DEPARTMENT OF MINES AND ENERGY
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EXPLANATORY NOTES FOR THE KIMBA 1:250 000 GEOLOGICAL MAP

GEOLOGICAL SURVEY

by

R B FLINT

and

L R RANKIN

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CONTENTS PAGE

TABLES

FIGURES

17.	Amygdaloidal basalt from the basal basalt horizon of the Kilroo Formation (Ꝑ*c*), eastern Polda Basin. Drillcore is from CRA 83KD1A, arrow is 1 cm long and indicates stratigraphic facing.	38561
18.	Sandy facies within the redbed sequence of the Kilroo Formation, within CRA 83KD1A. Note fine layering and low-angle trough crossbedding.	38562
19.	Glacigene diamictites of the Coolardie Formation (CPc) from Lock DDH1.	38563
20.	Grey, poorly-sorted sands interlayered with black carbonaceous sands of the Jurassic Polda Formation (Jup) within CRA 83KD1A, eastern Polda Basin.	38564
21.	Black carbonaceous sands of the Poelpena Formation (Tep) overlain by green-grey clays of the unnamed Pliocene sediments unit (Tp). Polda DDH9, eastern Polda Basin.	38565

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INTRODUCTION

The KIMBA 1:250 000 geological map sheet (hereafter referred to as KIMBA) lies in central Eyre Peninsula, extending between latitudes 33° to 34° S and longitudes 135° to 136°30'E (Fig 1). The principal towns are Kimba and Cleve, with smaller towns at Wudinna, Kyancutta, Lock, Rudall, Darke Peak, Pygery and Warramboo.

The area is crossed by the Eyre Highway in the north, the Flinders Highway along the west coast, the Lincoln Highway on the east coast, and the Ceduna-Port Lincoln and Buckleboo-Cummins railways.

The area has been extensively cleared for agriculture, particularly rotation cereal cultivation and livestock grazing. Major cereals are wheat and barley, and sheep are the most important livestock. Large tracts of native vegetation still exist, especially in the Pinkawillinie, Hambidge, Bascombe Well, Hincks and Carappee Hill Conservation Parks.

Mapping of KIMBA was based on Department of Lands 1981 black and white and colour aerial photos on a scale of 1:40 000. Geological boundaries were transferred to 1:100 000 topographic base maps which are available from SADME as black and white paper prints. Final compilation at a scale of 1:250 000 entailed some simplification of boundaries.

PREVIOUS INVESTIGATIONS

Early mining activities on KIMBA were summarised by Brown (1908). Jack (1912, 1914, 1922) briefly described aspects of regional geology and hydrogeology, but the most detailed previous geological investigations are those of Johns (1961) which included an evaluation of mineral occurrences and prospects, and Parker (1978) and Parker and Lemon (1982) who describe the stratigraphy and structure of the area near Cleve.

Regional geological descriptions of basement rocks are also included in Glen *et al*. (1977), Parker *et al*. (1981, 1985 and 1988) and Rutland *et al*. (1981).

Geophysical investigations on KIMBA began with the production of 4-mile aeromagnetic maps of Eyre Peninsula by the Bureau of Mineral Resources in 1953-55, initiating interest in prominent aeromagnetic anomalies at Kopi, Kyancutta and Warramboo (Whitten, 1960; Heath and Whitten, 1962; Whitten 1962, 1963a, b, c; Webb, 1966; Risely, 1963; Shackleton, 1963; Dutton, 1964; Whitten, 1965a, b; Whitten and Risely, 1968).

Previously published geological maps include the 1:63 360 scale maps of Rudall, Verran and Darke (Johns, 1957a,c,d) and a 1:253440 scale map of the eastern region (Johns, 1961). A preliminary edition of KIMBA was compiled by Botham (1967). All of the adjoining sheets have been published or are nearing completion. These are: LINCOLN (Johns, 1957b), PORT AUGUSTA (Dalgarno *et al*., 1968), WHYALLA (Parker, 1983), YARDEA (Blissett *et al*., 1988.), ELLISTON (Flint, 1989) and STREAKY BAY (Rankin and Flint, in prep.). Rudall 1:50 000 geological map (Rankin, 1987) details the basement geology north of Cleve and is a series continuation of Mangalo and Cowell map sheets to the east on WHYALLA.

The results of investigations within the Polda Basin are summarised by Gatehouse (1979, 1980a), with stratigraphic drilling reported by Gatehouse (1980a, b, c, 1981) and Kwitko (1982). Hydrogeological work in the Polda Basin is summarised by Smith (1984). Geochronological studies (using Rb-Sr and K-Ar) by AMDEL Ltd. and SADME are summarised in Webb *et al.* (1986). U-Pb isotopic studies on zircons are confined to the Carappee Granite (Flint *et al*., 1988a) and Bosanquet Formation (Rankin *et al*., 1988).

The results of exploration by numerous mining companies are discussed in the chapter ECONOMIC GEOLOGY.

PHYSIOGRAPHY

Climate (from Laut *et al.*, 1977 and Schwerdtfeger, 1985).

The climate grades from mild and moist near the coast in the southwest to warm and dry further inland. For Cleve, the mean summer (January) temperatures range from 15.6°C (min.) to 28.3°C (max.), decreasing to mean winter (June) temperatures of 6.8°C (min.) to 14.8°C (max.). The highest humidities occur in June-July, recorded at Cleve as 77% (0900 hrs) and 61% (1500 hrs), falling in summer to 44% (0900 hrs) and 33% (1500 hrs).

Annual rainfall varies from 300 mm in the north to over 450 mm in the south. Rainfall is, however, variable and unreliable. Summer rainfall varies across KIMBA from approximately 9% to 17% of annual total from west to east. The mean annual sunshine ranges from 2400 hours in the south to 2900 hours in the northwest.

The wind patterns for Cleve are fairly representative of those of Eyre Peninsula, with summer winds prevailing from the southeast (<30 km/hr) and winter winds prevailing from north to west (<40 km/hr). KIMBA is also affected by sea-breeze systems from both the eastern and western coasts of Eyre Peninsula.

Landforms (after Laut *et al.*, 1977; Twidale and Campbell, 1985b).

The topography of KIMBA is dominated by several areas of hilly uplands and granite plains with inselbergs and intervening sand-dune plains and peneplains. The principle physiographic features are shown in Fig. 2.

The Cleve Uplands in the east consist of ridges of quartzite, gneiss and iron formation, with valleys of eroded schist. Outliers of the Cleve Uplands include Darke Peak and Caralue Bluff, and Carappee Hill which is an imposing inselberg rising 270 m above the plains. The stepped nature of the surface of Carappee Hill suggests a series of progressive erosional levels.

Blue Range and Verran Hill represent northern extensions of the Lincoln Uplands.

The Cleve Uplands grade northwards into the Kimba Peneplain, an area of low, rolling relief and minor sand dune development. This is especially evident against the northern extremities of the Cleve Uplands.

In the Wudinna, Kyancutta and Mount Damper areas elevated colluvial fans and plains fringe isolated granitic inselbergs. The inselbergs typically exhibit flared slopes, A-tents, gnammas and tafoni (Twidale and Campbell, 1985b).

The majority of the land surface on KIMBA is dominated by sand dune plains, which can be separated into three types. The first and oldest type is the Sheringa Plain, an extensive region of anastomosing, calcreted dunes. Associated with these dunes is a subtle palaeodrainage channel extending westwards from near Tooligie Range towards Sheringa. The second type is the longitudinal dunefield terrain of the Tuckey and Lock Plains which extend from the northwest near Wudinna to the southeast around the Driver River. The seif dunes are typically oriented northwest-southeast, although disruption of this trend locally occurs around the margins of the uplands and inselbergs. The third and youngest type of dune plain is characterised by parabolic dunes, best illustrated in the Kwaterski dunefield within the Corrobinnie Depression.

Surface streams are few and typically small, with drainage out of the Cleve Uplands dominated by Mangalo, Yadnarie, Poolalalie and Gum Creeks. The Driver River, which is intermittant and saline, extends from near Kielpa to Arno Bay. Streams are rare elsewhere with mainly endorheic drainage into saline lakes.

Vegetation (from Specht, 1972; Laut *et al.*, 1977)

The western undulating calcarenite plains of KIMBA range from open scrublands of E. diversifolia to woodlands of Melaleuca lanceolata (with herbaceous understory). The coastal dunes near Sheringa support an open heath of Olearia axillaris, Leucopogon parviflorus and Acacia sophorae.

In the central, dunefield area of KIMBA, mallee broombrush is dominant; typically E. incrassata and Melaleuca uncinata with some E. foecunda, E. dumosa subsp. [pileata] and E. flocktonia. This association is well preserved in the Pinkawillinie and Hincks Conservation Parks. Around "Polda" area, Casuarina stricta is occasionally found.

In regions where loam soils have developed on Precambrian bedrock, notably the Cleve Uplands, Kimba Plains, isolated outcrops such as Carappee Hill, Darke Peak, Caralue Bluff and numerous granite inselbergs, the dominant vegetation is open scrubland of red mallee-yorell association (E. socialis - E. gracilis), with minor E. cladocalyx at Darke Peak and Tooligie. On the almost barren granite inselbergs, grasses and tall shrubs such as Dodnaea attenuata occur.

Around small gypsiferous lakes in the northwest, samphire shrublands of Arthocnemum holocnemoides and Salicornia quinqueflora - Suaeda australis associations occur.

HISTORICAL NOTES

(from Masters, 1974; Cockburn, 1984;
Twidale and Campbell, 1985a)

The first inhabitants of the KIMBA region were the aboriginal Navo, Banggala and Gugada tribes (Berndt, 1985).

European involvement in the KIMBA area started with mapping of the coastline of Eyre Peninsula by Matthew Flinders in the Investigator around 1802. One of the first Europeans to travel inland was C.C. Dutton, who set out from Port Lincoln in June 1842 intending to drive cattle overland to Adelaide. Dutton and his four companions died before completing their journey. Edward John Eyre led a search party three months later, but failed to find Dutton. Testimony by an Aborigine from the Middleback region revealed that Dutton and his companions were killed by Aborigines.

Eyre travelled across western Eyre Peninsula in 1839 during exploration from Port Lincoln to Streaky Bay, reporting low, barren country. Eyre's next expedition in 1840, seeking an overland route from South Australia to the west, passed Mt Wedge, which was named "from its shape" (Eyre, 1845). Two whalers, Richard Harris and George Cummings, also passed Mt Wedge as they walked from Fowlers Bay to Port Lincoln.

The reports of good lands by Harris and Cummings (S.A. register 15, 16 and 20 Dec., 1843; Smith, 1843) prompted John Charles Darke to explore the country from Port Lincoln to Mt Wedge on a privately-sponsored expedition. On his return, Darke was fatally speared by Aborigines at Waddikee

Rocks. He was buried at the base of Darke Peak, named after him twenty years later by the surveyor Thomas Evans. In 1910, the South Australian Government provided funds for a memorial to Darke to be erected.

Warburton travelled north from Mt Wedge in 1858 looking for grazing lands, and a pastoral station was established at Mt Wudinna in the late 1800's, utilizing water in soaks around granite inselbergs. J. F. High and W.R. Mortlock established themselves as pastoralists around Sheringa, also in the late 1800's. The hills around Cleve had been previously settled in the mid-1800's by the McKechnie brothers who ran sheep and, later, cattle on a number of pastoral leases. These leases were later (ca 1878) subdivided and fenced to form smaller farms.

Several of the locality names on KIMBA have historical backgrounds. Mt Bosanquet was named after Admiral Sir Day Hort Bosanquet, Governor of South Australia from 1907 to 1914, Verran after John Verran, Premier of South Australia, and Lock after Corporal A.E. Lock, an officer of the State Survey Department killed in action during World War 1. Cleve was named by Governer Jervois after his cousin's country seat in Devon, England!

STRATIGRAPHY

Archaean basement rocks, which are dominantly concealed in the central and western regions, form part of the Coulta Subdomain of the Gawler Craton. To the east, exposures of Early - Middle Proterozoic rocks are good and belong to the Cleve Subdomain (Thomson 1980; Parker and Lemon, 1982).

Superimposed on the Gawler Craton is a major east-west trending graben (and associated Bouguer gravity low anomalies Fig. 3) within which Middle and Late Proterozoic, Permian, Jurassic, and Early and Late Tertiary sediments were deposited during an episodic history of sedimentation and tectonism. Nomenclature for the graben has varied considerably, but preferred terms are Itiledoo Basin (new name) for Middle Proterozoic sediments and Polda Basin for all younger sediments. Both the Precambrian and Phanerozoic units are generally overlain by a thin cover of Quaternary sediments and palaeosols. The lithology and stratigraphic relationships of the rock units are summarised in Tables 1,2 and 3.

ARCHAEAN

Late Archaean rocks on KIMBA are part of the Sleaford Complex (Thomson, 1980) and consist of granites plus ortho- and paragneisses which have been subdivided into several units.

Paragneisses AꝐ*sg*

The majority of exposed Archaean rocks are of poorly- to well-foliated, fine- to medium-grained, garnetiferous quartzofeldspathic gneisses. The gneisses are commonly migmatitic and complexly folded, and are characterised by abundant coarse-grained aggregates of garnet and white potash feldspar megacrysts (Plate 1).

Gneisses recovered from drillcore in the Warramboo - Waddikee Rocks area by SADME (Whitten, 1963c), North Broken Hill Ltd and CRA Exploration Pty Ltd (1984) include poorly-banded quartz + feldspar + magnetite + cordierite + biotite + garnet + sillimanite assemblages. Sillimanite typically occurs as fine-grained inclusions within garnet and cordierite, but also as thin (<1 mm) bands (Whitehead, 1978).

A garnetiferous gneiss from SADME Warramboo WD1 drillhole gave a Rb-Sr age of 2520±163 Ma and initial ratio of 0.7041 ± 0.0069 (Webb *et al.*, 1986).

<u>Iron formation AP*si*</u>

Interlayered with and gradational from the garnetiferous paragneisses are magnetite-rich quartz + feldspar + garnet + cordierite gneisses. Magnetite content varies from 5% to 30%, with poor compositional banding (Whitehead, 1978). Magnetite is locally intergrown with ilmenite and partially oxidised to hematite. Iron formation occurs as isolated outcrops near Waddikee Rocks, but is more extensive in the subsurface (Whitten, 1963c, and Tectonic Sketch).

<u>Mafic granulite AP*sm*</u>

Medium-grained, banded feldspar + hornblende + clinopyroxene + orthopyroxene mafic granulites (and amphibolites) occur interlayered with garnetiferous gneisses (AP*sg*) and iron formation (AP*si*). The granulites commonly exhibit retrogressive textures and mineralogies, with development of feldspar + hornblende + clinopyroxene. The mafic granulites may represent metamorphosed mafic intrusives or extrusives, and are presently only known in drillcore from near Warramboo.

<u>Undifferentiated gneisses AP*s*</u>

Dominant lithologies within the undifferentiated Archaean sequence are poorly- to well-foliated granite gneisses and aplites, but also included are undifferentiated quartzofeldspathic, garnetiferous and magnetite-rich paragneisses. The gneisses are commonly migmatitic and complexly folded (Plate 2). Chlorite + biotite schists (recovered in North Broken Hill Pty Ltd drilling near Warramboo) may represent retrograded amphibolites.

An outcrop of relatively homogeneous granite gneiss at Bascombe Rocks has a foliation defined by wispy, attenuated and discontinuous trails of biotite.

A garnet-rich migmatitic gneiss at Waddikee Rocks gave a Rb-Sr age of 2428 ± 94 Ma and initial ratio of 0.7059 ± 0.0084 (Webb *et al.*, 1986).

<u>Gneissic granodiorite AP*sq*</u>

A granite gneiss (AP*s*) at Bascombe Rocks is intruded by a grey, medium-grained, homogeneous gneissic granodiorite. The rock consists of plagioclase (65-70%), quartz (20-25%), biotite (5%) muscovite (5%), with trace apatite, zircon, chlorite and opaques. Relic igneous plagioclose megacrysts range from 3-5 mm, and commonly show antiperthitic textures. Myrmekites are also common. Rb-Sr dating of this unit was unsuccessful, as the five samples analysed have a very restricted range in Rb/Sr ratios (Fanning and Webb, 1985).

PROTEROZOIC

EARLY PROTEROZOIC

The Early Proterozoic is represented on KIMBA by a sequence of supracrustal metasediments and metavolcanics (Hutchison Group and Bosanquet Formation) and slightly later syn-orogenic granite intrusives (Lincoln Complex).

Hutchison Group Ᵽ*h*

The Hutchison Group is a sequence of metamorphosed mixed clastic and chemical sediments, consisting of a basal calc-silicate plus quartzite unit (Warrow Quartzite), a mixed clastic/chemical sequence of carbonates, iron formation and schists (Katunga Dolomite, Lower and Upper Middleback Jaspilites, Cook Gap Schist) plus an overlying schist (Yadnarie Schist) (Parker and Lemon, 1982). The Bosanquet Formation most likely belongs to the Hutchison Group.

Warrow Quartzite Ᵽ*h*w

The Warrow Quartzite is the basal member of the Hutchison Group. On KIMBA, contacts with the Archaean basement are either not exposed or ambiguous, but elsewhere (e.g. Marble Range, LINCOLN) it is demonstrably unconformable (Parker *et al.*, 1988).

A spectacularly well-banded calcsilicate gneiss (Ᵽ*h*d) occurs locally at the base of the Warrow Quartzite and is best exposed in the core of an F_2 antiform extending from Sheoak Creek to northeast of Mount Rough (Plate 3). The unit consists of alternating layers (5-35 cm thick) of white dolomitic marble (containing only minor microcline and muscovite) and diopside + microcline + quartz + muscovite + dolomite calcsilicate. In thin section the calcsilicates are typically medium-grained and granoblastic to granoblastic-elongate. Diopside is intergrown with quartz, with optical continuity between grains suggesting that the diopsides were originally coarse-grained porphyroblasts (10 mm - 15 mm).

Warrow Quartzite exposed at Caralue Bluff is a medium- to coarse-grained massive quartzite, with locally preserved trough cross-bedding and distinct, but highly deformed, quartz-pebble conglomerate beds (Plate 4) (Parker & Lemon, 1982). The Warrow Quartzite generally grades upwards from massive and muscovite + feldspar-rich near the base, to flaggy, coarse-grained, sugary quartzite with numerous pelitic interbands near the top (Plate 5).

The Warrow Quartzite is considered to represent a sequence of fluvial to marginal marine arkosic sands, grading from fluvial in the west to marginal-marine in the east (Cowell-Cleve area). The marine transgression was westwards onto the Coulta Subdomain (Parker and Lemon, 1982).

Katunga Dolomite Ꝑ*h*k

The Katunga Dolomite locally overlies the Warrow Quartzite, and contains massive, grey, pink and white dolomitic marbles (occasionally silicified and altered to opalite), with minor layers of fine-grained quartzite and calcsilicate gneiss. Locally, as at the Cleve Council Pits, minor interlayers of tremolitic quartzite occur, and massive dolomitic marble contains aggregates of medium-grained serpentine, which has replaced olivine (Parker *et al.*, 1988).

The Katunga Dolomite varies greatly in thickness, being absent in many localities. The unit represents a series of metamorphosed shallow marine carbonates and marls.

Lower Middleback Jaspilite Ꝑ*h*m_1

Iron formation of the Lower Middleback Jaspilite is commonly absent in the Cleve Uplands area but locally occurs not only overlying and interfingering with the Katunga Dolomite (e.g. at the Cleve Council Pits and east of "Ningana") but also directly overlying the Warrow Quartzite (e.g. east of Gum Valley).

The best occurrence of the iron formation is in the Cleve Council Pits where it is a silicate-facies iron formation, consisting of recrystallised chert and graphitic chert with low iron content (Parker and Lemon, 1982; Parker *et al.*, 1988) (Plate 6). Grunerite commonly occurs with the iron oxides.

The iron formation, which grades into and is locally interlayered with the overlying Cook Gap Schist, represents a period of chemical marine sedimentation.

Cook Gap Schist Ꝑ*h*c

This unit is also locally known as the Mangalo Schist in the Cleve Uplands region (Parker, 1978). The base of the schist is gradational from the Lower Middleback Jaspilite and the Katunga Dolomite, or, where these units are absent, from the Warrow Quartzite. The unit consists of well-layered and well-foliated, quartz-veined semi-pelitic biotite + muscovite + garnet schists and gneisses, with local minor quartz + feldspar psammitic interbeds (Plate 7). In Mangalo Creek the average composition is quartz (20-50%), plagioclase (20-50%), microcline (10-45%), biotite (5-20%), muscovite (5-35%), plus minor garnet, tourmaline and opaques.

North of the Cleve Uplands, the Cook Gap Schist is of higher metamorphic grade, with zones of garnetiferous migmatitic gneisses and quartz + feldspar leucosome segregations.

Within the schists, well-foliated, multiply-deformed and concordant amphibolite bodies (Ꝑβ_1)

are common. Textures vary from fine-grained and schistose to massive and medium- to coarse-grained. Coarse hornblende grains are typically randomly oriented, while the finer-grained crystals commonly form a strong mineral lineation. Parker (1978) reported that the amphibolites have a chemical composition consistent with a quartz-tholeiitic basalt and hence they may represent either basaltic volcanics synchronous with sedimentation or basic intrusive sills. Alternatively, they may represent metamorphosed calcareous sediments. Amphibolites are best exposed in the creek section at Mangalo Creek.

In the area north-west of Cleve near Cockabidinie Reservoir, there are local magnetite-rich gneisses and calcsilicate bands interlayered with schist. Some of these carry anomalous basemetals.

Eight samples of Cook Gap Schist from Mangalo Creek were analysed for Rb-Sr dating, producing a model 2 isochron with an age of 1688 ± 76 Ma, an initial $^{87}Sr/^{86}Sr$ ratio of 0.7061±0.0042 and a MSWD of 23 (Webb *et al.,* 1986). K-Ar isotopic analyses yielded ages of 1629 and 1600 Ma (muscovite) and 1588 and 1537 Ma (biotite) (Webb *et al.,* 1986). Ages obtained from both Rb-Sr and K-Ar schemes reflect metamorphic overprinting.

The schist represents a progradation of clastics into the marine basin. Contact with the overlying Upper Middleback Jaspilite is gradational.

Upper Middleback Jaspilite Ꝑ *h*m_2

This unit is also locally known as the Mount Shannan Iron Formation (Carpentaria Exploration Pty Ltd, 1976a, b).

In Mangalo Creek, the unit grades from the semi-pelitic Cook Gap Schist into massive to poorly-banded, reddish-pink to grey dolomite (with occasional tremolite-rich layers) plus crenulated mica schists. These pass upwards into interlayered cherty quartzites (Plate 8) and medium- to fine-grained dolomites, grading from pink (sideritic) to white. The quartzites are fine-grained, laminated, and vary from grey to red jaspilitic bands between 5-30 mm thick (Parker *et al.,* 1988).

Lithologies recovered from drillholes in the Campoona Syncline - Cockabidnie Corner region (CRA Exploration Pty Ltd and Shell Co. Aust. Ltd, 1985b) and from SADME Broad View DDH1 east of Carappee Hill include banded calcsilicate and quartz + magnetite gneisses. Metasediments in Broad View DDH1 were subdivided into five principal lithologies (Rankin and Flint, 1987):

a) streaky-foliated fine- to medium-grained calc-silicate schist/gneiss;

b) poorly-banded, fine- to coarse-grained calc-silicate gneiss plus marble;

c) fine-grained quartz + feldspar + biotite schist/gneiss;

d) well-banded garnetiferous, magnetite-bearing calcsilicate schist gneiss; and

e) magnetite quartzite plus magnetite + amphibole schists (iron formation).

Elsewhere, the unit also contains brecciated, cherty and ferruginous quartzites, graphitic schists, dolomites and quartz + cummingtonite + grunerite + magnetite gneiss.

The Upper Middleback Jaspilite on KIMBA is a series of carbonate and silicate-facies iron formations, with considerably lower iron contents in comparison to their correlatives within the Middleback Ranges. The iron formations represent a period of marine transgression and chemical sedimentation (Parker and Lemon, 1982).

Yadnarie Schist Ᵽ*h*y

The Yadnarie Schist has only been recognised in the Cleve Uplands area; it has a minimum thickness of 1000 m and its top is not known. The unit consists of fine-grained muscovite + biotite + quartz + feldspar schist (with minor opaques, plagioclase, garnet and tourmaline), interlayered with psammitic layers up to several centimetres thick (Plate 9). Both the Cook Gap Schist and Yadnarie Schist units are very similar in outcrop appearance, however, the Yadnarie Schist has a greater proportion of muscovite, and contains no known amphibolites. The type locality for the Yadnarie Schist is the section exposed just north of Mangalo Creek.

A local variant of the unit occurs in weathered outcrop in the Campoona-Cockabidnie Corner area. A subunit (Ᵽ*h*yp) consists of iron-stained, quartz + sericite banded metasiltstones with sericite aggregates replacing sillimanite porphyroblasts, plus minor interlayered quartz + magnetite gneiss. The unit has a characteristic light- to dark-grey banded appearance resulting in the informal name "pyjama rock" by some company geologists. The Yadnarie Schist represents a second major period of retrograde clastic sedimentation.

Bosanquet Formation Ᵽ*b*

The Bosanquet Formation is not known elsewhere on the Gawler Craton and has only been recognised in a zone east of Carappee Hill which is at least 1 km wide and 5 km long. Surface contacts with other Proterozoic units are concealed by Cainozoic sediments. The type section for the unit is in Broad View DDH1 (Rankin and Flint, 1987). The (?)basal megacrystic rhyodacite contains abundant white coarse-grained microcline (Plate 10) and medium-grained, subround quartz phenocrysts within a recrystallised matrix of quartz + feldspar + biotite. This grades (?)upwards, and is interlayered with, a well-foliated, intensely-recrystallised mylonitic variety, with fewer and smaller microcline phenocrysts. Quartz phenocrysts exhibit rare embayed grain boundaries.

Interlayered with the metavolcanic units are well-banded, grey to green, quartz + microcline + plagioclase + hornblende + biotite + calcite calcsilicate gneisses and quartz + plagioclase + biotite + microcline gneisses.

To the east of the drillhole, exposures consist of conglomeratic calcsilicate with abundant clasts of dolomite, rhyolite, granite and quartzite in a coarse-grained, diopside-rich matrix (Plate 11). Interlayered with the conglomeratic calcsilicates are fine-grained, clast-free calc-silicate gneisses. The sequence represents a period of contemporaneous acid volcanism and carbonate sedimentation with considerable conglomeratic input.

Whole-rock geochemistry of volcanics within the Bosanquet Formation is dissimilar to other Early Proterozoic volcanics of the Gawler Craton (e.g. Myola and McGregor Volcanics) (Rankin and Flint, 1987). This is supported by U-Pb isotopic studies on zircons from a rhyodacite which yielded an age of 1845±9 Ma (Rankin et al., 1988). The contact relationship between the Bosanquet Formation and the Upper Middleback Jaspilite is ambiguous. The combined geochronological and geochemical evidence suggests that the Bosanquet Formation was deposited either as part of the Hutchison Group in a restricted area, or represents a distinct, younger episode of volcanism and sedimentation but prior to the Myola Volcanics on WHYALLA (Rankin *et al.*, 1988). The similarity of some calcsilicates interlayed with volcanics to those in the iron formation suggests affinity with the Hutchison Group.

Lincoln Complex

The Lincoln Complex consists of a series of syn-Kimban Orogeny granites, granitic gneisses plus minor mafic intrusives, with a complex timing of intrusion throughout the Kimban Orogeny (Parker *et al.*, 1988).

Undifferentiated granitic gneiss Ꝑ *l*

This unit includes fine- to medium-grained, orange to grey, well-foliated, quartz + feldspar + biotite granitic gneiss, massive to foliated, medium-grained granite and microgranite, migmatite gneiss, aplite and quartz + feldspar + muscovite + garnet + tourmaline pegmatite.

The well-foliated granitic gneisses are considered to have been granites injected either pre- or syn-D_1 of the Kimban Orogeny, and subsequently imprinted with a variable-intensity S_{1-2} foliation. These gneisses are probably equivalent to the Minbrie Gneiss of Parker (1983).

In the Gum Valley - High Bluff area, granite and granitic gneiss intrude the Hutchison Group. Schists have been migmatised, and both schist and iron formation occur as rafts within the gneisses. It is possible that partial melting of Hutchison Group metasediments at slightly greater depths was the source of some of the granites/gneisses. Interlayering with and migmatisation of the Warrow Quartzite by quartz + feldspar + muscovite granite gneiss are seen within drillcore from the Campoona Syncline - Cockabidnie Corner area (CRA Exploration Pty Ltd and Shell Co. Aust Ltd, 1985b).

The Ꝑ *l* gneisses and granites have been injected throughout the Hutchison Group metasediments and are either tectonically or intrusively intercalated with Archaean garnet gneisses (ALPsg) near "Windzel".

Granite PL γm

A pink to grey, medium-grained quartz + feldspar + biotite gneissic granite (Plate 12) is well exposed near Balumbah railway siding where it intrudes the earlier PLl granite gneisses. The granite contains abundant pegmatite veining, and more gneissic varieties contain garnet. The weak to moderate-intensity foliation suggests that the granite was intruded during D_2 of the Kimban Orogeny, making it equivalent to the Middle Camp Granite of Parker (1978, 1983).

Carappee Granite PL γc

This unit makes up the imposing inselberg of Carappee Hill, and is also found as small outcrops near Caralue Bluff and on the western flank of Darke Range. The unit is relatively homogeneous, consisting of tabular microcline megacrysts up to 2 cm in length within a fine- to medium-grained matrix of quartz + feldspar + biotite (Plate 13). Megacrysts are typically weakly aligned parallel to a vertical, spaced foliation trending approximately 010°. This foliation is interpreted as either S_2 or S_3 of the Kimban Orogeny.

On the western flank of Darke Range, the granite is locally in contact with the Warrow Quartzite. The foliation in the granite becomes more intense close to the contact, suggesting that the contact is tectonic.

U-Pb zircon isotopic data give an age of 1689±59 Ma for the Carappee Granite, with evidence of a high percentage of radiogenic lead loss from the zircons (Flint *et al.*, 1988a). This age is slightly younger than the U-Pb age of 1738±68 Ma obtained for the Middle Camp Granite (Fanning, 1987), and the Carappee Granite is therefore interpreted to have been intruded sometime during the period spanned by D_2 and D_3 of the Kimban Orogeny.

Muscovite-bearing granite PL γa

This is a massive to weakly-foliated, coarse-grained, cream to pink microcline + quartz + plagioclase + muscovite + garnet granite. The granite is best exposed in Poornamookinie Creek as sills intruding the Warrow Quartzite in the core of an F_3 antiform (Cleve Antiform) of the Kimban Orogeny. Partial melting and boudinaging of the Warrow Quartzite accompanied intrusion.

The granite is most likely equivalent to the Carpa Granite found near Elbow Hill (Parker, 1983), which was intruded into the Hutchison Group pre- or early syn-D_3. Two generations of pegmatite occur within the granite. These are:

a) garnetiferous pegmatite synchronous with granite intrusion and
b) late, coarse-grained, tourmaline-bearing (±andalusite ± sillimanite) pegmatite with sharp intrusive contacts.

Dolerite dykes Ᵽβ_2

In a creek section and drillholes (ZN1 to ZN5) north of Cleve, narrow northeast-trending, fine-grained plagioclase + pyroxene + hornblende dolerite dykes discordantly intrude both the Cook Gap Schist and concordant amphibolites (Ᵽβ_1). The dykes locally have a weak foliation, and are intensely chloritised. The age of the intrusions is uncertain but is estimated as post-D_3 and ca 1600 Ma (Parker *et al.,* 1988).

MIDDLE PROTEROZOIC

Blue Range Beds Ᵽ*c*b

Fluvial sediments, deposited unconformably on the Archaean-Early Proterozic basement, consist dominantly of unmetamorphosed sandstones and conglomerates (Flint and Parker, 1981).

Near "Ningana" the very basal conglomerates are not exposed, but round quartz cobbles up to 20 cm in diameter are common (Parker *et al.,* 1988). The lowermost unit exposed is a pebbly conglomerate (Ᵽ*c*bc) with subrounded to rounded quartzite clasts (Plate 14), overlain by interbedded granule conglomerates and sandstones. The conglomerates are poorly sorted, with abundant granules in a detrital quartz + feldspar + mica matrix. At Blue Range, sandstones are more dominant and better sorted, and are medium- to very coarse-grained with a subangular to subrounded arkosic matrix. Low-angle trough and planar crossbeds with foresets up to 0.5 m high are ubiquitous and graded bedding is common, while overturned foresets, sandstone dykes and slumped bedding also occur (Flint and Parker, 1981). A pervasive mauve and off-white mottling occurs either patchily or streaked along bedding planes. Liesegang banding is common (Plate 15).

Blue Range Beds are also exposed at Mount Wedge and were probably intersected in nearby Mucka Cudla 1 and Esso WF8. They are considered to be more extensive within deeper sections below the Polda Basin. The distribution of the Blue Range Beds on KIMBA and ELLISTON infer that an east-west graben was inititated during deposition of these coarse clastics.

The interpreted age and nomenclature of the sediments has varied considerably, but the unconformable basal contact with the Hutchison Group, and the presence of rhyolite (?GRV-style) pebbles in the conglomerates near Talia Caves on ELLISTON (Flint, 1989) suggest a maximum age ca 1590 Ma synchronous with the Gawler Range Volcanics. No contacts have been observed between the Blue Range Beds and granites of the Hiltaba Suite. Open folding of the Blue Range Beds with local dips up to 70°, and associated intrusion of botryoidal hematite veins near "Ninganna" and minor quartz veins in Blue Range suggest deposition prior to the Wartakan Event (D_4). The Blue Range Beds have therefore been correlated with the Middle Proterozic Corunna Conglomerate found at Moonabie Range (Flint & Parker, 1981), however, correlation with the Pandurra Formation is also possible.

The Blue Range Beds have, until now, been regarded as the initial sediments deposited within the Polda Basin. However, their distribution is areally more extensive, occurring at Mount Wedge, Blue Range and NW of Cleve - three areas traditionally excluded from the Polda Basin. To clarify the situation a new basin name, Itiledoo Basin, is introduced to describe the depositional setting of the ?Middle Proterozoic Blue Range Beds; the Polda Basin is restricted to younger sediments deposited within a narrower fault-bounded graben (Fig. 4). Elliston Trough is retained in the general sense and encompasses all sediments of all ages, ie. the Itiledoo and Polda Basins are specific depositional basins within the broader E-W trending Elliston Trough.

Hiltaba Suite

Post-Kimban Orogeny granites of the Hiltaba Suite are represented on KIMBA by two major varieties.

Phenocrystic granite Ꝑ γb

On northwestern KIMBA, isolated granite inselbergs occur at Pordia Rock, Peela Rocks, Little Wudinna Rock, Mount Damper, Cocata Hill and Ucontitchie Hill. The dominant rock type is a massive, phenocrystic granite to adamellite containing quartz, large pink K-feldspar phenocrysts and white-green plagioclase (Plate 16). Samples from Wudinna DDH1 produced a model 1 Rb-Sr age of 1519±67 Ma and an initial ratio of 0.7058±0.0082 (Webb *et al.*, 1986). From experience elsewhere on the Gawler Craton, it is likely that the true age of these granites is ca 1600-1580 Ma.

Granite Ꝑ γ*h*

Massive, coarse-grained granite and adamellite found in poor outcrop to the west of Bascombe Rocks is characteristically bright pink to red. Veins of aplite and pegmatite are common. A model 1 Rb-Sr age of 1477±34 Ma and an initial ratio of 0.7095±0.0040 was obtained for similar granites near Buckleboo and Minnipa on YARDEA (Webb *et al.,* 1986). The granite is also lithologically identical to the Calca Granite on ELLISTON (Flint, 1989) and likely to be also ca 1600 - 1580 Ma.

Gairdner Dyke Swarm (Ꝑβ_3)

Northwest-trending dolerite dykes of the Gairdner Dyke Swarm are interpreted to occur in the subsurface near Kimba (see Tectonic sketch). Interpretation is based on detailed aeromagnetic data but no outcrops of this unit are known.

LATE PROTEROZOIC

Kilroo Formation Ꝑ c

The deepest drillhole on KIMBA is CRA 83KD1A, located in the eastern Polda Basin and drilled to a total depth of 1398.2 m (CRA Exploration Pty Ltd, 1984). Beneath Carboniferous - Permian glacial diamictites, 792.9 m of flat-lying sediments and volcanics were recognised, and have been defined as Kilroo Formation (Flint *et al.*, 1988b). The unit is not exposed and had not been recognised in any other drillhole.

The Kilroo Formation consists of three intervals of clastic sediments, two zones of amygdaloidal basalts and one thin crystal tuff (Fig. 5; Plates 17 and 18). The sediments are reddish-brown siltstones and mudstones with thin laminations, graded bedding and detrital quartz, feldspar and mica. Aggregates, thin layers and veins of anhydrite are common.

Volcanic units are dominantly basalts which are medium to coarse-grained consisting of subophitic plagioclase laths, clinopyroxene, pseudomorphed olivine and opaques. Interstitial matrix is either chlorite or intensely-altered, very fine-grained basalt characterised by skeletal plagioclase laths. Amygdales up to 10 mm are abundant; constituent minerals are chlorite, calcite and prehnite. In the lowermost interval, 10 separate flows vary in thickness from 0.5 to 24 m thick and grade from massive at the base to medium-to coarse-grained amygdaloidal basalt in the centre to vesicular, purplish-brown at the top (CRA Exploration Pty Ltd, 1984).

A 2.6 m thick ?andesitic crystal tuff contains probable pumice clasts, glass shards and very angular fragments of quartz and feldspar in matrix consisting of chlorite, calcite and opaques. Ellipsoidal amygdales are common and constituent minerals are chlorite, calcite and anhydrite.

The abundance of reddish-brown clastic sediments, evaporite minerals, multiple basaltic lava flows and a crystal tuff suggest the environmental setting was probably an intracratonic graben or rift valley with predominantly basic volcanism contemporaneous with sedimentation in arid, terrestrial fluvial systems and playa lakes. Fault geometry and sub-basin configuration suggest a broader regional setting of a complex, dextral, wrench fault zone.

K-Ar geochronology on four pyroxene mineral separates from the amygdaloidal basalts yielded ages ranging from 235 ± 15 to 884 ± 97 Ma. Two ages determined on plagioclase phenocrysts were 764 ± 42 and 768 ± 9 Ma and are comparable to the age of the early Adelaidean Rook Tuff in the Willouran Ranges (Fanning *et al.*, 1986). This implies these evaporite red beds and interlayed volcanics in the eastern Polda Basin are also Late Proterozoic (Adelaidean) (Flint *et al.*, 1988b).

The older Blue Range Beds are now regarded as part of the Itiledoo Basin, hence, the Kilroo Formation is the basal succession of the Polda Basin.

PALAEOZOIC

CARBONIFEROUS-PERMIAN

Coolardie Formation CPc

Brown, grey, green and white diamictites, mudstones, sandstones and siltstones of glacial derivation characterise the Coolardie Formation (Cooper *et al.*, 1982).

Within CRA 83KD1A the Coolardie Formation contains two lithotypes. The first, lying unconformably on the Kilroo Formation, is a 12 m thick sequence of dark grey, matrix-supported massive diamictite with angular to subrounded, pebbles up to 6 cm across. Pebble types include pink granite, white and biotite-rich quartzite, quartz + feldspar + biotite schist, granite gneiss, granodiorite, feldspar + biotite + garnet granofels, black siliceous slate, grey slate, tourmaline-bearing schist and red-brown siltstone (CRA Exploration Pty Ltd, 1984). The upper unit is a 10 m thick sequence of white, well-sorted, fine-grained, thinly-bedded sandstone with minor pebble and diamictite bands. Pyrite framboids are common. The upper 9 m of the sequence is intensely kaolinised, and the weathering profile predates deposition of the unconformably overlying, carbonaceous, Late Jurassic Polda Formation.

The Coolardie Formation is interpreted as a series of glacially-derived diamictites and sediments. Palynology of samples collected from SADME Lock DDH1 (Cooper, 1980) and Polda DDH8 enabled Cooper *et al.* (1982) to correlate the Coolardie Formation with the lower Tamarian stage of the Permo-Carboniferous of Tasmania (Clark and Farmer, 1976; Truswell, 1978), and to locally correlate the unit with the Cape Jervis Beds of the Troubridge Basin and the Boorthanna Formation and basal Stuart Range Formation of the Arckaringa Basin.

The Coolardie Formation has only been intersected in a limited number of drillholes but is probably more extensive in the subsurface of the Polda Basin (Fig. 6). The unit was probably deposited over the surrounding basement rocks of the Gawler Craton but was totally eroded during the Mesozoic and Cainozoic. CRA 83KD1A is the only drillhole on KIMBA to fully penetrate the Coolardie Formation, which was only 22 m thick. Minimum thicknesses elsewhere include 108 m in Polda 8 and 181 m in SADME Lock DDH1, which is the type section for the formation (Kwitko, 1982; Cooper *et al.*, 1982; Plate 19).

MESOZOIC

JURASSIC

Polda Formation Jup

The Polda Formation is a fluviatile-lacustrine sequence restricted to the Polda Basin (Harris and Foster, 1974; Gatehouse and Cooper, 1982). Principal lithologies are grey, brown and black, clayey sands, grey carbonaceous silts and clays with interlayered lignite and coal (Plate 20). Clastic detritus within the sediments includes muscovite, weathered feldspar and igneous and metamorphic fragments.

The type section of the Polda Formation is an 86 m interval (from 68 m to 154 m) in SADME Polda DDH1. Within the type section, three informal members have been described by Gatehouse and Cooper (1982):

a) 68-99 m - dark brown to grey, medium- to coarse-grained sandstone, with minor pyrite and clay;

b) 99-117 m - dark grey to black carbonaceous claystone with interbeds of siltstone, lignite and sandstone;

c) 117-154 m - grey sandstone, siltstone and claystone.

Gatehouse and Cooper (1982) note that the section varies greatly between drillholes, with the sandy interval at the top of the basal unit missing in several drillholes, the middle carbonaceous claystone unit varying greatly in thickness and lignite content, and the upper sandstone removed by erosion in many areas prior to deposition of Tertiary sediments. Lignites of the Lock Coal Deposit are from the central carbonaceous unit.

The Polda Formation chiefly occurs in the subsurface of the Polda Basin, varying greatly in thickness due to both depositional controls and later erosion during the Tertiary (Fig. 7). Where present, thickness ranges from 11 m in LDH 31 to 282 m in CRA 83KD1A. Thickness of the Polda Formation in vicinity of the Lock Coal Deposit varies from 20-70 m. The formation overlies the Permo-Carboniferous Coolardie Formation and/or Archaean-Proterozoic basement rocks on the southern margin of the Polda Basin.

Exploration by Stockdale Prospecting Ltd west of "Ningana" area, has revealed exposed and subcropping sandstones which vary from medium to coarse-grained to conglomeratic varieties which are characterised by abundant kaolin in the matrix. Within the conglomerates, clasts up to 0.5m across are generally well rounded. Probable dreikanters also occur. Clast types include pink-red sandstone and quartzite (Blue Range Beds), quartz, schist and granitoid. Though fossiliferous evidence is lacking, these sandstones are interpreted to be Polda Formation.

Palynology by Harris (1964, 1970) and Harris and Foster (1974) of drill core and cuttings has enabled correlation with the Late Jurassic J6 microflora of Evans (1966), and therfore the unit is slightly older than the Jurassic of the Eromanga Basin. Harris and Foster (1974) noted from pollen frequency distribution that there appear to have been four major arboreal advances during sedimentation, implying a shrinking of marshlands in response to climatic changes.

CAINOZOIC

TERTIARY

Tertiary sediments and palaeosols extending from Eocene to Pliocene have been widely recognised on KIMBA. Sediments form extensive veneers on concealed Archaean - Proterozoic basement rocks and infill palaeochannels in the Mount Damper area and within the Elliston Trough. The environment of deposition is dominantly fluviatile, but with some marine sedimentation in the northwest. Greatest thickness of Tertiary sediments is in the eastern Elliston Trough where total thickness approaches 300 m.

Poelpena Formation Tep

The Poelpena Formation (Harris, 1966) is found extensively in the subsurface over much of KIMBA (Fig. 8). Within the Elliston Trough the unit disconformably overlies the Jurassic Polda Formation and is disconformably overlain by Pliocene sediments.

Thickness of the Poelpena Formation is highly variable. Within palaeochannels north of Mount Wedge up to 93 m of sediment are present in Mucka Cudla 1. Thicknesses greater than 100 m are common in the eastern Elliston Trough, and the greatest thickness intersected is 186 m in CRA 83KD1A (Fig. 8).

Dominant lithologies are brown - grey - black carbonaceous sands and silts with interbeds of brown lignite (Plate 21). Marine glauconitic and sponge spicule-bearing sands and sandy clays occur north of Mount Wedge and within the Yaninee Palaeochannel in the Mount Damper area.

Harris and Foster (1974) and Harris (1985) conveniently separated the Poelpena into three areas:

a) north of Mount Wedge;
b) central Polda Basin;
c) south of Kappawanta.

The area north of Mount Wedge contains highly carbonaceous dark grey silty, sapropelic clays, with rare to abundant glauconite and sponge spicules (Lindsay, 1974). The carbonaceous content is almost entirely of dinoflagellate-cyst origin, with recognition of <u>Chordosphaeridiun</u> sp., <u>Hystrickokolpon</u> sp., <u>Wetzeliella</u> sp., <u>Deflandrea phosphoritica</u> Eisenack and <u>Hystrichosphaeropsis</u> c.f. <u>H. borussica</u> (Eisenack) (Harris and Foster, 1974). Terrestrial spores recovered include <u>Triorities magnificus</u> Cookson, <u>Nothofagidites</u> spp. and <u>Podocarpidites</u> spp., placing the assemblage within the Triorityes magnificus Zonule of Middle to Late Eocene (Harris, 1971; Harris and Foster, 1974). The environment of deposition was a low-energy barred basin with depressed salinities, but with little contribution from fluvial stream or open marine sources.

The central Elliston Trough area consists of black to brown very coarse- to medium-grained sands (with angular to rounded quartz grains), brown carbonaceous and micaceous fine-grained sands, lignitic and clayey silts, dark brown lignites and orange clays. These sediments are lithologically very similar to those of the underlying Polda Formation but Tertiary sediments are generally brown whereas Jurassic sediments are grey (Harris and Foster, 1974). In CRA 83KD1A, distinction is based on geophysical logs and a change from cyclic sands/silts of Jurassic age to the mainly sandy Tertiary sediments. Assemblages from Polda DDH1 are entirely terrestrial, indicating alternating paludal and fluviatile environments (Harris and Foster, 1974). These include <u>Proteacidites</u> spp. (including <u>P. incurvatus</u> Cookson, <u>P. kopiensis</u> Harris, <u>P. tripartitus</u> Harris, <u>P. pachypolus</u> Cookson and Pike, <u>P. asperopolus</u> (Storer and Evans), <u>"Triorites" psilatus</u> Harris and <u>Nothofagidites</u> spp. The sequence has been correlated with the Middle Eocene <u>Proteacidities confragosus</u> Zonule (Harris, 1971; Harris and Foster, 1974).

Sediments from south of Kappawanta consist of paludal sands and silts, containing Proteacidities spp. (P. rectomarginis Cookson, P. annularis Cookson) plus abundant Nothofagidities spp. The microflora is correlated with the Sparganiaceae pollenites barungensis Zonule of Harris (1971), of Late Eocene - Early Oligocene age (Harris and Foster, 1974).

Undifferentiated sands Ts

This unit includes fluviatile, yellow and orange sands and pebbly sands with subangular to subrounded quartz grains. The sands are commonly silicified, but the exact timing of this sporadic development of a silcrete palaeosol is unknown. It is suspected to be Late Tertiary, consistent with the development of silcretes within Pliocene sediments in the Mount Damper area.

Unidentified occurrences of both Poelpena Formation (Tep) and Pliocene silts (Tp) are probably included within the unit.

Unnamed sediments Tp

Disconformably overlying the Eocene Poelpena Formation is a sequence consisting of green to grey-black carbonaceous clays, silts and sand (Plate 22). Ferricrete and silicrete are commonly developed near the top of the sequence in the Mount Damper area and very rare cream-coloured lacustrine limestone also occur. greenish hue is distinctive for some sediments. Environments of deposition include fluviatile and paludal for the carbonaceous clastics and lacustrine for the limestone. Distribution of these sediments is principally within palaeochannels in the Mount Damper area (Yaninee Palaeochannel) and in the eastern Elliston Trough, but Pliocene sediments have not been positively identified elsewhere on KIMBA (Fig. 9). Maximum thicknesses in the two respective areas are 46 m in CEC IR291 and 135 m in CRA 81LRM60. This distribution pattern suggests, that at this time, the Elliston Trough had been largely infilled by sediments. NW-SE trending faults, especially those between Cleve Uplands and Blue Range, were probably active and controlling areas of deposition.

The age for the sequence was originally interpreted by Harris (in Chevron Exploration Pty Ltd, 1974) as Miocene due to the presence of Nothofagidites sp., Haloragacidites harrisii, Botryococcus sp., Podocorpidites sp., Lygistepollenites florinni and Casuarinidites cainozoicus. However further work and re-interpretation indicated a Pliocene age (Harris, in Gatehouse, 1981; Cooper and Gatehouse, 1983).

Ferricrete Tfe

Lateritic and pisolitic ironstone palaeosols have developed within both basement rocks of the Gawler Craton and Tertiary sediments. Medium- to coarse-grained angular quartz granules are abundant throughout the iron-rich matrix. Laterite is particularly well developed on the ferruginous Cook Gap Schist and Upper Middleback Jaspilite in the Campoona Hill - High Bluff area. Ferricrete is developed near the top of the Pliocene sediments within the Yaninee Palaeochannel, thus giving a maximum age for this weathering episode.

Very thick kaolinitic and some ferruginous weathering profiles are extensive over basement rocks in the subsurface and some exposures (e.g. near "Windzel" and near Kimba). At least some of the weathering is thought to be Late Tertiary, coincident with the ferruginisation and silicification of

Pliocene sediments. No evidence of Early Tertiary weathering (pre- or post-deposition of the Poelpena Formation) occurs in drillholes intersecting Jurassic and Early and Late Tertiary sediments.

Plio-Pleistocene Cza

This unit consists of undifferentiated varicoloured gravelly clay, clay and sand. Colour mottling is common, particularly in shades of green, red and white. The unit incorporates very thin Tertiary sedimentary veneers and some sediments within the Polda Basin of uncertain age, but the sediments are thought to be predominantly either Pliocene (i.e. Tp sediments) or early Pleistocene.

PLEISTOCENE

Bridgewater Formation Qpb

The Bridgewater Formation consists of calcareous aeolianite dunes and associated calcretes which form spectacular cliffs near Sheringa but low undulating terrain inland. The unit unconformably overlies and blankets both Tertiary sediments and Archaean-Proterozoic basement over most of KIMBA, and is in turn overlain by SE-trending Pleistocene-Holocene longitudinal sand dunes. The Bridgewater Formation represents a sequence of widespread coastal and inland dune and loess deposits. Sediment thickness is at a maximum (>140 m) in former coastal dune complexes north and south of Sheringa. Away from the coast and sand source, the sequence of calcarenites is much thinner and is often less than 1 m thick.

The Bridgewater Formation has been divided into two members; a lower and an upper member (Firman 1967 a, b; Ambrose and Kinsman, 1973). The lower member consists of white-fawn aeolian calcarenite dunes with large foresets (up to 10 m), and interlayered reddish-brown clays, silt and loess with dispersed calcrete clasts.

The upper member consists of similar lithologies - soft white, cream and fawn aeolian calcarenites (again with very large forsets), white silt and loess. East of Mount Wedge, the upper member intertongues with a white fossiliferous lacustrine limestone (Qp1) containing abundant moulds of Coxiella striata (Ludbrook, 1984).

A jaw bone of a Diprotodontidae has been discovered in a loose boulder on Sheringa Beach ('Snow' Baker, pers. comm., 1989). Host lithology to the jaw bone is a fragmental fawn calcrete. Other boulders contain calcarenite and calcrete lithologies typical of the Bridgewater Formation, but also present are gastropod-rich lacustrine limestones. The inference is that the Diprotodontidae was attracted to a large lake situated in the Sheringa area and behind a former shoreline associated with deposition of the Glanville Formation, but as the lake was relatively saline the animal perished and was preserved in sediments near the lake margin.

Calcrete horizons are developed throughout the Bridgewater Formation, varying greatly in induration, thickness and nature. The top of the lower member is commonly capped by a dense, very hard, pinkish calcrete, and together with other multiple horizons of indurated nodular and sheet calcrete comprise the Ripon Calcrete (Qpr). Younger calcretes are developed throughout the upper member, and consist of soft, less-indurated calcrete, nodules and carbonate cements (Bakara Calcrete - Qca). Where no distinction was possible between calcrete types, the symbol Qca was used.

Glanville Formation Qpg

Intertonguing with and laterally equivalent to the Bridgewater Formation is the Glanville Formation, which consists of richly-fossiliferous shelly sands of intertidal to subtidal environments. This occurs on KIMBA in subsurface only. The Glanville Formation represents deposits formed during a high sea-level stand about 110 000 years ago (Belperio *et al.,* 1984). Most of the mollusc species found within the Glanville Formation are identical to those found in modern South Australian peritidal environments. However, the presence of Anadara trapezia and the formaminifera Marginopora vertebralis (e.g. Baird Bay, ELLISTON), which are no longer living in South Australian waters indicates former, warmer water conditions (Ludbrook, 1984).

Pooraka Formation Qpp

The Pooraka Formation consists of colluvial and fluvial sediments shed from topographic basement highs during the Pleistocene through to the Holocene. Sediments are predominantly dark brown and mottled green, gravelly clays, silts, clays and conglomerates. The formation is best developed as an apron around the Cleve Uplands and around isolated granitic inselbergs to the northwest.

Sands Qpo

A sequence of distinctive yellow-orange quartz sand and clayey siliceous sand forms the cores of inland seif dunes on Eyre Peninsula. The sands disconformably overlie the Bridgewater Formation and onlap basement exposures. The dunes are draped by a veneer of Holocene sand.

The sands contain soft, biscuity calcrete and carbonate pipes of the Loveday Palaeosol.

HOLOCENE

Yamba Formation Qhy

Halite, gypsite, gypsarenite, selenite and minor carbonate and gypsiferous muds of inland lakes constitute the Yamba Formation. The lakes typically occupy depressions on the Bridgewater

Formation. There are minor small lakes near Caralue in the east, but the best development of the Yamba Formation occurs around Kyancutta - Warramboo and Lake Yaninee.

Forbes (1960a, b) records Lake Yaninee as containing needles of gypsum within black-brown muds, and low gypsum dunes consisting of flour and seed gypsum. Gypsiferous lunettes on KIMBA typically occur on eastern margins of the lakes.

Lacustrine deposits Qhl

Along the west coast, east of Mount Wedge, and near the Driver River are Holocene to modern, saline lacustrine deposits of clays and silts, with only minor halite. Gypsum is absent. Also present, particularly within Sheringa Lagoon and Lake Hamilton, are lacustrine carbonates containing abundant gastropods and tepée structures.

Fluviatile sediments Qha

Modern fluvial channel sediments include gravelly clays, conglomerates, sands, silts and clays. The channels are restricted to the Driver River, and creeks draining the Cleve Uplands such as Yadnarie, Mangalo, Poornamookinnie, Poolalalie and Sheoak Creeks.

Moornaba Sand Qhs

Moornaba Sand consists of white, pale-grey and orange quartz sands which form spreads of modern dunes and veneers over the Pleistocene seif dunes from which it is derived.

The Moornaba Sand forms an elongate NW-SE zone of vegetated parabolic dunes within the Corrobinnie Depression, extending from Peela Rocks to Caralue Bluff. Dunes of Moornaba Sand are typically stationary due to thick native vegetation, although massive stripping of vegetation for agriculture has allowed reworking and remobilisation of some sand.

Semaphore Sand Qhe

A lateral equivalent of the Moornaba Sand is the Semaphore Sand. This sequence of aeolian dunes consists of white to pale-grey, quartz and shelly sands. The dunes are only partly vegetated. Semaphore Sand on KIMBA only occurs as a narrow dune ridge along the east coast near Arno Bay and on the west coast at Sheringa Beach. Semaphore Sand disconformably overlies the Bridgewater and Glanville Formations.

St Kilda Formation Qhk

The St Kilda Formation is a facies equivalent of the Semaphore Sand and Yamba Formation (Firman 1967a; Belperio *et al.*, 1983, 1984; Ludbrook, 1984), and consists of intertidal shelly muds and sands and stranded beach sands. Deposition was initiated approximately 6 600 years ago when sea level approached its present level.

GEOPHYSICS

A summary of all previous geophysical surveys (both regional and local) is presented on the KIMBA Mineral Exploration Index Series map (SADME Plan 78-735B), so further particulars for those surveys will not be discussed.

In 1966, an aeromagnetic survey was flown in the Great Australian Bight (OEL 33 & 38) for Outback Oil N.L. and Shell Development (Aust.) Pty Ltd. This survey indicated the presence of a narrow E-W trough containing a considerable thickness of sediments (>2000 m) and flanked to the north and south by shallow magnetic basement.

At this stage on Eyre Peninsula, extensive shallow drilling for groundwater had located an infrabasin containing at least Tertiary and Jurassic sediments. Regional, reconnaissance aeromagnetic surveys had been conducted earlier in 1953-55 by Adastra Hunting Geophysics Pty Ltd and the Bureau of Mineral Resources using a line spacing of 1.6 km and survey height of 460m (KIMBA Aeromagnetic map of total intensity - SADME Plan 77-800). To assist geophysical interpretation and test for any possible onshore extensions of the E-W trough, a regional gravity survey was conducted (Rowan, 1970). An E-W belt of gravity lows was clearly delineated with a pronounced trough between Lock and Rudall, linear E-W low west of Lock and a regional gravity low west of Mt Wedge (Fig. 3). The gravity lows were interpreted as troughs with at least 1000 m of sediments in the sub-basin east of Lock (Rowan, 1970).

Since the regional gravity survey, a variety of geophysical methods including detailed gravity, electrical and seismic have been used to explore the troughs (Nelson, 1977; Taylor, 1978; McInerney, 1979a, b; McPharlain, 1980; CRA Exploration Pty Ltd, 1982a, 1985; Gerdes, 1986; Nelson et al., 1986; Hough, 1987). As a result, the Lock Coal Deposit was delineated west of Lock (Gatehouse, 1979, 1980; Springbett, 1980; Electricity Trust of South Australia, 1984). Numerous holes were drilled within the troughs, principally exploring for groundwater, uranium mineralisation and coal. However, most drillholes are relatively shallow in comparison to the interpreted total thickness of sedimentary fill. No drillhole located within the troughs has intersected Early Proterozoic or Archaean basement and only one drillhole is sufficiently deep to penetrate through Permian sediments (CRA 83KD1A). Thus, the nature, thickness and age of deeper strata within the troughs are poorly known.

Due to protracted but episodic tectonism and sedimentation, each sub-basin displays different characteristics. The pronounced gravity low east of Lock (Kilroo Sub-basin) contains ~600m of Tertiary + Jurassic + Permian sediments overlying at least another 800m of Late Proterozoic sediments and volcanics. The Kilroo Sub-basin is flanked to the east, and may also be underlain, by Blue Range Beds of the Itledoo Basin. Conversely, the broad regional gravity low just west of Mt Wedge contains no known Jurassic, Permian or Late Proterozoic sediments. Sediments are conglomeratic sandstones of the Blue Range Beds and their interpreted thickness (1000 – 1500 m) adequately accounts for the gravity signature. The linear E-W gravity low SE of Mt Wedge (Lock Sub-basin) is probably similar in character to the Kilroo Sub-basin. Gerdes (1986) interprets up to 1500m of sediments. No drillhole has penetrated through the Permian so the precise nature or age for deeper strata are not known.

Pronounced gravity lows also occur in the Mt Damper - Ucontitchie Hill - Wudinna area and NW of Kimba township and are related to exposed or shallowly concealed granites of the Hiltaba Suite. Conversely, gravity highs in the Warramboo and Tooligie areas reflect shallow Archaean basement. Prominent linear aeromagnetic anomalies in these latter areas are due to iron formations and magnetite-rich gneisses.

Hutchison Group metamorphics and Lincoln Complex granitoids are apparently restricted to the eastern portion of KIMBA. Banded iron formations (Lower and Upper Middleback Jaspilites), steep-vertical foliations and tight folding with shallowly plunging fold axes collectively result in long, linear NE to N-trending anomalies in the aeromagnetics. Detailed magnetics in the Kimba area (Mines Administration Pty Ltd and Western Mining Corporation Ltd, 1986) suggest the presence of NW-trending dolerite dykes of the Gairdner Dyke Swarm - but these are yet to be confirmed by drilling.

The interpreted distribution of stratigraphic units depicted on the Tectonic Sketch is partly based on the reconnaissance regional aeromagnetic data of 1953-55.

All of KIMBA was incorporated in an airborne geophysical survey over much of Eyre Peninsula conducted by SADME during mid 1988. Geophysical data acquired includes aeromagnetic, radiometric and VLF-EM on 1km E-W flight lines and, in selected areas, on 0.5 km E-W flight lines and the flying height was 100 m above ground level. The data, when available, will greatly assist in a more-detailed assessment of the nature, distribution and economic potential of the major basement and basin lithologies.

STRUCTURE AND TECTONIC DEVELOPMENT

KIMBA lies within the central and eastern zones of the Gawler Craton; a large crystalline basement province consisting of Late Archaean to Middle Proterozoic rocks (Thomson, 1970; Parker *et al.*, 1985; Fanning *et al.*, 1988; Parker *et al.*, 1988).

The Gawler Craton contains three recognised megacycles of orogenic development. Fanning *et al.*, (1988) describe these megacycles as:

1. Late Archaean-Early Proterozoic - a volcano-sedimentary sequence subsequently intruded by granitoids during the Sleafordian Orogeny (ca: 2500-2300 Ma). This sequence is collectively known as the Sleaford Complex in the region of the Eyre Peninsula. To the northwest, its equivalent is the Mulgathing Complex (Daly, 1985).

2. Early Proterozoic - three phases of basin development and volcanism, particularly in the Cleve Subdomain (Parker and Lemon, 1982), with associated magmatism of the Lincoln Complex during the Kimban Orogeny. Sedimentation and magmatism during

megacycle 2 extended from 2000 Ma to ca 1650 Ma in the Cleve Subdomain, with the orogenesis and magmatism of the Kimban Orogeny possibly decreasing in age to the west.

3. Middle Proterozoic 0 extensive anorogenic extrusion of the Gawler Range Volcanics ~ 1592 Ma with contemporaneous clastic and volcaniclastic sedimentation, plus contemporaneous extensive granitoid plutonism of the Hiltaba Suite.

KIMBA straddles two of the major tectonic subdivisions of the Gawler Craton, namely the Coulta Subdomain and the western subzone of the Cleve Subdomain (Thomson, 1980; Flint & Parker, 1982; Tectonic Sketch).

The Coulta Subdomain, extending west from Caralue Bluff-Darke Peak - Tooligie, is "... a cratonic region characterised by scattered, poorly exposed remnants of the older Archaean - Early Proterozoic basement and probably representing the exposed source region for sediments of the Hutchison Group" (Parker *et al.*, 1988). Within the Coulta Subdomain on KIMBA, the earliest geological record is represented by megacycle 1 paragneisses formed by the deposition of sediments and associated volcanics on a supposed pre-existing sialic crust, followed by intrusion of granitoids and possible mafics. This sequence was then deformed and metamorphosed during the Sleafordian Orogeny at 2500-2300 Ma (Cooper *et al.*, 1976; Webb and Thomson, 1977; Webb *et al.*, 1986) to produce the Sleaford Complex. During this orogeny, the complex was deformed at upper amphibolite to granulite-facies metamorphism, with injection of granitoids, migmatisation of the supracrustals and variable development of a gneissic foliation. Granulite-facies assemblages have commonly undergone retrograde metamorphism to upper amphibolite-facies either during late stages of the Sleafordian Orogeny or during the younger Early Proterozic Kimban Orogeny.

The Sleafordian Orogeny was followed by a period of tectonic and magmatic quiescence prior to sedimentation of the Early Proterozoic Hutchison Group during megacycle 2 at about 1900-1850 Ma. The Hutchison Group represents a sequence of fluvial to marine clastics and chemical sediments plus minor mafic volcanics. Acid volcanics of the Bosanquet Formation are areally restricted and may be synchronous with deposition of the Upper Middleback Jaspilite. Deposition of the Hutchison Group occurred within the Cleve Subdomain, which extends east of the Coulta Subdomain and is "an Early Proterozoic orogenic belt .... probably representing a shelf or basinal depository for the Hutchison Group prior to its deformation during the Kimban Orogeny" (Parker *et al.*, 1988).

Deformation of the Hutchison Group occurred during the Kimban Orogeny, which extended from 1850 Ma to 1650 Ma (Webb *et al.*, 1986; Fanning *et al.*, 1986; Mortimer *et al.*, 1986). It resulted in interleaving of the Archaean Sleaford Complex and Hutchison Group to form a multiply-deformed, complex fold pattern. Three major events have been recognized in the Kimban

Orogeny, and their structural characteristics were outlined by Glen *et al.,* (1977), Parker (1978), Parker and Lemon (1982) and Parker *et al.,* (1985, 1988).

Event 1 (D_1) - a high-grade fabric-forming event not obviously related to folding, but responsible for the formation of pre-D_2, layer-parallel S_1 foliation.

Event 2 (D_2) - a high-grade deformational/metamorphic event characterised by very tight to isoclinal folds with pervasive axial-planar fabrics (S_2). S_2 is often layer-parallel (in fold limbs) and transposition on a mesoscopic scale is frequent and may also be important on a macroscopic scale.

Event 3 (D_3) - a lower-grade, retrogressive, deformational episode characterised by broad, tight to open folds and crenulations, and local, highly-deformed, mylonite zones. By contrast to F_2, D_3 folds generally lack a strong axial-planar schistosity.

The S_{1-2} foliation is the dominant planar fabric within the Hutchison Group metasediments on KIMBA, with S_{0-1} (?bedding) only rarely visible eg. within the Yadnarie Schist in the hinge of a major D_2 synform at Poolalalie Creek (Parker *et al.,* 1988). S_2 is seen at this locality as a subvertical axial-planar crenulation cleavage intersecting a compositional-metamorphic layering (S_{0-1}).

Tight to isoclinal, upright to overturned, macroscopic F_2 folds are dominant in the Cleve Uplands north of Poolalalie Creek, with steeply-dipping fold-axial planes varying from a northeast strike (in the south) to a northwest strike (in the north). Caralue Bluff is within the hinge of an F_2 syncline; a pervasive subvertical spaced cleavage (S_2) striking approximately north occurs in the quartzite. Parasitic Z-vergence F_2 folds plunging shallowly to the north also occur on the west flank of Darke Peak. The plunge of F_2 folds typically varies along strike, producing doubly-plunging fold axes.

Minor, open to tight F_3 folds are common throughout the scattered basement outcrops, but the only major macroscopic F_3 fold recognised is the Cleve Antiform, 2 km north of Cleve. This antiform is coaxial to F_2 folds, and continues eastwards onto WHYALLA, where F_2 macroscopic folds have been refolded (Parker, 1978; Parker and Lemon, 1982). The mylonitic foliation within the Bosanquet Formation is most likely associated with the D_3 deformational phase.

The combination of F_{2-3} folding dominates the general structural grain of the Early Proterozoic metamorphics. Intrusions of gneissic granite (Ᵽγm) Carappee Granite (Ᵽγc) and muscovite-bearing granite (Ᵽγa) are closely related to the D_2 and D_3 deformational phases.

The Kimban Orogeny was followed by granitoid intrusion of the anorogenic Hiltaba Suite during megacycle 3. This large-volume, high-level magmatic event is interpreted as contemporaneous with extrusion (to the north of KIMBA) of the Gawler Range Volcanics at ~ 1592 Ma (Fanning *et al.,* 1988). This was accompanied or closely followed by a period of extension manifest by the development of the east-west trending Itiledoo Basin in which the fluviatile Blue Range Beds were deposited. Development of a graben within the central portion of the basin resulted in a greater thickness of Blue Range Beds deposited within this zone. Within Archaean-Early Proterozoic rocks, further deformation during the Middle Proterozoic Wartakan Event resulted in open, upright north- and east-trending folds. Also associated with this event was north-south and east-west fracturing with development of massive quartz and botryoidal hematite veining. Major north-south and northeast-southwest faulting, evident from aeromagnetic interpretation on KIMBA, most likely occured during this event.

Subsequent to cratonisation of the Gawler Craton at about 1450 Ma, at least four major periods of epeirogenic activity occurred. These were largely confined to the Elliston Trough. The overall shape of the Elliston Trough, especially the separate depositional lobes and the orientation of the major faults (on KIMBA and ELLISTON), suggest that it is a complex, wrench fault zone with a dextral sense of movement. Wrench faulting may have initiated during the Middle Proterozoic controlling deposition of the Blue Range Beds within the Itiledoo Basin. However, it is more likely that wrench faulting began in the Late Proterozoic and was a major controlling influence on initial sedimentation of evaporitic mudstones and volcanism (Kilroo Formation) within the Polda Basin. Subsequent episodic tectonism along the same fundamental faults has resulted in various troughs and sub-basins enhancing the wrench fault zone.

Basaltic volcanics and terrestrial deposition of red beds and evaporites (Kilroo Formation) have been dated at about 770 Ma, probably synchronous with early rifting, volcanism and sedimentation of the Adelaide Geosyncline (Flint *et al.*, 1988b). This is in contrast to the previously assumed early Palaeozoic age for units of the Kilroo Formation which had prompted analogy of the Polda Basin with the Officer, Amadeus and Ngalia basins of central Australia (Nelson *et al.*, 1986).

During the Carboniferous-Permian, much of Eyre Peninsula was covered by ice sheets which retreated to deposit diamictites of the Coolardie Formation. These glacigene sediments have only been preserved within the Polda Basin due to downwarping within the graben.

During the Middle to Late Jurassic, tectonism initiated by the separation of Australia and Antarctica was accompanied by reactivation of faults bordering the Polda Basin and deposition of the Polda Formation. Fluviatile sediments of the Polda Formation appear to have been deposited within two major depocentres in the Kappawanta and Tuckey areas where sediment thickness often exceeds 100 m. The intervening area west of Lock has a thinner Jurassic sequence but importantly contains the Lock Coal Deposit, implying a restricted swampy environment between the two depocentres of predominantly sandy fluviatile sediments. The intervening area coincides with a pronounced narrowing of the Polda Basin, suggesting that the location of the Lock Coal Deposit was strongly influenced by the NW-trending fault on the southern margin of the eastern Polda Basin.

Although both Early and Late Tertiary sediments were deposited widely over KIMBA, the thicker sequences found over the Polda Basin area suggest that the graben, particularly the eastern portion, was tectonically active throughout the Tertiary. During the Early Tertiary, tectonism was probably along E-W fractures similar to previous episodic tectonism within the Polda Basin. However a significant change occurred during the Late Tertiary. The restricted distribution of Pliocene sediments infers a change to faulting along NW-SE fractures - particularly those between the Cleve Uplands and Blue Range. Uplift of basement rocks in the Cleve Uplands continued at this time and represents the last major phase of epeirogenic activity.

ECONOMIC GEOLOGY

Although the only commercial commodities currently produced on KIMBA are quartzite for rail ballast and agricultural-grade gypsum, the area has been explored for numerous commodities since early settlement in the mid 1800's. The following is a discussion of all known prospects, mines, economic and subeconomic mineral occurrences and exploration programs. The data are summarised in Table 4, and plans of all EL's and SML's on open file are shown in Figs. 11 & 12.

Base Metals and Silver

Minor base metal/silver prospects have been worked on KIMBA since the late 1800's. The first recorded prospect was a small trench within the Cook Gap Schist at Mangalo Creek, from which was recovered galena and associated silver (Brown, 1908). No record of production was kept.

A minor show of lead-silver near Darke Peak was worked by Mr G. Stanley in 1895, with a 12 m shaft sunk. The best recorded assay from this prospect was 1010 g/t Ag (Brown, 1908).

The Simms and Bradley Mine (Mineral Claim 1433) was worked by open cut and shaft within ferruginous amphibolite. From the open cut, 22.4 tonnes of ore averaging 10% copper were recovered (Brown, 1908).

A minor occurrence of copper was investigated in the open cut Yadnarie Mine (Gee, 1913) within Yadnarie Schist north of Mangalo Creek. The Sugarloaf Mine, 35 km NW of Cleve, was prospected for both copper and graphite (Jones, 1915). Two shafts were sunk to 19 m and 24 m respectively. Material removed consisted mainly of graphite schist and dolomite, with minor malachite. The best copper assays were 1.6% and 11.8% Cu from sampling dump-picked ore. The Silver Monarch of the West Mine near Mangalo Creek, and the Argent and Stanley mines near Mt. Bosanquet were worked for base metals and silver, but no records for these workings exist.

Mineral Claim 2274 was granted to A.E. Winckel and V. Gaskill over a small copper prospect near Campoona in 1957. Examination of the prospect by Johns (1959) indicated that mineralisation consisted of subeconomic concentrations of copper carbonate occurring as thin films and disseminations along joints and grain boundaries within a quartz + feldspar pegmatite. A sample taken from the bottom of the 6 m shaft assayed 2.3% copper, while an ore sample from the dump assayed

7.6%. Minor carnotite mineralisation was also recognised (assay 0.01% U_3O_8). The Darke Peak Copper Prospect was evaluated by Mason (1986) for Norton and Trezise's SML 161. Copper mineralisation was confined to thin bands parallel to compositional layering of the jaspilites and schists. Maximum assay was 3.40% Cu, while graphitic schists contain up to 14% C.

During exploration for Tertiary sediment-hosted uranium mineralisation, Kerr McGee Australia Pty Ltd found anomalous base metal concentrations in the Rudall area, with best values of 10 000 ppm Cu and 390 ppm Zn (Kerr McGee, 1968a,b; 1969).

Exploration for base metals by major exploration companies began in earnest in 1970, with exploration by Pacminex Pty Ltd (1973) for Broken Hill-style mineralisation within the Hutchison Group metasediments in the Cleve-Yeldulknie area. Stream sediment sampling delineated lead and zinc anomalies which were subsequently investigated with six diamond drillholes, which intersected Warrow Quartzite, Cook Gap Schist and amphibolites. Best results were 0.15% Pb and 0.17% Zn, encouraging further exploration for Broken Hill-style stratiform/stratabound base metal deposits within the Cleve Uplands. Carpentaria Exploration (1976a, b) recovered encouraging intersections of up to 0.58% Pb within biotite schists. CRA Exploration Pty Ltd (1979a, b), in joint venture with Shell Co. of Australia Ltd, explored for stratiform/stratabound Pb/Zn associated with iron formation in the Campoona Syncline Cockabidnie Corner area (EL 494) and the Mangalo Creek area (EL 485). Best drilling intersections were 4 m @ 3.4% Zn and 0.2% Pb (including 1 m @ 11% Zn and 0.44% Pb in dolomitic breccia) within Cook Gap Schist and Upper Middleback Jaspilite in the Campoona Syncline, and a 2 m intersection of 0.1% Pb and 1.75% Zn within the Cook Gap Schist. Extension of exploration by Shell Co. of Australia Ltd (1984) to the north, near Carappee Hill (EL 1162) was unsuccessful.

The Hutchison Group metasediments near High Bluff - Campoona (EL 1026) were explored by Esso Australia Ltd (1980) and partners, with only limited success.

Poorly exposed Archaean - Early Proterozoic rocks in the Kimba area were explored by Mines Administration Pty Ltd and Western Mining Corp. (1986), with extensive RAB drilling but with little success in locating mineralisation.

Archaean rocks of the Warramboo area were drilled by North Broken Hill and CRA Exploration Pty Ltd. Bottom-hole sampling recovered high-grade granitic gneisses and mafic granulites with low base metal values. The mineral potential of the Warramboo area and region to the north extending to the Pinkawillinie Conservation Park has been summarised by Cowley (1985).

Disseminated native copper was recorded by CRA Exploration Pty Ltd (1982a) in the Kilroo Formation basalts recovered from CRA 83KD1A within the Polda Basin.

Billiton Australia (1988) held EL 1333 near Waddikee during joint venture negotiations for base metal exploration. No exploration was undertaken.

Although no exploration in the period 1970-88 has identified an economic deposit of base metals (± silver), the discoveries of minor mineralisation within metasediments of the Hutchison Group, both on KIMBA and YARDEA (Higgins and Hellsten, 1986), are encouraging for further exploration of Broken Hill - Aggeneys and/or Balmatt-Edwards style of mineralisation (Parker, 1987). South of the Polda Basin, the thickness of veneering Cainozoic sediments is thin (<50 m - Fig. 9), and is an area almost totally devoid of exploration for base metals.

<u>Platinum-group metals</u>

No exploration on KIMBA has targeted on platinum-group minerals. No substantial bodies of mafic-ultramafic rocks are known and hence the most favoured source for platinum-group mineralisation is lacking. However at Coronation Hill (Northern Territory), the source for major Au-PGM mineralisation is enigmatic- but with the theorised source being Early Proterozoic carbonaceous shales. Anomalous PGM concentrations have also been recorded in Permian carbonaceous Kupferscheifer shales in Poland, bituminous coal in Kentucky and black shale related, base-metal deposits of the cental African Copper Belt in Zambia and Zaire (Hoatson and Glaser, 1989).

Within the Hutchinson Group, graphite is common not only associated with the Lower and Upper Middleback Jaspilites but also disseminated within the Cook Gap Schist. Additional disseminated Pb and Zn anomalies also occur within graphitic rocks. Therefore, the Cook Gap Schist may also contain anomalous platinum-group metals.

<u>Uranium</u>

Exploration for uranium has been conducted on KIMBA since 1967, with three main targets:

1. Tertiary sandstone - hosted deposits;
2. Alligator River - style (unconformity-related) deposits within Early Proterozoic metasediments and the unconformably-overlying Middle Proterozoic Blue Range Beds;
3. Primary mineralisation within Early Proterozoic granitoids and metamorphics;

Minor carnotite mineralisation, associated with copper mineralisation in the Campoona copper prospect was reported by Johns (1961a).

Kerr McGee Australia Pty Ltd (1969) examined radiometric anomalies within Precambrian and Tertiary rocks from Waddikee to Verran in the hope of finding concentrations of Tertiary sandstone-hosted uranium. Results were discouraging, with only minor uranium associated with Tertiary sediments of the Driver River.

Mines Administration Pty Ltd also explored for sandstone-hosted deposits within the Polda Basin west of Caralue Bluff and in the Driver River area (1971a, b; 1972a, b,c). Detailed gravity surveys were unsuccessful in delineating Tertiary palaeochannels (McInerney, 1980). Interest in the Driver River radiometric anomaly continued with exploration by Tal-Ray Trading (1970), Central Pacific Minerals NL (1972) and CRA Exploration Pty Ltd (1978). Work by Central Pacific Minerals

NL Pancontinental Mining Ltd *et al.,* (1982, 1983a) and Sweetapple and Veeh (1988) indicate that the anomaly is caused by radium trapped in clays of the river sediments and separated from its parent uranium source. Attempts to delineate Tertiary palaeochannels in the Driver River - Arno Bay area by CRA Exploration Pty Ltd were unsuccessful due to subcropping basement rocks (CRA Exploration Pty Ltd, 1978).

The Lock area of the Polda Basin was drilled by Endeavour Minerals NL (1971, 1972) and Chevron Exploration Corporation (1974) for Tertiary sedimentary uranium, with little success. The best value recorded by Endeavour Minerals NL was 153 ppm U_3O_8.

Tertiary sediments around Caralue Bluff, Darke Peak and Carappee Hill were examined by Urangsellschaft Australia Pty Ltd (1974) in the hope of finding localised concentrations of uranium transported from Precambrian basement highs. The exploration program also included sampling of granites and granite gneisses at Carappee Hill and Bunora to examine primary uranium mineralisation. Minor mineralisation was identified along joint planes within the granite at Carappee Hill.

In conjunction with their base metal exploration of the High Bluff - Campoona area, Wyoming Mineral Co. and partners also explored for Alligator River - style uranium mineralisation within the Hutchison Group metasediments. Weathered bedrock samples were analysed for uranium, with discouraging results. CRA Exploration Pty Ltd and Shell Co. of Australia Ltd (1985a, b) also explored for Alligator River-style uranium as a secondary target in the Campoona - Cockabidnie Corner area, with no success.

Pancontinental Mining Ltd (and partners) examined the unconformity at the base of the Middle Proterozic Blue Range Beds around Cockabidnie Corner and further south around Taragoro Verran for Tertiary and Middle Proterozoic sediment - hosted uranium deposits. The best recorded analysis was 1800 ppm U_3O_8 in a soil sample from the Driver River (Pancontinental, 1982a, b).

Exploration by Carpentaria Exploration Co. Pty Ltd (1981a, b, c) targetted on Tertiary sediment - hosted uranium deposits within the Yaninee Palaeochannel in the Mt Damper - Kyancutta area and extending northwards onto YARDEA. On KIMBA, best intersection was 1 m @ 1450 ppm U_3O_8, but to the north grades range up to 3550 ppm U_3O_8 over 1 m in clay (Binks and Hooper, 1984).

<u>Gold</u>

Exploration for precious metals (Au, Ag, Pt) was conducted by North Broken Hill Ltd and CRA Exploration Pty Ltd in conjunction with base metal exploration near Warramboo. However, gold values were generally at or below detection limit of 0.05 ppm and other elemental abundances were typical for the various lithologies (North Broken Hill Ltd and CRA Exploration Pty Ltd, 1984).

Shell Co. of Australia Ltd (1984), in testing iron formation horizons for possible gold in their Cleve Central licence (EL 1182) delineated a minor Au anomaly on their Silver Monarch grid. The best assay result was 0.16 ppm Au. Subsequent bulk sediment sampling in streams around Cleve located traces of Au near Mount Shannan.

Kaolin

Exploration for kaolin on SML 621 by Blacker Motors Pty Ltd (1971) concentrated primarily on deposits on LINCOLN, with only minor unsuccessful exploration on KIMBA (near Coomaba).

Pechiney (Australia) Exploration Pty Ltd (1972) discovered a kaolin deposit of approximately 32 million tonnes in the Kelly Tank - Bunora - Balumba area south of the township of Kimba. Although the kaolin is of insufficient quality for paper-coating grade, it has potential for use in ceramics manufacture. The largest deposits in South Australia with potential for high-grade kaolin production are on Eyre Peninsula at Moorkitabie (STREAKY BAY) and Mount Hope (LINCOLN). At Moorkitabie, a large resource is indicated and the kaolin has high brightness (i.e. paper-coating grade). However preliminary tests indicate that the kaolin fails to meet viscosity requirements, but more work is planned. The presence of such sizeable deposits on Eyre Peninsula together with extensive kaolinised profiles at least 20 m thick developed within basement rocks (e.g. Kelly Tank-Balumba area and Warramboo) are encouraging for locating further higher-grade deposits.

Heavy Minerals

Hillwood (1960) and Morris (1977, 1980) conducted reconnaissance studies along the coast of western Eyre Peninsula in a search for heavy mineral sands. Exploration by Australian Anglo American Ventures Ltd (1976) identified small, uneconomic concentrations of heavy minerals in the beach sands at Sheringa Beach.

Macmahon Construction Pty Ltd (1989) explored for heavy mineral sands in the Wombat Flat - Bald Hills are near Mount Wedge. A total of 10 rotary holes (totalling 257 m) defined an horizon of shallow marine to lacustrine clayey sand with anomalous Ti and Zr values, capped by 3–4 m of calcrete. The best values obtained were 5600 ppm Ti and 1380 ppm Zr, with only minor zircon and rutile found in assay samples. The area was considered unprospective for economic concentrations of heavy minerals, and the licence relinquished.

Graphite

Several minor deposits of graphite within graphitic schists associated with both the Cook Gap Schist and Upper Middleback Jaspilite were worked on Eyre Peninsula early in this century, and are summarised in Johns (1961). Graphite deposits at Uley/Mikira (LINCOLN), Carpa (WHYALLA) and Koppio (LINCOLN) are in equivalent metasediments.

The Sugarloaf Mine near Campoona was prospected for graphite (and copper) by sinking two shafts (19 m and 24 m respectively) (Jones, 1915; Jack, 1917). Minor veins of fine-grained graphite occur within ferruginous chert and schist. Graphite is associated with magnesite, but is uneconomic. Minor graphite also occurs in association with iron formation horizons to the east and north of Sugarloaf Hill.

Graphite was also prospected at Campoona Hill (Jack, 1917). A small pit exposed graphitic schist immediately above a thick dolomitic unit, with the graphite lode approximately 21 m wide. Graphitic schist was found to contain only about 6% flake graphite which assayed at 38% carbon. A small graphite prospect was dug within ferruginous schists near the unconformable contact of the Hutchison Group and Blue Range Beds near "Ningana". No records exist for this prospect. Graphite was recorded in chlorite-biotite schists in drillholes south of Waddikee Rocks sunk by North Broken Hill Pty Ltd and CRA Exploration Pty Ltd (1984). Graphite was intersected often within drillholes in the Kimba area by Mines Administration Pty Ltd and Western Mining Corp. Ltd (1986).

The widespread occurrence of graphite especially in the northern Cleve Uplands, suggests greater exploratory effort targetted on graphite may be successful.

Aggregate

Several rock units on KIMBA have been examined for use as road metal and/or rail ballast. They include the Warrow Quartzite, Lincoln Complex granites, Katunga Dolomite and ferruginised Tertiary sandstone. Calcarenite and calcretes of the Pleistocene Bridgewater Formation are also used extensively (Pain, 1985).

Johns and Cramsie (1967) and Cramsie (1967) reported on diamond drilling of the Katunga Dolomite north of Cleve during investigations for road metal. Warrow Quartzite has been extracted from both the Tooligie Range quarry (Mason, 1968a; Hiern, 1969; Nichol 1977; Shackleton, 1967) and the Darke Peak quarry (Nichol, 1975; Kingsbury, 1955) for rail ballast and road metal.

Oil

The first investigations for oil on Eyre Peninsula were by Wade (1915) who examined several occurrences of bituminous material along the west coast of Eyre Peninsula. Examination of this material indicated it was from an offshore origin and had been washed up onto the beaches.

After drilling of two deep boreholes in the offshore Polda Basin on ELLISTON for possible oil (McClure 1982a,b), PEL 35, covering the western section of the Polda Basin on KIMBA and ELLISTON, was taken out by Quadrant Energy Development Ltd and Continental Oil Exploration Pty Ltd. After initial Landsat and aeromagnetic interpretation the lease was dropped.

Coal

Carbonaceous material was first discovered in the Polda Basin in 1910 during Engineering and Water Supply Department drilling. In 1921, water bore cuttings from a well 15 km west of Lock contained carbonaceous fragments and generated sufficient interest to initiate formation of the Central Eyre Peninsula Coal and Oil Company (Gatehouse, 1979). Lignitic clays were intersected in a drillhole at 34 m and 46 m. Dickinson (1944), in an assessment of the possible coalfield, discouraged further work due to the expense of possible underground mining.

Hydrogeological drilling in the Polda Basin by SADME (Shepherd, 1963) recovered Jurassic sediments (Harris, 1964). Subsequently, SADME Polda 1 was drilled to examine the stratigraphy and economic potential of the Polda Basin (Harris & Foster, 1974). In 1976 the S.A. State Energy Committee recommended investigation and evaluation of South Australian coal deposits. Subsequent exploration by SADME and ETSA on EL280 in the Lock area included stratigraphic drilling (Gatehouse, 1980a, b; Harris, 1979), geophysical investigations (McInerny, 1977, 1979; Taylor, 1978; McPharlin, 1980), and delineated the Lock Coal Deposit. The complex Lock Coal Deposit consists of a Jurassic coal deposit and two Tertiary deposits with reserves estimated in excess of 300 million tonnes Jurassic coal and 180 million tonnes Tertiary coal (total of measured, indicated and assumed categories: (ETSA, 1984). The deposit is confined to a narrow E-W trending basin, 2-4 km wide and 15km long, consisting of numerous seams of high-ash coal, 0.5-6m thick and which are flat to gently dipping (2^o-5^o). Cumulative coal thickness reaches a maximum of 17m, but is generally between 5 and 15 m. Overburden is commonly 50-130 m, but ranges from 35 to 230 m. Feasibility studies for mining of the deposits have been prepared by ETSA (1983, 1984).

CRA Exploration Pty Ltd (1981, 1982a, b, 1983, 1985) explored for possible continuations of the Lock Coal Deposit. Drilling met with limited success, with a best intersection of 8.9 m lignite.

Esso Australia Ltd (1982) explored the western portion of the Polda Basin in 1980-82. Several lignite and coal intersections were recovered in drillcore, the best intersection being 4.8 m coal.

Salt

Mineral claims 1079, 10800, 10801, 10839/42 were pegged by V.P. Jones over Lake Yaninee and worked for salt by the Lake Gairdner Salt Co. in 1919. Approximately 4000 tonnes of salt were present as a very thin layer less than 3 cm thick over gypsum (Jack, 1921).

Gypsum

Minor gypsum was reported by Jack (1912) at Lake Yaninee. The Lake Gairdner Salt Co. harvested small quantities of gypsum in 1919 along with its salt harvesting (Jack, 1921).

Forbes (1960a, b) examined gypsum deposits at both Kopi and Lake Yaninee, describing the best gypsum at Kopi. Reserves were estimated at approximately 47 000 tonnes. The Lake Yaninee deposit was considered too small and inaccesible to be economic. Miscellaneous Purposes Lease

(MPL640) was pegged by H. Farquharson over a portion of the Kopi deposit (Moffit and Ashton, 1961).

John Gilfillan and Associates Pty Ltd (Butt, 1987) explored for a small gypsum deposit in the vicinity of Kyancutta (EL 1305) from 1985 to 1987. A significant resource of agricultural-grade gypsum as gypsite dunes was found in the Kappakoola Swamp area. A total of 82 auger holes drilled in 37 dunes and the lake floor outlined a probable resource of 4 176 700 tonnes with an average grade of 88% gypsum at a cutoff of 80% gypsum.

Gypsum is currently being exploited at Bayley Plains (ML 5426), Section 16, Hd Boonerdo for agricultural use. Between 1987 and 1988, 1903 tonnes were mined.

Other gypsiferous lakes in interdunal depressions may also have sources of agricultural-grade gypsum.

Iron

A small body of good-grade hematite at Campoona was described by Jack (1912, 1922). Hematite occurs within fine-grained quartzite and schists of the Upper Middleback Jaspilite.

Two small high-grade hematite deposits occur near "Ningana" and "Kelly" respectively (Appleby, 1960a,b). The deposit at "Ningana" consists of micaceous to botryoidal vein hematite along a vertical E-W fracture within Blue Range Beds conglomeratic sandstones.

Compilation of aeromagnetic maps over Eyre Peninsula by the BMR in 1953–55 initiated investigations by SADME in search of iron-ore deposits associated with aeromagnetic anomalies. Geophysical and geological investigations were conducted both regionally (Whitten, 1963a,b), and over aeromagnetic anomalies at Kyancutta (Shackleton, 1963) and Kopi (Whitten, 1963c, 1965b; Risely, 1963).

The majority of the work concentrated on the Warramboo aeromagnetic anomaly (Whitten, 1960, 1965a; Whitten & Risley 1968; Webb, 1966; Heath, 1962; Heath & Whitten, 1962a; Hayball, 1958; Dutton, 1964; Henderson, 1964). Drilling of the anomaly identified four magnetite-rich metasedimentary iron formation bands (Whitten & Risely, 1968) similar to those exposed at Kyancutta (Shackleton, 1963). The grade intersected in drilling was too low to warrant development.

Tungsten

During exploration south of Waddikee Rocks by North Broken Hill Pty Ltd, drilling of a coincident magnetic-gravity high recovered scheelite-bearing mafic granulites in several drillholes (the "Meaneys" occurrence). The best intersection was 3.6 m @ 0.17% WO_3 in NBH C1 (North Broken Hill Ltd and CRA Exploration Pty Ltd., 1984).

Potash

The potential for potash within deeper strata of the eastern Polda Basin prompted exploration by CRA Exploration Pty Ltd (1984). However, drilling of CRA 83KD1A to 1398 m only intersected small veins of anhydrite and calcite within reddish-brown mudstones. Within Mercury 1 in the offshore Polda Basin on ELLISTON, equivalent sediments include a sequence 1707 m thick of predominantly rock salt (McClure, 1982a). However, no deep drilling exists in the central Polda Basin (west of Lock), so the potential remains for potash or other salts in this unexplored portion of the basin.

Diamonds

Although kimberlites or lamprophyres with diamond potential have not been recorded on KIMBA, the likelihood of their presence is high. An underformed lamprophyre is known on WHYALLA in the Cleve Uplands (Parker, 1978) and several small magnetic anomalies may represent similar dykes or plugs on KIMBA.

Water Supply

Pastoral properties on KIMBA rely mainly on stock dams, boreholes and wells equipped with windmills, and limited reticulated water supplies. Catchment of runoff from granite/gneiss inselbergs was used in the Wudinna, Kimba and Carappee Hill regions early this century. A series of reservoirs built in the Cowell-Cleve region in 1912 supplied some reticulated water to the Cleve Uplands area. Kimba received a reticulated water supply in 1927–28 from the Roora Reservoir. Frequent water shortages occurred until 1975 when the Lock-Kimba pipeline from the Tod Trunk Main was connected to the Kimba reticulation system.

Groundwater has been recovered from three sources: Precambrian basement areas, Tertiary sediments and Quaternary sediments (Shepherd, 1978). Small, localised occurrences of fairly saline groundwater within the Cleve Uplands and Kimba Peneplain areas have been exploited since settlement.

The most important source of groundwater on KIMBA is the Polda (freshwater) Basin, first outlined by Lockhart Jack (Jack, 1912, 1914). Principal aquifers are calcarenites of the Bridgewater Formation and minor, more saline sources from underlying Tertiary sediments. Potable (<1000 mg/L) water occurs in 5 lenses within the hydrogeological basin (E&WS, 1983; Smith, 1984). The 5 lenses identified within the County of Musgrave are Polda, Kappawanta, Bramfield, Sheringa A+B and Talia which have a total exploitable resource of 9000 ML/annum. Pumping from the Polda Lens began in 1962 and the current rate of withdrawal, though seasonally variable, does range up to 2500 ML/annum which is very close to the estimated safe yield of 2600 ML/annum. Groundwater extraction from the other lenses is minimal, so considerable scope exists for utilisation of this water resource (E&WS, 1983).

For freshwater lenses in the County of Musgrave summaries of geophysical tests, establishment of meteorological stations and pumping tests were reported by Painter (1972) and a complete bibliography was compiled by Barnett in 1980. However the most complete report is by E&WS (1983) which documents all aspects of the water resources and reticulation systems for Eyre Peninsula. Included are assessments of the water quality, present utilisation and future water demand and management.

Ornamental Stone

Distinctive red granite of the Hiltaba Suite is quarried at Calca (ELLISTON) for dimension and monumental stone (Barnes and Young, 1987). Exposures of similar fresh, massive granites in the Wudinna - Minnipa area also have potential for providing slightly different coloured and textured varieties.

At Waddikee Rocks, grey migmatitic gneisses are relatively joint-free and display a 'swirly' pattern with abundant dispersed pink garnets. The result is a distinctly different ornamental stone. Mineral claim 2358 over Section 4, Hundred Koongawa was recently granted to Amatek Ltd.

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Table 1 ARCHAEAN - MIDDLE PROTEROZOIC STRATIGRAPHY

Age	Stratigraphic Unit	Symbol	Lithology	Field Relationships and Comments	Geochronology and Regional Correlation	Province
MIDDLE PROTEROZOIC	Gairdner Dyke Swarm	$E\beta_3$	Dolerite dykes	Interpreted in sub-surface from aero-magnetics only. NW trending.		Gawler Craton
MIDDLE PROTEROZOIC — HILTABA SUITE	Granite	$E\gamma h$	Massive, coarse-grained, pink-red granite plus adamellite and minor pegmatite.	Isolated outcrops	Equivalent to granites at Buckleboo (YARDEA)	Gawler Craton
MIDDLE PROTEROZOIC — HILTABA SUITE	Phenocrystic granite	$E\gamma b$	Massive, coarse-grained granite with large pink K-feldspar phenocrysts and white-green plagioclase. Minor adamellite.	Isolated outcrops	Rb-Sr 1519 ± 67 Ma (IR = 0.7058 ± 0.0082)	Gawler Craton
MIDDLE PROTEROZOIC	Blue Range Beds	Ecb	Medium- to very coarse-grained sandstone, with subangular to subrounded arkosic matrix, trough and planar crossbedding, graded bedding, sandstone dykes, and slump folding. Mauve to off-white mottling pervasive.	Deposition within intracratonic graben.	Equivalent to Corunna Conglomerate or Pandurra Formation	Itiledoo Basin (new name)
		Ecbc	Near "Ningana" - pebbly conglomerate with subrounded to rounded quartzite clasts (<20 cm). Conglomerates poorly sorted, with abundant granules in quartz + feldspar + mica matrix. Overlain by interbedded granule conglomerate and sandstone.	Unconformably overlies Hutchison Group (e.g. at "Ningana".) Contacts with $E\gamma b$ and $E\gamma h$ not seen.		
EARLY PROTEROZOIC	Dolerite dykes	$E\beta_2$	Fine-grained, plagioclase + pyroxene + hornblende dolerite. Weakly to non-foliated. Intensely chloritised.	Discordantly intrudes the Cook Gap Schist (Bhc) and amphibolites ($E\gamma_1$) north of Cleve. N-S oriented.	Possibly equivalent to N-S dykes on LINCOLN	Gawler Craton Cleve Subdomain
EARLY PROTEROZOIC — LINCOLN COMPLEX	Muscovite-bearing granite	$E\gamma a$	Massive to weakly-foliated, coarse-grained, microcline + quartz + plagioclase + muscovite + garnet granite.	Intrudes and migmatises Warrow Quartzite (Bhw) in core of Cleve Antiform (F_3) Poornamookinie Creek. Most likely intruded pre- or syn- D_3 (Kimban Orogeny).	Equivalent to Carpa Granite (WHYALLA)	

EARLY PROTEROZOIC — LINCOLN COMPLEX	Carappee Granite	Ɛγc	Coarse-grained, homogeneous granite. Tabular microcline megacrysts < 2 cm in fine- to medium-grained quartz + feldspar + biotite matrix.	In contact with Warrow Quartzite on western side of Darke Peake contact is, at least in part, tectonic. Most likely intruded ?D_2-D_3 (Kimban Orogeny).	Zircon 1738 ± 68 Ma Carappee Hill	Gawler Craton Cleve Subdomain
	Granite	Ɛγm	Pink-grey, medium-grained quartz + feldspar + biotite granite. Abundant pegmatite veining.	S_2 foliation suggests intrusion syn-D_2 (Kimban Orogeny). Intrudes undifferentiated Lincoln Complex gneisses (Ɛl) at Balumbah railway siding.		" "
	Undifferentiated granitic gneiss	Ɛl	Fine- to medium-grained, orange-grey, well-foliated granitic gneiss, medium-grained granite, micrograniti̇c, migmatite gneiss, aplite and pegmatite.	Well-foliated granitic gneisses considered pre- or syn-D_1 intrusion (Kimban Orogeny). Intrude Hutchison Group metasediments in Cleve Uplands. Tectonically or intrusively intercalated with Archaean gneisses (AƐsg) near "Windzel". Intruded by granite Ɛγm at Balumbah railway siding.	Possibly equivalent to Minbrie Gneiss (WHYALLA).	" "
?	Bosanquet Formation	Ɛb	Deformed and foliated megacrystic rhyodacite. Abundant white microcline and subrounded quartz phenocrysts in matrix of + feldspar + biotite. Interlayered with well-banded quartz + feldspar + hornblende + biotite + calcite calcsilicate gneiss. ?Overlain by conglomeratic calcsilicate with abundant dolomite, quartzite, rhyolite and granite clasts in diopside-rich matrix.	Relationship with Hutchison Group is enigmatic-possibly contemporaneous with Upper Middleback Jaspilite. ?Top unknown.	Zircon 1845 + 9 Ma Broad View DDH 1. No known correlative elsewhere on the Gawler Craton.	" "
HUTCHISON GROUP	Yadnarie Schist	Ɛhy	Fine-grained muscovite + biotite + quartz + feldspar schist. Minor psammitic layers.	Overlies Upper Middleback Jaspilite/Cook Gap Schist. (Ɛhm_2/Ɛhc). Top unknown. Minimum thickness 1000 m.	"	
		Ɛhyp	Iron-stained, quartz + sericite banded metasiltstone. Sericite aggregates after sillimanite. Minor interlayered quartz + magnetite gneiss.	Local variant of Yadnarie Schists in Campoona Syncline-Cockabidnie Corner area.		
Middleback Subgroup	Upper Middleback Jaspilite	Ɛhm_2	Dolomite and crenulated mica + tremolite schist, cherty quartzite, banded calcsilicate, quartz - magnetite gneiss, and silicate-facies iron formation.	Overlies Cook Gap Schist (Ɛhc) contact transitional.	Upper Middleback Jaspilite (WHYALLA). Also known as Mount Shannan Iron Formation.	"

EARLY PROTEROZOIC	HUTCHISON GROUP	Middleback Subgroup	Amphibolite	$E\beta_1$	Fine- to coarse-grained, schistose and massive hornblende + plagioclase amphibolite.	Concordant horizons within the Cook Gap Schist (PLhc) - represent either basaltic volcanics or dolerite sills.		Gawler Craton Cleve Subdomain
			Cook Gap Schist	Ehc	Well-layered, foliated, quartz-veined semipelitic biotite + muscovite + garnet schist and gneiss. Minor quartz + feldspar psammitic interbeds.	Transitional from Warrow Quartzite/Katunga Dolomite Lower Middleback Jaspilite. Overlain by Upper Middleback Jaspilite.	Also known as Mangalo Schist. 1688 ± 76 Ma (IR = 0.7061 ± 0.0042) 1629, 1600 Ma (musc) 1588, 1537 Ma (biot)	"
			Lower Middleback Jaspilite	Ehm_1	Recrystallised, iron oxide-bearing chert and graphitic chert. Minor grunerite.	Transitional from Katunga Dolomite, and transitional into Cook Gap Schist. Best exposed in Cleve Council Pits.	Lower Middleback Jaspilite (WHYALLA)	"
			Katunga Dolomite	Ehk	Massive, grey, pink and white dolomitic marble. Minor fine-grained quartzite and calcsilicate gneiss, and local tremolitic quartzite. Occasional serpentine in dolomite (after olivine).	Overlies Warrow Quartzite. Transitional into Lower Middle back Jaspilite/Cook Gap Schist. Best exposed in Cleve Council Pits.		"
			Warrow Quartzite	Ehw	Medium- to coarse-grained, massive to flaggy quartzite. Locally with trough crossbedding and deformed quartz-pebble conglomerate beds. Muscovite + feldspar-rich at base. Numerous schistose pelitic interbands at top.	Transitional into Middleback Subgroup. Locally underlain by basal calcsilicate (PLhd). Contact with Archaean Sleaford complex not observed, but unconformably overlies Archaen at Marble Range (LINCOLN).	"	
			Basal calcsilicate	Ehd	Dolomitic marble and well-banded diopside bearing calcsilicate gneiss.	Occurs at base of Warrow Quartzite (e.g. Sheoak Creek).		
ARCHAEAN — EARLY PROTEROZOIC	SLEAFORD COMPLEX		Gneissic granodiorite	AEsq	Medium-grained, grey gneissic granodiorite. Relic plagioclase megacrysts < 5 mm.	Intrudes granite gneiss (AEs) at Bascombe Rocks.		Gawler Craton Coulta Subdomain
			Granitic gneiss	AEs	Poorly- to well-foliated granitic and migmatitic gneiss, aplite, plus garnetiferous and magnetite-rich paragneiss. Minor chlorite + biotite schist.		Rb-Sr 242898 Ma (IR = 0.7059 ± 0.0084) at Waddikee Rocks	"

ARCHAEAN — EARLY PROTEROZOIC	SLEAFORD COMPLEX	Mafic granulite	ABsm	Medium-grained, banded feldspar + hornblende + clinopyroxene + oprtho-pyroxene mafic granulite. Commonly retrogressed to amphibolite.	Interlayered with garnetiferous gneiss (ABsg) and iron formation (ABsi) (e.g. Warramboo).		Gawler Craton Coulta Subdomain
		Iron Formation	ABsi	Quartz + magnetite + feldspar + garnet + cordierite gneisses.	Interlayered with and transitional from garnetiferous gneiss (ABsg) (e.g. Warramboo).		"
		Paragneisses	ABsg	Poorly- to well-foliated, fine- to medium-grained garnetiferous quartzofeldspathic gneiss. Porphyroblastic garnet and white K-feldspar are common. Commonly migmatitic. Minor sillimanite + cordierite.	Metasedimentary gneiss interlayered with iron formation (ABsi) and mafic granulite (ABsm).	Rb-Sr 2520 ± 163 Ma (IR = 0.7041 ± 0.0069) at Warramboo WD1	"

Table 2 LATE PROTEROZOIC - TERTIARY STRATIGRAPHY

Age	Stratigraphic Unit	Symbol	Lithology	Field Relationships and Comments	Geochronology and Regional Correlation	Environment	Province
CAINOZOIC — ?PLIOCENE–PLEISTOCENE	Unnamed clays	Cza	Varicoloured gravelly clay, clay and sand.	Thin Tertiary veneers + minor sediments within Polda Basin.	Possibly equivalent to Gibbon Beds (WHYALLA).	Fluvial & colluvial	
CAINOZOIC — PLIOCENE	Ferricrete	Tfe	Lateritic and pisolitic ironstone palaeosol with abundant coarse-grained quartz granules.	Very well developed on ferruginous Cook Gap Schist (Ɛhc) and Upper Middleback Jaspilite (Ɛhm$_2$). Locally developed on Pliocene sediments (Tp) (eg Mount Damper). Associated with deep weathering and kaolinisation of basement.		Palaeosol	
CAINOZOIC — PLIOCENE	Unnamed sediments	Tp	Green to grey-black carbonaceous clay, silt and sand. Rare cream-coloured lacustrine limestone.	Disconformably overlies the Poelpena Formation (Tep). Locally capped by ferricrete (Tfe) and silcrete (Ts) (eg Mount Damper area). Maximum thickness 135 m (81 LRM 60).	Pliocene-palynology Harris in Gatehouse, 1981; Cooper and Gatehouse, 1983.	Fluvial to lacustrine	Eastern Polda Basin and Yaninee Palaeochannel
CAINOZOIC — PLIOCENE	Undifferentiated sands	Ts	Yellow-orange fluviatile sand and pebbly sand. Commonly silicified.	May contain unidentified occurrences of Poelpena Formation (Tep) and Pliocene sediments (Tp).		Fluvial and colluvial	
CAINOZOIC — MIDDLE - LATE EOCENE	Poelpena Formation	Tep	Grey-black carbonaceous sand, silt and brown lignite. Locally with marine glauconite and sponge spicule - bearing sand and sandy clay.	Disconformably overlies Polda Formation (Jup) in Polda Basin. Disconformably overlain by Pliocene sediments (Tp). Maximum thickness 186 m - CRA 83KD1A.	1. *Triorities magnificus* Zonule (Middle-Late Eocene) - Mount Wedge area paludal 2. *Proteacidities confragosus* Zonule (Middle Eocene) - Central Polda Basin 3. *Sparganiaceae pollenites barungensis* Zonule (Late Eocene - Early Oligocene) - Kappawanta area. (Harris 1971; Harris & Foster 1974) Equivalent to Pidinga Formation.	Restricted marine-fluvial - Palaeochannel	Various palaeo-channels, Yaninee and Polda Basin
MESOZOIC — LATE JURASSIC	Polda Formation	Jup	Grey, brown and black clayey sand, grey carbonaceous silt and clay, with interlayered lignite and coal.	Unconformably overlies Coolardie Formation (CPc), Blue Range Beds (Ɛcb), and A-Ɛ basement. Disconformably overlain by Poelpena Formation (Tep). Maximum thickness 282 m - CRA 83KD1A.	Late Jurassic J6 palynology (Harris, 1964, 1970; Harris & Foster 1974)	Fluvial-paludal	Polda Basin

PALAEOZOIC — CARBONIFEROUS -PERMIAN	Coolardie Formation	CPc	Brown-grey, green and white diamictite, mudstone, sandstone and siltstone. Clasts of granite, gneiss, rhyolite, basalt and quartzite.	Unconformably overlies Kilroo Formation (Ɇc), Blue Range Beds (Ɇcb) and/or A-Ɇ basement. Unconformably overlain by Polda Formation (Jup). Maximum thickness > 181 m.	Lower Tamarian of Permo-Carboniferous (Tas.) (Cooper et al., 1982) - Correlated with Cape Jervis Beds (Troubridge Basin), Boorthanna Formation and basal Stuart Range Formation (Arckaringa Basin).	Glacigene	Polda Basin
LATE PROTEROZOIC	Kilroo Formation	Ɇc	Amygdaloidal and vesicular basalt, andesitic tuff, laminated clastic beds with minor halite and anhydrite.	Base unknown. Unconformably overlain by Coolardie Formation. Maximum thickness > 793 m in CRA 83KD1A.	K-Ar 768 ± 9 Ma plagioclase " 764 ± 42 Ma plagioclase " 235 ± 15 Ma plagioclase " to 884 ± 95 Ma pyroxene Possibly equivalent to Rook Tuff and/or Wooltana Volcanics (Adelaide Geosyncline). Equivalent to clastics and evaporites within Columbia 1 and Mercury 1 in western Polda Basin (ELLISTON).	Volcanism, arid fluvial and playa lake within intracratonic wrench fault system.	Polda Basin

Table 3 QUATERNARY STRATIGRAPHY

Age		Stratigraphic Unit	Symbol	Lithology	Field Relationships	Environment
CAINOZOIC	HOLOCENE	St Kilda Formation	Qhk	Shelly mud and sand.	Facies equivalent of the Semaphore Sand (Qhe) and Yamba Formation (Qhy). Disconfomably overlies the Glanville Formation.	Intertidal and stranded beach. 6600 yrs --> recent.
		Semaphore Sand	Qhe	White to pale grey quartz and shelly sand dunes. Only partly vegetated.	Facies equivalent of the St Kilda Formation (Qhk), Yamba Formation (Qhy), Moornaba Sand (Qhs) and lacustrine clays (Qhl).	Beach and coastal aeolian dunes.
		Moornaba Sand	Qhs	White, pale-grey and pale-orange quartz sand. Typically thickly vegetated.	Reworked from aeolian seif dunes (Qpo), over which it forms thin veneers. Locally forms sand spreads and modern parabolic dunes (eg. Corrobinnie Depression).	Inland aeolian dunes.
		Fluviatile sediments	Qha	Gravelly clay, conglomerate sand, silt and clay.	Derived dominantly from topographic basement highs (e.g. Cleve Uplands).	Modern fluvial channels.
		Lacustrine sediments	Qhl	Clay and silt. Minor halite, no gypsum.	Develops in topographic depressions. Locally intertongues with St Kilda Formation. (eg. Arno Bay).	Lacustrine.
		Yamba Formation	Qhy	Halite, gypsite, gypsarenite, selenite plus minor carbonate and gypsiferous mud.	Commonly bordered by low gypsum dunes. Inland facies equivalent of St. Kilda Formation (Qhk), Semaphore Sand (Qhe) and Moornaba Sand (Qhs).	Evaporitic lacustrine.
	PLEISTOCENE	Sands	Qpo	Yellow-orange quartz sand and clayey sand. Minor soft, carbonate and carbonate soil (Loveday Palaeosol).	Disconformably overlies Bridgewater Formation, onlaps A-B basement outcrop. Overlain by thin veneers of Moornaba Sand (Qhs).	Inland seif dunes.
		Pooraka Formation	Qpp	Dark brown and mottled-green gravelly clay, silt and conglomerate.	Best developed as an apron of sediments shed from Cleve Uplands and granite inselbergs.	Colluvial and fluvial
		Glanville Formation	Qpg	Richly fossiliferous shelly sand. Locally with Anadara trapezia, Pinctada carchariarum and Marginopora vertebralis	Intertongues with upper member of the Bridgewater Formation (Qpbu). Disconformably overlain by St Kilda Formation (Qhk).	Intertidal - subtidal. 110 000 yrs (maybe equivalent to Mambray Formation PORT AUGUSTA).

CAINOZOIC PLEISTOCENE	Calcrete	Qca	Nodular and sheet calcrete cements.	Mulitple, coalescing horizons of calcrete within Bridgewater Formation. Carbonate-cemented loess and colluvial sediments. Equivalent to Bakara Calcrete and undifferentiated Ripon Calcrete.	Palaeosol
	Limestone	Qpl	Fossiliferous, white limestone.	Occurs locally east of Mt Wedge - intertongues with Bridgewater Formation upper member (Qpbu).	Lacustrine
	Bridgewater Formation	Qpb_1			
	Upper member Qpbu	Qpbu	White, cream and fawn calcarenite, white silt and loess. Dunes with large crossbed foresets (>10 m).	Separated from lower member (Qpbl) by variable development of indurated calcrete (Qpr). Intertongues with lacustrine limestone (Qpl) and Glanville Formation (Qpg). Pervasive development of multiple coalescing calcrete horizons (Qca).	Aeolian
	Calcrete	Qpr	Indurated nodular and hard sheet calcrete.	Commonly caps the lower member of the Bridgewater Formation (Qpbl). Equivalent to Ripon Calcrete.	Palaeosol
	Lower member	Qpbl	White to fawn calcarenite dunes with large crossbed forests (< 10 m). Interlayered with red-brown clay, silt and loess, dispersed calcrete clasts.	Unconformably overlies both A-P basement and Tertiary sediments.	Aeolian

Table 4 SUMMARY DATA FOR COMPANY EXPLORATION

PERIOD	*SML, EL PEL	COMPANY	ENVELOPE NOS.	TARGET MINERALISATION	METHODS	GEOCHEMICAL ANALYSIS	COMMENTS
1967	SML 161	R.P. Norton and A.J. Trezise	885	Cu, Mn	c,d	Al,C,Cu,Fe,Mn,Si, Ti	Sugarloaf Hill Minor $CuCo_3$
1967-69	158, 163	Kerr McGee Australia Pty Ltd	838,871,1108	U Tertiary sandstone-hosted	a,b,c,d,g,j,p,q	Ag,Au,Cu,Mn,Mo,Ni, Pb,Sn,Th,U,V,Zn	Waddikee-Verran U in fault breccias in PLC- Best core assay 0.029% U_3O_8 10 000 ppm Cu 390 ppm Zn
1969-72	645 (344,469)	Mines Administration Pty Ltd	1238,1538,2143	U Tertiary sandstone-hosted	g,j,l,o,q,t,s	Th,U	Caralue Bluff Mirdinga Best value 52 ppm U_3O_8
1969-72	665 (348)	Pechiney (Australia) Exploration Pty Ltd/CSR Co. Ltd	1262,1948	Kaolin	b,g,q,w	Al,Fe,K	Bunora-Balumbah-Kelly Tanks 32 mill. tons kaolinitic material - low grade
1970-71	343	Mines Administration Pty Ltd	1326	U Tertiary sandstone-hosted	g,i,j,l,q,s	Al,Fe,Si,U	Caralue Bluff - Rudall No success in delineating palaeochannels by gravity
1970	322	Tal-Ray Trading Pty Ltd	1214	U Tertiary sandstone-hosted	c,k,n,s	Th,U	Taragoro - Driver River Best value 50 ppm U_3O_8
1970	387	W.B. Nelson	1331	Fe	k		Kyancutta ground magnetic surveys
1970-72	381	Pacminex Pty Ltd	1353	Base metals Early Proterozoic	b,c,d,e,f,h,j,n, r	Cu,Pb,Zn	Best values 680 ppm Pb 300 ppm Zn
1970-72	383	Pacminex Pty Ltd	1355	Base metals Early Proterozic	b,e,f,h,j,r	Cu,Pb,Zn	Best values 3 000 ppm Pb 3 700 ppm Zn
1970-73	642	Endeavor Minerals NL (483)	1513,1943	U Sediment-hosted	b,i,o,q,s,v	U	Lock - Cummins Best value 153 ppm U_3O_8

1971	621	Blacker Motors Pty Ltd/ Cresco Fertilisers Ltd	1757	Kaolin	b,g,r,q	Al,Fe,Si,Ti	Lincoln - Coomaba Kaolin widespread on LINCOLN, no success near Coomaba.
1971	577	Meekatharra Minerals (Australia) Pty Ltd	1663	U Tertiary sediment-hosted	b,d		Kyancutta - no results
1971	560	F.S. West	1645	U Tertiary sediment-hosted	b,d		Lake Gilles Kimba - no results
1971	626	Central Pacific Minerals NL/ Magellan Petroleum (NT) Pty Ltd/ Somiren spA/Urangesellschaft Mbh and Co	1792	U	b,f,i,s		Rudall Driver River Radium anomaly in sediments
1972-80	667	Pacminex Pty Ltd	1966	Base metals Early Proterozoic	h,i,m,p,r	Ag,Cu,Pb,Zn	Cleve - Yeldulknie Best intersections: 10 m 0.15% Pb 0.17% Zn 5 ppm Ag 4 m 1200 ppm Pb 4800 ppm Zn 7 m 1600 ppm Pb 6200 ppm Zn 6 m 3300 ppm Pb 5900 ppm Zn
1973-74	EL 37	Chevron Exploration Corporation	2256	U Sedimentary-hosted	a,b,c,o,q,r,t,		Lock area no success
1973	1032	CRA Exploration Pty Ltd	5078	Base metals Broken Hill - style	g,i,k,p,q	Ag,Cd,Cr,Cu,Hg, Mo,Mn,Ni,Pb,Zn	Lock area Best values: 100 ppm Cu 55 ppm Pb 170 ppm Zn
1973-76	218	Carpentaria Exploration Co. Pty Ltd	2296,2687, 2732	Base metals Early Proterozic	a,b,c,d,e,f,g,i, k,m,p,r,s	Ag,Cu,Pb,Zn	Cleve Yelduknie Best Intersections 7.6 m 0.58% Pb 7.6 m 0.35% Pb 10.7 m 0.34% Pb 6.1 m 0.51% Pb 18.3 m 0.21% Zn 10.7 m 0.38% Cu 67.1 m 0.22% Pb
1974	131	Urangesellschaft Australia Pty Ltd	2419	U Tertiary sediment-hosted	d,f,n,q,s	Th,U	Examined B granites and Tertiary sediments Darke Peak - Caralue-Carappee

1975-76	205	Australian Anglo American Ventures Ltd	2654	Heavy-mineral beach sands	r		Minor occurrences north of Lake Hamilton
1977-83	434 (280)	The Electricity Trust of South Australia/SADME	3384	Coal Tertiary - Jurassic	o,p,q,t,v,x,y	Al,Ca,Fe,K,Mq,Mn, Na,P,S,Si,Ti	Polda Basin - Lock Coal Deposit Feasability Study
1977-84	1185 (285,494, 877)	CRA Exploration Pty Ltd/ Shell Co. of Australia Ltd	2965,3573	Base metals Early Proterozoic stratiform U Alligator River - style	a,b,c,d,f,g,i,j k,l,m,m_1,n,o,p, q,w	Ag,Ba,Co,Cu,Fe Mn,Ni,P,Pb,Ti,V, W,Zn	Campoona Syncline Best intersection 1 m 0.44% Pb 11% Zn 4 m 0.2% Pb 3.4% Zn
1977-85	1182 (286,485)	CRA Exploration Pty Ltd/ Shell Co. of Australia Ltd	296,3541	Base metals Early Proterozoic stratifrom U Alligator River - style	a,b,c,d,e,f,g,h j,m,m_1,n,o,p,q, r,w	Ag,As,Au,Ba Cu,Fe,Mn,Pb,Zn	Mangalo Ck. - Silver Monarch Best intersection 2m 0.1% Pb 1.75% Zn Best U value 19 ppm U_3O_8
1978	395	CRA Exploration Pty Ltd	3335	U Tertiary sandstone-hosted	i,o,q		Arno Bay area - no palaeochannels located
1978-83	803,867,893 (431,453, 500)	Pancontinental Mining Ltd/ Afmeco Pty Ltd/Power Nuclear Corporation	3412,3519	U Early Proterozoic and unconformity-related	a,c,d,e,f,g,h,i j,k,l,m,n,o,p,q, s	Ag,As,Au,Bi,Co, Cr,Cu,F,Fe,Hg, Mo,Mn,Ni,Pb,Pt, Sn,Th,U,V,Zn	Tooligie -Darke Peak - Verran Best values 210 ppm Cu 3200 ppm Pb 3300 ppm Zn 1800 ppm U
1979-84	1026 (378,613)	Wyoming Mineral Co./Esso Australia Ltd/Shell Co of Australia Ltd/Westinghouse International Power Systems Co. Inc.	3235	Base metals Early Proterozoic U Alligator River - style	a,b,c,d,g,h,i, j,k,q,u	Ag,As,Au,Ba,Co,Cu Fe,Mn,Ni,Pb,Th,U, V,Zn	High Bluff Campoona Best values 0.17% Cu 2500 ppm Zn
1979-83	541,610	Carpentaria Exploration Co. Pty Ltd	3716,3717, 3809,3810, 4010	U Tertiary sandstone-hosted	b,c,d,g,h,i,j,k, l,m,m_1,q	Ag,As,Au,Ce,Cu, Ka,Mo,Th,Sn,U,W, Zn	Yaninee Palaeochannel Best intersection 1 m 1450 ppm 1_3O_8
1979-86	1181 (507,895)	Mines Administration Pty Ltd/ Western Mining Corporation	3583	Base metals Early Proterozoic	b,c,d,g,h,i,j,k, l,m,m_1,q	Ag,As,Co,Cr,Cu, Fe,Mn,Pb,Zn	Caralue - Kimba Best Values 3.5 ppm Ag 3400 ppm Pb 2000 ppm Zn

1980-82	712	Afmeco Pty Ltd	3992	U Proterozoic	c,d,g,h,i,j,l, n,o,q,s	Co,Cu,Mn,Pb,Th, U,Zn	Exploration on WHYALLA, western margin extends just onto KIMBA
1980-83	980 (756)	North Broken Hill Ltd/ CRA Exploration Pty Ltd	4230	Base Metals Precious metals Tungsten	g,h,k,l,m,p,q,r	Ag,Au,Ba,Co,Cu,Mo	Kyancutta - Warramboo Best values 780 ppm Cu 2000 ppm Pb 480 ppm Zn 3.6m @ 0.17% WO_3 in NBH.C1
1980-83	670,687, 688	CRA Exploration Pty Ltd	3973,4659	Coal (Eocene/Jurassic) Potash Base metals	l,o,p,q,t,y	Ag,Au,Co,Cu,Mo, Pb,Ta,U,W,Zn	Polda Basin Best intersection 8.9 m lignite
1980-82	1006 (589)	Esso Australia Ltd	3783	Coal (Eocene/Jurassic)	g,l,o,q,t,v,y		Western Polda Basin Best intersection 4.8 m coal
1983-84	1162	Shell Co. of Australia Ltd	5262	Base metals Early Proterozoic BIF - hosted	i,k,q,p	As,Au,Cu,Fe,Mn, Pb,Zn	Carappee Hill area Best value 160 ppm Zn
1985-86	PEL 35	Quadrant Energy Development Ltd/ Continential Oil Exploration Pty Ltd	6671	Oil	a,b,i		Western Polda Basin - no results
1985-87	EL 1305	John Gilfillan and Associates	6385	Gypsum	a,b,c,r	$CaSO_4$	Kappakoola Swamp deposit. Probable reserve 4 176 700 tonnes gypsum @ avg. 88% (cutoff 80%).
1986-88	1333	Shell Co. of Australia Ltd Western Mining Corp. Ltd.	6654	Base metals	-	-	Office evaluation only.
1988-89	EL 1308	Macmahon Construction Pty Ltd	8189	Heavy mineral sands	a,b,f,q	Ti, Zr	Wombat Flat - Bald Hills area. Minor Ti + Zr in clayey sands. Best values: 5600 ppm - Ti 1380 ppm - Zr

a	Photogeology	m	Ground resistivity survey
a_1	ERTS/LANDSAT interpretation	m_1	SIROTEM survey
b	Geological reconnaissance	n	Ground radiometric survey
c	Geological mapping	o	Geophysical borehole logging
d	Rock sampling	p	Diamond drilling and sampling
e	Stream sediment sampling	q	Rotary percussion drilling and sampling
f	Soil sampling	r	Auger drilling and sampling
g	Petrological studies	s	Groundwater sampling
h	Aeromagnetic survey	t	Palynology
i	Interpretation of aeromagnetic surveys	u	Thermal luminescence
j	Airborne radiometric survey	v	Seismic survey
j_1	Airborne EM survey	w	Costeaning and sampling
k	Ground magnetic survey	x	Engineering analysis
l	Ground gravity survey	y	Coal analysis

* SML's to 2/7/1972
EL's from 3/7/1972 to 3/7/1988

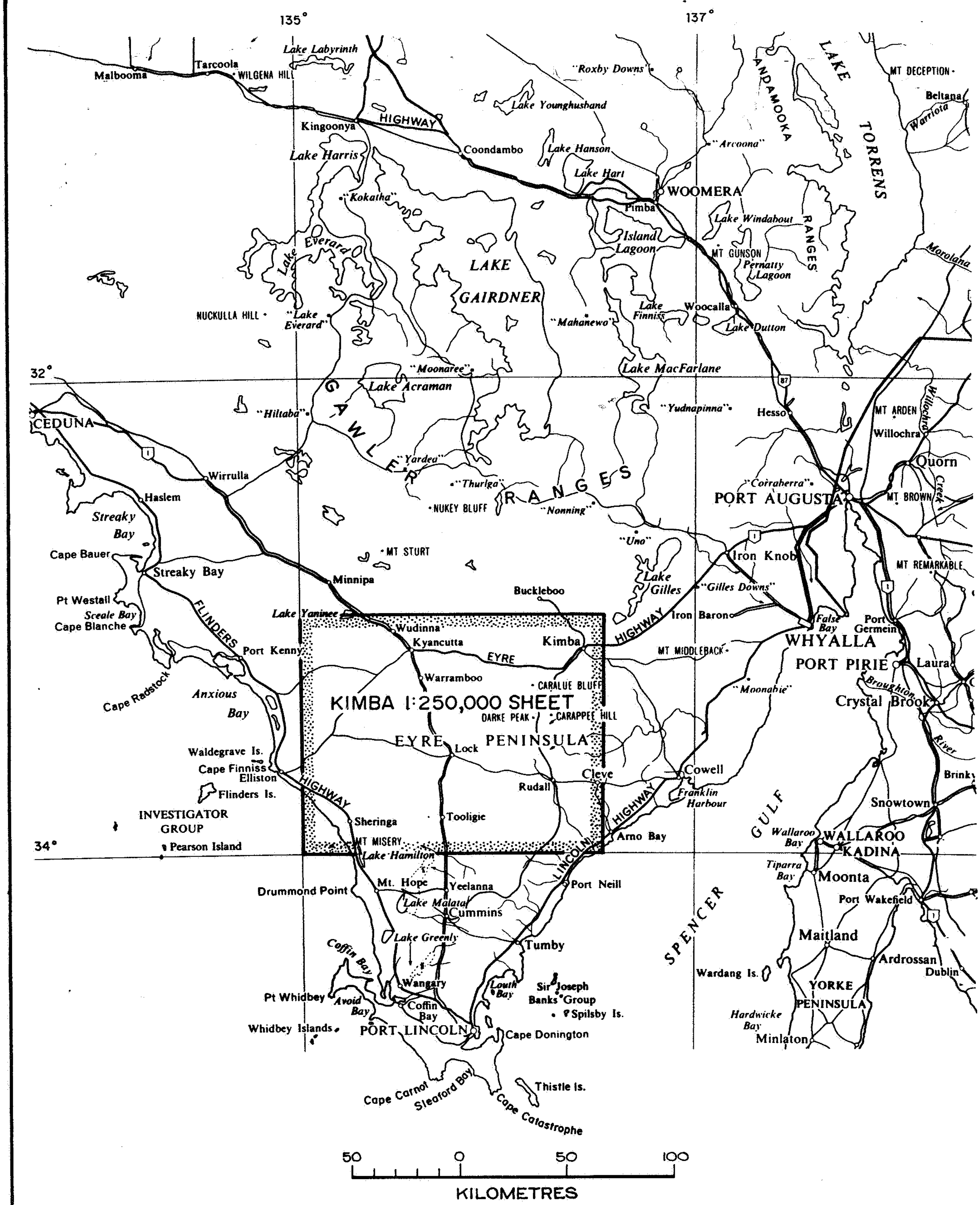


FIG. 1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

KIMBA 1:250,000 GEOLOGICAL MAP EXPLANATORY NOTES

REGIONAL LOCALITY PLAN

COMPILED R.Flint	C.D.O.	1·3·90 DATE
DRAWN J.W.	SCALE 1:2,500,000	
DATE 25-10-88	PLAN NUMBER	
CHECKED	S20398	

4533

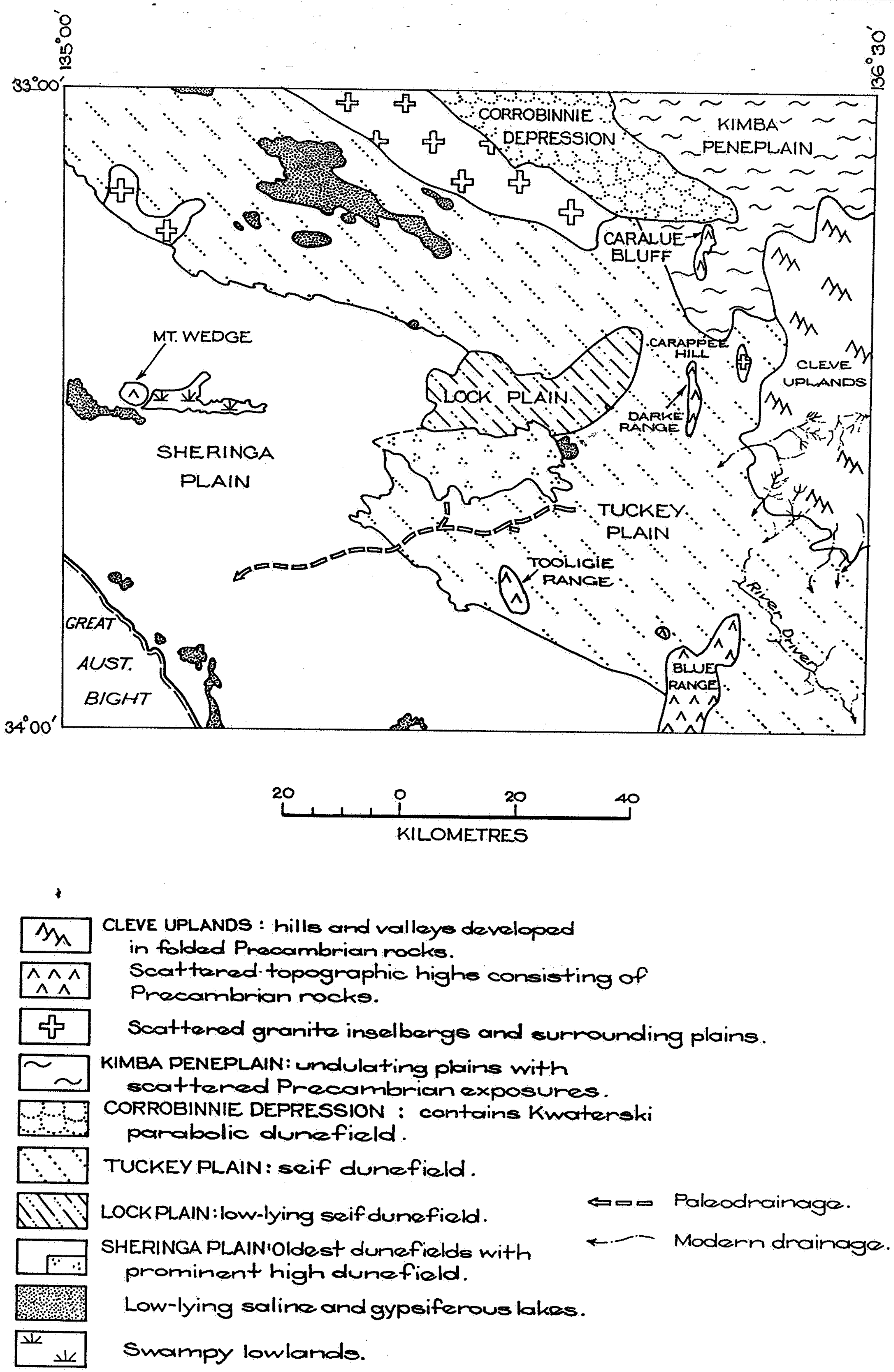


FIG.2

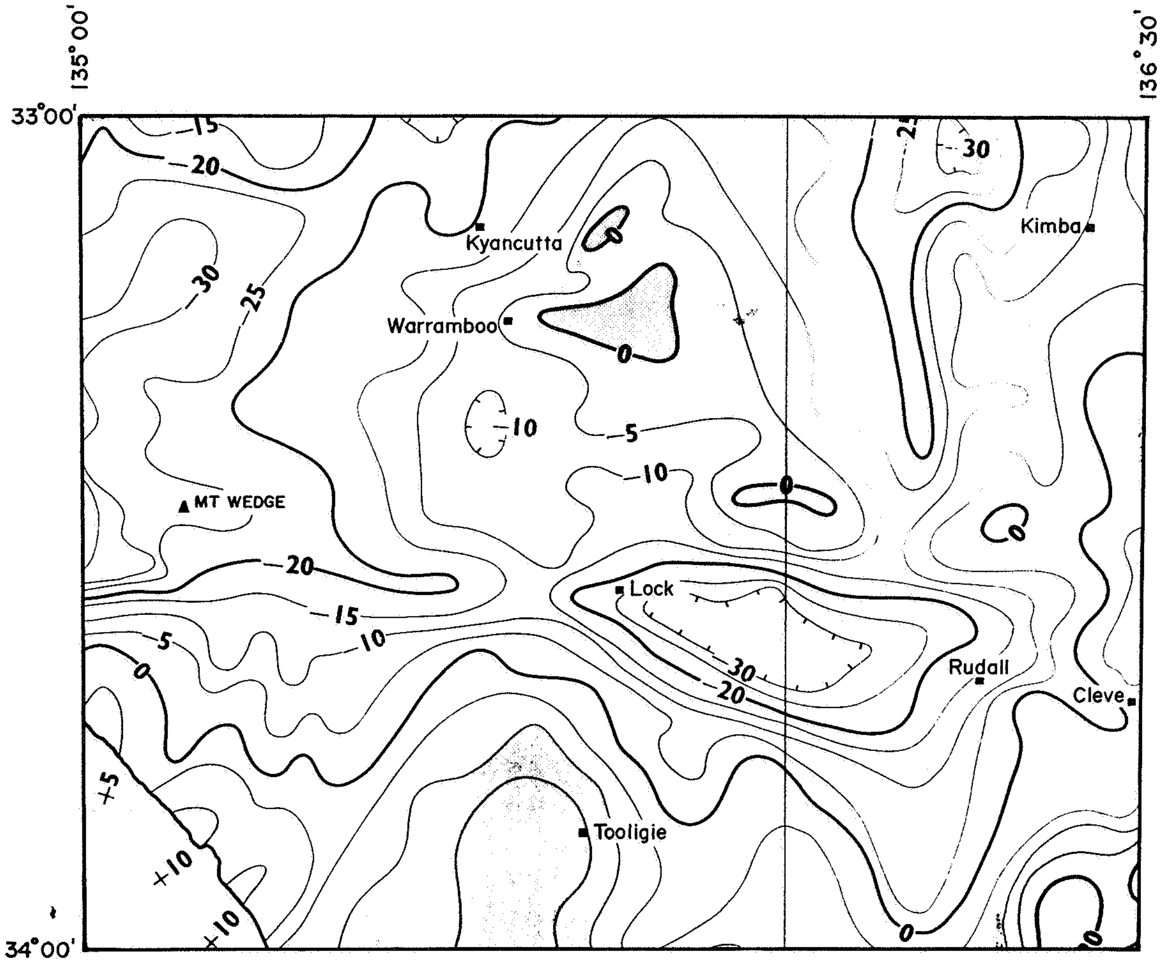
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

KIMBA 1:250,000 GEOLOGICAL MAP EXPLANATORY NOTES

PRINCIPAL PHYSIOGRAPHIC FEATURES

COMPILED R.Flint	C D O	1·3·90 DATE	
DRAWN J.W.	SCALE 1:1,000,000		
DATE 25-10-88	PLAN NUMBER S20399		
CHECKED			

4533



20 0 20 40

KILOMETRES

Bouguer gravity contour interval: 5 milligals

FIG. 3

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED R.Flint	C.D.O. 1·3·90 DATE
KIMBA 1:250,000 GEOLOGICAL MAP EXPLANATORY NOTES	DRAWN J.W.	SCALE 1:1000000
GRAVITY MAP OF KIMBA	DATE 25-10-88 CHECKED	PLAN NUMBER **S20400**

4533

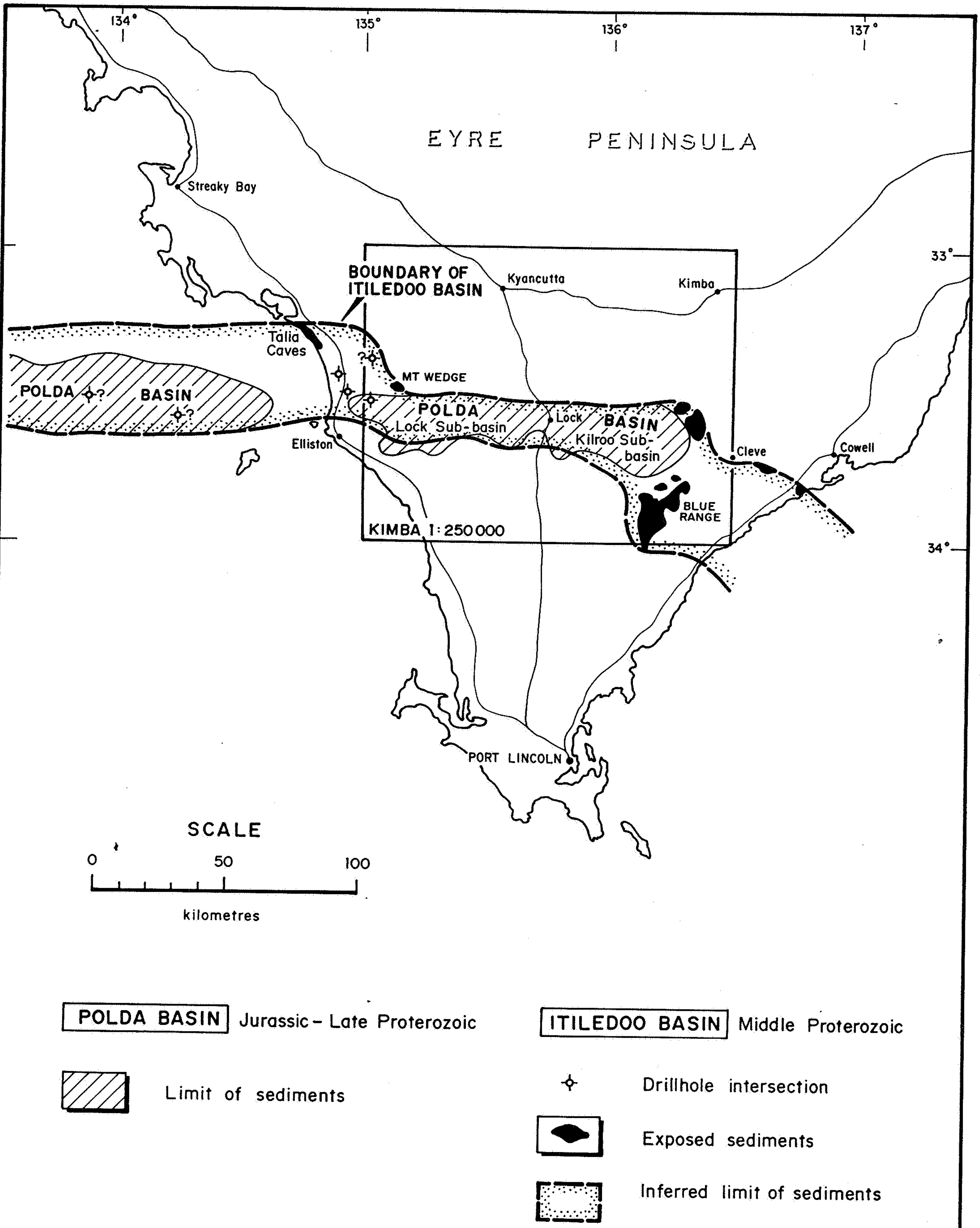


Figure...... 4

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

KIMBA 1:250 000 GEOLOGICAL MAP EXPLANATORY NOTES

EXTENT OF ITILEDOO AND POLDA BASINS

COMPILED L. Rankin	C.D.O.	DATE 1·3·90
DRAWN M.R.	SCALE 1:2000000	
DATE Jan '90	PLAN NUMBER	
CHECKED	S 21244	

4533

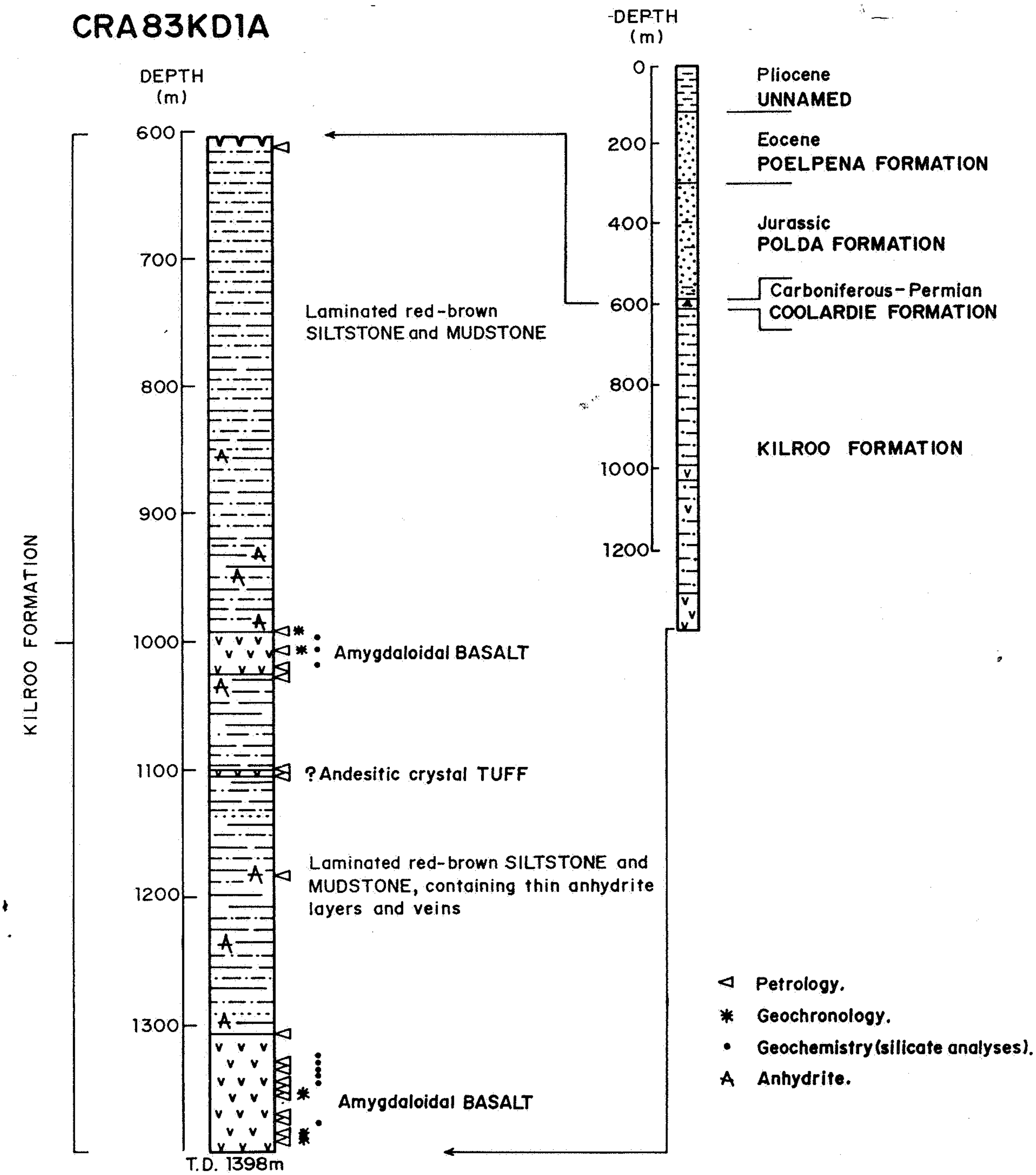
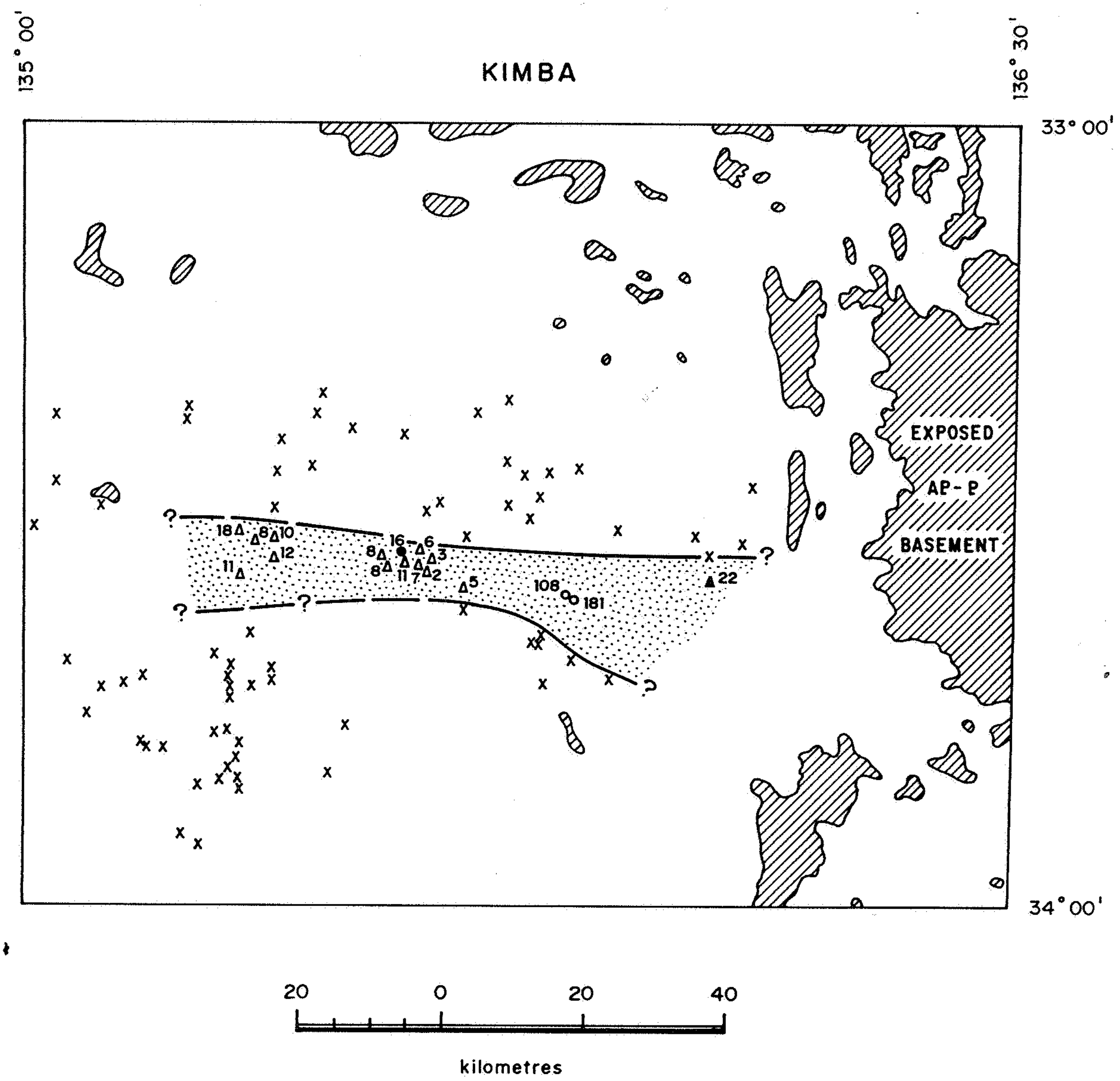


Figure 5

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED R. Flint	C D O 1·3·90 DATE
KIMBA 1:250,000 GEOLOGICAL MAP EXPLANATORY NOTES	DRAWN J.W	SCALE
GEOLOGICAL LOG OF CRA 83KD1A	DATE 25-10-88 CHECKED	PLAN NUMBER S20401

4533



TOTAL THICKNESS	MINIMUM THICKNESS	
●	○	Palynologically confirmed
▲	△	Lithologically interpreted

x .... Absent

Limit of Carboniferous - Permian sediments

Figure 6

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

KIMBA 1:250 000 GEOLOGICAL MAP EXPLANATORY NOTES

THICKNESS OF COOLARDIE FORMATION

COMPILED R. Flint	CDO DATE 1·3·90
DRAWN M.R.	SCALE 1:1 000 000
DATE Jan '90	PLAN NUMBER
CHECKED	S 20402

4533

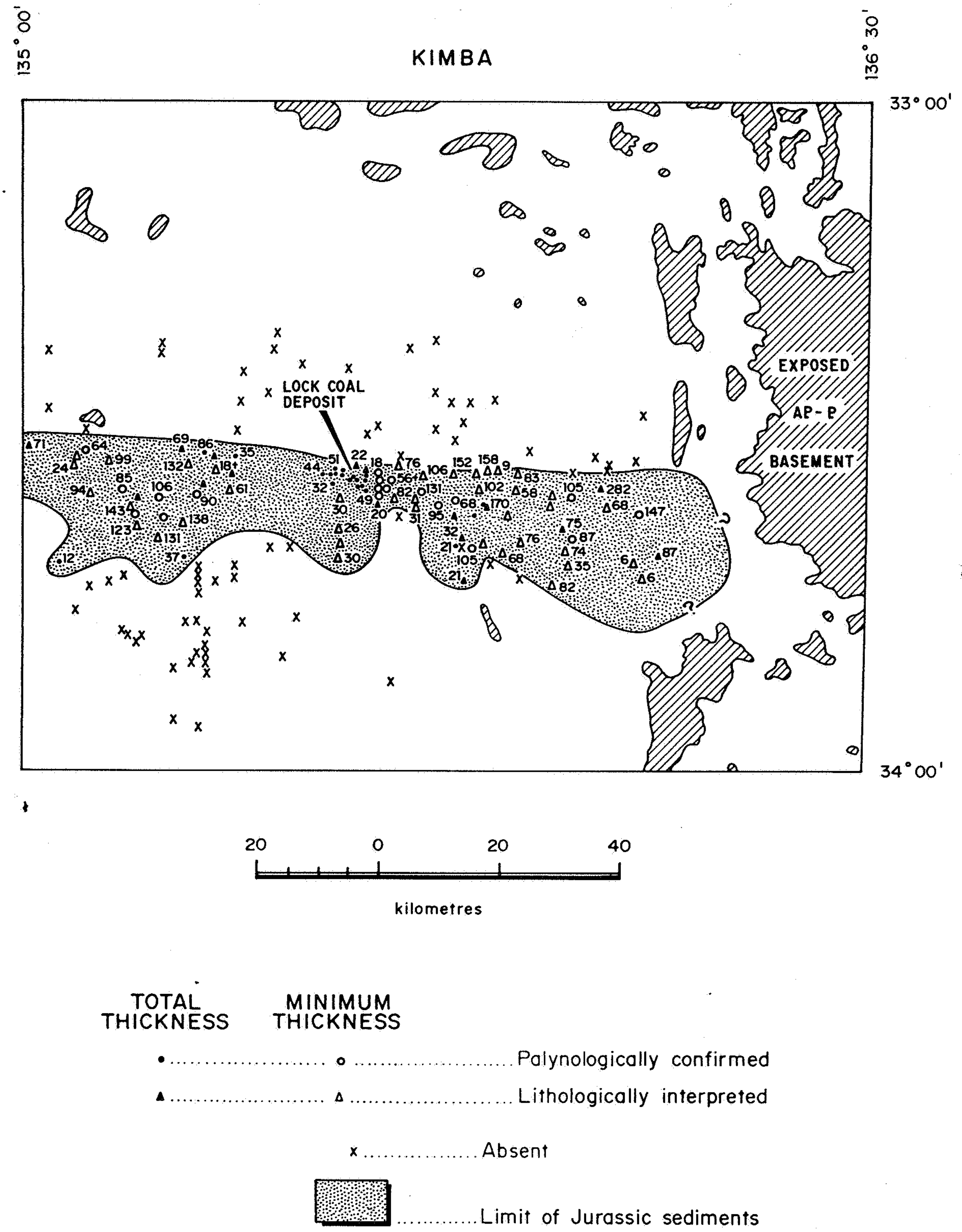


Figure 7

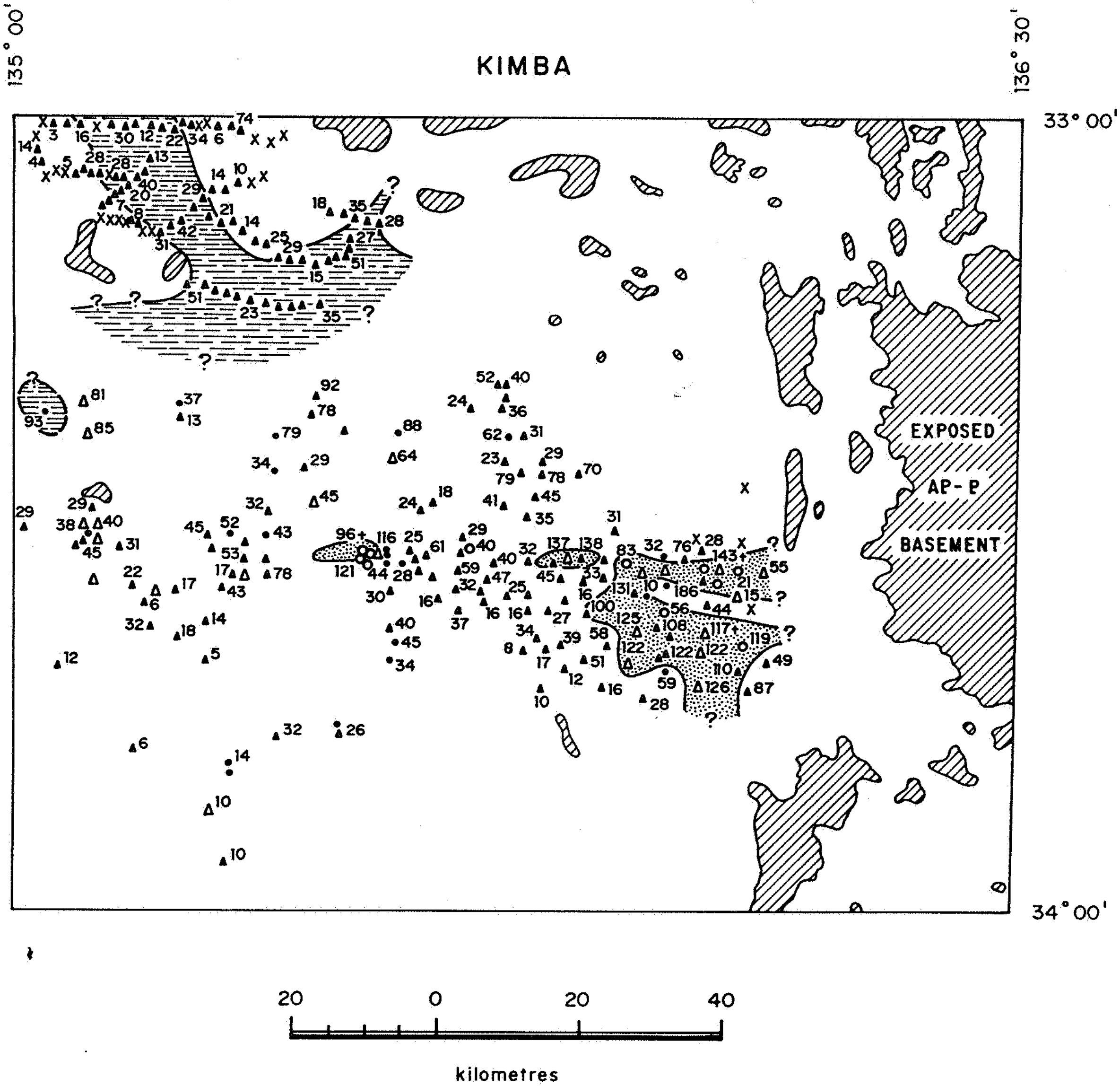
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

KIMBA 1:250 000 GEOLOGICAL MAP EXPLANATORY NOTES

THICKNESS OF POLDA FORMATION

COMPILED R. Flint	CDO DATE 1·3·90
DRAWN M.R.	SCALE 1:1 000 000
DATE Jan '90	PLAN NUMBER
CHECKED	S 20403

4533



TOTAL THICKNESS	MINIMUM THICKNESS	
•	o	Palynologically confirmed
▲	Δ	Lithologically interpreted

x .... Absent

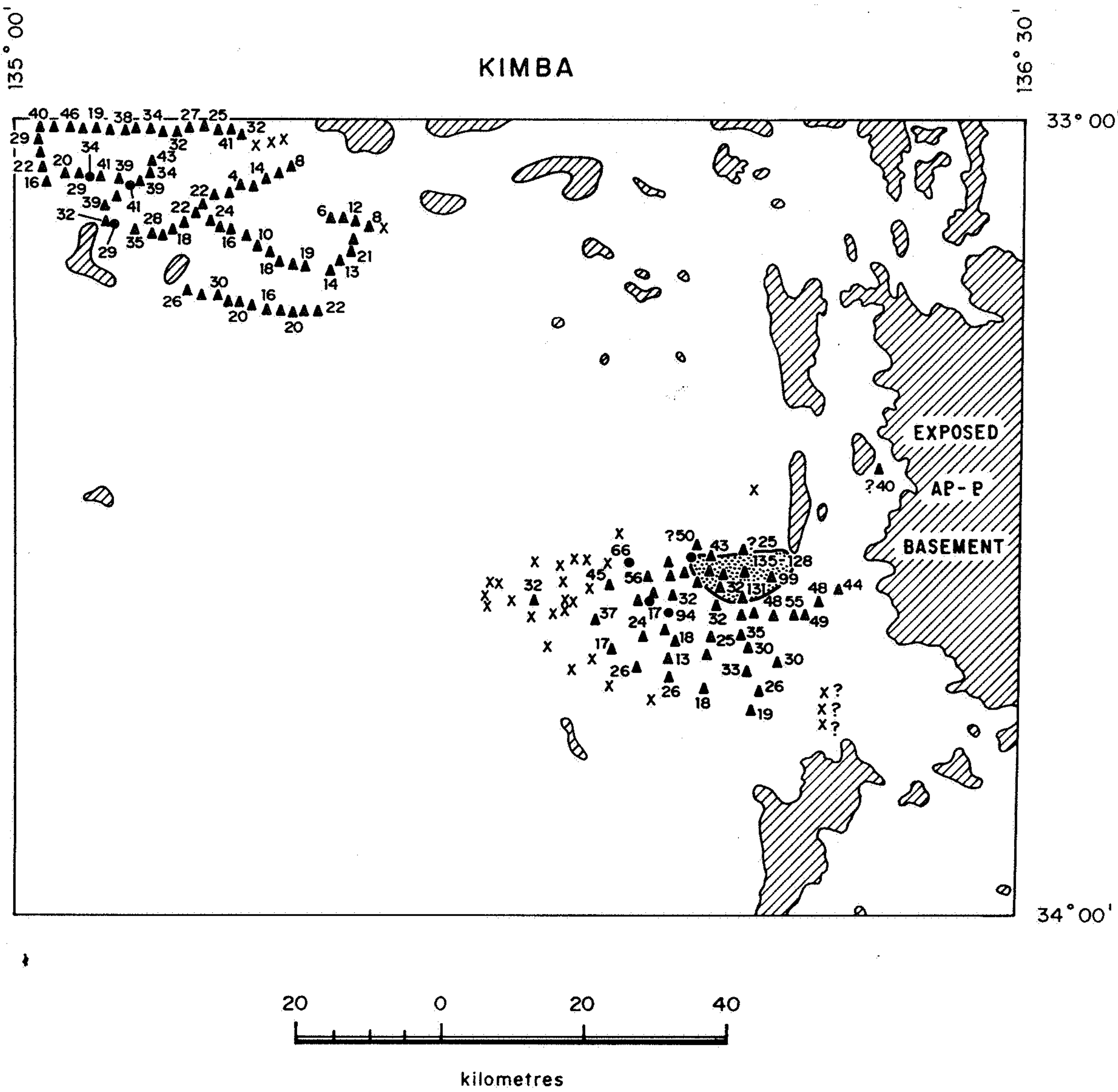
(stippled box) .... Thickness > 100m

(dashed box) .... Limit of marine sediments

Figure 8

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED R. Flint	UR 1·3·90 CDO DATE
KIMBA 1:250 000 GEOLOGICAL MAP EXPLANATORY NOTES	DRAWN M.R.	SCALE 1 : 1 000 000
THICKNESS OF POELPENA FORMATION	DATE Jan '90	PLAN NUMBER
	CHECKED	**S 20404**

4533



TOTAL THICKNESS	MINIMUM THICKNESS	
•	o	Palynologically confirmed
▲	△	Lithologically interpreted

x .... Absent

Area of thickness greater than 100m.

Figure 9

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

KIMBA 1:250 000 GEOLOGICAL MAP EXPLANATORY NOTES

THICKNESS OF PLIOCENE SEDIMENTS

COMPILED R. Flint	CDO	DATE 1·3·90
DRAWN M.R.	SCALE 1:1 000 000	
DATE Jan '90	PLAN NUMBER S 20405	
CHECKED		

4533

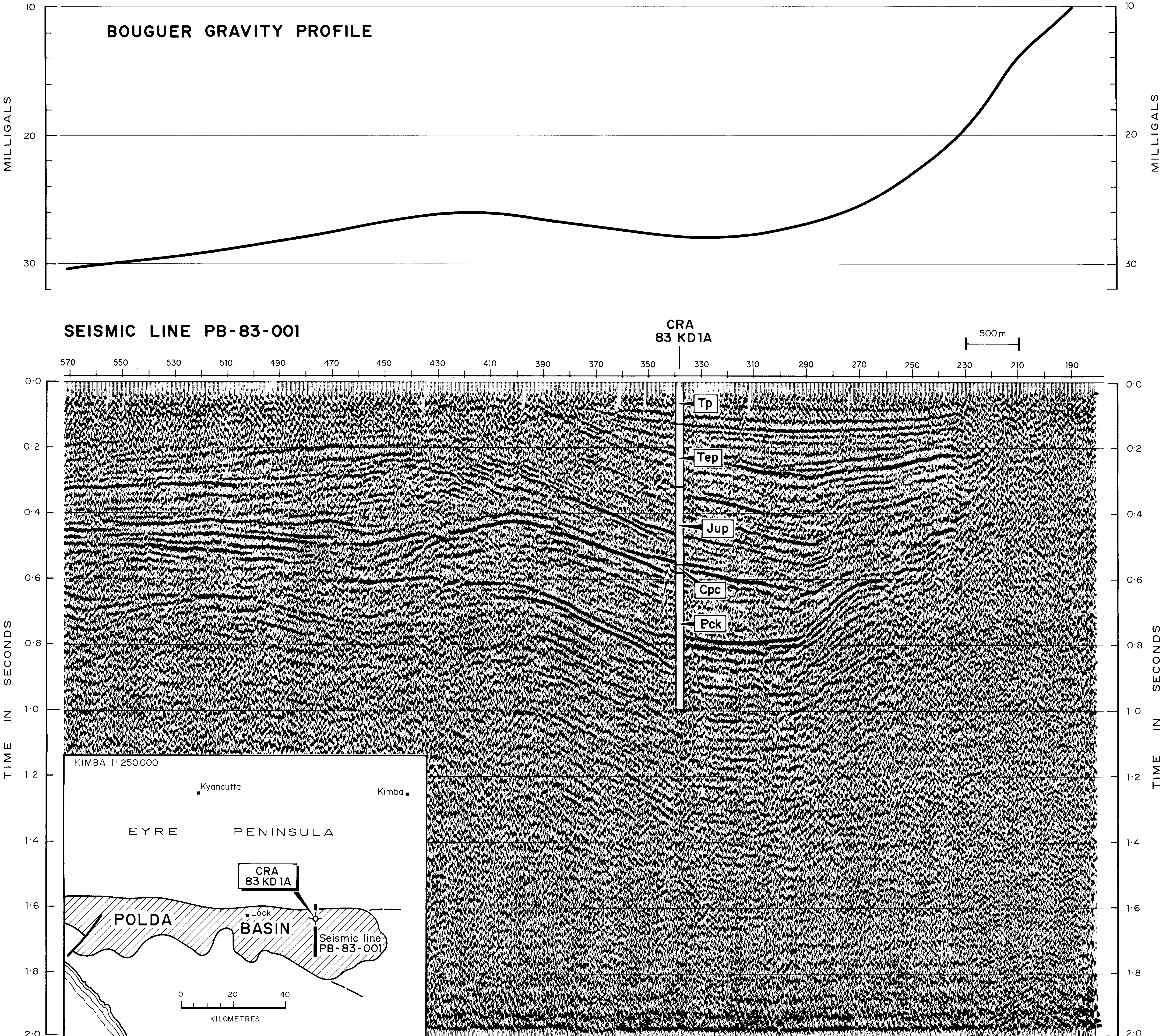


Figure 10

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

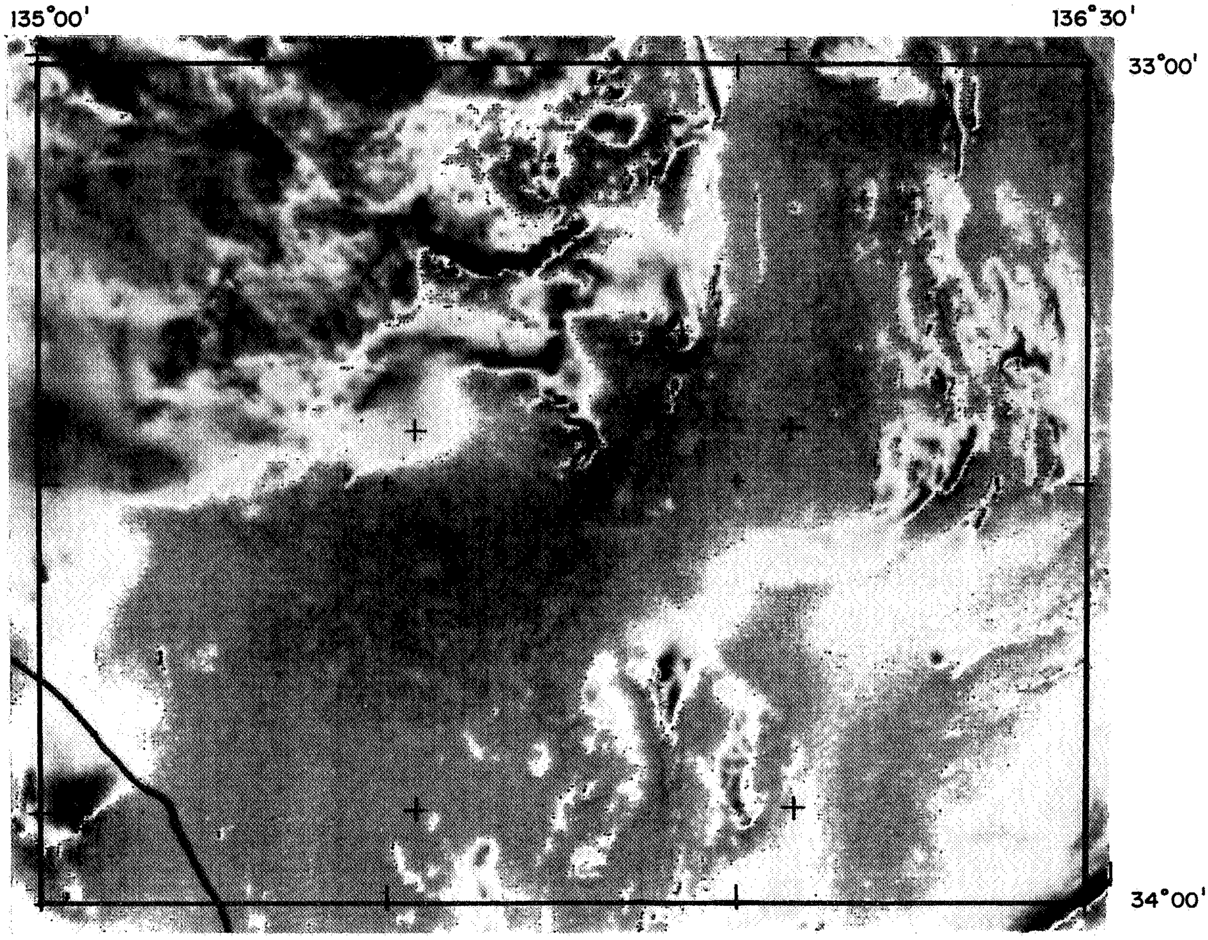
KIMBA 1:250000 GEOLOGICAL MAP EXPLANATORY NOTES

DRILLING RESULTS FOR CRA 83-KD1A VERSUS SEISMIC LINE PB 83-001

COMPILED	L. Rankin
C.D.O. / DATE	1·3·90
DRAWN	M.R.
SCALE	
DATE	Jan '90
CHECKED	
PLAN NUMBER	90-56

4533

KIMBA

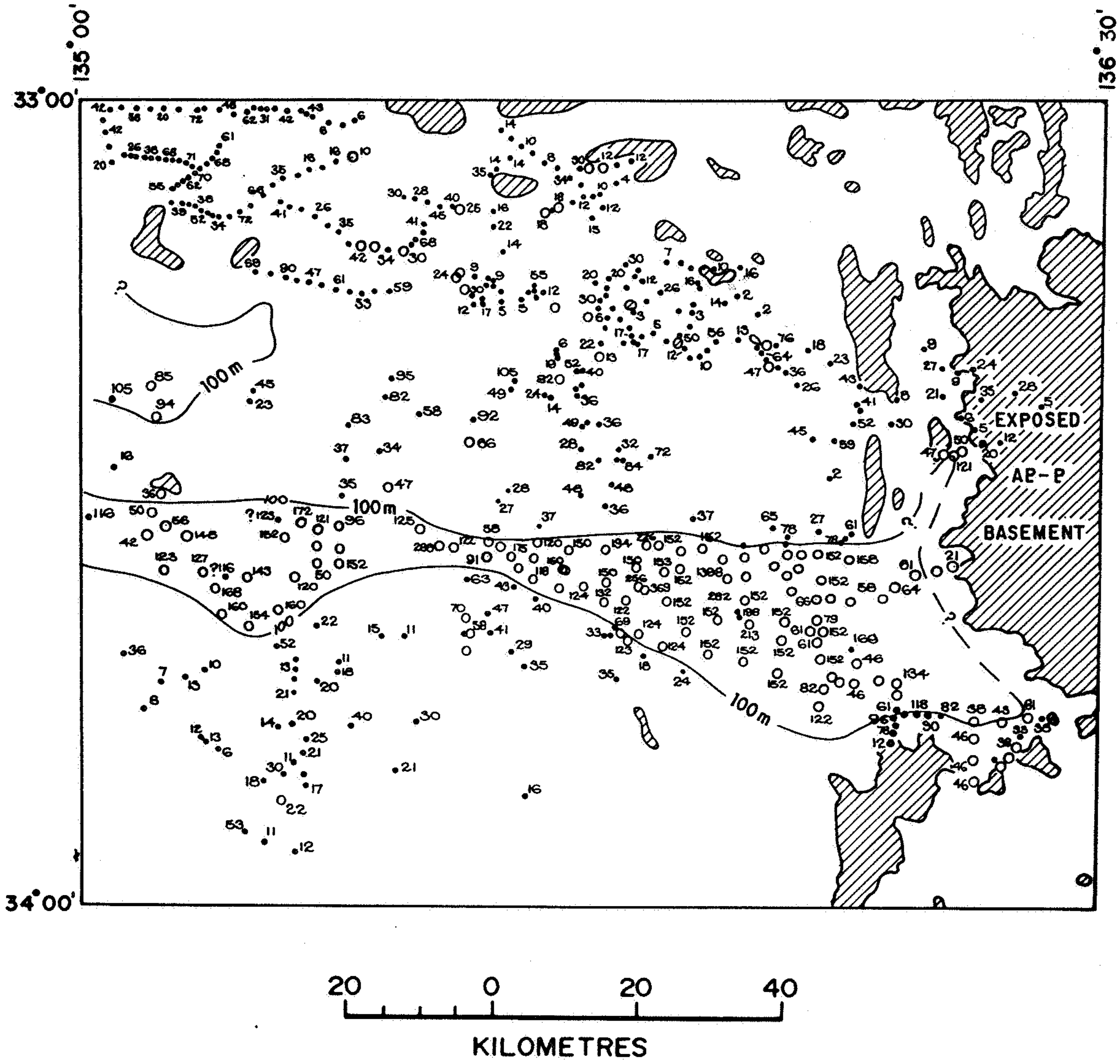


Pixel image of residual magnetic intensity at 1 : 1000 000 for KIMBA produced from digital data from the 1988 Eyre Peninsula airborne survey.

Figure.....11

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED L. Rankin	C.D.O. DATE
KIMBA 1 : 250 000 GEOLOGICAL MAP EXPLANATORY NOTES	DRAWN M.R.	SCALE 1 : 1000 000
PIXEL IMAGE OF RESIDUAL MAGNETIC INTENSITY	DATE Jan '90	PLAN NUMBER S21232
	CHECKED	

4533



- Depth to basement (metres below ground level).
- o Basement not intersected, minimum depth below ground level.
- 100m contour :- deeper contours not shown.
  Basement is all Archaean-Middle Proterozoic lithologies.

Figure 12

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED R. Flint	CDO	DATE 1·3·90
KIMBA 1:250,000 GEOLOGICAL MAP EXPLANATORY NOTES	DRAWN J.W.	SCALE 1:1000000	
DEPTH TO BASEMENT	DATE 25-10-88	PLAN NUMBER	S20406
	CHECKED		

4533

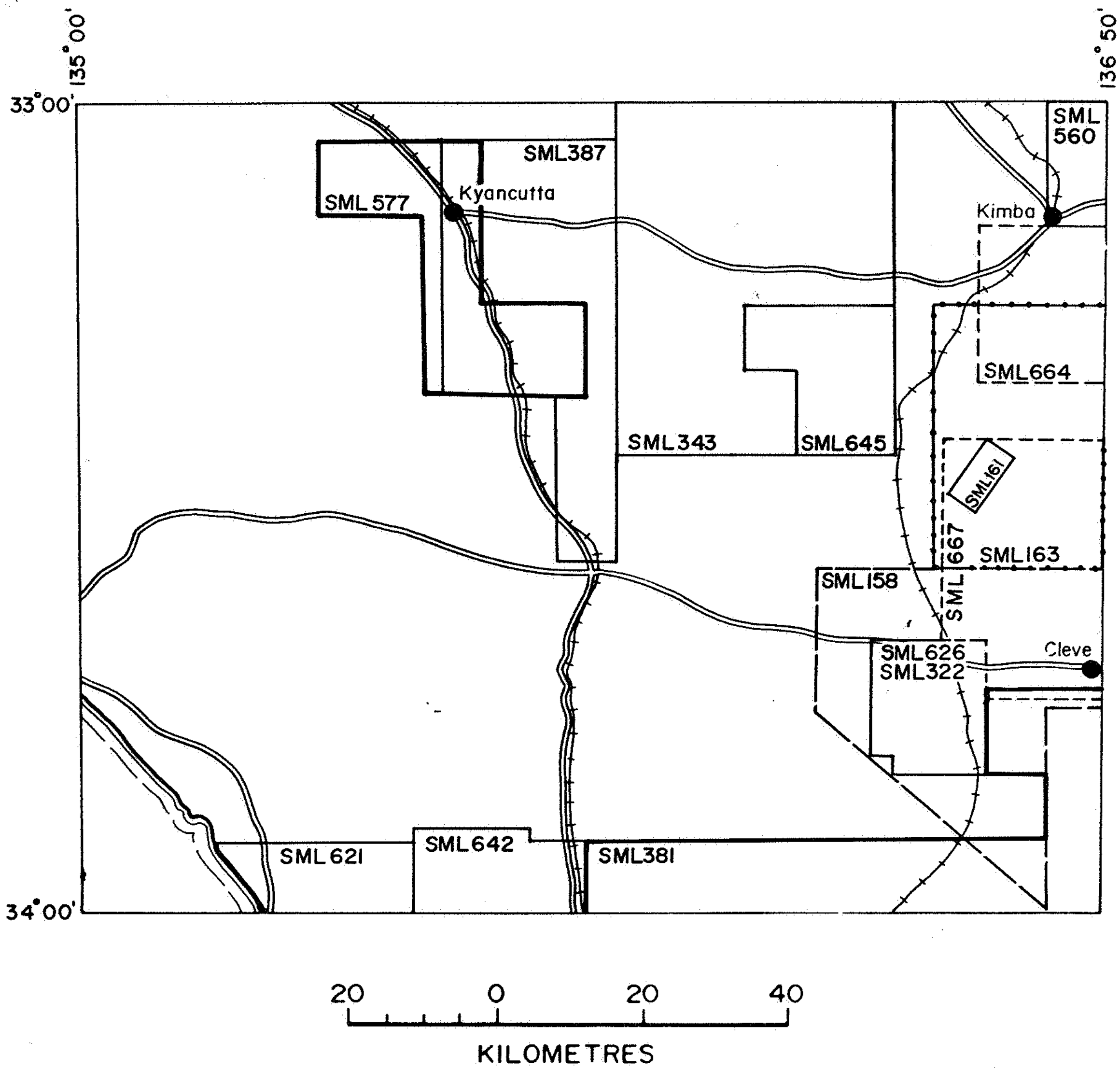


FIG. 13

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

KIMBA 1:250,000 GEOLOGICAL MAP EXPLANATORY NOTES

MAP OF SPECIAL MINING LEASES

COMPILED R.Flint	C.D.O.	DATE
DRAWN J.W.	SCALE 1:1000 000	
DATE 25-10-88	PLAN NUMBER	
CHECKED	S20407	

4533

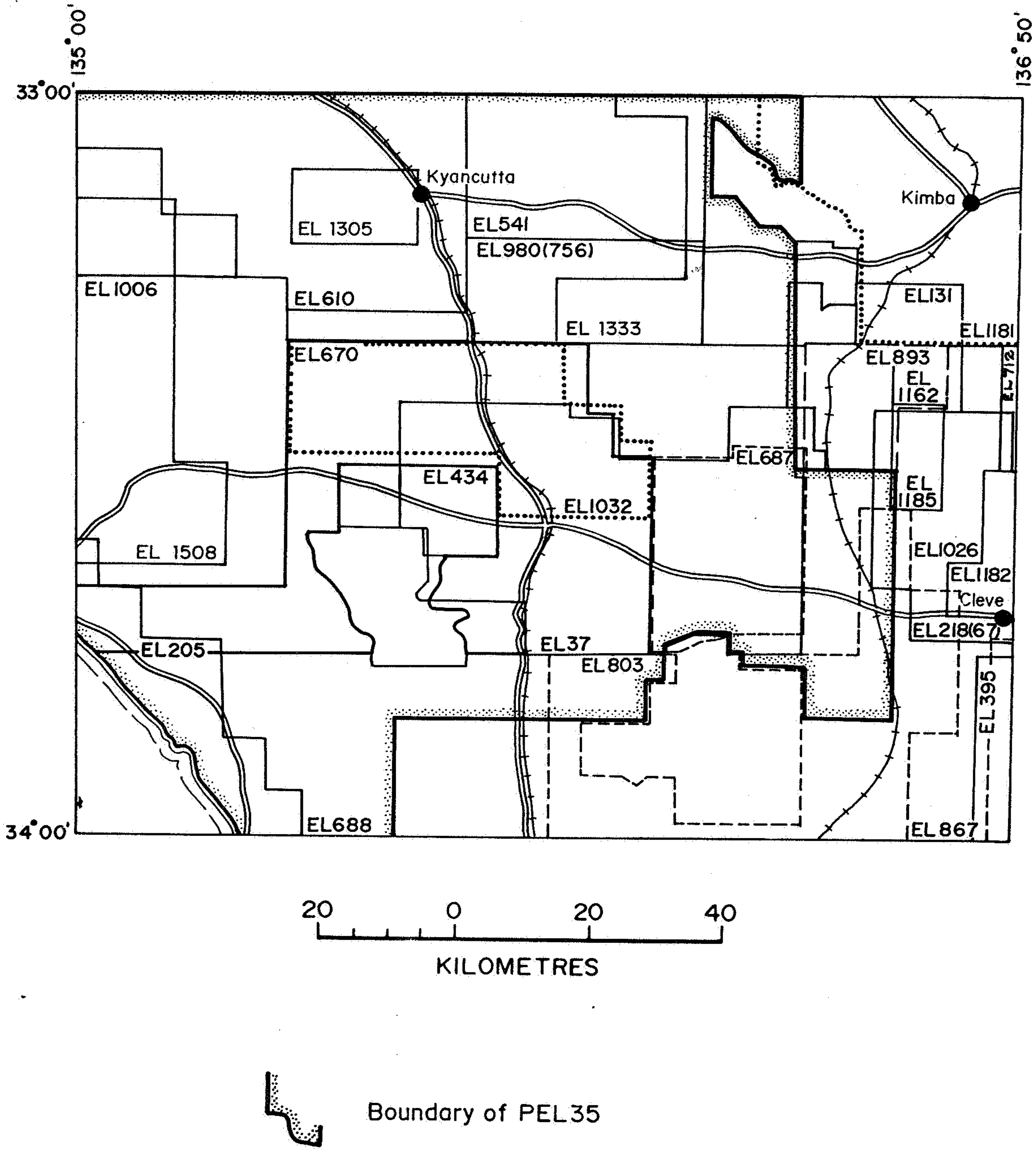


FIG. 14

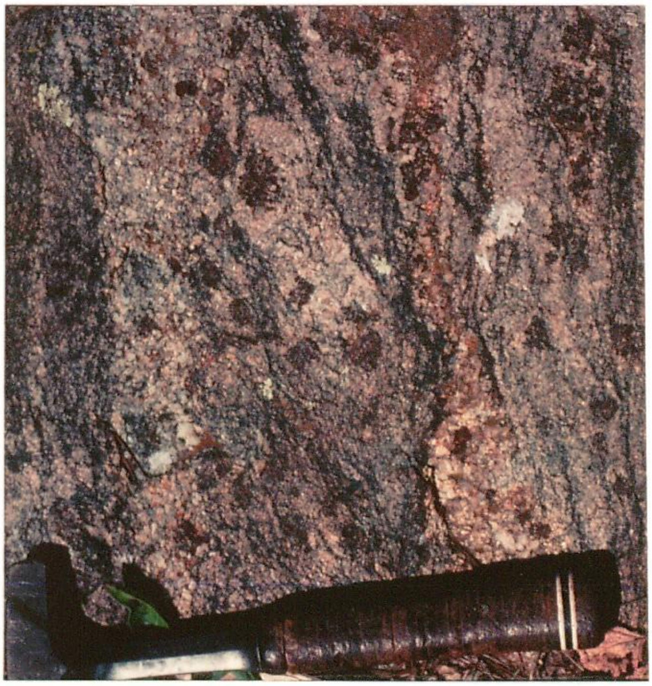
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

KIMBA 1:250,000 GEOLOGICAL MAP EXPLANATORY NOTES

MAP OF EXPLORATION AND PETROLEUM EXPLORATION LICENCES

COMPILED	R. Flint	CDO	DATE 1·3·90
DRAWN	J.W.	SCALE 1:1000000	
DATE	25-10-88	PLAN NUMBER	
CHECKED		S20408	

4533



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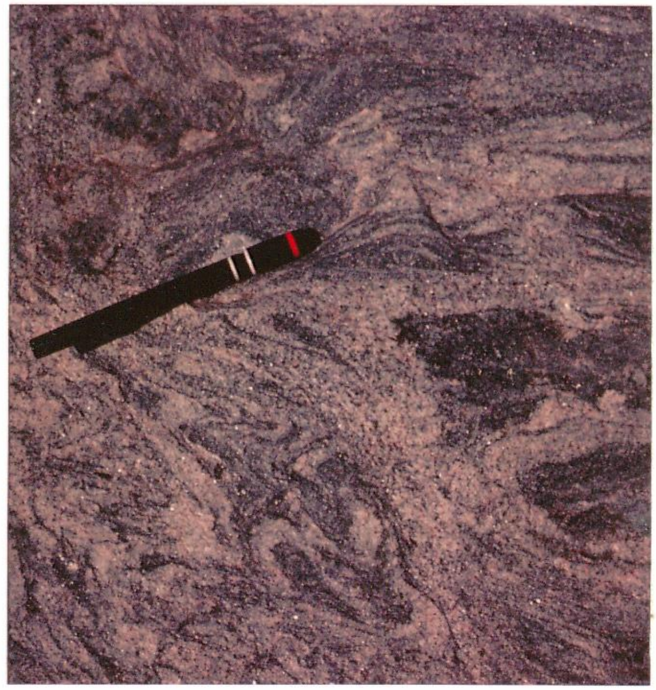

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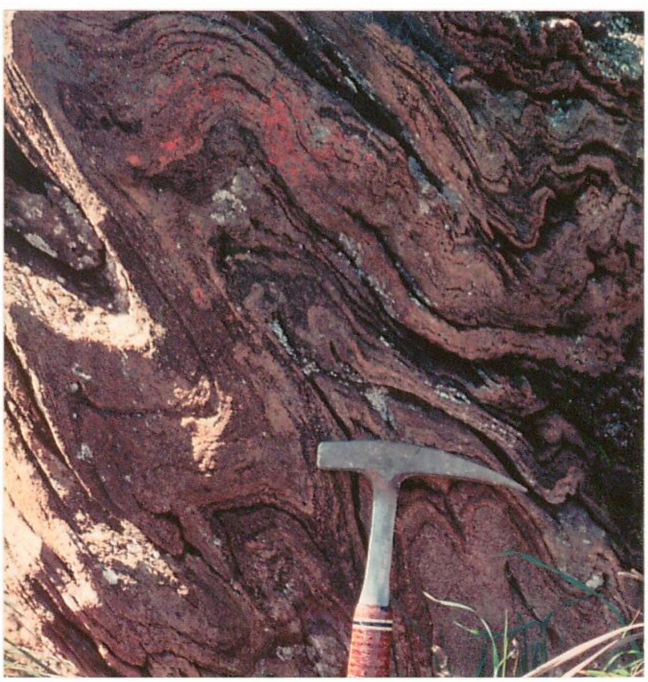

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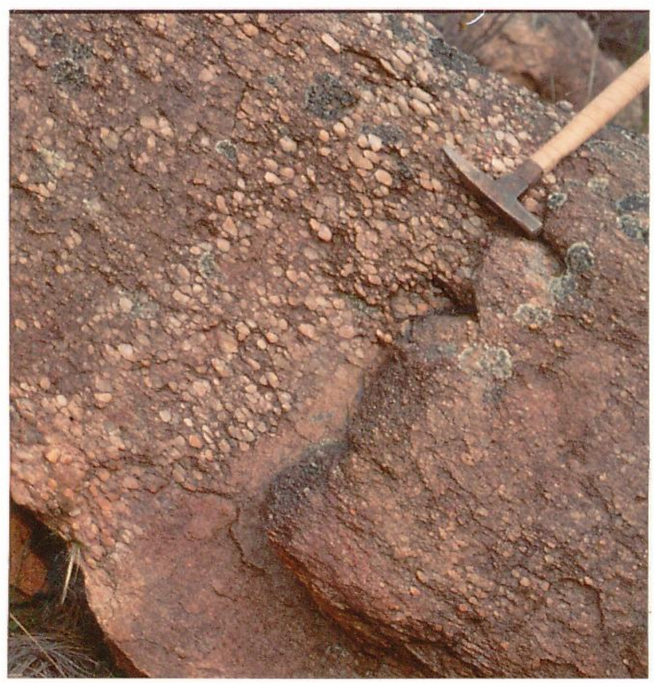

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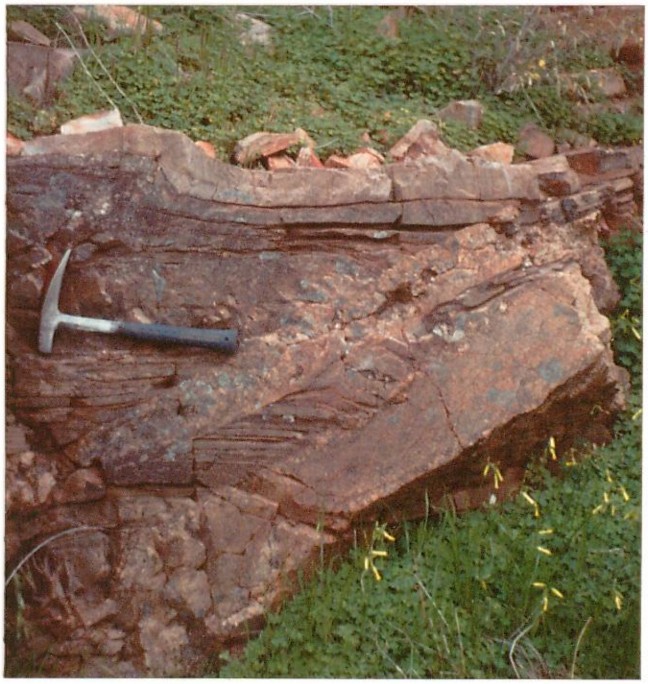

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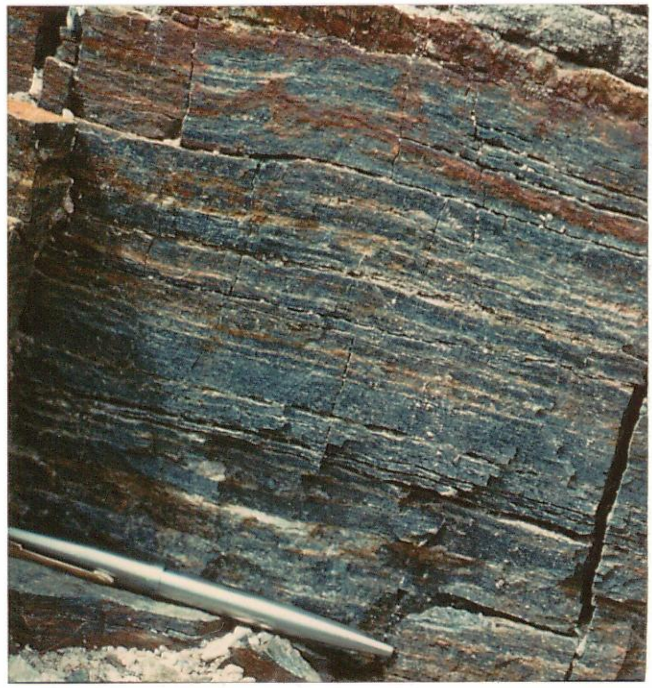

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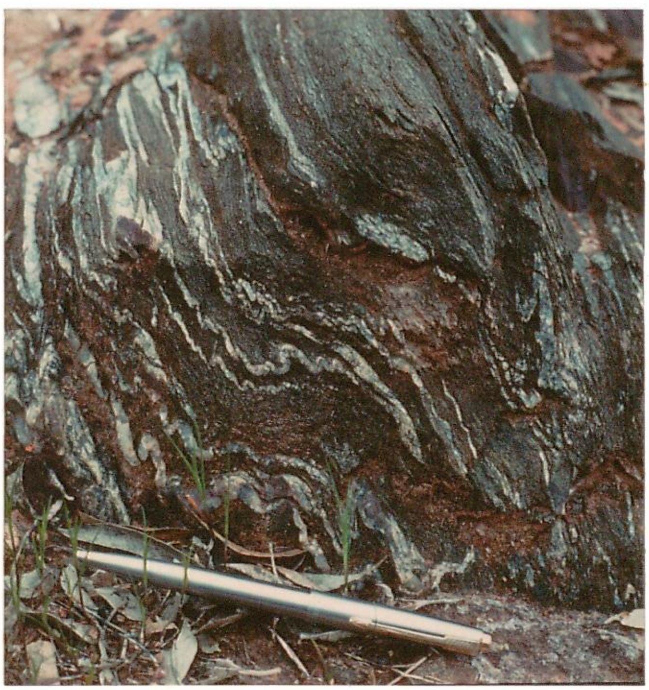

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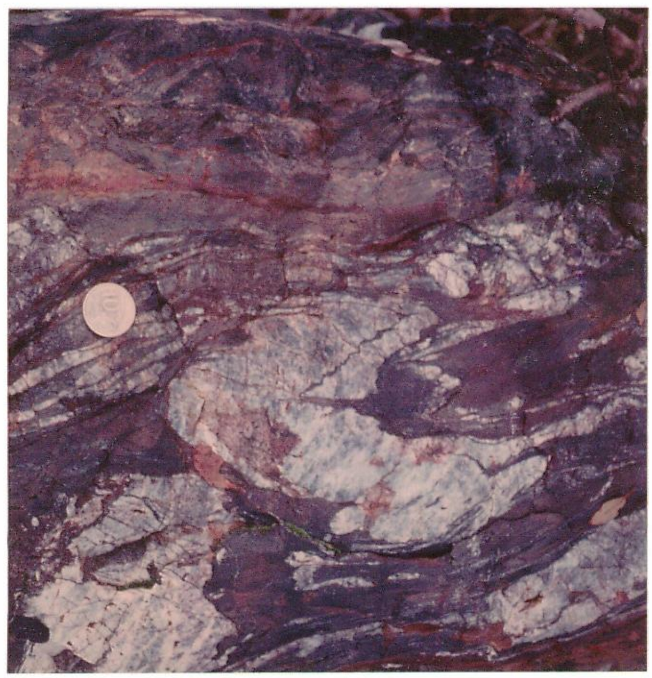

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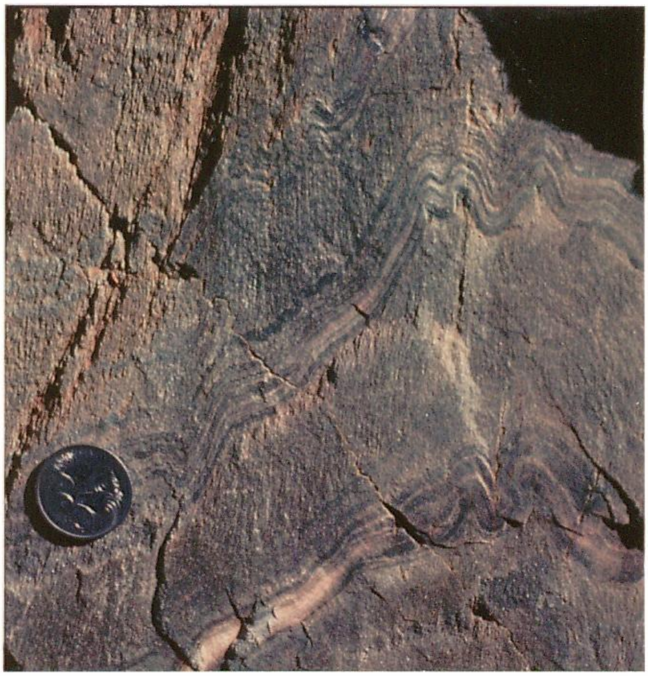

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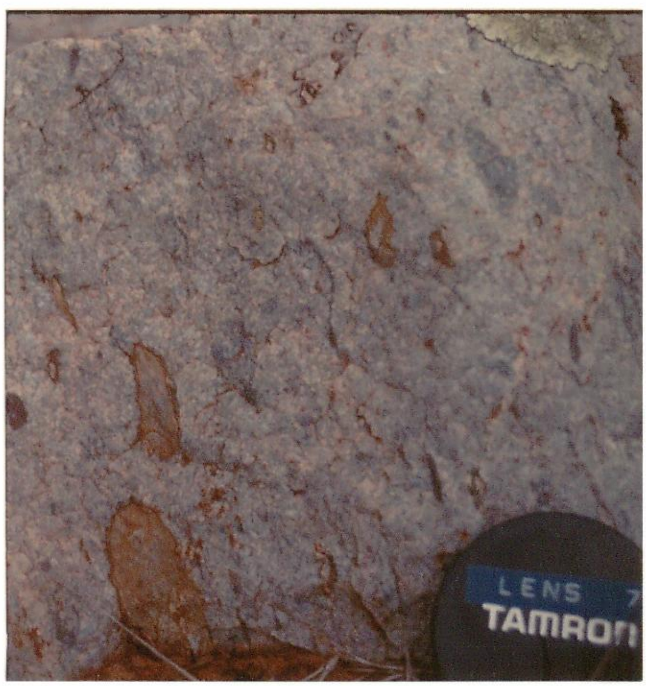

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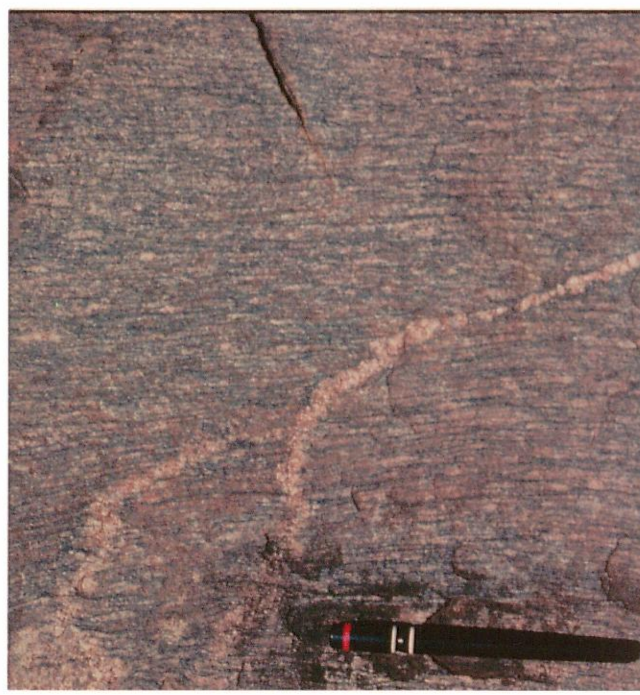

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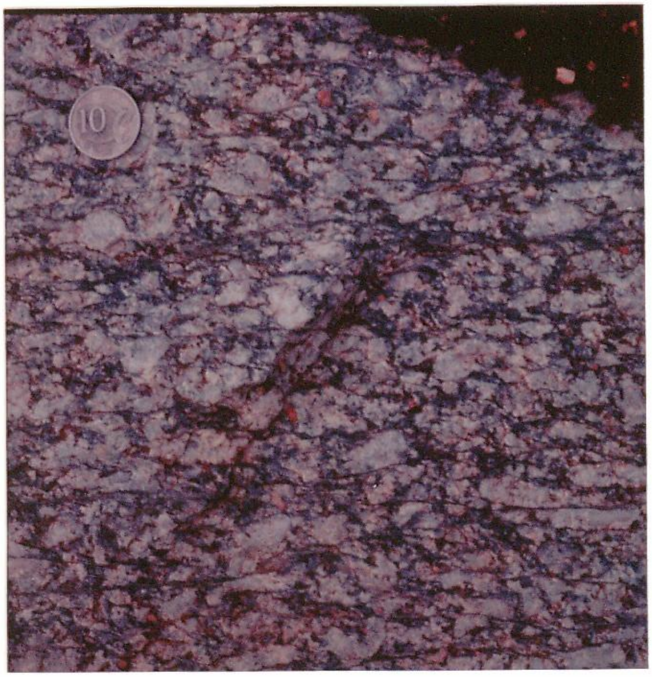

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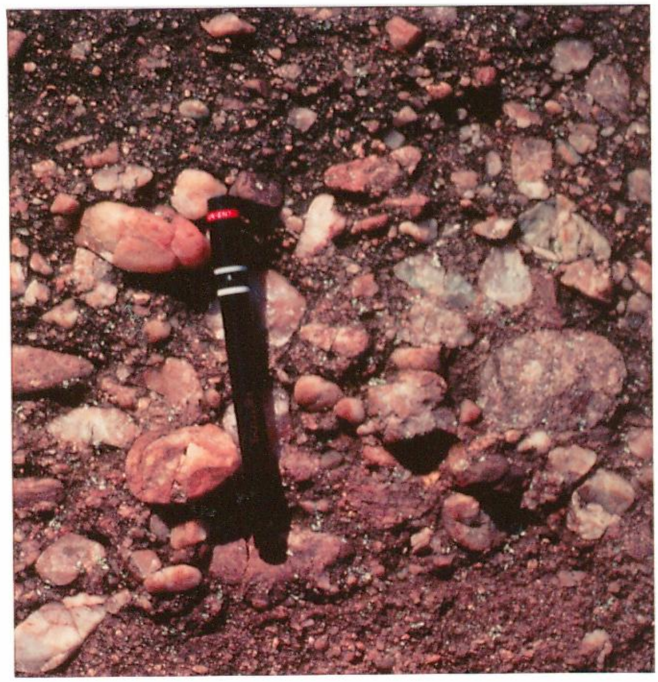

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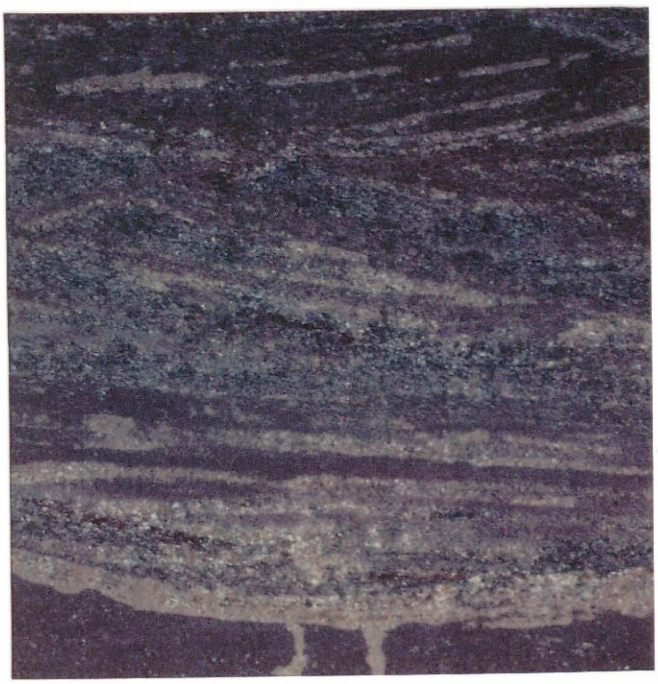

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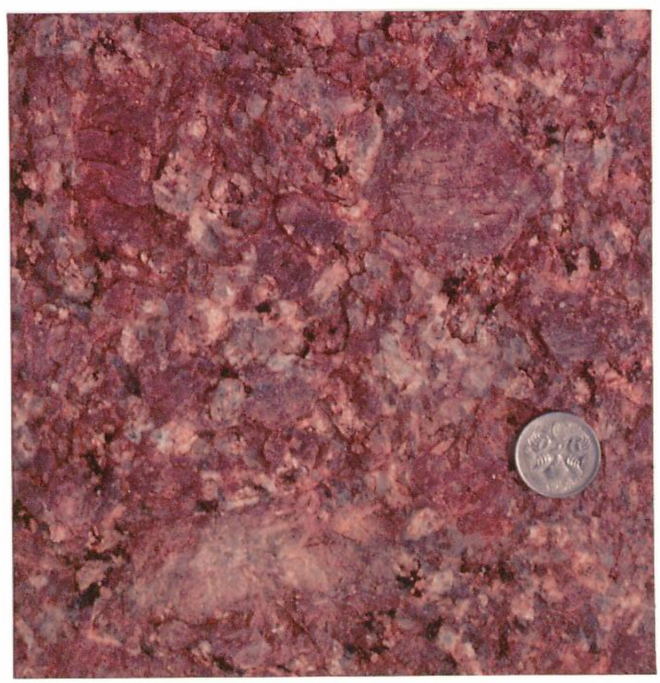

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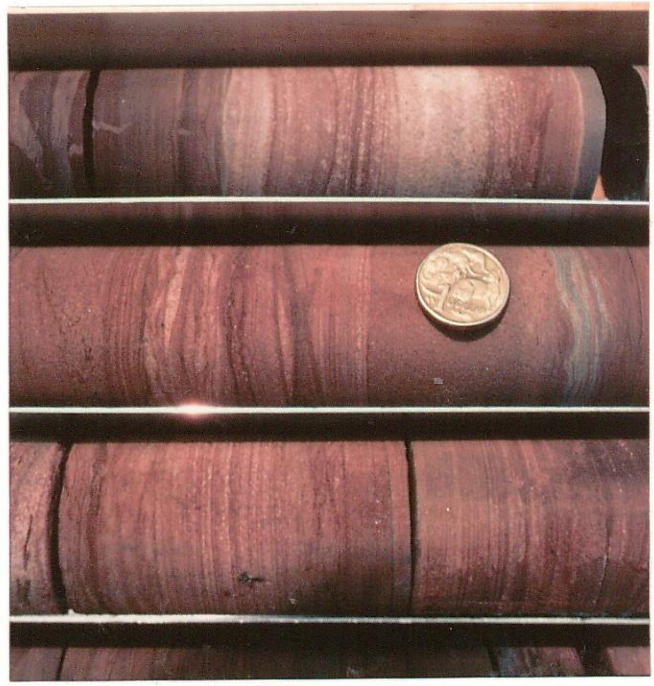

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