13-17 m	Upper saprolite, greenish, quartz + kaolinite + micas + chlorite.
17-18 m	Saprolite, yellowish, quartz + kaolinite + micas.
18-32 m	Saprolite, greyish with olive-green tint, quartz + kaolinite + micas + chlorite.
32-37 m	Saprolite, strong yellow, clay-rich.
36->47 m	Saprolite, greyish with abundant grey vein quartz; more competent than above interval.

NOTE: saprock and bedrock not penetrated.
E.O.H. at 50 m.

Regolith logged by M.J. Sheard

Figure 151: Benchmark 26, Golf Bore gold prospect drillhole 96GBAR093, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002). Drilling penetrated to 50 m but regolith chiptray sampling stopped at 47 m. In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehabilitation work. **Note:** depths have not been corrected for hole angle; to obtain true depths multiply by 0.86.

Table 66: Benchmark 26, regolith log to RC drillhole 96GBAR093 (after Lintern *et al*., 2002).

Hole: 96GBAR093. **Regolith Line**, Golf Bore gold prospect. Regolith descriptions (combined in-field + laboratory observations).

Location: Zone 53, 404759 E, 6726683 N, GDA 94. **AHD:** 179.026 m (differential GPS data)

Attitude: 60^o dip → 090^o.

Site: flat sandy area, vegetated.

Vegetation: *Acacia aneura* as Tall Shrubland over *Eremophila latrobei, Maireana georgei* and *Atriplex vesicaria* Low Open Shrubland, + many vehicle tracks (Botanical log by S. Lintern).

Soil: Um (sand, loose, medium grained throughout).

Calcrete: nodular.

Logged by: M.J. Sheard, 1999.

Depth (m)	Description of RAB cuttings
0-2	Reddish siliceous dune sand with paler podsol horizonation developed, loose, medium-grained sand, frosted sub-rounded grains + nodular calcrete.
2-<4	Red hardpan and calcrete, bulk is non calcareous but peds and blocks are carbonate dusted at 2-3 m. Unconformity just above 4 m.
<4-6	Pedolith (waste mantle) capping to saprolite, multicoloured and gypseous (well crystallised).
6-8	Pallid upper saprolite with bright yellow mottling & staining, mostly kaolinite + quartz grit, abundant grey vein quartz. [down hole contamination from red hardpan as well rounded quartz gravel and pebbles].
8-11	Pallid interval, greasy feel to cuttings (?talc) + kaolinite and quartz grit.
11-13	As above interval, but with greenish tint to saprolite, kaolinite + talc + quartz grit, red mottling at 12-13 m.
13-17	Greenish saprolite, quartz + kaolinite + micas + chlorite.
17-18	Yellowish saprolite, quartz + kaolinite + micas.
18-32	Greyish saprolite, with olive-green tint, quartz + kaolinite + micas + chlorite.
32-37	Saprolite, strong yellow hue, quartz + kaolinite + micas.
37->50	Greyish saprolite, greyish with abundant grey vein quartz; more competent than above interval.
E.O.H.	**Note:** depths have not been corrected for hole angle, to obtain true depths multiply by 0.86.

In situ Regolith

Bedrock wasn't penetrated by any drillholes on this prospect, but remnant corestones within the saprock indicate it has components typical of the Archaean Christie Gneiss. Generally saprolite and most of the weathered *in situ* regolith at this site follow descriptions for this prospect set out earlier. Pedolith however, appears to be truncated, probably by erosion (the site is on a buried escarpment where the silcrete roughly follows the palaeotopography). What remaining pedolith there is, is partly encapsulated by the silcrete horizon, and the remainder is difficult to be certain about (cuttings alone don't provide large enough fragments for complex weathering fabrics to be properly observed-described).

Transported Regolith

Aeolian dune sand forms the primary transported cover (~3 m thick) with an additional <1 m of primarily fluvial sediment (sand + gravel + pebbles +?colluvium) encapsulated by the silcrete duricrust. That silcrete possibly forms a major barrier or impediment to the upward migration of weathering associated solutions derived from buried mineralization.

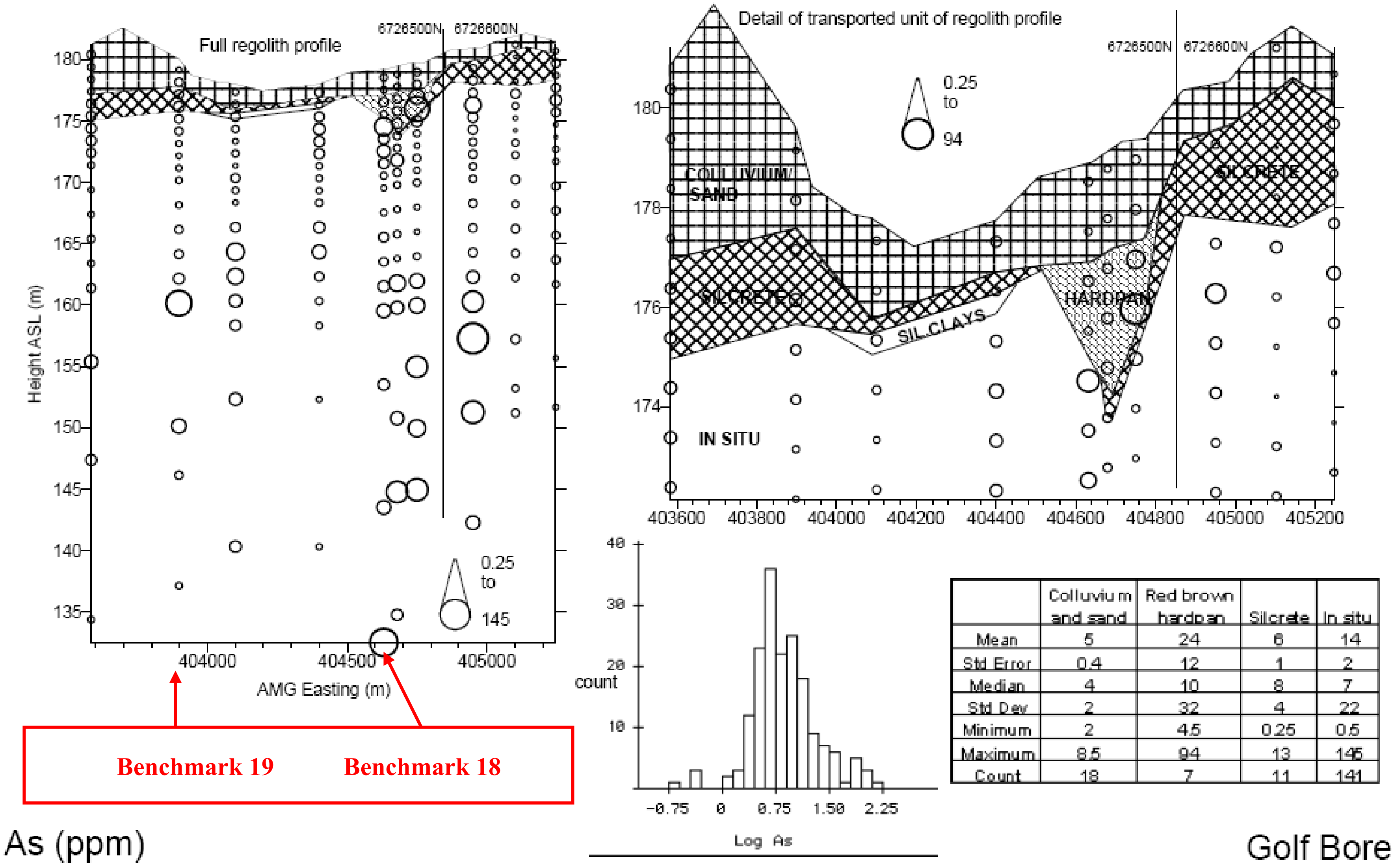
It is worth noting here that well rounded fluvial pebbles were shaken loose during drilling, from the silcrete and associated sediments, and similarly for nodular calcrete in the dune sands. These together formed significant down-hole contaminants in the RAB samples (to sample depths of ~30 m) and could mislead unwary sample loggers.

Geochemistry

Significant Au concentrations in the regolith are listed in Tables 63, 64. Gold concentrations above background (>1 ppb) were measured in both the transported cover and upper weathered *in situ* regolith at Golf Bore prospect (Figure 150). This Benchmark has the highest Au concentrations (Au 284 ppb at 35-36 m & 483 ppb at 46-47 m) in saprolite and those correspond with high Au concentrations found in the deeper regolith. Near surface, the highest Au concentration were located in and around a palaeochannel where sediment may be sourcing Au from the underlying-silcrete. The relationship between Au and Ca in the upper regolith is displayed under Benchmark 27 Geochemistry (Figure 157). That relationship is more tenuous within the heavily gypcreted zone due to metal signature dilution by gypsum. More general comments on associated elemental abundances and dispersion are made under the Golf Bore gold prospect Geochemistry heading.

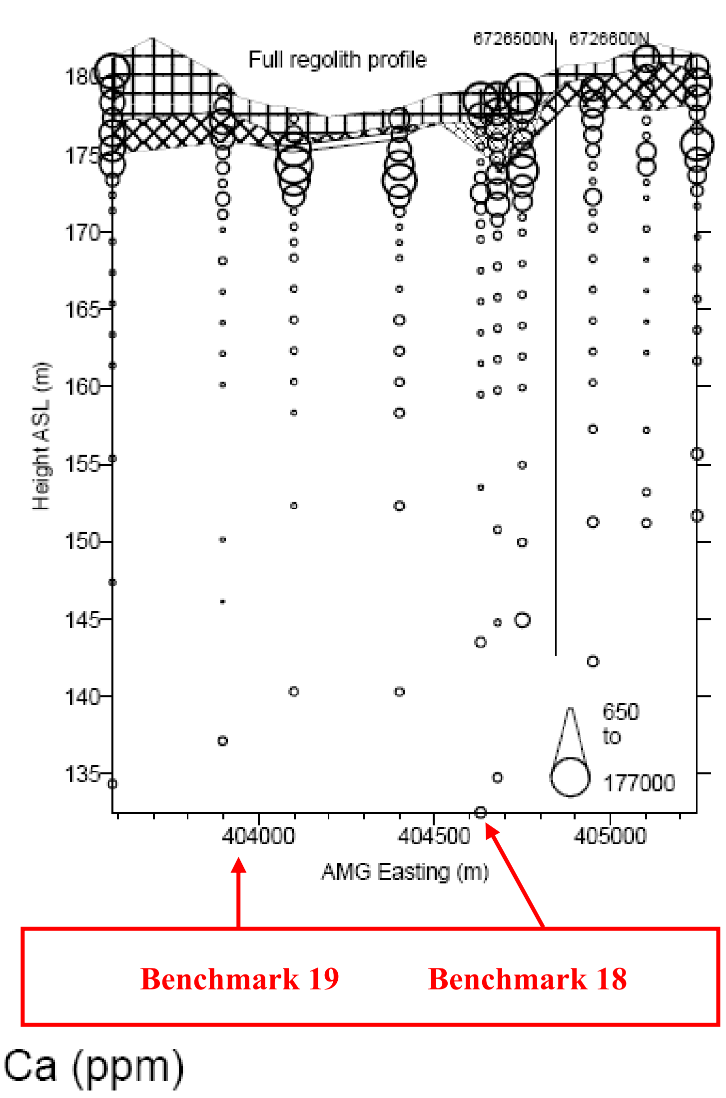
A 51 element assay package was applied to all samples and Lintern *et al*. (2002) have plotted elemental abundances for all of those on a cross-sectional backdrop. From those abundance plots a selected set, including As, Ca, S and W appear in Figures 152-155. Plots of Ca and S (Figures 153, 154), when compared, demonstrate the presence of both calcrete and abundant gypsum in the upper regolith. Arsenic is anomalous within the mineralized zone, its weathered equivalent, and also in the transported regolith. It therefore may serve as a regional pathfinder element to more cryptic mineralization in this area – particularly where Au signatures are weak. Tungsten here may serve as a deeper level secondary pathfinder element, although it is very low level in the upper regolith, and Au provides a much stronger signal on its own.

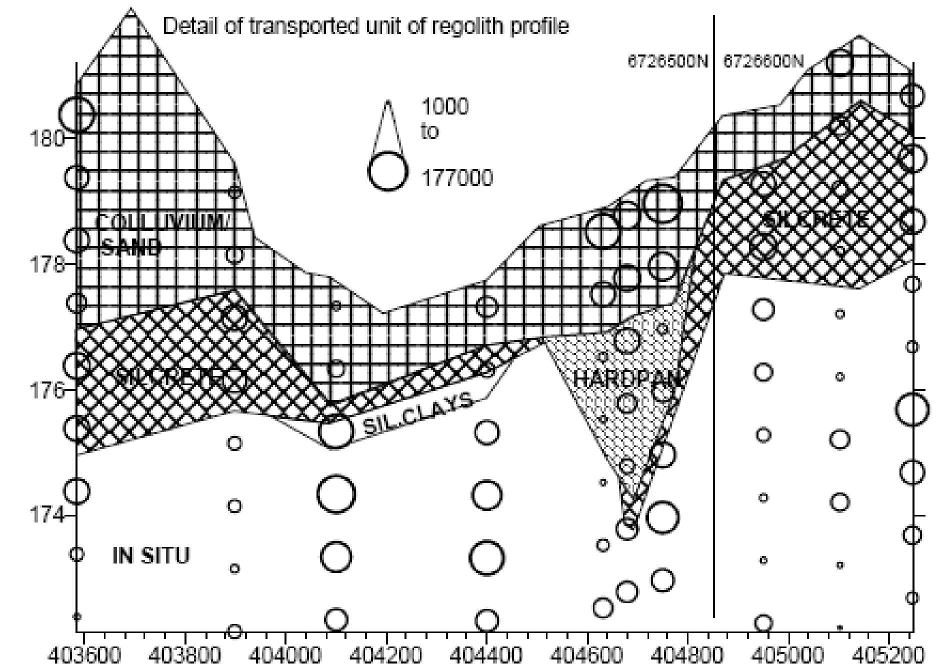
Compare this geochemical expression with that of Benchmark 27 set away from the defined Au mineralization and where the aeolian transported cover is thicker than for Benchmark 26.

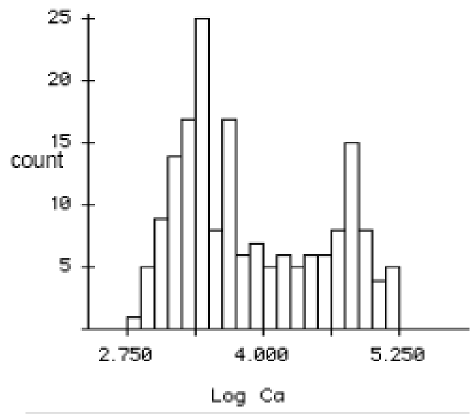


	Colluvium and sand	Red brown hardpan	Silcrete	In situ
Mean	5	24	6	14
Std Error	0.4	12	1	2
Median	4	10	8	7
Std Dev	2	32	4	22
Minimum	2	4.5	0.25	0.5
Maximum	8.5	94	13	145
Count	18	7	11	141

Figure 152: Golf Bore gold prospect regolith section, regolith architecture and As geochemical expression (*c.f.* Figures 150, 153-155). Lintern *et al*. (2002).



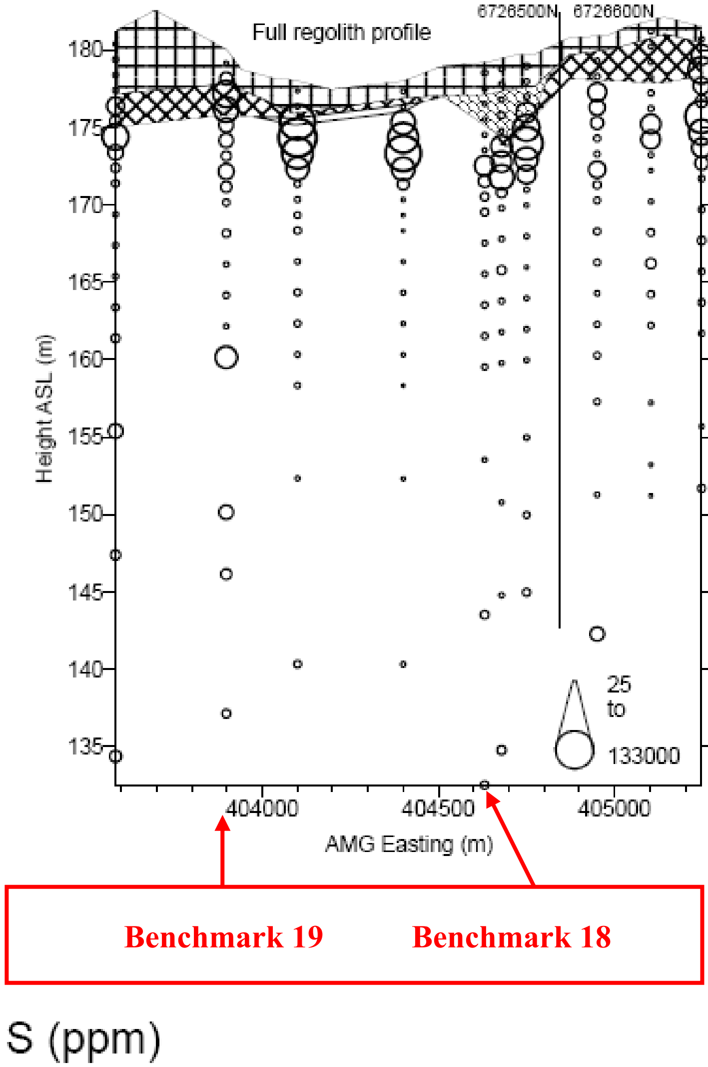


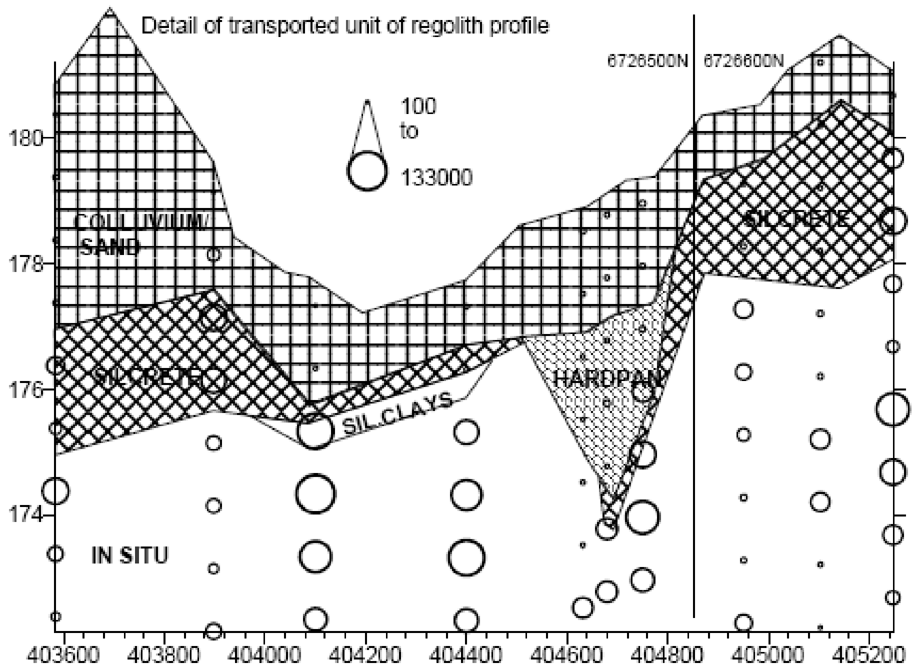


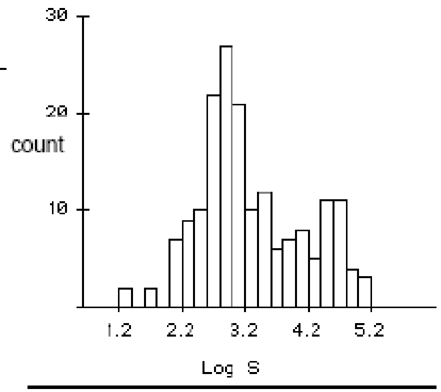
	Colluvium and sand	Red brown hardpan	Silcrete	In situ
Mean	70431	26729	57064	15512
Std Error	10863	9286	7803	2479
Median	64700	19700	69900	3350
Std Dev	48087	24570	25879	29441
Minimum	5460	3050	5300	650
Maximum	177000	70000	86900	164000
Count	18	7	11	141

Golf Bore

Figure 153: Golf Bore gold prospect regolith section, regolith architecture and Ca geochemistry (calcrete + gypsum; *c.f.* Figures 150, 152, 154, 155). Lintern *et al.* (2002).



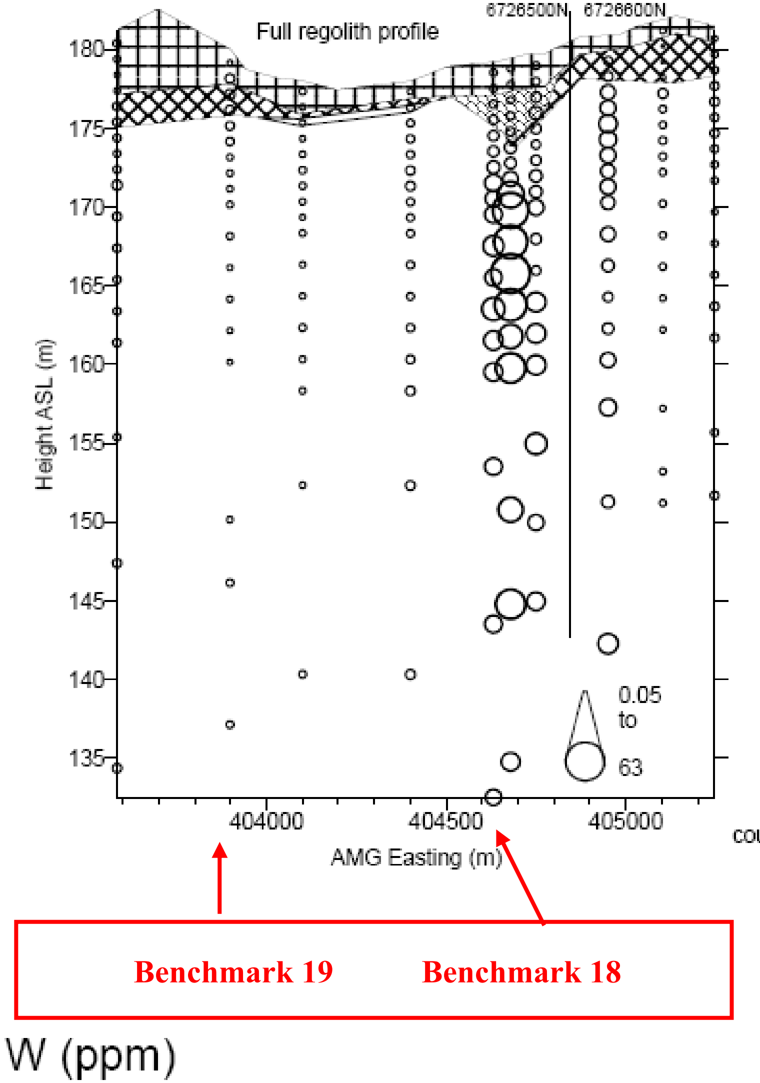


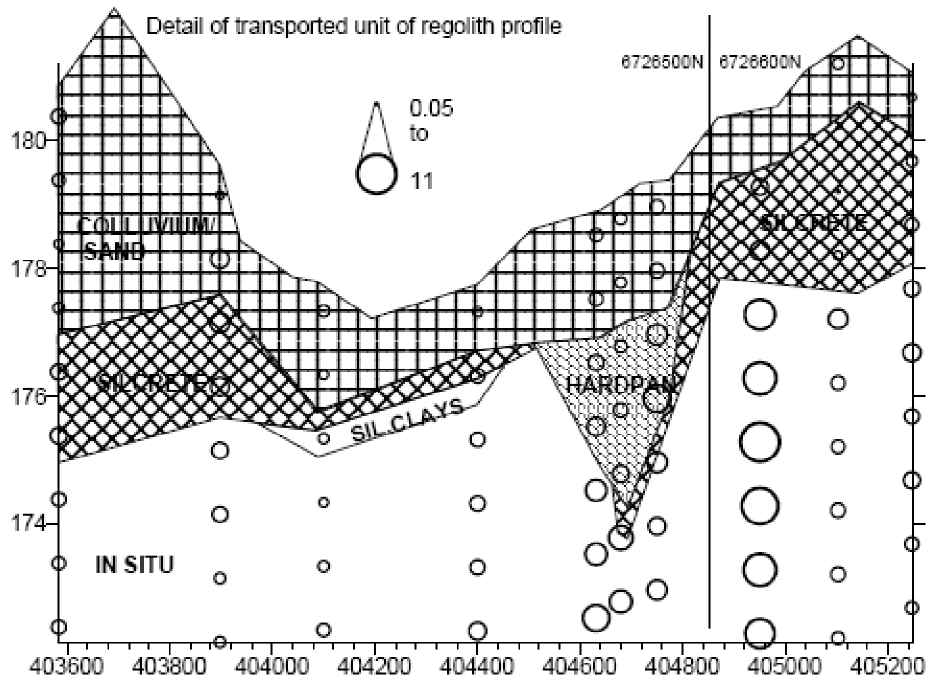


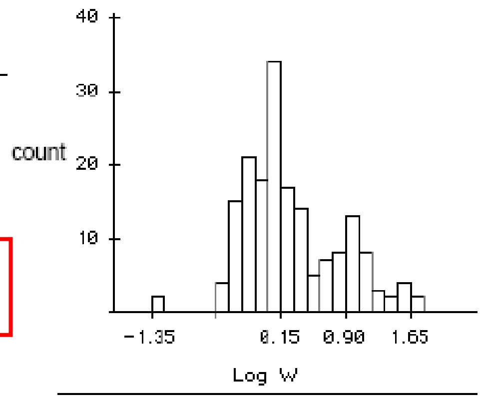
	Colluvium and sand	Red brown hardpan	Silcrete	In situ
Mean	1094	5107	23518	12206
Std Error	528	4452	7206	2082
Median	625	650	22600	1460
Std Dev	2240	11780	23898	24720
Minimum	100	200	250	25
Maximum	10000	31800	60000	133000
Count	18	7	11	141

Golf Bore

Figure 154: Golf Bore gold prospect regolith section, regolith architecture and S geochemistry (gypsum; *c.f.* Figures 150, 152, 153, 155). Lintern *et al*. (2002).







	Colluvium and sand	Red brown hardpan	Silcrete	In situ
Mean	0.8	2.1	1.6	5.6
Std Error	0.1	0.5	0.5	0.8
Median	0.7	1.7	1.5	1.5
Std Dev	0.5	1.4	1.8	9.9
Minimum	0.3	0.8	0.05	0.3
Maximum	2	5	6.5	63
Count	18	7	11	141

Golf Bore

Figure 155: Golf Bore gold prospect regolith section, regolith architecture and W geochemistry (*c.f.* Figures 150, 152-154). Lintern *et al*. (2002).

Benchmark 27: drillhole 96GBAR249

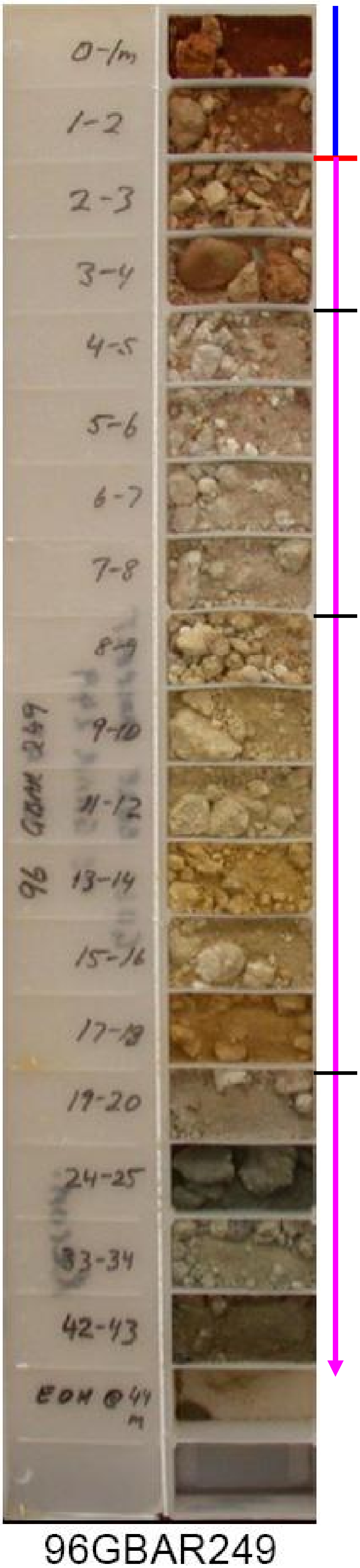
Quick reference items are set out in Table 67; detailed descriptions, figures and data tables follow on below. Golf Bore prospect lies about 36 km NE of the Challenger Gold Mine and can be accessed via a pastoral lease track running NW to Sandstone Bore from Commonwealth Hill Pastoral Station Homestead (Figures 110-112, 136, 147). Drilling for this RAB hole was vertical, while all RC holes were angular (60^{o} dip → 090^{o}). A summary of this profile is provided in Table 68 and chiptray photograph with regolith zonation is in Figure 156. Geochemical data are presented in Figures 150, 152-155, 157 and Tables 63, 64.

Table 67: Benchmark 27 reference data; drillhole 96GBAR249 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 110-112, 136.
Local-site location map	Figures 147-149.
GPS coordinates, attitude & elevation	RAB drillhole 96GBAR249: Zone 53, 404026 E, 6726683 N, GDA 94. Vertical. **AHD:** 179.650 m (differential GPS data.).
Site access, owner	About 36 km NE of the Challenger Gold Mine (Figure 136) and can be accessed via a pastoral lease track running NW to Sandstone Bore from Commonwealth Hill Pastoral Station Homestead. Site Lease holder: Commonwealth Hill Pastoral Station.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photo / log	Yes, Figure 156, Table 68.
Sample types	Drill chips in chiptrays + ~1 kg bags.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Not from thin-sections, only from binocular microscope observations.
Geochemistry	Yes, Figures 150, 152-155, 157 and Tables 63, 64.
XRD mineralogy	No.
PIMA spectral data	Yes, unpublished data only, used by Lintern *et al*. (2002) to produce kaolinite crystallinity indices for unconformity picks.
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	?As.
Useful sampling media	Calcrete & ? silcrete.
Key reference sources	Lintern *et al*. (2002); Lintern (2004b).

Background

Drillhole 96GBAR249 is selected to form this benchmark because it has a thin (2 m) transported cover and is sited away from the defined Au mineralization. The weathered *in situ* regolith is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 26 and the regolith cross-sections of Figures 148, 149. Exploration grid drilling on this prospect mostly involved RAB (typically without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes have terminated in saprock or lower saprolite rather than within fresh gneiss. Moreover, the same is true for all infill RC drilling, in that those mineralization targeted drillholes also terminated in saprolite-saprock due to the weathering front dropping to well below 55 m around mineralization. Cuttings were sampled from the drilled 1-2 m composites (not ideal for regolith investigations). These drillholes were not originally intended for use as benchmarks; they were later sampled and analysed as part of regional regolith and chemical dispersion studies (Lintern *et al*., 2002, 2003).



0-<2 m **Transported**: aeolian sand, reddish, siliceous uniformly sorted fine to medium grains, + nodular calcrete + minor silcrete with rounded quartz clasts & vein quartz (?lag).

>2-4 m ***In situ***: pedolith, silcrete with enclosed rounded quartz clasts & grey vein quartz. **Unconformity** >2 m.

<4-8 m Lower pedolith (waste mantle) plasmic (clay-rich) pallid & yellow mottled.

8-19 m Saprolite, yellowish to strong yellow, kaolinite + quartz, chalky.

19-44 m Saprolite, greys with olive-green chlorite-rich zones, some FeOH staining & abundant grey quartz; quartz + kaolinite + chlorite, more competent than above interval.

NOTE: saprock and bedrock not penetrated.
E.O.H. at 44 m.

Regolith logged by M.J. Sheard

Figure 156: Benchmark 27, Golf Bore gold prospect drillhole 96GBAR249, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002). Drilling penetrated to 44 m but regolith chiptray sampling stopped at 43 m. In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehabilitation work.

Table 68: Benchmark 27, regolith log to RAB drillhole 96GBAR249 (after Lintern *et al*., 2002).

Hole: 96GBAR249. **Regolith Line**, Golf Bore gold prospect. Regolith descriptions (combined in-field + laboratory observations).

Location: Zone 53, 404026 E, 6726683 N, GDA 94. **AHD:** 179.650 m (near drillhole 98ORAR001; differential GPS data)

Attitude: vertical

Site: on dune-silcrete rise.

Vegetation: *Acacia aneura* as Tall Open Shrubland over Shrubland over *Maireana georgei* and *Maireana integra* Low Open Shrubland over *Eragrostis eriopoda* Very Open Grassland (many dead *Acacia aneura* trees). (Botanical log by S. Lintern).

Soil: Um (sand, loose, medium grained throughout).

Calcrete: nodular.

Logged by: M.J. Sheard, 1999.

Depth (m)	Description of RAB cuttings
0-1	Reddish siliceous dune sand, loose, medium-grained, frosted sub-rounded grains + nodular calcrete.
1-2	Reddish siliceous dune sand, loose, medium-grained, frosted sub-rounded grains + calcrete + some silcrete & grey vein quartz.
2-4	Pedolith, silcrete with enclosed rounded quartz clasts & grey vein quartz. Unconformity >2 m.
4-6	Pedolith, cream clay zone (plasmic zone), yellow mottles, waste mantle.
6-8	Pallid interval, kaolinite and quartz grit.
8-9	Saprolite, yellow to off-white & grey, predominantly kaolinite.
9-13	Saprolite, yellowish, weak greasy feel, kaolinite + quartz +?talc.
13-14	Saprolite, bright yellow, kaolinite + quartz.
14-17	Saprolite, pale yellow, kaolinite + quartz.
17-19	Saprolite, strong yellow hue, kaolinite + quartz.
19->44	Saprolite, grey with olive-green chlorite-rich zones & abundant grey quartz; more competent than above interval.
E.O.H.	

In situ Regolith

Bedrock was not penetrated by drilling on this prospect, but remnant corestones within the saprock indicate it has components typical of the Christie Gneiss. Generally saprolite and most of the regolith at this site follow descriptions for this prospect set out earlier. A thick saprolite is present here and drilling may have come close to penetrating saprock. The pedolith appears to be truncated, probably by erosion (the site is on a buried escarpment where the silcrete roughly follows the palaeotopography). Some of the upper basement derived pedolith is partly encapsulated by the silcrete horizon, and the remainder is plasmic zone ± arenose zone (cuttings don't provide enough textural information to be certain).

Transported Regolith

Aeolian dune sand forms the primary transported cover (~2 m) with an additional <1 m of primarily fluvial-colluvial sediment (sand + gravel) encapsulated by the silcrete duricrust. That silcrete possibly forms a major barrier or impediment to the upward migration of weathering associated solutions derived from buried mineralization.

Geochemistry

Significant Au concentrations in the regolith on this prospect are listed in Tables 63, 64. Gold concentrations above background (>1 ppb) were measured in both the transported cover and upper weathered *in situ* regolith at Golf Bore prospect (Figure 150). However. this Benchmark is set well back from any defined Au mineralization and so its Au-in-regolith signatures are very low (1-3 ppb, Figures 150, 157. More general comments on associated elemental abundances and dispersion are made under the Golf Bore gold prospect Geochemistry section.

A 51 element assay package was applied to all samples and Lintern *et al*. (2002) have plotted elemental abundances for all of those on a cross-sectional backdrop. From those abundance plots a selected set, including As, Ca, S and W appear in Figures 152-155. Plots of Ca and S (Figures 153, 154) when compared demonstrate the presence of both calcrete and abundant gypsum in the upper regolith. Arsenic is anomalous within the mineralized zone, its weathered *in situ* equivalent, and also in the transported regolith. It therefore may serve as a regional pathfinder element to more cryptic mineralization in this area – particularly where Au signatures are weak. Tungsten may serve as a deeper level secondary pathfinder element, although it is very low level in the upper regolith here, and Au provides a much stronger signal on its own.

Compare this geochemical expression with that of Benchmark 26 over the defined Au mineralization and where the aeolian transported cover is marginally thicker than for Benchmark 26.

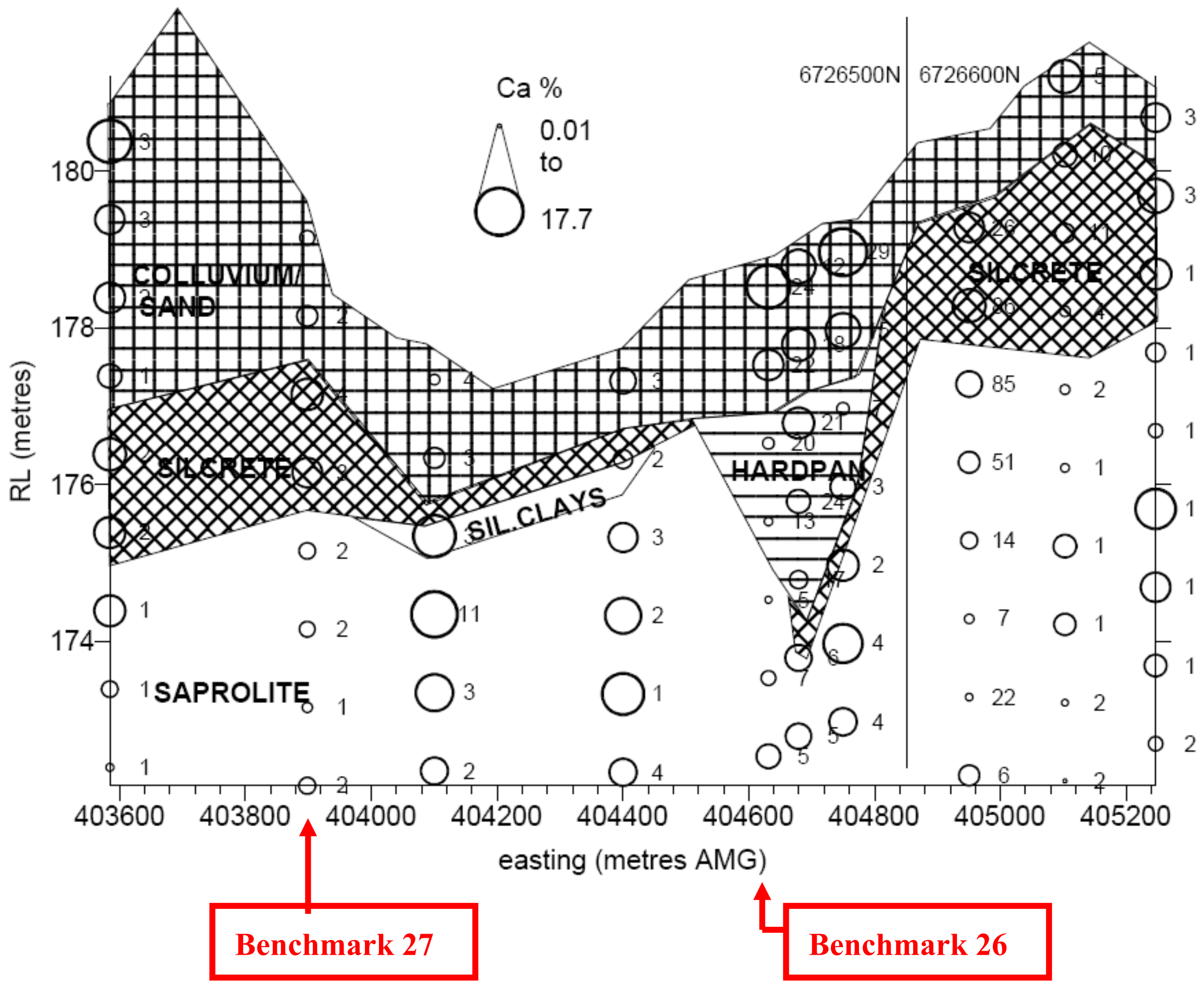


Figure 157: Golf Bore gold prospect. Distribution of Au (numerical data in ppb) and Ca (circular symbols) in the upper regolith section. Calcium is present principally as calcrete and gypsum.

South Hilga gold prospect

Background

South Hilga gold prospect lies about 130 km NW of Tarcoola and about 32 km ~W of Mulgathing Pastoral Station Homestead (Figure 136). It can be accessed via pastoral lease tracks and gazetted unsealed roads. The area is very flat and forms the lower ground between two silcrete capped relict mesa-plateaus (S and N of prospect). Reconnaissance bedrock drilling by SA Mines and Energy Department in 1991, included drill samples from this location. Gold was reported as being anomalous from the adjacent Woomera Tank drilling (~5 km NW of the South Hilga site) and from the South Hilga site (MIQ, 1991). Dominion Mining NL quickly assessed those drill samples, and applied the AMIRA developed Au-in-calcrete methodology (from W. Australia) to the near surface calcrete recovered by drilling. Their assay results demonstrated that Au was detectable in the pedogenic calcrete horizon. Thereby this technique became applicable to South Australian regolith. Dominion then acquired the relevant exploration tenements, leading eventually to their Challenger Gold Deposit discovery in 1994 (Edgecombe, 1997).

The South Hilga geochemically anomalous area (Figure 158) consists of Archaean basement (Christie Gneiss), typically deeply weathered, beneath relatively thin Cainozoic alluvial deposits and exposed calcrete. That weathered *in situ* Archaean basement generally has a 1-1.5 m thick silcrete duricrust capping. Most of the palaeotopography locally has been completely infilled with Cainozoic alluvial sediment, yielding the near flat surface exposed today. That terrain supports *Acacia* woodland with numerous shrubs (*Eremophila, Senna, Sclerolaena* and bluebush *Maireana*; after Lintern *et al*., 2002).

South Hilga gold prospect formed part of the larger Gawler Joint Venture tenement coverage, occupying most of the area in Figure 136. This Au anomaly has a calcrete maximum of ~100 ppb Au; Figure 158). It was extensively drill tested in 1996, mineralization appears to be restricted to numerous thin veinlets within a complex pattern–stockwork across the prospect (Lintern *et al*., 2002).

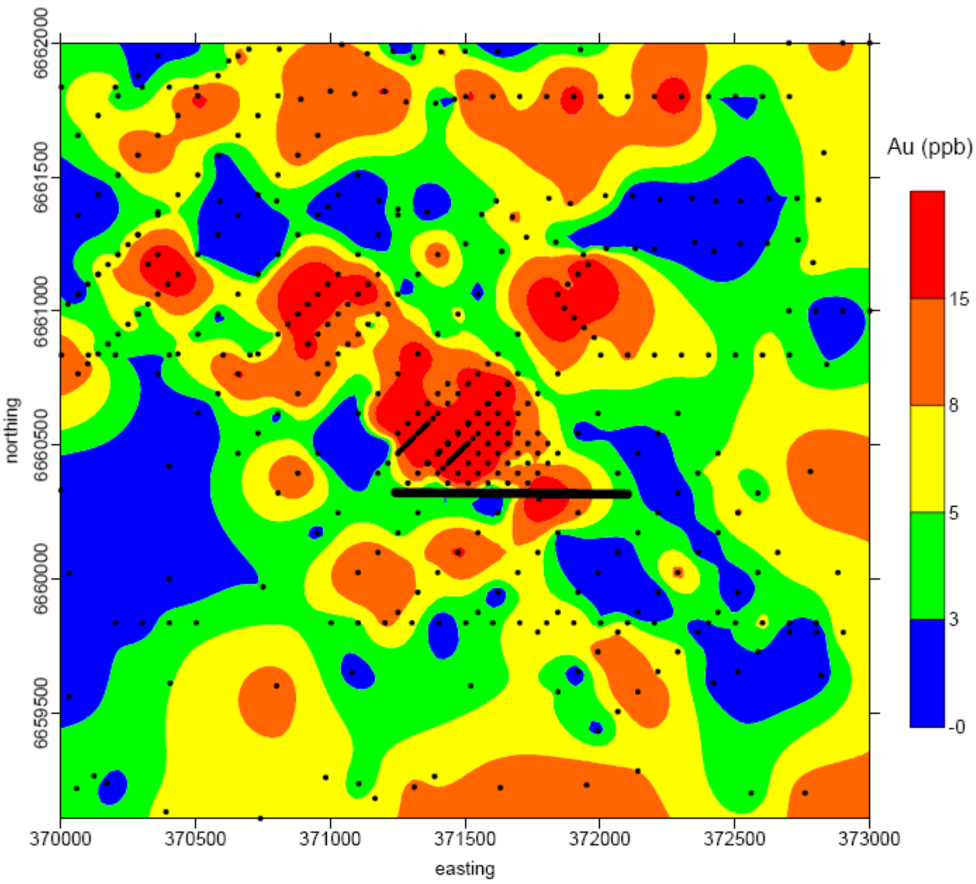


Figure 158: South Hilga gold prospect in plan, showing Au-in-calcrete anomaly. Black dots are sample points; black line is the Regolith Line of Lintern *et al*. (2002). No detailed DEM is available for this area. Original data supplied by the Gawler Joint Venture. **Note:** grid projection is in AGD66.

Regolith investigations by Lintern *et al*. (2002) began in 1998 as part of a broader regional study examining Au-in-calcrete anomalism. Complex gridded company RAB and RC drilling, many drill lines were oriented ~NE-SW but others were oriented E-W; they provided samples for regolith logging, characterisation and assay. Field inspection of drillhole spoil piles aided selection of a suitable study line (on local grid 6660305 m N, AGD66 [= 6660477 m N, GDA94]) on Figure 158, to investigate the surface geochemical anomalism and mineralization identified by drilling.

In situ Regolith

Bedrock (<5% weathered) was not penetrated by any of the exploration drilling on this prospect, however, remnant corestone fragments in lower saprolite to saprock indicate bedrock to be a garnet-bearing quartz-feldspar-mica gneiss, a granulite of fine- to medium-grain size and typically dark grey (Christie Gneiss). A more mafic character occurs between drillholes 96SHAR079 and 96SHAR145, as two distinct zones or bands, steeply dipping to the east (Figure 159), (Lintern *et al*., 2002).

Saprolith (saprock + saprolite) was the dominant weathered material encountered by drilling and its complex nature is displayed in the cross-sections of Figure 159. The more mafic bands penetrated yielded chloritic greens, and where further weathered, yielded FeOx and/or FeOH hues of brown to strong yellow (dominated by kaolinite + quartz ± smectite). Upper saprolite is commonly leached and has hues in pale yellows to pinks, where some mottling may also occur, however, within the mafic bands strong colours persist in the upper saprolite (Lintern *et al*., 2002).

Pedolith (extremely weathered) is remnant at best over this prospect but is commonly hard to pick from cuttings. PIMA Kaolinite Crystallinity Indices provide some assistance, although if the unconformity occurs within silcrete, its position may be indeterminate (too little kaolinite for reliable spectra), see red line on Figures 159, 160. A recognisable plasmic zone occurs below the silcrete capping horizon in a number of drill intersections but its fragile nature means its samples do not survive the drilling process well. Silcrete (0.5-1.5 m thick) occurs across the whole section near surface – even within the palaeochannel incisions. Within the silcrete are two separately sourced components: the lower part is silicified weathered *in situ* pedolith containing angular quartz grit and relict graphite flakes; while the upper portion is silicified colluvium containing subangular to subrounded quartz-rich gravel and an alluvium of well rounded quartz gravel with pebbles. Silcrete here is pedogenic in origin, is pale grey to cream and yellowish, and contains wisps of titania plus some Fe-staining (Lintern *et al*., 2002).

Transported Regolith

Red-brown alluvium-colluvium these materials cover the site to a depth of 2-3 m and also infill two distinct channels at the centre of the section, to depths of 6 m (Figures 159, 160). Much of the upper part is probably related to Quaternary alluvial fans flanking nearby higher ground, but the lower parts are significantly older, darker coloured and are partly indurated (hardpanized). Generally, these materials consist of rounded to subrounded quartz and lithics (fine sand to cobble sized) but is dominantly a gravel-rich clast to matrix supported sediment. These materials have a distinctly reddish to brown colour, with strongly developed ferruginous staining. Poor clast sorting suggests dominantly a short transport history (colluvial). The upper parts of this material are calcrete impregnated (Lintern *et al*., 2002).

Calcrete occurs throughout the upper regolith within the soil profile and upper colluvium-alluvium, as distinct near-white horizons. Forms include nodules, earthy powders, coatings and irregular low density sheets (0.5 m thick), some displaying karstic features (Lintern *et al*., 2002).

Soils range from uniform silty to sandy (Um, Uc) to gradational calcareous (Gc) lithosols in gravelly lag areas. These soils are generally poorly structured and with little organic matter present in the A horizons. All are strongly alkaline and are probably sodic (AS3) where clay-rich (Northcote and Skene, 1972; Northcote, 1979; Lintern *et al*., 2002).

PIMA Mineralogy

PIMA spectrometry of the upper regolith indicates poorly crystalline kaolinite and smectite in the colluvium and a sharp boundary with more crystalline kaolinite in the saprolite. The PIMA derived, plus the microscope and field studies derived, unconformity boundary are in general agreement. PIMA spectroscopy also indicates the presence of Mg-chlorite (371530 m E at 43-63 m), K-alunite (371880 m E at 24-25 m) and possibly, remnant diopside in the Fe-rich (probably goethitic) saprolite in drillhole MHP080b (Benchmark 28), (Lintern *et al*., 2002).

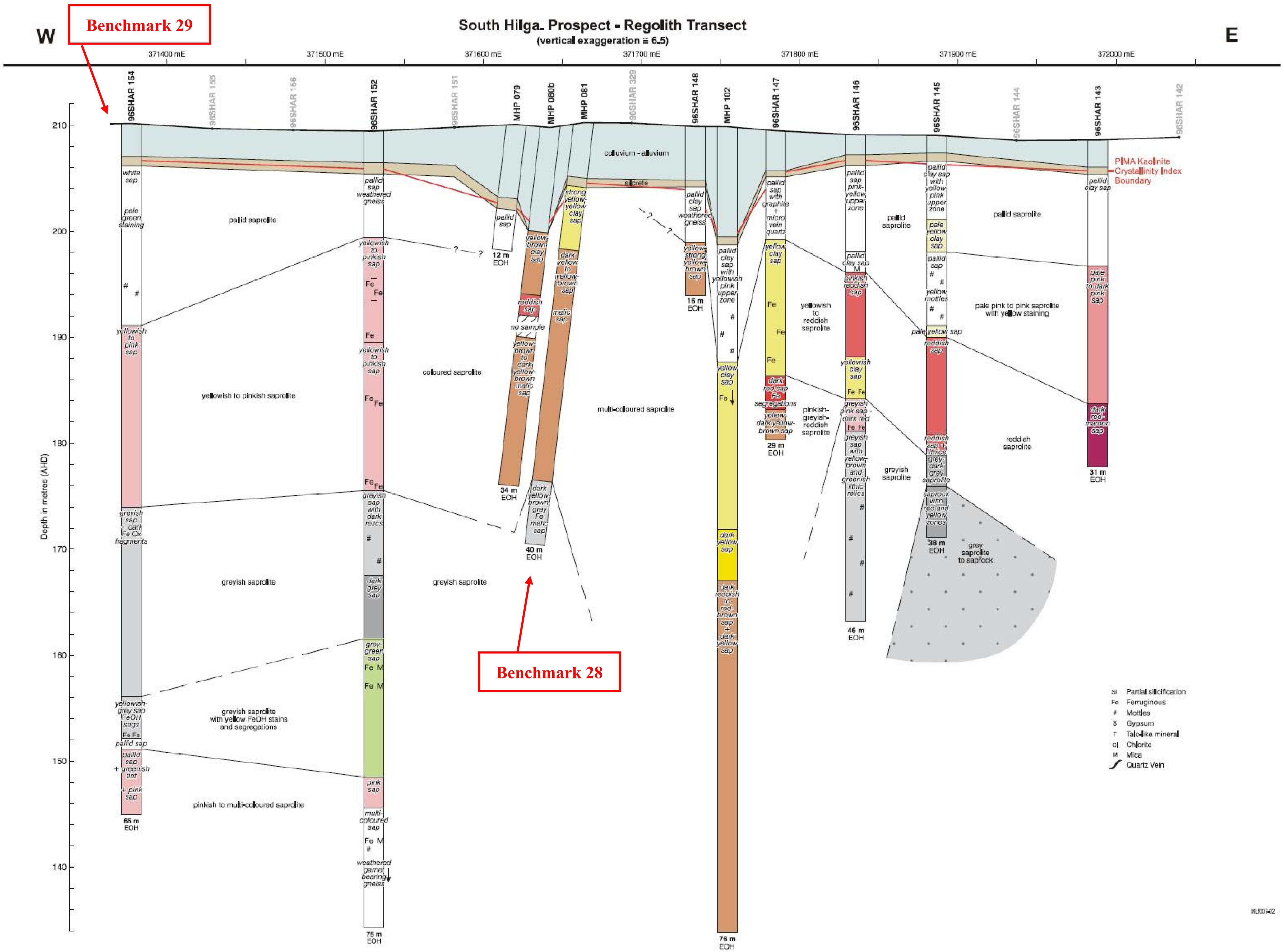


Figure 159: South Hilga gold prospect, full regolith section along line displayed in Figure 158 (Lintern *et al.*, 2002). Benchmarks 28 and 29 are indicated.

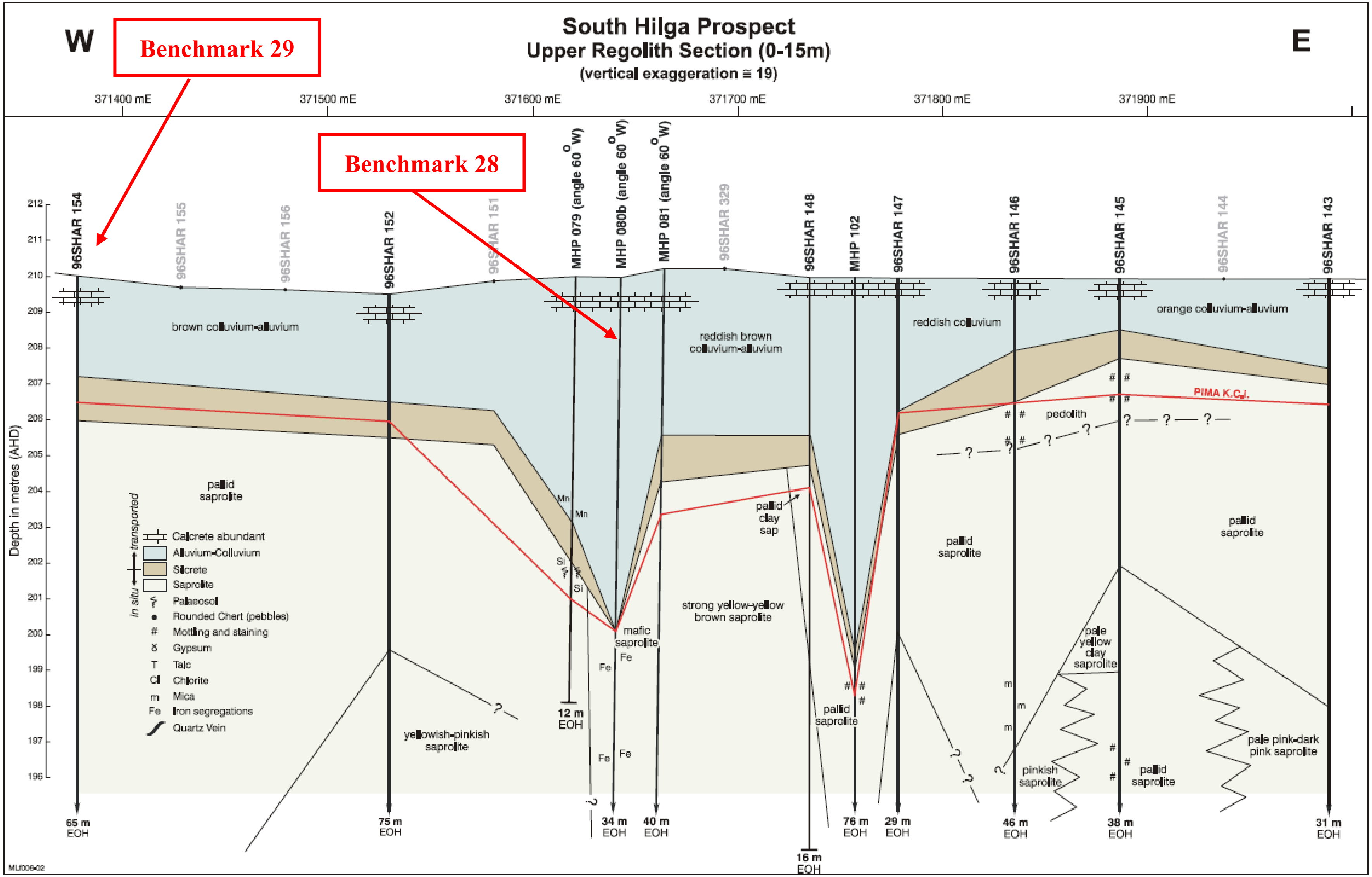
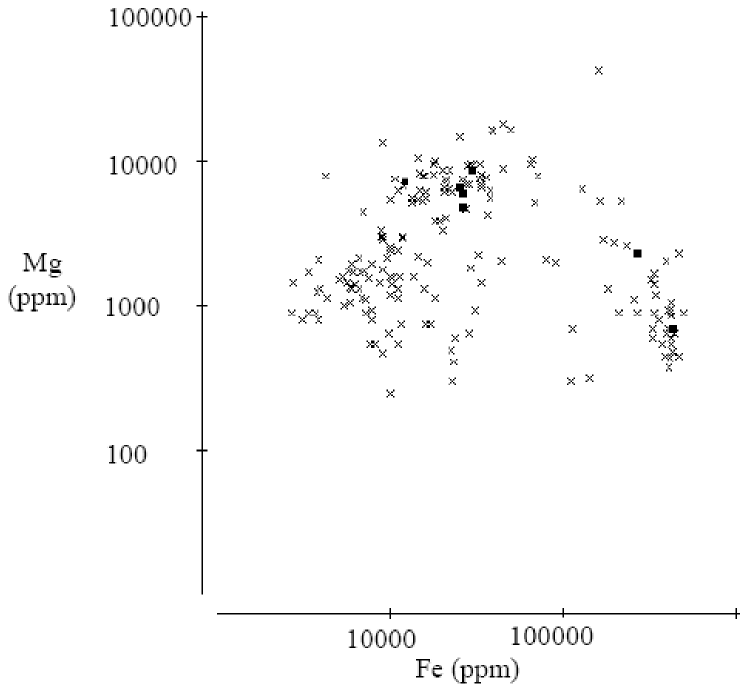


Figure 160: South Hilga gold prospect, upper regolith section along line displayed in Figure 158 (Lintern *et al*., 2002). Benchmarks 28 and 29 are indicated.

Geochemical expression

Iron concentrations associated with the weathered mafic rocks are particularly high in Fe but low in Mg (Figure 161). Iron is moderately associated with As, Co, Mn, Ni and Zn, probably due to adsorption on Fe oxyhydroxides.

a)



b)

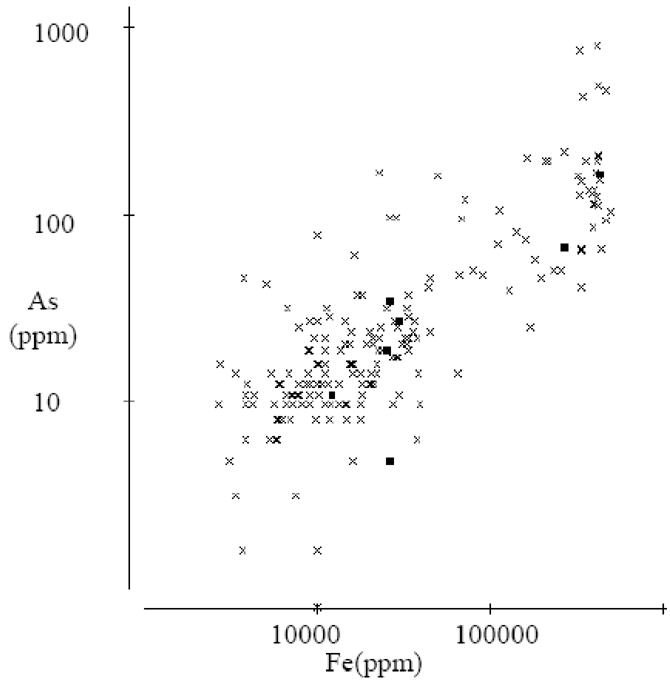


Figure 161: South Hilga gold prospect, scatter plots for selected elements. Box symbols indicate samples with the higher Au concentrations, (Lintern *et al*., 2002).

Plot a: Fe *v* Mg. Note the cluster of high Fe and relatively low Mg (lower right) indicating highly ferruginous saprolite (derived from a mafic parent).

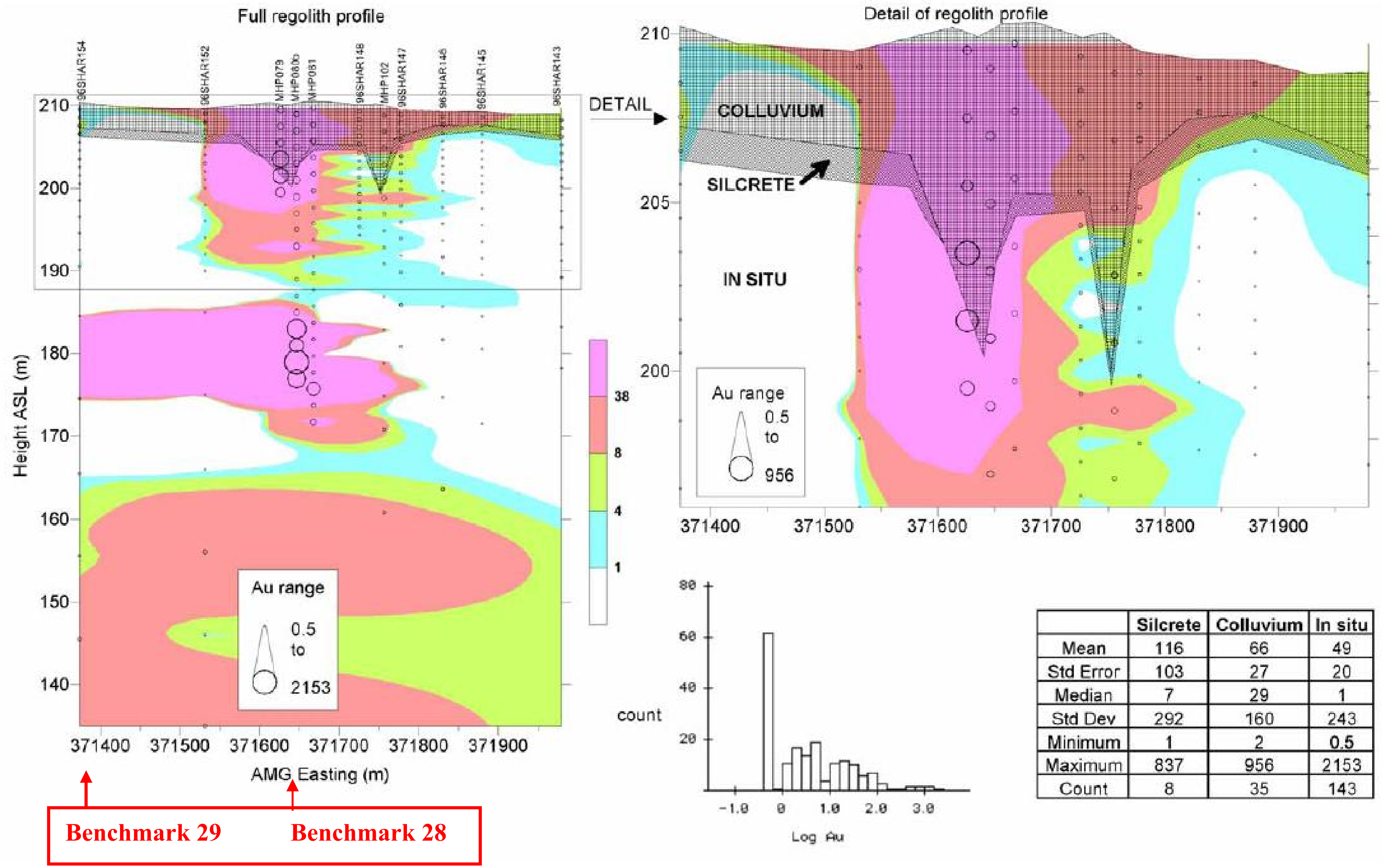
Plot b: Fe *v* As. Some pathfinders, e.g. As, are adsorbed by Fe oxyhydroxides (goethite).

The greatest Au concentration (2.2 ppm max.) is in the section about 30 m below surface in strongly ferruginous , yellow-brown, mafic saprolite and forms part of a mineralized interval averaging 8 m at 1.3 g/t. It is associated with moderate concentrations of Cu (mean 120 ppm; Table 69). As adjacent drillholes are relatively poor in Au, mineralization is probably confined to narrow veinlets. Above mineralization, however, anomalous Au is continuous through the 10 m deep transported material to the surface (Figure 162). Maximum concentrations in the transported regolith (960 ppb) at 6-8 m) are associated with slightly calcareous samples in a buried channel close to the interface between transported and weathered *in situ* units adjacent to mineralization. In calcrete, samples reach up to 100 ppb Au above mineralization. However, all these samples are down slope of mineralization to the north and so the origin of the anomalous concentrations is equivocal (Lintern *et al*., 2002).

Table 69: South Hilga gold prospect, highest Au concentrations and other anomalous drillhole intervals (Lintern, 2004b).

Drillhole	Interval (m)	Analyses (ppm, Au ppb)	Regolith type
MHP080b	26-34	Au 1340 ppb, Cu 120	saprolite
MHP079	4-12	Au 560 ppb	colluvium/alluvium and saprolite
MHP081	34-36	Au 530 ppb	saprolite
96SHAR147	13-14	Au <1 ppb, As 250, Sb 14	saprolite
96SHAR132	63-64	Au 3 ppb, Zn 3700, Ni 1150	saprolite
96SHAR145	24-25	Au <1 ppb, Pb 340	saprolite

In Summary; the South Hilga case study indicates that weathering has led to a 20 m thick saprolite zone depleted in Au. The old land surface and samples immediately beneath it still retain significant concentrations of Au, particularly in the silcrete. Calcrete in the transported overburden is also highly anomalous but, as stated above, due to the topographic effects on sediment dispersal, an origin for that Au is equivocal and may only be explained through a detailed 3D study (Lintern, 2004b).



	Silcrete	Colluvium	In situ
Mean	116	66	49
Std Error	103	27	20
Median	7	29	1
Std Dev	292	160	243
Minimum	1	2	0.5
Maximum	837	956	2153
Count	8	35	143

Figure 162: South Hilga gold prospect, regolith section, regolith architecture and Au geochemical expression (*c.f.* Figures 159, 160). All data are in ppb (Lintern, 2004b). Benchmarks 28 and 29 are indicated.

Benchmark 28: drillhole MHP080b

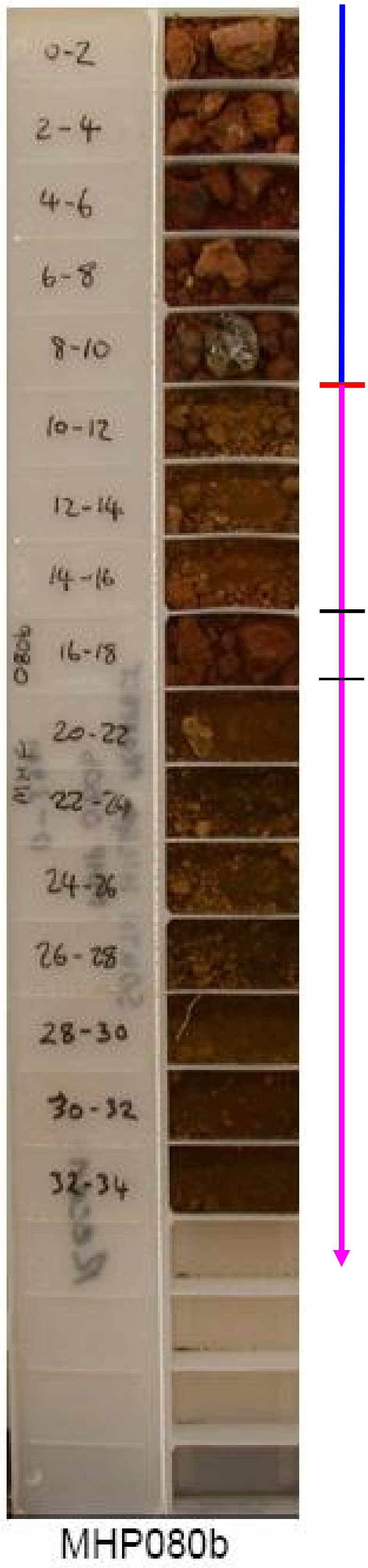
Quick reference items are set out in Table 70; detailed descriptions, figures and data tables follow on below. South Hilga prospect lies about 130 km NW of Tarcoola and about 32 km ~W of Mulgathing Pastoral Station Homestead (Figures 110-112, 136, 158). It can be accessed via pastoral lease tracks W of Mulgathing Pastoral Station Homestead. Drilling for this Rotary hole was angular (60^o dip → ~270^o), while all RAB holes were vertical. A summary of this profile is provided in Table 71 and chiptray photograph with regolith zonation is in Figure 163. Geochemical data are presented in Figures 161, 162, 164-167 and Table 69.

Table 70: Benchmark 28 reference data; drillhole MHP080b (Type 2, drill cuttings profile).

Items	**Figures, Data, Sources**
Regional location map	Figures 110-112, 136.
Local-site location map	Figures 158, 159.
GPS coordinates, attitude & elevation	Rotary drillhole MHP080b: Zone 53, 371775 E, 6660503 N, GDA 94. **Attitude**: angled (60^o dip → ~270^o). **AHD:** 209.971 (differential GPS data).
Site access, owner	About 130 km NW of Tarcoola and about 32 km ~W of Mulgathing Pastoral Station Homestead (Figure 136). Site can be accessed via pastoral lease tracks W of the main Homestead. Site Lease holder: Mulgathing Pastoral Station.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photo / log	Yes, Figure 163, Table 71.
Sample types	Drill chips in chiptrays + ~1 kg bags
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Not from thin-sections, only from binocular microscope observations.
Geochemistry	Yes, Figures 161, 162, 164-167, and Table 69.
XRD mineralogy	No.
PIMA spectral data	Yes, unpublished data only, used by Lintern *et al*. (2002) to produce kaolinite Crystallinity Indices for unconformity picks & some mineral identification.
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	?As, Cu, Zn.
Useful sampling media	Calcrete, soil, sediment & silcrete.
Key reference sources	Lintern *et al*. (2002); Lintern (2004b).

Background

Drillhole MHP080b is selected to form this benchmark because it includes a moderate thickness of transported cover and is located within the defined Au mineralization. The weathered *in situ* regolith is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 29 and the regolith cross-sections of Figures 159, 160. Exploration grid drilling on this prospect mostly involved RAB (typically without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes have terminated in lower saprolite to saprock rather than within fresh gneiss. Moreover, the same is true for all infill RC and rotary drilling, in that those mineralization targeted drillholes also terminated in saprolite or saprock for a variety of reasons. Cuttings were sampled from the drilled 2 m composites (not ideal for regolith investigations). These drillholes were not originally intended for use as benchmarks; they were later sampled and analysed as part of regional regolith and chemical dispersion studies (Lintern *et al*., 2002, 2003).



0-10 m — **Transported**: reddish colluvium-alluvium (deepest channel infill), poorly sorted silt + sand + gravel + pebbles of quartz & lithics; prominent carbonate at ~1 m. ~3-10 m is more indurated and possibly much older (?hardpanized).

10 m — **Unconformity**

10-16 m — ***In situ***: saprolite, yellow-brown clay-rich, ferruginous, crumbly.

16-18 m — Saprolite, reddish, quite ferruginous, clay-rich.

20->34 m — Saprolite, yellowish brown to dark yellowish brown, more competent than above interval.

NOTE: saprock and bedrock not penetrated.
E.O.H. at 34 m.

Regolith logged by M.J. Sheard

Figure 163: Benchmark 28, South Hilga gold prospect drillhole MHP080b, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002). In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehabilitation work. **Note:** no depth correction has been made for the 60^{o} angled drilling; to obtain true depths x 0.86.

Table 71: Benchmark 28, regolith log to Rotary drillhole MHP080b (after Lintern *et al*., 2002).

Hole: MHP080b. **Regolith Line**, South Hilga gold prospect. Regolith descriptions (combined in-field + laboratory observations).

Location: Zone 53, 371775 E, 6660503 N, GDA 94. **AHD:** 209.971 (differential GPS data)

Attitude: angled (60^o dip → ~270^o)

Site: flat and generally denuded.

Vegetation: Very Open Grassland with many dead *Acacia aneura*. (Botanical log by S. Lintern).

Soil: Um (sand, loose, medium grained throughout).

Calcrete: ? nodular to earthy.

Logged by: M.J. Sheard, 1999. **Note:** only 2 m interval drill spoil piles available.

Depth (m)	Description of RAB cuttings
0-10	Reddish colluvium-alluvium (deepest channel infill here), silt + sand + gravel + pebbles of quartz & lithics; prominent carbonate at ~1 m. ~3-10 m is more indurated and possibly much older (?hardpanized). Unconformity below 10 m.
10-16	Saprolite, yellow-brown clay-rich, ferruginous. [**Not** Algebuckina Sandstone as indicated by exploration company logging].
16-18	Saprolite, reddish, quite ferruginous, clay-rich.
18-20	No sample.
20->34	Saprolite, yellowish brown to dark yellowish brown, predominantly kaolinite + goethitic staining; mafic saprolite.
E.O.H.	**Note:** no depth correction has been made for the 60^o angled drilling; to obtain true depths x 0.86.

In situ Regolith

Bedrock was not penetrated by drilling on this prospect, but remnant corestones within the saprock indicate it has components typical of the Christie Gneiss. At this location the bedrock is mafic (from PIMA identified remnant diopside in the goethitic saprolite). Generally saprolite at this site follows the earlier descriptions for the prospect. Saprolite was not fully penetrated here, its total thickness can be inferred by reference to the regolith section of Figure 159. All evidence for pedolith appears to be missing from the samples, that zone most likely eroded by channel incision; but silcrete too seems to be absent, however, the 2 m bulk sampling may have inadvertently obscured evidence for silcrete and clayey pedolith (bulked cuttings are a poor substitute for core or outcrop).

Transported Regolith

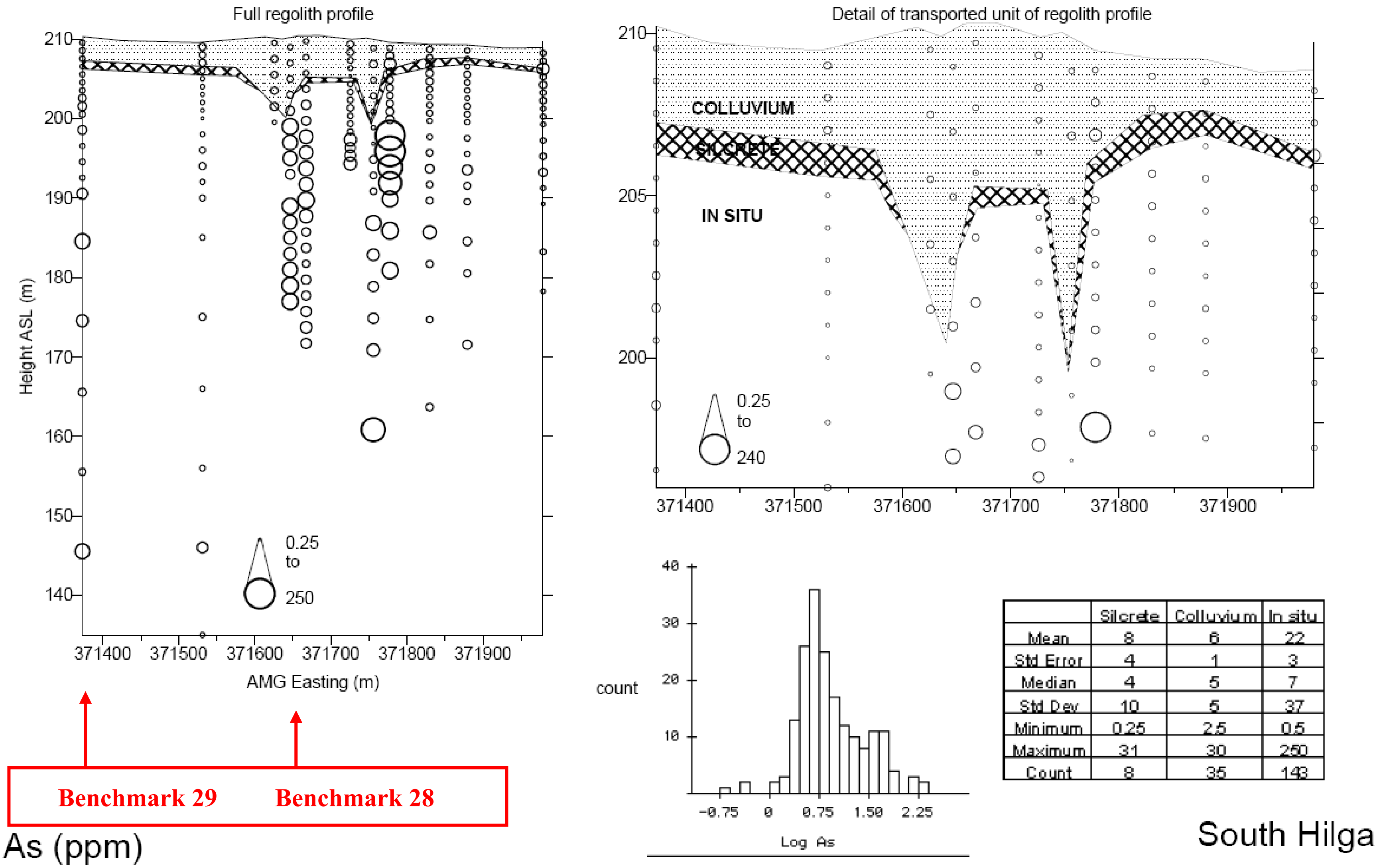
Colluvium and alluvium (mostly sand + gravel) forms the primary transported cover, as palaeochannel infill in this drillhole (~10 m). Clast rounding, the presence of lithics and the broad range of clast size indicate immature sediment with a local provenance. This site is currently deflating and eroding (partly due to stock grazing pressures) leading to extensive exposure of calcrete horizons and the basal soil horizon.

Geochemistry

Geochemical expression for South Hilga gold prospect has been outlined above and presented via Figures 161, 162 (Au) and Table 69 (As, Cu, Ni, Pb, Sb, Zn).

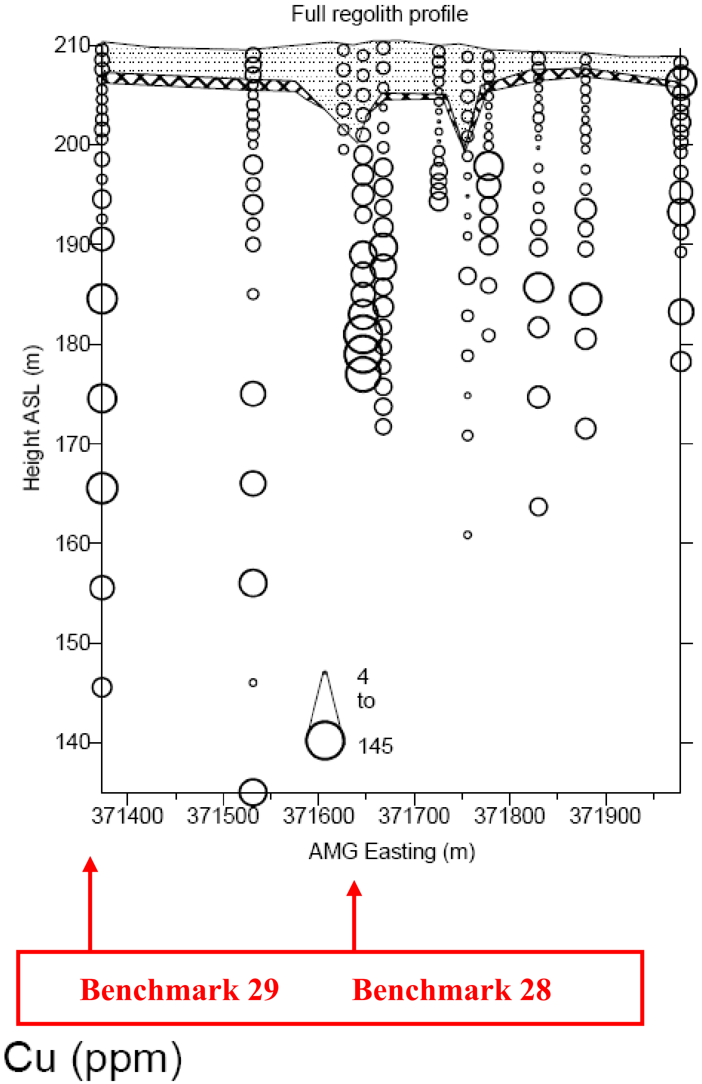
A 51 element assay package was applied to all samples and Lintern *et al*. (2002) have plotted elemental abundances for all of those on a cross-sectional backdrop. From those abundance plots a selected set, including: As, Cu, Fe and Zn appear in Figures 164-167. Copper and Zn may serve as pathfinder elements in this area but the Au values alone provide a far stronger signal.

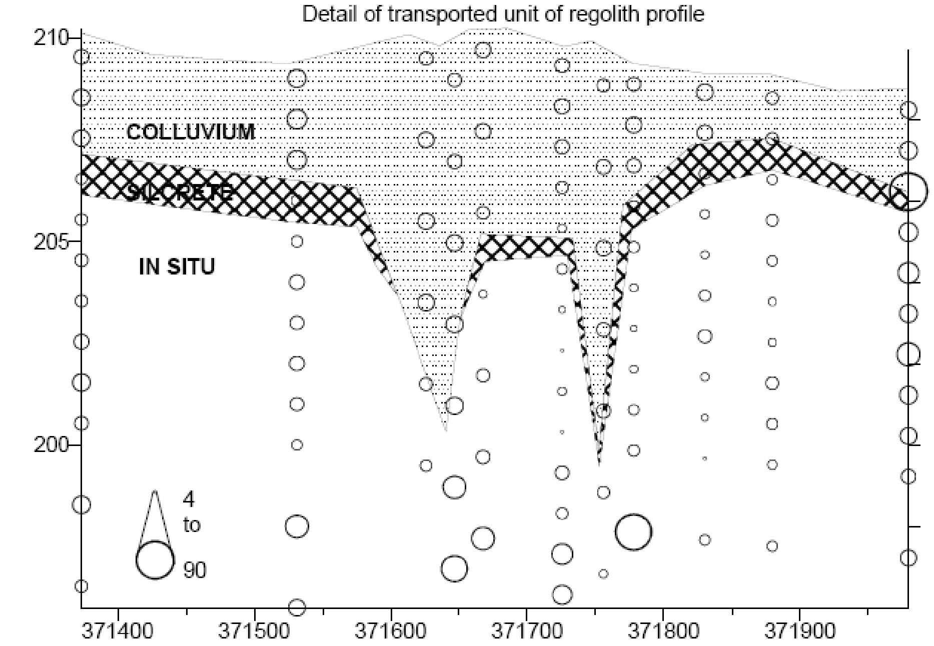
Compare this geochemical expression over defined Au mineralization with that of Benchmark 29 (in unmineralized ground) and where the transported cover is thicker than for Benchmark 29.

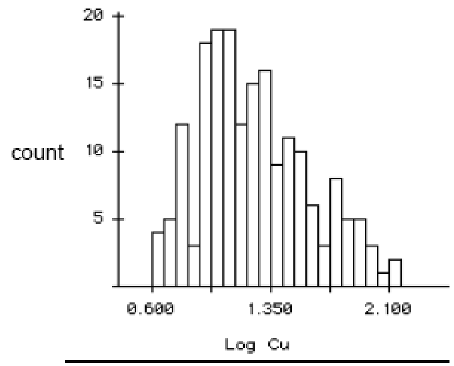


	Silcrete	Colluvium	In situ
Mean	8	6	22
Std Error	4	1	3
Median	4	5	7
Std Dev	10	5	37
Minimum	0.25	2.5	0.5
Maximum	31	30	250
Count	8	35	143

Figure 164: South Hilga gold prospect regolith section, regolith architecture & As geochemistry (*c.f.* Figures 165-167). Lintern *et al*. (2002). Benchmarks 28, 29 indicated.



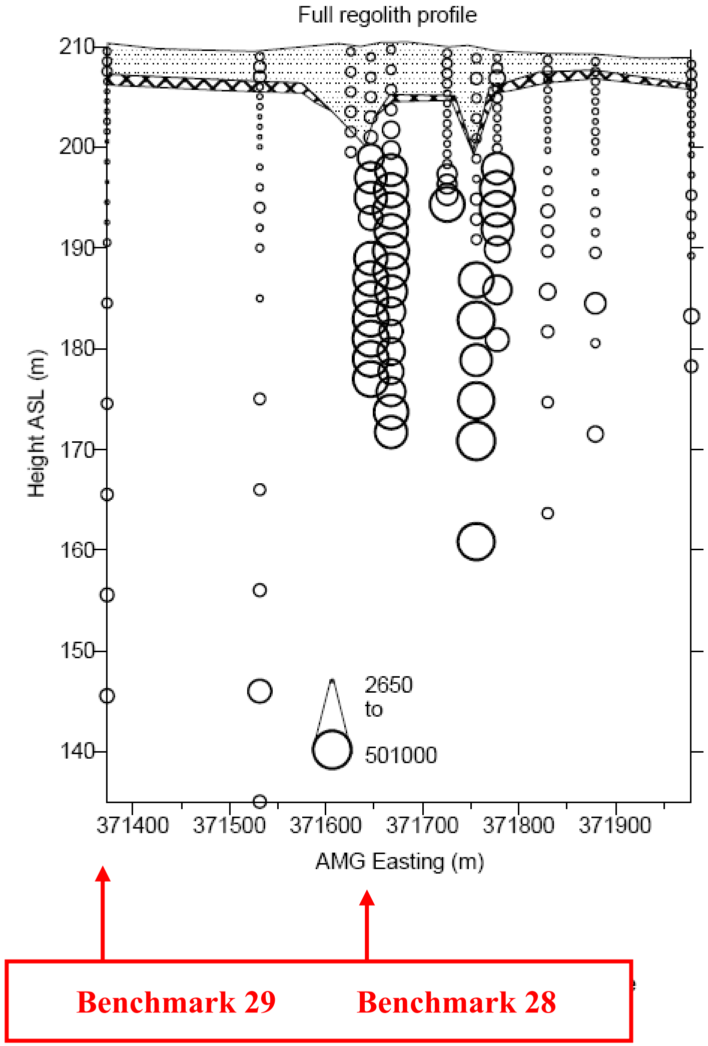


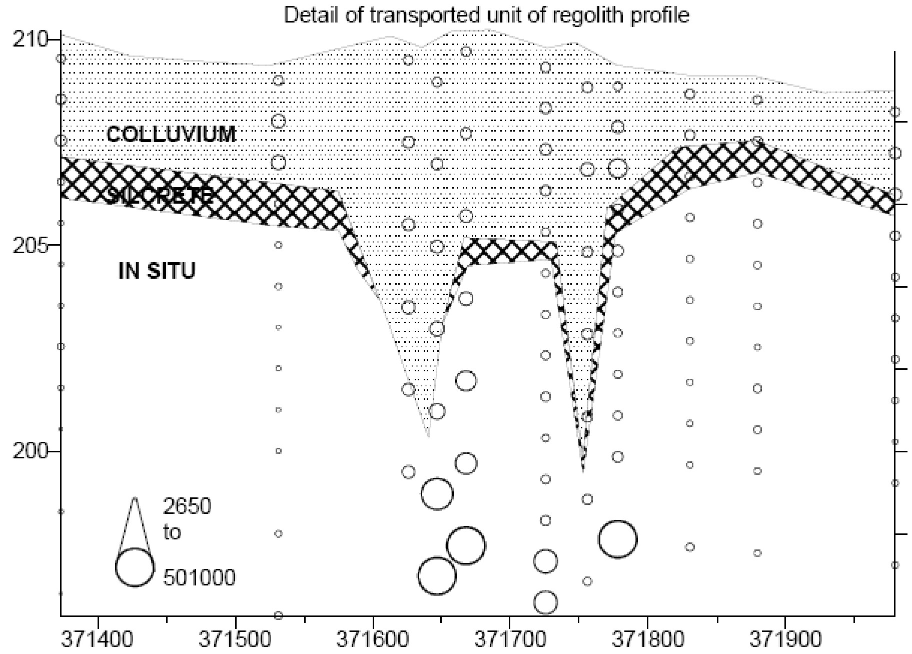


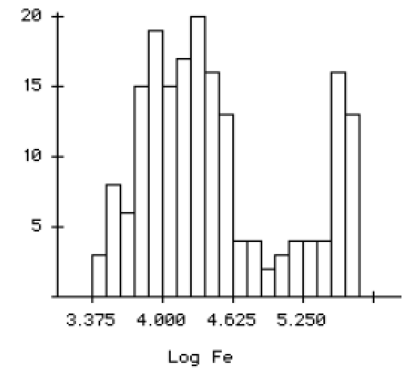
	Silcrete	Colluvium	In situ
Mean	20	15	28
Std Error	10	1	2
Median	10	15	19
Std Dev	29	3	27
Minimum	6	9	4
Maximum	90	23	145
Count	8	35	143

South Hilga

Figure 165: South Hilga gold prospect regolith section, regolith architecture & Cu geochemistry (*c.f.* Figures 164, 166, 167). Lintern *et al*. (2002). Benchmarks 28, 29 are indicated.





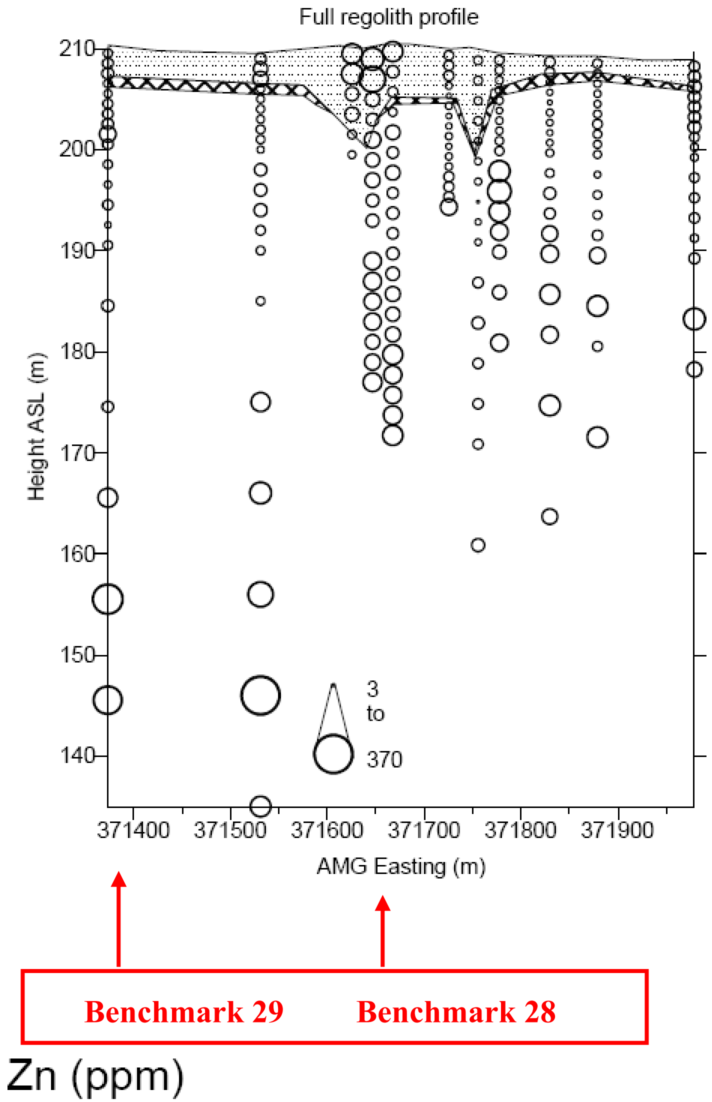


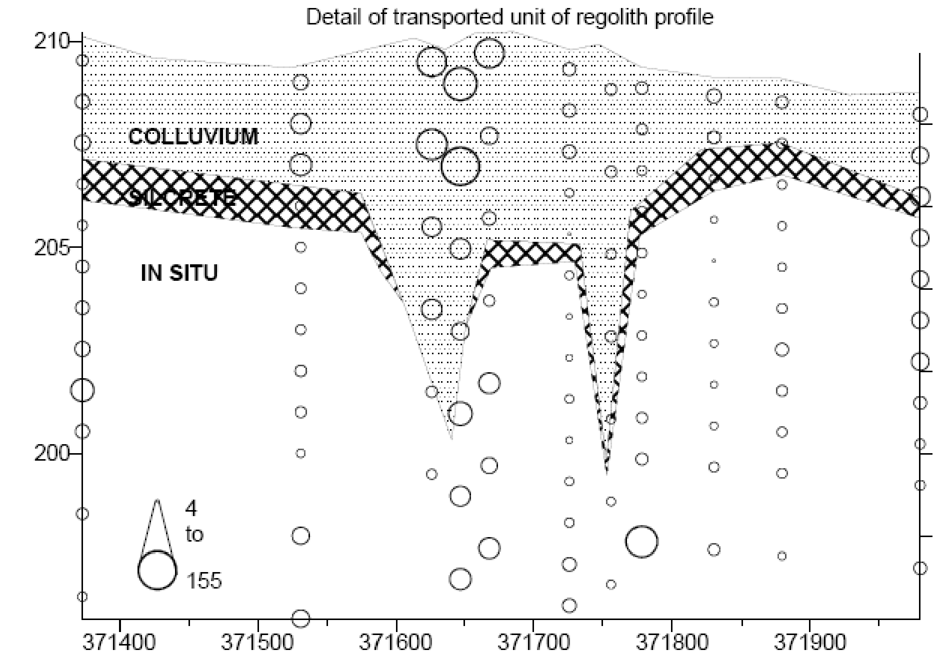
	Silcrete	Colluvium	In situ
Mean	16744	22929	113588
Std Error	3132	1934	13160
Median	13400	20300	23100
Std Dev	8857	11439	157372
Minimum	6900	10800	2650
Maximum	27800	69300	501000
Count	8	35	143

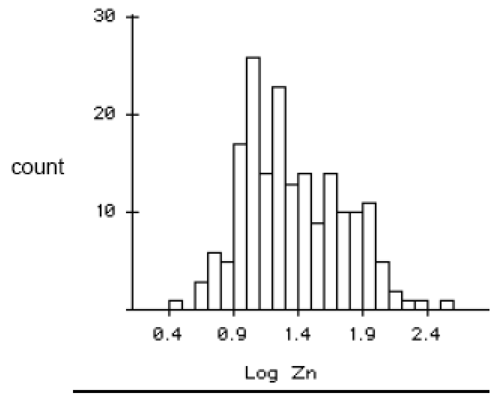
Fe (ppm)

South Hilga

Figure 166: South Hilga gold prospect regolith section, regolith architecture & Fe geochemistry (*c.f.* Figures 164, 165, 167). Lintern *et al*. (2002). Benchmarks 28, 29 are indicated.







	Silcrete	Colluvium	In situ
Mean	14	35	37
Std Error	4	6	4
Median	12	20	19
Std Dev	10	34	45
Minimum	4	8	3
Maximum	37	155	370
Count	8	35	143

South Hilga

Figure 167: South Hilga gold prospect regolith section, regolith architecture & Zn geochemistry (*c.f.* Figures 164-166). Lintern *et al*. (2002). Benchmarks 28, 29 are indicated.

Benchmark 29: drillhole 96SHAR154

Quick reference items are set out in Table 72; detailed descriptions, figures and data tables follow on below. South Hilga prospect lies about 130 km NW of Tarcoola and about 32 km ~W of Mulgathing Pastoral Station Homestead (Figures 110-112, 136, 158). It can be accessed via pastoral lease tracks W of Mulgathing Pastoral Station Homestead. Drilling for this RAB hole was vertical while most of the Rotary holes were angular (60^o dip → ~270^o). A summary of this profile is provided in Table 73 and chiptray photograph with regolith zonation is in Figure 168. Geochemical data are presented in Figures 161, 162, 164-167 and Table 69.

Table 72: Benchmark 29 reference data; drillhole 96SHAR154 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figures 110-112, 136.
Local-site location map	Figures 158, 159.
GPS coordinates, attitude & elevation	RAB drillhole 96SHAR154: Zone 53, 371502 E, 6660477 N, GDA 94. **Attitude**: Vertical. **AHD:** 210.054 (differential GPS data)
Site access, owner	About 130 km NW of Tarcoola and about 32 km ~W of Mulgathing Pastoral Station Homestead (Figure 136). Site can be accessed via pastoral lease tracks W of the main Homestead. Site Lease holder: Mulgathing Pastoral Station.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photo / log	Yes, Figure 168, Table 73.
Sample types	Drill chips in chiptrays + ~1 kg bags.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Not from thin-sections, only from binocular microscope observations.
Geochemistry	Yes, Figures 161, 162, 164-167, and Table 69.
XRD mineralogy	No.
PIMA spectral data	Yes, unpublished data only, used by Lintern *et al*. (2002) to produce kaolinite Crystallinity Indices for unconformity picks & some mineral identification.
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	?As, Cu, Zn.
Useful sampling media	Calcrete, soil, sediment & silcrete.
Key reference sources	Lintern *et al*. (2002); Lintern (2004b).

Background

Drillhole 96SHAR154 is selected to form this benchmark because it includes a 3.5 m thickness of transported cover and is located away from the defined Au mineralization. The weathered *in situ* regolith is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 28 and the regolith cross-sections of Figures 159, 160. Exploration grid drilling on this prospect mostly involved RAB (typically without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes have terminated in lower saprolite to saprock rather than within fresh gneiss. Moreover, the same is true for all infill RC and rotary drilling, in that those mineralization targeted drillholes also terminated in saprolite or saprock for a variety of reasons. Cuttings were sampled from the drilled 1-2 m composites (not ideal for regolith investigations). These drillholes were not originally intended for use as benchmarks; they were later sampled and analysed as part of regional regolith and chemical dispersion studies (Lintern *et al*., 2002, 2003).

0-~3 m **Transported**: brown colluvium-alluvium (silt + sand + gravel + pebbles of quartz & lithics); prominent carbonate in ~1st m.

~3-4 m **Unconformity.** Silcreted sediment & *in situ* weathered pedolith.

4-19 m ***In situ***: saprolite, white, clay-rich, has greenish staining (?fuchsite or ?Mg-chlorite) lithic relicts at 15-16 m, crumbly.

19-36 m Saprolite, yellowish to pinkish, clay-rich.

36-54 m Saprolite, greyish with dark coloured Fe oxide-rich fragments, more competent than above interval.

54-64 m Saprolite, yellowish grey and pallid, clay-rich, + brown Fe sesquioxide nodules and fragments.

64->65 m Saprolite, yellowish grey with greenish tint (?chloritic) clay-rich, + pinkish saprolite.

NOTE: chiptray sampling is irregular below 20 m, saprock and bedrock not penetrated.

E.O.H. at 65 m.

Regolith logged by M.J. Sheard

Figure 168: Benchmark 29, South Hilga gold prospect drillhole 96SHAR154, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002). In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehabilitation work.

Table 73: Benchmark 29, regolith log to RAB drillhole 96SHAR154 (after Lintern *et al*., 2002).

Hole: 96SHAR154. **Regolith Line**, South Hilga gold prospect. Regolith descriptions (combined in-field + laboratory observations).

Location: Zone 53, 371502 E, 6660477 N, GDA 94. **Attitude**: Vertical.
AHD: 210.054 (differential GPS data)

Attitude: vertical

Site: near edge of N-S access track, flat and generally denuded.

Vegetation: *Acacia aneura* Low Open Woodland over *Acacia aneura* Tall Open Shrubland over Shrubland over mixed Chenopodaceae Low Shrubland. (Botanical log by S. Lintern).

Soil: Um (sand, loose, medium grained throughout).

Calcrete: ? Sheet-like to earthy.

Logged by: M.J. Sheard, 1999.

Depth (m)	Description of RAB cuttings
0-~3	Brown colluvium-alluvium (silt + sand + gravel + pebbles of quartz & lithics; prominent carbonate within 1st m.
~3-4	Pedolith – silcrete, ~1 m thick, developed partly in sediment & partly in white saprolite. Unconformity ≅ silcrete mid point.
4-19	Saprolite, white clay-rich, has greenish staining ?fuchsite or ?Mg-chlorite, lithic relicts at 15-16 m.
19-36	Saprolite, yellowish to pinkish clay-rich.
36-54	Saprolite, greyish, with dark coloured Fe oxide-rich fragments, clay-rich.
54-58	Saprolite, yellowish grey, with brown Fe sesquioxide nodules and fragments, clay-rich.
58-59	Saprolite, pallid, clay-rich.
59->65	Saprolite, yellowish grey with greenish tint (?chloritic) + pink saprolite.
E.O.H.	

In situ Regolith

Bedrock was not penetrated by drilling on this prospect, but remnant corestones within the saprolith indicate it has components typical of the Christie Gneiss. Generally saprolite at this site follows descriptions for this prospect set out earlier. Saprolite was not fully penetrated here. Evidence for pedolith is scant and limited to the silcrete horizon.

Transported Regolith

Colluvium and alluvium (mostly sand + gravel) forms the transported cover, as palaeo-fan material (~3 m thick) emanating from nearby higher ground. Clast rounding, the presence of lithics and the broad range of clast size indicate immature sediment. This site is currently deflating and eroding (partly due to stock grazing pressures and track erosion by rain run-off) leading to extensive exposure of calcrete horizons and the basal soil horizon.

Geochemistry

Geochemical expression for South Hilga gold prospect has been outlined earlier and presented via Figures 161, 162 (Au) and Table 69 (As, Cu, Ni, Pb, Sb, Zn).

A 51 element assay package was applied to all samples and Lintern *et al*. (2002) have plotted elemental abundances for all of those on a cross-sectional backdrop. From those abundance plots a selected set, including: As, Cu, Fe and Zn appear in Figures 164-167. Copper and Zn may serve as pathfinder elements in this area but the Au values alone provide a far stronger signal.

Compare this geochemical expression away from the defined Au mineralization with that of Benchmark 28 (over mineralization) and where the transported cover is thinner than for Benchmark 28.

Monsoon gold prospect

Background

Monsoon gold prospect and its associated geochemical anomaly lie on flat to weakly undulating terrain about 150 km WNW of Tarcoola and about ~53 km W of Mulgathing Pastoral Station Homestead (Figure 136). It can be accessed via pastoral lease tracks and gazetted unsealed roads.

The Monsoon geochemically anomalous area (Figure 169) consists of outcropping and subcropping weathered Archaean Christie Gneiss, and is partly on-lapped by a wedge of Cainozoic alluvial sediment with silcrete and calcrete horizons. All weathered basement outcrop generally has a 1-2 m thick silcrete duricrust capping. Low points of the palaeotopography (>8 m depth) have been filled with Quaternary alluvium and the modern drainage lines follow the palaeodrainage. This terrain supports sparse *Acacia* woodland and numerous woody shrubs (*Eremophila, Senna* and bluebush *Maireana*) but the vegetation is more substantial just north of the geochemical anomaly (after Lintern *et al*., 2002 & Lintern 2004b).

Monson gold prospect formed part of the larger Gawler Joint Venture tenement coverage, occupying most of the area in Figure 136. The Au anomaly has a calcrete maximum of ~30 ppb Au; Figure 169). It was extensively drill tested in 1997; mineralization is patchily developed with the best interval averaging 1.22 ppm over 6 m at 30 m depth (Lintern *et al*., 2002; Lintern 2004b).

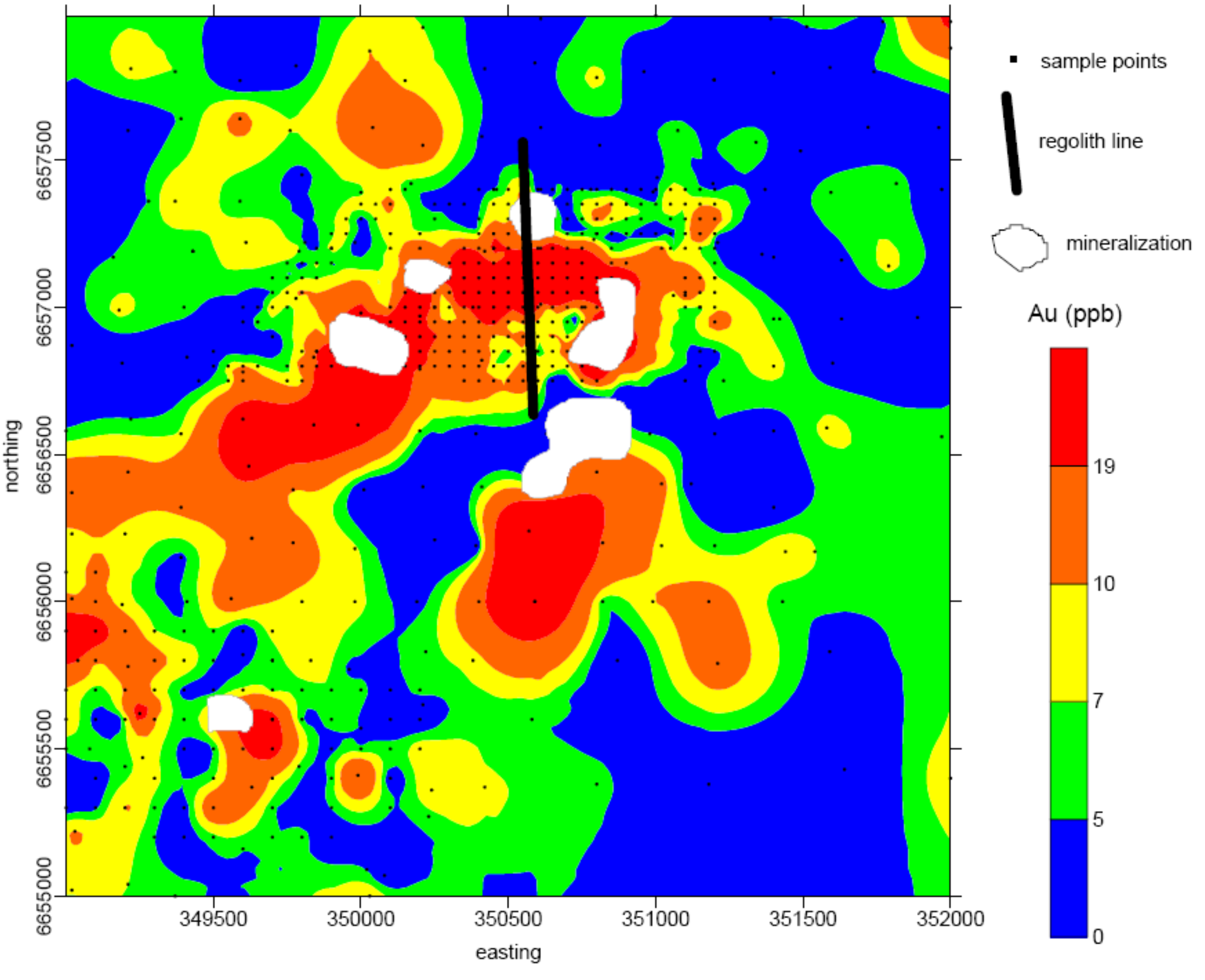


Figure 169: Monsoon gold prospect in plan, showing Au-in-calcrete anomaly. Black dots are sample points; black line is the Regolith Line of Lintern *et al*. (2002). No detailed DEM is available for this area. Original data supplied by the Gawler Joint Venture. **Note:** grid projection is in AGD66.

Regolith investigations by Lintern *et al*. (2002) began in 1998 as part of a broader regional study examining Au-in-calcrete anomalism. Gridded company RAB and RC drilling provided samples for regolith logging, characterisation and assay. Field inspection of drillhole spoil piles aided selection of a suitable NS oriented study line (along local grid ~350500 m E, AGD66 [= 350628 m E, GDA94]) on Figure 169, to investigate the surface geochemical anomalism and mineralization identified by drilling.

In situ Regolith

Bedrock (<5% weathered) was not penetrated by any of the exploration drilling on this prospect, however, remnant corestone fragments in saprock indicate bedrock to be Christie Gneiss – a quartz-feldspar-mica gneiss of granulite grade. It is typically dark grey and fine- to medium-grained. The northern two thirds of the Regolith Study Line has lithotypes richer in Fe, Mg and Mn (chloritic alteration) while the southern end appears to be more felsic (Figure 170). Quartz veins occur randomly throughout the weathered basement (Lintern *et al*., 2002; Lintern, 2004b).

Saprolith (saprock + saprolite) was the dominant weathered material encountered by drilling and its complex nature is displayed in the cross-section of Figure 170. The more mafic bands penetrated yield chloritic greens, and where further weathered, yields FeOx and/or FeOH hues of brown to strong yellow (dominated by kaolinite + quartz ± smectite). Grey saprock is thicker where rock grain size is finest. Total saprolite is >50 m thick in many places. Upper saprolite is commonly leached and has hues in pale yellows to pinks to browns or is white to cream coloured, within the mafic lithotype strong colours persist into the upper saprolite (Lintern *et al*., 2002; Lintern, 2004b).

Pedolith (extremely weathered) is best preserved along the northern two thirds of the Regolith Study Line and is hard to pick from cuttings at the southern end. The PIMA Kaolinite Crystallinity Index provided assistance, although where the pick is within silcrete, its location is questionable (too little kaolinite to provide a reliable spectra), see red line on Figures 170, 171. A recognisable clay-rich plasmic zone occurs below the silcrete capping horizon in a number of drill intersections and this has been in part silicified to porcellanite. Silcrete (0.5-2 m thick) occurs across the whole section and outcrops where weathered basement reaches the surface. Within the silcrete are two separately sourced components: the lower part is silicified pedolith containing angular quartz grit and relict quartz veins; while the upper portion is silicified colluvium containing subangular to subrounded quartz-rich gravel and an alluvium of well rounded quartz gravel with pebbles. Silcrete here is pedogenic in origin, is pale grey, cream or yellowish, and contains wisps of titania, some Fe-staining, and in the lower portions has relict *in situ* weathered minerals like graphite persisting (Lintern *et al*., 2002; Lintern, 2004b).

Transported Regolith

Hardpan, at Monsoon is 0-2 m thick (Figure 171), underlies the sand-rich modern creek alluvium and overlies the silcreted alluvium horizon. A strong brown colour and indurated clay-rich texture makes this sediment easily identifiable from all the others in the Monsoon regolith profile. It contains dark brown to black Mn-Fe sesquioxide and hydroxide cements and/or segregations, the matrix clay may also be partly silicified. In places this clay-rich material is carbonate coated or fracture impregnated (Lintern *et al*., 2002; Lintern, 2004b).

Dark reddish alluvium-colluvium, is restricted to the main sediment wedge (Figure 171), filling the lower portion of a distinct channel and consists of loose rounded to subrounded quartz plus lithic clasts; it ranges from fine sand to cobbles in clast size. This sediment is dominantly a gravel-rich unit with a distinct brown colour, ferruginous staining and calcrete coatings to clasts and/or cementation in distinct bands. Clast rounding and sorting variability suggests both local and distal sources. Drill sample evidence suggests there may be thin layers of reddish silty clay as lenses or localised low-flow regime stringers. An irregular upper boundary to this alluvium indicates later incision by the coincidental modern drainage regime (Lintern *et al*., 2002; Lintern, 2004b).

Modern alluvium, is also restricted to the main sediment wedge, this material fills the upper portion of a distinct channel and consists of loose rounded to subrounded quartz plus lithic clasts; in the fine sand to cobble size range, it is though predominantly sandy (Figure 171). This sediment is much paler in colour than the underlying alluvial unit, and contains calcrete as clast cementation within part of its overall thickness. Clast rounding and sorting variability suggests both local and distal sources, most of this sediment relates to modern creek activity (Lintern *et al*., 2002; Lintern, 2004b).

Colluvium: between drillholes 97MNAR118 and 052 (Figure 171) is a subsoil colluvium (<1 m thick) overlying the silcrete. This is essentially a weathering-erosional lag accumulation deposit, locally derived from exposed materials. Most clasts are angular to subrounded, range from blocks to fine gravel, and have a clast to fines ratio of >2:1. Calcrete has impregnated and stabilised this deposit, thus minimising later erosive affects (Lintern *et al*., 2002; Lintern, 2004b).

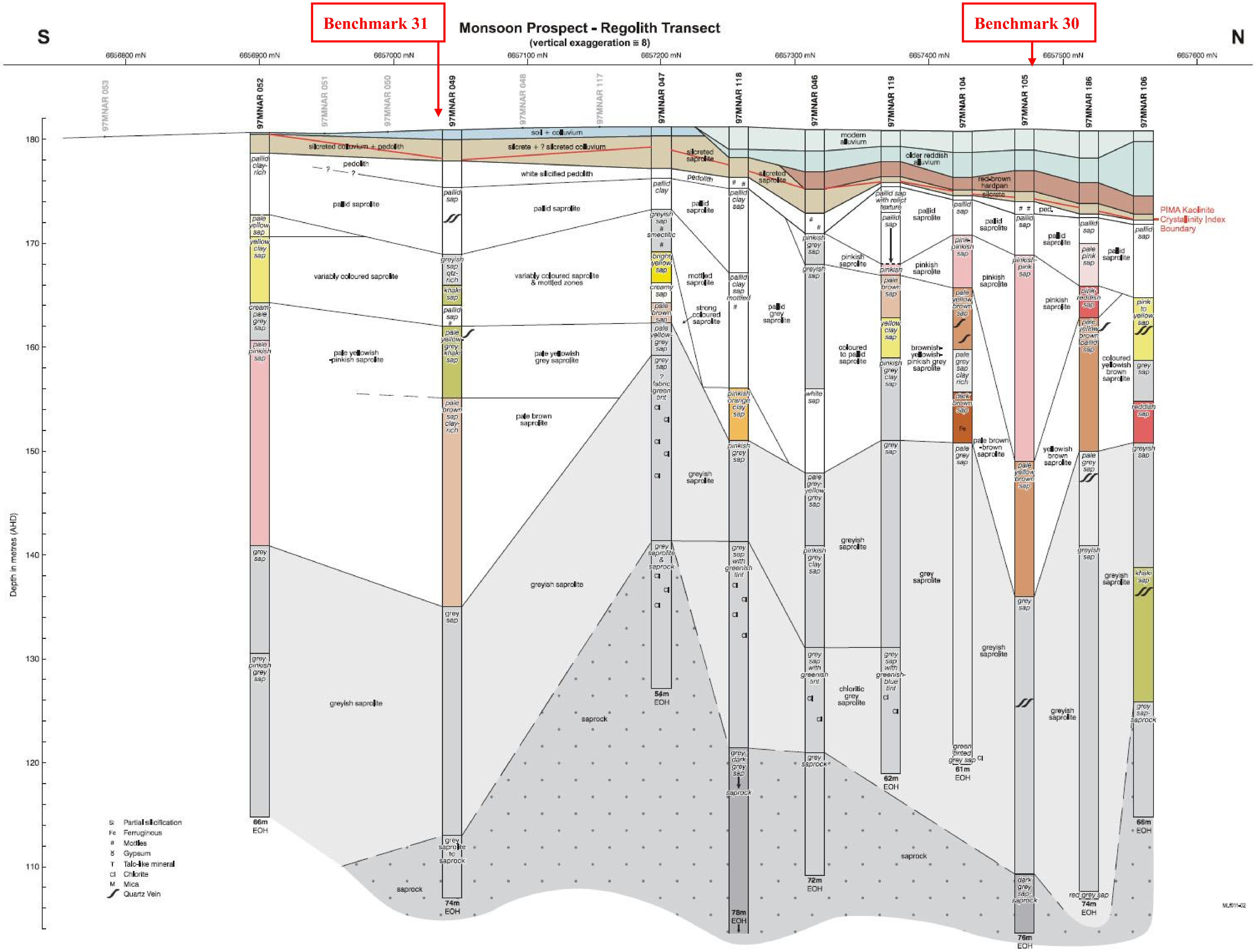


Figure 170: Monsoon gold prospect, full regolith section along line displayed in Figure 169 (Lintern *et al.*, 2002). Benchmarks 30 and 31 are indicated.

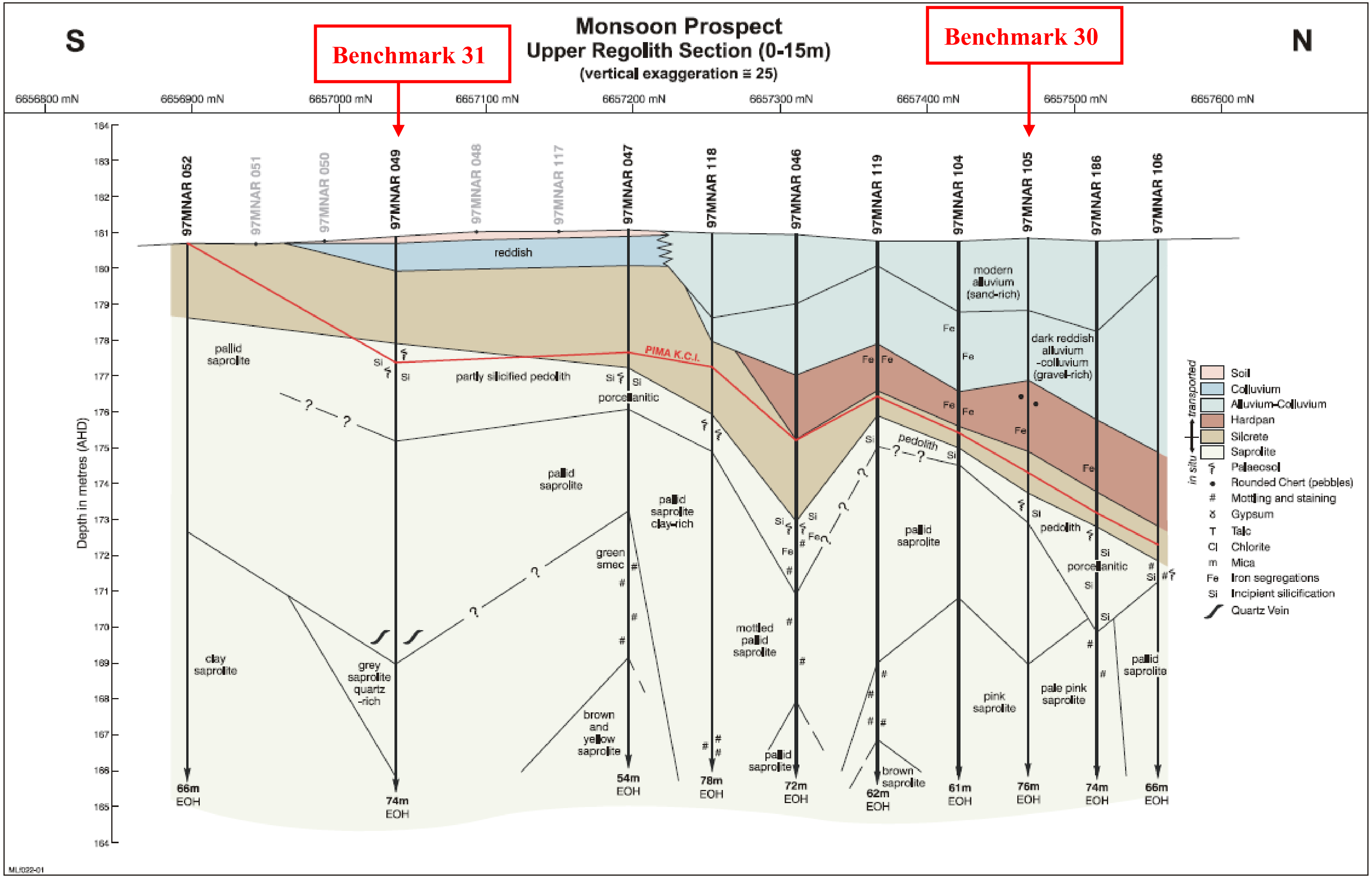


Figure 171: Monsoon gold prospect, upper regolith section along line displayed in Figure 169 (Lintern *et al.*, 2002). Benchmarks 30 and 31 are indicated.

Calcrete occurs across the upper regolith within the soil profile and colluvium. It coats the silcrete and penetrates several metres into the alluvium wedge. Forms include: nodules, earthy powders, coatings, irregular sheets and as irregular low density sheets (0.5 m thick) to thick horizons of very porous material (Lintern *et al*., 2002).

Soils range from uniform silty to sandy (Um, Uc) to gradational calcareous (Gc) to lithosols in gravelly lag areas. These soils are generally poorly structured and with little organic matter present in the A horizons. All are strongly alkaline and are probably sodic (AS3) where clay-rich (Northcote and Skene, 1972; Northcote, 1979; Lintern *et al*., 2002).

PIMA Mineralogy

PIMA spectrometry indicates crystalline kaolinite and smectite, with intermediate chlorite (Fe-Mg) and muscovite recorded in a few samples from the lower regolith. Poorly crystalline kaolinite and smectite characterise the alluvium and hardpan. There is a sharp boundary to well crystalline kaolinite in the weathered *in situ* regolith *versus* the transported regolith. Kaolinite crystallinity within the silcrete varies markedly from low to high but silcrete usually has a low abundance of kaolinite and this may yield spurious results. The field evidence is for silcrete at Monsoon enclosing both weathered *in situ* regolith and transported regolith (Lintern *et al*., 2002).

Geochemical expression

Iron at Monsoon correlates with As, Co, Cu and Ni, but unlike at Golf Bore prospect, not Mg, and not as strongly as at Jumbuck and Golf Bore prospects. Some samples relatively rich in S (up to 2.1%) and Fe are also relatively rich in Cd, Zn and Au suggesting some association with sulphide mineralization (Figure 172). The co-presence of S and Fe potentially provides a larger drilling target. Gold mineralization is also associated with elevated As, Cu, Ni, and Tl (Table 74), (Lintern *et al*., 2002; Lintern, 2004b).

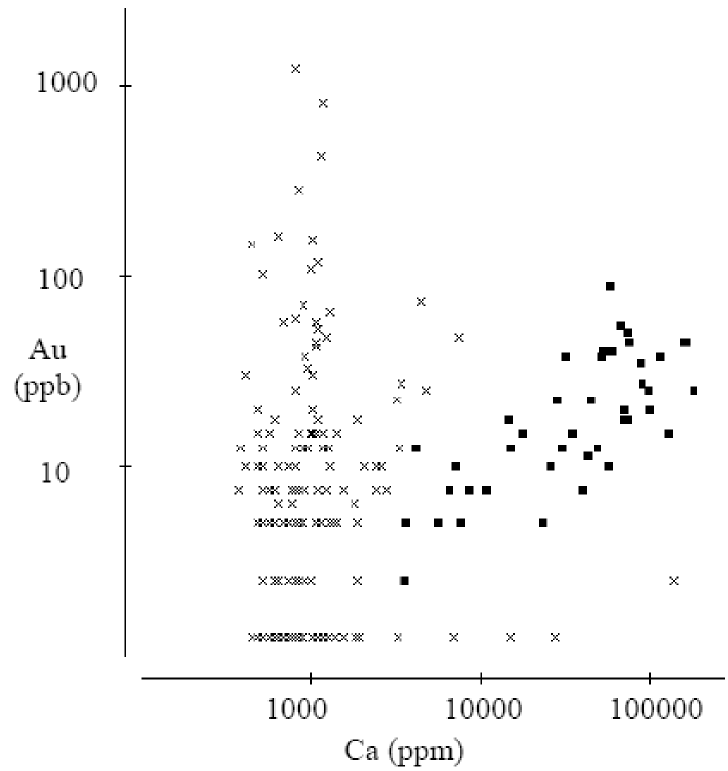
For the upper regolith, the highest Au concentrations (10-30 ppb) occur in the southern part of the section and are associated with Ca in the siliceous upper saprolite and thin colluvial units. Anomalous but lower Au concentrations (10-20 ppb) continue into calcareous facies of the adjacent alluvium. Gold is only weakly anomalous above mineralization in the siliceous units below the alluvium in the central part of the section (Figure 173). The dominant factor in the distribution of Au appears to be lateral dispersion related to known subcropping mineralization occurring to the west, and the presence of calcrete (Ca) with which it is strongly associated. The Ca versus Au scatter plot is particularly interesting since the strong correlation with surficial Ca suggests that the Au is probably mostly chemically derived since detrital Au would cause spikes in the data (Figure 172). There is no evidence of vertical migration of Au to the surface from mineralization located beneath 5 m of transported overburden (and ~30 m of leached saprolite) in the north of the section (Figure 173), (Lintern *et al*., 2002; Lintern, 2004b).

Table 74: Monsoon gold prospect, highest Au concentrations and other anomalous intervals in drillholes (Lintern, 2004b).

Drillhole	Interval (m)	Analyses (ppm unless stated)	Regolith type
97MNAR105	43-44	Au 495 ppb	saprolite
97MNAR104	44-45	Au 170 ppb	saprolite
97MNAR105	45-46	Au 320 ppb, Cu 550, Ag 2	saprolite
97MNAR105	55-56	Au 115 ppb, As 450, Zn 950, Ni 1050, Tl 15	saprock
97MNAR105	19-20	Au 2 ppb Se 20	saprolite
97MNAR119	31-32	Au 23 ppb Se 13, Cu 500	saprolite
97MNAR49	24-25	Au 4 ppb As 550	saprolite
97MNAR47	29-30	Au 65 ppb Ni 1350	saprolite

Conclusions: This case study is typical of a number from the Western Gawler Craton. It demonstrates how calcrete can be sampled to show the presence of underlying mineralization within basement derived regolith. For transported overburden, the buried mineralization is not reflected in hardpan or saprolite at the unconformity, and any surface expression in calcrete is obscured by lateral dispersion from the stronger anomaly associated with the basement derived regolith to the south (Lintern, 2004b).

a)



b)

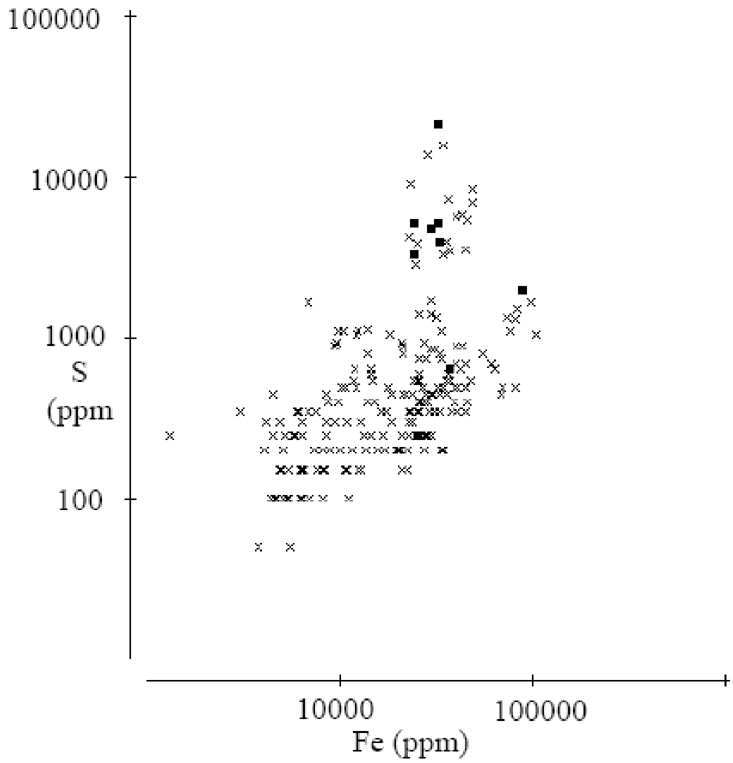
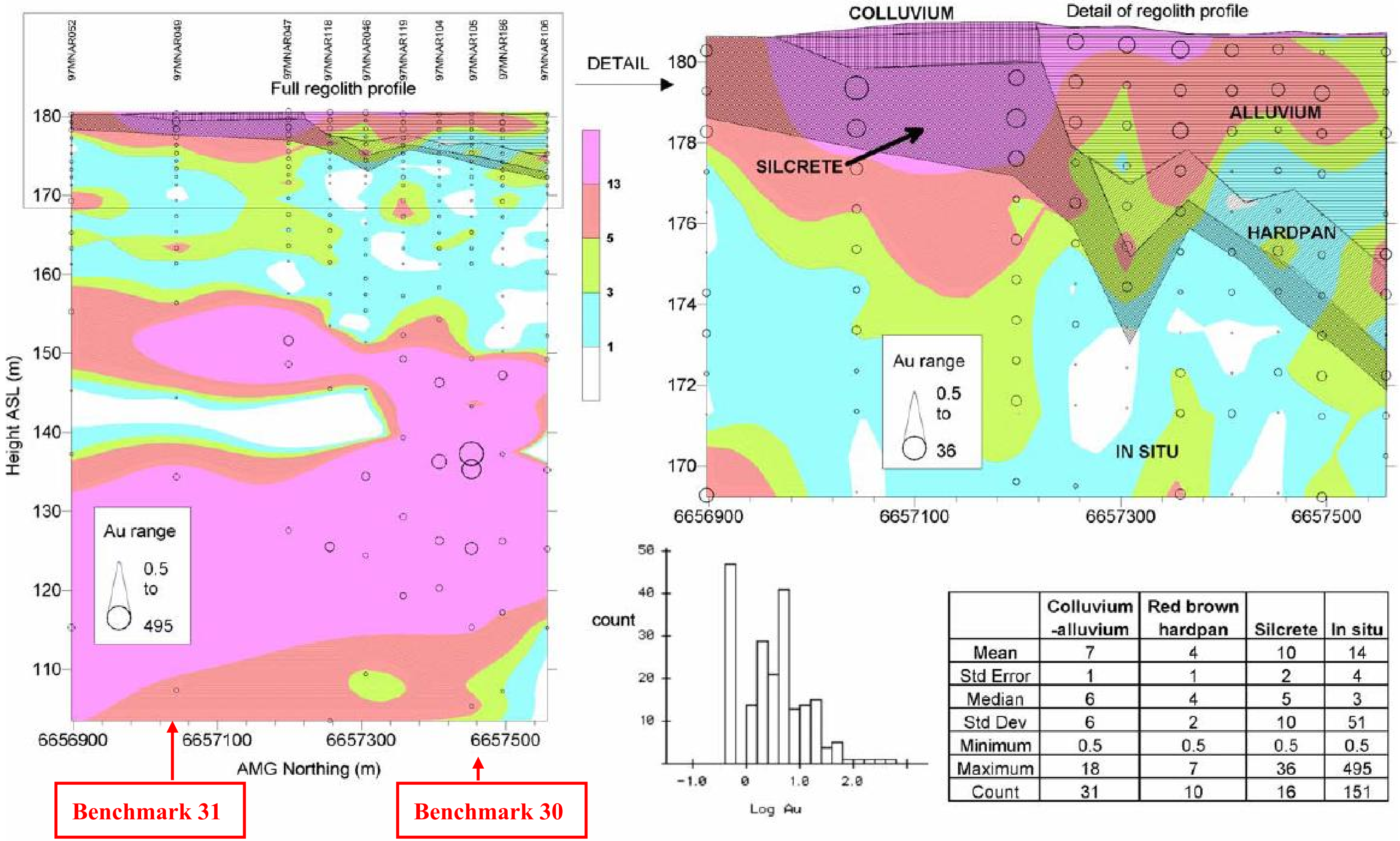


Figure 172: Monsoon gold prospect, scatter plots for selected elements.

Plot a. Ca *v* Au; large box symbols indicate highly calcareous surficial samples showing strong association between Ca and Au.

Plot b. Fe *v* S; large box symbols in top right of plot indicate samples with high Au contents.



	Colluvium -alluvium	Red brown hardpan	Silcrete	In situ
Mean	7	4	10	14
Std Error	1	1	2	4
Median	6	4	5	3
Std Dev	6	2	10	51
Minimum	0.5	0.5	0.5	0.5
Maximum	18	7	36	495
Count	31	10	16	151

73129: Monsoon gold prospect, regolith section, regolith architecture and Au geochemical expression (*c.f.* Figures 170, 171), (Lintern, 2004b). Benchmarks 30 and 31 are indicated.

Benchmark 30: drillhole 97MNAR105

Quick reference items are set out in Table 75; detailed descriptions, figures and data tables follow on below. Monsoon prospect lies about 150 km WNW of Tarcoola and about ~53 km W of Mulgathing Pastoral Station Homestead (Figures 110-112, 136, 169). It can be accessed via pastoral lease tracks and gazetted unsealed roads. Drilling for this RAB hole was vertical. A summary of this profile is provided in Table 76 and chiptray photograph with regolith zonation is in Figure 174. Geochemical data are presented in Figures 172, 173, 175-179 and Table 74.

Table 75: Benchmark 30 reference data; drillhole 97MNAR105 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figure 110-112, 136.
Local-site location map	Figures 169, 170.
GPS coordinates, attitude & elevation	RAB drillhole 97MNAR105: Zone 53, 350688 E, 6657625 N, GDA 94. **Attitude**: vertical. **AHD:** 180.823 (differential GPS data).
Site access, owner	About 150 km WNW of Tarcoola and about 53 km ~W of Mulgathing Pastoral Station Homestead (Figure 136). Site can be accessed via pastoral lease tracks and gazetted unsealed roads. Site Lease holder: Mulgathing Pastoral Station.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photo / log	Yes, Figure 174, Table 76.
Sample types	Drill chips in chiptrays + ~1 kg bags.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Not from thin-sections, only from binocular microscope observations.
Geochemistry	Yes, Figures 172, 173, 175-179 and Table 74.
XRD mineralogy	No.
PIMA spectral data	Yes, unpublished data only, used by Lintern *et al*. (2002) to produce kaolinite Crystallinity Indices for unconformity picks & some mineral identification.
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	?As, Bi, ?Cu, Ni.
Useful sampling media	Calcrete & silcrete.
Key reference sources	Lintern *et al*. (2002); Lintern (2004b).

Background

Drillhole 97MNAR105 is selected to form this benchmark because it includes a moderate thickness of transported cover and is located within the defined Au mineralization. The weathered *in situ* regolith is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 31 and the regolith cross-sections of Figures 170, 171. Exploration grid drilling on this prospect involved RAB (typically without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes have terminated in lower saprolite to saprock rather than within fresh gneiss. Cuttings were sampled from the drilled 1-2 m composites (not ideal for regolith investigations). These drillholes were not originally intended for use as benchmarks; they were later sampled and analysed as part of regional regolith and chemical dispersion studies (Lintern *et al*., 2002, 2003).

0-2 m **Transported**: siliceous alluvium, pale pinkish, sand to pebbles, loose to cemented by calcrete.

2-4 m **Transported**: colluvium-alluvium, dark reddish brown, calcareous in part, carbonate coatings on clasts, Fe-oxide staining.

4-6 m **Transported**: red-brown hardpan, palaeosol, partly Fe-oxide cemented.

~6 m **Unconformity**, base of palaeochannel.

6-8 m ***In situ***: pedolith, silcrete on/in incipiently silicified pallid plasmic zone.

8-12 m Upper saprolite, pallid, kaolinite + quartz grit.

12-32 m Upper saprolite, pinkish to pink, kaolinite + quartz grit.

32-45 m Upper saprolite, pale yellow-brown, kaolinite + quartz grit.

45-72 m Lower saprolite, grey, clays + quartz grit, bluish grey vein quartz at 55-56 m.

NOTE: saprock and bedrock not penetrated; irregular sampling below 20 m. E.O.H. at 76 m but chiptray image is only to 56 m.

Regolith logged by M.J. Sheard

Figure 174: Benchmark 30, Monsoon gold prospect drillhole 97MNAR105, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002). In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehabilitation work.

Table 76: Benchmark 30, regolith log to RAB drillhole 97MNAR105 (after Lintern *et al*., 2002).

Hole: 97MNAR105. **Regolith Line**, Monsoon gold prospect. Regolith descriptions (combined in-field + laboratory observations).

Location: Zone 53, 350688 E, 6657625 N, GDA 94. **AHD:** 180.823 (differential GPS data).

Attitude: vertical.

Site: within a shallow creek gully.

Vegetation: *Acacia aneura* Low Open Woodland over *Maireana sedifolia, Senna cardiosperma* subsp. *microphylla* and *Eremophila latrobei* Low Open Heath. (Botanical log by S. Lintern).

Soil: Uc (gravelly alluvium).

Calcrete: massive to platy.

Logged by: M.J. Sheard, 1999.

Depth (m)	Description of RAB cuttings
0-2	Siliceous alluvium, pale pinkish, sand to pebbles, loose to cemented by calcrete.
2-4	Colluvium-alluvium, dark reddish brown, calcareous in part as carbonate coatings to clasts, Fe-oxide staining. Older than unit above but still related to the modern creek channel.
4-6	Red-brown hardpan, palaeosol, partly Fe-oxide cemented.
6-8	Pedolith, silcrete on/in incipiently silicified pallid plasmic zone.
8-12	Upper saprolite, pallid, kaolinite + quartz grit.
12-32	Upper saprolite, pinkish to pink, kaolinite + quartz grit.
32-45	Upper saprolite, pale yellow-brown, kaolinite + quartz grit.
45-72	Lower saprolite, grey, clays + quartz grit, bluish grey vein quartz at 55-56 m.
72->76	Lower saprolite, dark grey, kaolinite + quartz grit.
E.O.H.	

In situ Regolith

Bedrock was not penetrated by drilling on this prospect, but remnant saprock corestones within the saprolite indicate it has components typical of the Christie Gneiss. Generally saprolite at this site follows descriptions for this prospect set out earlier. Saprolite was not fully penetrated here, its total thickness in adjacent drillholes can be inferred by reference to the regolith section of Figure 170. Pedolith is thinned at this site in comparison with that intersected in Benchmark 31, similarly for silcrete, it too is thinned – possibly by fluvial erosion.

Transported Regolith

Colluvium and alluvium (mostly sand + gravel) forms the thickest transported cover, as palaeochannel infill in this benchmark (~6 m thick). Clast rounding, the presence of lithics and the broad range of clast size indicate immature sediment with a local and some distal provenances. The underlying red-brown hardpan forms a readily identifiable stratum, having colluvial + minor alluvial and pedogenic character (~2 m thick). Red-brown hardpan is an extensively deposited unit in this region and can serve as a key stratigraphic marker bed. PIMA spectral data, as a derived Kaolinite Crystallinity Index, places the main unconformity within the silcrete, where it may well be here. However, the low levels of preserved kaolinite in silcrete and the 1 m drill chip sample bias may also be skewing the pick. Drillcore or an excavation would provide a more absolute answer.

Geochemistry

Geochemical expression for Monsoon gold prospect has been outlined earlier and presented via Figures 172, 173 (Au) and Table 74 (As, Cu, Ni, Se, Tl, Zn).

A 51 element assay package was applied to all samples and Lintern *et al*. (2002) have plotted elemental abundances for all of those on a cross-sectional backdrop. From those abundance plots a selected set, including: Ca *v* Au, Bi, Ni, S and V appear in Figures 175-179. The sulphur plot serves to demonstrate the presence of some gypsum in the palaeochannel sediments and sulphides at depth; compare with the

Ca *v* Au plot of Figure 175 where the high Ca includes both calcrete and minor gypsum. Bismuth, ?Cu and Ni may serve as limited pathfinder elements in this area, but all have weak near surface signals. Compare the geochemical expression over defined Au mineralization with that of Benchmark 31 (in unmineralized ground) and where the transported cover is thinner than for Benchmark 30.

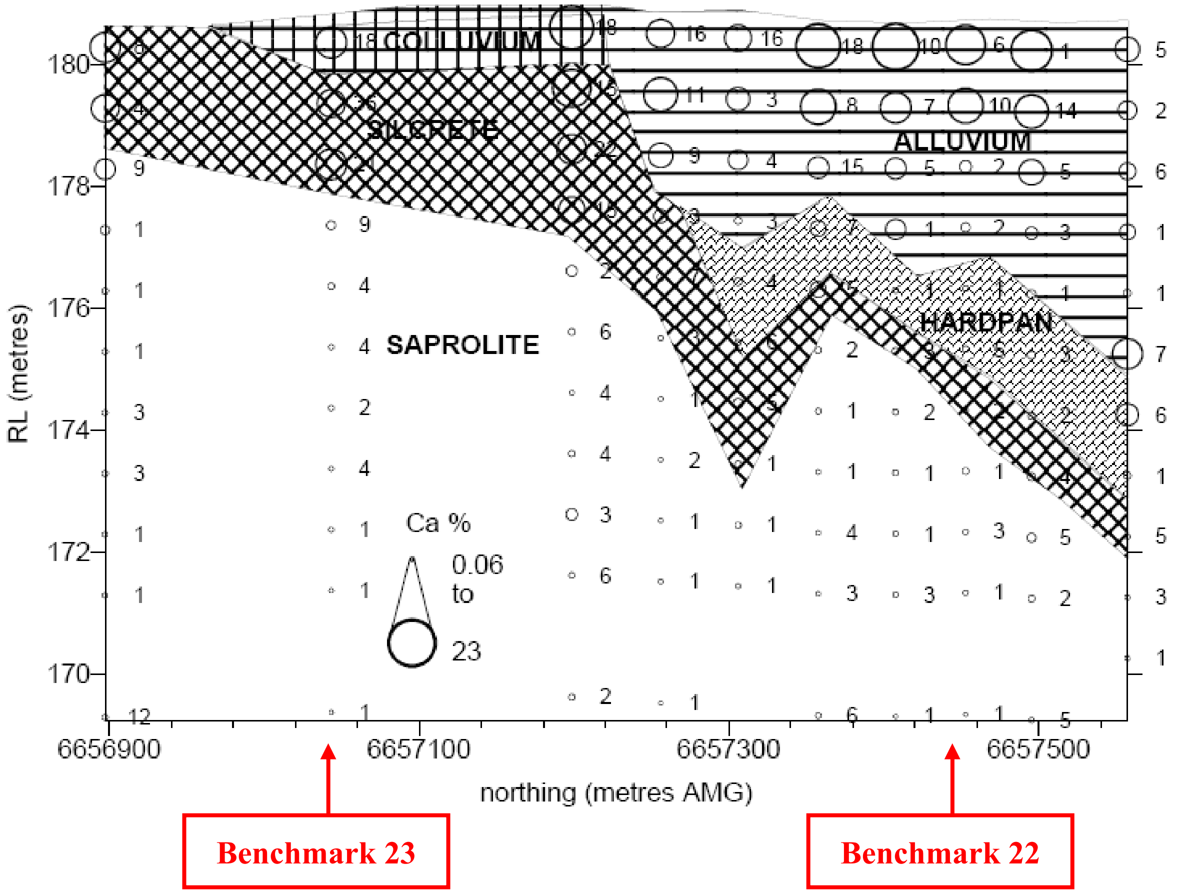
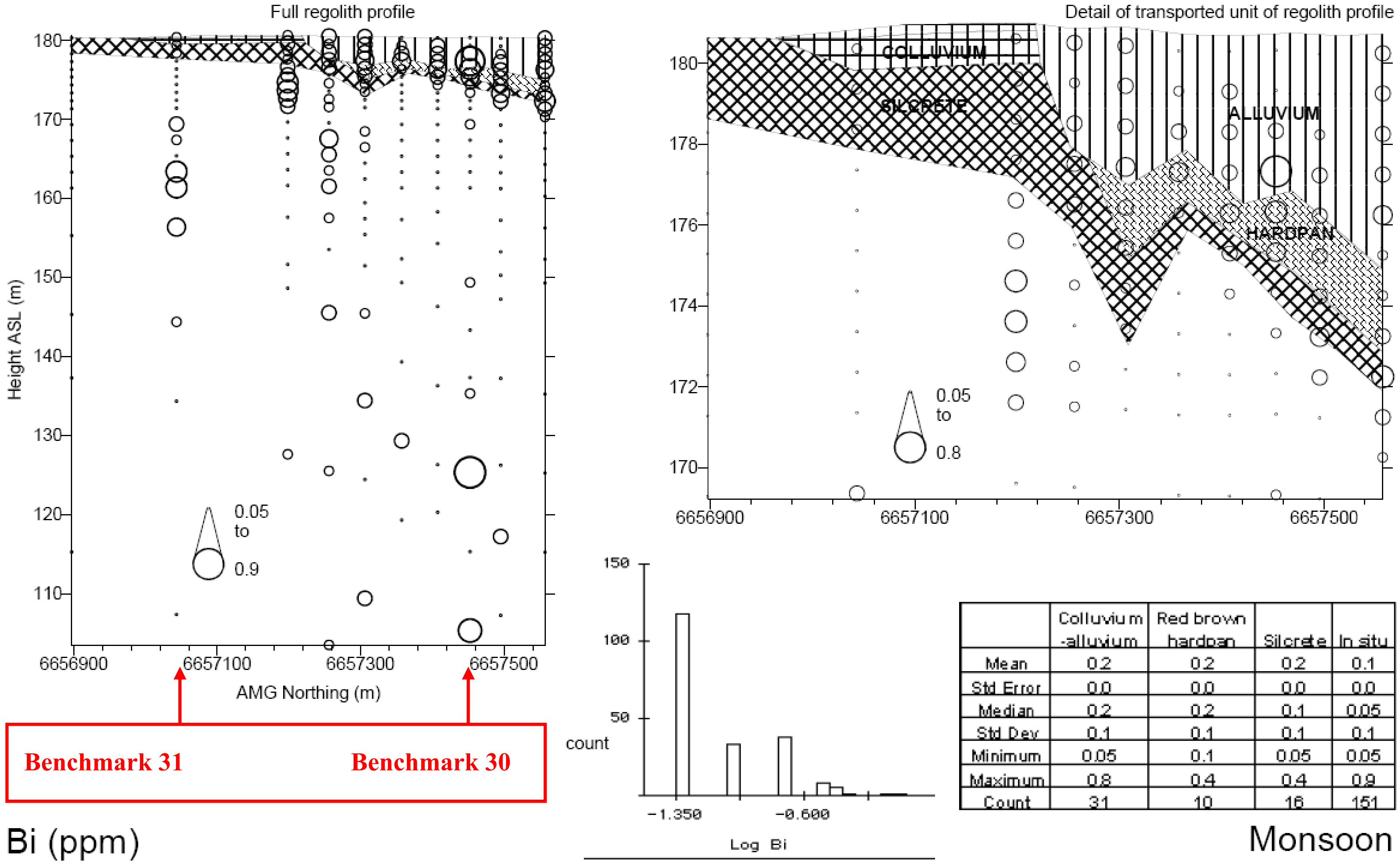
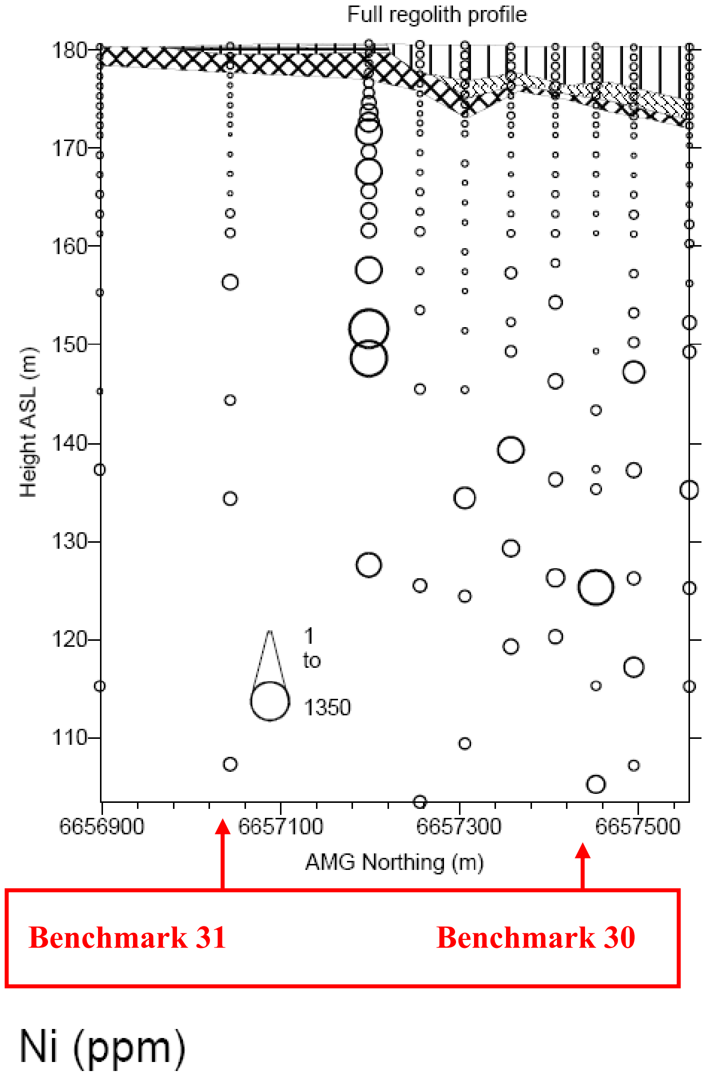


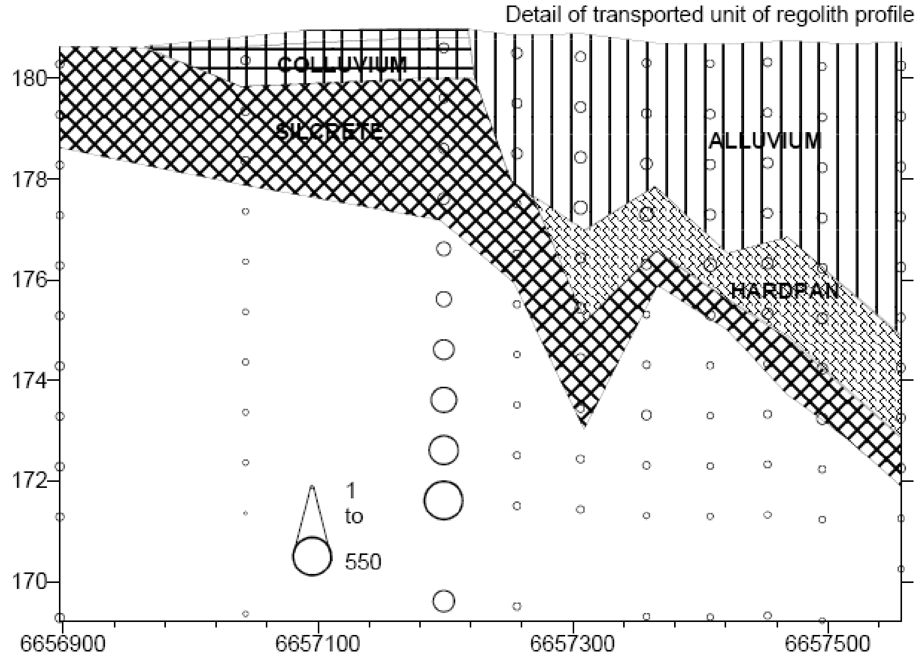
Figure 175: Monsoon gold prospect, distribution of Au (numerical data in ppb) and Ca (circular symbols) in the upper regolith. Calcium is present principally as calcrete but some gypsum is also present (*c.f.* S plot in Figure 178).

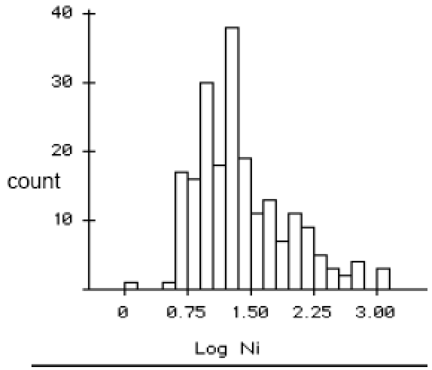


	Colluvium -alluvium	Red brown hardpan	Silcrete	In situ
Mean	0.2	0.2	0.2	0.1
Std Error	0.0	0.0	0.0	0.0
Median	0.2	0.2	0.1	0.05
Std Dev	0.1	0.1	0.1	0.1
Minimum	0.05	0.1	0.05	0.05
Maximum	0.8	0.4	0.4	0.9
Count	31	10	16	151

Figure 176: Monsoon gold prospect regolith section, regolith architecture & Bi geochemistry (*c.f.* Figures 177-179). Lintern *et al*. (2002). Benchmarks 30, 31 indicated.



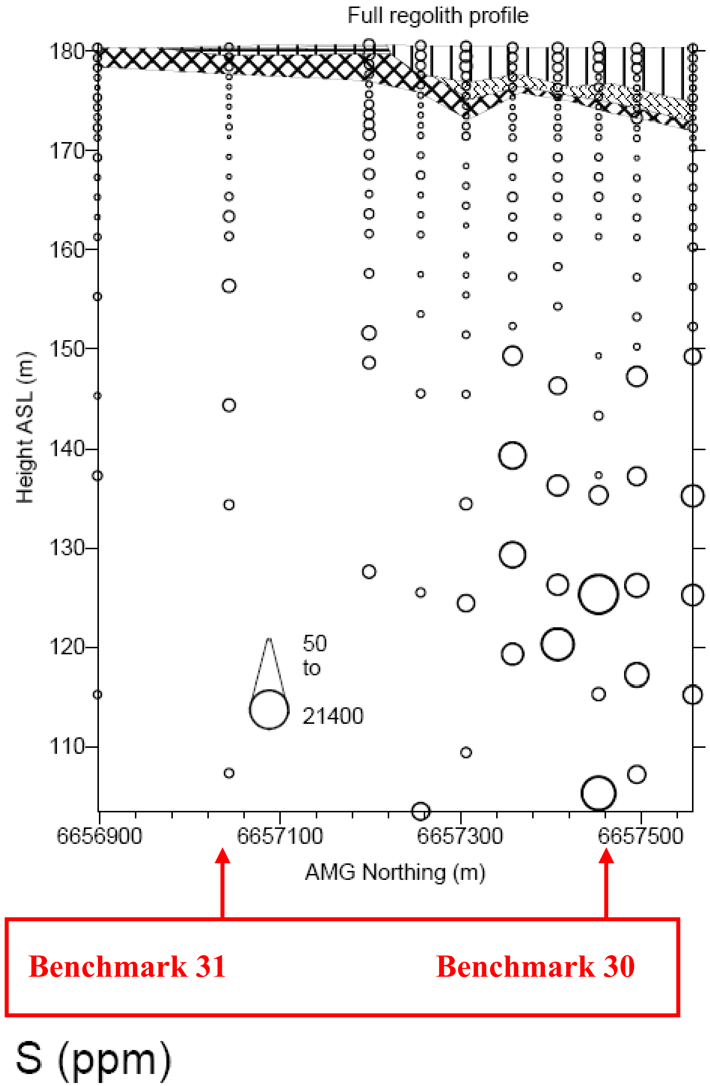


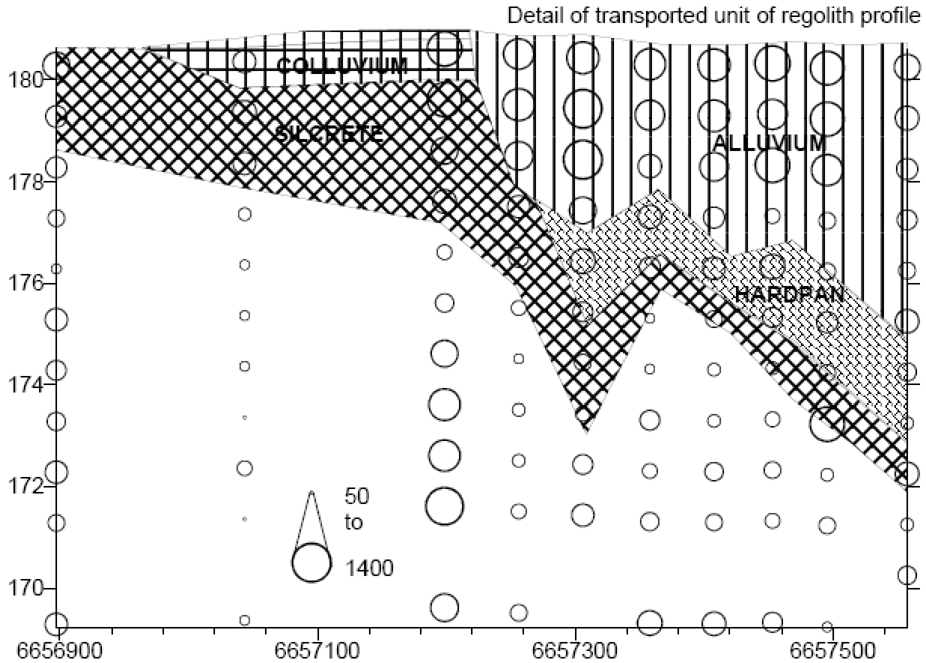


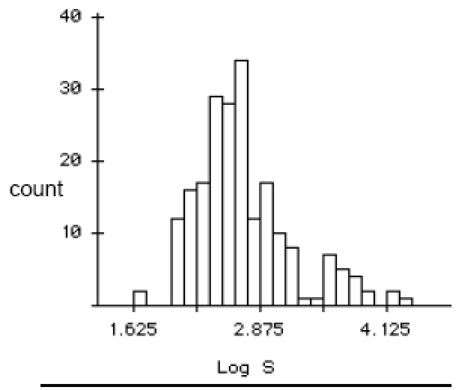
	Colluvium -alluvium	Red brown hardpan	Silcrete	In situ
Mean	22	29	17	89
Std Error	1	3	2	16
Median	21	26	18	17
Std Dev	7	11	7	193
Minimum	11	17	9	1
Maximum	46	51	32	1350
Count	31	10	16	151

Monsoon

Figure 177: Monsoon gold prospect regolith section, regolith architecture & Ni geochemistry (*c.f.* Figures 176, 178, 179). Lintern *et al*. (2002). Benchmarks 30, 31 are indicated.



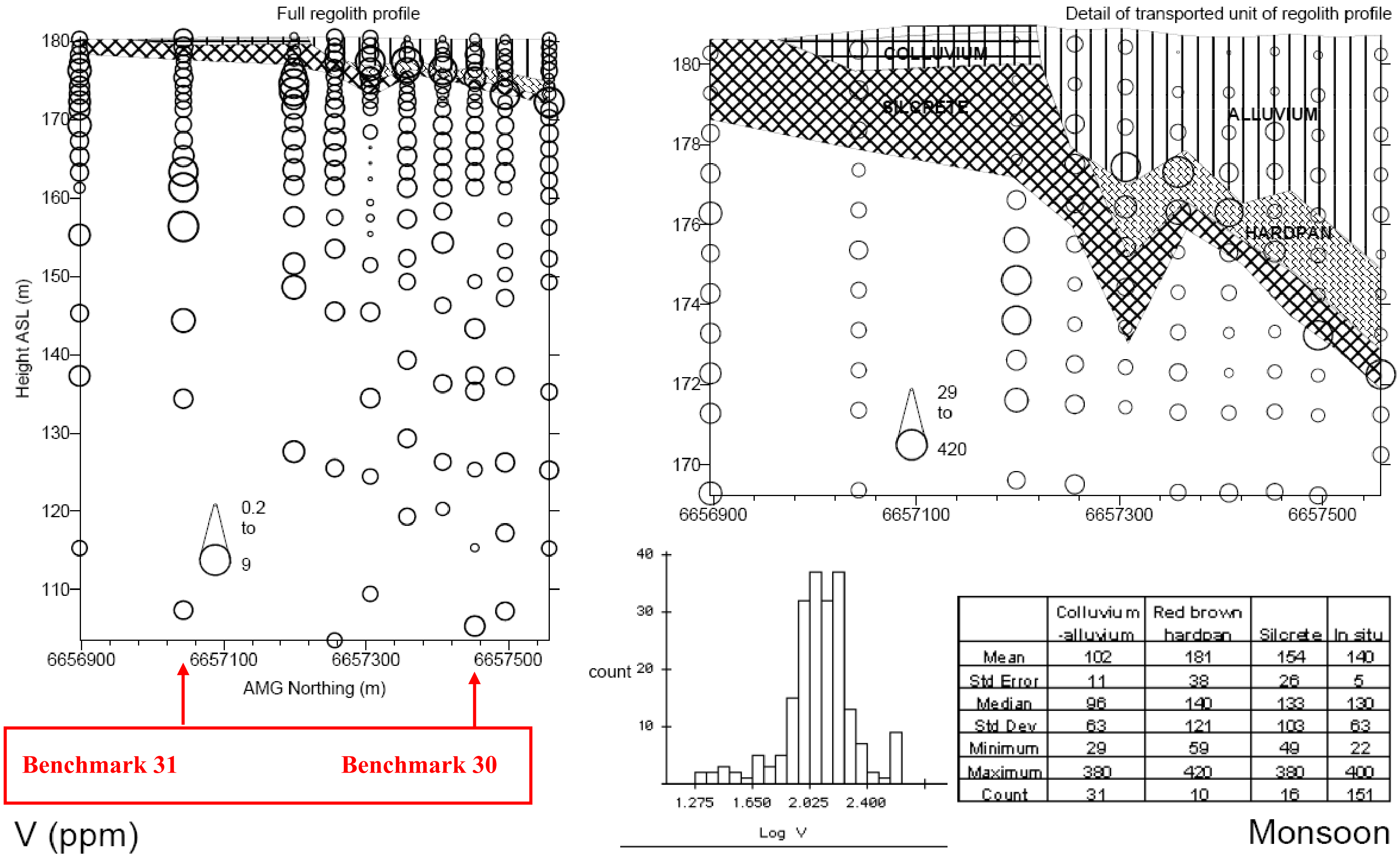




	Colluvium -alluvium	Red brown hardpan	Silcrete	In situ
Mean	742	385	494	1341
Std Error	60	42	69	232
Median	800	375	450	350
Std Dev	333	131	277	2852
Minimum	200	150	150	50
Maximum	1400	550	1100	21400
Count	31	10	16	151

Monsoon

Figure 178: Monsoon gold prospect regolith section, regolith architecture & S geochemistry (*c.f.* Figures 176, 177, 179). Lintern *et al*. (2002). Benchmarks 30, 31 are indicated.



	Colluvium -alluvium	Red brown hardpan	Silcrete	In situ
Mean	102	181	154	140
Std Error	11	38	26	5
Median	96	140	133	130
Std Dev	63	121	103	63
Minimum	29	59	49	22
Maximum	380	420	380	400
Count	31	10	16	151

Figure 179: Monsoon gold prospect regolith section, regolith architecture & V geochemistry (*c.f.* Figures 176-178). Lintern *et al*. (2002). Benchmarks 30, 31 are indicated.

Benchmark 31: drillhole 97MNAR049

Quick reference items are set out in Table 77; detailed descriptions, figures and data tables follow on below. Monsoon prospect lies about 150 km WNW of Tarcoola and about ~53 km W of Mulgathing Pastoral Station Homestead (Figures 110-112, 136, 169). It can be accessed via pastoral lease tracks and gazetted unsealed roads. Drilling for this RAB hole was vertical. A summary of this profile is provided in Table 78 and chiptray photograph with regolith zonation is in Figure 180. Geochemical data are presented in Figures 172, 173, 175-179 and Table 74.

Table 77: Benchmark 31 reference data; drillhole 97MNAR049 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figure 110-112, 136.
Local-site location map	Figures 169, 170.
GPS coordinates, attitude & elevation	RAB drillhole 97MNAR049: Zone 53, 350787 E, 6657214 N, GDA 94. **Attitude**: vertical. **AHD:** 180.859 (differential GPS data).
Site access, owner	About 150 km WNW of Tarcoola and about 53 km ~W of Mulgathing Pastoral Station Homestead (Figure 136). Site can be accessed via pastoral lease tracks and gazetted unsealed roads. Site Lease holder: Mulgathing Pastoral Station.
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photo / log	Yes, Figure 180, Table 78.
Sample types	Drill chips in chiptrays + ~1 kg bags.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Not from thin-sections, only from binocular microscope observations.
Geochemistry	Yes, Figures 172, 173, 175-179 and Table 74.
XRD mineralogy	No.
PIMA spectral data	Yes, unpublished data only, used by Lintern *et al*. (2002) to produce kaolinite Crystallinity Indices for unconformity picks & some mineral identification.
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	?As, Bi, ?Cu, Ni.
Useful sampling media	Calcrete & silcrete.
Key reference sources	Lintern *et al*. (2002); Lintern (2004b).

Background

Drillhole 97MNAR049 is selected to form this benchmark because it includes very thin transported cover and is located away from the defined Au mineralization. The weathered *in situ* regolith is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 30 and the regolith cross-sections of Figures 170, 171. Exploration grid drilling on this prospect involved RAB (typically without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes have terminated in lower saprolite to saprock rather than within fresh gneiss. Cuttings were sampled from the drilled 1-2 m composites (not ideal for regolith investigations). These drillholes were not originally intended for use as benchmarks; they were later sampled and analysed as part of regional regolith and chemical dispersion studies (Lintern *et al*., 2002, 2003).

97MNAR049

0-1 m **Transported**: Surficial lag + colluvium + thin lithosol, pale brown, calcreted.

>1 m, <2 m **Unconformity**, within silcrete horizon.

1-3 m **Transported/*in situ***: pedolith, silcrete: silicified brownish colluvium + pallid plasmic zone.

3-<6 m ***In situ***: pedolith, partly silicified pallid plasmic zone.

<6-12 m Upper saprolite, pallid, kaolinite + quartz grit, bluish vein quartz at 8-9 m.

12-15 m Upper saprolite, grey, quartz grit + less kaolinite

15-17 m Saprolite, khaki, kaolinite + quartz grit.

17-19 m Saprolite, pallid + brown micro-flecking, kaolinite + quartz grit.

19-30 m Saprolite, pale yellowish to grey to khaki, kaolinite + quartz grit, bluish vein quartz at 19-20 m.

30-50 m Lower saprolite, pale brown, dominantly clay.

50->74 m Lower saprolite to saprock, greyish with dark grey lithics (saprock corestones) increasing towards 70 m.

NOTE: bedrock not penetrated; irregularly sampled below 20 m

Regolith logged by M.J. Sheard

Figure 180: Benchmark 31, Monsoon gold prospect drillhole 97MNAR049, chiptray and regolith zonation (image extracted from Lintern *et al*., 2002). In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehabilitation work.

Table 78: Benchmark 31, regolith log to RAB drillhole 97MNAR049 (after Lintern *et al*., 2002).

Hole: 97MNAR049. **Regolith Line**, Monsoon gold prospect. Regolith descriptions (combined in-field + laboratory observations).

Location: Zone 53, 350787 E, 6657214 N, GDA 94. **AHD:** 180.859 (differential GPS data).

Attitude: vertical.

Site: on the upper part of a low flat outcrop area.

Vegetation: *Maireana sedifolia, Senna cardiosperma* subsp. *microphylla* and *Eremophila latrobei* Low Shrubland. (Botanical log by S. Lintern).

Soil: Uc (lithosol, gravelly colluvium).

Calcrete: massive to platy.

Logged by: M.J. Sheard, 1999.

Depth (m)	Description of RAB cuttings
0-1	Surficial lag + colluvium + thin lithosol pale brown, calcreted.
1-3	Pedolith, silcrete: silicified brownish colluvium + pallid plasmic zone.
3-<6	Pedolith, partly silicified pallid plasmic zone.
<6-12	Upper saprolite, pallid, kaolinite + quartz grit, bluish vein quartz at 8-9 m.
12-15	Upper saprolite, grey, quartz grit + less kaolinite.
15-17	Saprolite, khaki, kaolinite + quartz grit.
17-19	Saprolite, pallid + brown micro-flecking, kaolinite + quartz grit.
19-30	Saprolite, pale yellowish to grey to khaki, kaolinite + quartz grit, bluish vein quartz at 19-20 m.
30-50	Lower saprolite, pale brown, dominantly clay.
50->74	Lower saprolite to saprock, greyish with dark grey lithics (saprock corestones) increasing towards 70 m.
E.O.H.	

In situ Regolith

Bedrock was not penetrated by drilling on this prospect. Saprock was encountered in a some drillholes, samples indicate it has components typical of the Christie Gneiss. Generally saprolite at this site follows descriptions for this prospect set out earlier. Saprolite thickness is quite variable, refer to the regolith section of Figure 170 (Lintern *et al*., 2002). Pedolith is thicker at this site but it may still reflect significant erosion pre and post silcrete formation (ferruginous capping is not present and overall the total pedolith thickness is less than might be expected).

Transported Regolith

Colluvium and lags (mostly gravel to blocks) forms the residual transported cover (<2 m thick). Clast angularity, the presence of lithics and the broad range of clast size indicate a very immature sediment with a local provenance. The silcrete horizon enclosing the unconformity, contains colluvium in its upper portion. PIMA spectral data, as a derived Kaolinite Crystallinity Index, places the main unconformity within the silcrete too, confirming the visual observations (Lintern *et al*., 2002).

Geochemistry

Geochemical expression for Monsoon gold prospect has been outlined earlier and presented via Figures 172, 173 (Au) and Table 74 (As, Cu, Ni, Se, Tl, Zn).

A 51 element assay package was applied to all samples and Lintern *et al*. (2002) have plotted elemental abundances for all of those on a cross-sectional backdrop. From those abundance plots a selected set, including: Ca *v* Au, Bi, Ni, S and V appear in Figures 175-179. Bismuth, ?Cu and Ni may serve as limited pathfinder elements in this area, but all have weak near surface signals.

Compare the geochemical expression away from the defined Au mineralization with that of Benchmark 30 (over mineralized ground) where the transported cover is much thicker than for Benchmark 31.

Edoldeh Tank (ET) gold prospect

Background

ET gold prospect and its associated geochemical anomaly occupy sand dune dominated undulating terrain (relief <35 m) about 150 km W of Tarcoola and about 67 km WSW of Mulgathing Pastoral Station Homestead (Figures 136, 181, 182). The prospect is also ~16 km W of the Dog Fence, 21 km W of Mt Christie, and is outside the State's designated Pastoral Leases region. ET can be accessed via gazetted unsealed roads, the Dog Fence maintenance track and more recently made exploration access tracks (Figure 181). The name 'ET' is an acronym contraction derived from the nearby abandoned Edoldeh Tank (Lintern *et al*., 2002, 2003).

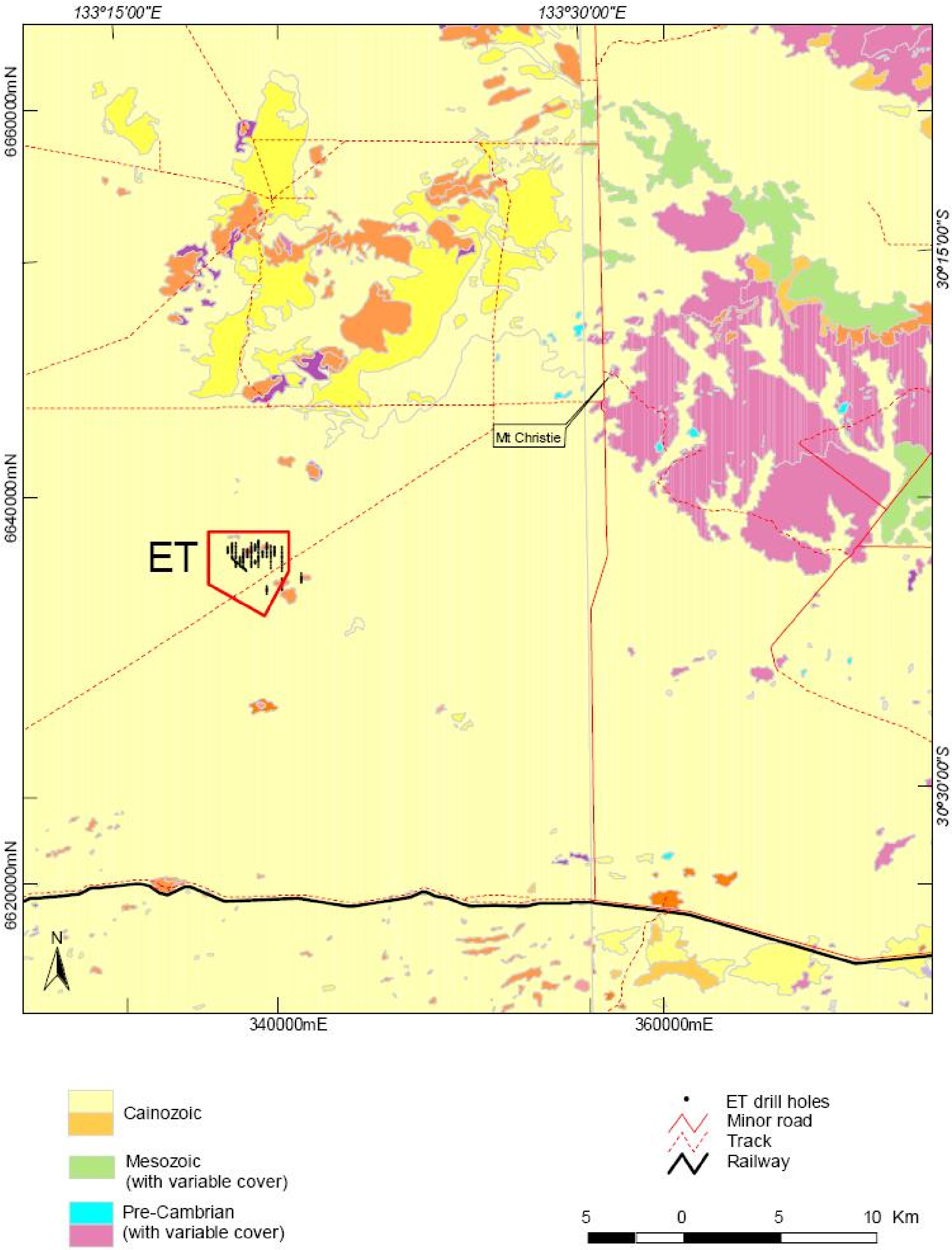


Figure 181: ET gold prospect (boxed) and drill lines in relation to Mt Christie, local roads and tracks, and regional geology (BARTON 250k sheet), (Lintern *et al*., 2003).

The ET geochemically anomalous area (Figure 182) consists of ubiquitous ~E-W trending sand dunes (Great Victoria Desert E fringe) and limited outcrop to subcrop of weathered Archaean Christie Gneiss, where silcrete and calcrete form duricrust cappings. Orange dunes generally mantle palaeotopography (Figures 183, 184), where siliceous sand can reach thicknesses of ~15 m and hosts substantial vegetative cover. Low points of the palaeotopography have been partly infilled with indurated Quaternary colluvium-alluvium in the form of red-brown hardpan (<1-<4 m thick; Lintern *et al*., 2003).

Climatically this region is arid with hot dry summers and cool winters, average rainfall is ~150 mm but annual evaporation exceeds 3500 mm. Pleistocene climate in general appears to have been drier, windier, and possibly cooler than present, leading to extensive desert dunefield development (Callen and Benbow, 1995; Sheard *et al*., 2006). The ET-local terrain and arid climate support woodlands, open woodlands, mallee over shrublands, dominated by large trees and woody shrubs (*Acacia, Eucalyptus, Casuarina, Cratystylis, Scleroleana* and *Senna*). Areas of thin sand cover support woodlands and open woodlands over open shrublands of woody shrubs and trees (*Casuarina, Senna, Eremophila, Santalum, etc*). Vegetation of this type and density impedes vehicle access and exploration but has stabilised the dune system (Lintern *et al*., 2002, 2003; Sheard *et al*., 2006).

ET gold prospect formed part of the larger Gawler Joint Venture tenement coverage, occupying most of the area in Figure 136. The Au anomaly covers an area of ~3 x 4 km^2 (an area larger than for the Challenger Gold Deposit), and has a calcrete maximum of ~115 ppb Au located atop a silcrete breakaway, Figure 182). ET prospect was extensively drill tested in 1996 (>200 RAB drillholes); mineralization below the anomaly pattern yielded best assays of 0.670 to 0.755 ppm over intersections of 2-6 m at depths of 40-50 m. However, evidence from the regolith studies of Lintern *et al*. (2002, 2003) suggest the geochemical anomaly is not necessarily directly over mineralization. Their findings indicate that the main source mineralization to the ET Au anomaly probably lies further west; furthermore, that supposition remains untested by drilling (to mid 2008).

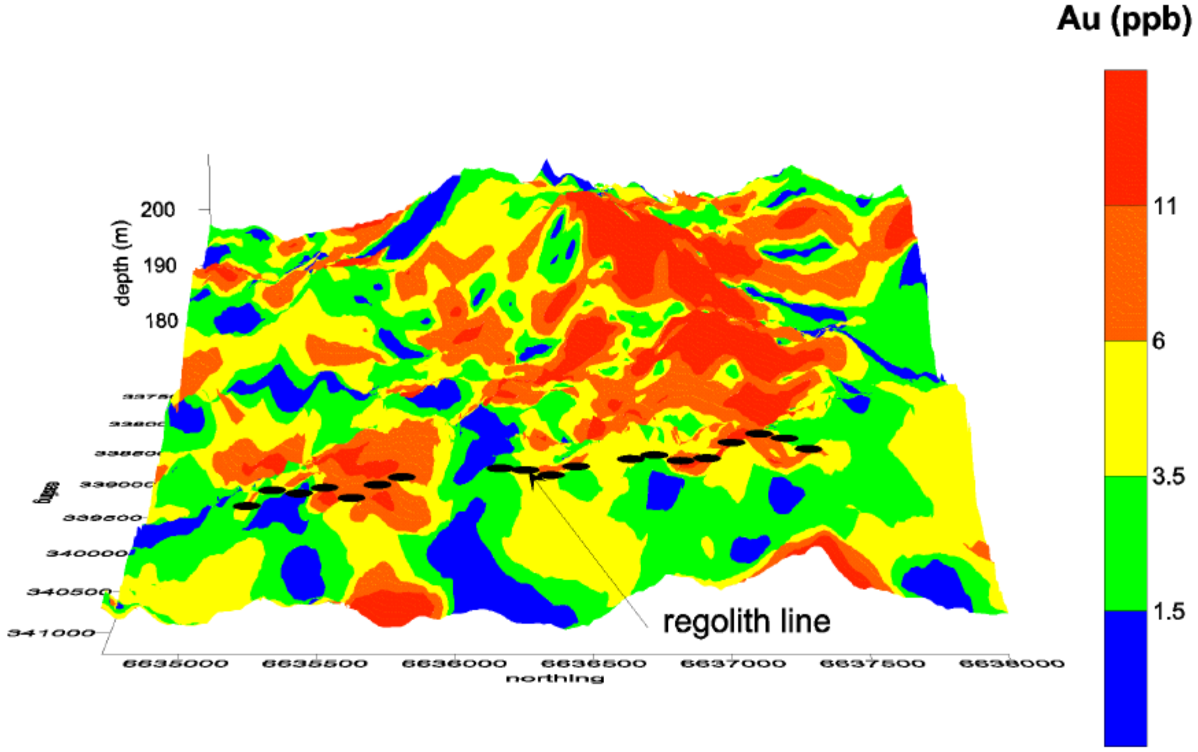


Figure 182: ET gold prospect showing Au-in-calcrete anomaly and drilled regolith study line overlaid on the DEM. Viewed from the east (Lintern *et al*., 2002). Original data supplied by the Gawler Joint Venture.

Regolith studies over the ET prospect by CRC LEME and PIRSA involved a two stage approach. Firstly, an initial N-S oriented section (340200 m N local grid) was selected in the east of the prospect, to investigate dispersion in the transported regolith (~11 m thick there; Lintern *et al*., 2002). In the second phase, the rest of the prospect was investigated in detail, including: i) 3D visualisation of the regolith volume and Au distribution; ii) construction of a detailed regolith landform map (1:10,000 scale; Craig, 2001); iii) use of remote sensing technologies to identify regolith materials (Tapley and

Cornelius, 2003); and iv) extensive regolith logging + geochemical assay + PIMA analysis of weathered minerals + XRD mineralogy (Lintern *et al.*, 2003). The following summary derives from those studies.

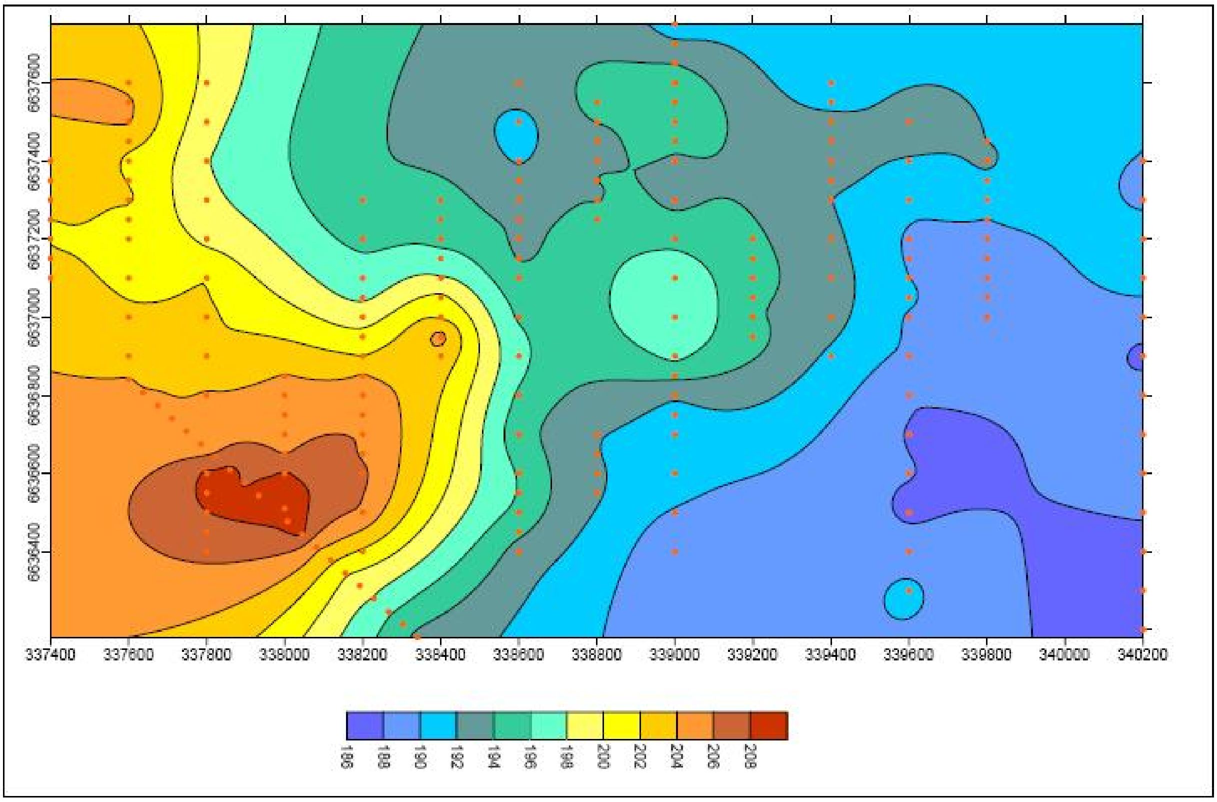


Figure 183: ET gold prospect DEM, derived from aerial photographs. It displays the westerly high ground and associated ridge trending SW. Drillholes are marked by red dots. (Lintern *et al.*, 2003).

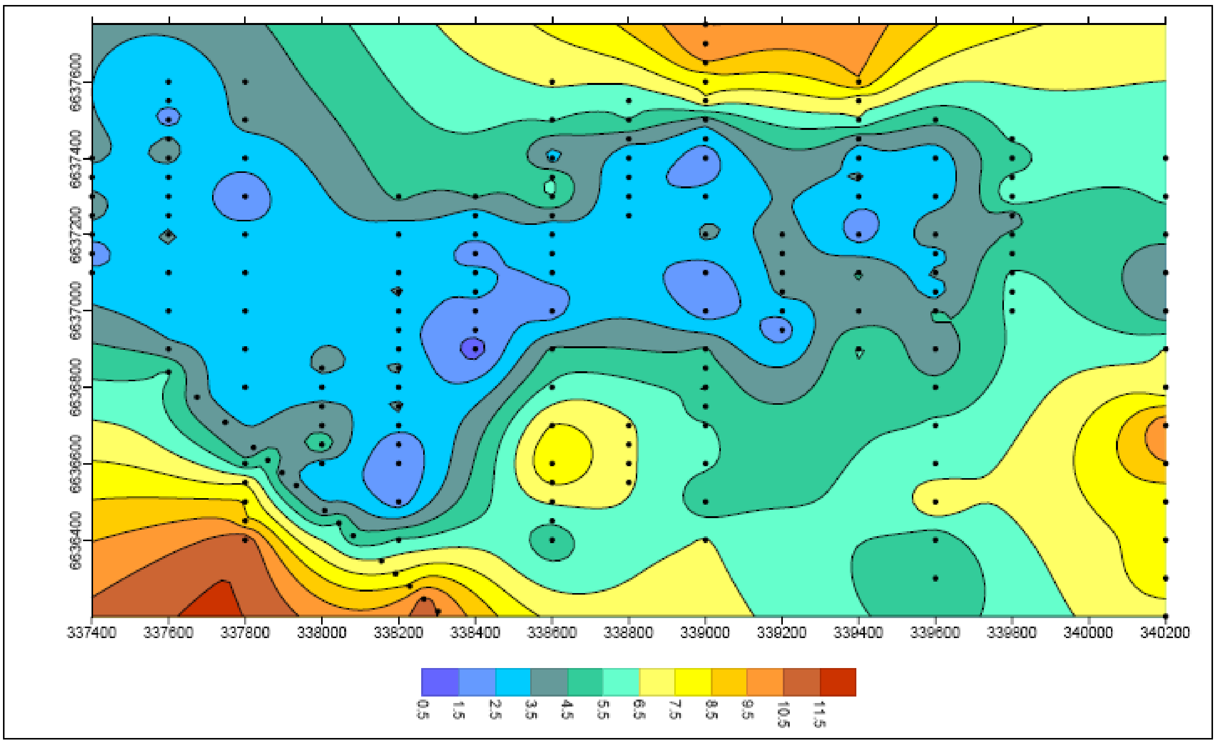


Figure 184: ET gold prospect, isopachs to transported cover. Comparison with the DEM (Figure 183) reveals that the sediments are infilling a palaeolandscape and that there is no significant topographic inversion. Sediment thins over the palaeo-ridgeline and most of the drillholes are sited within the area enclosed by the 4.5 m isopach. (Lintern *et al.*, 2003).

In situ Regolith

All basement outcrop and subcrop is deeply weathered (~50-70 m) and is generally capped by 1-2 m of silcrete duricrust onto and into which has developed calcrete. A breakaway ridge, comprised of abundant silcrete lag, scarce massive silcrete and rare saprolite, provides a window through the sand cover (Figure 185). The 3D and cross-sectional views of ET regolith are presented in Figures 186-188).

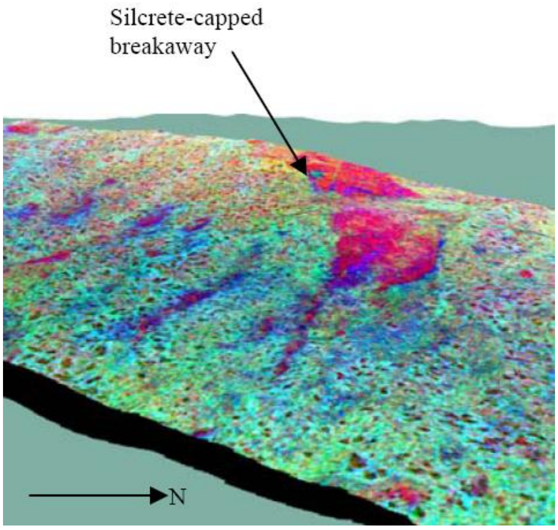


Figure 185: ET gold prospect, a 3D perspective view of colour composite image of HYMAP endmembers 6:5:4, overlaid on the TOPSAR DEM and viewed from the E, looking W across a 2.5 km swath of the prospect. Adapted from Tapley and Cornelius (2003).

Bedrock (<5% weathered), was intersected in only 14 of the >200 RAB drillholes. It is granulitic Christie Gneiss, compositionally layered, strongly foliated and of two distinct types. A felsic gneiss where the white mica is generally muscovite, and a basic-mafic to possibly ultramafic gneiss where biotite is the typical mica and amphibole after pyroxene is also present. Both forms have accessory garnet, cordierite and trace graphite These gneisses give rise to two distinctly different weathering profiles, the former is pale hued and poorer in Fe-minerals, while the latter is dark hued throughout and richer in Fe-minerals (Lintern *et al*., 2003) (Figure 187).

Saprock (>5-<20% weathered), was penetrated by ~ 60% of the RAB drilling, its thickness ranges from ~2->10 m. The felsic gneiss derived form is typically greyish in hue; but the mafic gneiss derived form is very dark grey to dark olive grey or dark olive, where chlorite and nontronite are typical alteration minerals (Lintern *et al*., 2002, 2003) (Figure 187).

Saprolite (>20% weathered) is the dominant weathering zone at ET prospect and generally has a darker coloured lower portion with a more leached upper portion. Its overall thickness ranges from ~25 m to >60 m, and like the bedrock, has two broad types: felsic gneiss derived and mafic gneiss derived. The felsic derived saprolite typically has a coloured lower portion and a pallid (kaolinite + quartz) upper portion; the mafic derived saprolite can be near equally darkly coloured in both upper and lower portions (Figure 186-188). Fe-oxide or Fe-hydroxide coloured mottles (?after garnets) may occur in the upper saprolite (*c.f.* earlier descriptions of a similar occurrence reported for the Challenger Gold Deposit saprolite). Weathering resistate mineral preservation in saprolite is highly variable between drillholes and may include graphite, ilmenite and some biotite. However, garnet, amphibole, pyroxene and muscovite do not persist into the upper saprolite.

An unusual alteration mineral observed within saprolite at ET prospect involves bright yellow-green to bright green clay (PIMA spectra suggest nontronite – a form of smectite) these are more common in the strongly coloured saprolite at depths of 14-26 + >32 m. SEM analysis indicated: Fe, K, Mn, Si, Al, O, Ni & Cr, where Cr = 2.5%. Spatial occurrence of these appear partly related to broad compositional mafic bands in the Christie Gneiss, while others are random occurrences (Lintern *et al*., 2002, 2003).

Pedolith (all weatherable minerals altered, new pedogenic fabric and texture). In this area the unconformity lies within a siliceous duricrust and in a few locations it lies at the silcrete top (see Silcrete below). Locating the pedolith base from drill cuttings alone has been very difficult at ET prospect because the plasmic zone in drill chips resembles the underlying saprolite, that stated, pedolith thickness ranges from <4 to perhaps as much as 20 m. Pedolith commonly includes a clay-rich plasmic zone ± an arenose zone + silcrete, and presents in two distinctly coloured forms: one derived from felsic basement (pale coloured), and a strongly coloured form derived from mafic basement (Fe-stained) (Figures 186-188). Neither form displays an Fe-rich pisolith horizon or remnant; whether Fe-rich pisoliths developed here was impossible to demonstrate from drill samples or outcrop. However, erosional evidence preserved within the silcrete exposures suggests 2-3 m of profile stripping occurred prior to silicification. Pedolith parallels the palaeotopography and grit-rich arenose zones indicate profile collapse has occurred during formation. Megamottling was not observed in outcrop in this area, and RAB sampling does not preserve such macroscopic features (Lintern *et al*., 2002, 2003).

Unusual minerals observed within pedolith at ET prospect include: bright yellow-green to bright green clay (confirmed as nontronite by PIMA), these are more common in the strongly coloured pedolith and deeper within saprolite (Lintern *et al*., 2002, 2003).

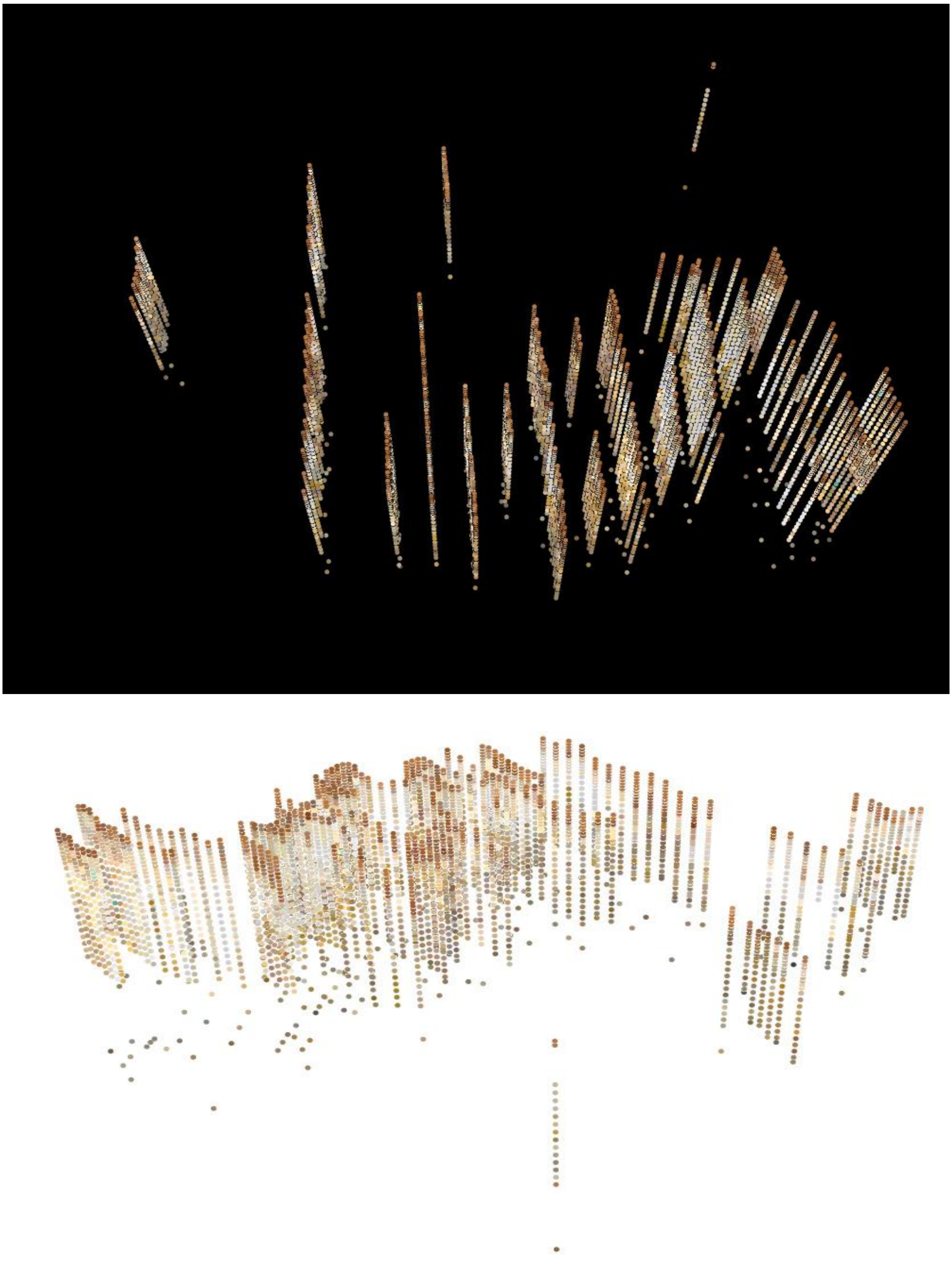


Figure 186: ET gold prospect. Munsell Colours (dominant) for samples from 200 RAB drillholes. Drillholes have been plotted in 3D using small circles for each 2 m sample, where the assigned Munsell colour has been converted from its original notational form to an equivalent digital RGB form. Two contrasting backdrops amply highlight the pallid zones, mafic lithotypes and weathering variations across this area. These view perspectives are not identical (Lintern *et al*., 2003).

Silcrete, forms a significant duricrust on the palaeolandscape at ET prospect and is a later pedogenic process to that which formed most of the deeply weathered basement. Silicification of the remnant earlier formed pedolith and an overlying colluvium-alluvium has occurred, forming a silcrete horizon with associated incipiently silicified profile below. Where the host was clay-rich then porcellanite has developed rather than the more ubiquitous "grey billy" form so common in sandier hosts. Outcrop displays well rounded to angular quartz gravel and pebbles suspended in a sandy to silty matrix, all silicified – forming the colluvial-alluvial upper component. Below the unconformity remnant collapsed quartz veins in a silicified grit-rich collapse fabric forms the lower massive silcrete portion. Graphite, remnant micro-mottles, delicate 3D MnOx dendrites have been encapsulated by the silicification process. PIMA spectral analysis and Kaolinite Crystallinity Indices also place the unconformity within the silcrete horizon (Figures 187, 188). As described above for saprolith and pedolith, silcrete at ET prospect has two distinct colour forms, a pale greyish type usually developed in/on pallid pedolith; and a darker hued Fe-stained form developed in/on ferruginous pedolith, although this colour association with strongly coloured pedolith is not consistent at every site. Thickness ranges from ~1-2 m, but siliceous fronts below the silcrete duricrust may increase the overall thickness to >6 m (Lintern *et al*., 2002, 2003).

Quartz veining, seems to occur randomly throughout the crystalline basement, although the 2 m RAB sampling precludes a more definitive structural description. Quartz in veins is usually semitranslucent and colours range from white to greys to bluish to dark bluish and zoned variants thereof. Vein mineralogy is typically unaffected by the weathering process and any entrapped minerals (micas, feldspar, amphibole, *etc*) remain in pristine condition even within the upper saprolith. Vein thickness ranges from sub-millimetre to tens of centimetres.

Transported Regolith

Colluvium-alluvium, mentioned above in the silcrete description, is consistent with sheet flow, gravity assisted clast movement and deflation of a slowly eroding landscape. Transport distance is generally short, clasts are dominated by gravel and pebbles derived from vein quartz fragments, the finer material derives from surface liberated quartz grit. This sediment in outcrop is poorly sorted and channelling is not obvious, there is commonly a gradational zone between pure colluvium and pure alluvium. Silicification of this sediment occurred well before deposition of the overlying hardpan sediment (Figure 188) (Lintern *et al*., 2002, 2003).

Red-brown hardpan, forms the next youngest sediment and is strongly coloured red-brown to brown by FeOx and FeOH cements. Hardpan forms a reliable marker unit in this area, and is of late Cainozoic age. Primarily a clay-rich, matrix supported sediment, containing rounded to angular quartz clasts of sand to gravel sizes. Clast morphology and distribution indicate a colluvial provenance dominating for this unit but alluvium is also present, therefore some sheet and minor channel flow was operating during deposition. Cementation includes ferruginous materials and hyaline silica. Younger calcrete may infill cracks or form surface coatings. Hardpan ranges from <1 to ~4 m thick and is located in topographic lows. Its upper surface forms another unconformity with overlying aeolian materials (Figure 188) (Lintern *et al*., 2002, 2003).

Dune sand, blankets a large portion of this prospect. These aeolian sands form an eastern fringe to the Great Victoria Desert stretching NW to skirt the Nullarbor Plain. Sand grains are siliceous, dominantly quartz (>80%) but includes feldspar (<20%), fines (<1%) and trace lithic grains. Grain size is fine to medium, grain sorting is uniform, and most sand is mostly free running when dry, except where cemented by calcrete. Colours are: moderate orange (5YR 6/7) to brownish orange (5YR 5/7) to light brown (5YR 5/6) to strong brown (5YR 4/6 and 4/8) and less commonly moderate reddish brown (2.5YR 4/5). In some instances, illuviated fines have established clayey sand dune cores that are more strongly coloured than the surrounding sand. Dune thicknesses range from ~4 to 11 m, and surrounding sand plains have thicknesses of <1-3 m (Figure 188) (Lintern *et al*., 2002, 2003). Luminescent dating of dune sand ~55 and 105 km W of ET prospect yielded dune core ages of ~200-220 ka and dune crest sands ages of 100-20 ka (Sheard *et al*., 2006). It is expected that the dunes on ET prospect have similar age characteristics.

Calcrete, occurs throughout the upper regolith in aeolian sand, impregnating near surface hardpan, silcrete and pedolith. Within dunes there are typically more than one calcrete horizon, these range from earthy powders to nodules and extensive sheets (Figure 188). Where developed into exposed silcrete, pedolith and saprolith, calcrete tends to be massive or of laminated sheets in form. Karstic weathering has developed into the more massive sheets yielding sizeable pot holes and rillen (Lintern *et al*., 2002, 2003) (Plate 34).

Plate 34: ET gold prospect, dune sand soil pit (~1 m deep) exposing a sheet calcrete B_{Ca} horizon (>50 cm thick) into which pipe karst has developed. Soil water dissolution and perhaps the activity of tree roots on the $CaCO_3$ have yielded this solution feature. Scale bar in pothole is 100 mm long (Lintern *et al*., 2003).

Lags, are a minor residual component of this landscape, consisting mostly of silcrete and vein quartz clasts. Lags range from fine gravel to blocks of up to 100 mm and various rounded pebbles (Lintern *et al*., 2002, 2003).

Soils, range from uniformly sandy (Uc) to poorly structured lithosols, especially surrounding silcrete and saprolith outcrop. They all have weakly developed horizonation with little organic component in the A horizon. All soils in this region have a strong alkaline reaction trend due to the presence of calcrete in the B_{Ca} horizon. Fines-rich soil types and those developed in exposed dune clayey sand cores, are probably sodic (type AS2; Northcote and Skene, 1972; Northcote, 1979). Soils like these are prone to gully erosion if their surfaces are disturbed because sodic clays are very dispersive in rain run-off waters (Lintern *et al*., 2002, 2003; Northcote and Skene, 1972).

PIMA Mineralogy

The major minerals identified in drill samples by PIMA in the weathered zone are kaolinite and smectite (PIMA does not detect quartz). Small amounts of poorly crystalline kaolinite and smectite occur in the dune sand with a sharp boundary to well crystallized kaolinite of the basement derived saprolite. Kaolinite in the silcrete horizon beneath dune sand and hardpan is mainly poorly crystalline, suggesting a large transported component. However, kaolinite in silcrete is typically in low abundance and may have undergone changes during silicification; whereas evidence from outcrop places the unconformity in the silcrete horizon's lower half (Lintern *et al*., 2002, 2003).

Selected samples were also analysed by XRD and SEM to identify or confirm unusual minerals and weathering products (see earlier information under *In situ* Regolith); also refer to Lintern *et al*. (2003) for specific particulars.

Geochemical expression

Elemental concentrations are primarily governed by regolith type. Element abundances in transported material (dune sand) are: i) generally lower than for the other regolith materials, except for Ca, Sr and, to a lesser extent, Au (Figure 189a), ii) correlated with one another and iii) restricted in their concentration ranges due to sediment mixing *e.g*. Fe and Ga (Figure 189b). Concentrations of pathfinder elements, commonly associated with Au, are generally low *e.g*. As, Cu and Ni (Table 79).

Along the study line (340200 m E; Lintern *et al*., 2002) Au concentrations in the dune sand are surprisingly high (Maximum 21 ppb; Figure 190) considering that the dunes are only a few hundred thousand years old according to Sheard *et al*. (2006). One Au concentration (drillhole 96ETAR189, 33 ppb) occurs close to the interface between the weathered *in situ* and transported regolith units and may be attributable to detrital Au in silicified alluvium at the base of a palaeo-gully. Another very high Au concentration of 755 ppb Au, was subsequently re-analysed at 0.1 ppb, and was also located at the unconformity, and is suggestive of either detrital Au or analytical contamination. Higher Au concentrations in the dunes appear to be not necessarily related to the calcrete but can also be relatively high in the carbonate poor surrounding material. Gold concentrations in the dune sand do not necessarily reflect higher Au in the upper saprolite or mineralization in the lower saprolite.

.

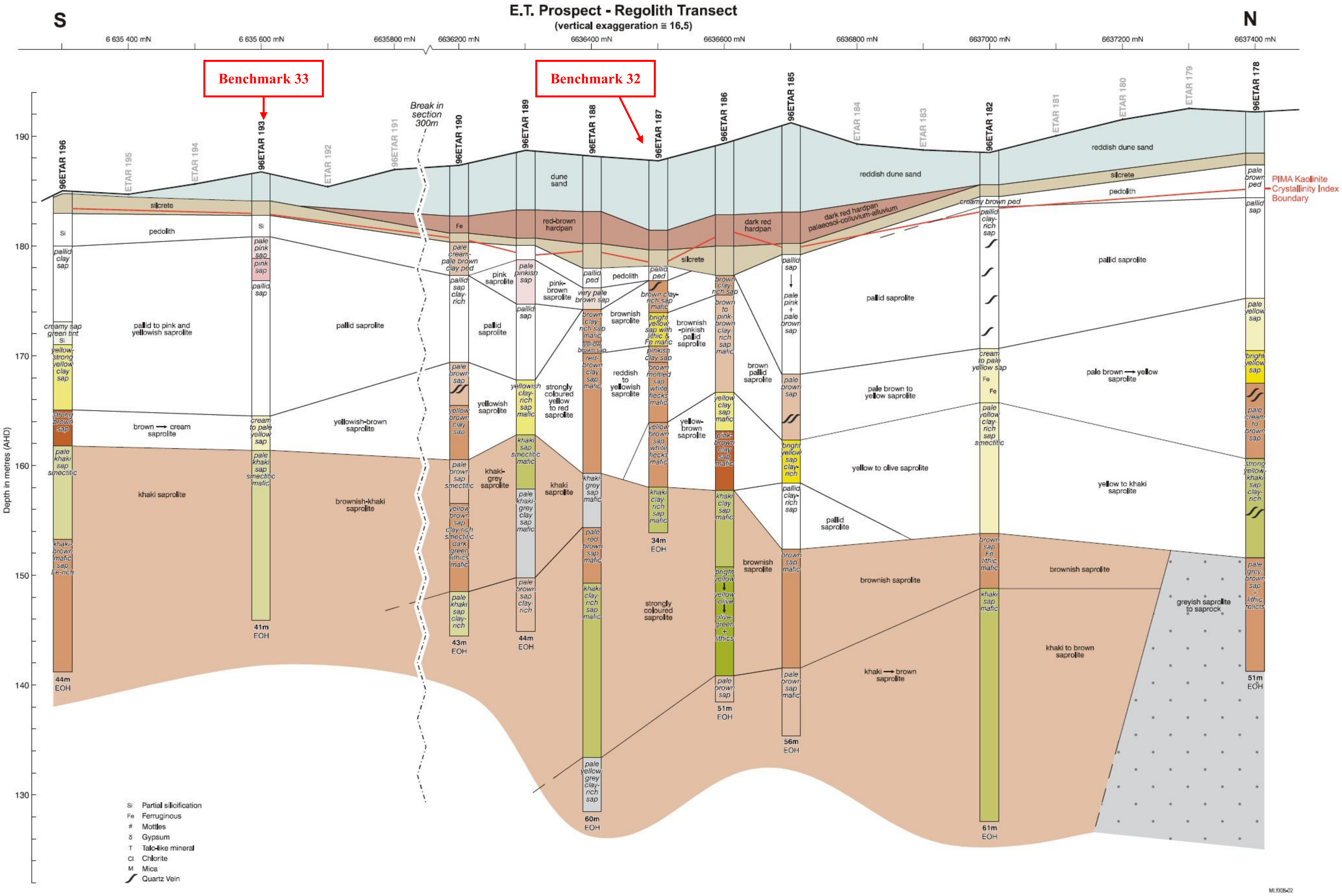


Figure 187: ET gold prospect full depth section along 340200 m E (local grid) the study line displayed in Figure 182 (Lintern *et al*., 2002). Benchmarks 32 and 33 are indicated.

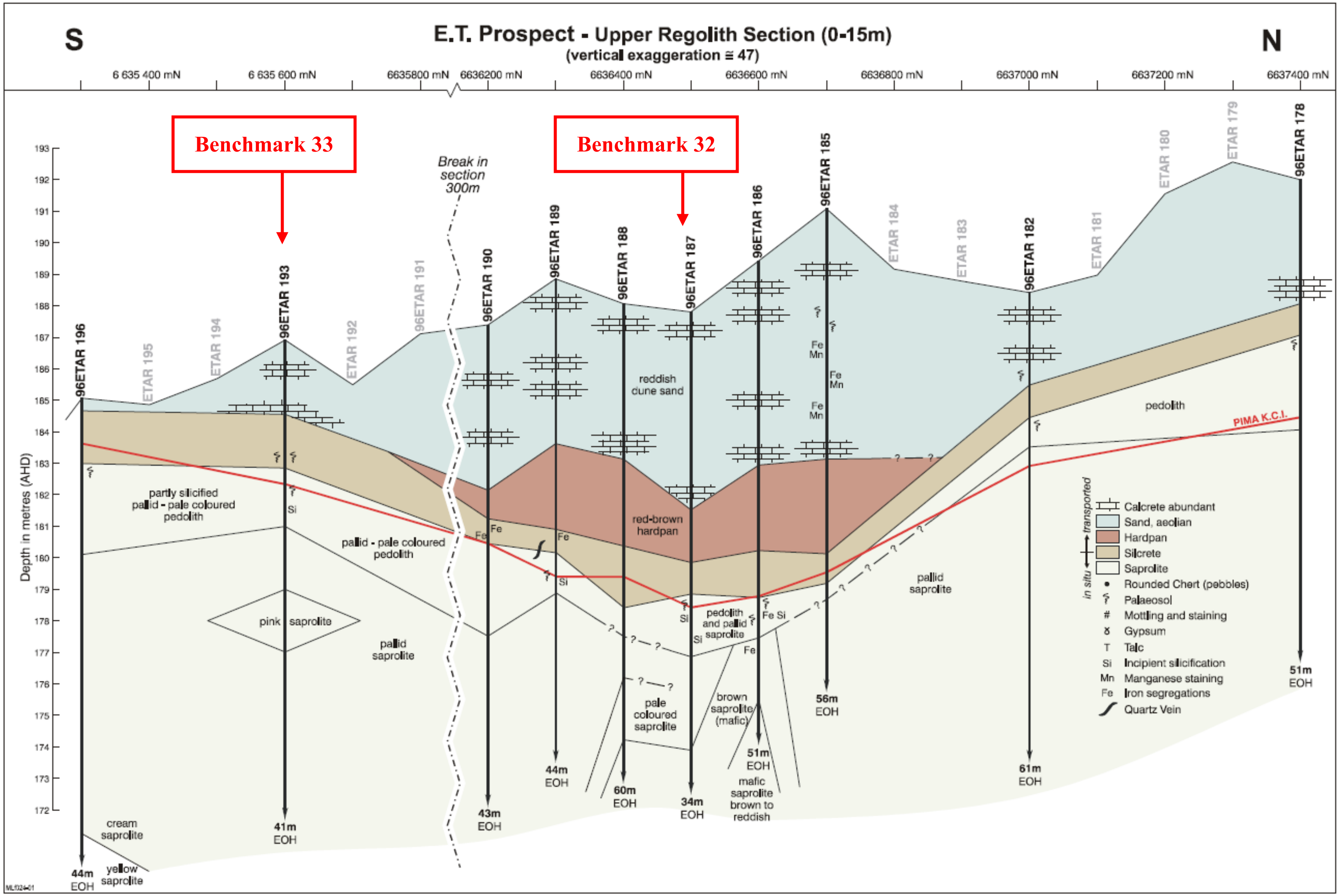
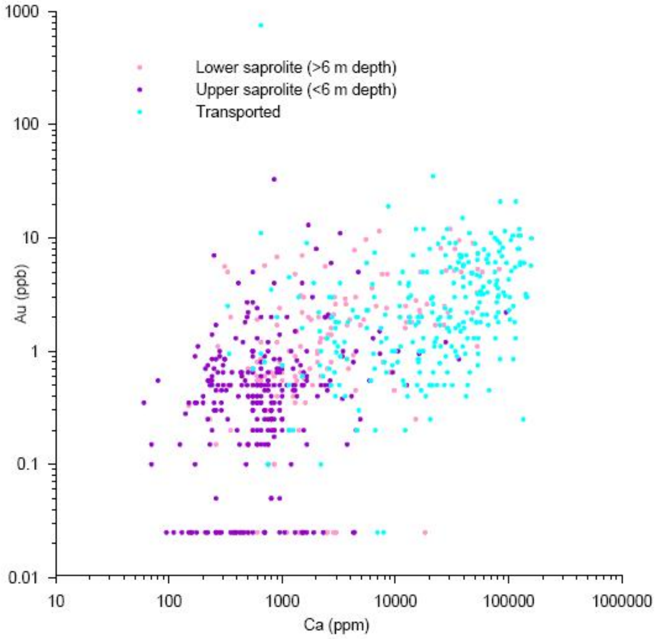


Figure 188: ET gold prospect, upper regolith section along study line (340200 m E local grid) displayed in Figures 182, 187 (Lintern *et al*., 2002). Benchmarks 32 and 33 are indicated.

a)



b)

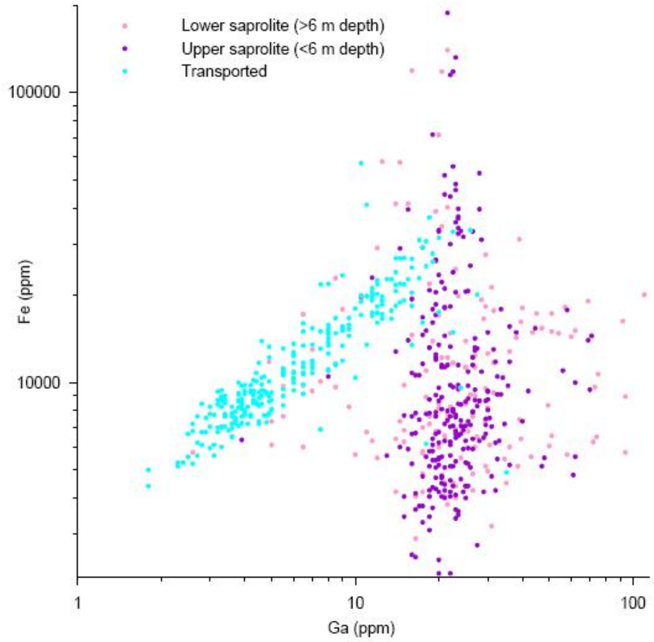


Figure 189: ET gold prospect, scatter plots (logarithmic axies) for: a) Ca *v* Au, and b) Fe *v* Ga.

Table 79: ET gold prospect, highest Au concentrations and other anomalous drillhole intervals for drilled section 340200 m E (local grid).

Drillhole	Interval (m)	Analyses (ppm unless stated)	Regolith type
96ETAR185	47-48	Au 390 ppb	saprolite
96ETAR187	33-34	Au 101 ppb	saprolite
96ETAR196	17-18	Au <1 ppb Cu 320	saprolite
96ETAR188	42-43	Au 30 ppb Ni 1400	saprolite

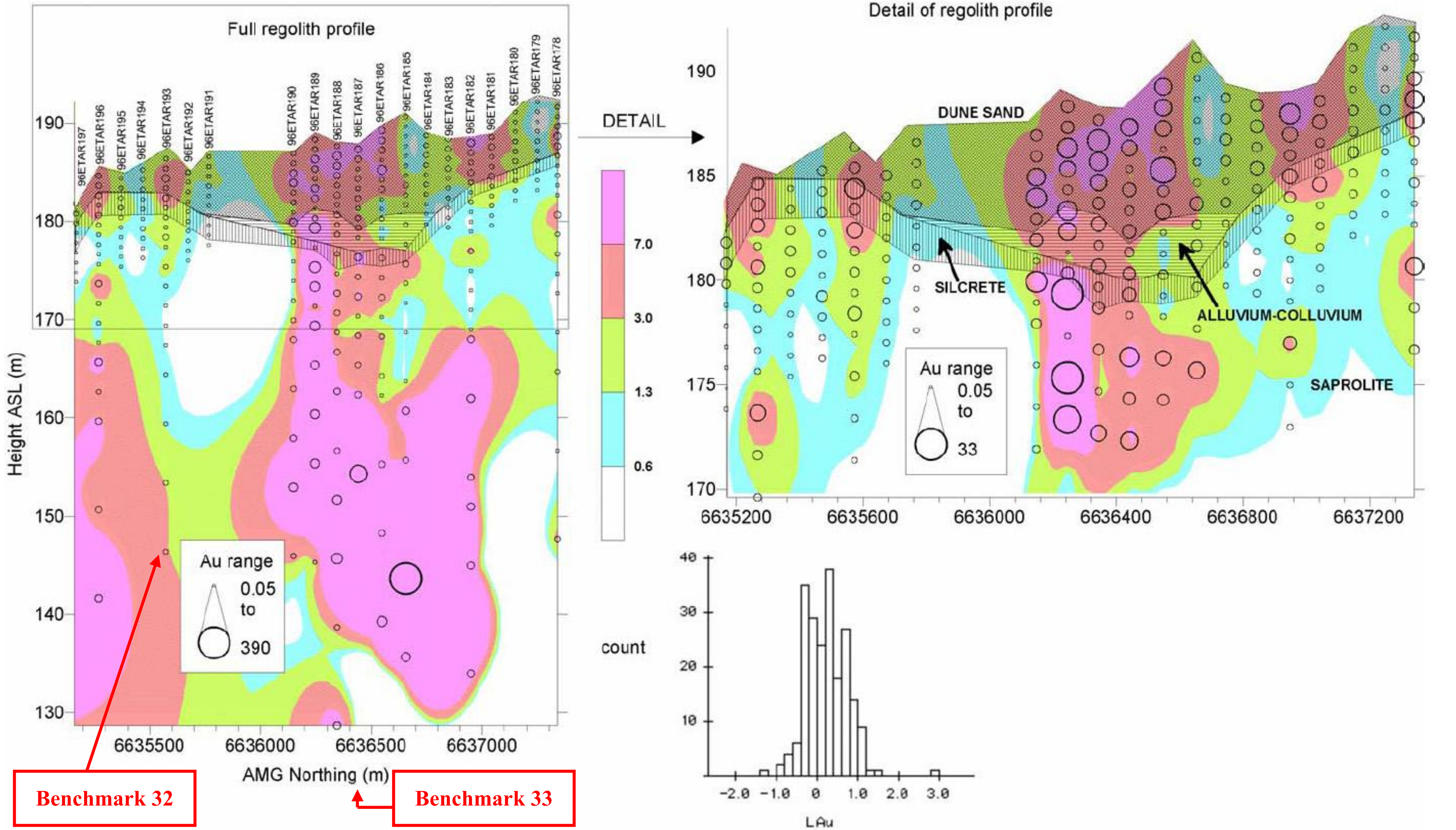


Figure 190: ET gold prospect, regolith section, regolith architecture and Au geochemical expression (*c.f.* Figures 187, 188, 193), (Lintern, 2004b). Benchmarks 32, and 33 are indicated.

From the second phase of study (Lintern *et al*., 2003) it was concluded that:

1. The main Au anomaly in calcrete is associated with a thinly covered, topographic high of weathered *in situ* (residual) regolith flanked by lower lying deeper sand. It is not directly coincident with the main Au anomaly found in the upper regolith, which is further E along the ridge. The reasons for this are unclear since there is a strong association with Au and carbonate in the drill cuttings.
2. Drilling data suggests that neither the main anomaly (upper regolith) nor that in calcrete is fully explained by the current understanding of the mineralization extent. Further drilling is required.
3. Multi-element geochemistry has limited value in delineating new anomalies but can support the Au data. For example, Ag (cyanide-soluble) is anomalous over the Au anomalies occurring in calcrete and the 0-1 m drill cuttings. However, Cu (cyanide-soluble) is much more related to lithotype than mineralization. Arsenic from lower saprolite appears to be following a structural trend and may be related to mineralization.
4. Whereas many anomalies within weathered *in situ* regolith are directly related to mineralization, there are several examples where the surficial data are not easily explained by the drilling data. The Au has either been displaced from its source and seemingly concentrated, or the drilling has been inadequate.
5. The best evidence for an anomaly occurring in transported regolith is drillhole 96ETAR070 (Figure 191). Gold concentrations in drill cuttings reach 35 ppb in calcareous sand over weak mineralization at 25 m. A nearby calcrete sample has an Au concentration of 30 ppb. In section there is no mineralization on the upslope ridge and Au in calcrete on the ridge attains a maximum of 10 ppb.
6. In some locations there are no surficial Au anomalies over concealed mineralization. This suggests surficial regolith materials cannot be relied upon to detect all mineralization at the prospect scale. Alternatively, the mineralization may be so weak that it does not form an anomaly or be discontinuous, in which case the data reflect the real situation and there is no surficial dispersion.
7. Vegetation Au data (0.5 km x 0.5 km grid) can potentially provide additional exploration targets, but their failure to substantiate existing anomalies in calcrete reduces the confidence in their use. The highest Au concentrations appear to be more related to transported regolith, suggesting that vegetation may be responding more to run-off from sub-crop on the ridge.
8. Soil sampling (0.5 km x 0.5 km grid) appears to delineate the main Au anomaly but is probably responding more to the presence of thin transported regolith above underlying anomalous calcrete.
9. The multi-disciplinary approach at ET prospect proved to be especially useful in interpreting geochemical anomalies and establishing regolith controls. Regolith mapping greatly benefited from Landsat TM data and digital elevation models. Regolith architecture and mapping of regolith materials is important for any exploration program since different sampling media give different responses.
10. Calcrete appears to be the best sampling medium at ET prospect.

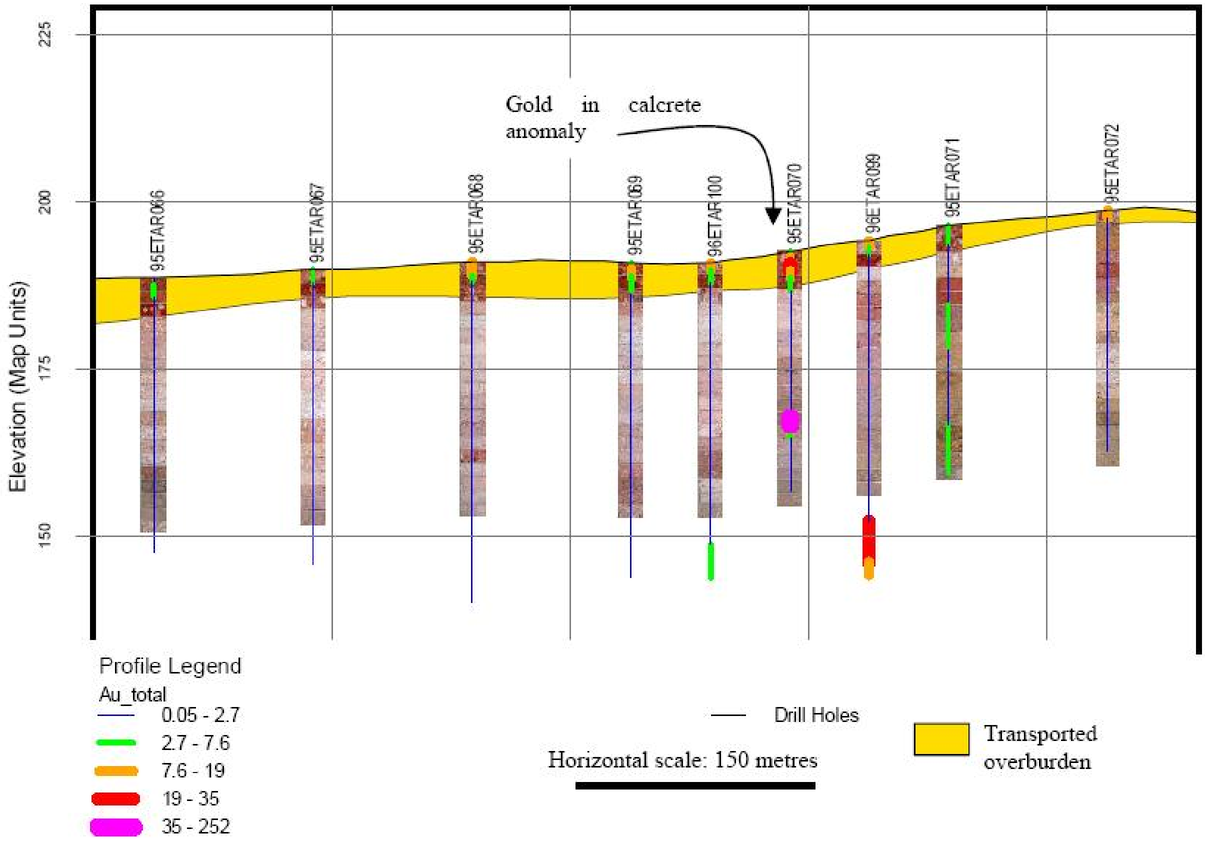


Figure 191: Gold-in-calcrete anomaly in transported regolith over mineralization along the southern portion of drilled section 339000 m E (local grid). Chiptray photos are behind the down hole Au traces, they display regolith colours (Lintern *et al*., 2003, 2004).

Benchmark 32: drillhole 96ETAR187

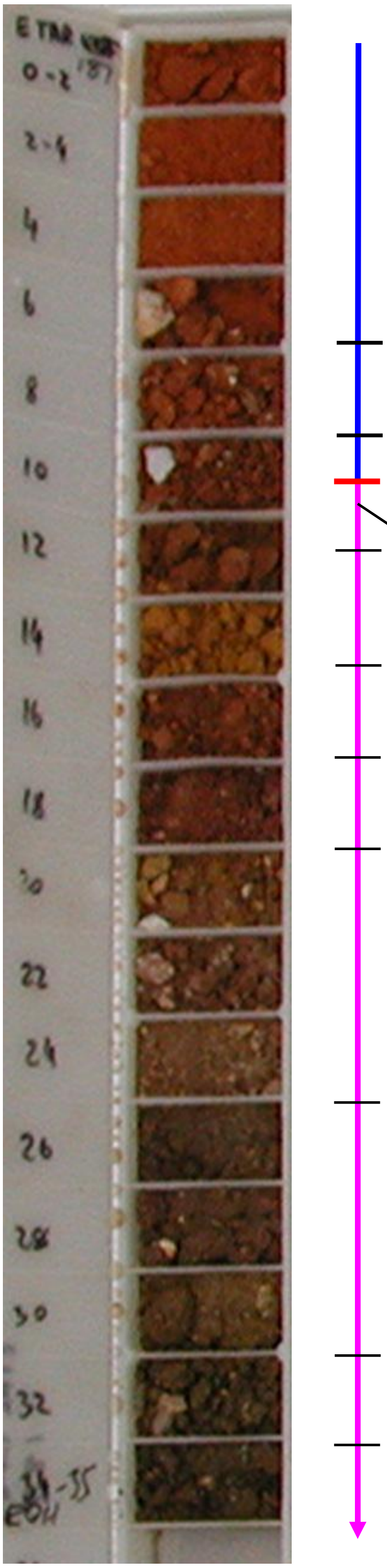
Quick reference items are set out in Table 80; detailed descriptions, figures and data tables follow on below. ET prospect lies about 150 km W of Tarcoola and about 67 km WSW of Mulgathing Pastoral Station Homestead (Figures 110-112, 136, 181-184). The prospect is also ~16 km W of the Dog Fence, 21 km W of Mt Christie, and is outside the State's designated Pastoral Lease western edge. ET can be accessed via gazetted unsealed roads, the Dog Fence maintenance track and more recently made exploration access tracks (Figure 181). Drilling for this RAB hole was vertical. A summary of this profile is provided in Table 81 and chiptray photograph with regolith zonation is in Figure 192. Geochemical data are presented in Figures 189, 190, 191, 193, 194 and Table 79.

Table 80: Benchmark 32 reference data; drillhole 96ETAR187 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figure 110-112, 136.
Local-site location map	Figures 181, 182-184, 187, 188.
GPS coordinates, attitude & elevation	RAB drillhole 96ETAR187: Zone 53, 340366 E, 6636613 N, GDA 94. **Attitude**: vertical. **AHD:** 187.830 (differential GPS data).
Site access, owner	ET prospect is ~150 km W of Tarcoola, ~67 km WSW of Mulgathing Pastoral Station Homestead. It is also ~16 km W of the Dog Fence, 21 km W of Mt Christie. ET prospect is outside the designated Pastoral Lease area. The site is accessed via gazetted unsealed roads, the Dog Fence maintenance track and exploration tracks (Figure 181).
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photo / log	Yes, Figure 192, Table 81.
Sample types	Drill chips in chiptrays + ~1 kg bags.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Not from thin-sections, only from binocular microscope observations.
Geochemistry	Yes, Figures 189, 190, 191, 193, 194 and Table 79.
XRD mineralogy	Yes, selected data in Lintern *et al*. (2003).
PIMA spectral data	Yes, selected data, used by Lintern *et al*. (2002, 2003) to produce kaolinite Crystallinity Indices for unconformity picks & some mineral identification.
Dating	Yes, for Christie Gneiss bedrock, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	Ag, ?As, ?Cu.
Useful sampling media	Calcrete, soil & ?silcrete.
Key reference sources	Lintern *et al*. (2002, 2003); Lintern (2004b).

Background

Drillhole 96ETAR187 is selected to form this benchmark because it includes a thick zone of transported cover, is located within defined Au mineralization and has a mafic profile. The weathered *in situ* regolith is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 33 (thinner cover and a felsic profile) and the regolith cross-sections of Figures 187, 188. Exploration grid drilling on this prospect involved only RAB method (typically without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes have mostly terminated in lower saprolite to saprock but a rare few terminate in bedrock. Cuttings were sampled from the drilled 1-2 m composites. These drillholes were not originally intended for use as benchmarks; they were later sampled and analysed as part of regional regolith and chemical dispersion studies (Lintern *et al*., 2002, 2003).



96ETAR187

0->6 m — **Transported**: aeolian sand (dune) siliceous, loose free running except where cemented by calcrete at ~1 & ~6 m.

>6-8 m — **Transported**: hardpan, strong red hue colluvium (clay-rich) & palaeosol, partly Fe-oxide cemented.

8-9 m — **Transported** & ***In situ***: Pedolith, silcrete horizon, incorporating alluvium-colluvium + *in situ* weathered plasmic zone. **Unconformity** at base of alluvium.

9-11 m — ***In situ***: pedolith, incipiently silicified plasmic zone.

11-14 m — Upper saprolite, brown, clay-rich, FeOH stained, grey quartz veins at 11-12 m.

14-17 — Upper saprolite, bright yellow, clay-rich, relict granulite texture & fabric, FeOH stained.

17-18 — Upper saprolite, pale reddish brown, clays + quartz grit.

18-24 m — Saprolite, browns with white flecks, clays + quartz.

24-30 m — Saprolite, yellow-brown with white flecks, clay-rich, mafic derived material.

30-34 m — Lower saprolite, khaki + darker hued relicts (marginal saprock remnants), clay-rich, mafic gneiss was parent lithotype.

30-34 m — Lower saprolite to saprock, grey-brown, clay-rich, weathered mafic gneiss.

NOTE: saprock barely penetrated.

Regolith logged by M.J. Sheard

Figure 192: Benchmark 32, ET gold prospect drillhole 96ETAR187, chiptray and regolith zonation. In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehabilitation work.

Table 81: Benchmark 32, regolith log to RAB drillhole 96ETAR187 (after Lintern *et al*., 2002, 2003).

Hole: 96ETAR187. **Regolith Line**, ET gold prospect. Regolith descriptions (combined in-field + laboratory observations).

Location: Zone 53, 340366 E, 6636613 N, GDA 94. **AHD:** 187.830 (differential GPS data).

Attitude: vertical.

Site: on aeolian dune, sandy & vegetated..

Vegetation: *Acacia aneura* and *Alectryon oleifolius* subsp. *canescens* Tall Shrubland over *Senna artemisioides* subsp. *petiolaris* and *Acacia aneura* Open Shrubland over *Acacia aneura* and *Scerolaena* Low Open Shrubland (vehicle track disturbance. (Botanical log by S. Lintern).

Soil: Um (sand).

Calcrete: nodular.

Logged by: M.J. Sheard, 1999.

Depth (m)	Description of RAB cuttings
0->6	Aeolian sand, dune, siliceous, loose free running except where cemented by calcrete at ~1 & ~6 m. Colour: 5YR 5/8, brownish orange. CO3 acid value = 2.
>6-8	Hardpan, colluvium, clay matrix+ gravel + silcrete + white vein quartz, palaeosol, strong red hue, partly Fe-oxide cemented. Colour: 2.5YR 5/6, greyish reddish orange. CO3 acid value = 1. Transported then weathered *in situ*.
8-9	Pedolith, silcrete horizon, incorporating alluvium-colluvium + weathered *in situ* plasmic zone. Colour: 5YR 4/8, strong brown. CO3 acid value = 1 (down hole contamination)
9-11	Pedolith, incipiently silicified plasmic zone. Colour: 5YR 4/8, strong brown.
11-14	Upper saprolite, brown, clay-rich, FeOH stained, grey quartz veins at 11-12 m. Colour: 7.5YR 4/5, moderate brown.
14-17	Upper saprolite, bright yellow, clay-rich, relict granulite texture & fabric, FeOH stained. Colour: 10YR 5/7, strong yellowish brown.
17->18	Upper saprolite, pale reddish brown, clays + quartz grit. Colour: 5YR 5/5, light brown.
>18-24	Saprolite, browns with white flecks, clays + quartz. Colours: (18-20 m) 10R 4/3, moderate reddish brown, (20-22 m) 10YR 4/4, moderate yellowish brown; (22-24 m) 2.5YR 4/3, greyish reddish brown.
24-30	Saprolite, yellow-brown with white flecks, clay-rich, mafic derived material. Colours: (24-26 m) 10YR 5/3, greyish yellowish brown; (26-28 m) 10YR 4/2, greyish yellowish brown; (28-30 m) 7.5YR 5/3, light brown.
30-34	Lower saprolite, khaki + darker hued relicts (marginal saprock remnants), clay-rich, mafic gneiss was parent lithotype. Colours: (30-32 m) 10YR 5/4, moderate yellowish brown, (32-34 m) 10YR 4/2, greyish yellowish brown.
34-35	Lower saprolite to saprock, grey-brown relict gneiss (marginal saprock remnants), clay-rich, weathered mafic gneiss. Colour: 10YR 4/1.5, greyish yellowish brown
E.O.H.	

In situ Regolith

Bedrock was only penetrated by 14 of the >200 drillholes on this prospect, they confirm that unweathered crystalline basement in this area is typical of the Christie Gneiss. Benchmark 32 barely penetrates the lower saprolite-saprock boundary at 35 m. Saprolite at this site is similar to descriptions set out earlier for material deriving from more mafic versions of Christie Gneiss. Saprolite was barely intersected here, its total thickness is ~24 m (Figures 187, 192). Pedolith has an eroded top at this site, see also for Benchmark 33, its thickness is ~5 m (including the overlying hardpan).

Transported Regolith

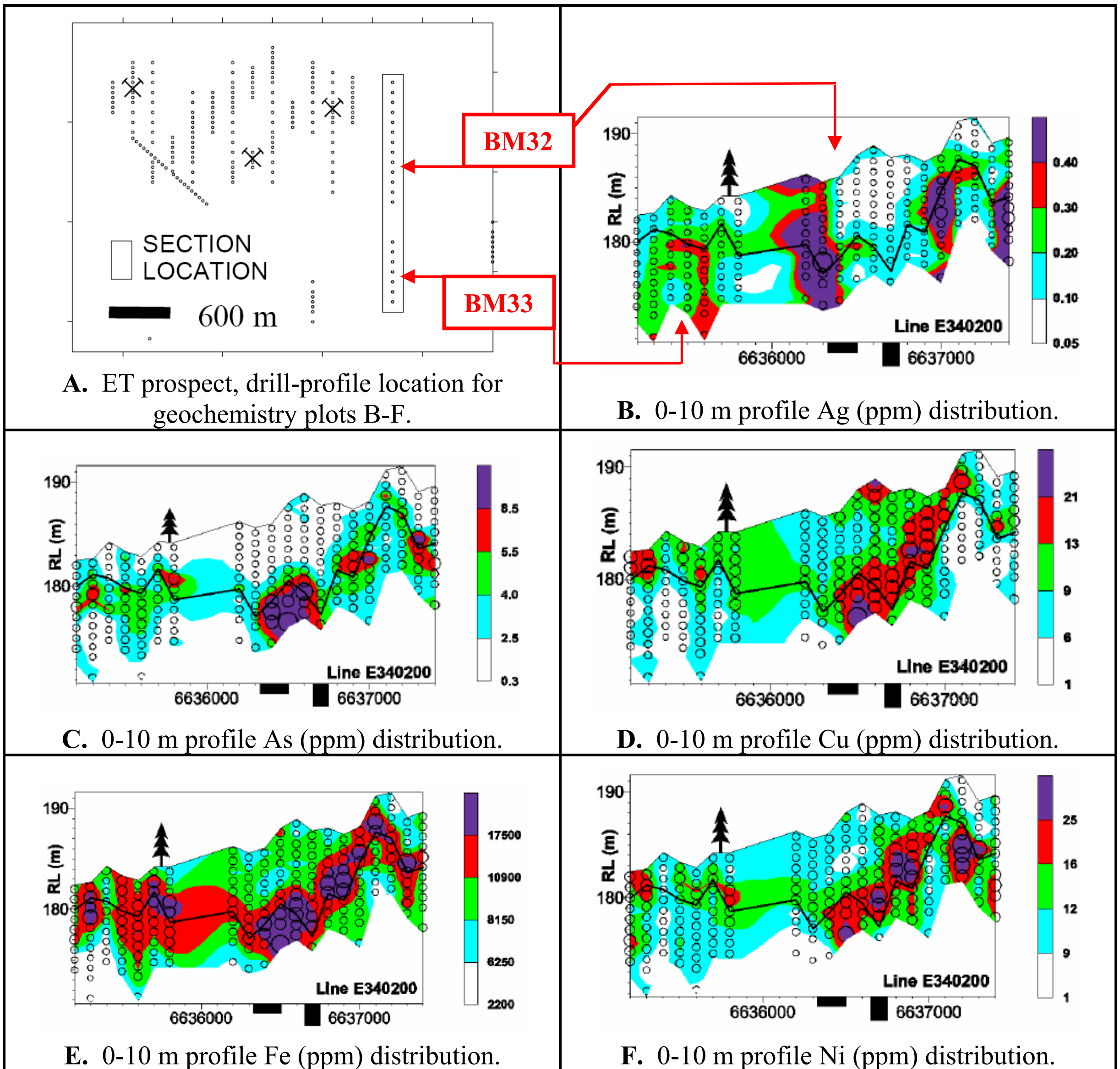
Aeolian dune sand forms the thickest transported cover unit at ET prospect. Underlying the dune sand is a ~2 m thick hardpanized colluvium-alluvium, with strong ferruginous colours (a readily identifiable bed) + some cementation and palaeosol-pedolith pedogenic modifications. Underlying the hardpan, within the silcrete horizon is colluvium and alluvium, mostly sand + gravel and here is <1 m thick. Clast rounding, the presence of lithics and the broad size range indicate immature sediment with partly local and some distal provenance. PIMA spectral data, as a derived Kaolinite Crystallinity Index, places the main unconformity just within the silcrete. However, the low levels of preserved kaolinite in silcrete and the 2 m drill chip sample bias may also be skewing the pick. Drillcore or an excavation would provide a more absolute depth.

Geochemistry

Geochemical expression for ET gold prospect has been outlined earlier and presented via Figures 189-191 (Au, Ca, Fe, Ga) and Table 79 (Au, Cu, Ni).

A 51 element assay package was applied to all samples and Lintern *et al*. (2003) have plotted elemental abundances for all of those on a cross-sectional backdrop. From those abundance plots a selected set, including: Ag, As, Ca, Cu, Fe, Ni & Mg appear in Figures 193, 194. Silver, Cu and Ni may serve as limited pathfinder elements in this area, but all have low to weak near surface signals and Cu seems to relate more to lithotype than mineralization.

Compare the geochemical expression over defined Au mineralization with that of Benchmark 33 (in unmineralized ground) and where the transported cover is thinner than for Benchmark 32.



A. ET prospect, drill-profile location for geochemistry plots B-F.

B. 0-10 m profile Ag (ppm) distribution.

C. 0-10 m profile As (ppm) distribution.

D. 0-10 m profile Cu (ppm) distribution.

E. 0-10 m profile Fe (ppm) distribution.

F. 0-10 m profile Ni (ppm) distribution.

Figure 193: ET gold prospect, geochemical expression along drill line 340200 m E (AMG grid) for selected elements Ag, As, Cu, Fe & Ni (Lintern *et al*., 2003). Benchmarks 32 and 33 are indicated in top panels. Compare these with Au plot in Figure 190.

Calcrete at ET is calcic near the surface but becomes more dolomitic with depth; however, at Benchmark 32 Mg is highest between 2-6 m (Figure 194).

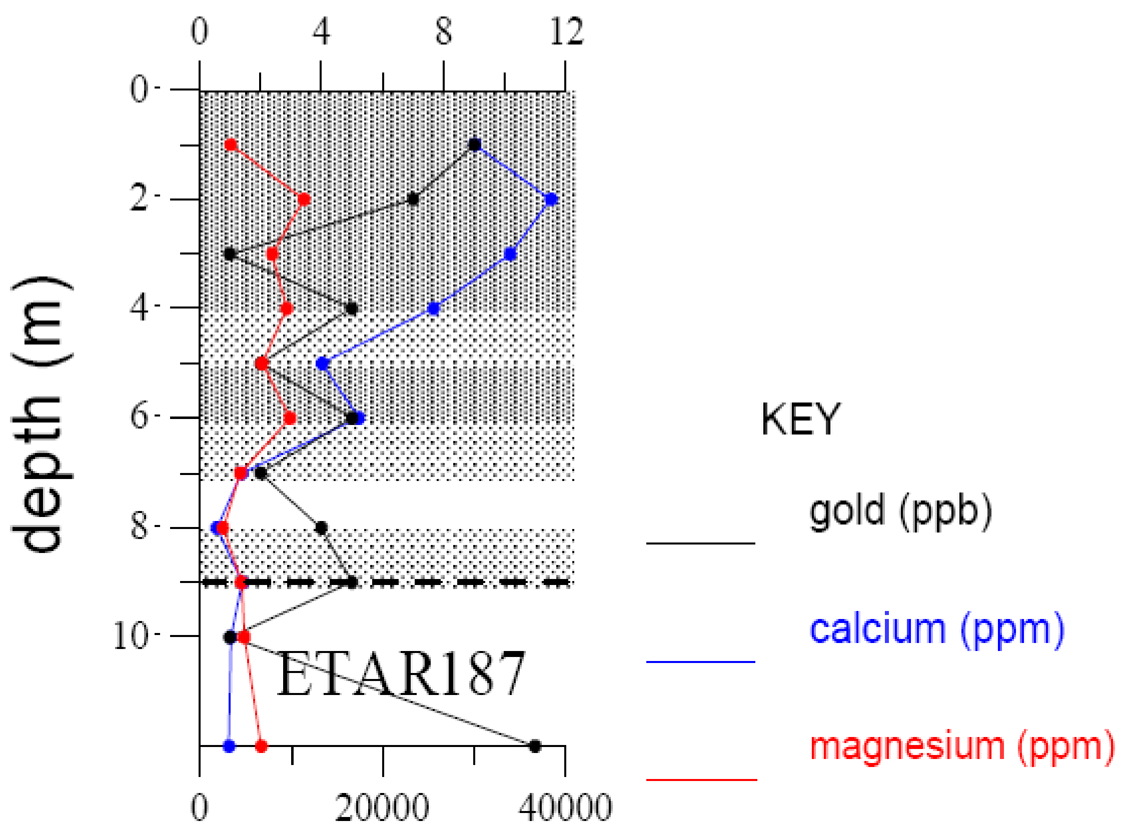


Figure 194: ET gold prospect, relationships between Au, Ca & Mg *versus* depth (0-12 m) for Benchmark 32 (Lintern *et al.*, 2003).

Benchmark 33: drillhole 96ETAR193

Quick reference items are set out in Table 82; detailed descriptions, figures and data tables follow on below. ET prospect lies about 150 km W of Tarcoola and about 67 km WSW of Mulgathing Pastoral Station Homestead (Figures 110-112, 136, 181-184). The prospect is also ~16 km W of the Dog Fence, 21 km W of Mt Christie, and is outside the State's designated Pastoral Lease western edge. ET can be accessed via gazetted unsealed roads, the Dog Fence maintenance track and more recently made exploration access tracks (Figure 181). Drilling for this RAB hole was vertical. A summary of this profile is provided in Table 83 and chiptray photograph with regolith zonation is in Figure 195. Geochemical data are presented in Figures 189, 190, 191, 193, 196 and Table 79.

Table 82: Benchmark 33 reference data; drillhole 96ETAR193 (Type 2, drill cuttings profile).

Items	Figures, Data, Sources
Regional location map	Figure 110-112, 136.
Local-site location map	Figures 181, 182-184, 187, 188.
GPS coordinates, attitude & elevation	RAB drillhole 96ETAR193: Zone 53, 340388 E, 6635744 N, GDA 94. **Attitude**: vertical. **AHD:** 186.895 (differential GPS data).
Site access, owner	ET prospect is ~150 km W of Tarcoola, ~67 km WSW of Mulgathing Pastoral Station Homestead. It is also ~16 km W of the Dog Fence, 21 km W of Mt Christie. ET prospect is outside the designated Pastoral Lease area. The site is accessed via gazetted unsealed roads, the Dog Fence maintenance track and exploration tracks (Figure 181).
Related drillholes	Part of the Gawler Joint Venture exploration multiple drillhole grid.
Drill sample photo / log	Yes, Figure 195, Table 83.
Sample types	Drill chips in chiptrays + ~1 kg bags.
Sample storage	PIRSA Drillcore Storage Facility, 23 Conyngham St, GLENSIDE.
Lithotypes	Weathered Christie Gneiss.
Petrology	Not from thin-sections, only from binocular microscope observations.
Geochemistry	Yes, Figures 189, 190, 191, 193, 196 and Table 79.
XRD mineralogy	Yes, selected data in Lintern *et al*. (2003).
PIMA spectral data	Yes, selected data, used by Lintern *et al*. (2002, 2003) to produce kaolinite Crystallinity Indices for unconformity picks & some mineral identification.
Dating	Yes, for Christie Gneiss, U-Pb zircon age of ~2440 Ma (Fanning, 2002), and peak metamorphic age of ~1710 Ma (Tomkins and Mavrogenes, 2002).
Target elements	Au.
Potential Pathfinder Elements	Ag, ?As, ?Cu.
Useful sampling media	Calcrete, soil & ?silcrete.
Key reference sources	Lintern *et al*. (2002, 2003); Lintern (2004b).

Background

Drillhole 96ETAR193 is selected to form this benchmark because it includes a thin zone of transported cover, is located away from the main Au mineralization, has a felsic profile, and fresh bedrock was penetrated. The weathered *in situ* regolith is relatively straight forward regarding its interpretation. A comparison is provided through Benchmark 32 (thicker cover and a mafic profile) and the regolith cross-sections of Figures 187, 188. Exploration grid drilling on this prospect involved only RAB method (typically without hammer) and so drillholes commonly terminated at or near blade refusal. Therefore drillholes have mostly terminated in lower saprolite to saprock but in this case it terminates in bedrock. Cuttings were sampled from the drilled 1-2 m composites. These drillholes were not originally intended for use as benchmarks; they were later sampled and analysed as part of regional regolith and chemical dispersion studies (Lintern *et al*., 2002, 2003).

0-2 m **Transported**: aeolian sand, dune flank, siliceous, strongly coloured, loose free running. Calcrete: nodular at ~1 m / massive on silcrete at ~2 m..

2-4 m **Transported** & ***In situ***: Pedolith, silcrete horizon, alluvium-colluvium + *in situ* plasmic zone. **Unconformity** at base of colluvium.

4-6 m ***In situ***: pedolith, incipiently silicified plasmic zone, pallid, + white vein quartz.

6-10 m Upper saprolite, pale pink (6-8 m) to stronger pink (8-10 m), kaolinite + quartz grit.

10-25 m Upper saprolite, dominantly pallid, clays + quartz grit.

25-38 m Saprolite, multi hued, relict granulite-gneiss texture & fabric, clay-rich (?smectitic near base).

38-40 m (not sampled here) Lower saprolite to saprock; clay + biotite-rich felsic gneiss, granulite, medium- to course-grained.

40-41 m Bedrock, dominantly biotite-rich felsic gneiss, granulite, medium- to course-grained.

NOTE: bedrock barely penetrated.

Regolith logged by M.J. Sheard

Figure 195: Benchmark 33, ET gold prospect drillhole 96ETAR193, chiptray and regolith zonation. In-field logging and selective bulk sampling (for assay) utilised drill spoil piles prior to prospect rehabilitation work.

Table 83: Benchmark 33, regolith log to RAB drillhole 96ETAR193 (after Lintern *et al*., 2002, 2003).

Hole: 96ETAR193. **Regolith Line**, ET gold prospect. Regolith descriptions (combined in-field + laboratory observations).

Location: Zone 53, 340388 E, 6635744 N, GDA 94. **AHD:** 186.895 (differential GPS data).

Attitude: vertical.

Site: on lower flank of aeolian dune, sandy & vegetated..

Vegetation: *Casuarina pauper* Woodland over *Acacia aneura* and *Acacia* sp. Tall Open Shrubland over *Senna cardiosperma* subsp. *gawlerensis* Shrubland over Low Open Shrubland. (Botanical log by S. Lintern).

Soil: Um (sand).

Calcrete: massive.

Logged by: M.J. Sheard, 1999.

Depth (m)	Description of RAB cuttings
0-2	Aeolian sand, dune, siliceous, strongly coloured, loose free running except where cemented by calcrete: nodular at ~1 m / massive on silcrete at ~2 m. CO3 acid value = 2. Colour: 5YR 4/4, moderate brown.
2-3	Pedolith, massive calcrete on silcrete, incorporating minor alluvium-colluvium + weathered *in situ* plasmic zone. Colours: 2.5YR 4/4, moderate reddish brown + 10YR 7/3, light greyish yellowish brown. CO3 acid value = 1.
3-4	Pedolith, silcrete horizon, incorporating weathered *in situ* plasmic zone. Colour: 10YR 7/3, light greyish yellowish brown. CO3 acid value = 0.
4-6	Pedolith, incipiently silicified plasmic zone, pallid, + white vein quartz. Colour: 10YR 7/3, light greyish yellowish brown.
6-10	Upper saprolite, pale pink (6-8 m) to stronger pink (8-10 m), kaolinite + quartz grit. Colours: (6-8 m) 5YR 7/4, moderate yellowish pink; (8-10 m) 2.5YR 6/5, light reddish brown.
10->22	Upper saprolite, pallid, clays + quartz grit. Colours: (10-12 m) 2.5YR 6/5, light reddish brown; (12-14 m) 10YR 8/3, pale orange yellow; (14-18 m) N 8/-, light grey; (18-20 m) 10YR 9/2, yellowish white; (20-22 m) 2.5Y 8/5, light yellow.
>22->25	Upper saprolite, pallid, clays + quartz grit. Colour: 2.5Y 8/3, greyish yellow.
>25-38	Saprolite, multi hued, relict granulite-gneiss texture & fabric, clay-rich (?smectitic near base). Colours: (25-26 m) 10YR 6/3, lt.gr.y.Br + 10YR 5/6, st.y.Br; (26-28 m) 2.5Y 7/2, y.Gr; (28-30 m) 2.5Y 6/3, lt.ol.Br + 10YR 5/6, st.y.Br; (30-32 m) 2.5Y 6/2, lt.ol.Br; (32-34 m) 5Y 6/2, lt.ol.Gr; & (34-36 m) 5Y 7/2, y.Gr; (36-38 m) 5Y 6/1, lt.y.Gr.
38-40	Lower saprolite to saprock; clay + biotite-rich felsic gneiss, granulite, medium- to course-grained. Colours: 5Y 7/2, yellowish grey.
40-41	Bedrock, dominantly biotite-rich felsic gneiss, granulite, medium- to course-grained. Colours: N 2/-, black + 5Y 7/2, yellowish grey.
E.O.H.	

In situ Regolith

This Benchmark is one of the few drillholes at ET prospect that seems to penetrate bedrock (fresh Christie Gneiss), however, the ~1 m intersection may also be a large corestone surrounded by saprolite. Saprock is quite thin here (~1 m, see previous comment), in adjacent drillholes this material is much deeper. Saprolite at this site is similar to descriptions set out earlier for material deriving from more felsic versions of Christie Gneiss. Saprolite total thickness is at least 33 m (Figures 189, 192). Pedolith has an eroded top at this site, see also for Benchmark 32, its thickness is ~4 m.

Transported Regolith

Aeolian dune sand forms the thickest transported cover unit at ET prospect. Underlying the thin dune sand, within the silcrete horizon is colluvium and alluvium, mostly sand + gravel and here is <0.5 m thick. Clast rounding, the presence of lithics and the broad size range indicate immature sediment with partly local and some distal provenance. PIMA spectral data, as a derived Kaolinite Crystallinity Index, places the main unconformity just below the silcrete. However, the low levels of preserved kaolinite in silcrete and the 2 m drill chip sample bias may also be skewing that pick. Drillcore or an excavation would provide a more absolute depth.

Geochemistry

Geochemical expression for ET gold prospect has been outlined above and presented via Figures 189-191 (Au, Ca, Fe, Ga) and Table 79 (Au, Cu, Ni).

A 51 element assay package was applied to all samples and Lintern *et al*. (2003) have plotted elemental abundances for all of those on a cross-sectional backdrop. From those abundance plots a selected set, including: Ag, As, Ca, Cu, Fe, Ni & Mg appear in Figures 193, 194. Silver, Cu and Ni may serve as limited pathfinder elements in this area, but al have low to weak near surface signals and Cu seems to relate more to lithotype than mineralization.

Calcrete at ET is generally calcic near the surface but becomes more dolomitic with depth, as indicated here, Mg does loosely follow that trend (Figure 196); but at Benchmark 32 that regional trend is much less obvious (*c.f.* Figure 194).

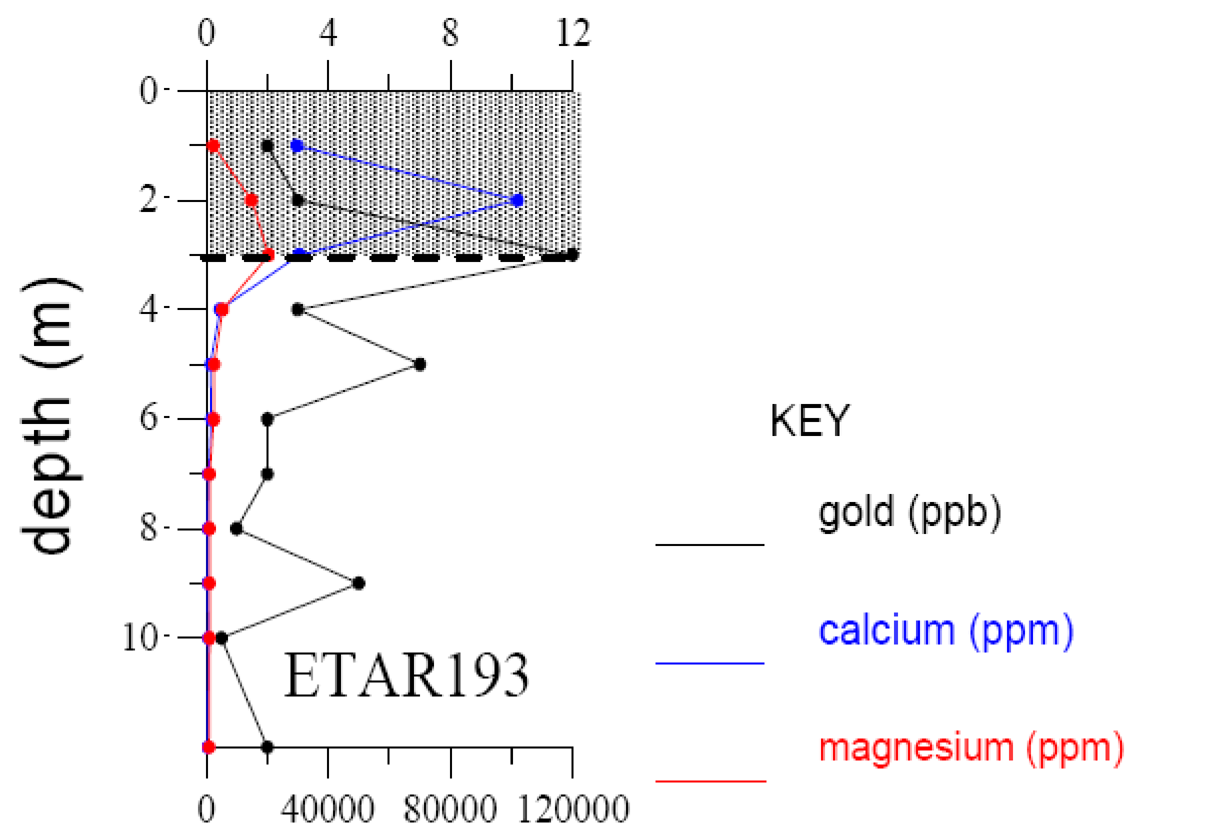


Figure 196: ET gold prospect, relationships between Au, Ca & Mg *versus* depth (0-12 m) for Benchmark 33 (Lintern *et al*., 2003).

REFERENCES

Bonwick, C.M. 1997. Discovery of the Challenger Gold Deposit: implications for future exploration on the Gawler Craton. *In*: New Generation Gold Mines '97. Case histories of discovery. *Conference Proceedings. Australian Mineral Foundation, Glenside, Australia*. pp. 7-1 to 7-15.

Callen, R.A. and Benbow, M.C., 1995. Chapter 11, Quaternary. The deserts – playas, dunefields and watercourses. *In*: Drexel, J.F. and Preiss, W.V. (Eds), 1995. The Geology of South Australia. Vol. 2, The Phanerozoic. *South Australia. Geological Survey. Bulletin*, 54:244-251.

Craig, M.A., 2001. ET Gold Prospect Regolith Landforms (1:10,000 scale) map. *Cooperative Research Centre for Landscape Evolution and Mineral Exploration, Perth / Geoscience Australia, Canberra*.

Craig, M.A. and Wilford, J.R., 1997a. Half Moon Lake Regolith-Landforms (1:100,000 scale) map. *Cooperative Research Centre for Landscape Evolution and Mineral Exploration, Perth / Geoscience Australia, Canberra*.

Craig, M.A. and Wilford, J.R., 1997b. Jumbuck Regolith-Landforms (1:50,000 scale) map, sheet 5638-III. *Cooperative Research Centre for Landscape Evolution and Mineral Exploration, Perth / Geoscience Australia, Canberra*.

Daly, S., 2003. Stop 6.2.2: Christie Gneiss – paragneiss outcrop south of Mt Christie at Christie Corner. *In*: Fairclough, M.C. and Schwarz, M.P. (Editors), 2003. Gawler Craton 2003: State of Play. The Excursion. *South Australia. Department of Primary Industries and Resources. Report Book*, 2003/17.

Daly, S.J. and Fanning, C.M., 1993. Chapter 3, Archaean. *In*: Drexel, J.R., Preiss, W.V. and Parker, A.J. (Editors), 1993. The Geology of South Australia. Volume 1, The Precambrian. *South Australia. Geological Survey. Bulletin,* 54. ISBN: 0 7308 4146 4.

Edgecombe, D., 1997. Challenger Gold Deposit. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 4:8-11.

Fairclough, M.C. and Schwarz, M.P. (Editors), 2003. Gawler Craton 2003: State of Play. The Excursion. *South Australia. Department of Primary Industries and Resources. Report Book*, 2003/17.

Fanning, C.M., 2002. Geochronology and isotope geochemistry of crust forming events, and timing of orogenic events in the Gawler Craton. *In*: Gawler Craton 2002: State of Play. *Office of Minerals and Energy Resources, South Australia. Department of Primary Industries. Workshop Proceedings*, CD-ROM.

Fanning, C.M., Reid, A.J. and Teale, G.S., 2007. A geochronological framework for the Gawler Craton, South Australia. *South Australia. Geological Survey. Bulletin,* 55. ISBN: 978 0 7590 1392 8.

Gray, D.J. and Lintern, M.J., 2004. Challenger Gold Deposit – further research and integration with other investigations. *CRC LEME Restricted Report 197R and CSIRO Exploration and Mining Report 1149R*; 33 pp.

GJV, 1998. Company Exploration Highlights: Gawler Craton, Dominion–Resolute Joint Venture. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 9:16.

Lintern, M.J. (Compiler), 2004. The South Australian Regolith Project Final Report – Summary and Synthesis. *Cooperative Research Centre for Landscape Environments and Mineral Exploration. Open File Report*, 156. ISBN: 0 643 06852 X.

Lintern, M.J., and Sheard, M.J., 1998. Silcrete – a potential new exploration sample medium: a case study from the Challenger Gold Deposit. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 11:16-20.

Lintern, M.J., and Sheard, M.J., 1999a. Regolith geochemistry and stratigraphy of the Challenger Gold Deposit. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 14:9-14.

Lintern, M.J., and Sheard, M.J., 1999b. Regolith studies related to the Challenger Gold Deposit, Gawler Craton, South Australia. Co-published as: *Cooperative Research Centre for Landscape Evolution and Mineral Exploration. Open File Report*, 78 / *Primary Industries and Resources of South Australia. Report Book*, 1998/10. ISBN v1: 0 643 06477 X v2: 0 643 06478 8 set: 0 643 06479 6.

Lintern, M.J., Sheard, M.J. and Chivas, A., 2006. The source of pedogenic carbonate associated with gold-calcrete anomalies in the Western Gawler Craton, South Australia. *Chemical Geology*, 235:299-324.

Lintern, M.J., Sheard, M.J. and Gouthas, G., 2002. Preliminary regolith studies at ET, Monsoon, Jumbuck, South Hilga and Golf Bore gold prospects, Gawler Craton, South Australia. Co-published as: *Cooperative Research Centre for Landscape Evolution and Mineral Exploration. Open File Report*, 115 / *CSIRO Exploration and Mining. Report*, 864R / *Primary Industries and Resources of South Australia. Report Book*, 2002_004. ISBN v1: 0 643 06783 3 v2: 0 643 06784 1 set: 0 643 06785 X.

Lintern, M.J., Tapley, I.J., Sheard, M.J., Craig, M.A., Gouthas, G. and Cornelius, A.J., 2003. Regolith Studies at Edoldeh Tank (ET) gold prospect, Gawler Craton, South Australia. Co-published as: *Cooperative Research Centre for Landscape Evolution and Mineral Exploration. Open File Report*, 150 / *CSIRO Exploration and Mining. Report*, 1081F / *Primary Industries and Resources of South Australia. Report Book*, 2003/4. ISBN v1: 0 643 068481, v2: 0 643 068503.

Mason, D.R. and Mason, J.E., 1998. A Petrographic study of Regolith Samples from the Challenger Project [Gawler Craton, South Australia]. For Mines and Energy, South Australia & CRC LEME. *Mason Geoscience Pty Ltd. Report*, 2413 (unpublished).

MIQ, 1991. SADME PROJECTS: Tarcoola-Tallaringa Bedrock Drilling. *South Australia. Mines and Energy Department. Mineral Industry Quarterly*, 64:3-6.

Parker, A.J., (1990). Gawler Craton and Stuart Shelf – regional geology and mineralisation. *In*: Hughes, F.E. (Editor), Geology of the mineral deposits of Australia and Papua New Guinea. *Australasian Institute of Mining and Metallurgy. Monograph Series*, 14:999-1008.

Poustie, T., 2006. The Challenger Gold Mine – looking forward and downward. *3rd Annual SA Explorers' Conference 2006. AusIMM-SACOM-GSA-ASEG-Primary Industries and Resources South Australia, CD-ROM*.

Poustie, T., Bamford, P. and Daly,, S., 2002. Challenger – South Australia's first Archaean gold mine. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 27:4-8.

Povey, D.A., 1999. An investigation into the distribution and geochemistry of surficial regolith materials at the Challenger Gold Deposit, South Australia. *University of South Australia. Honours Thesis* (unpublished).

Robertson, I.D.M. and Butt, C.R.M., 1997. Atlas of Weathered Rocks. *Cooperative Research Centre for Landscape Evolution and Mineral Exploration. Open File Report*, 1 / *CSIRO Division of Exploration Geoscience. Report*, 390, first revision. ISBN: 0 958 68572 X.

Rowett, A.I., 1997. Identification of a single wood fragment from the Gawler Craton, South Australia. *South Australia. Mines and Energy Resources Department. Report Book*, 97/53.

Sheard, M.J., Lintern, M.J., Prescott, J.R. and Huntley, D.J., 2006. Great Victoria Desert: new dates for South Australia's ?oldest desert dune system. *Quarterly Earth Resources Journal of Primary Industries and Resources South Australia. MESA Journal*, 42:15-26.

Swain, G., 2002. Provenance and tectonics of the Archaean Mulgathing Complex, central Gawler Craton: geochronological, geochemical and isotope evidence for plume-arc interaction. *University of Adelaide. Department of Geology and Geophysics. Honours Thesis* (unpublished).

Tapley, I.J. and Cornelius, A.J., 2003. The role of remotely sensed datasets in mapping landforms and regolith. *In*: Lintern, M.J., Tapley, I.J., Sheard, M.J., Craig, M.A.; Gouthas, G. and Cornelius, A.J., 2003. Regolith Studies at Edoldeh Tank (ET) gold prospect, Gawler Craton, South Australia. Co-published as: *Cooperative Research Centre for Landscape Evolution and Mineral Exploration. Open File Report*, 150 / *CSIRO Exploration and Mining. Report*, 1081F / *Primary Industries and Resources of South Australia. Report Book*, 2003/4. pp. 23-63. ISBN: 0643 068481.

Teasdale, J., 1997. Methods for understanding poorly exposed terranes: The interpretive geology and tectonothermal evolution of the Western Gawler Craton. *University of Adelaide. PhD thesis* (unpublished).

Tomkins, A.G. and Mavrogenes, J.A., 2002. Mobilisation of gold as a polymetallic melt during pelite anatexis at the Challenger Deposit, South Australia: a metamorphosed Archaean gold deposit. *Economic Geology*, 97:1249-1271.

van der Wielen, S., 1999. An investigation of the regolith stratigraphy at the Challenger Gold Deposit, South Australia. *University of South Australia. Honours Thesis* (unpublished).

Wilford, J., Craig, M.A., Tapley, I.J. and Mauger, A.J., 2001. Regolith landform mapping and its implications for exploration over the Half Moon Lake region, Gawler Craton, South Australia. *Cooperative Research Centre for Landscape Environment and Mineral Exploration, Perth/Canberra. Open File Report*, 80. ISBN: 0 643 06482 6

•——oo0oo——•