The Nifty–Kintyre–Duke Cu–U–Pb–Zn mineralizing events: links to the evolution of the Yeneena Basin, northwest Paterson Orogen

by

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Geoscience Australia in conjunction with the Geological Survey of Western Australia has recently completed a National Geoscience Agreement (NGA) project in the northwest Paterson Orogen, Western Australia. The project has focused on understanding the evolution of the Neoproterozoic Yeneena Basin and its subsequent inversion during the c. 650 Ma Miles and c. 550 Ma Paterson Orogenies. The basin is host to the Telfer Au–Cu and Nifty Cu deposits, and contains large areas of prospective terrain beneath relatively shallow cover.

A sequence stratigraphic analysis of the sedimentary succession of the Yeneena Basin shows that the Throssell Range Group coarsens up-sequence, whereas the spatially separated Lamil Group fines upwards. This suggests that the two groups are not lateral correlatives as had previously been speculated. The Lamil Group is now thought to be younger than the Throssell Range Group. Detrital zircon SHRIMP U–Pb age data from the Yeneena Basin yield maximum depositional ages of c. 980 Ma for the Coolbro Sandstone (Throssell Range Group) at the base of the succession, 920–915 Ma for the Malu Formation (Lamil Group), c. 845 Ma for the Puntapunta Formation (Lamil Group) and c. 960 Ma for the Wilki Formation (Lamil Group) at the top of the succession. Minimum ages for sedimentation of the Isdell and Puntapunta Formations (Lamil Group) are provided by SHRIMP U–Pb zircon ages of 837 ± 6 Ma for a mafic sill at the Hasties Reward prospect and 835 ± 4 Ma for a monzonite at the Duke Cu–Pb–Zn prospect. Carbonates from the Isdell Formation at Telfer yield a pooled Pb–Pb isochron age of 858 ± 29 Ma, interpreted to be the timing of diagenesis. Assuming the sedimentary rocks of the Yeneena Basin were deposited as a single supersequence within an intracratonic rift setting, sedimentation is thus constrained to have taken place between c. 860 and c. 835 Ma.

The Nifty Cu deposit consists of a series of broadly stratiform lenses hosted by the siltstone-dominated Broadhurst Formation in the lower part of the Yeneena Basin. Mineralization is localized on the northeastern limb of a south-southeasterly plunging syncline and is hosted by chloritic, carbonaceous, and locally pyritic, shale with localized lenses of dolostone. The deposit was initially discovered using a sediment-hosted stratiform copper exploration model (Haynes et al., 1993), but recent models interpret the mineralization to have occurred during the Miles Orogeny, 150 to 200 m.y. after deposition of the host succession, which is consistent with a strong structural control on mineralization observed at the mine (Anderson et al., 2001; van der Wacht et al., 2007).

In addition to chalcopyrite and pyrite, the ore zone at Nifty is characterized by intense silicification, with accessory dolomite and apatite. Stockwork apatite-breccia veins containing variable amounts of chalcopyrite and pyrite are localized along the margins of the ore zone, and have been locally folded and recrystallized. Sm–Nd dating of the apatite yields a pooled regression age of 791 ± 42 Ma, with an MSWD of 11.2, i.e. the data are somewhat scattered, perhaps reflecting some isotopic heterogeneity within the ore and/or minor isotopic disturbance. U–Pb data from the apatites are more complex, with apparent ages in the range between 850 and 600 Ma. The isotopic data are interpreted to indicate that the Nifty deposit formed early in the basin history, and was remobilized by deformation associated with the 650 Ma Miles Orogeny.

The use of initial ε_{Nd} in vein apatites to constrain ore fluid isotopic signatures (and thus potentially metal source rocks) is complicated by the extreme sensitivity of apatite ε_{Ndi} to age. For example, at 800 Ma, ε_{Nd} is ≈0, well above ε_{Nd800} for sedimentary rocks within the Yeneena Basin, or for Paleoproterozoic basement of the Rudall Complex. This isotopic contrast increases for any age <800 Ma. On the other hand, Nd isotope signatures of Nifty apatite, Yeneena Basin host rocks, and Rudall Complex basement rapidly converge for ages >800 Ma. For example, at 850 Ma the ore signature overlaps the range of some mafic sills within the Yeneena Basin. The Nd isotope systematics thus confirm that mineralization at Nifty must be 800 Ma or older, an age near 850 Ma

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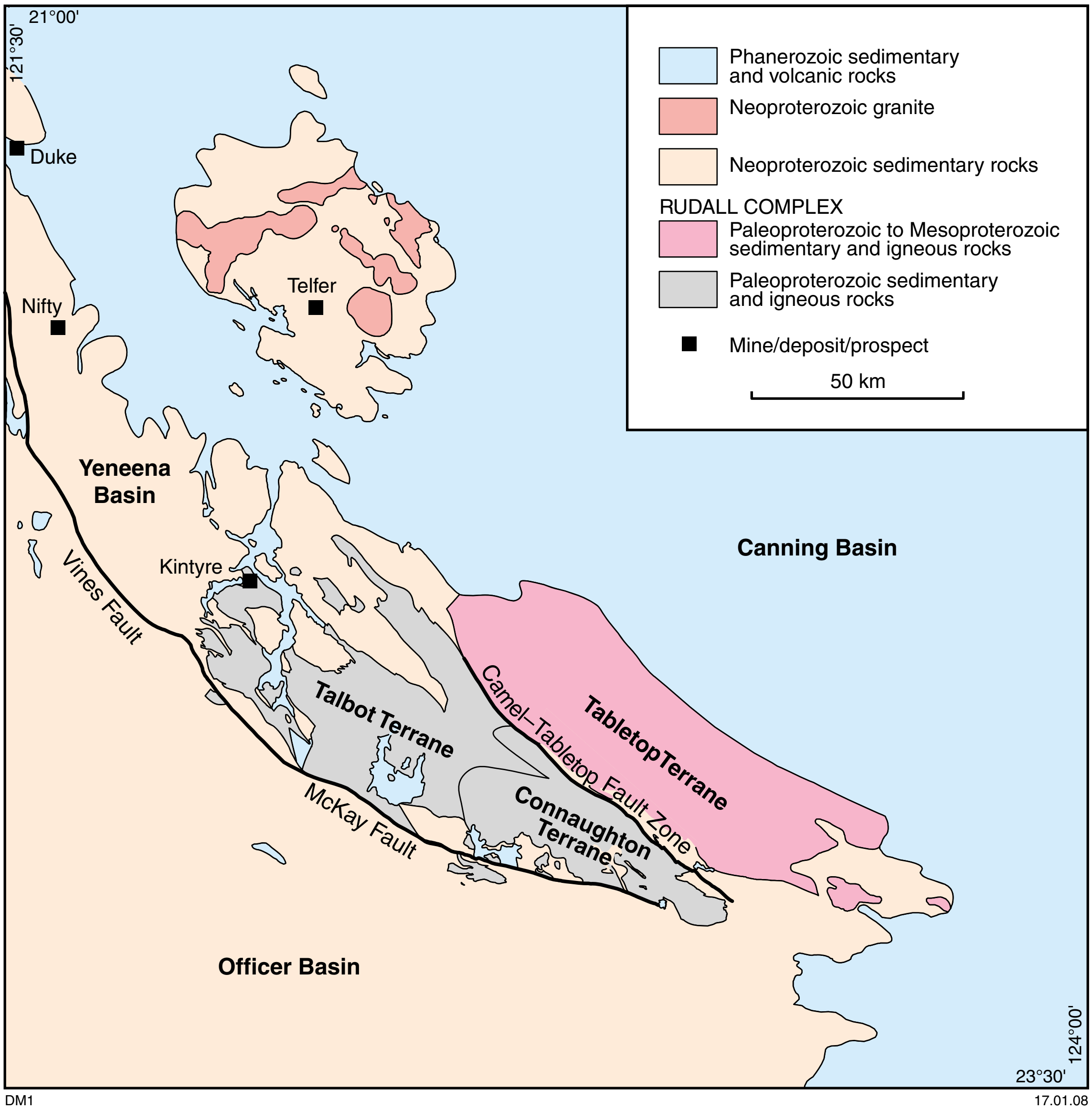

Figure 1. Simplified geological map of the NW Paterson Orogen, Western Australia

being most consistent with both the regional Nd isotopic data and other geochronological constraints. The data also suggest a possible role for mafic lithologies as a copper source, similar to the basaltic Cu sources for the world-class Mount Isa Cu deposit in Queensland (e.g. Wilson et al., 1985).

The age of the Nifty copper mineralization is similar to c. 830 Ma Cu–Pb–Zn skarn mineralization at the Duke Prospect and unconformity-related uranium mineralization at Kintyre in the Rudall Complex, recently dated at c. 850–840 Ma (Maas and Bagas, in press). Mineralization at Nifty, Kintyre, and Duke thus appear to comprise part of a broader mineral system that operated during the development of the Yeneena Basin. In this context, it is interesting to note that the Nifty deposit contains minor uraninite and pitchblende (Anderson et al., 2001) and that the Kintyre deposit and surrounding prospects contain Cu, Bi, Pb, Au, and Zn.

This polymetallic mineralization appears to have many of the characteristics of a sediment-hosted Cu system, in which low-temperature, saline brines migrate along permeable, typically oxidized units until they encounter a chemical reductant. Carbonaceous siltstone and dolomite of the Broadhurst Formation forms the lowermost reductant unit within the Yeneena Basin, overlying the basal Coolbro Sandstone, which could have acted as a fluid pathway. Chloritic and graphitic schists form reductants in the Rudall Complex basement, and host the mineralization at Kintyre.

The syn-sedimentary model outlined above is consistent with that proposed by Haynes et al. (1993) and implies that redox boundaries in the vicinity of major basement and basin faults are likely to be important in localizing mineralization. This contrasts with current exploration models that place importance on targeting thrust faults formed during the subsequent Miles Orogeny (Anderson et al., 2001; van der Wacht et al., 2007). The distribution of ore within the Nifty deposit itself is likely to be a result of folding of the mineralization and its subsequent remobilization into local anticlinal structures and the steep limb of the syncline (Czarnota and Gessner, 2007).

The northwest-trending Camel–Tabletop Fault Zone is a major Mesoproterozoic structure that is interpreted to have been active during the development of the Yeneena Basin (Bagas and Lubieniecki, 2000), but was not significantly reactivated during the Miles Orogeny. The fault zone is spatially associated with a series of polymetallic prospects, some of which have been interpreted as unconformity-related or sediment-hosted stratiform deposits (Bagas and Lubieniecki, 2000). Gravity data acquired as part of the NGA Paterson Project reveal the positions of other possible basement structures beneath shallow cover in the eastern part of the northwest Paterson Orogen, which remains a highly prospective Cu–Pb–Zn–Au–U province.

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