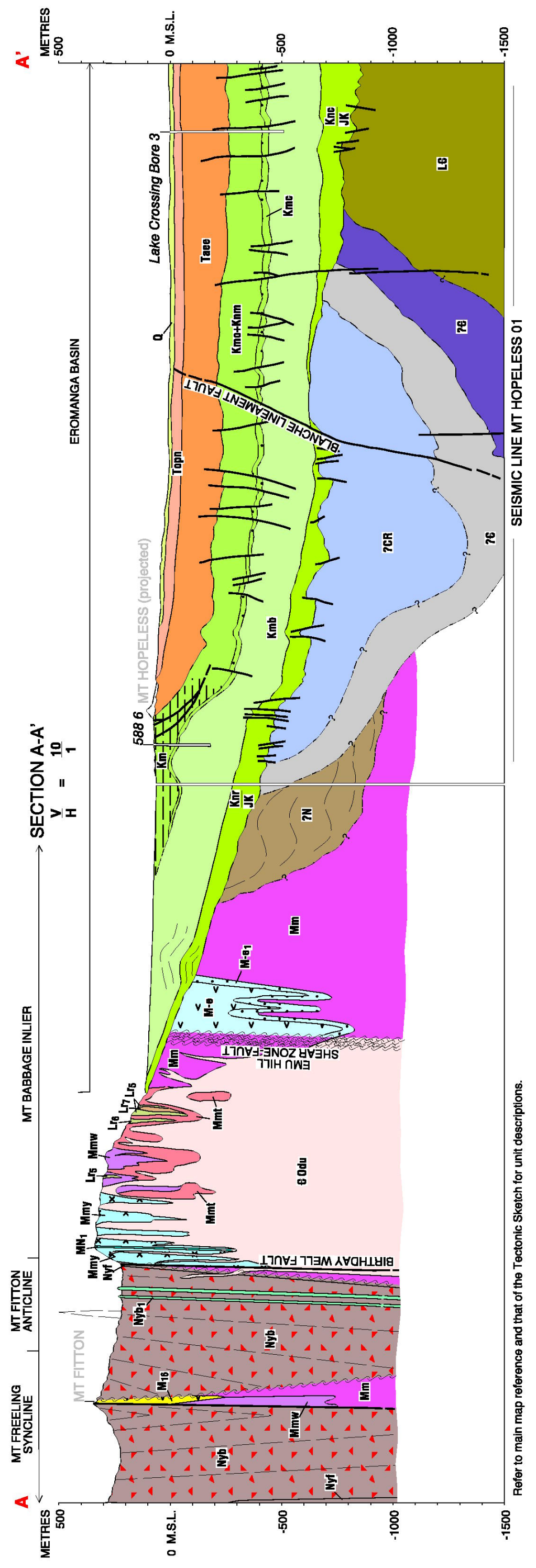
CALLABONNA

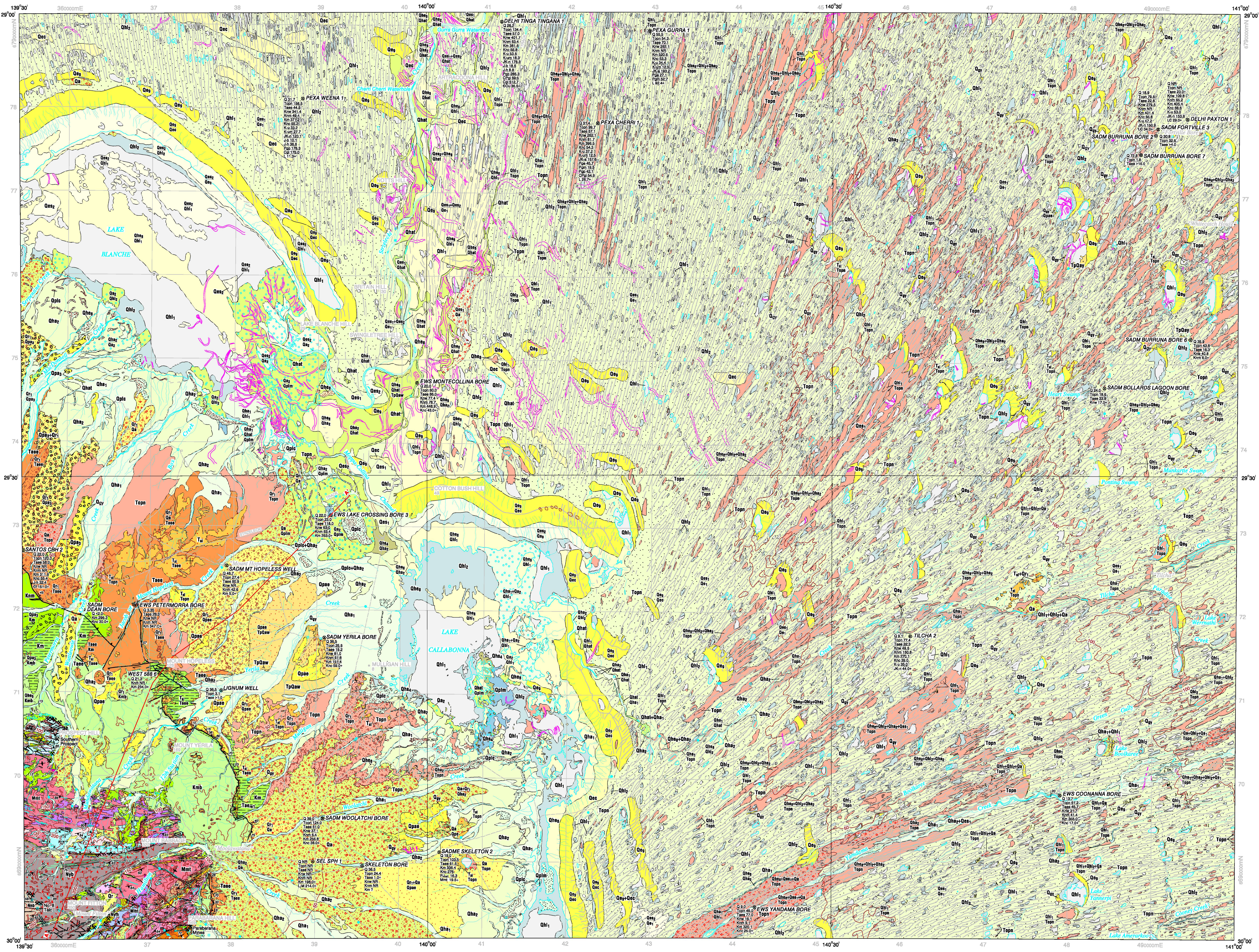
GEOLOGICAL SURVEY OF SOUTH AUSTRALIA
DEPARTMENT OF PRIMARY INDUSTRIES AND RESOURCES SA

AUSTRALIA 1:250 000

SA GEOLOGICAL ATLAS SERIES SHEET SH 54-6

FIRST EDITION 2001





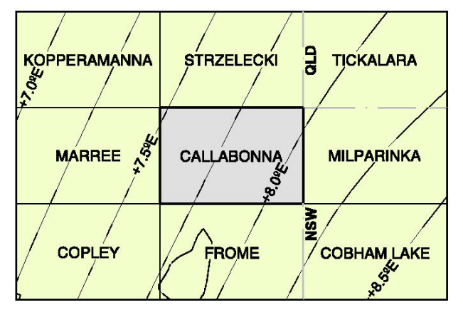
INDEX TO 1 : 100 000 SHEETS

MONTECOLLINA 6839	ARTRACOONA 6939	BURRUNA 7039
MOOLAWATANA 6838	CALLABONNA 6938	TILCHA 7038

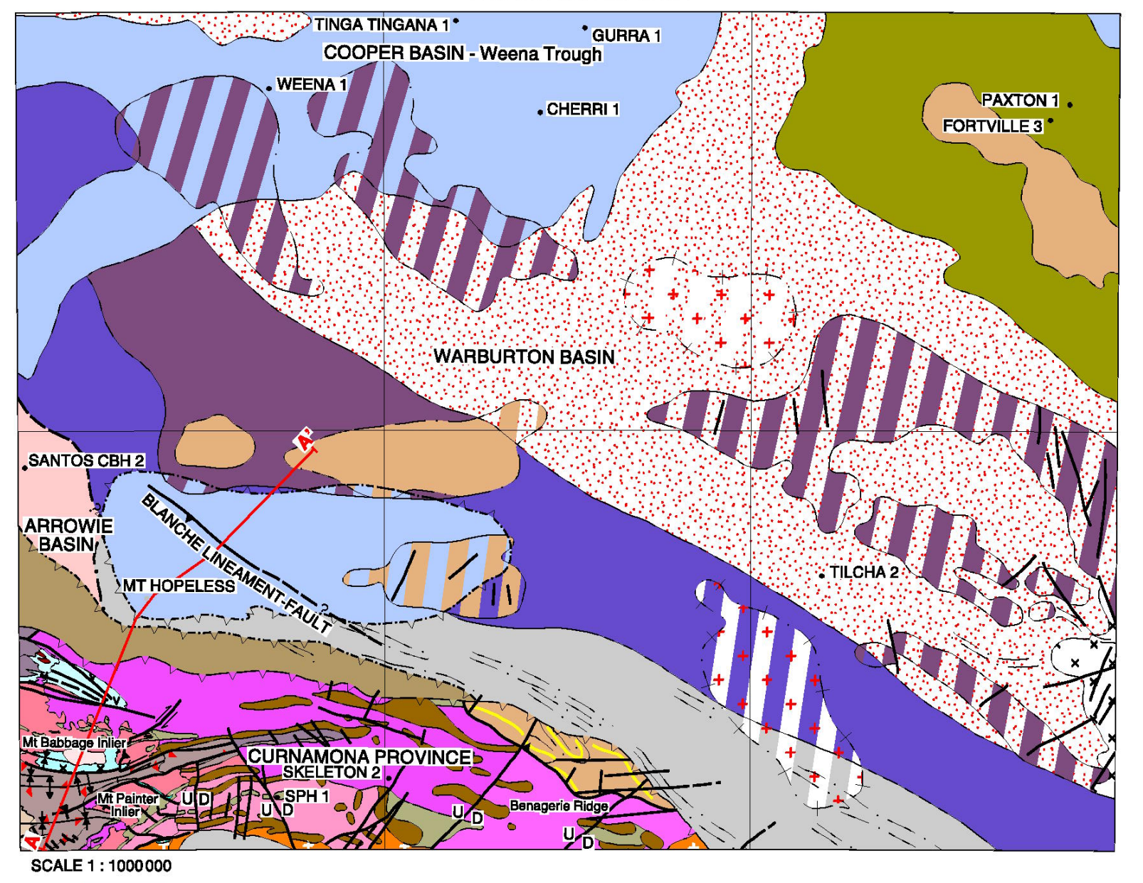
Note: Plots from digital data of Moolawatana 6838-3 are available at 1:50 000 scale.

INDEX TO ADJOINING SHEETS

Magnetic Declination 2000



TECTONIC SKETCH



SCALE 1 : 1000000

PALAEOZOIC

- **CR** Cooper Basin sediments and equivalents (undifferentiated)
- **€P$_2$** Post deformational ?mafic granitoids (deep)
- **€** Arrowie Basin ? Lake Frome Group
- **€O** Warburton Basin sediments (undifferentiated)
- **?€** ? Cambrian ?carbonate sediments (undifferentiated)
- **?€** ? Cambrian ?shales (undifferentiated)
- **L€** ? Proterozoic-Cambrian metasediments

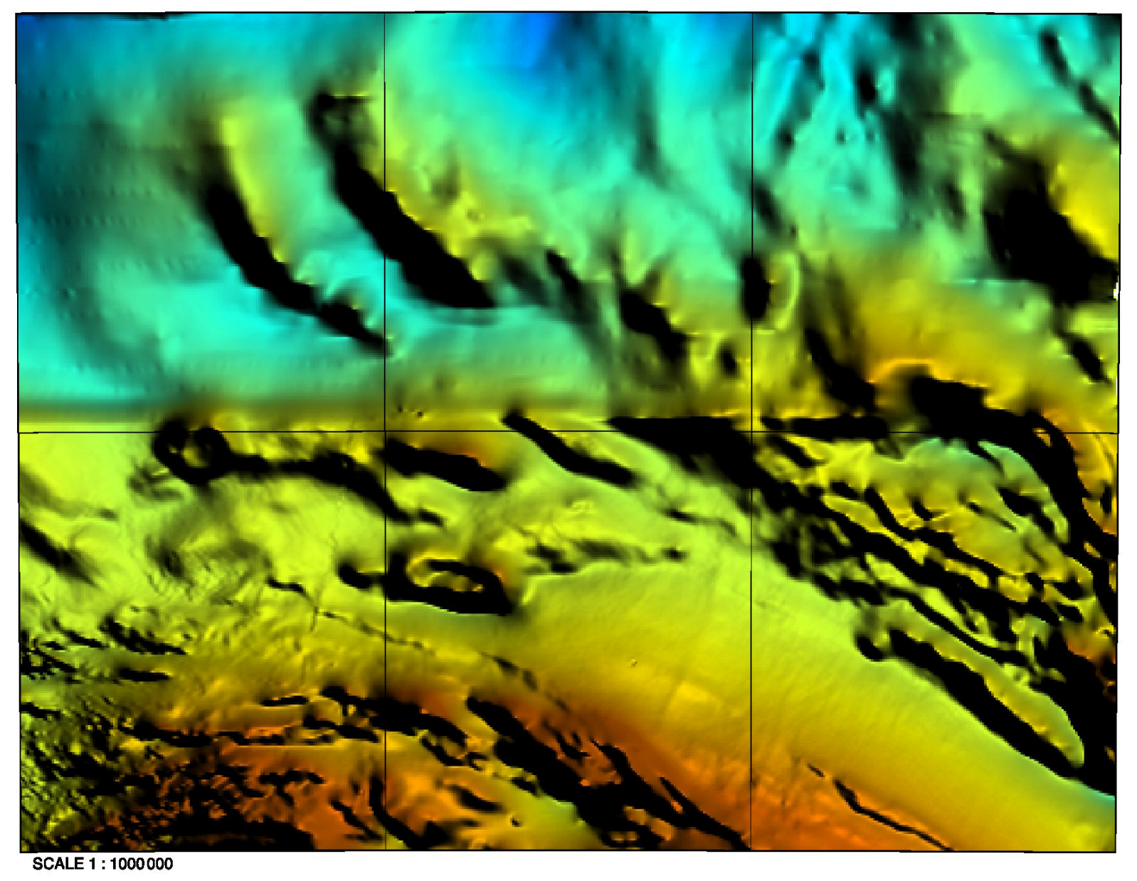
PROTEROZOIC

- **N** **Na** Neoproterozoic (undifferentiated) Paralana Quartzite
- **MN** Magnetic basement (undifferentiated)
- **Mm** Moolawatana Suite
- **M** Mesoproterozoic basement (undifferentiated)
- **LN** Magnetic metasediments and crystalline basement (undifferentiated)
- **LM** Magnetic basement, ?gneiss, Paleo- Mesoproterozoic
- **L** Palaeoproterozoic basement (undifferentiated)

Geological boundary - observed
Geological boundary - inferred
Unconformity - observed
Unconformity - inferred
Fault displaced relative - Up, Down
Fault displaced relative horizontal - Dextral, Sinistral
Fault displaced relative horizontal - Sinistral, Dextral
Fault - thrust
Fault - inferred
Inferred edge to magnetic rock unit
Inferred edge to gravity high - dense rock unit
Magnetic trend line
Geological section
Anticline
Recumbent anticline dip axial surface
Syncline
Drillhole

Refer to main map reference for descriptions of other units.

TOTAL MAGNETIC INTENSITY IMAGE



SCALE 1 : 1000000

The Total Magnetic Intensity Image was derived from the AGSO 1996 data and BMR 1963 data.

Aeromagnetic data has been merged, gridded and image processed by the Mineral Resources Group of the Department of Primary Industries and Resources SA.

nTesla
-360 -131 98.1 327 556 785

SCALE 1 : 250 000

KILOMETRES 5 0 5 10 15 20 25 KILOMETRES

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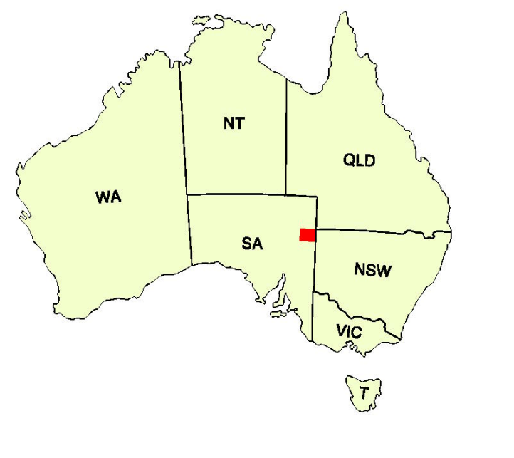
Grey numbered lines indicate the 10000 metre Map Grid

Transverse Mercator Projection, Geocentric Datum of Australia, 1994.



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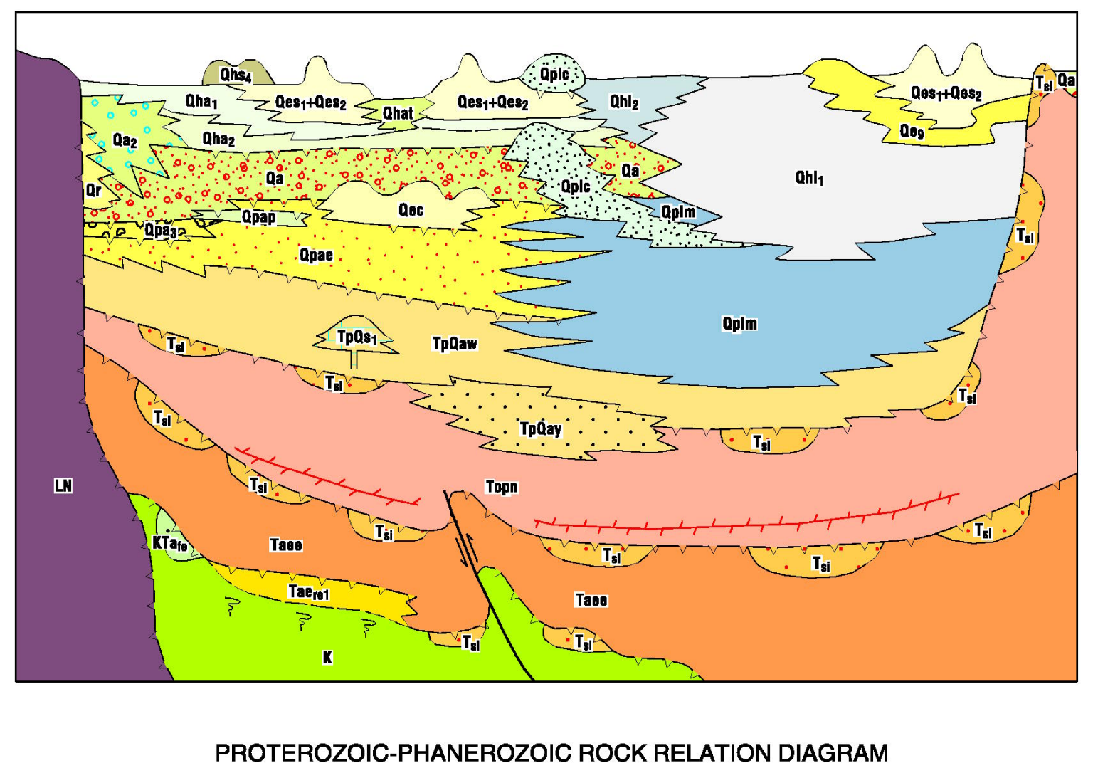
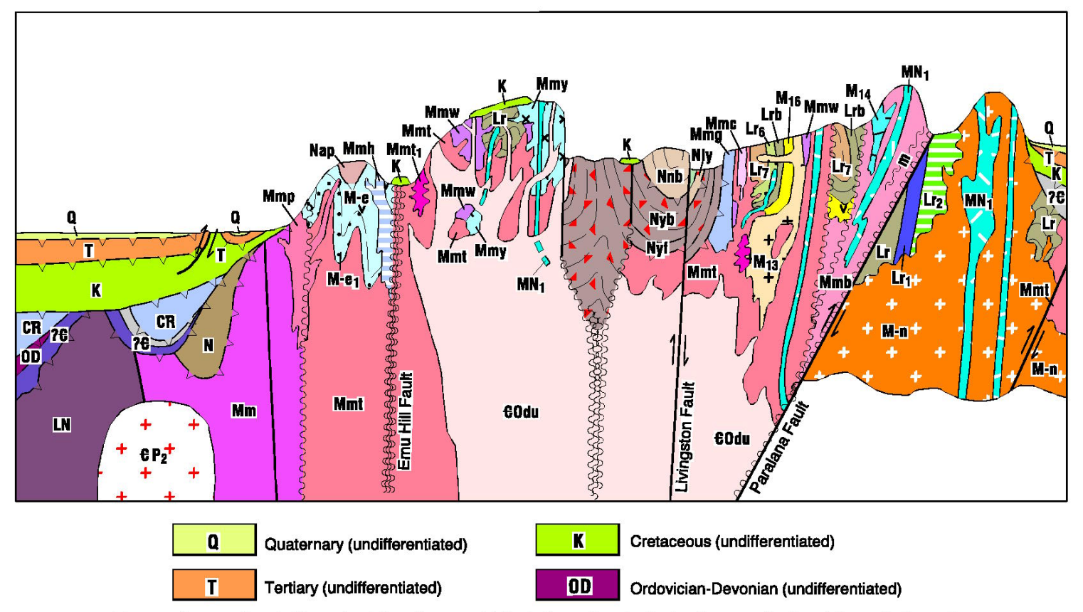
CAINOZOIC ROCK RELATION DIAGRAM



PROTEROZOIC-PHANEROZOIC ROCK RELATION DIAGRAM



- **Q** Quaternary (undifferentiated)
- **K** Cretaceous (undifferentiated)
- **T** Tertiary (undifferentiated)
- **OD** Ordovician-Devonian (undifferentiated)

These units are only for the rock relation diagrams. Refer to the main or tectonic references for descriptions of other units.

GEOLOGICAL BOUNDARY
- OBSERVED
- APPROXIMATE
- INFERRED
- UNCONFORMITY

FAULT
- OBSERVED
- APPROXIMATE
- INFERRED
- THRUST - OBSERVED
- THRUST - INFERRED
- DISPLACED RELATIVE - DEXTRAL, SINISTRAL
- DISPLACED RELATIVE - SINISTRAL, DEXTRAL

BEDDING
- HORIZONTAL
- VERTICAL
- INCLINED 25

FOLIATION
- VERTICAL
- INCLINED 30
- SHEAR ZONES

EXPLORATION DRILLHOLE .... ⊗

STRATA SEQUENCE (THICKNESS IN METRES)	Q 24.0 Topn 18.6
DELHI AUSTRALIA PETROLEUM LTD	*DELHI*
ENTERPRISE EXPLORATION CO. PTY LTD	*ENT*
DEPARTMENT OF ENGINEERING AND WATER SUPPLY	*EWS*
PEXA OIL NL	*PEXA*
SANTOS LTD	*SANTOS*
SELTRUST MINING CORPORATION PTY LTD	*SEL*
S. AUST. DEPT MINES	*SADM*
S. AUST. DEPT MINES AND ENERGY	*SADME*
WESTERN NUCLEAR (AUSTRALIA) LTD	*WEST*
PALAEOPROTEROZOIC - MESOPROTEROZOIC	L-M
MESOPROTEROZOIC	M
NOT RECORDED	NR

GEOLOGICAL SECTION .... A A'
TYPE SECTION LOCALITY
TREND OF BEDDING OR FOLIATION
DYKE VEIN
STRANDLINE
MINE
QUARRY
TRACK
STATE BORDER
LANDING GROUND
HOMESTEAD .... "Moolawatana"
IDENTIFIED POINT (ELEVATION IN METRES) 25
TRIANGULATION STATION
TOPOGRAPHIC CONTOUR (INTERVAL 50 METRES) 250
EPHEMERAL STREAM
CLAYPAN, SALTPAN, LAKE
SWAMP
WATERHOLE
MOUND SPRINGS

Topographic detail based on TOPO-250K GEODATA (source scale 1:250 000) supplied by Australian Surveying and Land Information Group (AUSLIG), ACT with amendments by Department of Primary Industries and Resources SA. The relationship between this data and PIRSA data is not guaranteed.

REFERENCE

CAINOZOIC — QUATERNARY

LAKE EYRE BASIN — CALLABONNA SUB-BASIN

Qha$_1$ Qha$_2$
Holocene river and creek alluvium Qha$_1$: Cobbles, gravel, sand, silt and clay, usually bouldery near ranges, mostly unconsolidated; these materials may be partly carbonate cemented near springs.

Holocene river and creek alluvium Qha$_2$: High terrace flood deposits — cobbles, gravel, sand, silt and clay. May have incipient soils developing within. Usually occur adjacent to Qha$_1$.

Qhat
TINGANA CLAY: Dark to pale grey clay with fine sand or clay pellets. Floodplain and channel deposits, includes 3000–8000 year old alluvium and recent thin sand spreads derived therefrom. Associated with Strzelecki Creek, with equivalents in Callabonna Creek. Interbedded with longitudinal dunes around floodplain margins. Palaeo-meanders, channels and scroll bars of prior streams shown where apparent. Aboriginal fire hearths within the top; ^{14}C dated at ~4300 years BP.

Qha$_7$
Scree and talus deposits: Unconsolidated angular rock fragments, usually clast supported, on steep slopes. Located commonly within the ranges or flanking resistive capped mesas.

Qhl$_1$ Qhl$_2$
Playa lake sediments Qhl$_1$: Halite and minor gypsum; brine-soaked sand, silt, clay, often organic rich, dark coloured to black and fetid below surface. *Chara* oogonia, ostracods, insects, fish, birds and algal mats.

Playa lake margin sediments Qhl$_2$ (larger playas): Beach deposits, offshore spits and bars of white sand, includes minor alluvial fan and slopewash material. *Chara* oogonia, ostracods, insects, fish, birds and algal mats. Also includes smaller playa lake clay to silt and sand deposits.

Qhs$_4$
Holocene spring deposits: Sand to silt, loose or in part carbonate cemented, and tufa, cream to brown colours, includes reworked Cretaceous and/or Tertiary sediments. Mound springs form part of this assemblage (Chimney Springs, Mulligan Springs).

Qhe$_8$
Unnamed aeolian quartz dune sand and sand spreads: Pale yellow to off-white, unconsolidated, mobile longitudinal and local transverse dunes. Derived from many sandy source rocks of Cretaceous to Quaternary age including modern creek alluvium. Age uncertain; probably Mid- to Late Holocene.

Qa
Quaternary creek alluvium undifferentiated: Cobbles, gravel, sand, silt and clay, red-brown, often poorly sorted. Consolidated and dissected terrace and distal fan deposits, may have incipient soil horizonation, often with gibber spreads and gypseous materials. Marginal to creeks and commonly forming the lowest dissected land surface. Can include undifferentiated forms of TINGANA CLAY, MILLYERA FM and EURINILLA FM. Overlies YANDRUWANTHA SAND or NAMBA FM in interdune corridor exposures.

Palaeo-meanders, channels and scroll bars of prior streams, surface expression, sharp to faint ghosts.

Qa$_2$
Quaternary alluvial fans: Flanking basement outcrop, consolidated but not cemented, with incipient to strongly developed soil horizonation. Poorly sorted, bouldery to gravelly proximal to source. Pleistocene forms are larger and dissected, Holocene forms are smaller. Also includes major deltas to larger creeks entering Lakes Blanche and Callabonna and the larger playa lakes. These latter deposits are sandy to clayey with rare larger clasts.

Qr
Quaternary colluvium–alluvium and/or regolith: Usually <1 m thick, stony lag with incipient soil horizon development (lithosols), limited transport history. Restricted to areas of crystalline or indurated rock outcrop. Clasts are usually angular to poorly rounded and very poorly sorted. (Qr) overprint where Quaternary colluvium and/or regolith overlies basement subcrop units.

Qr$_1$
Gibber armouring: Rounded silcrete and quartzite clasts, 30–150 mm diameter, within gypseous silty clay or sandy clay matrix; unit 0.2–0.8 m thick, covers many different older units of the Cretaceous to Quaternary. Clasts derived mostly from Tertiary silcrete duricrusts. Often covering areas of patterned ground; contour linear or mound gilgai which are developed in the upper part of units containing reactive clays (Cretaceous shale, NAMBA FM and EURINILLA FM).

Qgy
Gypsum crusts undifferentiated: Massive, veins, sheets and earthy forms. Older higher level saline groundwater deposits with clusters of disc-shaped crystals; lower level, younger, fibrous gypsum veins. Associated with celestite nodules, masses and layers near the larger playa lakes. Ages (U-series) range from 30 000 years BP to present.

Qes$_2$ Qes$_1$
SIMPSON SAND Qes$_2$: Hummocky, pale yellow, very fine to medium-grained quartz sand, marginal to windward side of pans and water courses. Grades into lunettes (leeside transverse dunes) and other dunes. Includes some local slopewash deposits from dune flanks.

Qes$_1$: Longitudinal single and multicrested dunes, fine to medium-grained quartz sand. White to pale yellow near watercourses, yellow to west of Strzelecki Creek and red-brown to orange to the east. Transverse dunes and sand ribbons west of Strzelecki Creek.

Qe$_9$
Lunettes: Leeside transverse dunes, fine to medium-grained sand mostly as clay pellets (parna) with variable amounts of quartz, seed gypsum and mineral silt, derived by deflation of windward pan and lake-floor sediments. Several generations are apparent at some locations, Pleistocene forms are larger than Holocene forms. Colours range from yellow to pale brown. Lunette crests are shown where apparent.

Qe$_1$
Undifferentiated aeolian sand: Minor dunes to larger sand spreads within the large areas of defined sand units where complex intermixing has occurred. May include SIMPSON SAND, COONARBINE FM and lunette materials. Colours range from yellow to pale orange and pale brown. May include clay pellets, some gypsum grains and exhibit incipient grain binding within the lower parts of deep sand. Equates to Qs1 on STRZELECKI sheet.

Qec
COONARBINE FORMATION: Transverse dunes, loosely to moderately indurated red-brown to yellow-brown silt to medium sand, unbedded or with medium to small-scale cross-bedding. High percentage of clay pellets and gypsum grains, producing 'badlands' erosional pattern. Sometimes loosely cemented by carbonate palaeosols. Some interdigitating relationships with SIMPSON SAND. Locally burrowed, with land snail shells and Aboriginal artefacts.

Qpap
POORAKA FORMATION (equivalent): Clay, silt and gravel with minor cobbles forming remnant deposits on the upper parts of dissected surfaces and plateaus. Possibly a distal facies equivalent to the Pleistocene high terrace gravels (Qpa$_3$) and also (Qa). Represents a piedmont slope distal deposit. Colour dark yellow to orange to red-brown. Upper parts usually fine grained (silty or clayey) and not gibber clad.

Qpa$_3$
High terrace gravels: Cobble to gravel deposits with coarse sand matrix, forming remnant sheets 1 to 5 m thick, on dissected palaeo-erosional surface emanating from the Flinders Ranges highland. Distinguished from other cobble lags by its well-rounded polymict clasts, with locally developed large-scale trough cross-bedding, usually poorly sorted, weakly to moderately cemented by clayey gypsum and/or calcrete.

Qplc Qplm Qpae
EURINILLA FORMATION Qpae: Three members recognised: lowest has a basal conglomerate cemented by groundwater carbonate, has greenish to grey gypseous clays with yellow to reddish mottles, and contains vertebrate remains; the middle member is poorly bedded to cross-bedded, pale orange sand and silt and is capped by a calcareous palaeosol; the upper member is more widespread, reddish to orange silty sand. Younger piedmont slope deposit than WILLAWORTINA FM and may interdigitate with MILLYERA FM near playa lakes. An Early to Late Pleistocene time range is inferred from fossil evidence.

COOMB SPRING FORMATION Qplc: Beach facies gravel and sand forming strand ridge lines marking palaeo- and modern high water stands to Lakes Blanche and Callabonna. Colours range from intense red-brown to greenish yellow to pale grey. It is in part equivalent to MILLYERA FM which it can also overlie. May contain fish bones, mollusc shells, ostracods, wood and algal remains. Usually uncemented and range from loose to consolidated. TL dating yields ages from 26.2±3.0 ka to <1000 years BP, and modern ridges from historic lake-filling events have been observed.

MILLYERA FORMATION Qplm: Lacustrine facies and lower floodplain deposit, may be capped by gypsite. Green to grey clay with subconchoidal fracture or soft and crumbly, interbedded fine sand and silt, persistent limestone lamellae near top. It is in part equivalent to COOMB SPRING FM which it can also underlie. Contains the Lake Callabonna megafauna in its upper part; may also contain fish bones, mollusc shells, ostracods, wood and algal remains. It may interdigitate with EURINILLA FM towards the ranges. Age range based on radiometric and TL dating: >80 000 to ~1000 years BP.

TpQaw
WILLAWORTINA FORMATION: Calcareous, silty to sandy clay and medium sand grading to boulder deposits near ranges — piedmont slope deposit. Interbedded greenish pebbly or sandy carbonates. Poorly sorted, cross-bedded in coarser fraction, crude horizontal stratification. Greenish grey, largely oxidised orange and red-brown with black mottling. Carbonate nodules, greenish brown, are common. Top may have intertonguing relationship with MILLYERA FM. Age: Late Miocene–Pliocene (stratigraphic), pedogenic carbonate in upper layers is >43 000 years BP (radiogenic).

TERTIARY

TpQs$_1$
Palaeo-mound spring tufa: Dense cream limestone, sometimes vuggy with plant moulds and casts, often contains gas escape structures. Hard, conchoidal fracture to splintery when struck. Forms relict mounds and lenses (to extinct springs) 3–5 m above current Great Artesian Basin mound spring level (Qhs$_4$). Age: ?Late Pliocene to Pleistocene.

TpQay
YANDRUWANTHA SAND (mostly subsurface): Medium to very coarse, loose, brown sand with rough, subangular grains; includes varying proportion of white clayey fine sandstone grains and yellow to red-coated grains. Contains reworked Mesozoic and Tertiary sand with aeolian input. Meanders, channels and scroll bars of prior streams indicated where apparent, usually as 'ghosts' in overlying units.

T$_{si}$
Silcrete undifferentiated: Grey to buff coloured microcrystalline to cryptocrystalline silica horizons, both massive groundwater and massive to columnar–vuggy pedogenic forms developed in older sandy to silty substrates. Where present in silty and shaly substrates, the forms include white porcellanite and grey fine-grained 'greybilly' silcrete. Anatase and titaniferous minerals included within pedogenic silcrete as wisps; exhibit golden colour on fresh surface. Coloured jaspers, chalcedony (bright yellow to red) and opaline forms occur within the pedogenic silcrete horizons. 'Ant-nest silcrete', reddish to purple, silicified ant or termite mound galleries, in palaeosol horizons within the mid- to upper EYRE FM. Pedogenic pseudo-breccia forms are silicified soil and/or weathering mottle patterns. Weathered surfaces often variously ferruginous or with 'desert varnish'. Symbol used as an overprint on host rock unit. Age: Eocene and Miocene–Pliocene, older silcretes implied from clast evidence in MULLIGAN DAM REGOLITH. Units commonly silcreted are PARABARANA SANDSTONE, MARREE SUBGROUP, EYRE FM and NAMBA FM. Worked extensively by Aboriginals for stone tools.

Topn
NAMBA FORMATION (upper unit): Olive-grey swelling clay with gypsum nodules near top, weathers to dark grey or black (hydrous manganese oxide staining) with yellow-orange flecks to mottles. Greenish laminated silt and fine sand with angular, well-sorted grains, white oolitic and conglomeratic dolomite nodules and beds. Bioturbated; burrows, rare invertebrate fossils, fine and medium cross-bedding, fast flow structures.
Lower unit (subsurface only): lithology as above, but with interbedded indurated dark sandy claystone with skew planes and sand (fine to coarse, low sphericity, subrounded and polished). Structures as above, burrows less evident; vertebrate, invertebrate and plant fossils. White, very fine-grained dolomite interbedded with olive-grey clay (palygorskite) is present near the base.
NAMBA FM is equated with ETADUNNA FM (Tope) to the W and NW of this sheet. Age: Latest Oligocene for lower unit to Late Miocene–Pliocene for upper unit.

Taee
EYRE FORMATION: Fluvial quartz sand, rounded to angular, fine to coarse-grained, grit beds common, cross-bedded channel fill, occasional laminated lacustrine silt and clay, basal gravel with highly polished well-rounded clasts (quartz, chalcedony, silicified wood, silcrete), consolidated but not cemented, occasional leaf impressions, often lignitic in drilled section. Palaeosols marked by reddish 'ants-nest' silcrete or columnar to massive pedogenic silcrete. Silcrete clasts occur in basal gravel. Overlies MULLIGAN DAM REGOLITH. Palynology age range: Late Paleocene to Middle Eocene.

Tae$_{re1}$
MULLIGAN DAM REGOLITH upper unit: Massive to indistinctly bedded gravelly to pebbly sandstone, contains well-rounded silcrete pebbles, yellow-grey to yellow-brown, exhibits cavernous weathering, gradational with lower unit. Thickness 1 to >5 m.
Lower unit: A basal pallid (pale grey to pale khaki) blotchy to mottled (red) pedolith to saprolith zone (1–2 m thick) developed as a weathering profile in Late Cretaceous shale. Mottled zone grades into upper unit via a colluvial zone (<0.3 m thick). Age: ?Paleocene (stratigraphic).

KTa$_{fe}$
Groundwater ferricrete: Ferruginous chemical precipitate forming cement in sandstone beds, palaeo- to modern aquifers, black to very dark brown, often with boxwork structures in upper part, otherwise massive to variously laminated. Formed by oxidative precipitation of soluble groundwater iron in once permeable sandstone. Age: ?Cretaceous to Paleocene.

MESOZOIC — CRETACEOUS

EROMANGA BASIN

NEALES RIVER GROUP (Kn) — MARREE SUBGROUP (Km)

Knw
WINTON FORMATION (subsurface only): Dark grey-brown sandy silt–clay, finely laminated and cross-bedded, fluvial to paludal–lacustrine, weakly bioturbated. Basal portions carbonaceous to lignitic, lowest coal commonly taken as base. Where lowest coal not present, contact with the underlying MACKUNDA FM is often gradational and difficult to place. Fossil wood and leaves, freshwater bivalves, fish, and vertebrates. Age: Cenomanian.

Knm
MACKUNDA FORMATION (upper unit): A marginal marine deltaic facies, distinctly bimodal cross-bedding, yellow-brown fine to medium sand interbedded with greenish to grey silt and silty clay. Lower unit: (major part of formation, mostly subsurface) pale grey-green interbedded, cross-bedded, glauconitic, sand–silt–shale and calcareous shale; mud and clay intraclasts are common within the silty to sandy interbeds. Fossiliferous; molluscs, forams, wood, diverse microflora, fish and vertebrates. Marginal marine to paralic, Late Albian regression.

Kmo
OODNADATTA FORMATION Kmo: Dark grey to grey mudstone with fossiliferous limestone concretions (molluscs, forams, wood, diverse microflora, fish, vertebrates), bioturbated, interbedded with calcareous siltstone and fine-grained sandstone. Shallow marine. Age: Albian. Recognised in subsurface; surface exposures often indistinguishable from BULLDOG SHALE if no COORIKIANA SANDSTONE present, and shown as MARREE SUBGROUP.

Kmc
COORIKIANA SANDSTONE Kmc: Silty fine to medium-grained sand, broadly cross-bedded, buff to yellow, gradational base with sandy upper part of BULLDOG SHALE below. Fluvial–deltaic equivalent exposed at Mt Yerila, otherwise subsurface only. Shoreface to open marine. Age: Albian.

Kmb
BULLDOG SHALE Kmb: Laminated marine clay to silt, sandy lenses. Dark grey to dark grey-brown, bioturbated, contains mid-unit concretions and exotic lonestones. Onlaps basement inliers. Glendonites (middle BULLDOG, Late Aptian) indicate very cold basinal waters; ?seasonal periglacial conditions. Fossiliferous; molluscs, forams, wood, microflora, fish teeth and vertebrates. Open marine, shallow to moderate water depth. Age: Aptian to Albian.

Km
MARREE SUBGROUP Km: Undifferentiated, includes BULLDOG SHALE, COORIKIANA SANDSTONE and OODNADATTA FM — laminated marine shale, silt and clay, bioturbated, dark grey, with occasional shelly beds.

Knr Knct
PARABARANA SANDSTONE Knr: Fluvial to marginal marine quartz sandstone, gritty to gravelly at base, contains exotic lonestones, has occasional pebble lenses and carbonaceous clays as basal channel infill. Bioturbated and fossiliferous; bivalves, leaves and wood. Upper surface usually calcite cemented and can be silcreted. Onlaps basement inliers with rare wave-polished granite surfaces preserved. The Trinity Well Sandstone Member (Knct) is included within the upper part of Knr. Time equivalent to CADNA-OWIE FM (Knc) to the north and PELICAN WELL FM (Knp) to the west.

K-u K-um
MURTA FORMATION (mostly subsurface): Dark grey laminated carbonaceous siltstone, graded beds, ripple marks with interbeds of fine-grained to locally coarse-grained sandstone, ripple laminated, bioturbated. Carbonate-cemented layers near top, diagenetic siderite common. Dewatering disruptions and soft-sediment deformation in lower parts. Top may grade into the CADNA-OWIE FM – PARABARANA SANDSTONE. Lacustrine with basal transition to the McKinlay Member (K-um), a lake margin and fluvial basal unit.

JK-n
NAMUR SANDSTONE (subsurface only): White, fine to coarse-grained sandstone, flat to cross-bedded, locally with calcareous cement, channel lag conglomerate. Siltstone interbeds, especially in middle part. Minor mudstone and coal stringers. Sandy lacustrine and fluvial (braided river). Age: Late Jurassic to Early Cretaceous (palynological). Basin margin equivalent is ALGEBUCKINA SANDSTONE (JK-a).

JURASSIC

J-b
BIRKHEAD FORMATION (subsurface only): Dark grey-brown siltstone with minor mudstone and buff sandstone. Carbonaceous, sideritic, burrows, root casts and mottling, interbedded with coal as thin beds and stringers. Lacustrine, paludal, fluvial (meandering river). Age: Middle to Late Jurassic (palynological).

J-h
HUTTON SANDSTONE (subsurface only): White, fine to very coarse-grained and conglomeratic quartzose sandstone, flat to cross-bedded. Common reworked clasts and minor interbeds of mudstone. Carbonaceous partings. Mainly fluvial, with possible aeolian and lacustrine deposition. Age: Middle Jurassic (palynological). Basin margin equivalent is ALGEBUCKINA SANDSTONE (JK-a).

JK-a
ALGEBUCKINA SANDSTONE (subsurface only): Undifferentiated alluvial and fluvial deposits, chiefly white, medium to coarse-grained, quartzose and pebbly, kaolinitic. Replaces NAMUR SANDSTONE and HUTTON SANDSTONE as the interbedded, finer grained rock units lens out towards the Eromanga Basin margin. Age: Early Jurassic to Early Cretaceous (palynological).

PALAEOZOIC-MESOZOIC — LATE PERMIAN-EARLY JURASSIC

PJ$_{re1}$
BOPEECHEE REGOLITH: A widespread regolith of chemically altered rocks (palaeosol) often overlain by a mechanically derived debris (waste mantle). Exposed at the edges of the Flinders Ranges, developed in Mesoproterozoic granites and Neoproterozoic metasediments. The saprolite zone (white, cream, yellow to brown), thickness <2 to >20 m, is strongly kaolinised, original rock fabric preserved by more resistate minerals. The unit is discontinuous due to post-development erosion. The overlying waste mantle thickness is 0.1 to ~1.5 m; this can grade into the overlying Mesozoic sandstones. It is a colluvium–slope debris of angular fragments, unsorted, with pseudo-layering to crude layering at its top. Clast type and matrix strongly reflect the underlying parent saprolite materials. Best exposures SW of Prospect Hill (S of Dog Fence), underlying the PARABARANA SANDSTONE. Age: ?Late Permian to ?Early Jurassic from stratigraphic evidence here and elsewhere.

PALAEOZOIC — EARLY PERMIAN — ? LATE CARBONIFEROUS

COOPER BASIN (subsurface only)

GIDGEALPA GROUP (CPg)

Pge
EPSILON FORMATION: Off-white, fine-grained, ripple-laminated, thinly bedded sandstone, locally thick with interlaminated siltstone, or thin with interbedded mudstone and coal. Three depositional cycles; base and top are upward-coarsening sandstone, middle is coal dominant. Fluvial to lower delta plain and delta front. The formation is diachronous, being younger to the west.

Pgm
MURTEREE SHALE: Dark grey, interbedded, carbonaceous mudstone and siltstone with minor sandstone, characteristic fine-grained variably pyritic and muscovite. Laminated, and calcareous. Lacustrine, cyclic oxic to anoxic conditions.

Pgp
PATCHAWARRA FORMATION: Interbedded, grey, buff or brown sandstone (locally pebbly), mudstone with carbonaceous partings and coal. Stacked channel and upward-fining deposits. Thick coal seams in lower part. Upper levels dominated by mudstone with thin interbeds of siltstone and sandstone. Fluvial (point bars, meandering river), backswamp and floodbasin. Spore–pollen assemblage is of cold to cool-temperate flora.

CPgl
TIRRAWARRA FORMATION: Buff-white, medium to coarse-grained sandstone, massive to flat-bedded and cross-bedded. Rare mudstone and coal stringers. Stacked multistorey sand bodies. Paraglacial, fluvial (braided river).

Cgl
MERRIMELIA FORMATION: Buff-white, fine-grained sandstone, ripple-bedded, soft-sediment deformation. Massive to crudely bedded conglomerate, framework supported with reworked early Palaeozoic clasts and glauconite pellets. Poorly sorted diamictite, matrix supported, dropstones. Dark grey claystone and siltstone, flat-laminated or graded with interbeds of fine-grained sandstone. Fluvioglacial outwash, lacustrine (shallow to relatively deep water), subaerial and subaqueous tillites. Sparse spore–pollen assemblage indicates a Late Carboniferous to Early Permian age.

CAMBRIAN-ORDOVICIAN

ARROWIE BASIN (subsurface only)

€f ?LAKE FROME GROUP (€f)
Red bed sequence. Feldspathic flat to cross-bedded sandstone-mudstone, planar reactivation surfaces common, mudcracks and local bioturbation zones. Diagenetic red mottling and green reduction patches. One ?trilobite trail observed. Sandy shoreface - shallow subtidal environment with some subaerial exposure. Known only from SANTOS CBH-2, ?PANTAPINNA FM.

WARBURTON BASIN (subsurface only)

DULLINGARI GROUP (€Ou)

€P$_1$
Unnamed sandstone €P$_1$: Altered sandstone and mudstone as a series of quartzite, shale and silica-cemented equivalents (known only from Weena 1). Rusty red with minor green (chlorite) and white, poorly sorted very fine to very coarse-grained sandstone, ubiquitous large mica flakes, intraclasts of mudstone within sandstone beds. Unfossiliferous. Moderate to low-energy marine shelf environment with cyclic fluvial input.

€Ou
DULLINGARI GROUP (€Ou): Dark grey to black shale, laminated, pyritic, variably calcareous. Interbedded locally with cream spiculitic chert, siltstone and fine to coarse-grained lithic sandstone, conglomeratic in part. Graptolites in shale facies indicate a middle Cambrian to ?early-middle Ordovician age. Marine outer shelf and deep basin.

PHANEROZOIC INTRUSIVES

€Odu €Odu$_1$
MUDNAWATANA TONALITE: Medium-grained, equigranular, white to grey granodiorite to tonalite, locally with xenoliths and associated coarse-grained felsic pegmatite dykes and apophyses (€Odu$_1$). Delamerian syn- to post-tectonic granitoid formerly known as the MUDNAWATANA GRANITE. (Rb–Sr age 427±133 Ma).

PROTEROZOIC — NEOPROTEROZOIC — ADELAIDEAN

ADELAIDE GEOSYNCLINE

MARINOAN — UPALINNA SUBGROUP (Ni)

Nib
AMBEROONA FORMATION: Finely laminated green to grey-green siltstone, ?conformably overlies YANKANINNA FM.

Niy Niy$_1$
YANKANINNA FORMATION: Thinly bedded grey siltstone with buff-weathering grey dolomite as diachronous lenses up to 30 m thick (Niy$_1$). Unconformably overlies BALCANOONA FM with clasts of this underlying unit within a basal conglomerate layer.

STURTIAN — UMBERATANA GROUP (Nu) — NEPOUIE SUBGROUP (Nn)

Nnb
BALCANOONA FORMATION: Brown-weathering pale grey dolomite, strongly recrystallised obscuring most original layering. Locally metasomatically altered to talc, tremolite, scapolite and chlorite schists. Has a basal conglomerate ~1 m thick and unconformably overlies BOLLA BOLLANA TILLITE. Rare relict stromatolite 'ghosts' occur in the dolomite.

YUDNAMUTANA SUBGROUP (Ny)

Nyb Nyb$_1$
BOLLA BOLLANA TILLITE: Massive tillite, lithic and quartz clasts with slatey to sandy matrix. Clasts are subangular to well rounded and usually deformed by later folding. Basal contact with FITTON FM is often gradational. Minor siltstone and quartzite, usually tillitic, are metamorphosed to calc-silicate and para-amphibolite lenses and beds (Nyb$_1$).

Nyf Nyf$_3$
FITTON FORMATION: Dark grey laminated siltstone, minor quartzite, sparse lithic clasts, gravel to cobble sized, recurrence of boulders (Prospect Hill). Has occasional beds and lenses of scapolitic and amphibolitic calc-silicate tillite and siltstone (Nyf$_3$).

Nyfh
Hamilton Creek Member of the FITTON FM: Granite clasts ranging up to 2 m diameter with an arkosic to silty matrix, clasts subangular to well rounded and partly deformed by later folding. Unit ranges from clast to matrix supported from base upwards and its top is often gradational with the main FITTON FM.

Nyf$_1$
Quartzite conglomerate – tillite member of the FITTON FM: Quartzite clasts ranging up to 3 m diameter with a slaty to fine sandy matrix; clasts subangular to well rounded and usually deformed by later folding. An unconformity surface forms the basal contact near Prospect Hill.

WILLOURAN — CALLANNA GROUP (Nc) — ARKAROOLA SUBGROUP (Na)

Nap Naps
PARALANA QUARTZITE: Equivalent; with basal Shanahan Conglomerate Member (Naps), massive to poorly bedded orthoquartzite, heavy-mineral bands near base. The conglomerate member consists of rounded quartzite cobbles with magnetite and pyrite-rich quartzite matrix. This member interdigitates with the main quartzite and in some locations forms two or three ~1 m thick basal beds. The base rests on a major unconformity surface.

CURNAMONA PROVINCE

Mt Babbage and Mt Painter Inliers

MN$_1$
Meta-mafic dykes, minor sills, and intrusive pods: Original basalt, dolerite and gabbroic rocks with rarer andesite, are all variously amphibole to biotite–chlorite altered. Most dykes are deformed and foliated, some are intensely sheared. Age of emplacement is uncertain (Meso- to Neoproterozoic).

pg pg-Mmt pg-Mmy
Pegmatite dykes and sills undifferentiated: Felsic (pg); also areas where pegmatite dykes intrude granite hosts (Mmy and Mmt) in a 50:50 mix of dyke to host rock (pg/Mmy, pg/Mmt). Pegmatites include those of Proterozoic and Phanerozoic age.

MESOPROTEROZOIC — MOOLAWATANA SUITE (Mm)

Mmg 1. **Mmc 2.** **Mmh 3.** **Mmp 4.**

1. **GOLDEN POLE GRANITE:** Mostly non-porphyritic, reddish, xenolith-free, tourmaline-rich (orbicules and clots), fine to coarse-grained biotite granite. Composed of K-feldspar, plagioclase, quartz and biotite, with accessory tourmaline, opaques, apatite, locally scheelite and copper sulphides.
2. **CON BORE GRANITE:** Mostly non-porphyritic, greyish, large volcanic xenoliths, partly granophyric, fine to coarse-grained biotite granite. Composed of quartz, K-feldspar, plagioclase and biotite, with accessory fluorite, apatite, tourmaline, pyrite and chalcopyrite.
3. **WHITE WELL GRANITE:** Tabular feldspar biotite granite, greyish. Intrudes the PETERMORRA VOLCANICS at Prospect Hill. Composed of microcline, bluish quartz, plagioclase, biotite and secondary muscovite, with accessory zircon, monazite and apatite.
4. **PROSPECT HILL GRANITE:** Sparsely porphyritic adamellite, dark grey, with tourmaline clots and orbicules, wispy volcanic and granitic xenoliths. Leucocratic near upper intrusive contact with PETERMORRA VOLCANICS at Prospect Hill. Composed of scattered anhedral to round microcline phenocrysts set in a groundmass of subequal amounts of orthoclase, plagioclase, bluish quartz and ~10% biotite, with accessory tourmaline, fluorite, monazite and allanite.

Mmt Mmt$_1$
TERRAPINNA GRANITE: Massive to gneissic coarse-grained grey porphyritic rapakivi-like granite to adamellite (pink weathering). Has minor comagmatic varieties including melanocratic, medium-grained and a sparsely porphyritic to xenocrystic form (Mmt$_1$). Contains metasedimentary and granitic xenoliths. Mostly composed of ovoid microcline and round quartz phenocrysts set in a mosaic of K-feldspar, quartz, biotite, muscovite and albite, accessory tourmaline, opaques, apatite and zircon. (U–Pb zircon age 1557±6, 1556±4 Ma).

Mm$_1$
WATTLEOWIE GRANITE – TERRAPINNA GRANITE: Intimate apophyses, association as a 50:50 mix. Map grouping of convenience.

Mmw
WATTLEOWIE GRANITE: Weakly gneissic white to grey adamellite, medium to coarse-grained, minor melanocratic and minor phenocrystic varieties. Locally texture can be gradational with medium-grained varieties of the younger TERRAPINNA GRANITE. Composed of microcline, quartz, oligoclase, albite and biotite with accessory zircon, apatite and opaques. Relative age: post-YERILA GRANITE and pre-TERRAPINNA GRANITE.

Mmy
YERILA GRANITE: Lineated tabular feldspar phenocrystic granite, gneissic, usually melanocratic, grey to dark grey, enriched in rare earth elements. Composed of microcline laths, albite, quartz, biotite, muscovite, with accessory apatite, zircon and tourmaline. Strong actinolite alteration in an area northwest of Birthday Well. (U–Pb zircon age 1556±10 Ma).

Mmb
BOX BORE GRANITE: Coarse-grained (phenocrystic) alkaline, potassic granite, strongly foliated to mylonitic, red K-feldspar augen in melanocratic to leucocratic (often ribboned) groundmass. Augen enwrapped by secondary biotite set in a mosaic of quartz, K-feldspar, biotite and minor plagioclase, with accessory fluorite, allanite, zircon and monazite. (U–Pb zircon age ~1555 Ma).

M-e M-e$_1$
PETERMORRA VOLCANICS: Meta-quartz–feldspar porphyry and associated volcaniclastics to epiclastics, and including a conformable basal unnamed sericitic sandstone member with no observable bedding (M-e$_1$). The volcanics are strongly deformed, poorly bedded to massive, grey to dark grey and contain post-emplacement tourmaline clots as does the underlying sericitic sandstone member. (U–Pb zircon age 1560±2 Ma).

M$_{16}$
Unnamed felsic porphyries and volcanics: northern end of the Mt Painter Inlier, strongly deformed, intruded by both TERRAPINNA GRANITE and BOX BORE GRANITE, associated with minor granitoids. Age uncertain (Mesoproterozoic).

M$_{14}$
Porphyries undifferentiated: high-level intrusives, subvolcanic, red to pink to grey, fine-grained sugary matrix with quartz and/or feldspar phenocrysts 2–5 mm in diameter. Age uncertain.

M-n
MOUNT NEILL GRANITE: Massive, grey, porphyritic, coarse-grained granite with minor adamellite. Broad chill margins of porphyritic microgranite; unit includes minor ?extrusive equivalents, very weakly deformed to undeformed. Composed of ovoid microcline phenocrysts in a groundmass of quartz, microcline, plagioclase, biotite, muscovite–sericite, with accessory opaques, zircon, fluorite and epidote. (U–Pb zircon age 1569±14 Ma). Formerly known as MOUNT NEILL GRANITE PORPHYRY.

M$_{13}$
Granitoids undifferentiated: includes; granite, adamellite, granodiorite and diorite intrusives. Age relationships uncertain; most appear to be Mesoproterozoic.

PALAEOPROTEROZOIC — RADIUM CREEK METAMORPHICS (Lr)

Lr$_7$
Quartzites undifferentiated: medium to coarse-grained orthoquartzite, quartzite and psammitic schist, meta-quartz sandstone, sericitic sandstone, minor immature sandstone and rare heavy-mineral banding. Isoclinal folding may be rarely observed.

Lr$_6$
Schist undifferentiated: psammitic and mica schists as a 50:50 mixture: metasandstone and metamudstone–siltstone. Often exhibit multiple deformation fabrics; crenulations and kink bands.

Lr$_5$
Schist undifferentiated: quartz–feldspar–mica schist: immature metasandstone–siltstone. Often exhibit multiple deformation fabrics; crenulations and kink bands with rodding of quartz bands occasionally present.

Lr$_4$
Gneiss undifferentiated: quartz–feldspar–mica gneiss: meta-feldspathic sandstone and arkose.

Lrb Lrb$_1$
BRINDANA SCHIST: psammitic schist, muscovite and biotite schist, minor garnet–sericite schist, and calc-silicate rocks including: epidote quartzite, hornfels, garnet rocks and skarns. Often exhibits multiple deformation fabrics; crenulations and kink bands. Lenses and discontinuous bands of cordierite–mica rock and para-amphibolite (Lrb$_1$).

Lr$_3$
Quartzite undifferentiated: metamorphosed sandstone, pebbly sandstone, feldspathic sandstone and pebbly arkose.

Lr$_2$
Banded calc-silicate gneiss: epidotised banded quartz–albite gneiss, containing many variously orientated blocks, ?brecciated, near Parabarana Hill. Banding exhibits multiple deformation fabrics and refolded isoclinal folds. Carries anomalous base-metal values at Parabarana Hill. Considered to be a possible Willyama Supergroup equivalent. Intruded by MOUNT NEILL GRANITE.

Lr$_1$
Calc-silicate–marble: meta-limestone, marble, recrystallised with calc-silicate minerals. Carries anomalous base-metal values and secondary copper mineralisation at Parabarana Hill. Considered to be a possible Willyama Supergroup equivalent. Deformed and fragmented by the Paralana Fault and shear zone.

PROTEROZOIC-PALAEOZOIC

Northern Curnamona Province

L€
Quartz–muscovite phyllite: pale to medium green-grey, finely laminated and bedded with low-angle dips, pearly lustre, variably finely fractured, flattened pyrite, rare carbonaceous matter (Gurra 1). The unit in Paxton 1 consists of grey coarse-grained greywacke and medium-grey metasiltstone; both are occasionally carbonaceous and the siltstone is pyritic. Phyllite in Fortville 3 is weathered, tightly folded, sheared and of low metamorphic grade. Generally these rocks are tight, with most fractures mineral infilled. Previously correlated with the Willyama Supergroup (Lw); age now in question.

OTHER ROCK SYMBOLS

br$_1$
Breccia: fault crush zone, fault gouge, often ferruginous, may carry minor pyrite, marcasite and chalcopyrite.

sh$_1$ m
Tectonic shearing (overprint symbol ~~): strong localised schistose fabric. Tectonic schists, mylonite and minor breccia within Paralana Fault and shear zone (sh$_1$). Strong mylonitic fabric (overprint symbol ~m~).

qz
Vein quartz: hydrothermal, massive, white to grey, sometimes ferruginous staining along joints and fractures.

qz$_2$
Vein quartz–tourmaline: hydrothermal, massive, medium to coarse-grained, usually 50:50 mix qz:tm, grey to black, Prospect Hill area.

qz$_3$
Quartz fault zone infill: banded, white to grey, sometimes exhibit annealed brecciation, may also be strongly mylonitic.

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