

QUARTERLY GEOLOGICAL NOTES

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HISTORICAL PERSPECTIVE: The Kyancutta Museum

B.J. Cooper

One of the more unusual episodes in the history of geology in South Australia is the story of Robert Bedford (1874-1951) and the Kyancutta Museum. Founded soon after the First World War in the remote Eyre Peninsula town of Kyancutta, this institution was officially opened by the Governor of South Australia on 26 June 1929. As organiser and administrator of the Museum, Robert Bedford became a world authority on fossil archaeocyaths and was widely recognised as a student of meteorites. Regrettably, because of his independent nature and his insistence that the Kyancutta Museum was a public institution, Bedford antagonised his potential colleagues in Adelaide. The bitterness of these disputes subsequently led to the dispersal of the Museum's collections interstate and overseas after Bedford's death.

Robert Bedford was born as Robert Buddicom in Shropshire in 1874. He completed an Arts degree at Oxford in 1897, majoring in biology and chemistry. Around the turn of the century, he studied geology under Lapworth at Birmingham and became a Fellow of the Geological Society. From 1900 to 1901, he was curator of the Plymouth Museum, while from 1906 to 1914, he was demonstrator and lecturer at the London Hospital Medical School. Quite early, Buddicom showed interest in such widely divergent fields as classical poetry, philosophy, engineering and business, as well as in medicine, zoology and geology. However, as the First World War approached, he became progressively pessimistic about the future of Britain. Following court action against him, which determined misrepresentation in a Company prospectus, Buddicom and his family migrated to South Australia in 1915 under the surname Bedford. He became a pioneering wheat farmer near Kyancutta and began serving the basic needs of his small community as physician, veterinary surgeon and general spokesman.

In 1922, Bedford moved into Kyancutta township where he built the Museum and operated a small general store that later became the post office. As it developed, the Kyancutta Museum amassed a remarkable collection of geological and archaeological material. It included large numbers of meteorites and fossils, native artifacts from Australia and New Guinea, convict leg irons from Hobart, one of the first two telephones installed in Australia, 17th century English armour, and an Egyptian mummy with case. The collection, accompanied by a fine library, was rated highly by independent authorities in Australia and overseas.

In 1927, Bedford made the first of his notorious collecting trips to Nildottie and Swan Reach for Aboriginal artifacts, and to Ardrossan for archaeocyaths. The latter stop initiated his research into these remarkable Cambrian fossils. The following year, he collected fossil vertebrates at Lake Callabonna, as always travelling in his private car and relying on personal resources. In 1930, after the fall and discovery of the Karoonda meteorite, Bedford's interest in meteorites was heightened. Concurrent with his palaeontological researches he then proceeded to build up a superb meteorite collection by purchase and exchange, mostly facilitated by material collected from the Henbury meteorite crater in Central Australia from 1931 to 1938. By despatching much of his Henbury collection to the British Museum however, he incurred the wrath of Adelaide geologists, and even the press. Subsequently, due to the ill feeling generated, he was obliged to publish his palaeontological research himself in the *Memoirs of the Kyancutta Museum Vols 1-5 (1934-1939)*. In 1936, the Kyancutta Museum mounted a special exhibition at the Royal Adelaide Show. The following year another display was held in New Zealand during the Australian and New Zealand Association for the Advancement of Science Conference.

In the tiny communities of Eyre Peninsula Bedford's scientific studies and exploratory feats in the outback became legendary. To Adelaide geologists, despite their appreciation of his talents, Bedford came to be an intruding nuisance. From the modern perspective, the remarkable nature of Robert Bedford deserves recognition. From his isolated Australian home, he also made notable contributions to meteorology, aviation and wheatgrowing, and even published his own philosophical ideas.

KEYWORDS: GEOLOGICAL MUSEUM/Kyancutta/Eyre Peninsula/SI53-7/6031

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NUYTS 1:250 000 GEOLOGICAL MAP and EXPLANATORY NOTES

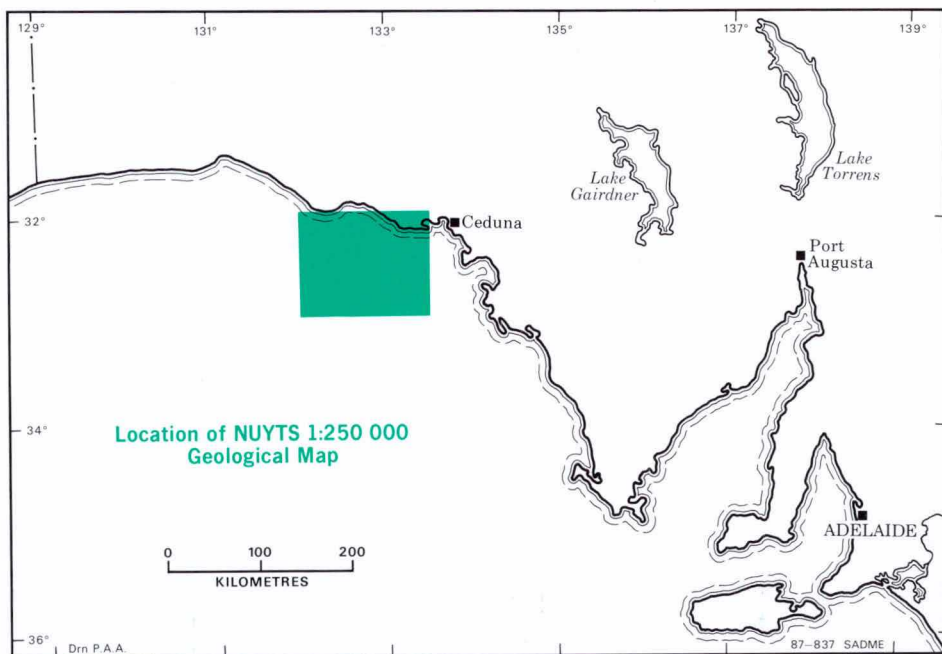
The geological map and Explanatory Notes, compiled by R.B. Flint, cover the coastline west of Ceduna, extending offshore to include numerous small islands within the Nuyts Archipelago. This part of the coastline was first discovered by the Dutch 360 years ago and prompted the French explorer D'Entrecasteaux to write in 1792: 'It is not surprising that Nuyts has not recorded any details of this sterile coast, whose aspect is so uniform that the most fertile imagination could find nothing to say about it.'

Precambrian exposures are restricted to headlands and the offshore islands, and consist of syn- and post-Kimban Orogeny granitoids, volcanics and dolerite dykes of the western Gawler Craton. Rock types include migmatitic granodiorite gneiss, granitic gneiss, foliated granite, adamellite and granodiorite, and garnetiferous granite. Porphyritic rhyolite-rhyodacite is associated with three suites of rhyolitic-dacitic dykes and a grey, pyroxene bearing granite. Rb-Sr geochronology suggest an age for acidic volcanism and plutonism of approximately 1480 to 1490 Ma, but a recent U-Pb zircon study indicates a crystallisation age of 1631 ± 3 Ma, which is older than the revised age for the Gawler Range Volcanics.

The Lake MacDonnell gypsum deposit, regarded as the most important deposit for size and quality in Australia, contains indicated reserves of 575 million tonnes in a unit nearly 4 m thick and average grade of over 90%. Between discovery in 1919 and 1986, only 12 million tonnes have been mined. Gypsum occurs as an upward fining sequence of selenite, gypsarenite and gypsite precipitated by simple, single stage, seawater evaporation in a Holocene coastal salina. Drilling of the Lake MacDonnell gypsum deposit has been extensive, contrasting with minimal exploratory drilling elsewhere on the map sheet.

Map and Explanatory Notes are available from the Department at a combined price of \$5.

R.B. Flint



DEFINITION of the KESWICK CLAY, Adelaide/Golden Grove Embayment, Para and Eden Blocks, South Australia.

*M.J. Sheard and G.M. Bowman**

An investigation into the problem soils of Metropolitan Adelaide was recently carried out by the Department of Mines and Energy and the CSIRO Division of Soils, Adelaide.

The definition of Keswick Clay is based on its intersection in 62 drillholes cored during the course of this study.

Derivation of Name: Keswick railway yards, western edge of the west Park Lands, Adelaide; grid reference 2792061313, Adelaide 1:50 000 Sheet, 6628-III, Zone 54.

Distribution: On the eastern margin of the St Vincent Basin the Keswick Clay covers an area of 150 km². It is extensively developed in the Adelaide/Golden Grove Embayment (Fig. 1) and onlaps the Para Fault Block, while to the south the distribution is more restricted on the Eden Fault Block (Ward, 1966; Firman, 1969a; Daily *et al*, 1976; Sheard and Bowman, in prep.). The Keswick Clay is cut by the River Torrens, Sturt Creek and Brownhill Creek.

* CSIRO Division of Soils, P.O. Box 639, Canberra City, ACT 2601.

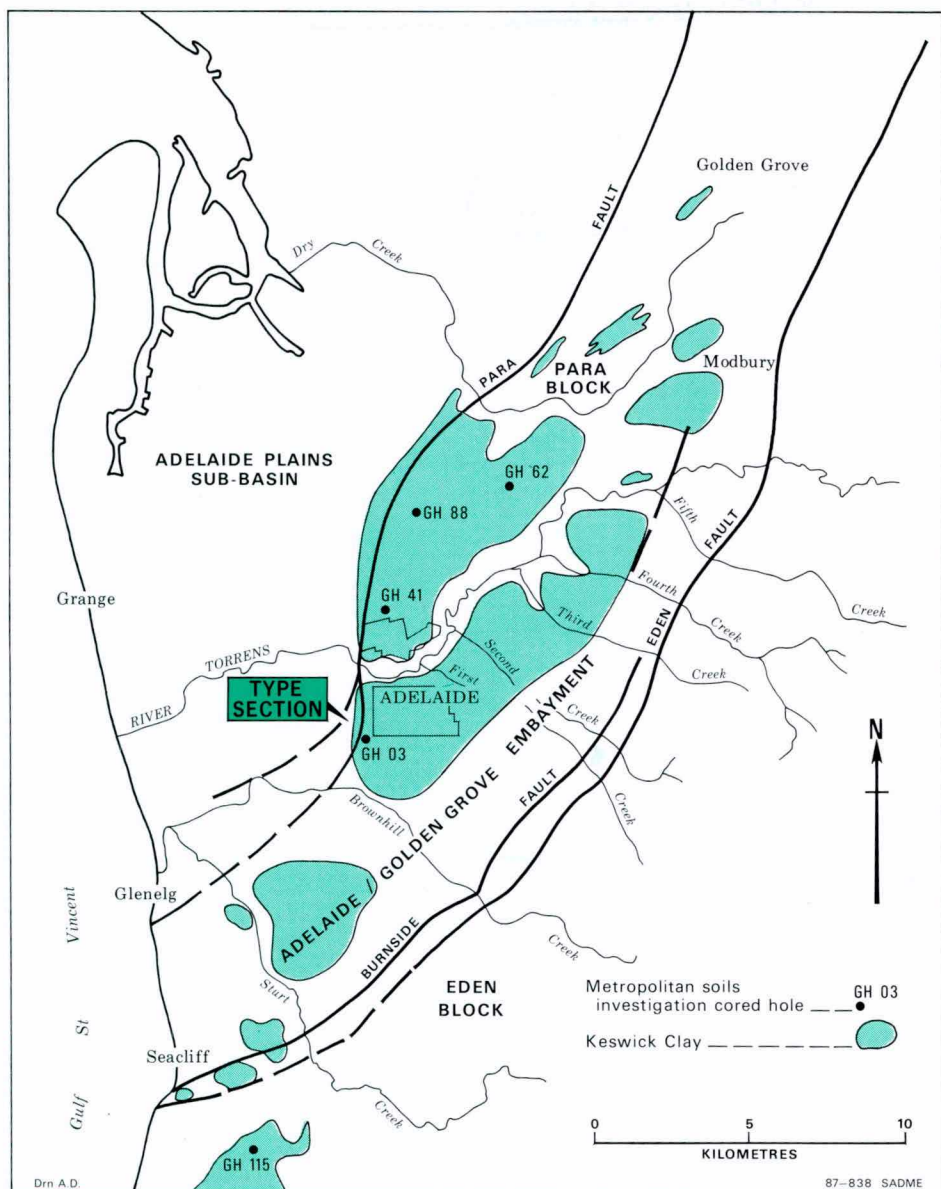


Fig. 1 Distribution of Keswick Clay and location of cored drillholes.

Type Section: A cutting in the Keswick railway yards, where 4 to 5 m of green-grey stiff plastic clay is exposed, variously mottled with reddish ferruginous colours (Ward, 1966). This unit is overlain by 1 to 2 m of carbonate rich, brown solonised soil and is underlain by stiff brown clays of the Hindmarsh Clay.

Type Drillhole: This is located 180 m east of the Keswick railway cutting and 450 m north of Greenhill Road, Wayville (GH 03 on Figs 1 and 2), where coring revealed 5.2 m of greenish grey (5GY 6/1) to light olive-grey (5Y 6/1) stiff plastic clay (standard colour notation: Munsell Soil Color Charts, 1975).

This core is now held in the Department of Mines and Energy Core Library Complex, Glenside: Reference No. 662800301773. The clay is randomly mottled, light grey-brown (10YR 5.5/3) to brown (10R 4/8), with mottles ranging in size from 3 to 25 mm (colour names: Kelly and Judd, 1976). At this location both upper and lower boundaries are well defined in terms of colour and texture (Fig. 2) although in other areas one or both of the boundaries can be difficult to recognise.

Additional Drillholes: Cored holes GH 41, 62, 88 and 115 from the Metropolitan Adelaide soils investigation (Figs 1 and 2) in which cores display variations in colour, thickness and nature of the upper and lower boundaries of the Keswick Clay.

Lithology: Clay; silty to gritty (quartz sand) in bands of variable thickness and occasionally sandy or silty throughout. The clay ranges in texture from light to heavy, often having a waxy lustre and feel. In general, it is massive to poorly bedded with lenses of sand and silt where proximal to alluvial fans or ephemeral creek lines. The clay often displays slickensided fissures or failure planes at steep or shallow angles. Gilgai structures are a common feature of the Keswick Clay, especially where its upper surface is within 1 to 2 m of the land surface. Clay colours range from yellow-greys to green-greys (gley colours) and some mottling appears to be associated with zones of bioturbation, which include tubules similar to root channels and small animal burrows. At any one site, the colour of mottles is restricted to one (or at most two) Munsell hues - these being reddish or yellowish. Usually the yellowish mottles occur above the reddish mottles, probably due to weathering or alteration of iron oxides in the modern environment. The reduced greyish (gley) colours of the Keswick Clay may have resulted from post-depositional reduction in oxygen-poor groundwaters. X-ray diffraction studies indicate that the clay minerals present are predominantly smectite, with lesser illite and randomly interstratified clays.

Geomechanical Properties: Liquid limits range from 40 to 130% and the plastic limits range from 17 to 30%. Excluding seasonal variations within 4 m of the ground surface, field moisture approximates the plastic limit. Pocket penetrometer values range from 100 to 400 kPa (unconfined strength).

Thickness: Range, 0.5 to 6.8 m.

Relationships and Boundary Criteria: The Keswick Clay stratigraphically overlies the Hindmarsh Clay (Firman, 1966, 1969a; Taylor *et al.*, 1974; Daily *et al.*, 1976). The basal contact with Hindmarsh Clay is a disconformable erosion surface, as indicated by Selby and Lindsay (1982) after Allchurch (1966), and is often sharp. At other locations the boundary is unclear or diffuse (holes GH 41 and 88, Fig. 2). The upper boundary is sharply defined when overlain by calcareous red-brown soils or clays, or gradational when overlain by black cracking clays (Fig. 2). The western limit of the Keswick Clay is defined by the Para Fault escarpment, where the unit thins out or disappears over a 400 to 600 m wide zone, probably indicating that it postdates early Quaternary faulting. To the east and south the Keswick Clay (as defined here) is not recognisable within the upper piedmont slope deposits. Drilling indicates that in this area its character alters by facies change or by interfingering to younger 'gley clays' and alluvial/colluvial deposits that have emerged from the Eden-Burnside Fault escarpment.

Isolated irregular remnants of Keswick Clay occur in bedrock depressions on the upthrown Adelaidean metasediments of the Eden and Para Blocks.

Type drill hole section

GH03, Core Library No.
662800301773

Keswick/South West Parklands

DEPTH (m)

Brown solonchised soil
Un6.21. Calcrete bar.
Carbonate silt and
pisoliths.

Carbonate silt to clay
as a gradational unit.
Heavy clay, stiff and
plastic, green gray
(5GY 6/1).

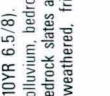
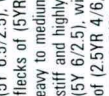
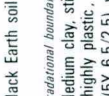
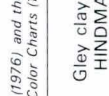
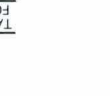
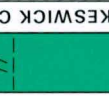
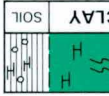
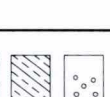
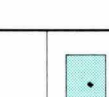
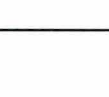
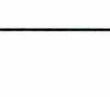
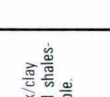
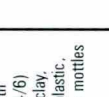
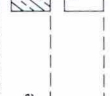
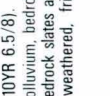
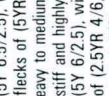
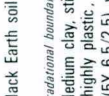
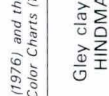
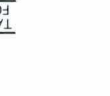
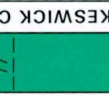
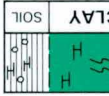
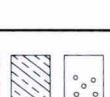
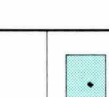
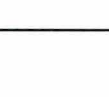
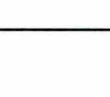
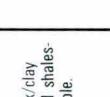
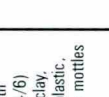
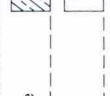
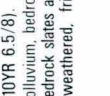
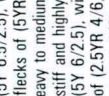
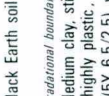
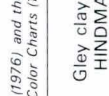
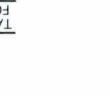
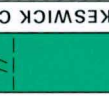
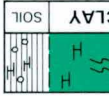
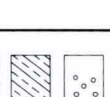
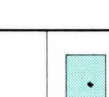
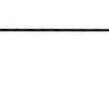
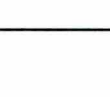
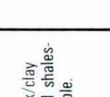
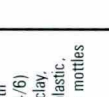
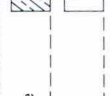
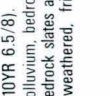
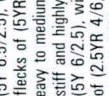
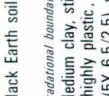
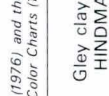
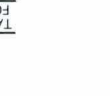
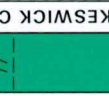
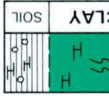
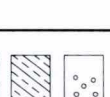
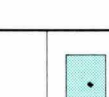
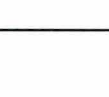
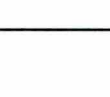
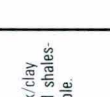
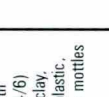
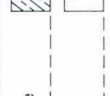
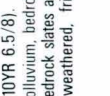
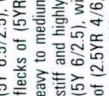
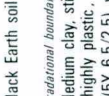
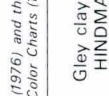
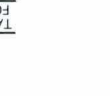
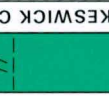
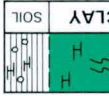
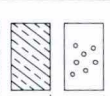
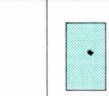
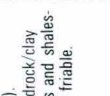
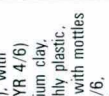
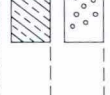
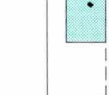
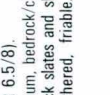
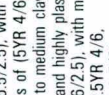
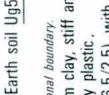
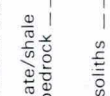
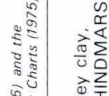
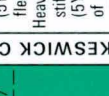
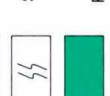
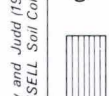
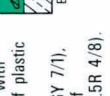
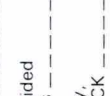
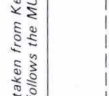
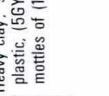
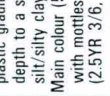
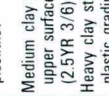
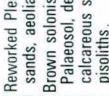
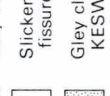
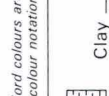
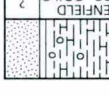
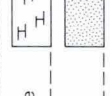
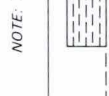
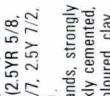
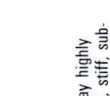
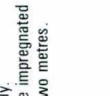
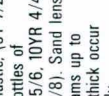
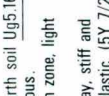
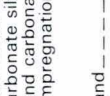
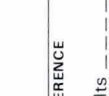
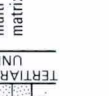
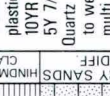
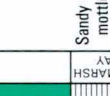
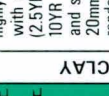
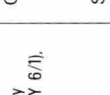
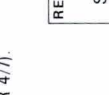
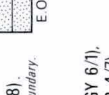
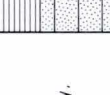
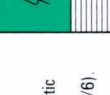
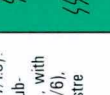
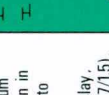
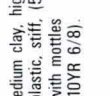
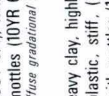
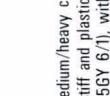
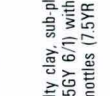
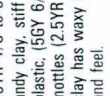
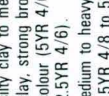
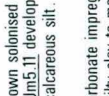
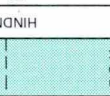
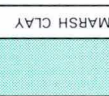
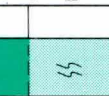
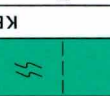
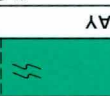
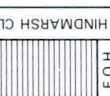
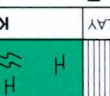
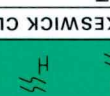
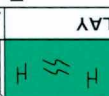
light gray brown mottle
(10YR 5.5/3).
lime impregnated.

Grading to:

Heavy clay with main
colour light olive green
(5Y 6/1).

mottle colour strong
brown (10R 4/8).

Heavy clay, medium red
brown (10R 4/7) with
bands and mottles of
light brown gray
(10YR 5.5/1) and dark
orange yellow
(10YR 6/8).



Depositional Environment: Firman (1969a) suggested a terrestrial, possibly alluvial fan, origin for the Keswick Clay whereas our work indicates two distinct but related origins for the unit (Sheard and Bowman, in prep.). Within the Adelaide/Golden Grove Embayment Keswick Clay probably formed as a result of terrestrial, alluvial fan and overbank sedimentation. However, on the Para and Eden blocks the unit appears to have derived from weathering of Adelaidean shales and slates with minimal prior transport of the sediment. The latter deposits occur in isolated topographic depressions in the bedrock. The various Keswick Clay deposits have been correlated on the basis of stratigraphic and toposequence relationships (Sheard and Bowman, in prep.).

The predominantly clay texture of the Keswick Clay might reflect a period of landscape stability between episodes of movement on the Para and Eden-Burnside Faults. Relative landscape stability would allow advanced weathering of the Adelaidean bedrock shales and slates into clay, whereas episodic fault movement and concomitant increased erosion would result in lithic-rich, clay-poor sediments. Ward (1966) proposed an aeolian origin for the Ngalinga Clay (Noarlunga-Willunga embayments), the unit he equated with the Keswick Clay. However micromorphological studies of the Keswick Clay do not support an aeolian origin for these sediments (Sheard and Bowman, in prep.).

Age and Evidence: The unit is not fossiliferous. Firman (1969a and b) and Daily *et al.* (1976) state that Keswick Clay stratigraphically overlies Hindmarsh Clay and underlies Pooraka Formation, placing it within the Middle Pleistocene in their age framework. Drilling now confirms this stratigraphic relationship and depositional time frame.

Synonymy: Allchurch (1965) referred to this unit as *mottled clay*, Ward (1966) equated the unit with Ngalinga Clay of the Noarlunga and Willunga Embayments. Firman (1966) considered the unit to be part of Hindmarsh Clay as, subsequently, did Allchurch (1967). Selby and Lindsay (1982) refer to the unit as the *upper member* of the Hindmarsh Clay and also cite *Adelaide Clay* as an informal name in common use.

KEYWORDS: KESWICK CLAY/ stratigraphic definition/ Adelaide clay/ mottled clay/ Hindmarsh Clay/ Ngalinga Clay/ soils investigation/ geomechanical properties/ St Vincent Basin/ Adelaide-Golden Grove Embayment/ Eden Fault Block/ Para Fault Block/ SI54-9/6628.

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REDEFINITION of the UPPER BOUNDARY of the HINDMARSH CLAY, Adelaide Plains Sub-Basin and Adelaide/Golden Grove Embayment.

*M.J. Sheard and G.M. Bowman**

Many geoscientists have described the clay-rich deposits overlying fossiliferous Tertiary marine sediments of the Adelaide Plains. Tate (1878, 1882) originally referred to the deposits as Plio-Pleistocene 'pipe clay' and 'drift', but following the discovery of *Diprotodon* remains within the upper layers of the deposits, he subsequently called them 'Mammaliferous Drift' and claimed that they were up to 400 feet (122m) thick (Tate, 1890). Howchin (1888) initially referred to the deposits as 'argillaceous sands', but in later papers (Howchin, 1896, 1912) described them as 'tenaceous blue to brown clays' of Pleistocene age. In numerous descriptions of water bores, excavations and natural exposures Howchin (1918, 1923, 1930, 1935, 1936) referred to Tate's 'mammaliferous drift' as 'alluvial mottled clays' of Pliocene to Pleistocene age.

A variety of informal names have also been applied to the deposits: 'fan delta deposits' (Miles, 1952); 'alluvial mottled clays' (Reynolds, 1953); 'terrestrial mottled clays' (Aitchison *et al.*, 1954); 'variegated clays' (Glaessner and Wade, 1958).

Ward (1966) equated the upper parts of the Pleistocene deposits in the Adelaide area with the Ngalinga Clay, which he defined in the Noarlunga and Willunga Embayments to the south. However, the name Hindmarsh Clay was formally assigned to the Pleistocene clays of the Adelaide Plains Sub-Basin by Firman (1966). Later papers by Firman (1967), Lindsay (1969), Daily *et al.* (1976) and Selby and Lindsay (1982) further discussed this unit - particularly the characteristics of its base.

There remains some confusion, however, as to what constitutes the upper boundary of the Hindmarsh Clay. Within the Adelaide/Golden Grove Embayment both the Hindmarsh Clay and the overlying Keswick Clay are similar in appearance and mineralogy (Sheard and Bowman, 1987), resulting in misidentification of both units, particularly by engineering geologists and civil engineers. Both clay units are prone to shrink-swell movements in response to changes in moisture content and salinity, but in general the Hindmarsh Clay is less reactive than the overlying Keswick Clay, possibly because of differences in mineral and chemical composition (Sheard and Bowman, in prep.). Hence, there is a need to define the upper boundary of the Hindmarsh Clay and to characterise the upper part of the unit.

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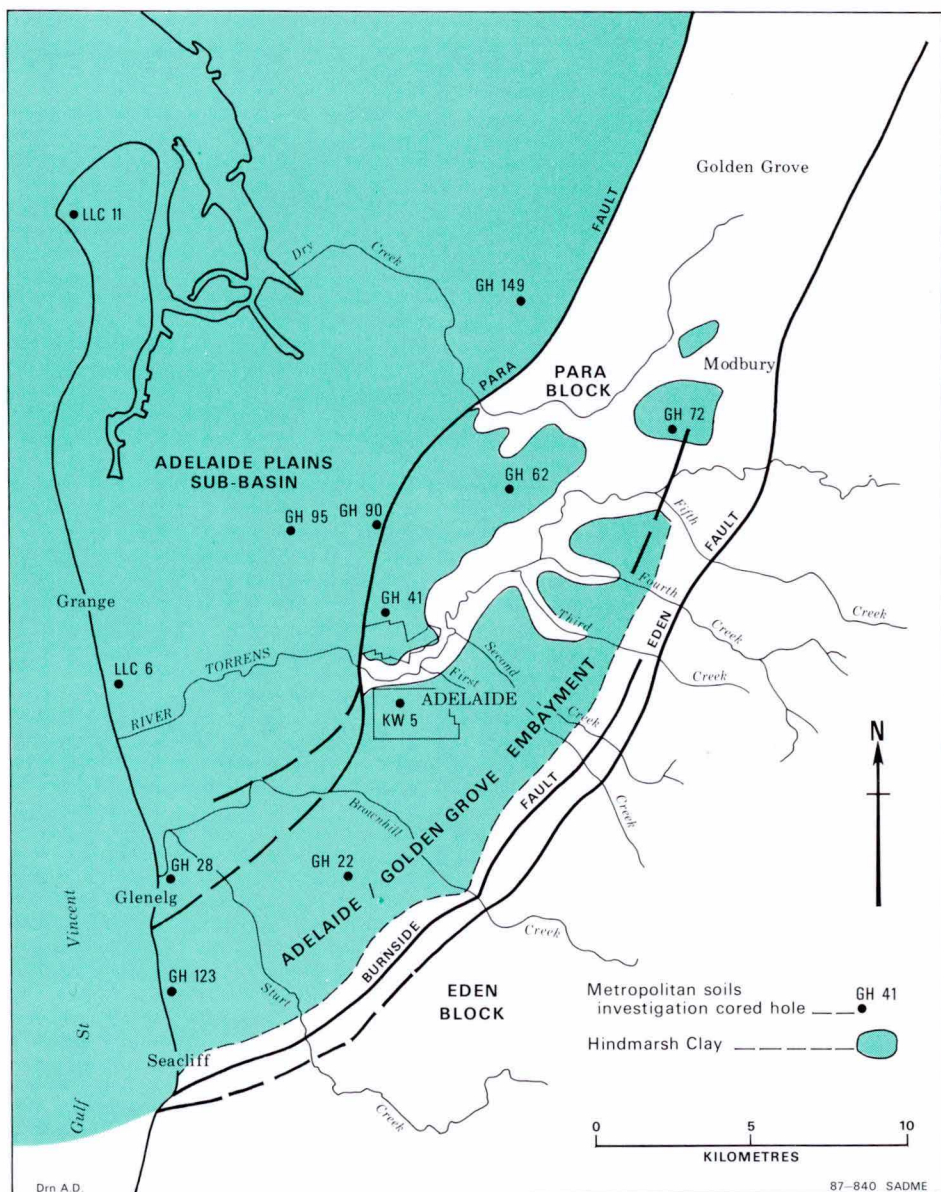


Fig. 1 Distribution of Hindmarsh Clay in the southern Adelaide Plains Sub-Basin and Adelaide/Golden Grove Embayment.

During the course of a joint CSIRO-Department of Mines and Energy investigation into the problem soils of Metropolitan Adelaide, Hindmarsh Clay was intersected in 95 drillholes and the following description results from a detailed study of these cores.

DISTRIBUTION

Hindmarsh Clay is widely distributed throughout the St Vincent Basin and the Adelaide Plains Sub-Basin (Howchin, 1888, 1923, 1935, 1936; Miles, 1952; Glaessner and Wade, 1958; Belperio, 1985) but is less extensive in the Adelaide/Golden Grove Embayment (Daily *et al.*, 1976; Selby and Lindsay, 1982) (Fig. 1). The eastern and southern limits of the Hindmarsh Clay are formed by the Eden-Burnside Fault zone and associated emergent alluvial fans. To the west, the Hindmarsh Clay extends well beyond the present shoreline into the St Vincent Basin Graben (Glaessner and Wade, 1958; Lindsay, 1969; Belperio, 1985), while to the north it continues into the Northern Adelaide Plains Sub-Basin and onlaps the Para Block. In the Adelaide/Golden Grove Embayment the River Torrens has dissected the unit.

UPPER ZONE LITHOLOGY AND BOUNDARY CRITERIA

Table 1 summarises the main characteristics of the upper zone of the Hindmarsh Clay and also indicates how it differs between the Adelaide Plains Sub-Basin and the Adelaide/Golden Grove Embayment.

The unit is predominantly clay, but is often sandy, silty or gravelly and contains lenses of these materials where fluvial influences have been pronounced (Fig. 2). Mica is conspicuous in many of the coarser sediments. West of the Para Fault, rapid lateral and vertical facies changes from sands and gravels to silts and clays are common. East of the Para Fault, the Hindmarsh Clay contains less quartz sand and only rare mica in its upper zone. Generally, the clay matrix consistency ranges from very stiff to extremely stiff, with samples exhibiting plastic to sub-plastic behaviour within the light to heavy clay texture range.

In the Adelaide/Golden Grove Embayment, and generally at depth within the unit, colours of the Hindmarsh Clay tend to be gleyed (i.e. reduced oxide colours - greyish or greenish) (Table 1). West of the Para Fault zone colours range from red/yellow to grey. Ferruginous mottled patterns are varied and can take the form of large coloured patches up to 100 mm across, or small randomly spaced mottles from 2 to 10 mm in diameter.

The upper 1 to 3 m of Hindmarsh Clay often exhibits relict soil profiles similar to the contemporary Red-Brown Earths (red and brown Duplex soils) of the Adelaide Plains. These relict profiles include occasional remnant 'A' horizons and more commonly remnant 'B' horizons, in which are developed layers of carbonate segregations (pisoliths, nodules and concretions) (Table 1 and Fig. 2, holes LLC 11, GH 28 and 95). Repeated soil development is indicated by successive layers of relict soil 'B' horizons.

The palaeo-drainage system of the area is reflected in the 1 to 10 metres of topographic relief superimposed upon the predominantly westerly dip of the upper surface of the Hindmarsh Clay. In most cases this surface forms an erosional discontinuity with overlying strata. However, in the Adelaide/Golden Grove Embayment and on the Para Block the boundary between Hindmarsh Clay and the overlying Keswick Clay is either gradational or diffuse (Fig. 2, GH41 and 72) (Sheard and Bowman, 1987). Within the Adelaide City area a fluvial sand deposit separates these two clay units (Fig. 2, KW1). Allchurch (1966) described clay-filled desiccation cracks within the upper portion of the sand deposit. Rather than differentiating this sand deposit as a separate entity or including it with the Keswick Clay (Sheard and Bowman, 1987), for convenience we have opted to incorporate it within the Hindmarsh Clay (Fig. 2, KW1). This sand unit has been referred to as the Hindmarsh Clay 'sand member' by Conner (1979) and Selby and Lindsay (1982). Similar sand separator beds or lenses are found elsewhere in the Embayment but are of limited extent. We believe these to be of fluvial origin. Where no sand separator bed exists, and where the Hindmarsh and Keswick Clays are of similar character, the boundary between the two units is difficult to establish (Fig. 2, GH41 and 72).

ADELAIDE PLAINS SUB-BASIN: Coastal Zone

Hole: LLC11

Core Library No.: 652800100208

Area: 170m E Pilot Station, Outer Harbor

DEPTH (m)
17 Fine to medium grained quartz sands with some marine shells and fragments.
18 micaceous silt interbeds and a basal gravel.
19 Light yellow brown (10YR 6/5).

20 Transgressive gravel.
21 Stiff sub-plastic grey clay
22 Palaeosol, relict soil
horizonation and carbonate
pisoliths in upper 1.3m.
Green gray (5GY 5/1) with
brownish mottles (7.5YR 5/6,
10YR 2.5/8, 2.5Y 8/4).

LLC6

652800301926

E & W.S. Reserve, Henley Beach

7 Quartz sand, fine to medium
grained transgressive marine
sands, abundant shell
fragments and seagrass
remnants. Yellow gray
(10YR 7/2), loose.

8 Stiff plastic clay with relict
soil horizonation-Palaeosol
(Red-brown Earth/Red Duplex
soil and irregular carbonate
segregations, light brown
(7.5YR 5/4).

GH28

662850001909

Patawilya Reserve, North Glenelg

6 Loose sand, marine, medium
yellow brown (10YR 5/5) to
light olive gray (5Y 6/2) with
clay pellets at base.

7 Palaeosol, highly mottled.

8 Quartz sand, ferruginous.

9 Heavy clay, Palaeosol, relict soil
horizonation, medium yellow
brown, (10YR 4/4).

10 Stiff plastic clay, grey mottled
(5Y 5/1.5) and silty clay
zones, brown (7.5YR 4/5).

ADELAIDE /GOLDEN GROVE EMBAYMENT:

Coastal Zone

GH123

662701000764

Minda Home, North Brighton

5 Quartz sands, fine grained, well
sorted, with abundant shells and
shell fragments, marine/aeolian
coastal dune deposit, light yellow
brown (10YR 7/4).

6 Transgressive gravel.

7 Sub-plastic clay with relict soil
horizonation (Red-brown Earth/
Red Duplex soil-Palaeosol),
strong brown (5YR 4/8).

ADELAIDE PLAINS SUB-BASIN: Inland Zone

GH90

662840002061

Prospect Rd Reserve, Prospect

3 Various buried soils with strong
silty texture-LOESSIC multi
coloured-browns.

4 Silty to rubbly clays-Para Fault
Colluvium, multi coloured-
browns, highly calcareous
at base.

5 Calcrete bar-cap.

6 Gritty stiff plastic grey clay,
light greenish gray (5GY 7/1)
with brownish mottles
(7.5YR 5/8, 10R 4/8).

GH149

662832002124

Para Hills West

5 Various alluvial-colluvial clays
to silty clays with soft
carbonate segregations and
relict lithic clasts to 30mm
common.

6 Colours strong brown
(2.5YR 3/6) to light brown
(5YR 5/6).

7 Alluvial sands/clays as a
cyclical bed-bank deposit,
multi coloured mostly browns.

8 Stiff plastic clay, Palaeosol,
relict soil horizonation and
carbonate pisoliths. Brown
(2.5YR 4/6) with light olive
gray mottles (5Y 6/2).

GH95

662840002066

Challa Gardens Primary School

5 Cyclic fluvial quartz sands, clays
and minor silts-micaceous,
multi coloured mostly browns.

6 Sand to clayey sand, quartz,
fluvial, brown (5YR 4/6).

7 Very stiff sub-plastic clays with
relict soil horizonation
(Red-brown Earth/Red Duplex
soil-Palaeosol). Medium brown
(5YR 4/4).

ADELAIDE /GOLDEN GROVE EMBAYMENT:

Inland Zone

GH22

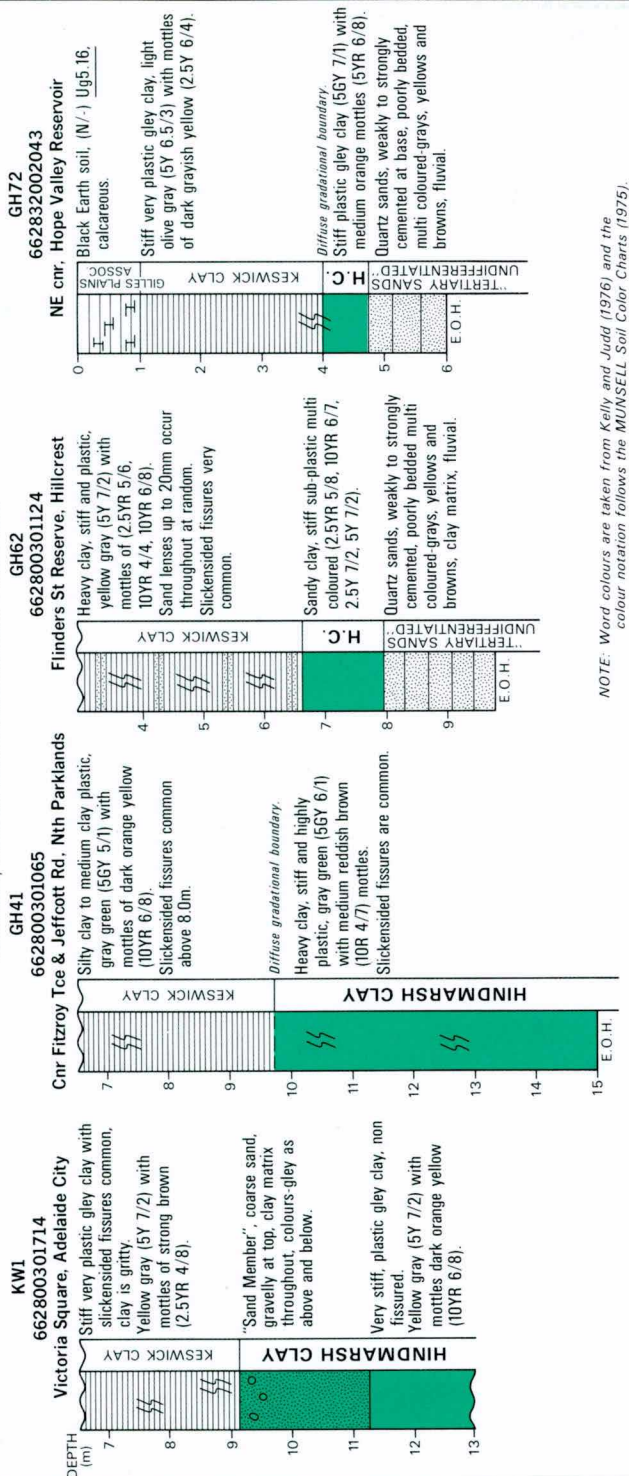
662850000617

Bailey Reserve, Clarence Gardens

4 Highly mottled plastic clay.
Plastic clay, firm to stiff, yellow
gray (10YR 7/2) with gray mottles
(5Y 7/2), very calcareous
throughout.

5 Stiff sub-plastic clay, grey colours
(5Y 7/2) with brown mottles
(5YR 5/7), carbonate pisoliths in
upper portion, calcareous
throughout.

ADELAIDE/GOLDEN GROVE EMBAYMENT: Para Block



NOTE: Word colours are taken from Kelly and Judd (1976) and the colour notation follows the MUNSELL Soil Color Charts (1975).

REFERENCE



Sand



Silts



Clay



Carbonate, powdery



Gravel, pisoliths



Slickensided fissures



HINDMARSH CLAY



Seagrass matts/fibres



Fossils (shells)

Drm P.A.A.

87-841b SADME

Fig. 2 Drillhole Sections displaying lithology and thickness variations.

The Hindmarsh Clay has a predominant consistency that is very stiff to extremely stiff (>200kPa, unconfined strength), compared with the overlying clays which are firm to stiff (<200 kPa), according to data in Conon (1979) and Selby and Lindsay (1982). The latter authors attribute stiffening of the Hindmarsh Clay, which they term 'pseudo-overconsolidation', to post-depositional desiccation, weathering and soil development.

A calcrete mantle occurs on the Hindmarsh Clay within the Adelaide Plains Sub-Basin (Fig. 2, GH90). This calcrete is usually discontinuous and has a complex internal structure (Fig. 2) (Table 1) indicative of multiple carbonate influxes and repeated surficial redistribution. Hence, it is not a reliable stratigraphic marker horizon.

Along the present coastline, marine units that overlie the Hindmarsh Clay include the Glanville Formation, as redefined by Cann (1978) and Belperio (1985), and the St Kilda Formation, as redefined by Cann and Gostin (1985) (Fig. 2, LLC6 and 11, GH28 and 123). Further from the coast, the Hindmarsh Clay is overlain by fluvial sands, silts and clays which are usually unconsolidated to weakly bound (Fig. 2, GH22, 90, 95 and 149). According to Firman (1966), within the suburb of Hindmarsh (which is the type area), Hindmarsh Clay forms a subcrop with an overlying shallow soil. It also crops out in the banks of the River Torrens, according to Firman (1966) and Selby and Lindsay (1982).

East of the Para Fault zone, Hindmarsh Clay is directly overlain by Keswick Clay, Pooraka Formation or alluvial fan deposits (Fig. 2, KW1, GH22 and 62). Towards the northern end of the Adelaide/Golden Grove Embayment Hindmarsh Clay is thin or absent (Fig. 2, GH62 and 72) and this may be due to sporadic movement of the Para Block during and/or following deposition of the Hindmarsh Clay.

DEPOSITIONAL ENVIRONMENT

Tate (1890), Howchin (1888, 1918, 1935, 1936) and Glaessner and Wade (1958) concluded that the Pleistocene clays of the Adelaide Plains were terrestrial alluvial deposits. Firman (1966) extended this description when he referred to Hindmarsh Clay as a terrestrial alluvial fan or piedmont deposit and Lindsay (1969) concluded that the basal western zone of the Hindmarsh Clay contained minor marine to estuarine facies.

Our extensive drilling programme has produced evidence of alluvial fan deposition in the upper 10 m of the Hindmarsh Clay, including many shoe-string sand/gravel/boulder deposits within the clay and large areas of cyclic sand/silt/clay layers (Sheard and Bowman, in prep.)

CONCLUSIONS

A redefinition of the upper boundary of the Hindmarsh Clay has several implications:

- Hindmarsh Clay no longer incorporates the newly defined Keswick Clay (Sheard and Bowman, 1987).
- The characteristics of the upper zone of the Hindmarsh Clay differ between the Adelaide Plains Sub-Basin and the Adelaide/Golden Grove Embayment. These differences are summarised in Table 1.
- The Hindmarsh Clay 'sand member' (Selby and Lindsay, 1982) is here included within the Hindmarsh Clay for convenience.
- The properties of the upper zone of the Hindmarsh Clay outlined in this paper, together with the properties of the Keswick Clay set out in the preceding paper (Sheard and Bowman, 1987), should facilitate identification of and distinction between these two units. This should result in more reliable geotechnical site investigations.

Reference cores shown in Fig. 2 are stored in the Department of Mines and Energy Core Library Complex, Glenside.

TABLE 1. Primary differences in characteristics of Hindmarsh Clay upper zone.

	ADELAIDE PLAINS SUB-BASIN	ADELAIDE/GOLDEN GROVE EMBAYMENT

FEATURES		
<i>Colours</i>		
Dominant	Oxidised colours: reddish, brownish, yellowish	Reduced oxide colours: greenish, greyish
Subdominant	Reduced oxide colours: greenish, greyish, bluish	Oxidised colours: reddish, brownish, yellowish

<i>Texture:</i>		
Dominant	Sandy to silty clay	Clay to gritty clay
Subdominant	Silt, sand, gravel	Silt, sand, gravel

<i>Consistency</i>		
(geo-mechanical)	Very stiff to extremely stiff	Stiff to very stiff

<i>Upper Boundary</i>	Erosional disconformity, sharp	Disconformity, unclear to diffuse

<i>Palaeosols</i>	Common in upper 3 m	Uncommon to absent

<i>Carbonate Segregations</i>	Common - pisoliths, nodules, concretions in cyclic layers and zones	Uncommon to absent

<i>Atterberg Limits</i>	Common	Less Common
Plastic Limit	13-24%	25-29%
Liquid Limit	22-55%	56-79%

	Common	Less Common
Plastic Limit	13-24%	25-29%
Liquid Limit	22-55%	56-79%

	Common	Less Common
Plastic Limit	13-30%	31-42%
Liquid Limit	30-80%	81-113%

KEYWORDS: HINDMARSH CLAY/definition/Keswick Clay/mottled clay/soils investigation/St Vincent Basin/Adelaide-Golden Grove Embayment/Eden Fault Block/Para Fault Block/SI 54-9/6628.

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