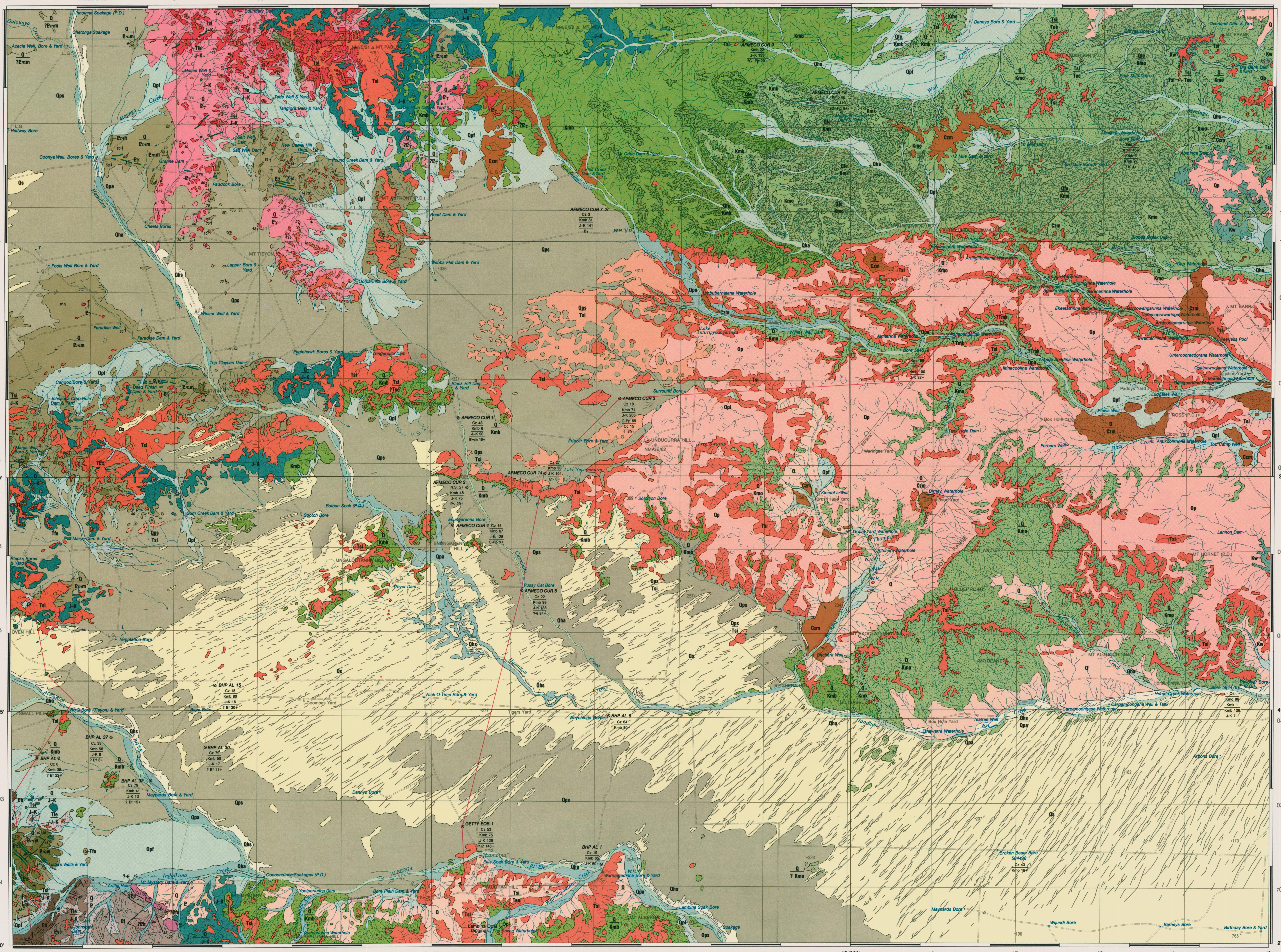
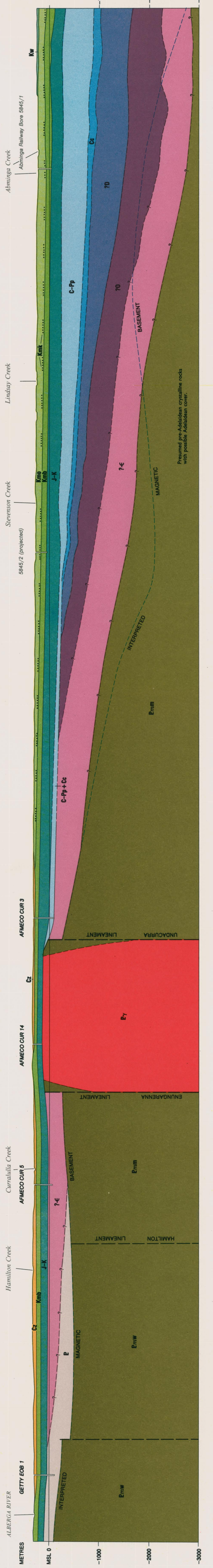
ABMINGA

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA
DEPARTMENT OF MINES AND ENERGY, ADELAIDE

AUSTRALIA 1 : 250 000

S.A. GEOLOGICAL ATLAS SERIES SHEET SG 53-10 ZONE 5





FIRST EDITION 1984

REFERENCE

CAINOZOIC

QUATERNARY — HOLOCENE

- **Qha** — Sand, gravel, silt and clay of modern drainage channels.
- **Qhs** — Sand of source-bordering dunes adjacent to larger streams.
- **Qfe** — Spreads of ferruginous gravel (including maghemite) with silcrete and porcellanite clasts, forming a lag on pale-brown silt and red-brown clay. Overlies various Cretaceous units as shown on map.
- **Q** — Undifferentiated Quaternary deposits, including reworked PEDIRKA FORMATION, equivalents of POORAKA FORMATION and CALLABONNA CLAY, minor calcrete and gypsite. Where thin, shown as an overlay on underlying sedimentary unit.

LATE PLEISTOCENE

- **Qpf / Qpa** — Consolidated clay, silt, sand and gravel of floodplains and low-angle slopes (Qpf) and older alluvium of the larger streams (Qpa). Includes WOODGATE GRAVEL: Weakly calcreted sand and gravel; clasts are predominantly silcrete and Mesozoic sediments.
- **Qs** — SIMPSON SAND: Red-brown, fine to medium quartz sand of linear dunes and clayey sands of interdunal flats.
- **Qps** — Flat spreads of red-brown sand and silt with scattered patches of fine maghemite gravel.
- **Qp** — PEDIRKA FORMATION: Red-brown, structured sandy clay, overlain by thick mantle of silcrete clasts.

?MIOCENE – EARLY PLEISTOCENE

- **Czm** — MOUNT WILLOUGHBY LIMESTONE and equivalents: White cryptocrystalline limestone and pinkish-brown very fine sandy limestone with a capping of chalcedonic and opaline silica. Passes laterally and vertically into red-brown ferruginous sandstone and siltstone with opaline silica, minor carbonate, and clasts of ironstone, silcrete and Mesozoic sediments.

TERTIARY — ?MIOCENE

- **Tmk** — MIRACKINA CONGLOMERATE equivalent: Brown-black ferruginous and silicified medium to very coarse quartz sandstone with rounded silcrete pebbles.

EOCENE–OLIGOCENE

- **Qps/Tsi, Tsi, Tfe** — CORDILLO SILCRETE (Tsi): Hard, pale-grey siliceous duricrust often showing a columnar structure, overlying weaker nodular silcrete. Qps/Tsi: Silcrete gravel with thin overlays of sand. Tfe: Dark-brown ferruginised and silicified coarse quartz sandstone.

PALEOCENE–EOCENE

- **Tee** — EYRE FORMATION: Fine to coarse quartz sandstone with basal conglomerate of polished quartz and chert pebbles. (Rock Relation Diagram only).
- **Cz** — Undifferentiated Cainozoic sediments; includes thick sequences of sandstone, gravel, clay and silt of Tertiary age underlying the sand plains. (Drillhole, Section and Rock Relation Diagram only).

SEQUENCE OF EROMANGA BASIN

MESOZOIC — CRETACEOUS — ALBIAN–?CENOMANIAN

- **Kw** — WINTON FORMATION: Bleached and porcellanitised, fine to coarse clay arenite with claystone clasts; claystone, siltstone and very fine sandstone with thin lenticular bedding and cross-lamination (may include MOUNT ALEXANDER SANDSTONE MEMBER of OODNADATTA FORMATION).

ALBIAN — NEALES RIVER GROUP — MARREE SUBGROUP

- **Kmo** — OODNADATTA FORMATION: Deeply-weathered, interbedded claystone, siltstone and fine to very fine sandstone.
- **Kmk** — COORIKIANA SANDSTONE: Khaki-yellow, ferruginous, burrowed clayey and silty fine to very fine sandstone, thin beds of medium to coarse quartz sandstone, siltstone and claystone.

NEOCOMIAN–APTIAN

- **Kmb** — BULLDOG SHALE: Medium to dark-grey (fresh), silty claystone and siltstone with burrowed lenticular laminae of silt and very fine sand, pyritic and carbonaceous; ferruginised silty very fine to fine quartz sandstone. Rarely fossiliferous. Basal part with layers of clayey and pebbly very fine to very coarse quartz sandstone and scattered rounded Adelaidean boulders, equivalent to CADNA-OWIE FORMATION.

JURASSIC

- **J–K** — ALGEBUCKINA SANDSTONE: Upward-fining fluvial sequences of grey carbonaceous claystone with minor coal layers, grading down to pale-grey silty very fine to very coarse cross-bedded kaolinitic quartz sandstone with basal quartz pebble layers and claystone clasts; scattered Adelaidean clasts.

SEQUENCE OF PEDIRKA BASIN (SUBSURFACE ONLY)

PALAEOZOIC — CARBONIFEROUS PERMIAN

- **C–Pp** — PURNI FORMATION: Thinly-interbedded, off-white, kaolinitic siltstone, very fine sandy siltstone and silty very fine to fine sandstone; pale blue-grey laminated siltstone with minor clay lenticules.
- **Cc** — CROWN POINT FORMATION: Kaolinitic fine to coarse quartz sandstone with rounded pebbles and cobbles of Adelaidean quartzite and siltstone.

SEQUENCE OF WARBURTON BASIN

(Extrapolated from sequences of Mt Johns Ranges (EVERARD 1 : 250 000) and Mt Crispe 1 and Witcherrie 1 drillholes (DALHOUSIE 1 : 250 000))

- **?D** (?DEVONIAN) — Sediments of unknown lithology interpreted in the subsurface. May include equivalents of FINKE GROUP and MEREENIE SANDSTONE. (Section and Rock Relation Diagram only).
- **?O** (?ORDOVICIAN) — Sediments of unknown lithology interpreted in the subsurface. May include equivalents of STAIRWAY SANDSTONE. (Section and Rock Relation Diagram only).
- **?-Є** (?CAMBRIAN) — WALLATINNA FORMATION equivalent?: Purplish-brown, well-indurated, fine to very coarse feldspathic sandstone with mudstone intraclasts and heavy-mineral laminae, lenticular bedding and cross-bedding, interbedded purplish-brown siltstone and grey-green claystone. Fine-grained sandy feldspathic granitic conglomerate. Equivalents of PERTAOORRTA GROUP may occur in Eringa Trough.

SEQUENCE OF BITCHERA RIDGE AND MOORILYANNA GRABEN

LATE PROTEROZOIC — ADELAIDEAN — MARINOAN

- **?Ᵽe** (?YERELINA SUBGROUP) — MOUNT CURTIS TILLITE equivalent?: Grey and red-brown, silty and sandy diamictite with clasts of quartzite, chert, limestone, sandstone and granite; grey and red-brown micaceous laminated siltstone and fine sandstone; medium to coarse feldspathic quartzite.
- **?Ᵽfe** (UMBERATANA GROUP — WILLOCHRA–FARINA SUBGROUPS) — ENORAMA SHALE equivalent?: Purple and grey siltstone and very fine sandstone; pale-grey medium to very coarse feldspathic quartzite with interbeds of brown and grey-green siltstone.
- **?Ᵽh** — ETINA FORMATION equivalent?: Dark-grey to black massive silty limestone with thin interbeds of pebbly and coarse sandy dolomite; minor calcareous medium sandstone.
- **Ᵽf** — RODDA BEDS and TAPLEY HILL FORMATION equivalent (undifferentiated): Calcareous and dolomitic siltstone with interbeds of grey-brown limestone and dolomite. Grey-green siltstone with interbeds of very fine to coarse feldspathic sandstone.

STURTIAN

- **Ᵽyc** (YUDNAMUTANA SUBGROUP) — CHAMBERS BLUFF TILLITE: Yellow-brown and purple-brown (hematitic) diamictite with silty to fine sandy matrix, and granules to boulders of quartz, quartzite, chert, jasper and granite; interbeds of pebbly medium to very coarse feldspathic sandstone and quartzite.
- **Ᵽb** (BURRA GROUP — ?BELAIR SUBGROUP) — White, pale-brown and purplish-grey thin-bedded medium quartzite and feldspathic quartzite; white, pale-grey and yellow-brown siltstone and fine sandstone. Basal quartz pebble conglomerate.
- **Ᵽ** — Undifferentiated Adelaidean sediments.

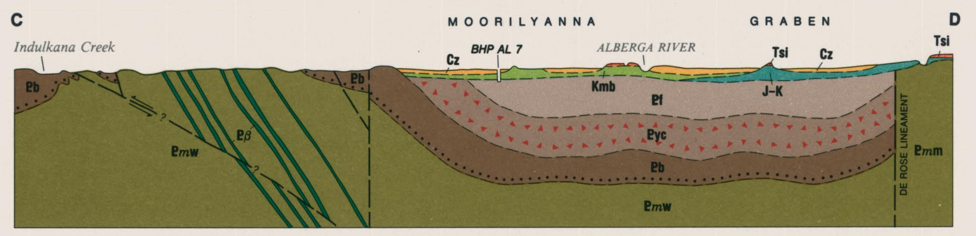
CRYSTALLINE BASEMENT OF MUSGRAVE BLOCK

EARLY–MIDDLE PROTEROZOIC

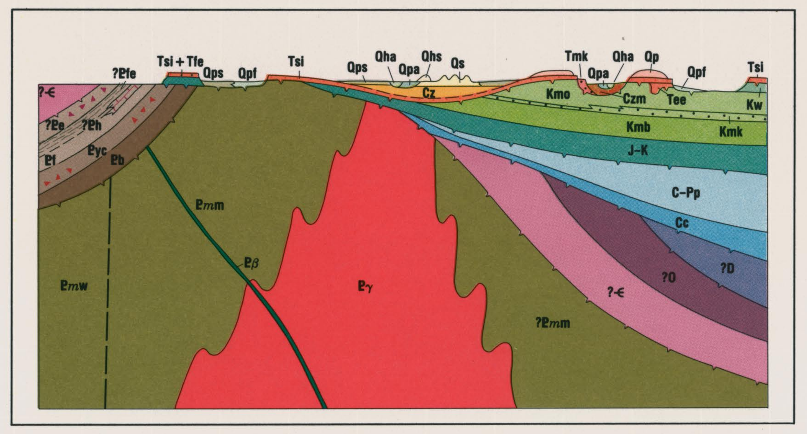
- **Ᵽβ** — Dolerite and gabbro dykes.
- **Ᵽγ, Q/Ᵽγ** — Porphyritic biotite adamellite, porphyritic hornblende-biotite adamellite and granite, porphyritic leucogranite and microgranite, and minor biotite granodiorite; pegmatite, aplite and quartz veins. K-Ar ages of 1031–1124 Ma.
- **Ᵽmm, Q/Ᵽmm** (MUSGRAVE–MANN METAMORPHICS) — Foliated feldspar-quartz-biotite and quartz-biotite gneiss of granitic and adamellitic composition.
- **Ᵽmh** — Hornblende-plagioclase gneiss (north of Coonya Well).
- **Ᵽmw, Q/Ᵽmw** — WATARU GNEISS: Metasedimentary foliated granitic and adamellitic biotite gneiss and augen gneiss, quartz-feldspar-muscovite schist; quartz and pegmatite veins. Outcrops south of Moorilyanna Graben. Quartzite.

GEOLOGICAL BOUNDARY	
OBSERVED	FLOODPLAIN
INFERRED	DRAINAGE DEPRESSION
FAULT	WATERHOLE, DAM (W.H.)
OBSERVED	BORE, WELL, TANK (W, T)
INFERRED	RELIEF FEATURES
BEDDING	TRIANGULATION STATION
STRIKE AND DIP (30)	ASTRONOMICAL STATION
TREND	ESCARPMENT
METAMORPHIC FOLIATION	MESA, PINNACLE
STRIKE AND DIP (50)	IDENTIFIED POINT
VERTICAL	SPOT HEIGHT (ELEVATION IN METRES) (223)
MACROFOSSILS	SAND DUNE
GEOLOGICAL SECTION (A–B)	CULTURAL FEATURE
SEISMIC SURVEY LINE	SECONDARY ROAD
ABANDONED OPAL DIGGINGS (Op)	TRACK
EXPLORATION DRILLHOLE	PASTORAL BOUNDARY FENCE
HYDROGRAPHIC FEATURE	HOMESTEAD ("Abminga")
DRAINAGE (INTERMITTENT)	YARD (Yd)
	LANDING GROUND (L.G.)

SECTION C–D
(DIAGRAMMATIC)



ROCK RELATION DIAGRAM



SCALE
1 : 250 000

KILOMETRES 5 0 5 10 15 20 25 KILOMETRES

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Geological mapping by R. B. Major, B.Sc.(Hons) and P. A. Rogers, B.Sc.(Hons) with contributions from R. P. Coats, B.Sc., B. G. Forbes, Ph.D., J. E. Johnson, G. W. Krieg, B.Sc.(Hons), G. M. Pitt, B.Sc., A. F. Williams, B.Sc.(Hons) and H. M. Wing.

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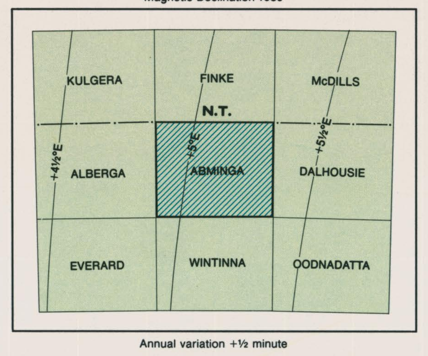
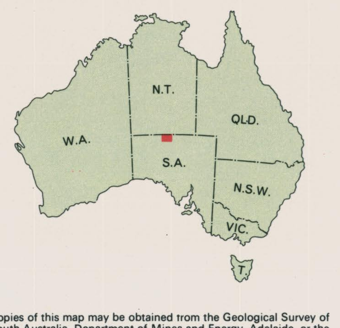
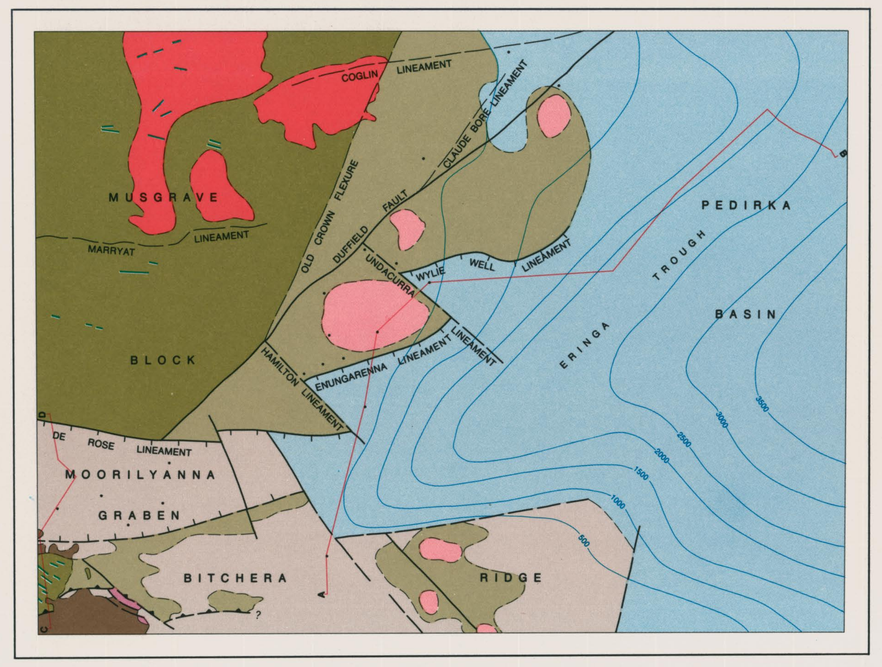


Annual variation +½ minute



TECTONIC SKETCH (PRE-MESOZOIC)



- Permian and older Palaeozoic sediments of Pedirka and Warburton Basins
- ?Cambrian sediments of western Bitchera Ridge
- Adelaidean sediments of Bitchera Ridge and Moorilyanna Graben: Outcrop and near-surface; Subsurface
- Proterozoic dolerite and gabbro dykes
- Proterozoic granitic rocks: Outcrop and near-surface; Subsurface
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- Interpreted magnetic lineament
- Interpreted depth to magnetic basement contours (metres below sea level)(from SADME 1 : 1 000 000 map, published 1981) (1500)
- Borehole intersecting pre-Mesozoic rocks
- Geological Section (A–B)

ABMINGA
SHEET SG 53-10

ABMINGA

SOUTH AUSTRALIA

Explanatory Notes

1: 250 000 Geological Series—Sheet SG/53-10

Geological Survey of South Australia

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

ABMINGA

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P. A. ROGERS

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Explanatory Notes for the ABMINGA 1:250 000 Geological Map

P.A. Rogers

INTRODUCTION

The ABMINGA 1:250 000 map area (referred to in these notes as ABMINGA) lies in the extreme north of South Australia, between latitudes 26° and 27°S and longitudes 133°30′ and 135°E. The South Australia-Northern Territory border forms the northern boundary of the map area.

Portions of several large cattle stations cover the map area. These are: Tieyon, Granite Downs, Lambina, Crown Point, Hamilton, and Todmorden. Granite Downs Station, in the southwest corner of ABMINGA, has been incorporated in the Pitjantjatjara Land although the present pastoral lease has not yet expired. Apart from Tieyon and Lambina homesteads, the sheet area is uninhabited. The nearest settlements are Oodnadatta, Indulkana and Marla in South Australia, and Finke and Kulgera in the Northern Territory.

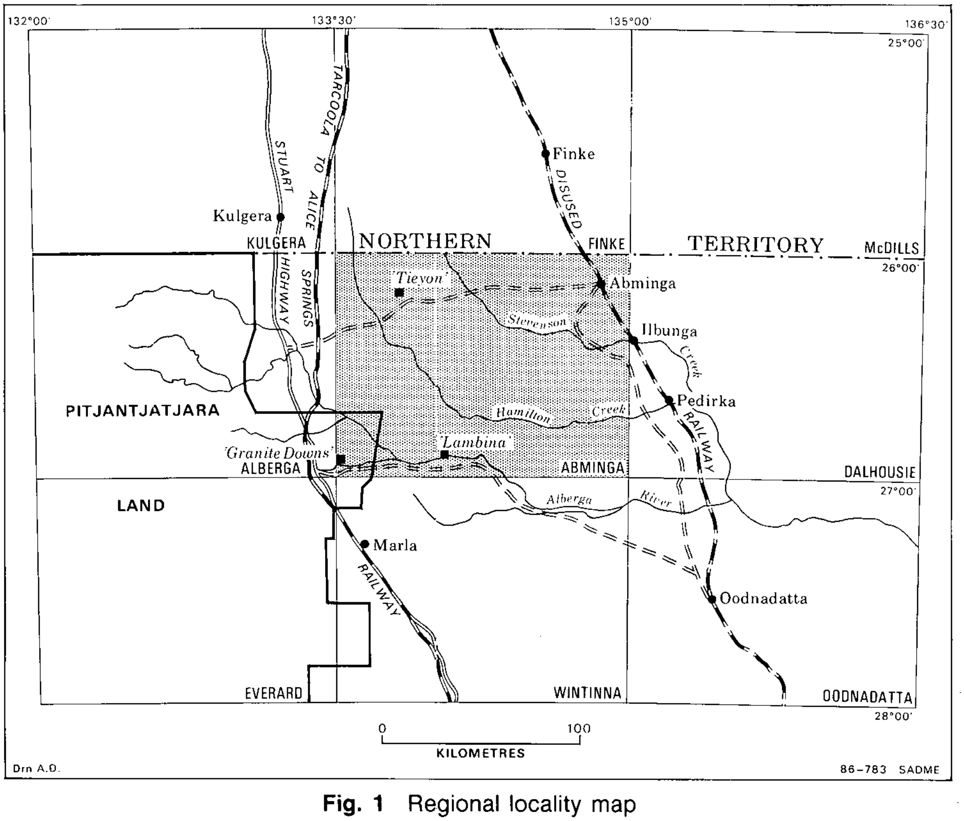

Fig. 1 Regional locality map

The Oodnadatta Track, which joins the Stuart Highway near 'Granite Downs', passes through the southwestern part of ABMINGA, and station tracks provide access to most of the map area. The old Marree-Alice Springs railway that passes through the northeast corner of ABMINGA is now disused, and the siding camp at Abminga has been abandoned. The new Tarcoola-Alice Springs railway lies about 10 km west of the sheet area, and the Stuart Highway is up to 20 km further west.

The area has a hot dry desert climate with short cool to mild winters. Mean annual rainfall (150 mm) is low compared to mean annual evaporation (4000 mm). Seasonal and diurnal ranges in temperature are high. At Oodnadatta, mean maximum and minimum temperatures for January are 38.2°C and 23.2°C, while the corresponding temperatures for July are 19.4°C and 5.8°C.

The location and geological setting of the map area are shown in Figures 1 and 3. Photo-interpreted geological boundaries were drawn on colour aerial photographs at 1:87 500 scale (Surveys 2674-2677, flown 3-4 March, 1981).

PREVIOUS WORK

Early work on the geology of ABMINGA is described in Brown (1905) and Jack (1915).

The present phase of geological investigations commenced in 1953, with a reconnaissance survey by R.C. Sprigg, R.B. Wilson, R.P. Coats and J.E. Johnson. A helicopter survey of the western Great Artesian Basin in 1971 included 78 observations on ABMINGA (Krieg, 1973a). Between 1968 and 1973, R.B. Major carried out fieldwork in the sheet area, particularly on the basement outcrops in the west. Photo-interpreted geological boundaries were drawn on black and white aerial photographs at scales of 1:59 000, 1:79 000 and 1:80 900. These boundaries were plotted onto 1:78 000 topographic bases covering the twelve 1-mile sheet areas, but a 1:250 000 preliminary geological map was not compiled.

Most adjoining 1:250 000 geological maps have been published. These are: ALBERGA (Coats, 1963; Sprigg and others, 1959), OODNADATTA (Freytag and others, 1967), EVERARD (Krieg, 1973b), McDILLS (Stewart, 1968), KULGERA (Stewart, 1967), FINKE (Wells, 1969) and DALHOUSIE (Krieg, 1985). A preliminary edition of WINTINNA has been compiled (Barnes, 1974). In addition, two adjoining 1:63 360 geological maps have been published: *Chandler* (Sprigg and others, 1956) and *Indulkana* (Sprigg and others, 1955). Conor (1978a, b, c, d) has mapped the four 1:50 000 sheets of the *Eateringinna* 1:100 000 sheet—the most recent and detailed mapping within the Musgrave Block in South Australia.

Hancock (1970) prepared a report and geological map covering the *Tieyon* 1:63 360 map area for Kennecott Explorations (Aust.) Pty Ltd. In 1979, Afmeco Pty Ltd drilled five diamond drillholes in the central part of ABMINGA, which provided valuable information on subsurface Mesozoic and Palaeozoic units (French, 1980).

The regional geology of the Musgrave Block is discussed in Thomson (1975). Smith (1979) used aeromagnetic and gravity data to produce a structural interpretation of the Musgrave Block; this interpretation was later refined in the ABMINGA area (French, 1980). Geochronological work on the

Musgrave Block, carried out by AMDEL between 1969 and 1977, is summarised in Webb (1985).

Youngs (1975) describes the geology and hydrocarbon potential of the Pedirka Basin. For treatments of the Amadeus and Eromanga Basins in areas adjacent to ABMINGA, see Wells and others (1970) and Senior and others (1978). Recent work on the Officer Basin in South Australia is summarised in Pitt and others (1980) and Benbow (1982). Gatehouse (1982) has written a report on the Early Palaeozoic Warburton Basin in South Australia.

PHYSIOGRAPHY AND VEGETATION

The ABMINGA sheet area can be divided into five physiographic zones (see Fig. 2) which are described in the following notes, based largely on the work of Laut and others (1977).

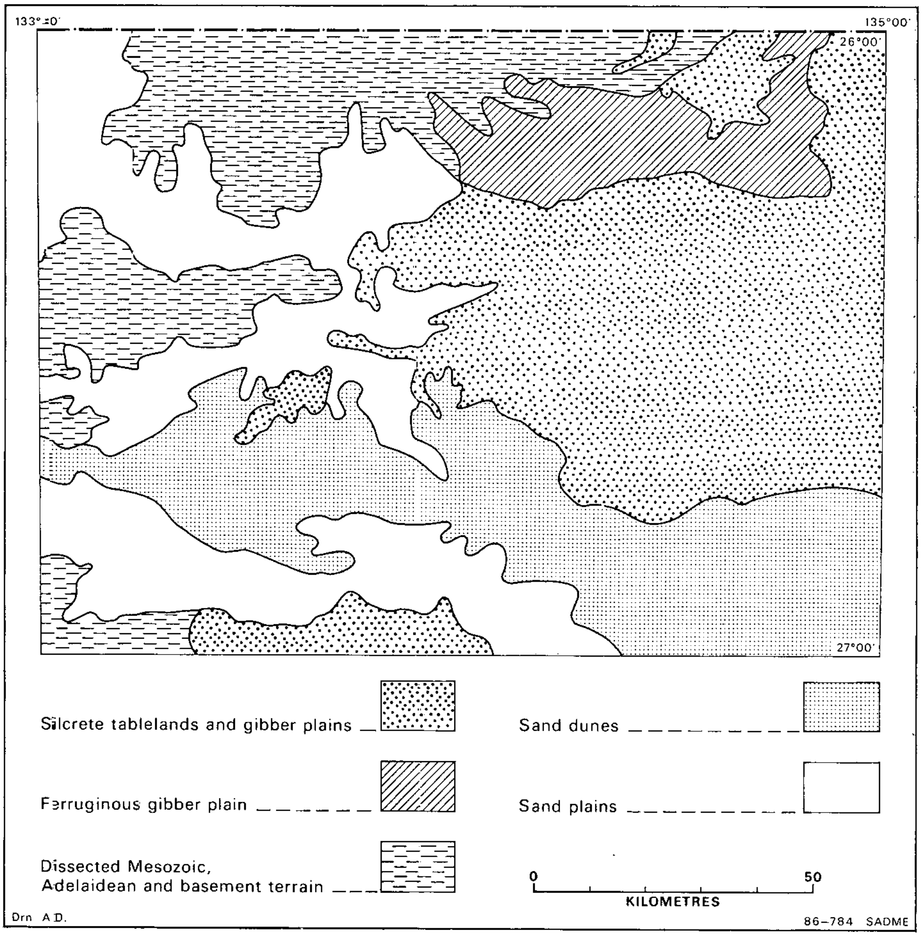

Fig. 2 Physiographic regions

Silcrete tablelands and gibber plains: These areas consist of dissected Tertiary silcrete tablelands with gibber plains both overlying the silcrete, and forming broad slopes at the feet of silcrete escarpments. Altitude ranges from 185 m in the extreme northeast corner of ABMINGA, to 334 m at Mount Britton.

The area is vegetated with a sparse shrub cover of saltbush (*Atriplex* spp.) and bindyi (*Bassia* spp.), with short-lived tufted grasses such as Mitchell grass (*Astrebla pectinata*), kerosene grass (*Aristida contorta*) and blackheads (*Enneapogon* spp.). Gidgee (*Acacia cambagei*) and coolibah (*E. microtheca*) grow in the watercourses.

Ferruginous gibber plain: This zone is made up of a gently undulating plain interspersed with numerous mesas of altered Mesozoic sedimentary rocks, and covered by gravel composed largely of ironstone derived from iron-rich zones in the Mesozoic units. The high ironstone content of the surface gravel gives this area a prominent dark colour on aerial photographs and LANDSAT imagery. Altitudes range from 251 m to 327 m.

Vegetation consists of a low open woodland of mulga (*Acacia aneura*), witchetty bush (*A. kempeana*) and native fuchsia (*Eremophila* spp.), with a ground cover of kerosene grass, cotton grass (*Digitaria brownii*), blackheads, bindyi and forbs. Gidgee, coolibah and mulga grow in the watercourses.

Dissected Mesozoic, Adelaidean and basement terrain: In these areas, the underlying rocks are usually deeply weathered and are overlain in places by remnants of a Tertiary silcrete surface. Inselbergs of granitic rocks are common in the west. The Mesozoic terrain of central northern ABMINGA has a distinctive very fine dendritic drainage pattern, well displayed on aerial photographs. Altitudes vary from 308 m to 544 m at Mount Darling, the highest point on ABMINGA.

The areas are vegetated with a low open woodland of mulga, native fuchsia and witchetty bush with a ground cover of saltbush (*Atriplex vesicaria*), bindyi, mountain wanderrie (*Eriachna mucronata*), cottongrass and forbs. The large watercourses and floodplains are marked by groves of redgum (*E. camaldulensis*), elegant wattle (*Acacia victoriae*), mulga, red mallee (*E. socialis*), beefwood, bloodwood and needlebush (*Hakea* spp.).

Sand dunes: The northeast-trending linear sand dunes are approximately 6 m high, up to 16 km long and are from 0.5 to 1 km apart. The dunes are superimposed on a gently undulating plain rising westwards from 165 m (the lowest point on ABMINGA) to 290 m.

The sand hills support a tall shrubland of needlebush, *Grevillea* spp., sandhill wattle (*Acacia ligulata*) and mintbush, with a ground flora of bandicoot grass, kerosene grass and feathertop spinifex (*Triodia* sp.). A mulga woodland similar to that of the sand plains (see below) occupies the interdune corridors.

Sand plains: These include large areas of sandy outwash adjacent to basement and Mesozoic outcrops, and sand spreads marginal to areas of sand dunes. The sand plains are flat to gently undulating with altitudes ranging from 233 m to 356 m.

Vegetation consists of a low open woodland of mulga, native fuchsia, birdseye (*Cassia* spp.) and needlebush with a ground cover of bandicoot grass, woollybutt and cotton grass.

STRATIGRAPHY AND GEOLOGICAL HISTORY

The stratigraphic relationships of the various rock units are summarised in Tables 1, 2, 3 and 4. Aspects of stratigraphy and geological history are discussed briefly in these notes.

Proterozoic metamorphic rocks of the Musgrave Block are exposed in the west of ABMINGA. These are intruded by Proterozoic granitic bodies and dolerite dykes.

A sequence of Adelaidean sediments crops out in the southwest corner of the sheet area, and occurs in the subsurface in the southern part of ABMINGA.

Clastic sediments of probable Cambrian age, are exposed in a small area in the southwest of ABMINGA, and have been encountered in drillholes in the central part of the sheet area. A thicker Palaeozoic sequence is inferred in the Eringa Trough from seismic data.

Carboniferous-Permian deposits of the Pedirka Basin overlie the older Palaeozoic rocks.

Much of the sheet area is blanketed by Jurassic-Cretaceous fluvial and marine sediments of the Eromanga Basin, and various Cainozoic units.

Early to Middle Proterozoic

Musgrave-Mann Metamorphics (Ꞓmm+Ꞓmw)

The oldest rocks on ABMINGA are amphibolite facies granite and adamellite gneisses of the *Musgrave-Mann Metamorphics* (Thomson, 1964) which outcrop in the west of the map area. The gneisses can be divided into two units separated by the Moorilyanna Graben: Wataru Gneiss, and undifferentiated Musgrave-Mann Metamorphics. Biotite gneiss in the 'Granite Downs' area is referred to the *Wataru Gneiss* (Major, 1971), which is included within the Musgrave-Mann Metamorphics. North of the graben, undifferentiated Musgrave-Mann Metamorphics show more effects of granitisation, possibly as a result of greater uplift in the north of the sheet area.

The foliated granitic gneisses in the northwest of ABMINGA have a typical composition as follows:

microcline	25-30%
plagioclase	25-30%
quartz	25-30%
biotite	10-15%
opaques(mainly magnetite)	1-2%

with traces of sphene, zircon and apatite (Whitehead, 1969). Altered and partly silicified quartz-biotite gneiss, and hornblende-pyroxene-calcic plagioclase gneiss (Ꞓmh) north of Coonya Well are the only variations in an otherwise uniform sequence (Hancock, 1970).

The well-foliated biotite gneiss of the Wataru Gneiss also shows little variation in lithology, apart from a thin quartzite layer which is seen just east of 'Granite Downs'. The quartzite can be traced onto ALBERGA where it overlies an amphibolite (Coats, 1963).

UNITS	EVENTS		AGE (Ma)	
PEDIRKA BASIN SEDIMENTS (C-P)	Fluvial and glacial deposition.		270–290	PALAEOZOIC
(unconformity)	Gentle uplift and tilting; thrust faulting at basement margins	ALICE SPRINGS OROGENY	~340–360	
WARBURTON BASIN SEDIMENTS (Є-?D)	Sedimentation, probably with periods of non-deposition or erosion. Coarse clastic deposition at basin margin.		~350–550 521 ± 142	
(unconformity)	Deformation of Adelaidean sediments.	PETERMANN RANGES OROGENY	~600	LATE PROTEROZOIC
ADELAIDEAN SEDIMENTS (Ꝑ)	Sedimentation with periods of non-deposition or erosion.		~700–800	
(unconformity)	Uplift and erosion.			
BASIC DYKES (Ꝑβ)	Intrusion of mafic magma along fractures.	MUSGRAVIAN OROGENIC PHASE	1000–1120	EARLY-MIDDLE PROTEROZOIC
(unconformity)	Uplift and erosion, crustal fracturing.			
KULGERAN GRANITES (Ꝑγ)	Melting of gneisses.			
MUSGRAVE-MANN METAMORPHICS (Ꝑmm)	High-grade metamorphism and deformation. Acid volcanism?		1600–1700	

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Table 1 Summary of Proterozoic and Palaeozoic geology

Geochemical studies of the metamorphic sequence on the *Eateringinna* 1:100 000 sheet area (ALBERGA) suggest that most of the gneisses are derived from igneous rocks. The granitic gneisses, for example, are shown to have an acid igneous origin, and rhyolitic ignimbrites or lavas are proposed as likely parent materials (C.H.H. Conor, pers. comm.). Similar granitic gneisses on ABMINGA are also thought to have an acid igneous origin.

Rubidium-strontium dating of Musgrave-Mann Metamorphics from areas west of ABMINGA has shown that these rocks were subjected to a period of high-grade metamorphism between 1700 and 1600 Ma, contemporaneous with the Kimban Orogeny of the Gawler Craton (Webb, 1985).

However, it should be noted that Gray (1978) interpreted a much younger metamorphic age (about 1200 Ma) for gneisses in the western Musgrave Block. This age is roughly contemporaneous with the beginning of the Musgravian Orogenic Phase (see below). Gray regarded older Rb/Sr ages of 1330-1550 Ma as the age of formation of the parent materials, which he thought were acid volcanics. In this case, the acid volcanics would be contemporaneous with the Gawler Range Volcanics.

Kulgeran granites (Ꝑγ)

A variety of granitic rocks have intruded gneisses of the Musgrave-Mann Metamorphics in northwest ABMINGA. Different types noted by Hancock (1970) and R.B. Major (MS) are:

1. grey fine to medium grained biotite granodio-ite
2. pink porphyritic microgranite

3. reddish coarse-grained granite
4. medium to coarse-grained hornblende adamellite and hornblende granite
5. medium to coarse-grained porphyritic biotite adamellite with microcline phenocrysts.

These varieties are listed roughly in order of increasing age, as inferred from intrusive relationships. However, clear intrusive contacts have not been seen between all the units, so the chronological order should be regarded as approximate only. Also, it is possible that some types are the result of differentiation within a single intrusion. Because of patchy outcrop and uncertain relationships, all the granitic rocks have been mapped as one unit (Pγ).

The porphyritic adamellite (type 5) is the dominant intrusive type on ABMINGA, with a typical composition as follows:

microcline	20-30%
plagioclase	20-30%
quartz	20-30%
biotite	5-15%
magnetite	1-2%
sphene	1-2%

with traces of amphibole, apatite, zircon and allanite (Whitehead, 1969). Differentiation within the adamellite has produced areas richer in biotite (10-15%) and magnetite (1-5%).

The effects of granitisation increase northwards. In the Granite Dam and 'Tieyon' areas, granite occurs as bands within foliated gneiss. Some bands of gneiss pass transitionally northwards into granite of similar composition. The granite bands have flow-oriented feldspar phenocrysts and contain deformed xenoliths of the adjacent gneiss. These features suggest that the granites have formed by melting of the gneisses, with limited mobilisation. Further north, the granites are massive or irregularly flow-banded, with intrusive contacts and xenoliths of gneiss which cannot be matched with the intruded rock.

Pegmatite, quartz and minor aplite veins intrude all the basement rocks on ABMINGA. They are most abundant in the granites and adjacent gneisses, and were the last intrusive elements to be formed during the period of granitisation. Pegmatites consist of quartz, feldspar, biotite, magnetite and minor allanite. Some are up to 2 m wide and are zoned with K feldspar margins and quartz centres. Widespread thin quartz veins, and quartz-feldspar veins in the Wataru Gneiss which are parallel to gneissosity, formed as a result of segregation during the earlier period of high-grade metamorphism.

Potassium-argon dating of granitic rocks from ABMINGA has yielded ages ranging from 1124 to 1031 Ma. Rubidium-strontium and K-Ar dating of granites from other locations in the Musgrave Block indicates that granitisation occurred in the period from 1120 to 1000 Ma. This magmatic event was previously called the *Kulgeran Orogeny*, and is now referred to as the *Musgravian Orogenic Phase* (Thomson, 1980). However, the granites formed at this time are still referred to informally as Kulgeran granites. The K-Ar dates mentioned above were obtained from both hornblende and biotite and, in general, the hornblende dates are older by up to 100 million years. This suggests a slow regional cooling that allowed continued outgassing of radiogenic argon from biotite until temperatures fell to about 230°-350°C, when argon began to be retained within the biotite (Webb, 1985).

Basic dykes (Ɛβ)

The youngest igneous event of the Musgravian Orogenic Phase was the intrusion of tholeiitic and olivine basalt magma along fracture zones in the gneisses and granites, resulting in the formation of a series of dolerite dykes. The mantle-derived basic magmas gave rise to dolerite, quartz dolerite and olivine dolerite varieties, with the coarse grained equivalents, gabbro and olivine gabbro, occurring in the centres of larger dykes. The dyke rocks typically contain plagioclase (labradorite) (40-60%), clinopyroxene (20-50%) and iron oxide (1-10%). Orthopyroxene (5-10%), olivine (5-20%) and quartz (up to 5%) may also be present (Whitehead, 1969).

In the northwest of ABMINGA, large dykes trend in east to east-southeast directions; these are up to 15 m wide and can be traced for up to 24 km. Several smaller dykes have a northeasterly strike. Dolerite dykes intruding Wataru Gneiss in the 'Granite Downs' area have a northwesterly orientation, and are up to 60 m wide. In places, the larger dykes are multiple and consist of two or three closely spaced parallel dykes. The larger east to northwest-trending dykes, and the smaller northeast-trending dykes probably correspond to separate phases of dyke intrusion, as mapped by Conor (1978) on ALBERGA.

Potassium-argon dates of the dolerites show too wide a scatter to provide a usable geochronological age (Webb, 1985).

Between Coonya Well and 'Tieyon', deuteric alteration of the basic dykes has resulted in intense epidotisation of the dyke rocks and adjacent gneisses and granites (Hancock, 1970).

Adelaidean

A sequence of late Proterozoic sediments is exposed in the southwest corner of ABMINGA, to the north and southeast of an area of Wataru Gneiss. Further Adelaidean sediments occur in the subsurface in the Moorilyanna Graben and along the Bitchera Ridge. In addition, a late Proterozoic age has been inferred for steeply-dipping siltstone and argillite in Purni-1 and Mokari-1 drillholes on DALHOUSIE (Krieg, 1985), suggesting a probable continuation of Adelaidean rocks under the Pedirka and Warburton Basins in the east of ABMINGA.

The oldest Adelaidean unit exposed on ABMINGA consists of quartzite and siltstone of the *Burra Group*, probably belonging to the Belair Subgroup. Between the Oodnadatta Track and Indulkana Creek, a basal conglomerate of the Burra Group is seen in nonconformable contact with Wataru Gneiss. The basal conglomerate is 1.5 m thick and is composed of quartz pebbles. Elsewhere, a faulted contact is indicated between the Burra Group and Wataru Gneiss. Burra Group rocks also outcrop north of the Wataru Gneiss, on the southern margin of the Moorilyanna Graben.

On ALBERGA, 13 km northwest of 'Granite Downs', Wataru Gneiss underlying the Burra Group is partially kaolinised to a depth of about 6 m, providing evidence of Precambrian weathering.

The Burra Group in the Indulkana Creek area is succeeded, with a slight angular discordance, by a thick sequence of diamictite with interbeds of

AGE	STRATIGRAPHIC UNIT AND SYMBOL			LITHOLOGY	ESTIMATED THICKNESS (metres)	REMARKS
MARINOAN	UMBERATANA GROUP	?YERELINA SUBGROUP	?Ᵽe	Silty and sandy diamictite; micaceous siltstone and fine sandstone, medium to coarse feldspathic quartzite	650	Possible equivalents of Mount Curtis Tillite
MARINOAN	UMBERATANA GROUP	WILLOCHRA AND FARINA SUBGROUPS	?Ᵽfe	Siltstone and very fine sandstone; medium to very coarse feldspathic quartzite with siltstone interbeds.	530	Possible equivalents of Enorama Shale
MARINOAN	UMBERATANA GROUP	WILLOCHRA AND FARINA SUBGROUPS	?Ᵽh	Dark massive limestone with thin beds of pebbly and sandy dolomite.	Uncertain due to structural complexity	Possible equivalents of Etina Formation
STURTIAN	UMBERATANA GROUP	WILLOCHRA AND FARINA SUBGROUPS	Rodda Beds, Tapley Hill Formation equivalents – Ᵽf	Calcareous and dolomitic siltstone with interbeds of carbonate. Siltstone with interbeds of very fine to coarse feldspathic sandstone.	~6000	Undifferentiated on ABMINGA
		Probable disconformity				
STURTIAN	UMBERATANA GROUP	YUDNAMUTANA SUBGROUP	Chambers Bluff Tillite(Ᵽyc)	Silty and sandy diamictite; interbeds of pebbly medium to very coarse feldspathic sandstone and quartzite.	2400	Correlated with Bolla Bollana Formation
	Minor unconformity					
STURTIAN	BURRA GROUP	?BELAIR SUBGROUP	Ᵽb	Quartzite, siltstone and fine sandstone; basal quartz pebble conglomerate.	1280	

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Table 2 Adelaidean stratigraphy

pebbly sandstone and quartzite. These interpreted glacial-marine deposits form the *Chambers Bluff Tillite* (Wilson, 1952) which is regarded as a lower glacial unit (Sturtian) of the Umberatana Group. The diamictites contain glacial erratics derived mainly from local basement and Burra Group rocks, but R.B. Major has recorded two lithologies which have come from more distant sources:

1. quartz-jaspilite granule conglomerate similar to the Proterozoic Peela Conglomerate Member of the Tarcoola Formation (Daly, 1985) from Wallabyng Range, KINGOONYA
2. black oolitic chert similar to chert from the Adelaidean Wright Hill Beds on the northern margin of the Officer Basin.

These provenances suggest directions of ice movement from southerly and westerly quarters.

Basic volcanics and associated sediments of the *Wantapella Volcanics* (Krieg, 1973b) overlie Chambers Bluff Tillite on EVERARD and WINTINNA, but do not occur on ABMINGA.

A very thick sequence of siltstone with sandstone interbeds overlies the Chambers Bluff Tillite in the Indulkana Creek area. The contact is not exposed, but is likely to be disconformable. The siltstone, considered to be equivalent to the *Tapley Hill Formation*, grades upwards into calcareous siltstone with carbonate interbeds, which are named the *Rodda Beds* (Krieg, 1973b). These two units are not differentiated on the geological map because of their gradational and intertonguing boundaries, and their similar appearance on aerial photographs.

Holes drilled by BHP Ltd in the Moorilyanna Graben bottomed in greenish-grey siliceous siltstone which resembles the Tapley Hill Formation equivalents. Chambers Bluff Tillite and Burra Group sediments are assumed to underlie the siltstone. A thick sequence of siltstone and fine sandstone cut in Getty-EOB1 drillhole on the Bitchera Ridge may also be Tapley Hill Formation equivalents.

The Tapley Hill Formation equivalents and Rodda Beds in the Indulkana Creek area are folded in a synclinal pattern. In the centre of this structure is an area of limestone which is partly fault-bounded and partly in sedimentary contact with the underlying siltstones. The dark, fine-grained and massive limestone is correlated with the *Etina Formation* of the Flinders Ranges. Thin interbeds of calcareous granule to pebble conglomerate contain clasts of quartz, feldspar, granitic gneiss and quartzite, and limestone intraclasts. These interpreted debris flow deposits are strongly contorted, which suggests that the Etina Formation equivalents have been involved in large-scale slumping.

Immediately northeast of the Etina Formation equivalents is a sequence of siltstone, sandstone and quartzite which may be equivalent to the *Enorama Shale*. However, a Cambrian age cannot be ruled out for this sequence. The nature of the contact with the Etina Formation equivalents is not certain, but it is likely to be faulted.

In a northwesterly direction along strike from the possible Enorama Shale equivalents is a sequence of quartzite and silty diamictite. Although this sequence is along strike from the Enorama Shale equivalents, it is not part of this unit but is thought to be a younger Marinoan glacial unit, possibly equivalent to the *Mount Curtis Tillite*. The two units of different ages have been juxtaposed by faulting. Both upper and lower boundaries of the glacial unit are faulted, and shearing associated with movement along the faults has broken up a massive quartzite layer into large detached masses surrounded by the more mobile diamictite.

The small isolated outcrop of quartzite labelled as P on the map is of uncertain age. The outcrop is possibly a detached block which has been involved in a fault zone.

Early Palaeozoic

Sediments of inferred Cambrian age overlie the Adelaidean sequence in the southwest corner of ABMINGA. The main area of outcrop near Indulkana Creek consists of about 230 m of interbedded feldspathic quartz sandstone and grey-green siltstone. These sediments are separated from the Adelaidean sequence by a fault which is marked by a zone of quartz-hematite rock.

Further to the southeast is a small area of folded coarse-grained feldspathic quartzite which has also been assigned a possible Cambrian age. The quartzite appears to unconformably overlie the Rodda Beds-Tapley Hill Formation interval to the south, and is truncated by a fault to the north.

As mentioned before, it is possible that the sequence shown on the map as Enorama Shale equivalents is in fact part of the Cambrian sequence. Also, a Cambrian age is possible for the quartzite labelled as Ꞓ. Faulting in this area may have resulted in a degree of induration and veining much higher than that of Cambrian sediments in the Officer Basin.

The feldspathic sediments on ABMINGA are similar to the *Wallatinna Formation* described by Benbow (1982) from the Mount Johns Range at the northeastern extremity of the Officer Basin (EVERARD). Benbow has assigned an Early Cambrian age to the Wallatinna Formation, and it is for this reason that a probable Cambrian age has been given to similar sediments on ABMINGA.

The outcropping Cambrian(?) rocks on ABMINGA can also be compared with the *Moorilyanna Conglomerate* (Wilson, 1952) and *Levenger Arkose* (Major and others, 1967) which were deposited in the Moorilyanna and Levenger Grabens respectively (see Fig. 3), and with the Mount Currie Conglomerate (Forman, 1966) of the Amadeus Basin.

Sediments of probable Cambrian age have been encountered in Afmeco-CUR3 and CUR5 drillholes in the centre of the sheet area. These consist of very coarse arkose (CUR3) and fine to coarse feldspathic quartz sandstone interbedded with siltstone (CUR5). Farrand (1981) cites petrographic features such as rounding of grains, freshness of feldspar, coatings of iron oxide and fairly good sorting as evidence of fluvial deposition in a desert environment. The coarser sediments in CUR3 may have been deposited on alluvial fans adjacent to granitic uplands.

Rubidium-strontium analyses of siltstones from Afmeco-CUR5 produced an isochron of 521 ± 142 Ma, which indicates a Cambrian age. The large variation is a result of a coarser detrital component, derived from basement rocks, within the fine-grained sediment (Webb, 1981).

The sediments in the Afmeco drillholes were laid down on the margin of the Palaeozoic *Warburton Basin* (Wopfner, 1972; Gatehouse, 1982) as shown in the Tectonic Sketch. The similar sediments that outcrop near Indulkana Creek may not be physically continuous with the Warburton Basin sequence, but are more likely to be a fault-bounded sliver within the Bitchera Ridge.

Geophysical evidence indicates a considerable thickening (up to about 2000 m) of Warburton Basin sediments towards the eastern margin of ABMINGA. Deep drillholes on DALHOUSIE have cut sediments of inferred Devonian, Ordovician and Cambrian ages which have been correlated with sequences in the Amadeus Basin (Youngs, 1975a). Units tentatively identified in cores include the *Pertaoorrta Group* (Cambrian), *Stairway Sandstone* (Ordovician) and *Finke Group* (Devonian) (Wells and others, 1970). These units are assumed to extend westwards into the Eringa Trough area in the eastern part of ABMINGA, as indicated on the cross section A-B.

Late Palaeozoic

Sediments of Carboniferous to Permian age occupy the *Pedirka Basin* (Wopfner, 1972) which overlies the Warburton Basin and is overlain in turn by the Mesozoic Eromanga Basin (see Fig. 3). These Late Palaeozoic sediments do not outcrop on ABMINGA, but are inferred to underlie the eastern part of

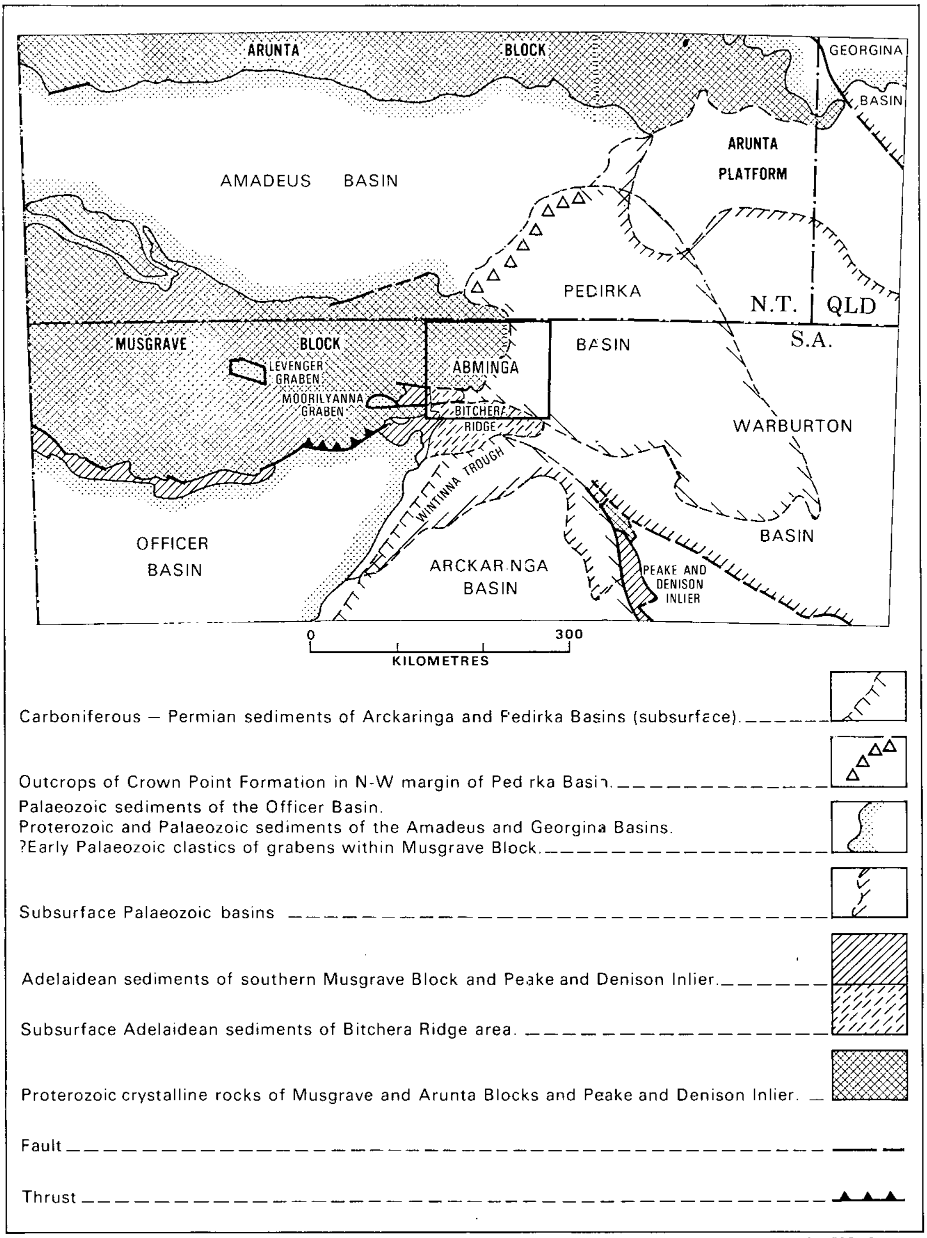

Fig. 3 Pre-Mesozoic geological setting

the map area. The Pedirka Basin sediments are shown on Section A-B as resting on the Warburton Basin sequence with a slight angular unconformity.

Late Palaeozoic units have been cut in Afmeco-CUR3 and CUR4 drillholes on the western margin of the Pedirka Basin. Afmeco-CUR3 intersected a much reduced sequence, 80 m thick, consisting of *Purni Formation* (Youngs, 1975b) overlying *Crown Point Formation* (Wells and others, 1966). The Purni Formation in CUR3 consists of thinly interbedded fluvial siltstone and fine sandstone, which resembles the Upper Member of this formation as described by Youngs (1975b). Laminated blue-grey siltstone of the Purni Formation occurs at the base of CUR4. Purni Formation sands may also underlie Mesozoic sands in CUR9 and CUR18 drillholes.

The Crown Point Formation in Afmeco-CUR3 is a coarse sandy conglomerate containing rounded pebbles and cobbles of Adelaidean quartzite and siltstone. Outcrops of this formation in the Northern Territory include diamictites with some striated clasts, which are interpreted as glacial deposits. It is likely that the coarse conglomerate in CUR3 is a glaciofluvial deposit, and this is supported by the presence of dropstones in the immediately overlying Purni Formation.

Seismic surveys indicate the presence of a much thicker Pedirka Basin sequence in the east of the map area. For example, a thickness of up to 800 m is indicated at the northeastern end of Section A-B.

The age of the late Palaeozoic glacial sequences in South Australia is still open to question. These sequences were formerly thought to be entirely of Permian age, but Cooper (1981) argues for a Late Carboniferous age for the older glacial deposits which include, in the Pedirka Basin, the Crown Point Formation and the lowermost beds of the Purni Formation. The Late Carboniferous age is adopted on the ABMINGA geological map, but it should be noted that some workers, for example, Foster (1983), disagree with this interpretation. Until the age problem is resolved, it would be better to regard the Pedirka Basin sequence as of undifferentiated Permian-Carboniferous age.

Mesozoic

Much of the map sheet is covered by an eastward-younging conformable sequence of the Eromanga Basin, of Jurassic to Cretaceous age. The sequence can be divided into an initial freshwater phase (Algebuckina Sandstone), a marine transgressive phase (Bulldog Shale, Coorikiana Sandstone and Oodnadatta Formation), and a regressive freshwater phase (Winton Formation).

The oldest Mesozoic unit on ABMINGA is the *Algebuckina Sandstone* (Wopfner and others, 1970). This formation outcrops in the west of the sheet area, where it rests unconformably mainly on deeply weathered (kaolinised) crystalline basement. The thickness of the weathering zone extends to about 13 m in Afmeco-CUR2.

The best sections of Algebuckina Sandstone on ABMINGA are seen in the Afmeco drillholes. In Afmeco-CUR5, the Algebuckina Sandstone displays upward-fining sequences, typically commencing with poorly-sorted kaolinitic quartz sands, sometimes pebbly, passing up to fine sand, silt, and carbonaceous clay with thin coal layers. These sequences can be interpreted as fluvial channel deposits and overbank floodplain and swamp deposits.

A microflora from the base of the Algebuckina Sandstone in Afmeco-CUR5 yielded an earliest Middle Jurassic to latest Early Jurassic age (Alley, 1985), and a rich, non-marine microflora of Early Cretaceous (Neocomian) age was obtained from the top part of the formation in Afmeco-CUR16 (B.E. Balme, in French, 1980).

AGE		ABMINGA	MARGINAL EROMANGA BASIN (OODNADATTA 1:250 000) 1.	CENTRAL EROMANGA BASIN 2.
LATE CRET.	CENOMANIAN	Not Exposed	WINTON FORMATION	WINTON FORMATION
EARLY CRETACEOUS	ALBIAN	WINTON FORMATION	MT ALEXANDER SST. MEMBER	MACKUNDA FORMATION
		OODNADATTA FORMATION	OODNADATTA FORMATION	ALLARU MUDSTONE
			WOOLDRIDGE LST. MEMBER	TOOLEBUC FORMATION
		COORIKIANA SANDSTONE	COORIKIANA SST. MEMBER	WALLUMBILLA FORMATION
	APTIAN	BULLDOG SHALE	BULLDOG SHALE	
	BARREMIAN		MT ANNA SST MEMBER	WYANDRA SST. MEMBER
	NEOCOMIAN		CADNA–OWIE FORMATION	CADNA–OWIE FORMATION
JURASSIC	LATE	ALGEBUCKINA SANDSTONE	ALGEBUCKINA SANDSTONE	MOOGA FORMATION
		NO DEPOSITION		WESTBOURNE FORMATION
				ADORI SST.
	MIDDLE			BIRKHEAD FORMATION
				HUTTON SANDSTONE
	EARLY			"BASAL JURASSIC"

1. *Wopfner et al (1970)* 2. *Delhi Santos Usage 1986*

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Table 3 Mesozoic stratigraphy and correlation

The Algebuckina Sandstone passes conformably upwards into the *Bulldog Shale* (Freytag, 1966), a thick sequence of marine claystone and siltstone with minor fine sandstone. In other areas of the Eromanga Basin, a transitional marginal marine unit, the *Cadna-owie Formation* (Wopfner and others, 1970) is recognised between the Bulldog Shale and Algebuckina Sandstone. However, on ABMINGA, this transitional unit is either entirely missing (e.g. in Afmeco-CUR5) or is of limited thickness (up to 4 m in Afmeco-CUR4). For this reason, the Cadna-owie Formation has not been mapped as a separate unit, but is included with the Bulldog Shale.

In outcrop and in drillcore, the transitonal unit consists of claystone with intervals of bioturbated quartz-rich coarse sand and fine gravel with clayey matrix. These are possibly reworked debris flow deposits (see Flint and others, 1980) and are the probable source of the numerous large well-rounded clasts of Adelaidean quartzite which are found lying on the surface in areas near the Bulldog Shale-Algebuckina Sandstone boundary.

Bivalves of Aptian (Lower Cretaceous) age (*Maccoyella reflecta* and *M. corbiensis*) occur in the Bulldog Shale, northeast of Gap Hole Dam (Ludbrook, 1966). R.B. Major records *Fissilunula* sp. and a small ammonite from the same location. Marine microfloras of Aptian age, belonging to the *Odontochitina operculata* zone of Morgan (1980), have been recovered from Bulldog Shale cut in BHP AL15 drillhole (B.J. Cooper, S. Aust. Dept of Mines & Energy, 1986). It should be noted that the Bulldog Shale as mapped on ABMINGA includes beds equivalent to the Cadna-owie Formation, which has been assigned a Neocomian to earliest Aptian age in other parts of the Eromanga Basin.

The Bulldog Shale is succeeded by the Early Albian *Coorikiana Sandstone*. This unit was originally defined by Freytag (1966) as a basal member of the

Oodnadatta Formation; it is now regarded as a separate formation (Moore and Pitt, 1982) marking a significant marine regression which Morgan (1980) relates to a eustatic fall in sea level.

In the north of ABMINGA, Coorikiana Sandstone can be traced southwards to Eyutalyera Creek, where it may terminate against a possible monoclinal flexure, represented by the dipping silcrete surface at Mount Treloar. Coorikiana Sandstone is also seen in the Mount Isabel area, but cannot be traced between the two areas of outcrop because of deep weathering and an extensive cover of silcrete.

The Coorikiana Sandstone is overlain by the *Oodnadatta Formation* (Freytag, 1966) of Early to Late Albian age. Scattered outcrops of sandstone occur within the Oodnadatta Formation, for example, between Mount Walter and Bluff Point, below the Bagot Range. It is not possible to correlate these sandstones, with any degree of certainty, with the Mount Alexander Sandstone Member of the Oodnadatta Formation; they may be inliers of Coorikiana Sandstone.

The youngest Mesozoic unit on ABMINGA is the *Winton Formation* of late Albian to Cenomanian age. This unit is exposed mainly in the northeast corner of the map area, under the silcrete tableland of Hearne Range and southeast of Abminga R.S. On the adjoining DALHOUSIE map area, the lower boundary of the Winton Formation has been placed to include the *Mount Alexander Sandstone Member* (Freytag, 1966) of the Oodnadatta Formation, as these two predominantly sandy units could not be clearly separated for mapping purposes (Krieg, 1985). It is likely that the Winton Formation as mapped on ABMINGA also includes beds equivalent to the Mount Alexander Sandstone Member, and may be equivalent in part to the Mackunda Formation.

Cainozoic

Tertiary

The oldest Tertiary unit on ABMINGA is the *Eyre Formation* (Wopfner and others, 1974), a fluvial quartz sandstone with a prominent basal conglomerate of well-rounded and polished quartz pebbles. The Eyre Formation on ABMINGA is a relatively thin unit (usually up to about 2 m thick) of restricted occurrence: it is seen only in the Hearne and Anderson Ranges, near the Lambina opal diggings, and at Warrataddy Hill. The Eyre Formation rests disconformably on deeply weathered Mesozoic sediments and is overlain by silcrete. Its age has elsewhere been determined to extend from Late Paleocene to Late Eocene (Wopfner and others, 1974).

The prominent silcrete that outcrops widely on the ABMINGA sheet can be referred to the *Cordillo Silcrete* of Wopfner (1974, 1978). Wopfner (1978) deduced a Late Eocene-Oligocene age for the silcrete, although Krieg (1985) suggests that silcrete formation may have extended as far back as the Early Eocene. On ABMINGA, the Cordillo Silcrete rests on deeply weathered Mesozoic sediments and basement, and, less commonly, on sandstone and conglomerate of the Eyre Formation.

The Cordillo Silcrete was formed during a period of deep weathering and silicification, which resulted in a deep profile (up to 30 m) of chemical alteration in the underlying rocks. The profile is characterised by kaolinisation (bleaching), with some accumulation of iron oxides. Silicification of kaolinised

QUATERNARY	HOLOCENE	Q, Qfe Qha	Source bordering dunes (Qhs)
		Fluvial Sediments Qpf	SIMPSON SAND
	LATE PLEISTOCENE	WOODGATE GRAVEL Qpa	PEDIRKA FORMATION
		Un-named fluvial sands (Qps)	
	MIDDLE-EARLY PLEISTOCENE	MOUNT WILLOUGHBY LIMESTONE	
		LOWER CLASTIC SEQUENCE	Crocodile teeth from Fools Well
	PLIOCENE		
TERTIARY	MIOCENE	MIRACKINA CONGLOMERATE	
	OLIGOCENE	CORDILLO SILCRETE; Tfe	
	EOCENE	EYRE FORMATION	
	PALEOCENE		

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Table 4 Summary of Cainozoic stratigraphy

host rocks in the upper part of the profile has produced brittle flinty rocks known as porcellanite.

In the northeast of ABMINGA, the silcrete has been largely removed by erosion, but extensive outcrop of porcellanite indicates its former extent. For example, between Mt. Critic Dam and Mount Treloar there is a large area of prominent dissected low tableland composed of porcellanite with a distinctive red-brown colour resulting from a weak infusion of iron oxides. Only minor remnants of silcrete occur in this area.

In the west of the sheet area, small areas of *ferruginous coarse sandstone* (Tfe) rest on basement or Algebuckina Sandstone. These flat-topped remnants appear to be part of the same geomorphic surface as the Cordillo Silcrete, and are considered to be of the same age.

Small outcrops of strongly ferruginised coarse quartz sandstone with silcrete pebbles occur in the valley of Stevenson Creek. This unit is correlated with the *Mirackina Conglomerate* of Barnes and Pitt (1976) who described the unit from the Mirackina Palaeochannel, remnants of which outcrop on the WINTINNA and MURLOOCOPPIE sheets to the south. The abundant rounded silcrete pebbles indicate an age younger than Cordillo Silcrete; Barnes and Pitt (1976) suggest a Miocene or Early Pliocene age. The presence of Mirackina Conglomerate shows a considerable antiquity for the Stevenson Creek Valley, which was incised into the Cordillo Silcrete surface in mid-Tertiary time.

Sequences of partly silicified ferruginous clastics and carbonates on ABMINGA are correlated with the *Mount Willoughby Limestone* (Nichol, 1971). This unit can be divided into two parts: an upper chalcedonic limestone; and a lower clastic sequence.

The chalcedonic limestones are restricted to areas low in the landscape; for example, between Bloods Creek and Ross Creek, and in the Bitchera Well area. These areas are remnants of a palaeodrainage system, in which limestones were deposited in valley lakes and swamps (see Fig. 6). The most prominent palaeodrainage feature lies between Bloods Creek and Ross Creek. This consists of two palaeochannels which merge together just west of the map boundary, and extend eastwards into the Ilbunga R.S. area on DALHOUSIE. In a creek section near Ilbunga R.S., the limestone overlies the clastic sequence, and this relationship is seen elsewhere in the palaeodrainage system. The limestone is often capped by chalcedonic and opaline silica, and is sometimes entirely replaced by silica.

The lower clastic sequence, without a limestone capping, occurs along the upper reaches of Stevenson Creek, and in a low tableland 20 km west of Abminga R.S. The clastic sequence often contains abundant ferruginous clasts of a pisolitic nature, carbonate veins,and patchy silicification.

The age of the Mount Willoughby Limestone is uncertain. Krieg (1985) has inferred a maximum age of Late Oligocene-Early Miocene for the lower clastic part of the unit, which is equivalent to the *Doonbara Formation* (Wopfner, 1974). Krieg also suggests a correlation of the upper limestone with the Miocene *Etadunna Formation* (Stirton and others, 1961). However, a Late Pliocene-middle Pleistocene age for the Mount Willoughby Limestone has been suggested by Firman (1971, 1981) and Barnes and Pitt (1976). The unit strongly resembles the *Mangatitja Limestone* (Major, 1973a) which outcrops extensively in the Musgrave Block.

Thick Cainozoic clastic sequences (up to 79 m in BHP-AL30 and AL32 drillholes) underlie the sand plains on ABMINGA. These sediments are poorly described from drillhole cuttings which often indicate the presence of silcrete, either in place or as reworked clasts, at the base of the Cainozoic sequences. Cainozoic sediments cored in Afmeco-CUR1 also post-date Cordillo Silcrete, and a correlation with the lower clastic sequence of Mount Willoughby Limestone seems reasonable. However, it is likely that older Tertiary units, such as Eyre Formation, underlie the sand plains in places.

The Tertiary sediments of ABMINGA are unfossiliferous, except for an occurrence of fossil teeth from a depth of about 15 m in Fools Well, 26 km west-southwest of 'Tieyon'. These teeth are similar to those of the crocodile *Pallimnarchus pollens* which have been found in the Pliocene Chinchilla Sand of southeastern Queensland (N. Pledge, S.A. Museum, in prep.).

Quaternary

The *Pedirka Formation* (Krieg, 1985) is a red-brown structured sandy clay, with gypsite and a weak carbonate paleosol developed in places. The unit ranges in thickness from 1 to 3 m, and rests on Cordillo Silcrete. A characteristic feature of the unit is an extensive cover of large silcrete clasts (gibbers) which are coated with a reddish desert varnish.

Krieg (1985) suggests a Miocene to Pliocene age for the Pedirka Formation, based on a possible intertonguing relationship with Mount Willoughby Limestone at Ilbunga R.S. However, I regard the Pedirka Formation as younger; possible equivalents are the late Pleistocene Pooraka Formation and Callabonna Clay. Note that these correlations suggest a younger age for the Pedirka Formation than that shown on the geological map.

The Pedirka Formation and similar units form vast areas of stony tableland soils in the arid zone of inland Australia. In most cases, these soils rest directly on a substrate (such as silcrete) of dissimilar composition, i.e. with no clay or gypsum content. Jessup (1960) considers that the clay and gypsum of the stony tableland soils are aeolian, and have been derived through deflation of lacustrine sediments exposed in the beds of dried-up lakes. This is likely to have occurred during the period of maximum aridity, about 18 000 years ago (Bowler, 1976).

The silcrete gibbers that mantle areas of Pedirka Formation have been derived from the underlying silcrete duricrust. Shrinking and swelling movements in the expansive clays of the Pedirka Formation, due to changes in moisture content, are thought to be the main agency involved in the upward movement of silcrete fragments (Mabbutt, 1977). These soil movements are also responsible for the formation of patterned ground, or stony gilgai, which feature prominently on aerial photographs as a concentric arcuate pattern in areas of gentle slopes.

The flat *sand plains* (Qps; see Major, 1973b) show a dendritic pattern of drainage courses on aerial photographs. The drainage courses carry a thicker cover of mulga than the intervening areas, and this tree cover outlines a fine crescentic gilgai pattern within the drainage courses. The sand plains are interpreted as sandy outwash derived from surrounding uplands of basement and Mesozoic rocks. This fluvial activity is thought to have occurred before the main period of sand dune formation, and the drainage courses are probably no longer active.

The area of Qps north of the Alberga River on the *Lambina* 1:100 000 sheet shows a gilgai pattern of scattered crabholes with no drainage lines. Here, it is likely that aeolian reworking of surficial sand has obscured traces of earlier fluvial activity.

The *Simpson Sand* (Firman, 1970), originally defined for aeolian dune sands of the Simpson Desert, has been extended here to include dune sands between Hamilton Creek and the Alberga River. The Simpson Sand is reworked from the underlying un-named unit (Qps) of fluvial sands. The main period of aeolian reworking and dune formation took place about 18 000 years ago (Bowler, 1976).

The linear dunes on ABMINGA trend in a northeasterly direction, which reflects the prevailing wind direction in this area at the time of dune formation. Holocene fluvial sediments of Hamilton Creek, south of Mount Algoochinna (*Bagot Range* 1:100 000 sheet) truncate linear dunes of Simpson Sand. Younger *source-bordering dunes* (Qhs) of Holocene age overlie the fluvial sediments from which they were reworked. The Holocene dunes have a marked easterly divergence from the adjacent late Pleistocene dunes (055° and 035° respectively); this reflects a shift in the wind regime between the two periods of dune formation.

The *fluvial sediments* of the main stream channels on ABMINGA include weakly calcreted, cross-bedded sand and gravel, which is equated with the late Pleistocene *Woodgate Gravel*, defined by Krieg (1985) from the adjoining DALHOUSIE sheet.

Ferruginous gravel spreads (Qfe) are a very distinctive feature on aerial photographs and satellite imagery. This unit forms an overlay on Bulldog Shale, Coorikiana Sandstone, and Oodnadatta Formation, either resting directly on the Mesozoic unit or on an intervening thin clayey or silty soil. The clasts consist of ferruginised sandstone and siltstone (derived from Bulldog Shale and Coorikiana Sandstone), and fine-grained concretionary ironstone (derived from Oodnadatta Formation). There is usually some admixing of silcrete and non-ferruginous Mesozoic clasts; the component of ferruginous fragments ranges from about 50% to greater than 90%.

STRUCTURE AND SUB-SURFACE INTERPRETATION

Musgrave Block

The foliation of the basement gneisses strikes in a northeast to northwest direction and dips mainly to the west. In the northeast part of the *Tieyon* 1:100 000 sheet there are several folds exposed with north-northeast to northwest trending axes and with minor folding of the limbs. Changes in strike and dip of foliation suggest the possibility of major recumbent folds in the gneisses (Hancock, 1970). Wataru Gneiss in the 'Granite Downs' area (ALBERGA) has been folded into a recumbent anticline with a north-striking axial plane which dips steeply to the east (Sprigg and others, 1955). This deformation occurred during the period of high grade metamorphism (1600-1700 Ma).

The pre-Mesozoic tectonic sketch (see geological map) is based largely on the aeromagnetic map of total intensity (Fig. 4) which was interpreted by Smith

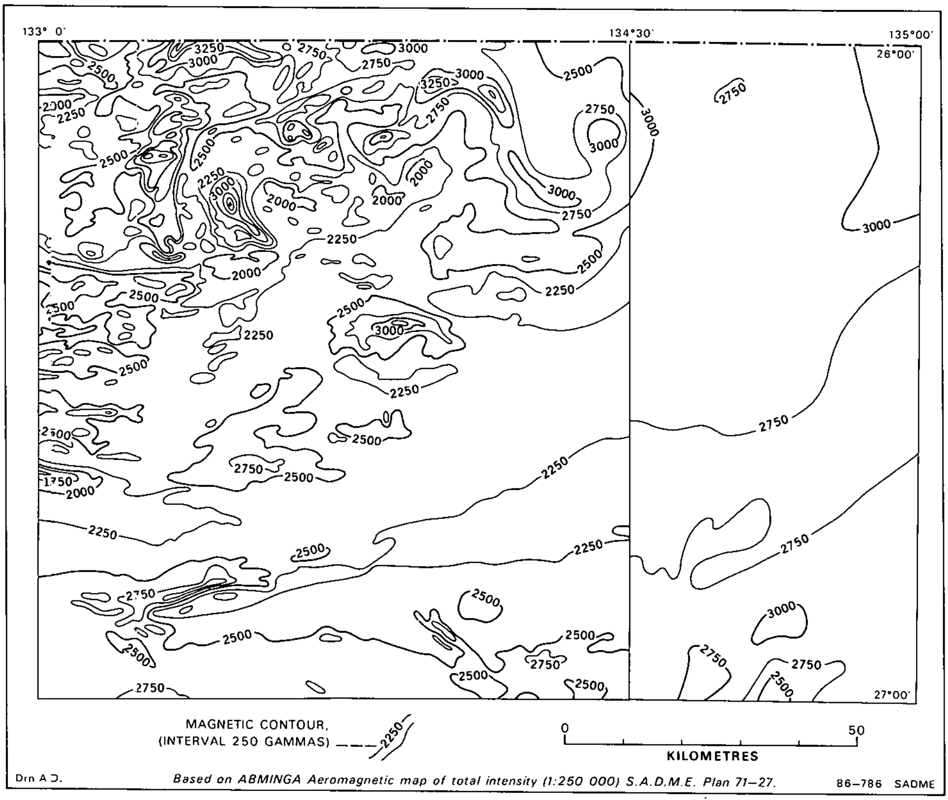

Fig. 4 Aeromagnetic map of total intensity

(1979) and French (1980). One of the main features of the aeromagnetic map are large zones of complex magnetic relief, dominated by high magnetic values, which coincide with areas of magnetite-bearing Kulgeran granite.

The Kulgeran granites on the *Tieyon* 1:100 000 sheet are delimited to the south by a zone of east-west trending magnetic contours. This zone has been named the *Marryat Lineament* and is a probable extension of the Marryat Fault Zone and Lineament mapped by Conor (1978a, b, d) on ALBERGA. A similar aeromagnetic lineament called the *Coglin Lineament* appears to form a northern boundary to granitic rocks in the Gap Hole Dam area (*Treloar* 1:100 000 sheet). This magnetic lineament coincides with a pronounced photolineament.

The eastern limit of outcropping and shallow subsurface basement rocks is marked by the *Old Crown Flexure*, a monoclinal structure which has also disturbed overlying Cretaceous sediments in the Mount Mead area. The *Duffield Fault* is a major magnetic feature which is truncated to the south by the Moorilyanna Graben. French (1980) has recognised this structure as a photolineament in the Duffield R.S. area (FINKE).

Moorilyanna Graben and Bitchera Ridge

The *De Rose Lineament* is a clearly defined magnetic lineament that marks the northern boundary of the Moorilyanna Graben The aeromagnetic map indicates a northward displacement of the lineament near the eastern limit of the graben. Further possible fault-displaced extensions of the De Rose Lineament have been interpreted in French (1980) and are shown on the pre-Mesozoic Tectonic Sketch. These extensions (named the *Enungarenna Lineament* and *Wylie Well Lineament*) are probably monoclinal folds or flexures which locally form the western margin of the Pedirka and Warburton Basins.

The abrupt change in magnetic contour values across the De Rose Lineament is not repeated on the southern edge of the Moorilyanna Graben. This suggests that the Moorilyanna Graben on AEMINGA is better described as a half-graben, with perhaps only minor faulting on the southern margin (see Section C-D).

The structural high south of the Moorilyanna Graben was named the *Bitchera Ridge* by Devine and Youngs (1973). The high is thought to be composed predominantly of Adelaidean rocks. Aeromagnetic highs suggest the presence of areas of basement rocks within the Bitchera Ridge, and along the southern margin of the Moorilyanna Graben.

Deformation of Adelaidean rocks in the Indulkana Creek area is probably related to the late Proterozoic Petermann Ranges Orogeny (about 600 Ma). Uplift and faulting related to this event also initiated deposition of clastic sediments of inferred Cambrian age on the western edge of the Warburton Basin, and elsewhere. The effects of the early Palaeozoic Delamerian Orogeny cannot be traced with certainty further north than the Peake and Denison Ranges.

Strong deformation and dislocation of Adelaidean sediments adjacent to the Wataru Gneiss in the far southwest corner of ABMINGA, and in the adjoining area of ALBERGA, suggest that a significant fault forms the contact between the two units. The nature of the fault is not known; one likely possibility is that it is a low-angle thrust, perhaps more gently dipping than that shown in Section C-D. In this case, the embayment of Burra Group sediments within

Wataru Gneiss can be interpreted as an area where erosion of overthrust crystalline basement has exposed Adelaidean rocks underlying the thrust plane.

A thrust fault contact between basement and Palaeozoic sediments of the Officer Basin has been interpreted from geophysical evidence on EVERARD (Milton and Parker, 1973). Similar overthrusting on the northern margin of the Amadeus Basin is related to the Late Devonian Alice Springs Orogeny (Wells and others, 1970).

On ABMINGA, Adelaidean and Cambrian rocks further east along the Bitchera Ridge have also been disrupted by faulting, as shown on the geological map. A marked northerly swing in strike of Cambrian rocks in the Ariltja Hole area is truncated sharply by the linear northern boundary of outcrop. This suggests the presence of an additional major fault which is interpreted to lie close to the northern margin of Cambrian outcrop. The isolated outcrop of Adelaidean quartzite (P) may be a detached block within the fault zone. This interpreted fault may be a continuation of the inferred thrust, as shown on the Tectonic Sketch, although there is no evidence that the fault maintains the character of a low-angle thrust. The aeromagnetic map suggests the presence of shallow magnetic basement to the north of the Wallatinna Formation equivalents.

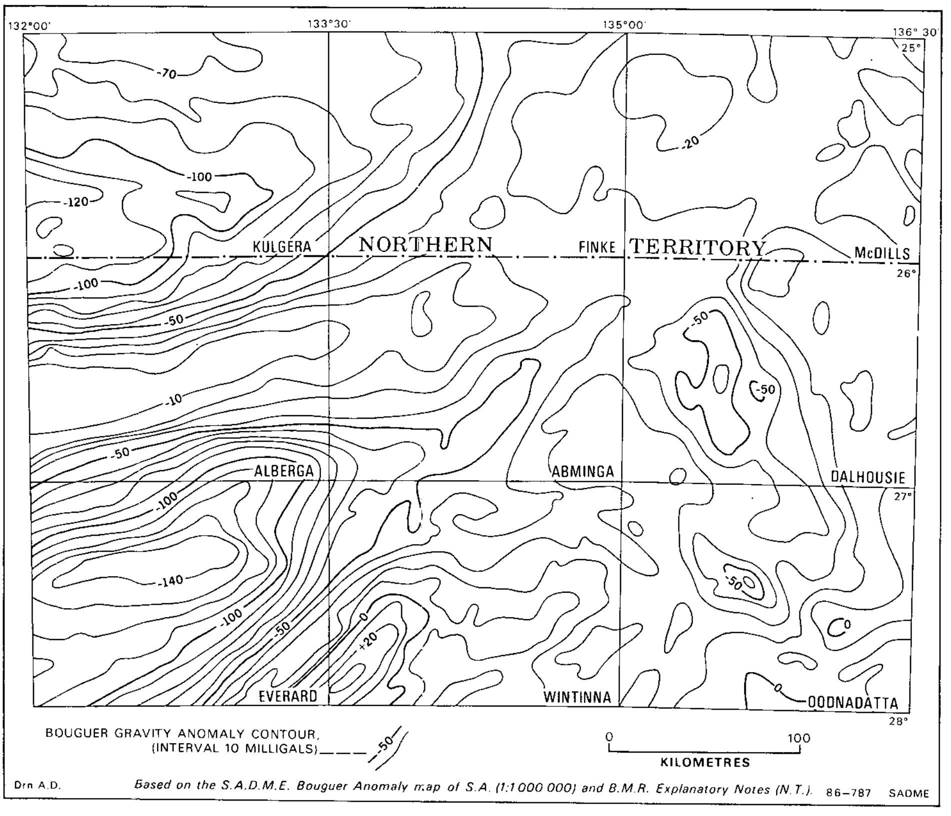

Fig. 5 Bouguer gravity anomaly map

Warburton and Pedirka Basins

The Bouguer gravity anomaly map (Fig. 5) shows a major gravity low extending northeastwards from the Moorilyanna Graben and Bitchera Ridge area, with the axis of the low passing close to Bloods Creek R.S. The gravity low outlines the *Eringa Trough*, which is filled with up to about 2500 m of Palaeozoic sediments. The stratigraphy of the Eringa Trough is unknown, and extrapolations have been made from the Afmeco drillholes to the west and from deep drillholes on DALHOUSIE.

Seismic surveys carried out in the east of ABMINGA (Compagnie Generale de Geophysique, 1966; United Geophysical Corporation, 1970) provide further information on the Palaeozoic sequence. Data from line 8 of the Mount Ross Seismic Survey (UGC, 1970) and line CC of the Emery Seismic Survey (CGG, 1966) were used in the compilation of the geological cross section A-B.

Four seismic reflectors have been recognised in the Palaeozoic sequence (Youngs, 1975a):

P—	top of Purni Formation
Pi—	base of Upper Member Purni Formation
Z—	top of inferred Finke Group
D—	top of inferred Stairway Sandstone

In line 8 of the Mt. Ross Seismic Survey, the 'Pi' reflector truncates the 'Z' reflector, which suggests a slight angular unconformity between sediments of the Pedirka Basin and units of the Warburton Basin, as shown in Section A-B. This unconformity is probably related to the Late Devonian Alice Springs Orogeny (Wells and others, 1970). This orogeny is probably responsible for dips of up to 10° observed in Cambrian sediments cored in Afmeco-CUR5.

Mesozoic and Cainozoic Structure (Fig. 6)

The Mesozoic sediments on ABMINGA are usually undeformed, although gentle warping can occur near areas of outcropping basement, probably as a result of minor faulting, or differential compaction over an irregular basement surface.

In the Mount Mead area, the Bulldog Shale has been folded by the monoclinal *Old Crown Flexure*. Dissection of a ferruginous sandstone layer in the lower part of the Bulldog Shale, on the upfolded western side of the monocline, has resulted in the prominent linear feature seen on aerial photographs and satellite imagery. It is likely that the Old Crown Flexure is the surface expression of a basement fault. Additional lineaments interpreted from LANDSAT satellite imagery are shown in Fig. 6.

The main area of Cordillo Silcrete between Bloods Creek and Hamilton Creek appears to be a gentle synclinal structure, which formed in Late Oligocene to Miocene time after formation of the silcrete (see Krieg, 1985). Late Cainozoic clastic and carbonate deposits were laid down in the Stevenson and Bitchera Palaeochannels which formed in the low parts of the syncline.

The synclinal area is bordered to the north by a region of uplift, where most of the silcrete has been stripped off Mesozoic sediments, and to the south by a zone of subsidence. The southern and northern boundaries appear to be

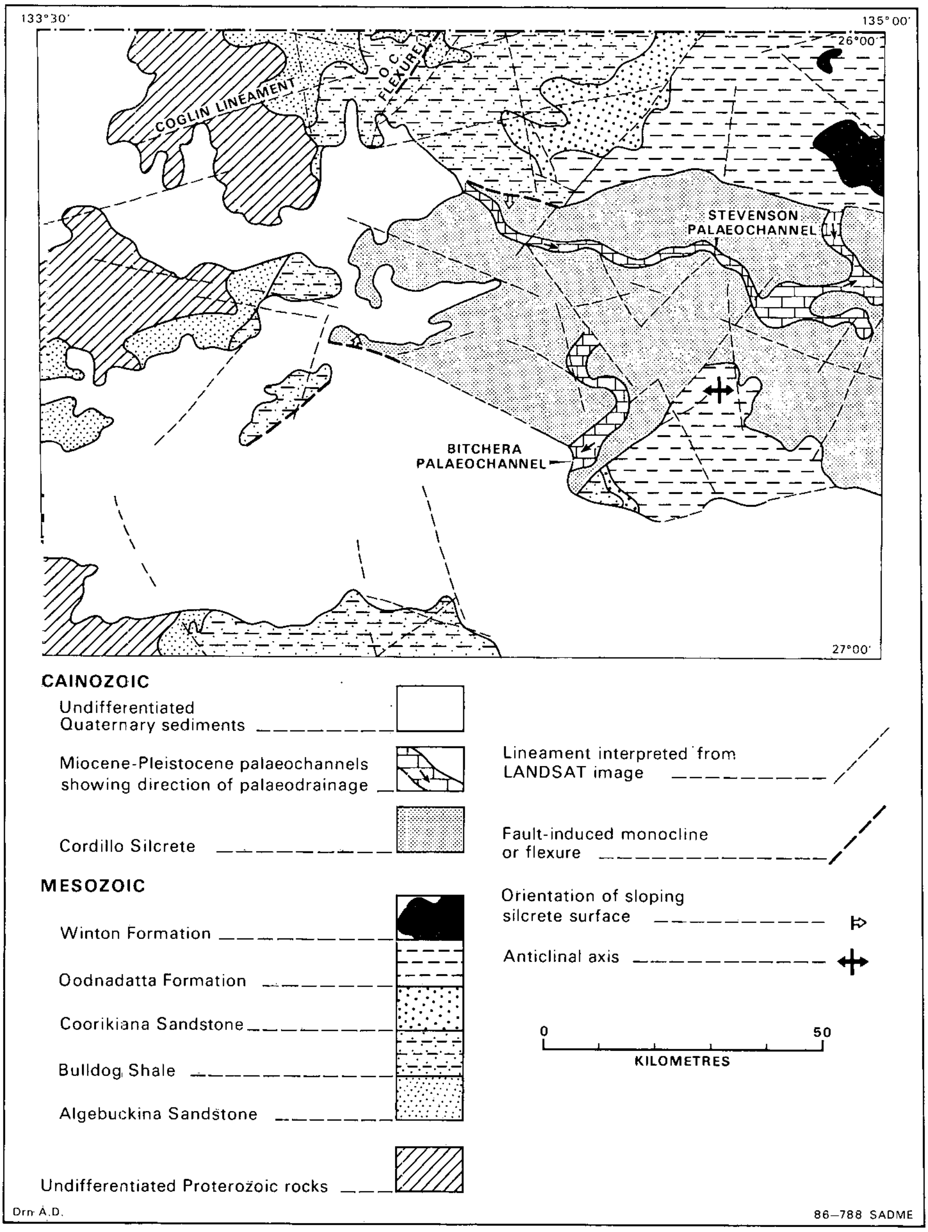

Fig. 6 Mesozoic and Cainozoic structural sketch

structurally controlled and show a strong alignment with photolineaments. Further west, the boundaries are formed by prominent sloping silcrete surfaces, for example, at Mount Treloar, which may be related to monoclinal flexures.

The silcrete surface north of Hamilton Creek is breached by erosion along a gentle anticlinal structure which appears to die out in the vicinity of Mount

Britton. The lineament-controlled Bagot Range forms a sharp western edge to the anticlinal structure. These lineaments have also diverted southwards the course of the Bitchera Palaeochannel.

Subsidence in the area between Hamilton Creek and the Alberga River has resulted in the accumulation of a relatively thick sequence of late Cainozoic clastics. Flooding out of Hamilton Creek southeast of Ungalootanna Hill suggests that subsidence has continued into Quaternary time.

ECONOMIC GEOLOGY

Groundwater (from Herraman, 1978)

The main aquifer on ABMINGA is the Algebuckina Sandstone (including the Cadna-owie Formation). Bores completed in this aquifer are not flowing because of the lower water pressures at the shallow margin of the Eromanga Basin. Standing water levels are more than 150 m deep in central ABMINGA. Salinities are in the range of less than 1000 mg/L to 3000 mg/L.

Smaller quantities of water can be obtained from shallow (1-20 m) Quaternary aquifers associated with the main creeks. Groundwater from these aquifers is highly variable in salinity. Good quality water (85-1000 mg/L) is found in some areas. However, groundwater from the Stevenson Creek and from the southern area of sand dunes is more saline (3000-11 000 mg/L). In the west of ABMINGA, salinities of up to 16 000 mg/L are recorded.

Opal

Lambina Opal Diggings (Flint, 1980; Barnes and Townsend, 1982)

The opal diggings, 10 km south of 'Lambina', consist of surface workings which probably date from the 1930s. The first recorded mining was in 1956 and mining continued spasmodically until 1979. The amount of opal produced is unknown.

The workings lie on the northern slopes of a low silcrete rise. Excavations are in bleached claystone with sand lenses of the Bulldog Shale. This is overlain by up to 2 m of silty colluvium, calcrete, gypcrete and jasper of the late Tertiary-Pleistocene Russo Beds (Barker and others, 1979).

Opal occurs in Bulldog Shale as infillings of joints in the claystone, as a matrix cementing sand lenses and tubules, and as seams at the contacts between sand lenses and underlying claystone. In the Russo Beds, opal occurs as chips in the silty colluvium, and as thin veinlets through the jasper.

Granite Downs Opal Diggings No. 2 (Nichol, 1975; Barnes and Townsend, 1982)

These diggings lie on the north side of a silcrete mesa immediately south of the Oodnadatta Track, 3 km southeast of 'Granite Downs'. The workings comprise a 7.5 m deep shaft, and numerous small open pits.

A trace of pale potch opal was found as a thin vein in deeply weathered Wataru Gneiss underlying the silcrete. Pale pink chalcedonic quartz is common as float in the area, and may have been mistaken for opal by prospectors.

Base Metals

Geological mapping in the northern half of the *Tieyon* 1:100 000 area (Hancock, 1970) revealed the following examples of mineralisation:

- titanium concentrations in metasomatised gneiss and deuterically altered basic dykes
- magnetite and allanite in pegmatites
- traces of pyrite and possible sphalerite in granites
- traces of pyrite in some basic dykes.

No surface indications of economic mineralisation were found.

Coal

High quality coal occurs in the Upper Member of the Purni Formation, and has been cut in drillholes on DALHOUSIE (Krieg, 1985). The coalbearing strata can be expected to extend into the eastern part of ABMINGA.

CRA Exploration Pty Ltd evaluated available seismic data and outlined prospective areas in the northeast of ABMINGA, where high energy seismic reflectors were thought to be related to thick sections of coal. Within one prospective area, at the eastern edge of ABMINGA (near Ilbunga R.S.), six good reflectors occur with a minimum thickness of 15 m for each reflector (Finlayson, 1981).

CRA concluded that the prospects of finding coal at a depth of less than 500 m were poor (McBain, 1982).

Uranium Exploration

BHP Ltd investigated the possible occurrence of Mesozoic sedimentary uranium deposits in the southwest of ABMINGA (BHP Ltd, Exploration Dept, 1975).

A total of 56 rotary holes were drilled, to an aggregate depth of 6684 m. Of these, 50 holes were located in the southwest corner of the map area. Structural contours of the Adelaidean/Algebuckina Sandstone unconformity, derived from these holes, reveal two northeast-trending palaeovalleys.

Geophysical logging of holes AL21 to AL56 revealed some gamma ray anomalies in the Algebuckina Sandstone, ranging from 4 to 18 times the background value. The highest anomaly was in AL50, corresponding to an estimated value of 195 ppm U_3O_8 over an interval of 0.75 m.

Selected samples of drill cuttings were analysed for U, Th, Se, V, Ra and Cu.

BHP Ltd considered the results of exploration disappointing and did not renew their Exploration Licence (EL97).

Afmeco Pty Ltd searched for uranium deposits in the Algebuckina Sandstone of central ABMINGA (French, 1980). This work involved the drilling of 5 diamond drillholes and 11 rotary air holes.

Geophysical logging of selected holes included gamma and neutron logs, and electrical logs. Gamma logs of five water bores were also obtained. Radiometric anomalies were found in six drillholes; the highest anomaly (190 c.p.s.) was recorded from the Algebuckina Sandstone in CUR13.

Chemical analyses of drill samples showed several anomalous uranium values in CUR13, the highest being 190 ppm. Drill samples and water samples from selected holes were also analysed for Cu, Pb, Zn, Se, Th and V.

French (1980) suggested that CUR13, near Enungarenna Hill, may be almost at a redox front, i.e. at an interface between reduced and oxidised sediments.

Hydrocarbon Prospects

The most promising source beds are the coals of the Purni Formation. Hydrocarbons could have been generated from the coals in the deeper parts of the Pedirka Basin on ABMINGA, and accumulated in structural or stratigraphic traps.

The Mount Ross Seismic Survey (United Geophysical Corporation, 1970) detected a northeast-trending anticlinal structure underlying the Mount Barr area. Hydrocarbons may have accumulated in Jurassic or Permian reservoir sands in this structure. A drillhole (Mount Barr-1) was proposed to test the hydrocarbon prospects of the Mount Barr Structure, but was never drilled (South Australian Dept Mines, 1973).

The Palaeozoic sequence of the Warburton Basin in eastern ABMINGA remains stratigraphically unknown and completely untested for hydrocarbons. Source and reservoir beds are known from Palaeozoic sequences in adjoining areas, and it is possible that these extend into the map area (see Youngs, 1975).

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