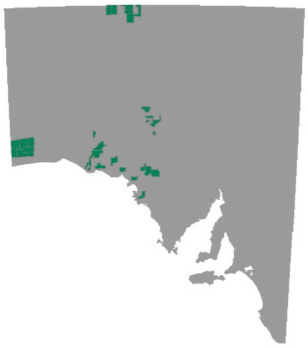
Government of South Australia
Department for Energy and Mining

Exploration release areas Batch 3 – Western to Central Gawler, Far West, North-West



This ERA release includes the prospective Gawler Craton, Coompana and Musgrave provinces overlain by basins hosting a wide range of commodities.

Geological setting

Basement:

- Western to Central Gawler: Archaean to early Mesoproterozoic Gawler Craton
- Far West: Coompana Province
- North-West: Middle to late Mesoproterozoic Musgrave Province

Basins:

- Western to Central Gawler: Middle to late Mesoproterozoic Cariewerloo Basin Neoproterozoic Stuart Shelf, Late Carboniferous to Triassic Arckaringa Basin
- Far West: Neoproterozoic Officer Basin, Late Carboniferous to Triassic Denman Basin, Jurassic to Cretaceous Bight Basin, Cenozoic Eucla Basin
- North-West: Late Carboniferous to Triassic Pedirka Basin, Jurassic to Cretaceous Eromanga Basin, Cenozoic Hamilton Basin and Eucla Basin (Serpentine Lakes)

Western to Central Gawler

The Gawler Craton is the oldest and largest geological province in South Australia, preserving a complex tectonic history spanning from ~3250 Ma to 1450 Ma. The craton comprises a Mesoarchean-Paleoproterozoic core that is intruded and overlain by Paleoproterozoic to Mesoproterozoic rocks. The Mesoarchean history of the Gawler Craton is dominated by felsic magmatism, the Neoarchean to Paleoproterozoic history by sedimentation and bimodal magmatism, and the Mesoproterozoic history by bimodal magmatism.

The Gawler Craton comprises Late Archean to Mesoproterozoic crystalline basement rocks. The oldest basement is the c. 3150 Ma Cooyerdoo Granite, a small body that crops out in the southeastern part of the craton. The oldest geologically coherent crust includes the c. 2520–2440 Ma Sleaford and Mulgathing complexes, found in the southern Eyre Peninsula and central Gawler Craton respectively. The complexes comprise meta-igneous, metavolcanic and metasedimentary packages that have been multiply metamorphosed and deformed. These rocks originated during a period of basin development and formed as a once contiguous basin, which was subsequently separated by Paleoproterozoic tectonism. The basin developed in a back-arc or rift setting which accommodated the eruption of the c. 2560 Ma Devils Playground Volcanics and c. 2520 Ma mafic to ultramafic magmas of the Lake Harris Komatiite in the north, and the c. 2520 Ma Hall Bay Volcanics in the south. Deposition of sediments occurred contemporaneously with the volcanism, including protoliths to the Christie Gneiss, and continued until c. 2440 Ma. Bimodal magmatism continued in the northern portion of the basin from c. 2490–2460 Ma. Basin development was terminated by deformation and metamorphism of the c. 2470–2410 Ma Sleaford Event. Sedimentation recommenced during the Paleoproterozoic from c. 2000–1650 Ma, covering much of the Gawler Craton. The sedimentation was disrupted by a small-scale orogenic event at c. 1850 Ma and the craton-wide Kimban Event at c. 1730–1690 Ma. In the western Fowler Domain, metasedimentary rocks c.1740–1700 Ma were intruded by the bimodal Peter Pan Supersuite (and later metamorphosed during the Kimban Event). Late Paleoproterozoic bimodal intrusive magmatism occurred pre-, syn and post- Kimban Event deformation (i.e. at c. 1745–1700 Ma and c. 1690 Ma) in the central and southern Gawler Craton.

The latest Paleoproterozoic and Mesoproterozoic were dominated by magmatism; however, sedimentation occurred in the eastern Fowler Domain c. 1610 Ma and small depositional basins developed during the early stages of magmatism associated with the Gawler Range Volcanics c. 1594–1590 Ma. Intrusion of the bimodal c. 1650–1610 Ma St Peter Suite occurred largely in the Nuyts Domain, and these, together with Hiltaba Suite magmas, also intruded the c. 1610 Ma metasedimentary rocks in the eastern Fowler Domain. Extrusion of the c. 1594–1587 Gawler Range Volcanics in the central Gawler Craton was accompanied by widespread intrusion of the c. 1595–1575 Ma bimodal Hiltaba Suite magmas. The magmatism was followed by high-grade metamorphism and shear zone development and reactivation across the western and central Gawler Craton at c. 1570–1540 Ma.
The youngest basement event recorded in the Gawler Craton consists of the reactivation of shear zones between c. 1470 and 1450 Ma at greenschist to amphibolite facies in the western Gawler Craton, and magmatism and granulite facies metamorphism in the northern Gawler Craton at c. 1450 Ma.

The Gawler Craton is a world-class metallogenic province, prospective for a wide range of commodities and deposit styles. Locally significant orogenic and intrusion-related gold deposits are known in the central and northwestern Gawler Craton (e.g. Challenger, Tarcoola, Tunkillia) with numerous prospects showing similar structural and mineralisation styles (e.g. Aurora Tank, Golf Bore, Greenewood, Campfire Bore, Typhoon, Monsoon).

The Fowler Domain of the western Gawler Craton has demonstrated potential for magmatic Ni-Cu. A series of mafic to ultramafic intrusions host Ni sulphide mineralisation with extensive zones of elevated Ni such as at the Sahara, Splendour and Woodford prospects. Semi-massive sulphide accumulations recognised at Sahara host grades of over 1% Ni and elevated Co and Cu. Weathering of ultramafic intrusions have potential for high-grade nickel oxide mineralisation such as demonstrated at Mystic (18 metres at 2.06% Ni including 5 metres with 4.29% Ni).

The area where the western margin of the Eromanga Basin is overlying the Muckannipie Anorthosite Complex is an emerging high-grade, shallow titanium-rich heavy mineral sand province.

The Cenozoic Eucla Basin hosts several significant strandline-hosted heavy mineral sand deposits and prospects including the Jacinth Ambrosia mine, and Tripitaka, Typhoon, Sonoran and Atacama prospects. Further inland, heavy mineral prospects are also known within the Ooldea Range such as Barton, Barton West and Irish Well. Extensive paleodrainage systems over the central to western Gawler Craton host uranium occurrences (e.g. Yarranna – Narlaby Paleochannel; Ealbara and Warrior – Kingoonya Paleochannel) and are prospective for paleochannel-hosted uranium and rare earth mineralisation.

Deep weathering of basement rocks of the Gawler Craton, particularly across the Eyre Peninsula, has led to exceptionally pure kaolin deposits such as Great White. The product's brightness, fine particle size and purity make it a premium material for ceramics and high purity alumina. In addition, recognition of the naturally occurring nanotube form of kaolin (halloysite) has potential for specialist products such as in the medical field, potentially providing additional value.

Mineral prospectivity

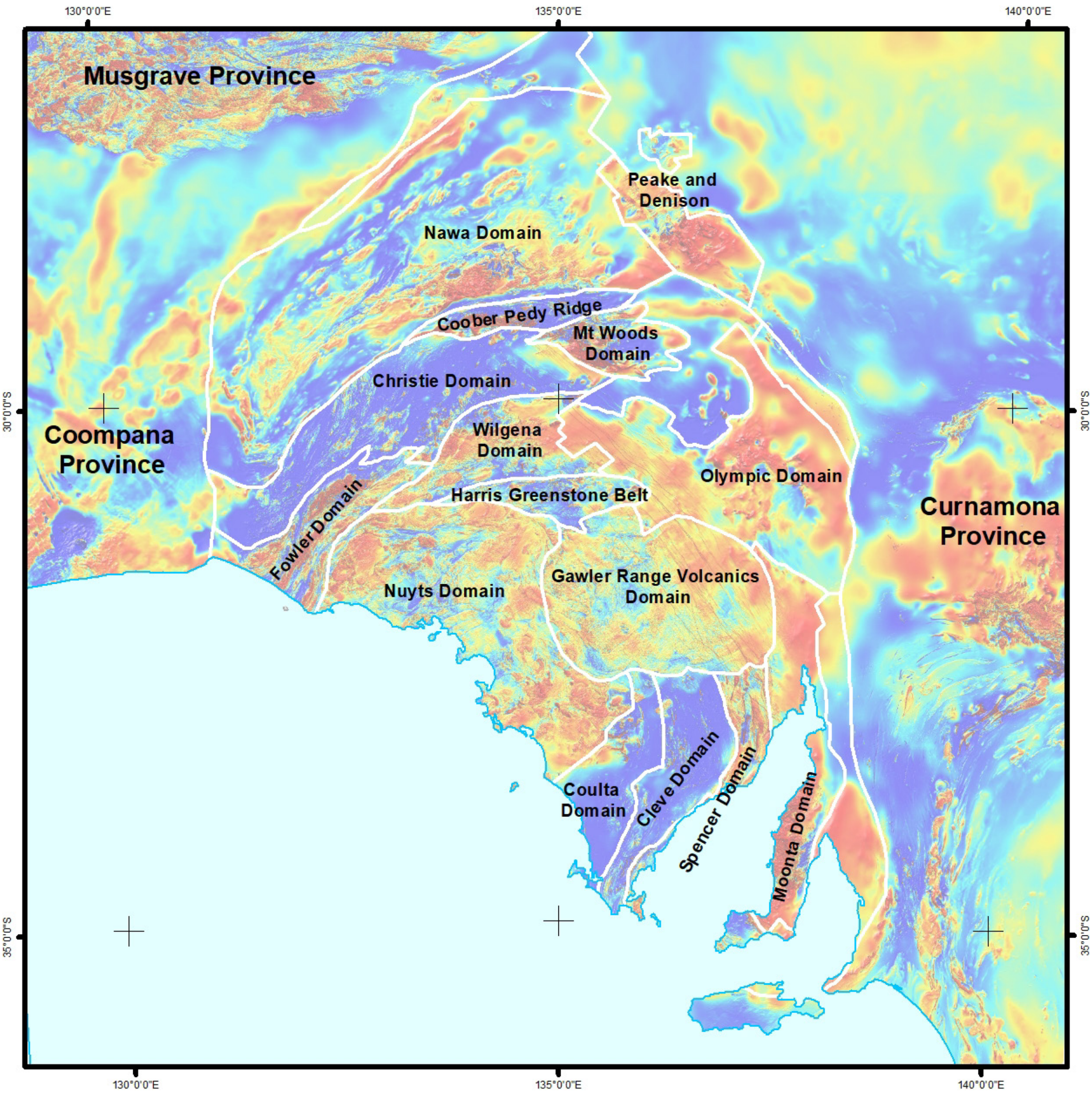
Prospective commodities

- Metals: Au, Cu, Ag, Pb, Zn, Co, Ni, Cr, Mn, Ti, V, platinum group elements (PGE), iron ore, rare earth elements (REE)
- Energy: U_3O_8
- Industrial minerals: kaolin, heavy minerals, graphite, gypsum,
- Extractives: vast resources of road making material (sand, gravel, calcrete, limestone, dolomite, quartzite, sandstone, granite, gneiss), dimension stone (granite and gneiss) and regolith clay (brickmaking and refractory).

Major exploration models

- Intrusion-related Au (Central Gawler Gold Province, e.g. Tarcoola, Tunkillia, Barns, Weednanna)
- Orogenic Au (e.g. Challenger)
- Late Archean komatiitic and magmatic intrusive-hosted Ni-Cr-PGE (Lake Harris Greenstone Belt, Aristarchus)
- Magmatic Ni-Cr-Cu sulphides and PGE (Fowler, Nuyts and Christie domains)

- Epithermal-style Ag-Pb-Zn (e.g. Paris) and Au-Ag-Pb-Zn (e.g. Parkinson Dam)
- Unconformity and paleochannel U and Au (e.g. U-Yarranna; Au-Corunna Conglomerate)
- High purity kaolin-halloysite
- Clay-hosted and paleochannel-hosted rare earths
- Heavy Mineral Sands (e.g. Jacinth-Ambrosia, Mojave West, Rosewood)



Domains of the Gawler Craton.

References and publications

- GP2: next generation mineral systems mapping. Data package.
- SA Geology 1st Editon. SARIG map and project page.
- Remapping the paleovalley systems of the central-western Gawler Craton, South Australia. Report book and data package.
- Gold mineral systems and exploration strategies for the Gawler Craton, South Australia. Report book.
- Paleovalley mapping in the northwestern Gawler, South Australia. Gawler Phase 2 Paleovalley Extension Project. Drillholes report.
- Landscape pattern recognition map for the central-western Gawler Craton, South Australia. Report book.
- The Penong Complex: a new unit with big implications for the Nuyts Domain. Slide package and video presentation.
- Halloysite mineral nanotubes – geology, properties and applied research. *MESA Journal* article.
- Northwestern Eyre Peninsula kaolin province - New analytical technique aids resource assessment. *MESA Journal* article.
- Halloysite in Cenozoic sediments along the Eucla Basin margin. *MESA Journal* article.

Far West (Coompana Province)

The Coompana Province straddles the border between South Australia and Western Australia, and lies between the Gawler Craton to the east, the Madura Province to the west, and the Musgrave Province to the north. The eastern boundary of the Coompana Province is interpreted as the Jindarnga Shear Zone, and the western boundary is the Mundrabilla Shear Zone. The Coompana Province is entirely covered the Officer, Denman, Bight and Eucla basins.

Prior to 2013, the main knowledge of the Coompana Province has come from geophysical datasets and a small number of basement intersecting drillholes providing physical samples. Several exploration diamond drillholes targeting remnant magnetised bodies, including BN 1, BN 2, CD 1 and KN 1, intersected mafic rocks in the southwest corner of South Australia.

The first drilling program focused on understanding the geological history of the Coompana Province was undertaken in the western part of the province by the Geological Survey of Western Australia in 2013. This was followed by a drilling campaign undertaken by the Geological Survey of South Australia in southwest South Australia in 2017, providing the first drill core samples across a large area of the eastern Coompana Province. As a result, these samples allowed the work started in Western Australia to be expanded, significantly increasing the understanding of the architecture and geological evolution of the eastern Coompana Province. It was concluded that significant magmatism including large volumes of mafic magma intruded as large plutonic bodies across the Coompana Province in the late Mesoproterozoic, and these mafic bodies are prospective for Ni-Au-PGE mineralisation as is known from similar aged intrusions in the Musgrave Province. Further findings from this project can be accessed via a series of Geological Survey publications, conference presentations and journal articles listed below.

Mineral prospectivity

Prospective commodities:

- Minerals: Ni, Cu, Cr, Co, PGE, Au, REE
- Extractives: limestone, calcrete, sand

Major exploration models

- Magmatic Ni–Cu–PGE (±Co)
- Cu–Au (and Cu–Ni)
- Rare Earth metals in felsic intrusives (Nb–Ta, potentially HFSE/REE association)

References and publications

- Coompana drilling project page.
- Interpreted geology of the eastern Coompana Province map.
- Magnetic depth to basement mapping over the Coompana area. Report book.
- Source magnetisation studies of the reverse magnetic anomalies in the Coompana area. Report book.
- Extending the Warakurna Supersuite into southern Australia. *MESA Journal* article.
- Regolith map of the Coompana region.
- Regional geochemistry of the Coompana area. Report book.

North-West

The Musgrave Province covers an area of approximately 120,000 km^2, straddling the border between South Australia, the Northern Territory and Western Australia. It is a Proterozoic lithospheric domain that largely lacks evidence of Archean provenance, in contrast to the surrounding basement provinces of the West, North and South Australian cratons (WAC, NAC and SAC, respectively). The Musgrave Province consists mainly of reworked remnants of Paleo- to Mesoproterozoic oceanic crust modified by intra-oceanic subduction processes.

The oldest known rocks of the Musgrave Province in South Australia belong to the Paleo- to Mesoproterozoic Birksgate Complex. These rocks consist of felsic to minor mafic gneisses with igneous intrusive, volcanic, volcaniclastic and, less commonly, sedimentary precursors that probably formed in oceanic arc environments. Within these rocks, igneous zircon populations of inferred proximal intra-provincial magmatic arc origin, i.e. zircons not derived as detritus from more distant Archean cratonic sources, document more or less continuous felsic magmatic arc activity between c. 1.7 and c. 1.5 Ga, with a frequency peak around 1.6 Ga. Similar igneous rocks of the c. 1610–1540 Ma Warlawurru Supersuite form the oldest components in the western Musgrave Province. Igneous protoliths typically have calc-alkaline affinities and trace element tectonic discrimination plots as well as juvenile isotopic compositions suggest that the protoliths to the Birksgate Complex formed in a volcanic arc setting and record formation of juvenile crust by construction of successive oceanic arcs.

Minor localised early Mesoproterozoic magmatism was recorded in form of c. 1480–1440 Ma mafic orthogneisses in the central part of the Musgrave Province and by felsic gneisses of the c. 1400 Ma Papulankutja Supersuite in its western part. Metasediments with a c. 1400 Ma depositional age were reported to occur in the eastern Musgrave Province, but their extent is poorly known.

In the western Musgrave Province, a younger suite of calc-alkaline granitoids, the Wankanki Supersuite, intruded and crystallised between c. 1345 to 1290 Ma during the Mount West Orogeny. Near synchronously, a sedimentary package composed mostly of paragneisses and termed the Wirku Metamorphics, were deposited in the Ramarama Basin between c. 1340 and 1270 Ma. Currently there is no evidence that these units are present within the South Australian portion of the Musgrave Province.

The above rocks were subsequently deformed and metamorphosed at amphibolite to granulite facies during the province-wide c. 1220–1120 Ma Musgrave Orogeny. Large volumes of predominantly felsic magma intruded during this orogeny and have been grouped into the Pitjantjatjara Supersuite. This magmatism is isotopically juvenile and reflects crustal thinning, possibly due to lithospheric delamination and asthenospheric upwelling processes following earlier accretionary activity.

The Musgrave Orogeny was followed by the c. 1085–1030 Ma Giles Event, which includes the mafic-ultramafic layered to massive Giles Suite intrusions, dykes of the Alcurra Dolerite, granites and bimodal volcanics of the Warakurna Supersuite, and associated rift sediments of the Bentley Supergroup/Bentley Basin. The Giles Event has been interpreted to form part of the Warakurna Large Igneous Province, which affected much of central and western Australia.

The Giles Event was followed by dyke intrusions of the c. 825–760 Ma Amata Dolerite, a correlative of the Gairdner Dolerite that intruded the Gawler Craton in central South Australia, marking the beginning of the break-up of the Rodinia supercontinent. This time also marks the onset of sediment deposition in the Centralian Superbasin, on top of the older rocks of the Musgrave Province, which was largely buried beneath this subsiding Neoproterozoic basin during the time interval c. 850–540 Ma.

The c. 630–520 Ma Petermann Orogeny was a major intracratonic crustal shortening event, which resulted in the reactivation of several crustal-scale east-west trending shears, faults and thrusts and was accompanied by the development of widespread mylonitic shear fabrics and the extensive formation of pseudotachylite veins. The transpressional tectonics led to the exhumation of the Musgrave Province from beneath the Centralian Superbasin. Coeval with the Petermann Orogeny was the development of the Levenger and Moorilyanna grabens, which were infilled with coarse clastic sediments derived from the locally exposed Musgrave Province basement. At around the same time, north-directed thrusting and uplift led to the development of a basement-cored nappe complex at the northern margin of the Musgrave Province, accompanied by synorogenic molasse-like foreland sedimentation in the adjacent Amadeus Basin.

During the c. 450–300 Ma Alice Springs Orogeny internal east-trending structures were reactivated across large parts of the Musgrave Province, including the Woodroffe Thrust in the central-northern part of the province, and the Marryat, Coglin, Echo, De Rose and Wintiginna faults in its eastern part. Apatite fission track and (U-Th)/He apatite and zircon analysis indicate that two discrete cooling events recorded in the eastern Musgrave Province, one at c. 450–400 Ma and one at c. 310–290 Ma, represent uplift associated with the Alice Springs Orogeny.

There is also evidence for reactivation of the Munyarai – Everard thrust system along the southern margin of the Musgrave Province, where basement was thrust southward over Neoproterozoic and early to mid-Paleozoic sediments of the Officer Basin causing synorogenic deposition of Devonian sediments. Synorogenic deposition associated with uplift of the Musgrave Province during the Alice Springs Orogeny is also recorded for the Amadeus Basin. Furthermore, deformation of the Cambrian sediments of the Levenger and Moorilyanna grabens also occurred during the Alice Springs Orogeny. Substantial epidote and silica alteration occurring along structures in the eastern Musgrave Province has been linked with fluid flow facilitated by fault reactivation during the Alice Springs Orogeny.

Following the Alice Springs Orogeny, the Musgrave Province has undergone at least one phase of intensive deep weathering and erosion prior to the deposition of clastic sediments of the Mesozoic Eromanga Basin along its eastern margin. Intense chemical weathering of these sedimentary deposits as well as the basement rocks resulted in a deep weathering profile that can reach up to 90 m below the present-day surface. The typically composite weathering profiles are characterised by kaolinisation and mottled or varicoloured, pallid, ferruginous or siliceous zones. Multiple phases of post-Mesozoic dominantly siliceous and ferruginous induration led to the formation of widespread silcrete and ferruginous duricrust.

During the early Paleogene, rivers incised up to 70 m into the older cover sediments and the basement rocks. The channels were subsequently filled during two distinct phases of fluvial sedimentation: first in the Eocene-Oligocene, followed by a second fluvial phase in the Early to Late Pliocene. These fluvial periods are separated by a marginal marine to estuarine interval deposited during the Late Miocene to Early Pliocene. In the Quaternary, the onset of aridity, with episodes of alluvial and aeolian activity, resulted in today's landscape with the formation of alluvial plains, sand plains and aeolian dunes and dunefields.

Mineral exploration in the Musgrave Province has predominantly focussed on Ni–Cu–PGE sulfide mineralisation within the Giles Complex, as demonstrated by the significant Nebo–Babel deposits in the Western Australian portion of the Musgrave Province. In South

Australia, numerous Giles Complex and related Alcurra Dolerite intrusions exhibit similar magmatic processes, including assimilation of felsic crust, indicating strong potential for additional Nebo–Babel–style Ni–Cu–PGE mineral systems that can be targeted by integrated geophysical and geochemical exploration focused on identifying magma feeder zones and structural traps.

Considerable lateritic Ni-Co-Fe mineralisation, developed on mafic and ultramafic rocks of the Giles Complex, has been identified around the Claude Hills deposit in the far northwestern corner of the State. Copper occurrences across the Musgrave Province are common but generally of low significance. Stratabound Cu identified at Kenmore 2 prospect and the surrounding area is generally low grade but demonstrates potential for further mineralisation of this style within gneiss of the Birksgate Complex.

Heavy mineral sand contents within stream sediments of up to 38% have been identified at Victory Downs with zircon content up to 8.6% and TiO_2 up to 8.9%. Rare earth elements values were also found to be anomalous.

Mineral prospectivity

Prospective commodities

- Metals: Ni, Co, Cu, PGE, Cr, V, Ti, Au, Ag, Pb, Zn, REE
- Energy: U_3O_8
- Industrial minerals: Graphite, chrysoprase, agate
- Extractives: calcrete, quartzite, dolerite, gabbro, dolomite, gravel

Major exploration models

- Magmatic nickel-copper sulphides and PGE (e.g. Smeagol, Caroline)
- Stratiform chromite cumulates
- Stratiform vanadiferous titanomagnetite cumulates
- Laterite nickel-cobalt deposits (e.g. Wingellina East)
- VHMS and hydrothermal gold veins in volcano-sedimentary rocks
- VHMS and SEDEX in metamorphosed basement rocks

References and publications

- Geology of the Tieyon (5464) 1:100 000 mapsheet. Report book and map.
- Petrogenesis of Fe-Ti-V oxide mineralisation in the Kalka intrusion. Journal paper.
- Petrogenesis of the Kalka, Ewarara and Gosse Pile layered intrusions, Musgrave Province, South Australia, and implications for magmatic sulfide prospectivity. Journal paper.

- Boots on ground: release of the new Alcurra 1:100,000 map in the eastern Musgrave Province. *MESA Journal* article.
- Amata Dolerite, Musgrave Province: connections to Neoproterozoic mantle plume magmatism within Rodinia. *MESA Journal* article.
- Repeated failure: long-lived faults in the eastern Musgrave Province. *MESA Journal* article.
- Optically stimulated luminescence dating revealing new insights into the age of major regolith units of the eastern Musgrave Province, South Australia. Report book.
- Mineral potential and prospectivity analysis, Musgrave Province, including APY Lands. Report book.
- Nickel in South Australia. *MESA Journal* article.

More information

- SARIG map https://map.sarig.sa.gov.au/
- SARIG catalogue https://catalog.sarig.sa.gov.au/
- South Australia major exploration models
- South Australia mineral explorer's guide

SA Geology 1st Editon

https://map.sarig.sa.gov.au/

https://www.energymining.sa.gov.au/industry/geological-survey/gssa-projects/south-australian-discovery-mapping

SA Digital Explanatory Notes

https://explanatorynotes.sarig.sa.gov.au/

Copper

- Copper in South Australia
- South Australian Neoproterozoic sediment-hosted copper occurrences map

Gold

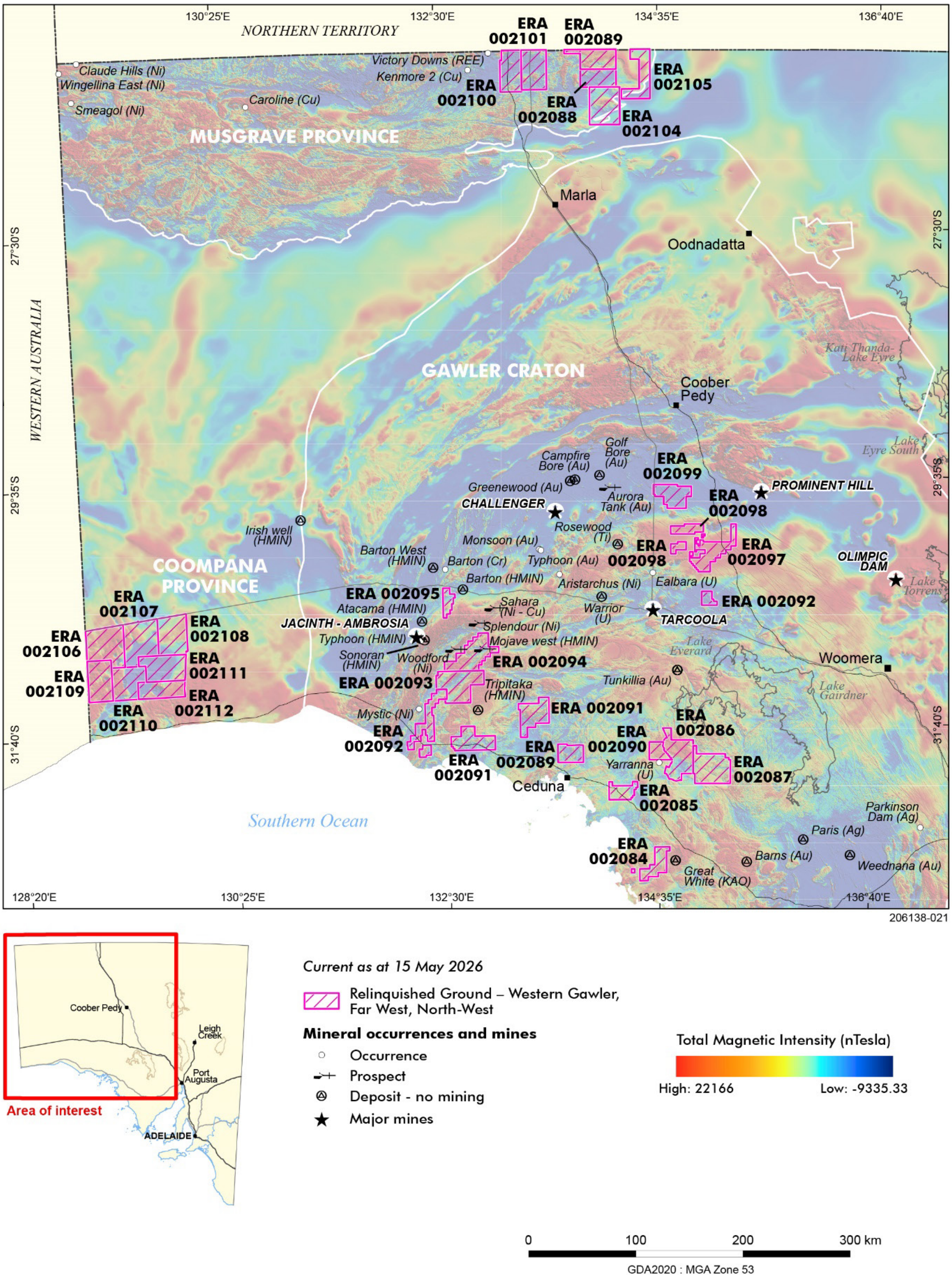
- Gold in South Australia

Uranium

- Uranium in South Australia
- Uranium and uranium mineral systems in South Australia
- South Australian uranium occurrences map

Critical minerals (REE)

- Rare Earth Elements: Critical mineral potential of South Australia
- South Australia's Critical Minerals and Mine Waste dashboards
- Secondary prospectivity of South Australia's mine waste - review



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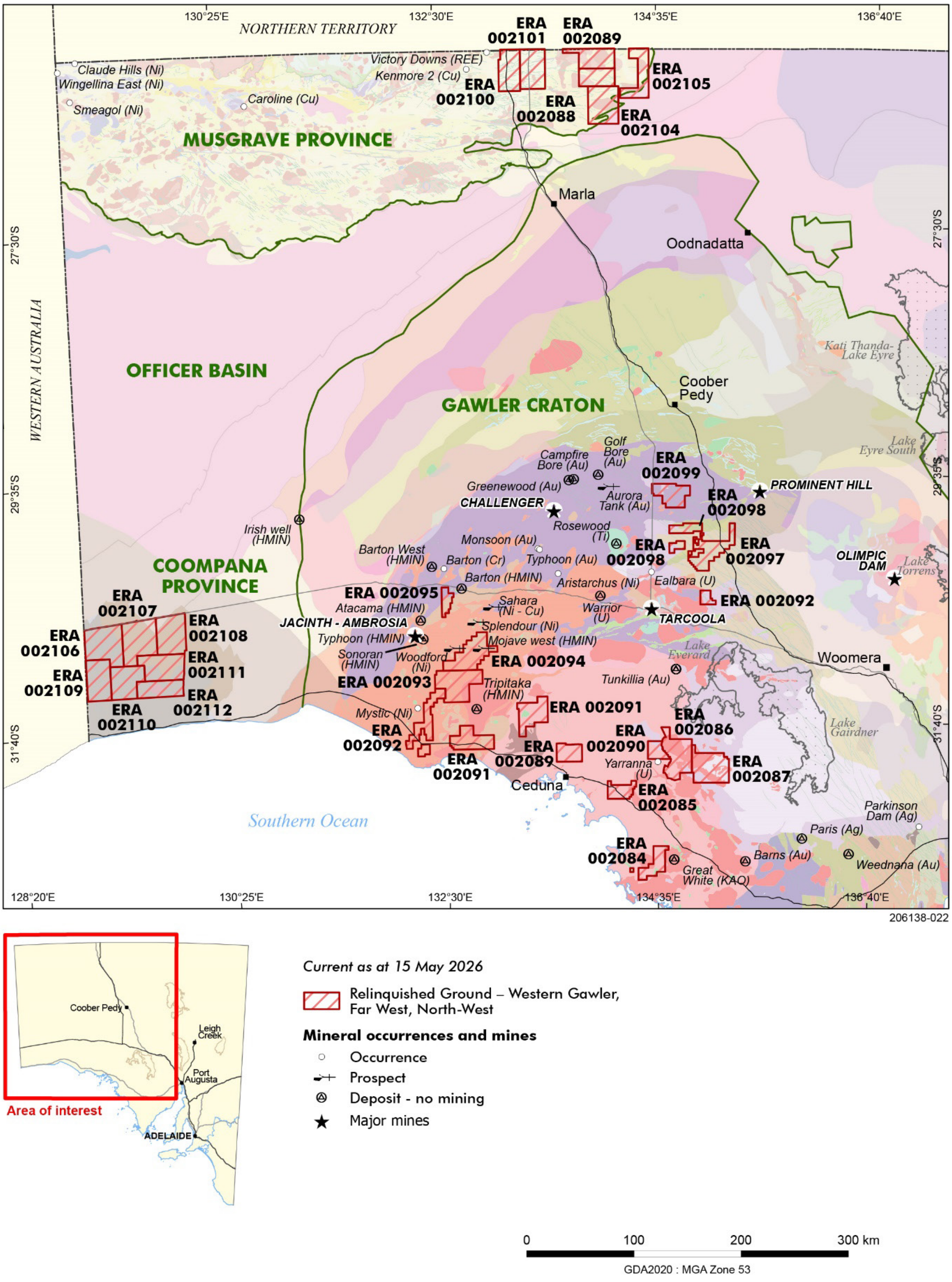

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