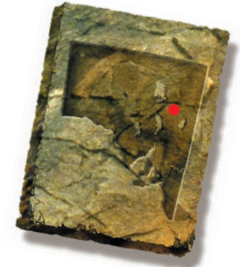
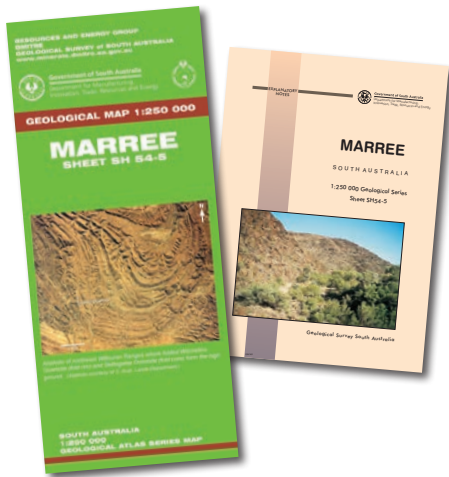


# MARREE 1:250 000 geological map (2nd edition) and explanatory notes



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A new second generation MARREE 1:250 000 scale geological map and explanatory notes have been published. An image of the new map together with a summary of the physiography, geology, previous investigations and economic geology are provided below.

## Physiography

The MARREE 1:250 000 map area includes the southwestern portion of Strzelecki Desert and part of Tirari Desert, northwestern Flinders Ranges and northeastern Willouran Ranges, between latitudes 29° to 30°S and longitudes 138° to 139°30'E (Fig. 1). Three large playas form the ephemeral lakes Blanche, Eyre North and Gregory that partially extend onto the map's northern zone; their floors are only ~2 m above sea level. The Flinders and Willouran ranges form highlands to the surrounding plains. Significant peaks include Dingo Hill (366 m), Mount Distance (335 m), Mount Freeling (384 m), Mount Gardiner (339 m), Mount Livingston (586 m) and Twenty Mile Hill (287 m). Numerous creeks debouch from highland terrain and drain dominantly northerly towards the three large playas. This area is broadly northerly sloping to flat to

convex, and is partly covered by dune field sands of the afore mentioned deserts. MARREE is adjacent to and west of South Australia's driest region (Lake Callabonna, 100 mm/a). It is dominantly arid with hot dry summers and cool winters; sporadic rainfall of ~150 to 180 mm may occur between autumn to late spring.

## Previous and recent investigations

Systematic geological atlas mapping in this region began in 1955, culminating in four 1:63 360 maps, of which Gardiner, Marree and Wilpoorinna cover part of southern MARREE (Campana et al. 1961; Coats, Horwitz and Webb 1963; Forbes and Coats 1963). Later, a revision of part of that work was combined with additional mapping to be released as the 'Mount Painter Province geological map' (1:125 000 scale, Coats et al. 1969),

included in the Mount Painter Province bulletin (Coats and Blissett 1971).

Earlier geological investigations by Mawson (1912, 1923), Segnit (1939) and Coats (1964) had established a basic stratigraphic framework for compilation of the first generation MARREE Geological Atlas Series Map (1:250 000; Forbes et al. 1965) and associated report of investigations (Forbes 1966). Later work by Thomson et al. (1976), Coats and Forbes (1977), Coats (1981), Preiss (1987, 1993), Preiss et al. (1998, 2011), Preiss and Cowley (1999) and Williams et al. (2011) added greatly to the regional understanding of the Adelaide Geosyncline sedimentary succession. Investigations of mollusc and foram fossils by Ludbrook (1960, 1961, 1966) established a biostratigraphic framework for the Mesozoic Eromanga Basin sediments of this region. Many later microfossil and stratigraphic

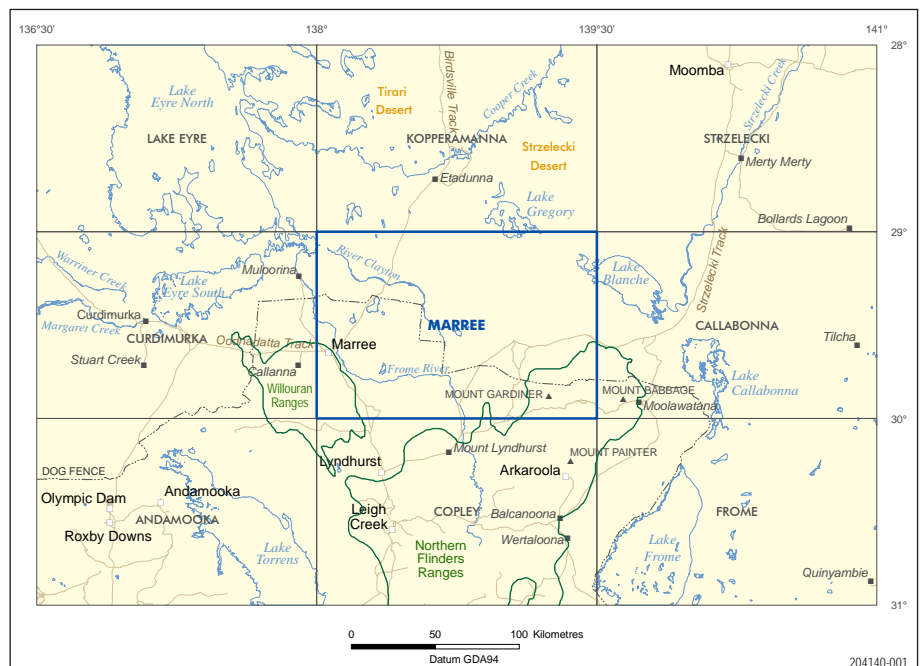


Figure 1 Regional locality plan displaying the MARREE 1:250 000 map area and adjoining maps.

studies have added to the understanding of this region's Mesozoic to Cenozoic sedimentary history.

The latest geological mapping program (1993 to 1997) culminated in six digital 1:100 000 maps and a second edition 1:250 000 map (White 2000a, b, c; White and Reid 2000; White, Sheard and Reid 2000a, b, 2012). Ground surveys were carried out primarily by MR White, PW Reid and MJ Sheard, with occasional input from GW Krieg, NF Alley, PA Rogers and WV Preiss. Logged drillholes provided essential subsurface detail for the map and peripheral diagrams, and material presented within the latest explanatory notes (Sheard 2012).

The first generation MARREE geological map delineated 41 rock units (35 at formation level, 6 at member level) and placed around half of the formations within four stratigraphic groups. The second generation map and report differentiates 140 units (59 at formation level, 28 at member level and 45 unnamed units) and places more than half of all units within nine stratigraphic groups. Some Mesozoic and Cenozoic strata are not formally grouped or named. Newer dating methods, petrology and assays have assisted in refining detail in the basement, sedimentary stratigraphy and deformational history. Microfossil and macrofossil biostratigraphic analyses have assisted in refining basin sediment ages and with interpreting environments of deposition.

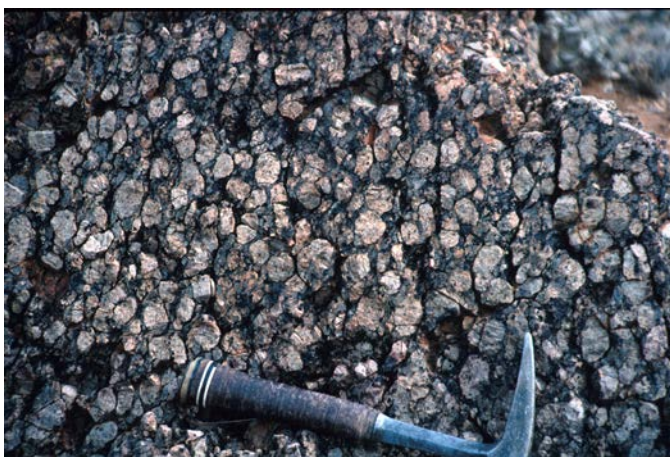
## Stratigraphy

Mesoproterozoic rocks are the oldest in this area and comprise crystalline metasediments of the c. 1590 Ma Radium Creek Group, and igneous rocks of the c. 1560 Ma Petermorra Volcanics and c. 1555 Ma Moolawatana Suite, within Mount Babbage Inlier. The western third of that inlier extends onto MARREE where it forms a deformed northwestern corner to the Paleo-Mesoproterozoic Curnamona Province. Most of the Radium Creek Group units are intruded by Moolawatana Suite granites. Petermorra Volcanics crop out as a series of low E–W-trending ridges in the Prospect Hill area of the adjacent CALLABONNA area, but a limited western extension occurs on MARREE. Within Mount Babbage Inlier the Moolawatana Suite forms elongated E–W aligned bodies, a product of regional orogenic folding (Sheard 1996). All intrusive phases and Radium Creek Group rocks are crosscut by related very coarse grained pegmatite dykes, which are usually moderately deformed (Sheard, Fanning and Flint 1992; Sheard 2009). Both the Moolawatana Suite and Radium Creek Group have been intruded by Mesoproterozoic to ?Cambrian amphibolitic meta-mafic dykes.

Neoproterozoic sediments of the Adelaide Geosyncline are exposed within: the northwestern Flinders Ranges (map SE corner) unconformably overlying the Mesoproterozoic Mount Babbage Inlier; a small area of low relief (central southern edge); and

forming the northeastern Willouran Ranges and low relief surrounds (SW corner). Callanna Group rocks are the oldest Neoproterozoic units; these have limited and disjointed exposures. Burra Group rocks unconformably overlie Callanna Group and have variable exposure, from near 100% to partly obscured. Next are Umberatana Group rocks deposited during the Sturt glaciation onto an unconformity surface, followed by the thick Wilpena Group spanning the Elatina glaciation with interglacial sediments in between. Billy Springs Formation of the upper Wilpena Group includes the Ediacaran period and its internationally renowned trace meso-scale fauna. Diapirs have brought Callanna Group rocks to the surface within and adjacent to the Willouran Ranges; however, only pseudomorphs of the original evaporitic minerals driving that Neoproterozoic diapirism are observed now.

Paleozoic rocks are represented by Cambrian sediments, a Cambro-Ordovician tonalite and the newly identified Devonian Ooloo Hill Formation. Cambrian sediments occur within the Arrowie Basin, adjacent to and partly within the northern Flinders Ranges; they disconformably overlie Neoproterozoic Adelaide Geosyncline rocks. These rocks include Early Cambrian Hawker Group (now includes Western Spur Limestone – new name) and the Middle Cambrian Lake Frome Group. Mudnawatana Tonalite is restricted to the Mount Babbage Inlier where two small lobes of this pluton crop out near the map's SE corner, but

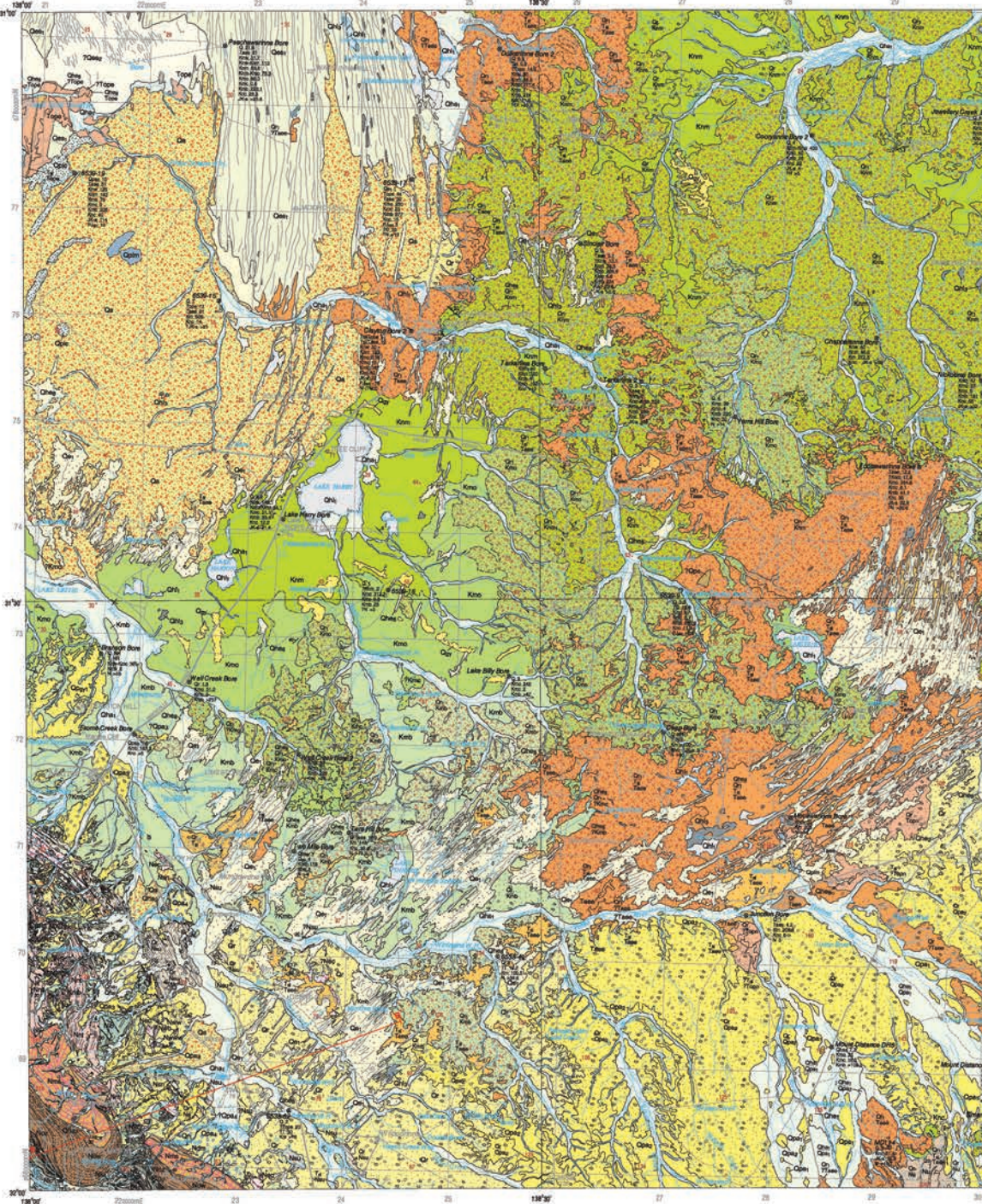
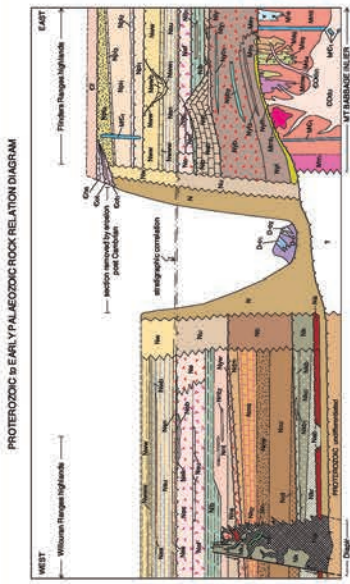
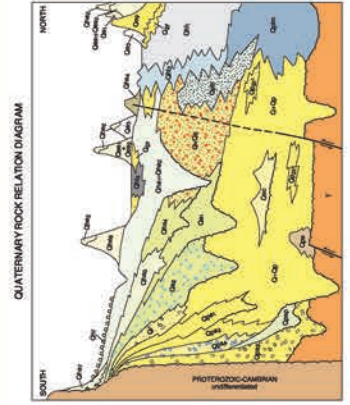


*Terrapinna Granite outcrop displaying its typical very coarse grained porphyritic texture, 1 km SW of Prospect Hill. If very fresh, this rock is grey with the quartz phenocrysts being bluish and grey. Hammer is 300 mm long. (Photo 410048)*

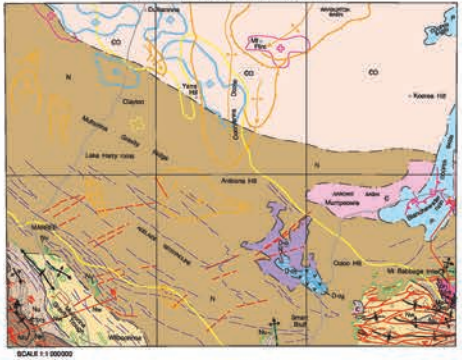


*Burr Well Member (Wonoka Formation) showing grey laminated dolomite containing a deformed clast of massive yellow dolomite, ~2 km NW of Mount Livingston. Lens cap is 55 mm wide. (Photo 410049)*

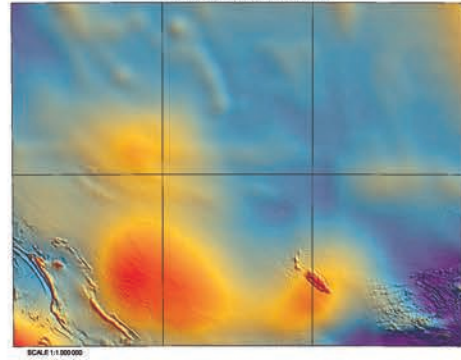
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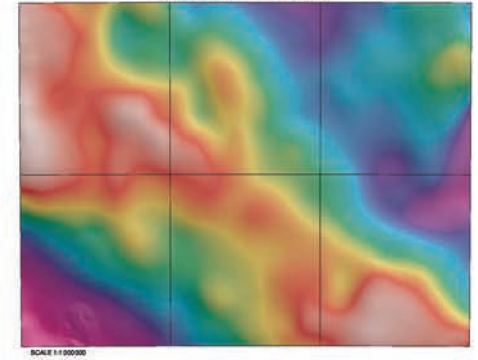
STRUCTURAL INTERPRETATION SKETCH



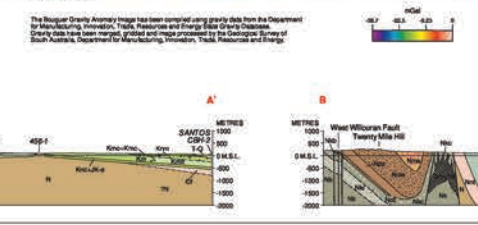
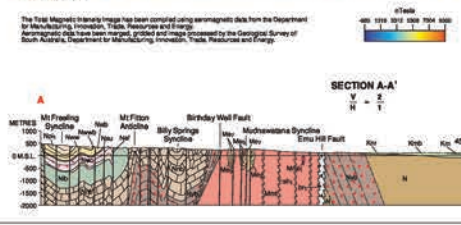
TOTAL MAGNETIC INTENSITY IMAGE



BOUGUER GRAVITY ANOMALY IMAGE



- SCALE 1:1 000 000
- FAULTS**
    - Faults (see types opposite)
    - Vertical, up - down
    - Horizontal, displacement
    - Dome edge
    - Dome side band
    - Thrust
    - Shear
  - FOLDS**
    - Anticline & plunge
    - Syncline & plunge
    - Linear fold
    - Lineation
  - MAGNETIC ROCK**
    - > 1 000 m deep
    - > 300 m deep
    - MAGNETIC ROCK & GRAVITY HIGH
    - > 1 000 m deep
    - Edge of gravity high
    - Deep seated gravity high source > 4 km
    - Deep seated gravity low
  - GEOLOGICAL BOUNDARY**
    - Observed
    - Inferred
  - BEDDING TRENDS**
  - UNCONFORMITY - MAJOR**



- GEOLOGICAL BOUNDARY
- Observed
  - Inferred
- FAULTS
- Vertical, up - down
  - Horizontal, displacement
  - Dome edge
  - Dome side band
  - Thrust
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- MAGNETIC ROCK
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  - Deep seated gravity high source > 4 km
  - Deep seated gravity low
- GEOLOGICAL BOUNDARY
- Observed
  - Inferred
- BEDDING TRENDS
- UNCONFORMITY - MAJOR



its subsurface intrusive extent further west is uncertain due to a paucity of drilling. Pegmatite dykes associated with Mudnawatana Tonalite are only weakly deformed (unlike those of Moolawatana Suite); these intrude Radium Creek Group, Moolawatana Suite and Adelaide Geosyncline rocks. Ooloo Hill Formation is partly penetrated by three drillholes ~75 km east of Marree village. It consists of a marine sedimentary succession of Paleozoic age (detrital zircon dated), with a more localised submarine basaltic volcanic member including some interflow clastics containing shelly fossils (3 basalt flows K–Ar dated yield a combined minimum age of  $388 \pm 14$  Ma, mid Devonian). Geochemically and isotopically these lavas resemble Lachlan Fold Belt basalts rather than more local mafic rocks (Sheard 2012).

Mesozoic deposits are represented by Jurassic–Cretaceous Eromanga Basin sediments. Along the southern portions of MARREE the Eromanga Basin onlaps Proterozoic basement and crops out around the margins of the Flinders and Willouran ranges. This sedimentary succession (~550 m thick) also rests unconformably on a SW extension of the late Paleozoic Cooper Basin, on the northern Arrowie Basin, on the southern part of the early to middle Paleozoic Warburton Basin, and on the Devonian Ooloo Hill Formation. A depositional hiatus with associated deep weathering spans the latest Permian to Jurassic timeframe, and is

represented by the Bopeechee Regolith pallid zone developed in pre-mid-Mesozoic rocks. Jurassic to Cretaceous fluvial sedimentation of Algebuckina Sandstone and Village Well Formation begin the Mesozoic succession and mostly derive from eroded Bopeechee Regolith. These are followed by Cretaceous Neales River Group sediments that include Cadna-owie Formation and Parabarana Sandstone, Marree Subgroup (Bulldog Shale + Coorikiana Sandstone + Oodnadatta Formation), Mackunda Formation and Winton Formation. Mesozoic strata are unconformably overlain by Cenozoic sediments.

Cenozoic basins within the map area contain a sediment thickness of <200 m. Tertiary units are distributed across much of this area and comprise part of the Lake Eyre Basin. The Callabonna Sub-basin, after Gravestock et al. (1995), refers to the portion of the basin east of the Birdsville Track Ridge (manifested in large surface anticlines of the Cooryanna and Gason domes). This sub-basin was formerly contiguous across the Birdsville Track Ridge with equivalent sediments in the Lake Eyre – Simpson Desert region (Tirari Sub-basin). Quaternary sediments abound and derive by erosion from the older strata; only 5 of the 36 Quaternary units have been formally named.

Fossils found on MARREE include poorly preserved Neoproterozoic stromatolites and trace fossils from the Ediacaran to Cambro-Ordovician. Rare marine phosphatic and carbonate shells

occur within Devonian Ooloo Hill Formation. Shelly fauna, trace fossils, carbonaceous flora and coal have been recovered from the Eromanga Basin succession. Neales River Group sediments commonly contain abundant shells, calcified wood and many animal burrows. Leaf impressions, animal burrows, and vertebrate bones and teeth occur within the lower to middle Cenozoic units but are not common. Quaternary units have yielded some vertebrate bones from the once common Australian mega fauna. These finds include Diprotodon species, large wombats and tall browsing kangaroos.

### Structural overview

Structural elements that dominate this area include the Curnamona Province – Mount Babbage Inlier, Adelaide Geosyncline, Muloorina Gravity Ridge, Arrowie Basin, Warburton Basin, Cooper Basin and Cooryanna Dome. The ranges high ground contains folded Neoproterozoic sedimentary rocks of the Adelaide Geosyncline, underlain in the Flinders Ranges by crystalline hard rock composed of highly deformed Mesoproterozoic metasediment rafts and keels supported by variably deformed Mesoproterozoic granites and volcanics. Numerous faults and shear zones also exist; the most extensive occur within the Flinders Ranges exposures, where they trend approximately E–W and have had a prolonged movement history.

The surrounding plains are underlain by sediments occupying several



Trinity Well Sandstone Member (Cadna-owie Formation) at its type section, ~400 m NW of Western Spur (2.5 km west of Flinders Ranges). The strongly cross-bedded nature of this marine beach facies here is a typical feature of this unit. Hammer is ~300 mm long. (Photo 410052)



Clayton 2 Bore headworks (pillar at rear), outflow pipe and storage pool, Clayton Pastoral Station. This artesian water is initially hot (>75 °C) and is used for stock supply after cooling in the storage pool. Note the condensing steam near pipe outflow. The aquifers are Algebuckina Sandstone and Cadna-owie Formation. (Photo 410053)

deposits: Cambrian Arrowie Basin and early to middle Paleozoic Warburton Basin; late Paleozoic to Mesozoic Cooper Basin; Mesozoic Eromanga Basin; and Cenozoic Lake Eyre Basin. Active erosion and deformation continue to expose previously buried strata in many areas.

Crustal deformations occurred during the early Mesoproterozoic (c. 1580–1560 Ma); basic dykes were injected during tensional stress (c. 1100 to <500 Ma) and the Neoproterozoic geosynclinal sediments were folded during the Delamerian Orogeny (c. 500 Ma). The inlier basement was also affected by the Delamerian Orogeny but to a smaller degree. Block faulting of the Flinders Ranges took place sporadically throughout the Cenozoic (c. 55 Ma to today) and has uplifted these more weathering-resistant rocks by 50 to >550 m. Warping of the Eromanga and Lake Eyre basins has yielded a series of regional dome structures, one of which is the Cooryanna Dome. The southern portion of this covers about 15% of MARREE.

## Economic geology

Prospecting and exploration since the 1870s have located Pb, Zn, Ag, Cu, Fe, Mn and associated Sb, As, Sn, Co, Cd, Bi, V, and trace Au mineralisation. Rare earth elements (including U) are also known from this area. Non-metallic minerals include talc, dolomite and

minor magnesite. Mining has extracted Zn, Pb, Ag, Cu, minor Sb, As, small amounts of Au, and abundant talc.

## Natural history

Rock and soil types and geomorphology commonly dictate where the region's biota reside, feed and breed. The flora and fauna of this area are diverse. Sparse grass and shrub lands cover many areas and these plants are denser in low lying parts. The rivers, creeks and marshlands, subject to occasional flooding, are commonly fringed by trees. Within the rangelands, vegetation tends to be denser and of a larger stature.

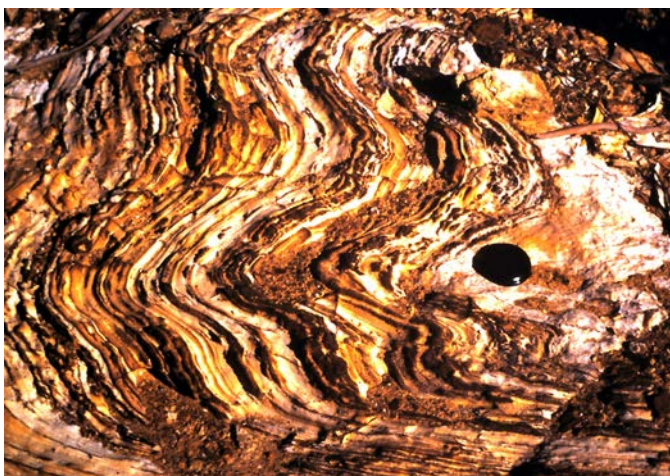
Large indigenous animals include: kangaroos, wallabies, dingo, echidna, reptiles, emu, bustards, parrots, raptors, crows, finches, pigeons, aquatic birds and freshwater fish. Introduced feral animals comprise horse, donkey, goat, camel, rabbit, cat, fox, rats and mice.

## Aboriginal heritage

Aboriginal occupation and history spans many tens of millennia and evidence for their longstanding presence abounds over much of MARREE (worked stone, habitation sites, fire hearths, shell or bone middens etc.). Those indications and relics are to be respected and left undisturbed unless formally authorised to do otherwise (*Aboriginal Heritage Act 1988*).

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Outcrop of Bopeechee Regolith showing kaolinite-rich saprolite developed in steeply dipping shale of Neoproterozoic Billy Springs Formation, 4 km SW of Trinity Well. Weathering has highlighted the sandstone lamellae (now darkly ferruginised) to reveal intense folding produced during the Delamerian Orogeny. Such structures are very difficult to see in the unweathered near-black rock. Lens cap is 55 mm wide. (Photo 410050)



Silicified Eyre Formation preserving a lanceolate leaf impression in fine detail, ~10 km SE of Marree village. The fluvial–paludal sediment is dominated by fine-grained quartz sand and silt, and has been overprinted by groundwater silcrete. Coin is 19 mm wide. (Photo 410051)

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The MARREE 1:250 000 geological map, the six component 1:100 000 geological maps, and explanatory notes are available for download via SARIG <[www.sarig.dmitre.sa.gov.au](http://www.sarig.dmitre.sa.gov.au)>. Printed copies (map \$20; map and explanatory notes \$30) can be ordered via the SARIG Online Shop or from Customer Services phone +61 8 8463 3000, email <[Resources.CustomerServices@sa.gov.au](mailto:Resources.CustomerServices@sa.gov.au)>.

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Ediacaran facies: Billy Springs Formation unnamed member (Npi4; equivalent to upper Rawnsley Quartzite elsewhere). Sandstone with a bedding plane displaying the fossilised disc-shaped remains identified as *Aspidella*. Scale block black bars are 10 mm long. (Photo 41054)



Ediacaran facies: Billy Springs Formation, unnamed member (Npi4; equivalent to upper Rawnsley Quartzite elsewhere). Sandstone with a bedding plane displaying the fossilised remains identified as *Yelovichnus gracilis* which resembles *Palaeopascichnus*. Scale block black bars are 10 mm long. (Photo 410055)