COBALT

Critical mineral potential of South Australia

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SOUTH AUSTRALIA

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Cobalt

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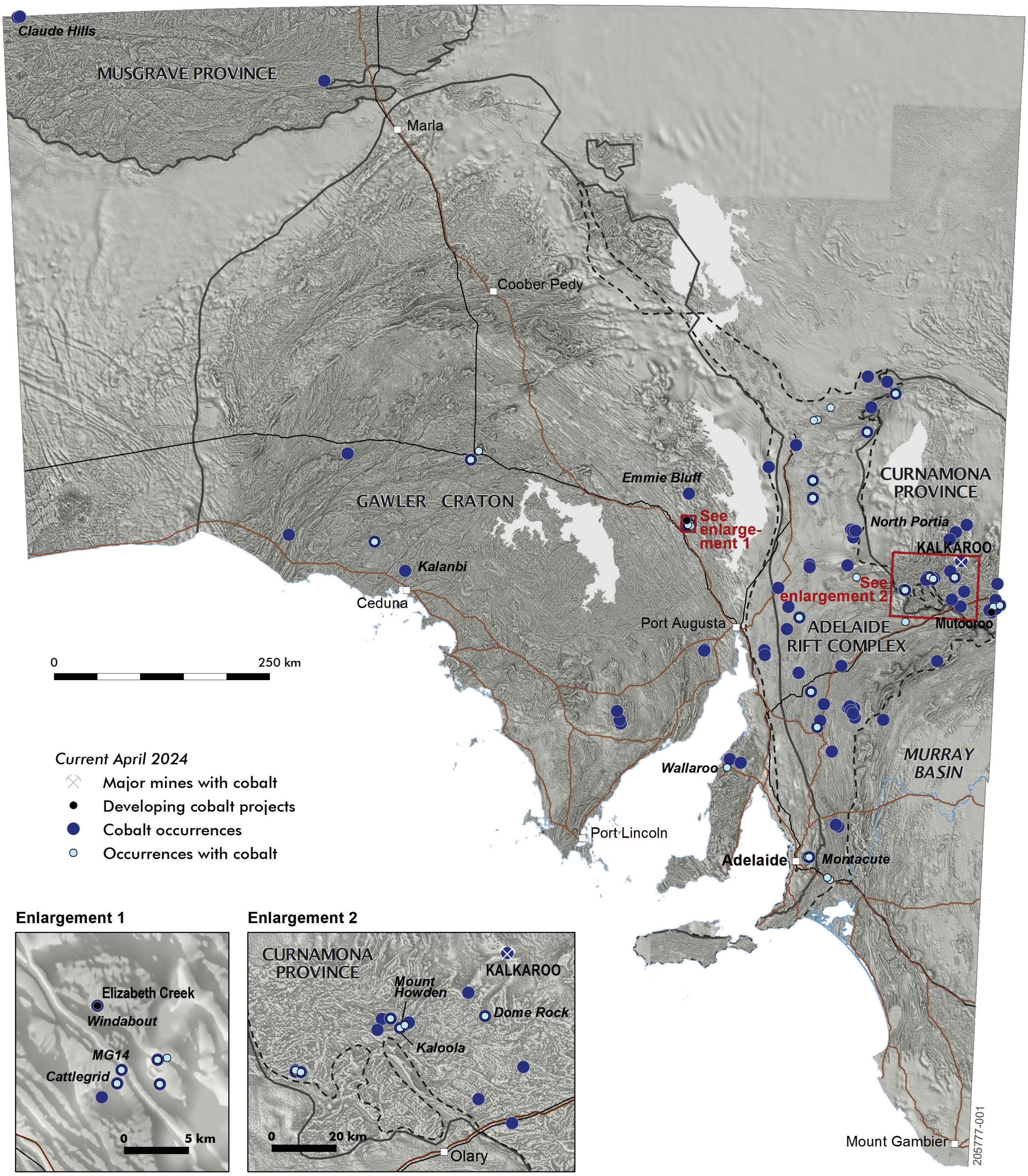

Figure 1. Occurrences of cobalt and cobalt-bearing minerals in South Australia. (205777-001 PDF 6.4 MB)

Cobalt

Peter Keller, Alexander Corrick and Alicia Caruso

Cobalt is a silver-grey metal that has diverse uses based on key properties including ferromagnetism, hardness and wear-resistance when alloyed with other metals, low thermal and electrical conductivity, high melting point and production of intense blue colours when combined with silica (Slack et al. 2017). Estimates of the crustal abundance of cobalt lies between 15–30 ppm, similar to other transition metals such as scandium, copper, zinc and nickel (S. R & Gunn G 2014). Cobalt is most abundant in ultramafic rocks with an average concentration of about 110 ppm (S. R & Gunn G 2014).

USES

Cobalt is primarily used to manufacture electrodes for rechargeable batteries, which are used in portable electronics, power tools, electric vehicles, and energy storage units (Slack et al. 2017). Other notable uses can include chemical catalysts, pigments, magnetic alloys, corrosion-resistant alloys, superalloys, and cemented carbides (Slack et al. 2017; Hughes et al. 2023).

TYPES

Approximately 98% of the world's cobalt is produced as a by-product from three major deposit types:

- Stratiform sediment-hosted copper deposits
- Magmatic nickel-copper-cobalt sulfide deposits
- Nickel-cobalt laterite deposits.

Minor amounts of cobalt are produced, or have been historically produced from:

- metamorphic black shale-hosted deposits
- polymetallic/five-element (Ag-Ni-Co-As-Bi) and other copper-rich vein deposits
- volcanogenic massive sulphide (VMS) deposits
- iron-copper-gold skarn and replacement deposits
- iron oxide-copper-gold (IOCG) deposits
- metasedimentary rock-hosted cobalt-copper-gold deposits
- Mississippi Valley-Type (MVT) deposits.

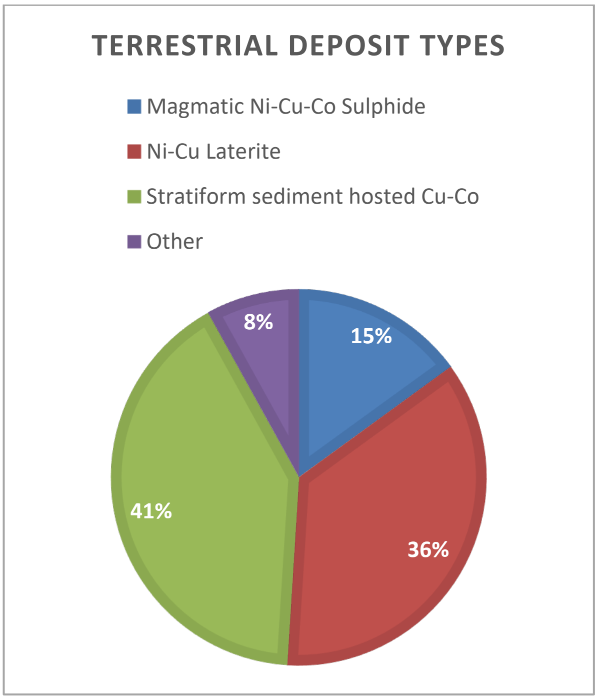

Figure 2. Pie chart showing proportions of cobalt contained in worldwide terrestrial mineral deposit types. Includes past production, current reserves and resources. Reproduced from Slack et al. (2017).

Of these minor deposit types, only black shale-hosted, polymetallic cobalt-rich veins and VMS deposits contributed to the remainder of global cobalt production (Slack et al. 2017). As minor sources, these deposit types are unlikely to be targeted by cobalt explorers, as many are represented by rare or unique variations of deposits not traditionally enriched in cobalt. However, the cobalt content of these deposit types warrant investigation to determine their economic potential.

Numerous sources also acknowledge sea-floor iron-manganese nodules and VMS deposits as potential future cobalt resources (Dehaine et al. 2021; Roberts and Gunn 2014; Slack et al. 2017). However, extraction of cobalt from these sources is complicated by environmental, legal, economic, and technological barriers (Dehaine et al. 2021) and therefore are not discussed in this report. Extracting cobalt from secondary resources such as mine tailings and smelter slag is attracting interest, particularly from waste associated with stratiform sediment-hosted copper deposits (S. and Gunn G 2014; Dehaine et al. 2021).

There are numerous cobalt-bearing minerals of economic interest. In primary (hypogene) deposits, key minerals may include carrolite ($CuCo_2S_4$), linnaeite ($Co^{2+}Co^{3+}{}_2S_4$), siegenite ($CoNi_2S_4$), skutterudite ($CoAs_3$), safflorite ($(Co,Ni,Fe)As_2$), cobaltite (CoAsS) and glaucodot ($(Co_{0.50}Fe_{0.50})AsS$) (S. and Gunn G 2014). Some older publications also refer to smaltite as a primary cobalt mineral, however, this is now regarded as a synonym of skutterudite (Mindat.org 2024). Pyrite, pyrrhotite and pentlandite can also contain significant amounts of cobalt (Dehaine et al. 2021). In secondary (supergene) deposits, common minerals of economic importance include erythrite $Co_3(AsO_4)_2{\cdot}8H_2O$, heterogenite ($Co^{3+}O(OH)$), asbolane ($(Ni,Co)_{2-x}Mn^{4+}(O,OH)_4{\cdot}nH_2O$), kolwezite ($CuCo(CO_3)(OH)_2$) (Dehaine et al. 2021).

MAJOR DEPOSIT TYPES

Stratiform sediment-hosted copper deposits

As stated previously, stratiform sediment-hosted copper deposits, also referred to as stratabound sediment-hosted copper or hydrothermal sediment-hosted deposits, are responsible for most of the global cobalt production. This is derived predominately from deposits in the Democratic Republic of Congo (DRC) and Zambia. Cobalt grades from these deposits can range between 200–9,000 ppm, with an average grade of 2,900 ppm, based on sixty-one stratiform sediment-hosted copper-cobalt deposits (Dehaine et al. 2021).

Typical cobalt-bearing minerals in stratiform sediment-hosted copper-cobalt deposits include heterogenite, carrollite and kolwezite (Dehaine et al. 2021). Unfortunately, copper processing techniques often do not efficiently extract cobalt, resulting with cobalt within mine tailings and smelter slag (Roberts and Gunn 2014). There is significant interest in reprocessing these waste products to recover cobalt. In 2021, The University of Queensland established the Mine Waste Transformation through Characterisation (MIWATCH) research group, to enable the geoenvironmental characterisation of mine waste and assess how it should be best managed to reduce environmental risks. In collaboration with other states and partners they have identified potential resources of cobalt, indium, antimony and rare earth elements in Australia’s mine waste (University of Queensland 2024).

Magmatic nickel-copper-cobalt (Ni-Cu-Co) sulphide deposits

Magmatic Ni-Cu-Co sulphide deposits are hosted in mafic/ultramafic igneous rocks and principally mined for nickel but they may also produce cobalt as a by-product. Deposits are divided into various subtypes (e.g. Archean tholeiitic or komatiitic, intrusion-related, meteorite impact melt-related) however, this is not discussed here. For a brief overview of different subtypes, see Mudd and Jowitt (2014). Continental rift settings are ideal for emplacement of these types of deposits because it’s easier for mantle-derived magma to penetrate the crust (Barnes and Lightfoot 2005). Deposits are comprised of semi-massive to massive sulphides, predominantly pyrite, pyrrhotite and pentlandite, which often contain some cobalt (Slack et al. 2017). Where cobalt is a recoverable by-product, grades are usually between 400–800 ppm (Roberts and Gunn 2014). This is supported by an assessment by Dehaine et al. (2021), which determined the average cobalt grade across forty-two reported deposits was 700 ppm. Although most economic examples fall within the range, active mines produce cobalt as a by-product, from ore with grades as low as 100 ppm (e.g., the Kevitsa deposit in Finland) (Dehaine et al. 2021).

Nickel-cobalt laterite deposits

Nickel-cobalt laterites are formed by deep weathering of ultramafic bedrock and their serpentinised equivalents. The deposits are primarily mined for nickel, but cobalt, and rarely, scandium, can be produced as by-products from this type of deposit. Nickel laterites can be divided into three sub-types based on the dominant minerals hosting nickel:
a) oxides
b) hydrous magnesium silicates
c) clay silicates.

Of these, the oxides such as asbolane and lithiophorite, make up to 60% of all nickel laterites and are therefore the most important for cobalt (Butt and Cluzel 2013). Laterite deposits derived from hydrous magnesium silicates such as olivine-rich peridotites and komatiites are particularly valued, as they typically contain higher cobalt concentrations than pyroxenites (Vasyukova and Williams-Jones 2022).

A global compilation of nickel-cobalt laterite deposits by Dehaine et al. (2021) notes thirteen active mines with cobalt grades between 600–1,200 ppm, although this increases to 2,200 ppm if upcoming projects are included. This review determined an average cobalt grade of 800 ppm based on studied nickel-cobalt laterite deposits.

MINOR DEPOSIT TYPES

Metamorphosed black shale-hosted deposits

One of the minor producers of cobalt outside of the principal deposits discussed above is the Talvivaara nickel-zinc-copper-cobalt deposit in eastern Finland, where mineralisation is hosted in amphibolite facies black shale. Many metals within this large, low-grade deposit, occur as pyrrhotite and pentlandite, containing an average cobalt grade of 200 ppm (Kontinen and Hanski 2015; Dehaine et al. 2021).

Polymetallic/five-element (Ag-Ni-Co-As-Bi) and cobalt-rich vein deposits

Polymetallic (Ag-Ni-Co-As-Bi) vein deposits, also referred to as five-element vein deposits, are typically mined for silver and cobalt and represent the only deposit type where cobalt is mined as the primary commodity rather than a by-product (Dehaine et al. 2021). Cobalt mineralisation within these vein deposits usually occurs as skutterudite, safflorite, cobaltite, erythrite or linnaeite (Dehaine et al. 2021; Slack et al. 2017; Vasyukova and Williams-Jones 2022). Notable economic examples include deposits in the Erzgebirge region (Czech Republic and Germany), Great Bear Lake and Cobalt-Gowganda districts (Canada) and the Bou Azzer district (Morocco), though only the latter is currently in production (Vasyukova and Williams-Jones 2022).

Volcanogenic massive sulfide (VMS) deposits

Volcanic massive sulphide (VMS) deposits are not typically associated with economic enrichment of cobalt. However, rare examples with high grades may occur, particularly in association with ultramafic or mafic volcanics (Slack et al. 2017). Notable examples containing significant cobalt include the Kylylahti deposit in the Outukumpu district, Finland with 1500 ppm Co, the Windy Craggy deposit in northwestern British Columbia, Canada with 660 ppm Co (Horn et al. 2021), and the Derni deposit in the Qinhai Province, China with 890 ppm Co (Wang et al. 2000).

Iron-copper-cobalt skarn and replacement deposits

In this deposit type, cobalt mineralisation usually occurs as cobaltite and/or cobaltiferous pyrite, and copper as chalcopyrite (Slack et al. 2017). The Goroblagodat and Magnitogorsk deposits in Russia which contain 160 Mt at 0.022% Co and 500 Mt at 0.018% Co respectively, and the Cornwall deposit in Pennsylvania, USA, which contains up to 100 Mt at 0.025% Co, are good examples of this style of mineralisation (Slack et al. 2017).

Iron oxide-copper-gold (IOCG) deposits

This type of deposit is characterised by the association of copper, gold and iron oxides (haematite/magnetite) mineral systems. A case can be made to include sub classifications such as iron sulphide, copper gold (ISCG) deposits (Skirrow 2022). IOCG deposits are associated with enrichments of other elements such as uranium, silver, rare earths, nickel, bismuth, selenium, indium and cobalt (Skirrow 2022). Cobalt-bearing minerals in IOCG deposits may include cobaltite, carrollite, glaucodot and cobaltiferous pyrite (Dehaine et al. 2021; Roberts and Gunn 2014). While no IOCG deposits currently produce cobalt, the deposit type is still acknowledged in numerous reviews (Dehaine et al. 2021; Roberts and Gunn 2014; Slack et al. 2017). Cobalt grades, gathered from data of deposits in Australia, China and Mauritania range from 140–600 ppm (Slack et al. 2017), with the average grade being 400 ppm (Dehaine et al. 2021). IOCG deposits that are being mined, or previously mined, have potential to produce cobalt from waste products sufficiently enriched in cobalt to be suitable for reprocessing.

Metasediment-hosted cobalt-copper-gold deposits

Metasediment-hosted cobalt, copper and gold (Co-Cu-Au) deposits, represent a broad classification encompassing a variety of deposits, thought to originate from different mechanisms, such as diagenetic or epigenetic, and where the source(s) of fluid and metal often remains poorly understood (Slack et al. 2017). Mineralisation occurs as semi-massive to massive stratabound or stratiform lenses, veins or breccias, where cobalt may occur as cobaltite and/or cobaltiferous sulphides such as pyrite and arsenopyrite (Slack et al. 2017). In some metasediment-hosted Co-Cu-Au deposits spread across Canada, Finland, Norway, and the United States, grades vary between 300 ppm at the Vähäjoki deposit, Finland, and 7,350 ppm at the Blackbird Mine, Idaho, USA (Slack et al. 2017). Although no metasediment-hosted Co-Cu-Au deposits are currently in production, several are in the development process (Slack et al. 2017). One such example is the NICO and Werner Lake deposits in Canada. The NICO deposit contains a proven mineral reserve of 20,735 kt @ 0.11% Co (Burgess et al. 2014), and the Werner Lake deposit contains an indicated mineral resource of 57,900 t @ 0.51% Co (Global Energy Metals Corp 2018).

Mississippi Valley Type (MVT) deposits

MVT deposits do not usually contain sufficient cobalt to be extracted as an economic by-product (Slack et al. 2017). However, rare cobalt-rich examples include the Mine La Motte-Fredericktown and Migdon deposits in Missouri, USA, which contains an average cobalt concentration of 2,000 ppm with siegenite as the main ore mineral (Seeger 2008). Numerous attempts were made to recover cobalt from the deposit between 1903 and 1961, but production was complicated by the erratic distribution of cobalt throughout the ore and difficulties separating siegenite from other sulphide minerals (Seeger 2008). The Higdon deposit contains siegenite, cobaltiferous bravoite ($(Fe,Ni)S_2$), gersdorffite (NiAsS) and marcasite-pyrite with an average grade of 0.14% Co. Despite attempts to mine the deposit in the 1960s, there was no production (Mindat 2024). Further exploration in the 2000s revealed another larger deposit, higher nickel and cobalt grades (Parra-Avila 2009).

Secondary resources: mine tailings and smelter slag

Both the tailings and slag produced from mining and processing stratiform sediment-hosted copper deposits may be enriched in cobalt. Concentration of cobalt within the tailings is often the result of processing copper sulphide ore using flotation techniques, which are inefficient for cobalt recovery. During smelting of copper ores, cobalt also tends to follow iron into the slag fraction (Roberts and Gunn 2014).

In the Democratic Republic of Congo (DRC) decades of mine tailings and smelter slags have accumulated and become environmental problems (Lutandula and Maloba 2013) Large mine waste dumps have now become a resource around established mining centres such as Kolwezi (112 Mt @ 1.49% Cu and 0.32% Co), Kakanda (18 Mt @ 1.20% Cu and 0.14% Co), Kambove (36 Mt @ 0.89% Cu and 0.19% Co), Shituru and Panda (13 Mt @ 1.50% Cu and 0.23% Co) (Lutandula M.S and Maloba B 2013). Since the early 2000s, the DRC have been incorporating these waste products into their ore feeds and reprocessing slag from the Big Hill Smelter in Lubumbashi (Lutandula and Maloba 2013).

Although most of the cobalt recovery is currently associated with sedimentary copper systems, waste products from cobalt-bearing IOCG deposits are also of interest. For example, the world-class Olympic Dam IOCG deposit in South Australia, with a total measured resource of 4.2 Gt (BHP 2023), contains average cobalt grades in ore of ~80 ppm, but can reach maximum values of ~900 ppm, associated with chalcopyrite-pyrite and occurring as carrollite, cobaltite and cobaltiferous pyrite (Ehrig et al. 2012). This cobalt is not recovered but resides within the smelter slags, which may represent a potential resource if suitable recovery methods can be developed (Cook et al. 2021). A recent report evaluating the potential of mine waste in South Australia identified Mount Gunson as a potential source of cobalt recoverable from mine tailings (Jackson et al. 2023).

OCCURRENCES IN SOUTH AUSTRALIA

There are 105 known occurrences of cobalt in South Australia (see appendix). Many of these occur with multiple commodities including copper, gold, nickel, molybdenum and uranium. The eight cobalt ore minerals that have been identified in the State are cobaltite, carrolite, erythrite, glaucodot, linnaeite, skutterudite and sphaerocobaltite.

The two principal commodities associated with cobalt are copper and gold. These are primarily located in the southern Curnamona Province, associated with the Willyama Supergroup; Flinders Ranges, associated with various sedimentary Neoproterozoic units of the Adelaide Rift Complex; Musgrave Province with associated lateritic nickel and the western Gawler Craton associated with the Neoproterozoic Tapley Hill Formation.

Adelaide Rift Complex

The Montacute mine (MinDep no. 5863) near Adelaide recorded production of 4.1 t of 7.7% Co and 1.3% Ni ore in 1866–67 (Davis 2004). Copper mineralisation occurs within quartz veins along shear zones and fractures through Burra Group rocks, notably the Montacute Dolomite (Newton 1981). The Mount Lily mine (MinDep no. 3404) 14 km northeast of Adelaide which operated between1865–69 on several copper lodes in Montacute Dolomite, records the sinking of a cobalt shaft and widespread cobalt mineralisation in outcrop (The Register 1865). Samples of ore sent to Melbourne assayed 1.6% Co (The Register 1866). Small occurrences of nickel and cobalt mineralisation also occur in the northern Flinders Ranges at the Gills Bluff mine (MinDep no. 4248) where the minerals ullmanite and skutterudite occured in narrow ferro-calcite veins cross cutting the Tapley Hill Formation (Teale 1988). The Mount Ogilvie gold mine (MinDep no. 4330) also contains Co-Ni-Cu mineralisation with the minerals erythrite, gersdorffite, skutterudite and ullmannite being recorded (Noble et al. 1983).

Manganese oxides with cobalt values of up to 2% were discovered in 1886 (Brown 1908) at the Willowie Forest occurrence (MinDep no. 6292), near Melrose in the Flinders Ranges. The mineralisation is hosted within metasediments of the Tapley Hill Formation. Investigations by Intex Pty Ltd in the early 1990s identified a potential for stratabound primary mineralisation to extend from Willowie Forest, 6 km south to the Melrose Mine (MinDep no. 6122) and a further 6 km north to the Spring Creek copper mine (MinDep no. 6228) where a copper-cobalt bearing zone was estimated to be ~20 m thick (Carr and Oliver 1994). Percussion drilling by RMC Minerals Ltd obtained values up to 0.03% Co from 39 m to 52 m depth while a grab sample taken by Intex Pty Ltd at Willowie Forest assayed 1.8% Co, 1.5% Cu and 1% Zn (Carr and Oliver 1994). Of particular interest at the Melrose mine is a number of altered dolerite intrusives with central cores of more acidic quartz ceratophyres (Carr and Oliver 1994). Minor occurrences of cobalt are associated with diaparitic structures in the Flinders Ranges. These are favourable for both MVT type Zn-Pb-Ag, and sediment hosted copper systems. Youngs Cobalt Mine (MinDep no. 3218), where copper was mined in the late 1890s, occurs within the Blinman Dome Diapir and recorded significant cobalt and nickel in assays (Brown 1908). Mineralisation is associated with small dolerite intrusions (Hasslet 1972). Mosely's (MinDep no. 3173) is located 16 km due north of the Blinman Mine within the Patawarta Diapir. Traces of cobalt minerals were identified associated with copper in veins of ferruginous carbonates and micaceous haematite hosted in metasediment of the Curdimurka Subgroup. Samples carrying up to 12% Co were recorded (Brown 1908). The Willipa and Martins Well Dome diapiric structures host minor copper and cobalt occurrences. The Mount Josephine occurence (MinDep no. 10922), where base metal exploration was carried out in the 1980s, recorded cobalt values up to 0.05% Co from rock chip samples of earthy manganiferous rock (Cook 1985). Exploration by Taruga Minerals Ltd have identified the possibility of these structures hosting MVT style mineralisation (Taruga Minerals Ltd 2022).

Geochemical and rock-chip sampling between Burra and Jamestown in the Mid North of the State identified widespread anomalous cobalt values at the Cartarpo Mine (MinDep no. 644), where an average ore grade of 6.2% Cu and ~5% Co was obtained from a six tonne parcel of ore in 1867. Rock-chip sampling in 2018 returned values up to 1.78% Co (Hill 2018). At Willalo (MinDep no. 10919), rock-chip sampling carried out in 2018 returned best values of up to 6,920 ppm Co. Both of these occurrences are hosted by the Waukaringa Siltstone, part of the Umberatana Group sediments (Ausmex Mining Group Ltd 2018). The Yarcowie prospect (MinDep no. 10920) is hosted by Tapley Hill Formation metasediments, where rock-chip sampling in 2017 returned values up to 0.94% Co (Archer Exploration Ltd 2018). Geochemical sampling at Cudmores (MinDep no. 9129) identified patchy anomalous Cu-Co with best assay 1,100ppm Co and 1,500ppm Cu, hosted by Callana Group metasediments (Department for Energy and Mining 2024). This region has good potential for sediment hosted copper-cobalt mineralisation.

Curnamona Province

At the Dome Rock Copper Mine (MinDep no.1025) north of Olary, cobalt minerals are associated with copper in albitised metasediments of the Willyama Supergroup. Dome Rock is the type locality for cobaltaustinite, which is probably derived from Co bearing arsenopyrite and pyrite while löllingite has been identified as containing a small amount of cobalt (Munro-Smith 2006). To the west of Dome Rock and northeast of Yunta lies a cluster of small historic mines near Ethiudna (MinDep no. 973) on Plumbago Station. Copper-cobalt-nickel mineralisation is hosted in a tightly folded calcsilicate rocks, bearing secondary copper minerals with primary sulphides including arsenopyrite, chalcopyrite, cobaltite, galena, molybdenite, pentlandite, skutterudite and sphalerite being recorded (Noble et al. 1983). South of Cockburn near the SA/NSW border lies the Mutooroo deposit (MinDep no. 842). Copper was mined between 1887–1953, with >15,000 t of ore produced. Inferred resources are 13.1Mt @ 1.48% Cu, 0.14% Co, 0.23g/t Au (Havilah Resources 2010). Cobalt mineralisation also occurs within the Bimba Formation, a member of the Willyama Supergroup at the Mount Howden Mine (MinDep no. 1024) north of Olary. Small quantities of surface high grade cobalt ore, mainly erythrite ($Co_3(AsO_4)_2 \cdot 8H_2O$), occurring along joints and fractures, were mined in the late 19th century (Peterson 1955).

Percussion drilling through a sequence of banded quartz-diopside-pyrite metasediment and gossan of the Broken Hill Group at Kaloola (MinDep no. 10915) north of Olary, gave best results of 0.17% Co from 13 m (Fraser et al. 1988). The nearby Kalkaroo deposit (MinDep no. 8455) is a replacement-style deposit located on the northern, and faulted portion of a major structural dome. It contains a JORC ore reserve of 100 Mt based on a contained 1.1 Mt Cu, 3.1 Moz Au, 23.2 Kt Co. Molybdenite is also present with an inferred resource of 4.5Mt @ 615 ppm Mo as well as minor vein style U mineralisation (Havilah Resources 2022). North Portia (MinDep no. 4503), situated 30 km north of Kalkaroo, contains a supergene sulphide zone of mainly chalcocite ore with associated cobaltian pyrite and gold. Additional but undetermined reserves of cobaltian pyrite also occurs in the primary sulphide zone (Havilah Resources 2018). The deposit has a measured JORC resource estimate of 3.856 Mt at 0.73% Cu,154 ppm Co and 0.5 g/t Au with a total contained cobalt resource of 594 t (Havilah Resources 2018).

Gawler Craton

Minor occurrences of cobaltite and skutterudite were encountered during copper mining at the Wallaroo Mines, Kadina (MinDep no. 7300) between 1859–1923 (Noble et al. 1983). The Cattlegrid deposit (MinDep no. 3051) at Mount Gunson, operated between 1974–1986 and produced 7.2 Mt of ore @1.9% Cu and 8.3 g/t Ag (Bampton 2003). Mount Gunson is a stratabound sediment-hosted copper deposit with minor lead, zinc and cobalt occurring at the contact between the Pandurra Formation and overlying Whyalla Sandstone (Bampton 2003). To the north of the Cattlegrid mine are a number of other base metal occurrences including Emmie Bluff (MinDep no. 3035), hosted in flat-lying undeformed Late Proterozoic sedimentary rocks, deposited on the Stuart Shelf. The main Cu-Co-Ag-Zn mineralisation occurs at a depth of 400 m and hosted by pyritic, black dolomite shales of the Tapley Hill Formation. The primary copper mineral is chalcopyrite, while cobalt occurs mainly as carrolite. The combined indicated and inferred mineral resource stands at 43 Mt @ 1.3% Cu, 470 ppm Co, 11 g/t Ag and 0.15% Zn (Coda Minerals 2021). Other prospects include MG14 (MinDep no. 3090) and Windabout (MinDep no. 3140). Mineralisation at MG14 and Windabout is similar to Emmi Bluff but occur at much shallower depths. MG14 contains a total of 1.7 Mt @ 1.24% Cu and 334 ppm Co, while Windabout contains 17.67 Mt at 0.77% Cu and 492 ppm Co. These three deposits are interpreted to be examples of Zambian-style copper-cobalt deposits (Coda Minerals 2021).

Diamond drilling by Western Areas Ltd at Sahara (MinDep no. 11817) northwest of Ceduna encountered magmatic nickel and copper bearing sulphides hosted by a pyroxenite intrusive body. Assays returned broad low grade copper and nickel mineralisation with minor cobalt, palladium and platinum. Best cobalt values were 0.1 m at 1,130 ppm Co from 340.4 m (Western Areas Ltd 2020). Aircore drilling in 1995 at the Kalanbi prospect (MinDep no. 10923) near Ceduna identified elevated Ni-Cr-Co values with the best values in a drillhole at 36–37m depth assaying 0.34% Co, 0.88% Cr and 0.26% Ni within gabbroic rocks associated with the Mulgathing Complex (Twenty Seven Co. Ltd 2018).

Musgrave Province

Geological mapping during the late 1950s identified outcrops of weathered nickeliferous rocks within the Giles Complex at Claude Hills (MinDep no. 6789) in the far northwest corner of the state (Coles 2007). It has a resource estimate of 33 Mt @ 39% Fe, 0.81% Ni and 0.07% Co (Metals X Ltd 2013). The deposit is similar to the nearby Wingellina deposit in Western Australia.

PROSPECTIVITY IN SOUTH AUSTRALIA

Cobalt production in Australia is currently limited to deposits in Western Australia (Hughes et al. 2023). However, the potential to produce cobalt in South Australia is based on favourable geology, particularly associated with stratiform sediment-hosted copper deposits identified across the State. There is also significant potential for new and extensions of existing lateritic nickel-cobalt deposits in the Musgrave Province. The northern and western Gawler Craton and Musgrave Province remains highly prospective for magmatic nickel sulphide deposits (Reid and Bockmann 2022). The extraction of cobalt from secondary resources such as mine waste and smelter slag from a variety of sites is also an ongoing area of interest (Cook et al. 2021; Jackson et al. 2023).

Table 1. Summary of deposit types which may contain economic concentrations of cobalt in South Australia.

Key deposit types	Regions of interest in South Australia
Major deposit types:	
Stratiform sediment-hosted copper	• Gawler Craton – Mt. Gunson district (Bockmann et al. 2022); Adelaide Rift Complex – Flinders Ranges (Teale 1988; Carr and Oliver 1994)
Magmatic nickel sulfide deposits	• Musgrave Province and Gawler Craton (Reid and Bockmann 2022)
Nickel-cobalt laterite deposits	• Musgrave Province – Claude Hills (Coles 2007)
Minor deposit types:	
Iron oxide-copper-gold (IOCG)	• Gawler Craton – Olympic Dam (Ehrig et al. 2012)
MVT deposits	• Adelaide Rift Complex – Martins Well (Taruga Minerals Ltd 2022)
Secondary sources:	
Mine tailings / smelter slag	• Mine waste at Mount Gunson, Dome Rock and Olympic Dam smelter slag (Cook et al. 2021; Jackson et al. 2023)

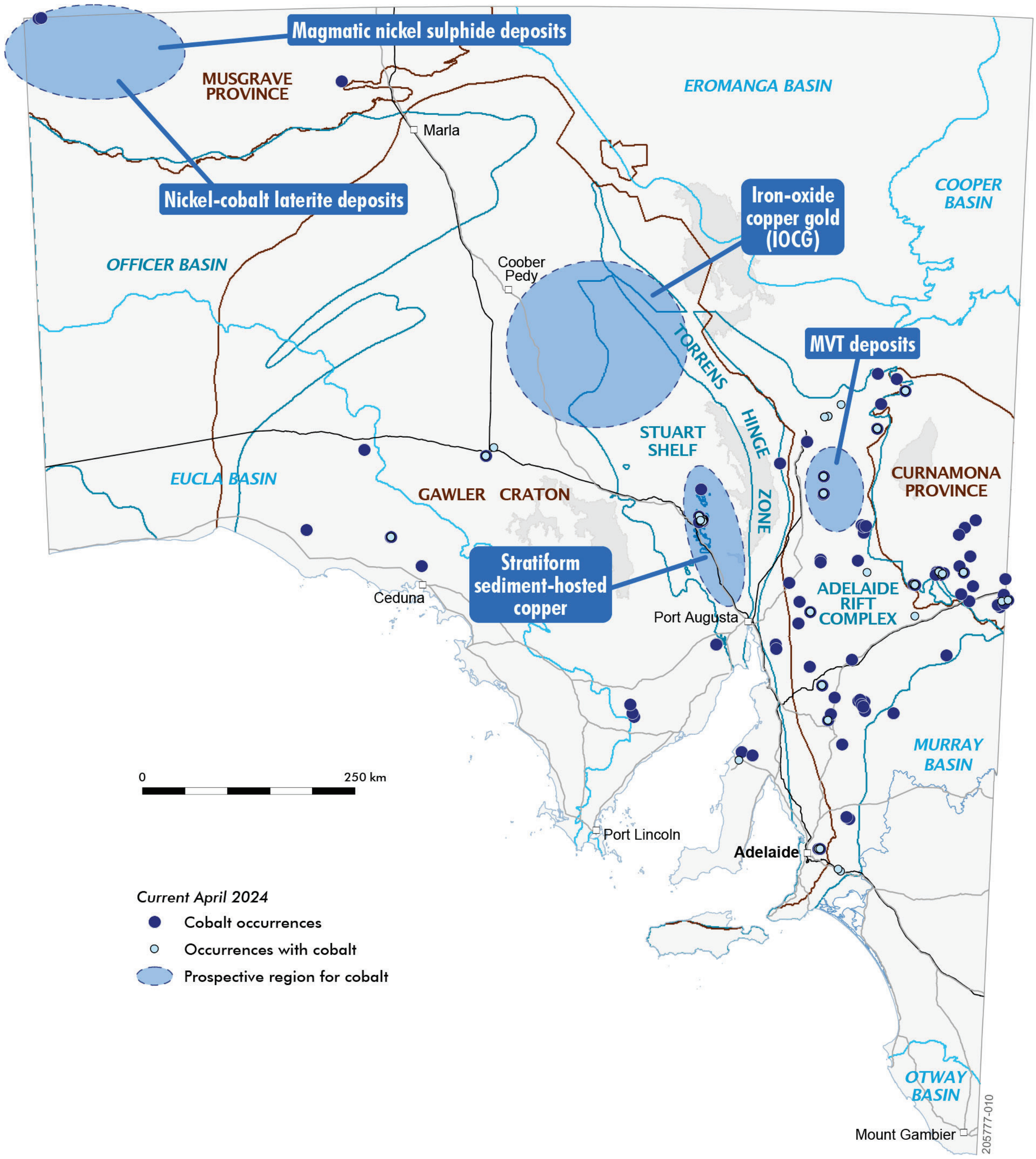

Figure 3. Location of South Australia's cobalt occurrences and characteristic cobalt forms. (205777-010 PDF 188 KB)

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RELATED LINKS

Cobalt webpage
https://www.energymining.sa.gov.au/industry/minerals-and-mining/mineral-commodities/cobalt

South Australian commodity resource information (SARIG)
http://map.sarig.sa.gov.au/MapViewer/StartUp/?siteParams=DashboardWidget%7CcommoditiesIndicators

Critical Minerals South Australia dashboard
https://www.energymining.sa.gov.au/industry/geological-survey/gssa-projects/critical-minerals-south-australia/south-australias-critical-minerals-dashboards

Critical Minerals South Australia project
https://www.energymining.sa.gov.au/industry/geological-survey/gssa-projects/critical-minerals-south-australia

South Australia's Mineral Deposit (MinDep) database
https://minerals.sarig.sa.gov.au/MineralDepositSearch.aspx

APPENDIX

Occurrence data

Combined data available from South Australia's Mineral Deposit (MinDep) database as displayed in Figure 1 (as at July 2024).
Click to open attachments panel.