

## NICKEL SULPHIDE METALLOGENIC PROVINCES: *resources & potential*

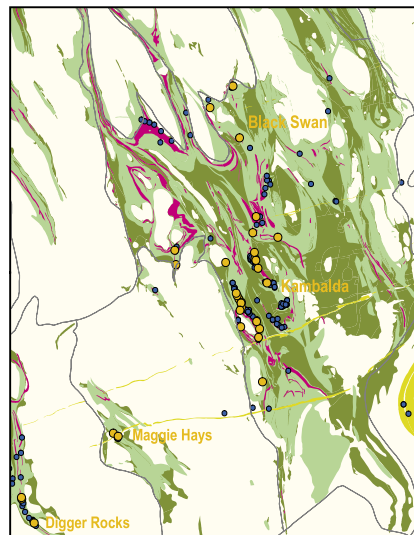
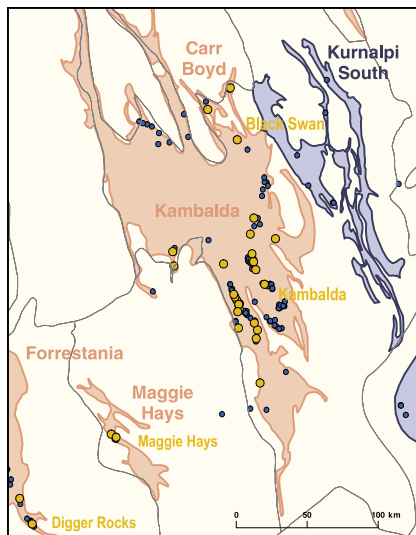
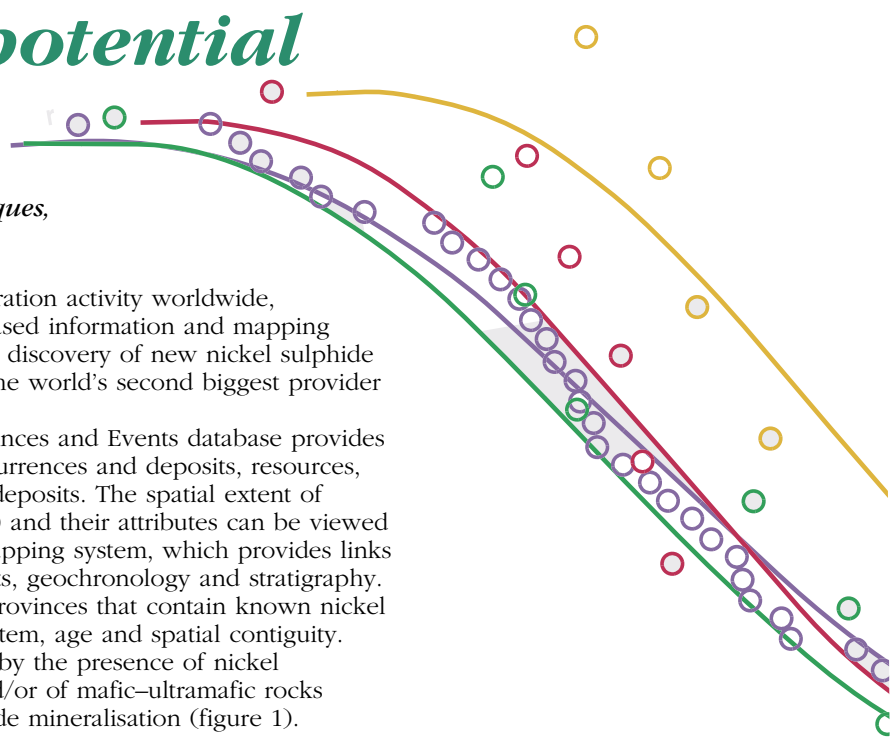


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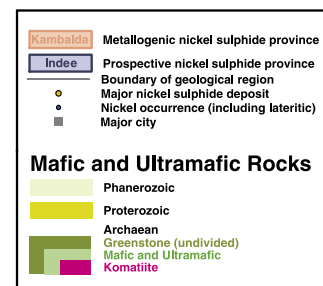
As strong demand for nickel stimulates exploration activity worldwide, Geoscience Australia has developed a web-based information and mapping system of metallogenic provinces to assist the discovery of new nickel sulphide resources to maintain Australia's position as the world's second biggest provider of this valuable mineral.

Geoscience Australia's Oracle-based Provinces and Events database provides information on regional geology, mineral occurrences and deposits, resources, and age of mineralisation of nickel sulphide deposits. The spatial extent of nickel provinces (currently metallogenic only) and their attributes can be viewed through Geoscience Australia's web-based mapping system, which provides links to other national databases of mineral deposits, geochronology and stratigraphy.

Three basic criteria define metallogenic provinces that contain known nickel sulphide mineral systems: style of mineral system, age and spatial contiguity. Additional prospective provinces are defined by the presence of nickel occurrences (with no recorded resources) and/or of mafic-ultramafic rocks interpreted to be favourable for nickel sulphide mineralisation (figure 1).



◀ **Figure 1.** Metallogenic nickel sulphide provinces in the Kambalda region. The map on the left shows provinces from the nickel province map of Australia, metallogenic (in orange) and prospective (in blue). The map on the right shows the distribution of mafic and ultramafic rocks, known mineral deposits and occurrences that delineate the provinces.



Global metallogeny of nickel sulphide deposits/events shows that komatiite-related Ni-Cu deposits (such as Kambalda in Western Australia and the Abitibi and Thompson belts in Canada) are of Archaean and Proterozoic age, with relatively larger deposits formed ~2700 Ma (million years ago) and ~1900 Ma. Komatiites older than 3000 Ma are generally not mineralised.

Basal Ni-Cu sulphide deposits (such as Voisey's Bay in Canada) are not age-specific, although larger deposits of this type tend to be younger than ~2060 Ma. Stratabound deposits of platinum group elements, nickel and copper (PGE-Ni-Cu) associated with large Archaean-Proterozoic layered mafic-ultramafic complexes (such as the Great Dyke, Zimbabwe and Merensky Reef, South Africa) contain large resources of nickel (5 to 6 Mt Ni metal), but are of low grade (<0.2% Ni).



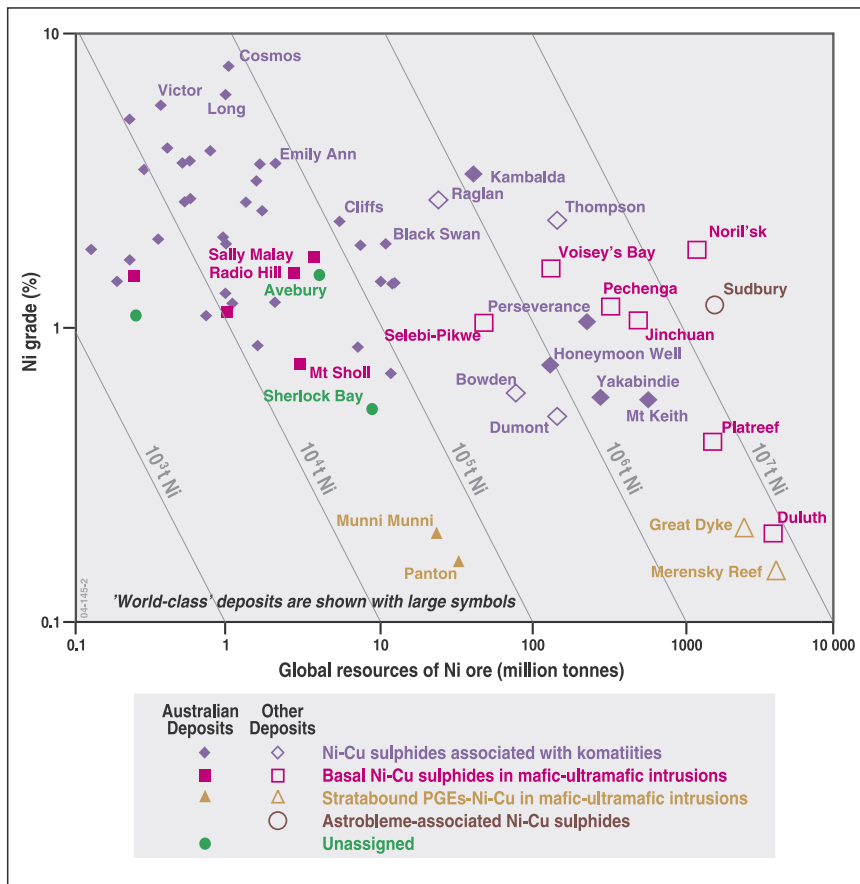


Figure 2. Logarithmic plot of nickel grade (wt%) versus global resources of nickel ore (production plus reserves and resources in million tonnes) for the major nickel sulphide deposits of the world. Australian deposits are shown with filled symbols and other deposits with open symbols. The grey diagonal lines show contained Ni metal in tonnes (source of data: OZMIN 2004, Naldrett 2002, Eckstrand 1995).

Australia is well represented by world-class nickel sulphide deposits (>1 Mt of Ni metal), and smaller, rich deposits (5–8% Ni) (figure 2). Australian deposits are associated with ultramafic and/or mafic igneous rocks and occur in three main geotectonic settings:

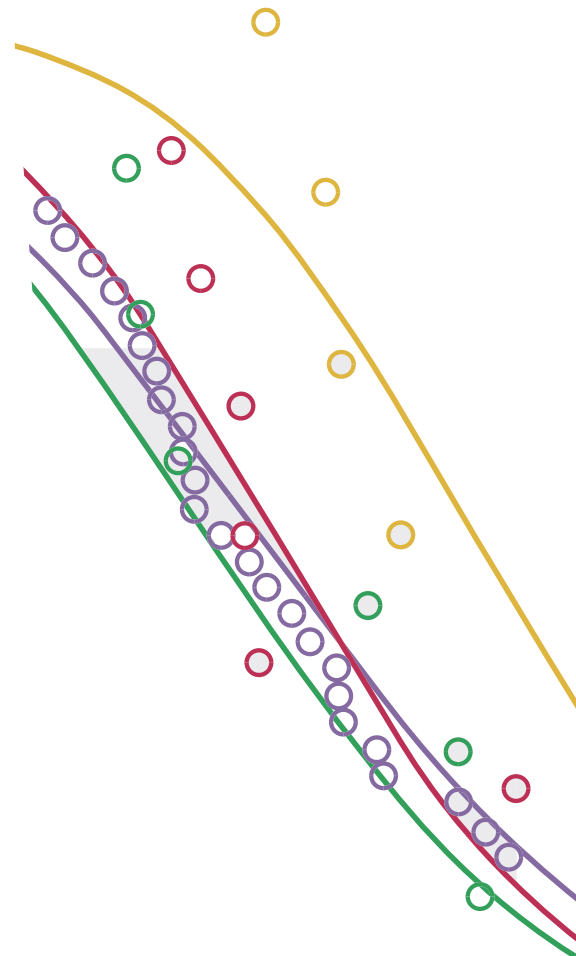
- Archaean komatiites in granite–greenstone terranes
- Precambrian tholeiitic mafic–ultramafic intrusions emplaced in former rift zones in Archaean cratons and Proterozoic orogens
- Remobilised-hydrothermal deposits of various ages and tectonic settings.

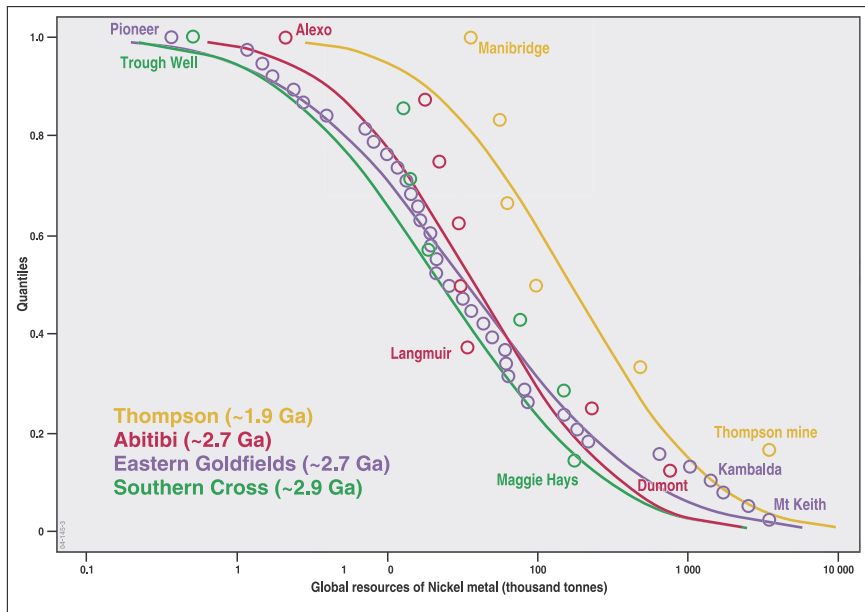
Australia's nickel–sulphide production and resources are dominantly associated with the komatiite-hosted deposits of the Yilgarn Craton formed ~2.71–2.70 Ga (billion years ago). The Mount Keith and Kambalda metallogenic provinces are the most endowed, containing ~9.5 and ~2.0 million tonnes of nickel (past production plus resources), and host the world-class deposits of Mount Keith and Kambalda. The older komatiitic sequences in the Pilbara Craton (~3.3–3.0 Ga) and the younger Lake Harris (~2.5 Ga) komatiite (Hoatson et al, 2005) in the central Gawler Craton appear to be less mineralised but have potential for further discoveries.

A comparison of global resources of nickel in deposits associated with komatiites (figure 3) shows generally similar cumulative frequency distribution curves for the Archaean Southern Cross, Eastern Goldfields and Canadian Abitibi provinces, reflecting their similar nickel endowment. This suggests that the Southern Cross Province (~2900 Ma) may host large undiscovered deposits of either the Kambalda or Mount Keith type and size.

The curve for the Palaeoproterozoic Thompson Belt shows a shift to the large-tonnage deposits. This belt has geological and geochemical features similar to those in the Eastern Goldfields and Abitibi provinces, except for the intense remobilisation of nickel sulphide mineralisation in the former. The rich Thompson mine is hosted by intensively deformed and metamorphosed sulphidic carbonaceous sediments, which suggests that intensive remobilisation could have led to the formation of a small number of high-grade nickel sulphide deposits.

Basal Ni–Cu–Co±PGE sulphide mineralisation is associated with tholeiitic mafic–ultramafic intrusions emplaced in former rift zones in Archaean cratons and Proterozoic orogens at ~2.93–2.89 Ga in the west Pilbara (e.g. Radio Hill, Mt Sholl), ~2.8–2.7 Ga in the Yilgarn Craton (Carr Boyd Rocks), ~1.86–1.84 Ga in the Halls Creek Orogen (Sally Malay, Corkwood), and ~1.08 Ga in the Musgrave Block (Nebo, Babel).





◀ **Figure 3.** Cumulative frequency distribution of global resources of nickel metal (production plus reserves and resources) for the major nickel-bearing komatiite belts and provinces of the world (source of data: OZMIN 2004, Naldrett 2002, Eckstrand 1995).

In contrast to stratabound PGE deposits hosted by large layered mafic-ultramafic bodies (Munni Munni, Weld Range), basal Ni-Cu-Co sulphide deposits occur in small to medium size mafic bodies that may be layered or massive. Other styles of mineralisation of exploration interest include small, remobilised-hydrothermal nickel sulphide deposits in western Tasmania (Avebury) that are thought to be associated with Devonian granites that intrude Cambrian mafic-ultramafic sequences.

Analysis of the metallogenic provinces suggests considerable potential for further komatiite-hosted deposits in under-cover extensions of the mineralised komatiite sequences in the Yilgarn Craton. Similar potential exists for Ni-Cu-Co±PGE sulphide mineralisation associated with basal contacts and feeder conduit zones of sulphur-saturated tholeiitic mafic-ultramafic intrusions in the Musgrave, Halls Creek, Arunta and Gawler provinces, and unexposed areas of the Albany-Fraser Province region.

The recently discovered Collurabbie Ni-Cu-PGE prospect in the northeast Yilgarn Craton is an unusual, PGE-enriched nickel sulphide komatiite deposit that highlights the potential of poorly exposed Archaean greenstone sequences near the margins of the craton. There is also some potential for Noril'sk-type Ni-Cu-PGE deposits associated with major igneous provinces in western and northern Australia (such as Antrim Plateau Volcanics), although no deposits of this type are currently known (Wingate et al 2004).

## References

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