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Web-Based Mapping of Australia's Nickel Sulphide Metallogenic Provinces: Resources and Potential

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This poster presents a web-based information and mapping system for defining nickel sulphide metallogenic and prospective provinces. The system contains information on regional geology, mineral occurrences and deposits, resources, and age of mineralisation for most Precambrian nickel sulphide deposits.The three basic criteria used to delineate the metallogenic provinces are: same style of mineral system, similar age, and spatial contiguity of geology. Metallogenic provinces map the extent of known metallogenic events (mineral deposits with known nickel resources) whereas the prospective provinces are defined by the presence of nickel occurrences and/or of mafic-ultramafic rocks interpreted to be favourable for nickel sulphide mineralisation (Figs. 1 to 7).

The information on Australia's metallogenic provinces is stored in Geoscience Australia's (GA) ORACLE-based Provinces and Events database with links to other national databases of mineral deposits, geochronology, geochemistry and stratigraphy (Fig. 8). The spatial extent of provinces and attributes can be viewed through GA's web-based mapping system.

Global metallogeny of nickel sulphide deposits/ events shows that komatiite-related Ni-Cu deposits (such as Kambalda and in the Abitibi Belt) are of Archaean and Proterozoic age with relatively larger deposits formed at ~2700 Ma and ~ 1950 Ma (Fig. 9). Komatiites older than 3000 Ma are generally not mineralised. Australia is well represented by world-class deposits (>1 Mt of Ni metal) and smaller rich (5 to 8% Ni) deposits (Fig. 10). Basal Ni-Cu sulphide deposits (such as Voisey's Bay) are not age-specific although larger deposits of this type tend to be younger than ~2060 Ma. Stratabound PGEs-Ni-Cu deposits that are associated with large Archaean-Proterozoic layered mafic-ultramafic complexes (such as in the Great Dyke and Merensky Reef) contain large resources of nickel (5 to 6 Mt Ni metal), but are of low grade (< 0.2% Ni).

More than 97% of the global resources of nickel in Australia are contained within komatiite-associated deposits (Fig. 11), which is more than five times the contribution of similar deposits world wide (Fig. 12). A comparison of global resources of nickel in deposits associated with komatiites shows that the Eastern Goldfields region hosts ~ 62% of the resources in thirty eight deposits (Fig. 13). Although the Thompson Belt in Canada accounts for only 23% of nickel resources it hosts a smaller number of relatively larger deposits (Fig. 14). This feature is also seen on cumulative frequency distribution curves of nickel resources for four important nickel-producing komatiite provinces/belts. The curves for the Archaean Southern Cross, Eastern Goldfields and Abitibi provinces have generally the same character reflecting similar nickel endowment, which suggests that the Southern Cross Province (~ 2900 Ma) may host yet to be discovered large deposits of either Kambalda- or Mount Keith-type. The deposits in the Palaeoproterozoic Thompson Belt have 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 remo-bilisation could have led to the formation of a small number of high-grade nickel sulphide deposits.

Analysis of the metallogenic provinces suggests high potential for further komatiite-hosted deposits in under-cover extensions of the mineralised komatiite sequences in the Yilgarn. There is also significant potential for Ni-Cu-Co±PGE sulphide mineralisation associated with basal contacts and feeder zones of S-saturated tholeiitic mafic-ultramafic intrusions in the Musgrave, Halls Creek, Arunta, Gawler provinces, and unexposed areas of the Albany-Fraser Province. There is some potential for 'Noril'sk-type' Ni-Cu-PGE deposits associated with voluminous continental flood basalt systems in western and northern Australia (such as Antrim Plateau Volcanics) although none are currently known.

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Legend for Figures 1-7

Kambalda — Metallogenic nickel sulphide province

Indee — Prospective nickel sulphide province

Boundary of geological region

Major nickel sulphide deposit

Nickel occurrence (including lateritic)

Major city

Mafic and Ultramafic Rocks

Phanerozoic

Proterozoic

Archaean

Greenstone (undivided)

Mafic and Ultramafic

Komatiite

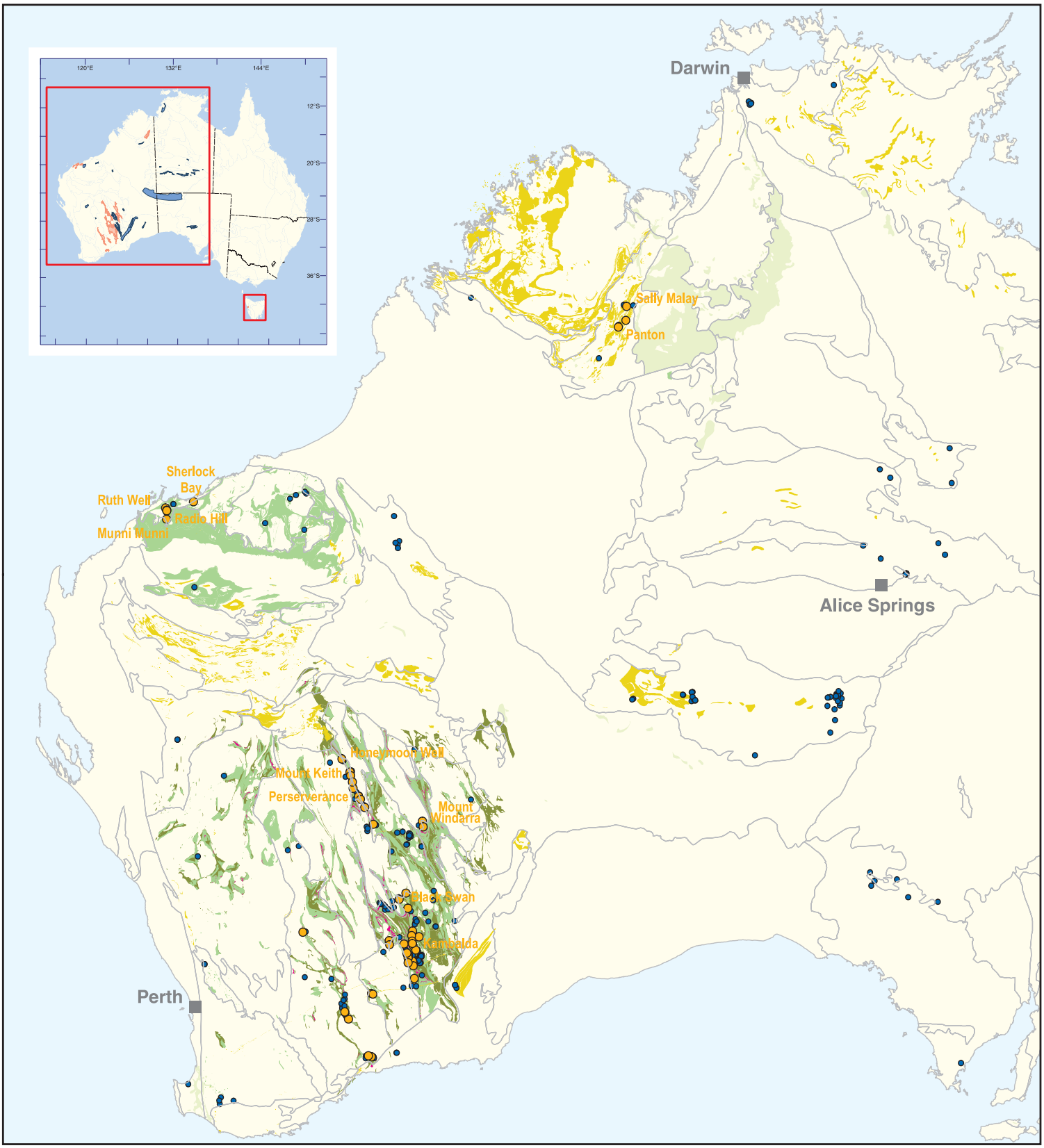

Fig. 1: Distribution of major nickel deposits, nickel occurrences, and mafic-ultramafic rocks.

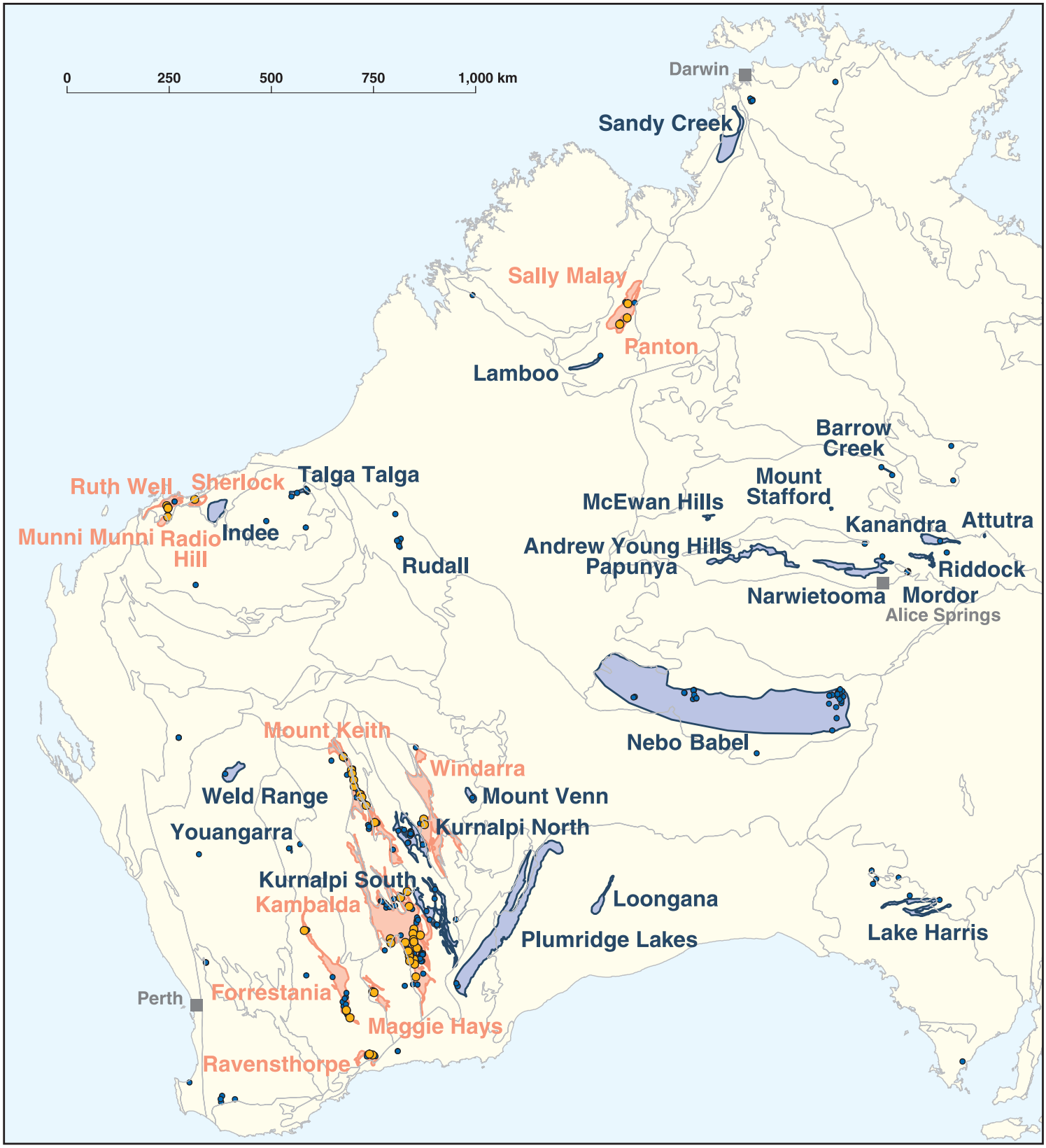

Fig. 2: Distribution of metallogenic nickel sulphide and prospective nickel sulphide provinces.

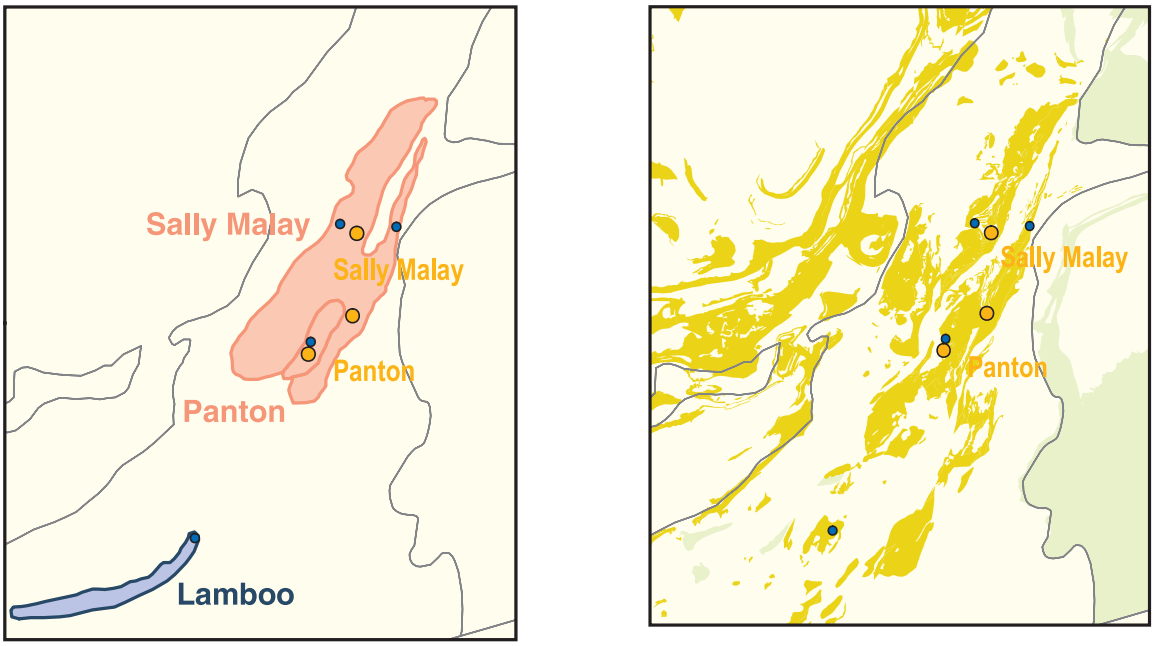

Fig. 3: Metallogenic nickel sulphide provinces in the East Kimberley region.

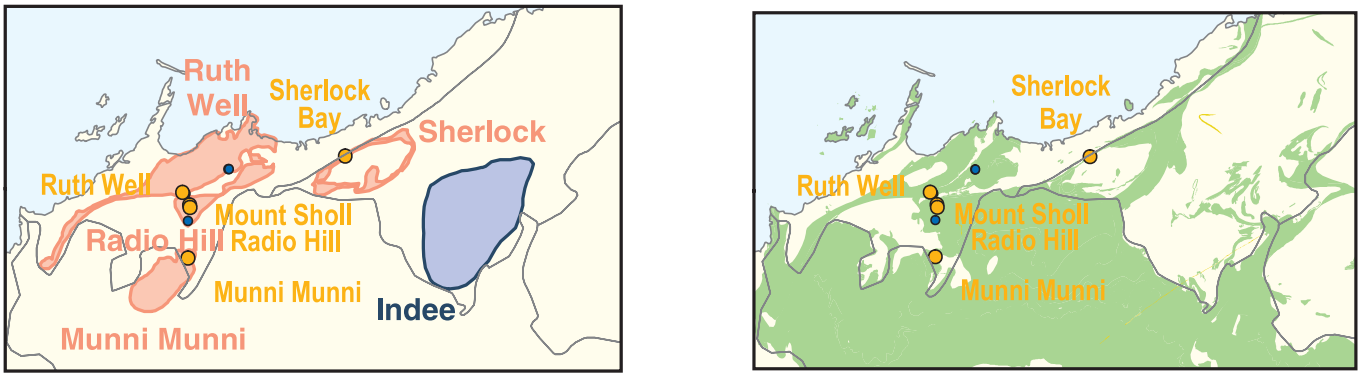

Fig. 4: Metallogenic nickel sulphide provinces in the west Pilbara region.

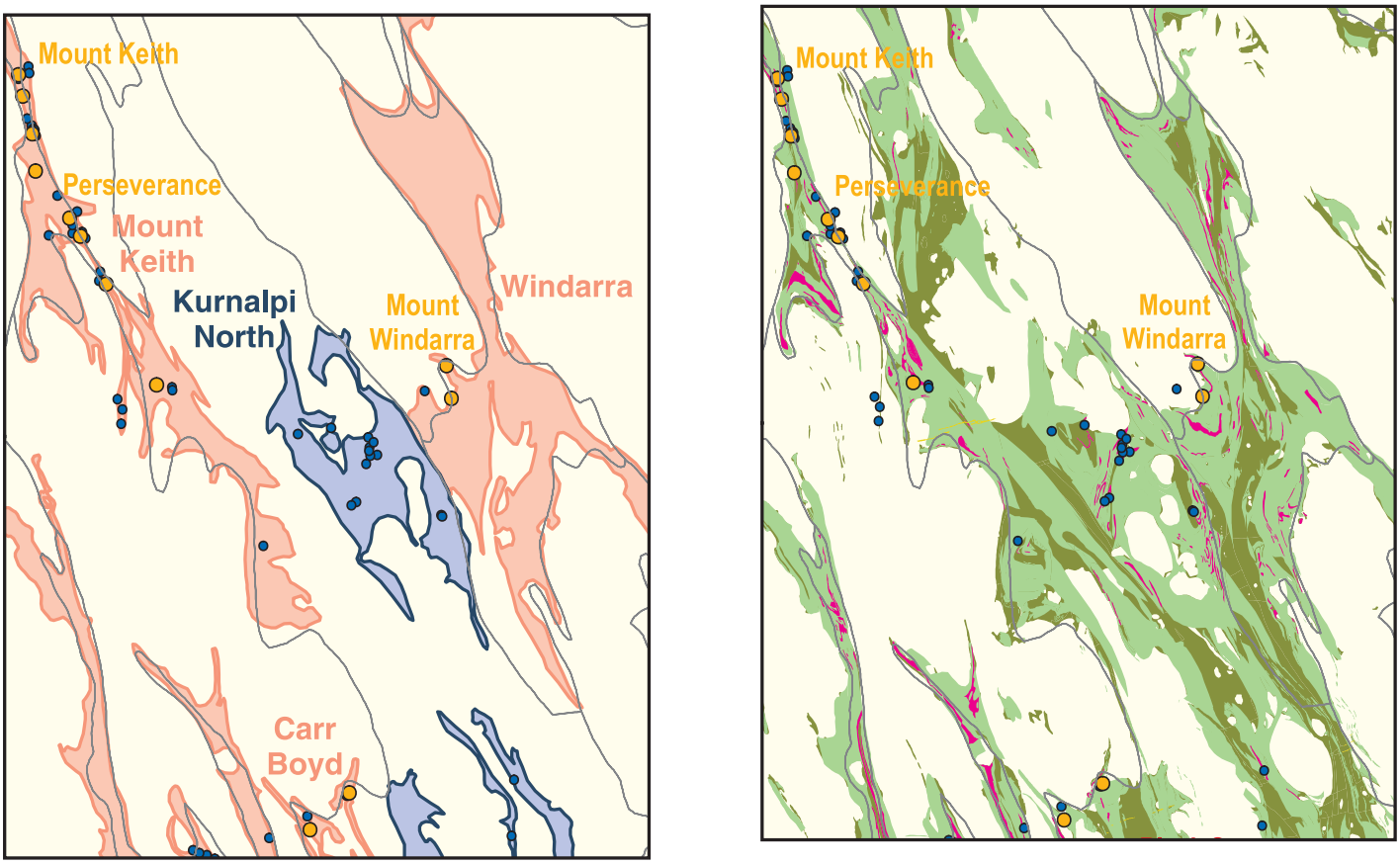

Fig. 5: Metallogenic nickel sulphide provinces in the Mount Keith and Windarra regions.

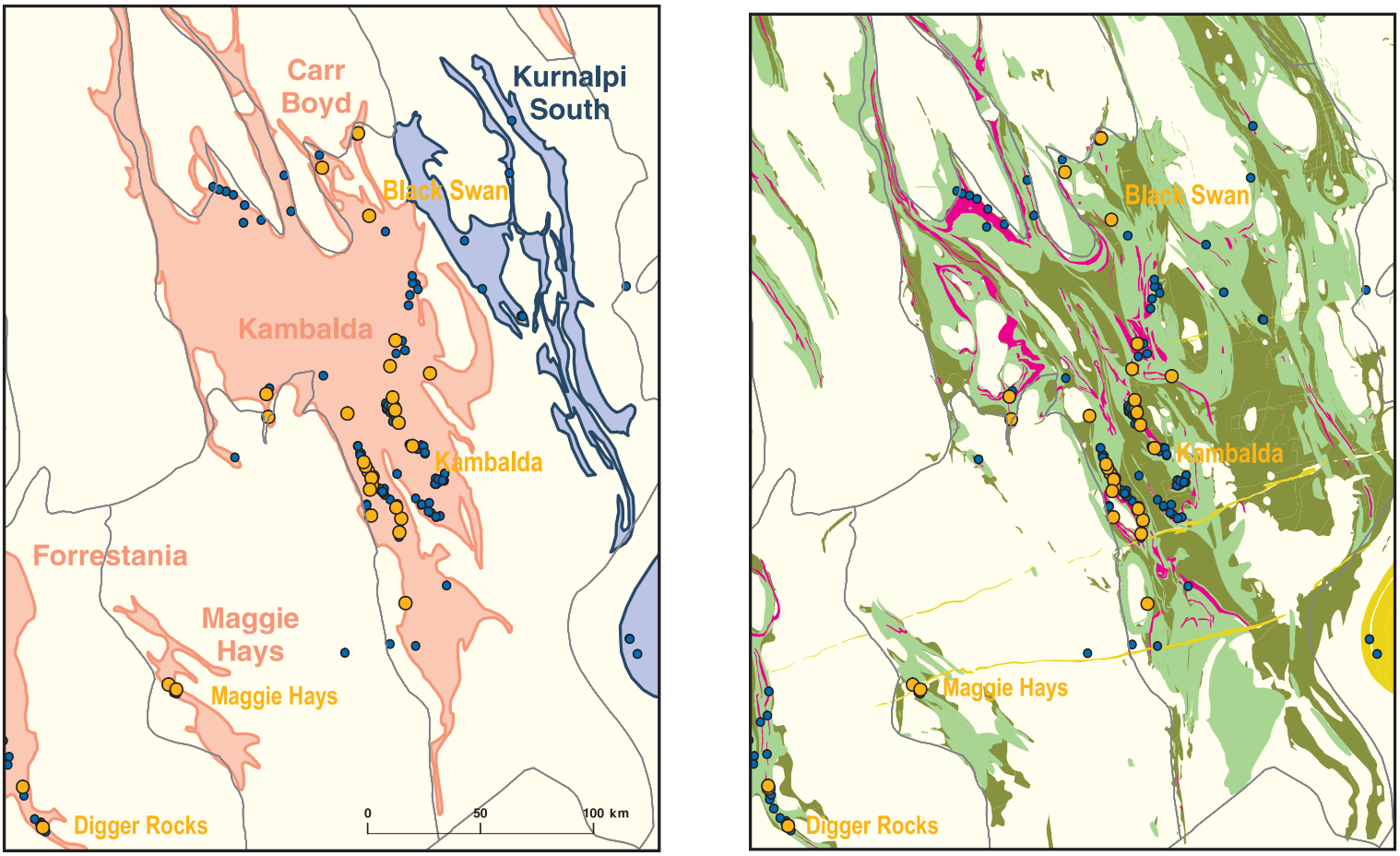

Fig. 6: Metallogenic nickel sulphide provinces in the Kambalda region.

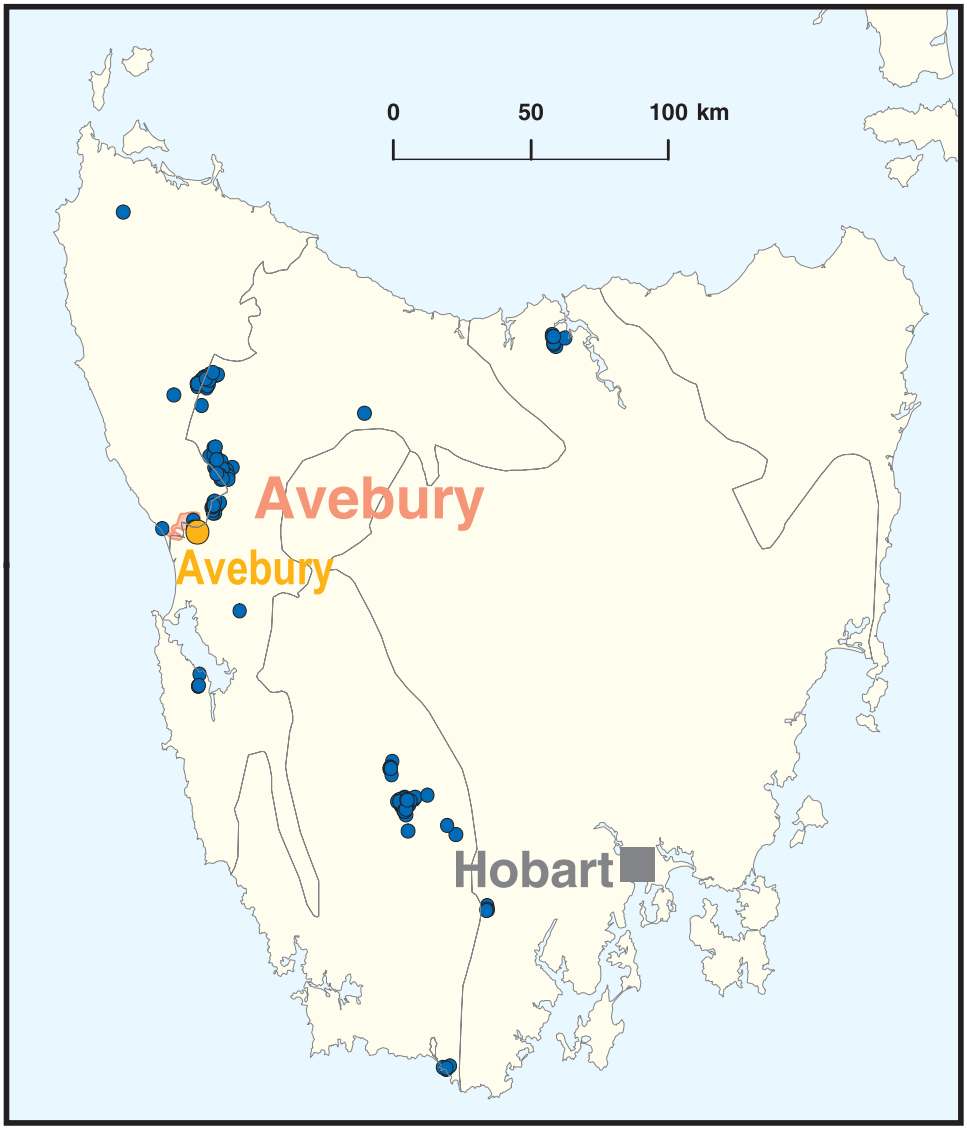

Fig. 7: Metallogenic nickel sulphide province in west Tasmania.

Mount Keith Nickel Metallogenic Province

Entity ID: 39725 **Compiled by:** Hoatson, D. 2003 **Status:** Informal
Rank: Province **Type:** metallogenic **Subtype:** mafic/ultramafic extrusive **Location:** Onshore
Synonyms: No data **Symbol:** No data
Minimum Age: Archaean (2705 ± 4 Ma) **Age Method:** isotopic(U/Pb)
Maximum Age: No data **Age Method:** No data
Summary: Archaean (2710-2700 Ma) komatiite-associated nickel metallogenic province. The province hosts a number of world-class deposits and several smaller deposits. This province also contains Kambalda-type deposits (massive sulphides) such as Cosmos and Waterloo.
Attributes:
Classification: Komatiitic Ni-Cu
Commodity: Nickel; Copper; Platinum group elements; Cobalt
Deposit size: world class (world class deposits (Mount Keith) to several occurrences)
Sulphides present: yes
Sulphur-bearing host rocks: yes
Sulphur-saturation level: yes
Basal contact: yes (Major ores at Mount Keith are of disseminated type, others are massive sulphides at basal contact)
Crustal contamination: yes
Geosetting: craton (rifting/extensional in stable Archaean craton)
Country: AUS
Parent: No data
Child Provinces: No data
Relationships:
Is contained within -
Yilgarn Craton
Constituents: No data
Events: No data
Mineral Deposits: Perseverance, Mount Keith, Yakabindie, Weebo Bore, Honeymoon Well, Cosmos, Cliffs, Marriott
Key Reference: No data
Comments: Ages of komatiites in province are poorly constrained (>2750±7 Ma for diorite dyke cutting volcanics at Wiluna West Lode Gold Mine provides probable minimum age of associated komatiites: Kent & Hagemann, 1996)
Overview: Archaean (2710-2700 Ma) komatiites in the Eastern Goldfields Province have traditionally been a focus for Ni-Cu-Co sulphide mineralisation. Basal accumulations of massive sulphides are concentrated in depressions in the basal contacts of thick ultramafic flows at Kambalda, but the world-class Mount Keith deposit consists of disseminated Ni-Cu-Co sulphides in a thick dunite sequence. This province also contains Kambalda-type deposits (massive sulphides) such as Cosmos and Waterloo.
Images: No data
Source Information:

• For Minage: Kent, A.J.R., Hagemann, S.G., 1996. Constraints on the timing of lode-gold mineralisation in the Wiluna greenstone belt, Yilgarn Craton, Western Australia. Australian Journal of Earth Sciences, 43(5), p. 573-588 (Refid: 22558).
• For Provsubtype: Marston, R.J., Groves, D.I., Hudson, D.R., Ross, J.R., 1981. Nickel sulfide deposits in Western Australia: a review. Economic Geology, 76(6), p. 1330-1363 (Refid: 38453).
• For Provsubtype: Lesher, C.M., 1989. Komatiite-associated nickel sulphide deposits. In: Whitney J.A. and Naldrett A.J. (Eds), Ore deposition associated with magmas. Reviews in Economic Geology, No. 4, p. 45-101 (Refid: 1751).

• For Provsubtype: Barnes, S.J., Gole, M.J., Hill, R.E.T., 1988. The Agnew nickel deposit, Western Australia: Part I. Structure and stratigraphy. Economic Geology, 83(3), p. 524-536 (Refid: 41392).
• For Provsubtype: Barnes, S.J., Hill, R.E.T., Gole, M.J., 1988. The Perseverance ultramafic complex, Western Australia: a product of a komatiite river. Journal of Petrology, 29, p. 305-331 (Refid: 1748).
• For Provsubtype: Marston, R.J., 1984. Nickel Mineralisation in Western Australia, Geological Survey of Western Australia. Mineral Resources Bulletin, 14. (Refid: 1700).
• For Provsubtype: Hill, R.E.T., Gole, M.J., Barnes, S.J., 1987. Physical volcanology of komatiites: a field guide to the komatiites between Kalgoorlie and Wiluna, Eastern Goldfields Province, Yilgarn Block, Western Australia, Geological Society of Australia, Excursion Guidebook, 1, 77 pages (Refid: 1747).

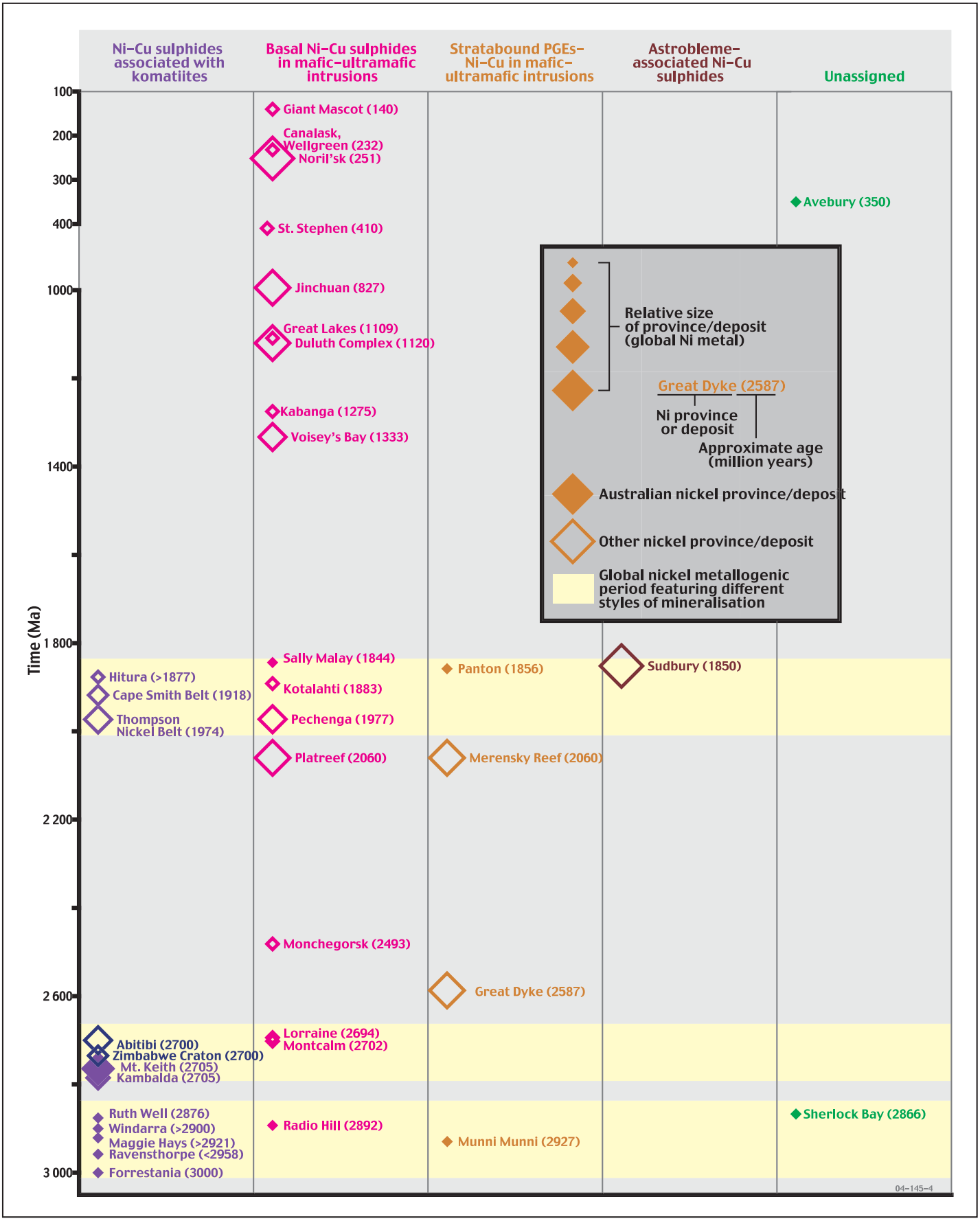

Fig. 9: Time–nickel sulphide metallogenic event plot showing approximate ages and relative sizes of nickel provinces and deposits in the world (source of data: various publications available from senior author).

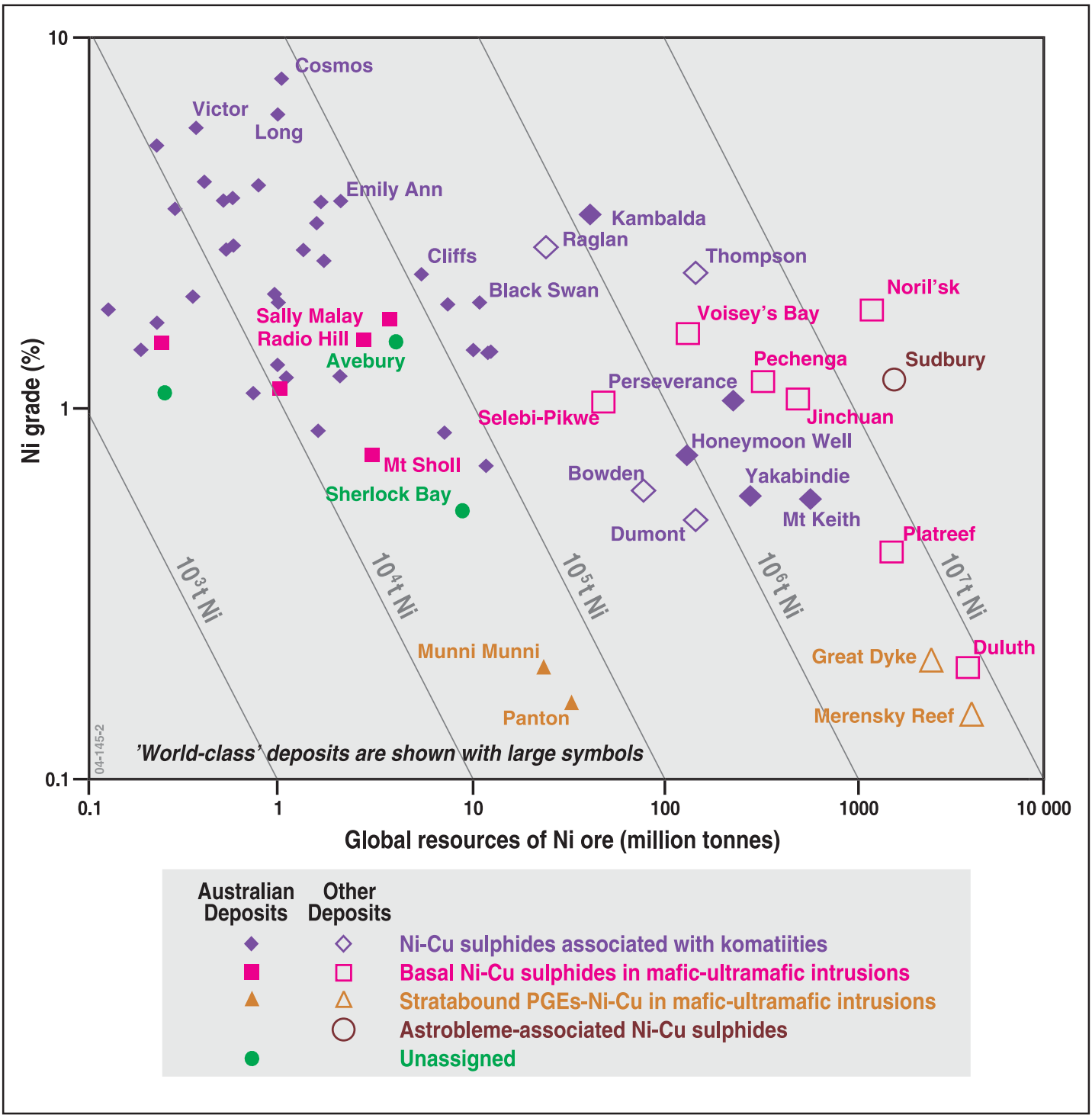

Fig. 10: Logarithmic plot of nickel grade (wt%) versus global resources of nickel ore (production plus reserves and resources in million tonnes) for the major nickel sulphide deposits of the world. Australian deposits are shown with filled symbols and other deposits with open symbols. The grey diagonal lines show contained Ni metal in tonnes (source of data: OZMIN 2004; Naldrett, 2002; and Eckstrand, 1995).

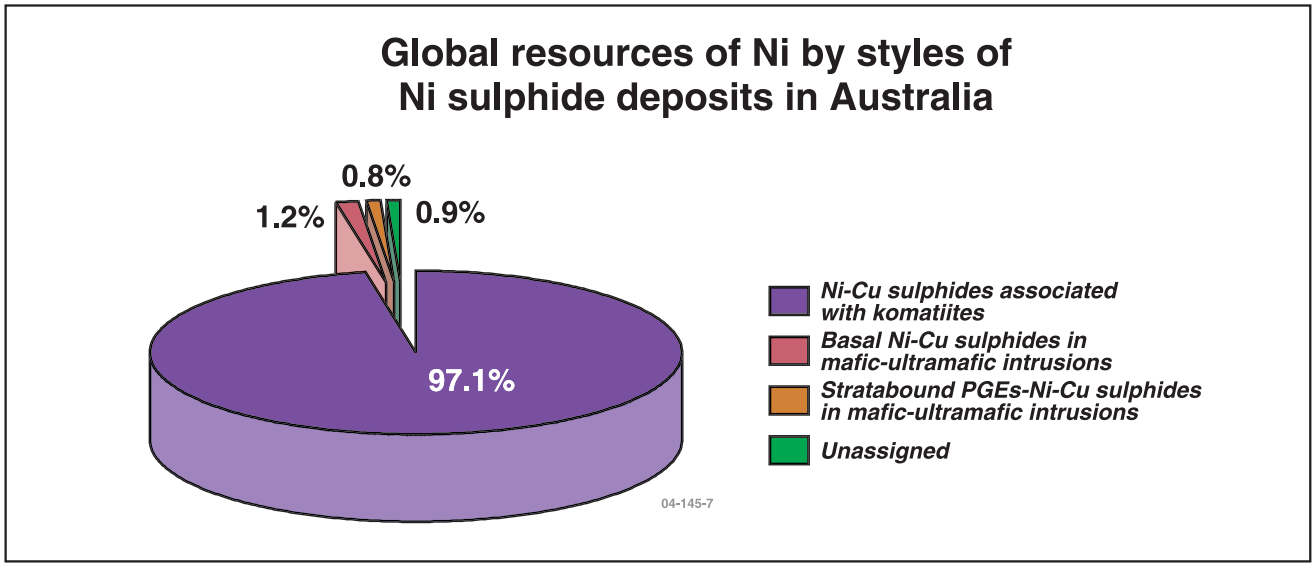

Fig. 11

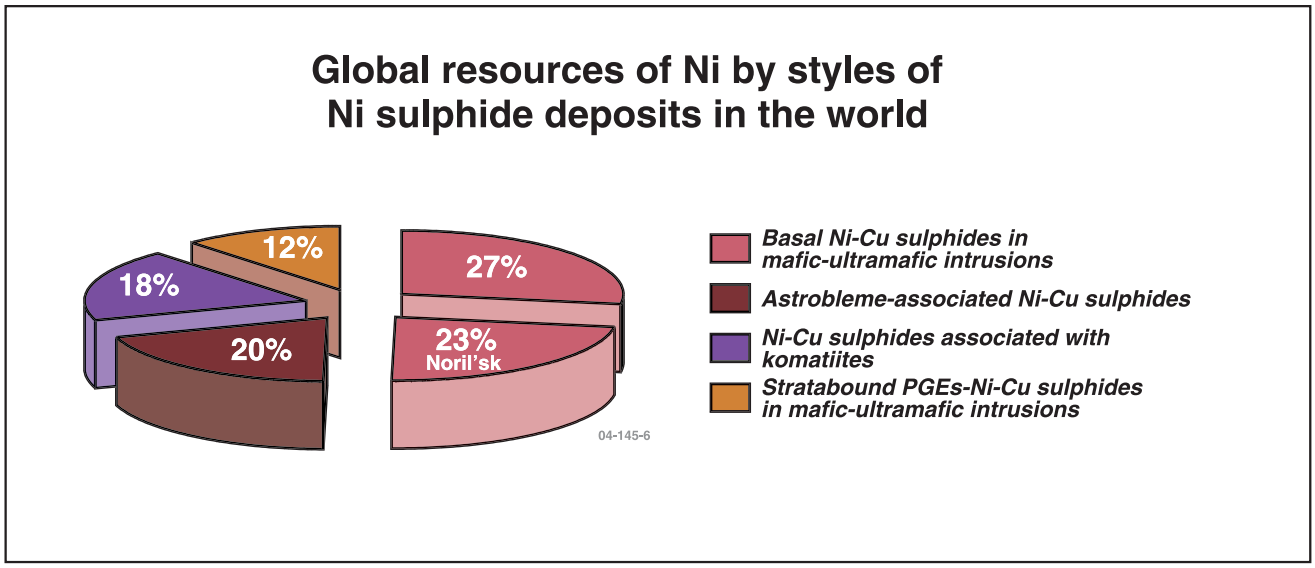

Fig. 12

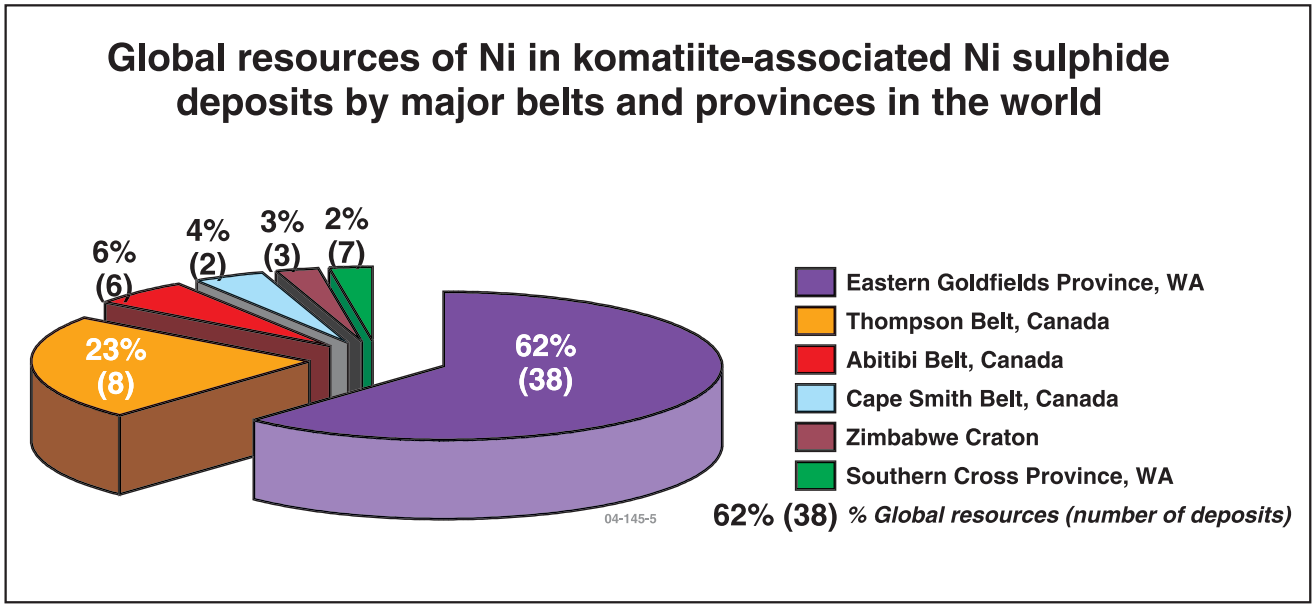

Fig. 13

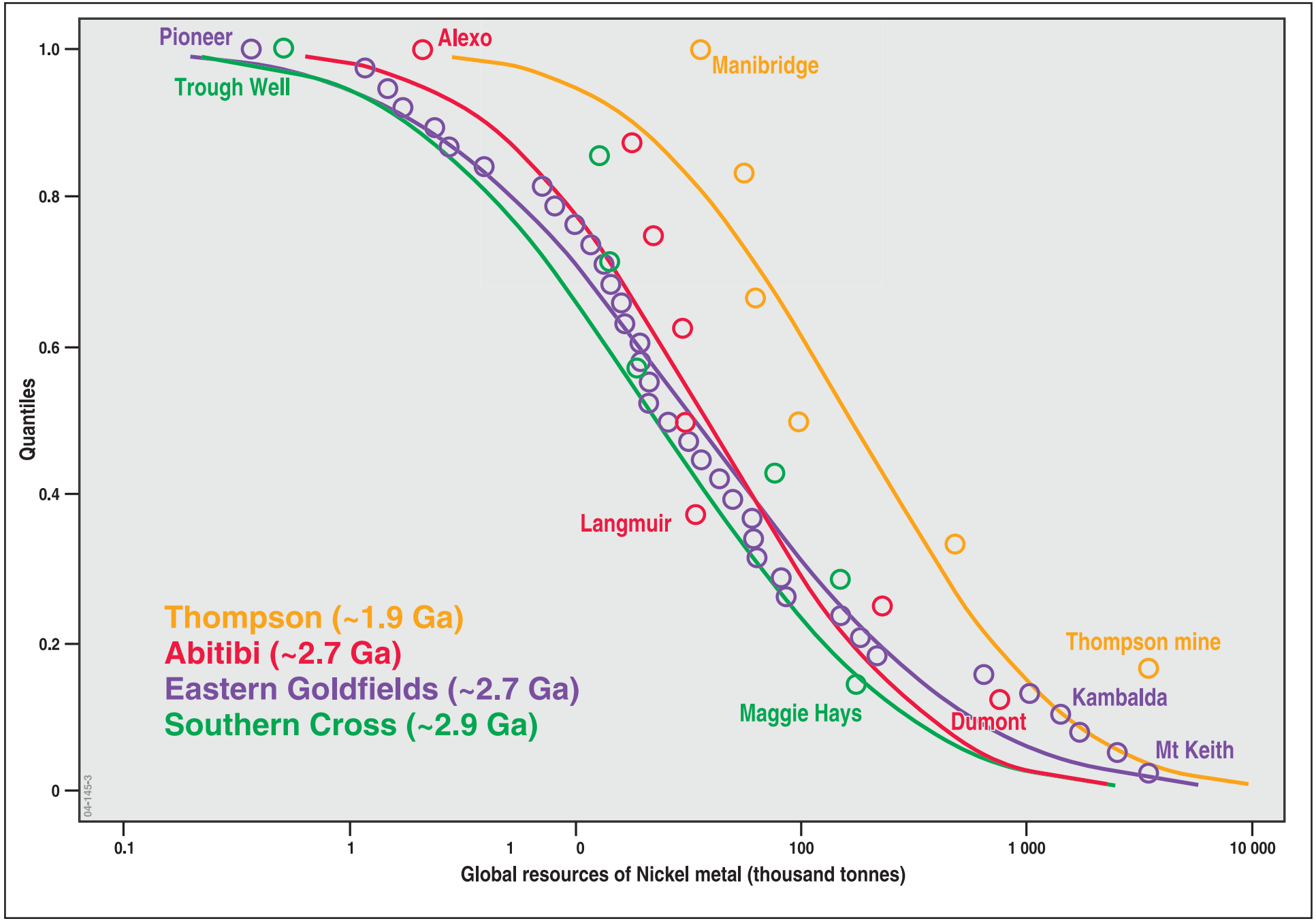

Fig. 14: Cumulative frequency distribution of global resources of nickel metal (production plus reserves and resources) for the major nickel-bearing komatiite belts and provinces of the world (source of data: as for Fig. 10)