

# The geology of the Fisher East Komatiite-hosted nickel sulfide prospects

by

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## Introduction

Most economic komatiite-hosted nickel sulfide deposits in the Eastern Goldfields Superterrane (EGST) of the Yilgarn Craton — including world-class examples such as Perseverance and Mount Keith — are located within the Kalgoorlie Terrane (Barnes, 2006a). Neighbouring terranes such as the Burtville and Kurnalpi Terranes, appear to be relatively poorly endowed in such deposits. As a result, exploration for komatiite-hosted nickel sulfide deposits in the Yilgarn Craton has tended to focus on the Kalgoorlie Terrane. However, the occurrence of large mafic-ultramafic complexes and small komatiite-hosted Ni-Cu-PGE deposits in the Kurnalpi and Burtville Terranes suggests these terranes could also be prospective. The fundamental exploration question is raised: are these terranes intrinsically less prospective compared to the Kalgoorlie Terrane, or are they simply underexplored?

Mineral explorers have relatively recently expanded their search for komatiite-hosted nickel sulfides to well outside the Kalgoorlie Terrane, resulting in several notable discoveries of deposits which straddle the poorly defined boundary between the Kurnalpi and Burtville Terranes — for example, Fisher East (Rox Resources Limited, 2015), AK47 (Cullen Resources Limited, 2015), Rosie (Duketon Mining, 2015), and Mulga Tank (Impact Minerals Limited, 2015) (Fig. 1). Though none of these are yet known to be a major deposit, their existence suggests that greenstones in the Kurnalpi and Burtville Terranes could be prospective for major komatiite-hosted Ni-Cu-PGE deposits, with a similar hidden potential to the Kalgoorlie Terrane. To test this hypothesis, we investigated the nickel prospectivity of the Kurnalpi Terrane by comparing the lithogeochemical and mineralogical characteristics of nickel sulfide-mineralized komatiites at the newly discovered Fisher East prospects with komatiites from the highly nickel-endowed Kalgoorlie Terrane.

The Fisher East prospects include komatiites associated with shale, sulfidic chert, quartz porphyry, banded iron-formation and basalt. All rock units are strongly deformed, and komatiites have been pervasively altered to talc-carbonate assemblages, with complete loss of original igneous textures. The Fisher East prospects appear to be typical type 1 komatiite-hosted nickel sulfide deposits, based on the classification of Lesher and Keays (2002), with mostly massive sulfides located at the basal contact between komatiites and stratigraphically underlying metasedimentary rocks. Sulfide mineralogy includes pentlandite, violarite, pyrite, pyrrhotite and minor chalcopyrite.

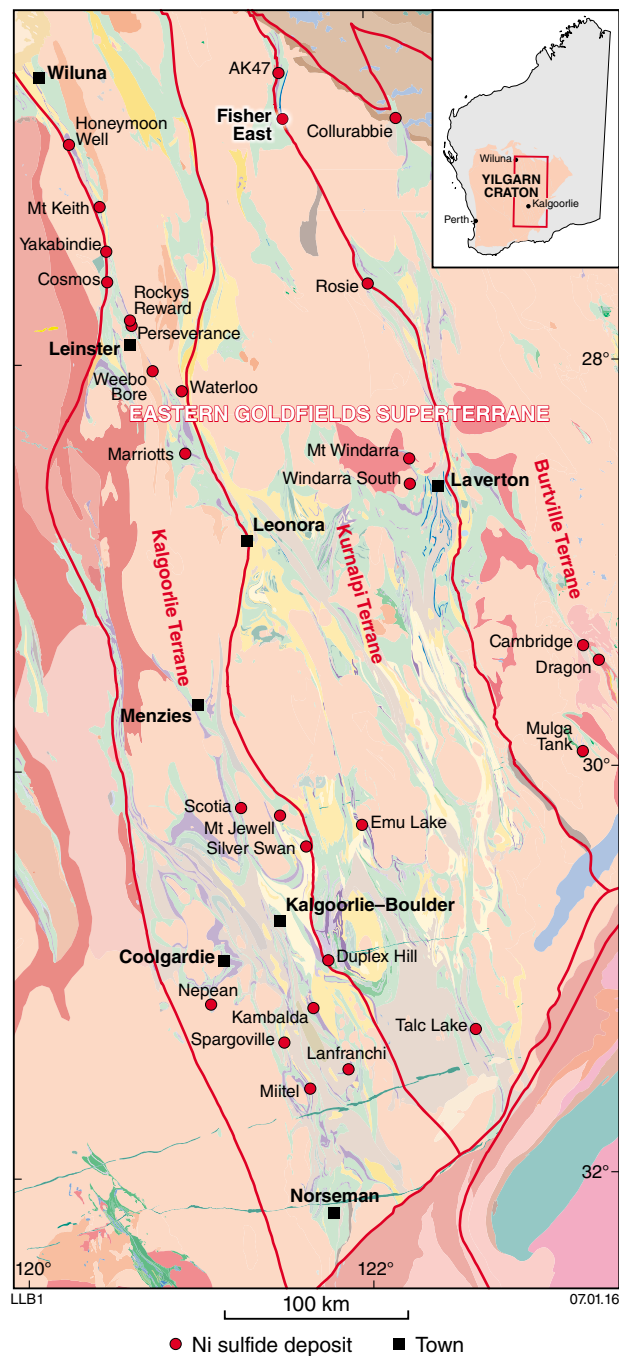
## Komatiite facies architecture and geochemical characteristics

Based on secondary textures (Fig. 2a–d), mineralogy derived from hyperspectral data, and geochemistry, it is possible to discriminate komatiite units at Fisher East into upper A-zones (probably originally spinifex textured) and lower B-zones (olivine cumulates). This differentiation is important as a high proportion of B-zone komatiite in a flow reflects high-flux magma pathways or conduits — the ideal environment where nickel sulfide mineralization can form and be preserved (Hill, 2001; Barnes et al., 2004). A-zones contain crosscutting carbonate-quartz veins, and have more chlorite and higher proportions of Zr, Ti, and Al<sub>2</sub>O<sub>3</sub> than B-zones, which comprise a talc-rich matrix with carbonate knots of variable size and colour, together with higher MgO and Ni contents. B-zones identified at Fisher East are commonly much thicker than A-zones (Fig. 3). Ni/Ti and Ni/Cr ratios, which can be used to track high-flux magma pathways (Barnes et al., 2004), suggest komatiites at Fisher East were domains of higher flux, originally rich in olivine cumulate. However, relatively low FeO/MgO ratios indicate these were not olivine adcumulates (dunites), as seen in the large deposits of the northern Kalgoorlie Terrane (Barnes and Fiorentini, 2012). Features of the Fisher East komatiites are consistent with eruption in a channelized sheet flow environment, similar to the type facies architecture envisaged at Kambalda (Lesher et al., 1984; Barnes et al., 2004). In particular, the absence of sedimentary units observed in flanking drillholes suggests thermomechanical erosion and channelization have removed these units in mineralized drillholes.

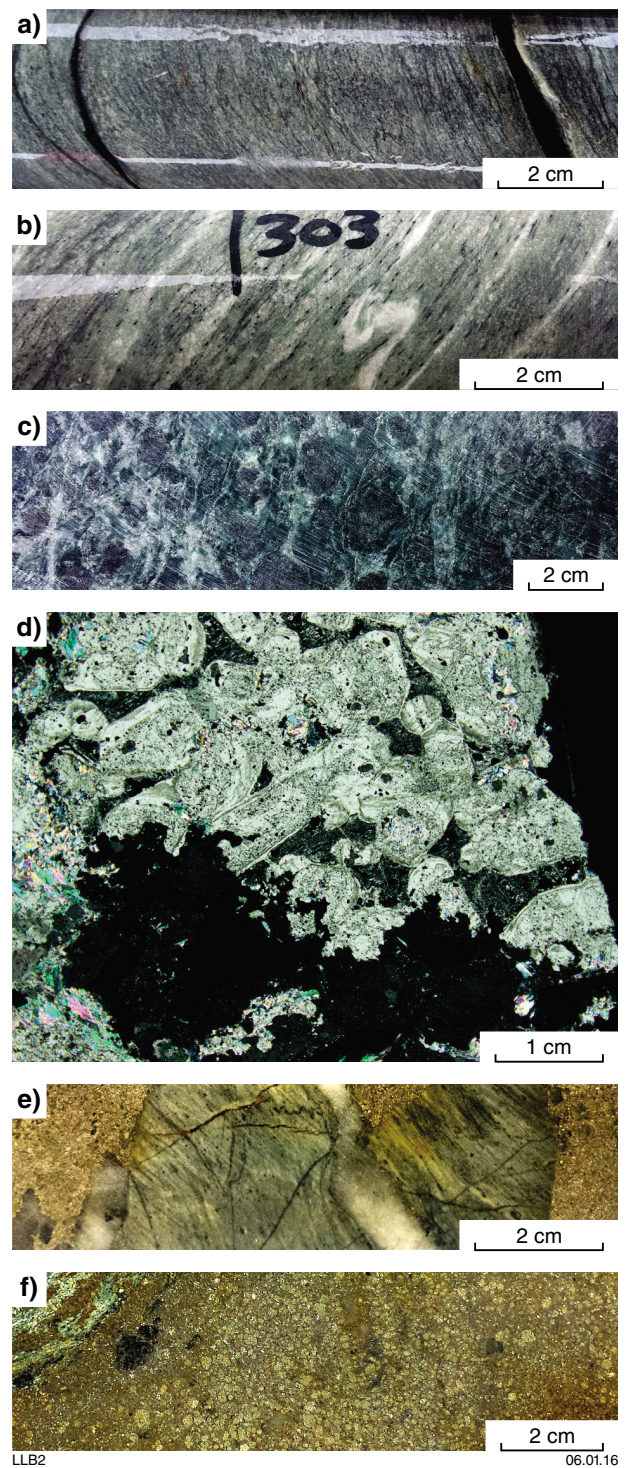
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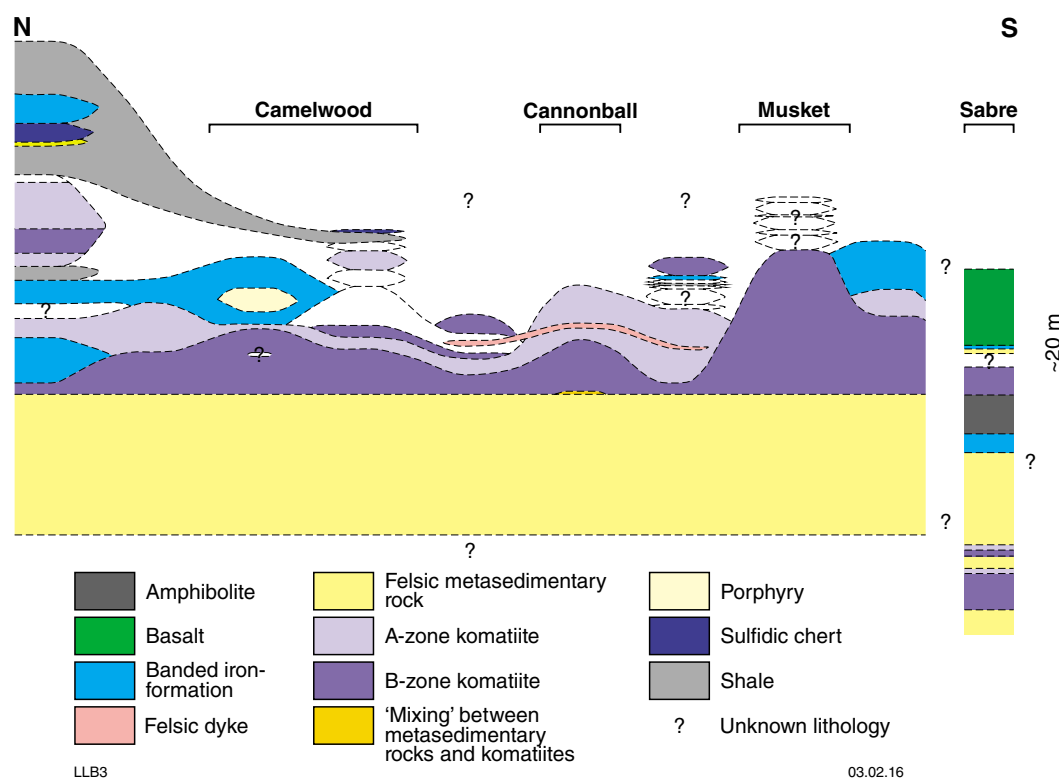
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**Figure 1.** Major greenstone belts of the EGST, with major nickel sulfide deposits/prospects highlighted. Terrane boundaries from Geological Survey of Western Australia (2015).



**Figure 2.** a, b) A-zone komatiites, showing a chlorite-rich matrix and crosscutting carbonate-quartz veins; c) and d) B-zone komatiites, with a talc-rich matrix and carbonate knots; e) 'rip-up' sediment clasts in massive sulfides; f) massive sulfide mineralization.



**Figure 3.** Interpretive flow field model of the Fisher East prospects based on core logging, geochemistry and hyperspectral data. Note the separation of the Sabre prospect in the south, some distance away from the other prospects. The four prospects outlined show considerable nickel sulfide mineralization. The basal komatiite contact has been used as the horizontal datum, to depict variation in thickness in the flows.

The accepted model of formation for komatiite-hosted nickel sulfide deposits, as outlined in Lesher (1989), has erupting sulfur-undersaturated komatiitic magmas, with contamination by an external source of sulfur required to form mineralization. In komatiites, the foremost method of acquiring this sulfur is by thermomechanical erosion and assimilation of S-bearing lithologies during lava emplacement (Lesher et al., 1984; Huppert et al., 1984). Detailed drillhole logging revealed erosional and contamination features at the base of the Fisher East komatiites. These include 'rip-up' clasts of substrate material (Fig. 2e) and sulfides invading the footwall. In addition, patterns of incompatible trace element ratios such as  $Zr/TiO_2$ ,  $La/Sm$ ,  $Th/Nb$  and  $Th/Yb$  indicate crustal contamination of both Fisher East and Kalgoorlie Terrane komatiites.

$Al_2O_3/TiO_2$  ratios show the Fisher East komatiites to be relatively Al-undepleted, implying that they were derived from a shallow depth in the mantle (Barnes, 2006b; Arndt, 2008; Maier et al., 2009). Significantly, on average they have  $Al_2O_3/TiO_2$  values somewhat higher than typical Al-undepleted komatiites (Hoatson et al., 2006; Barnes, 2006b; Arndt, 2008), falling just below the chondritic mantle line. This difference may indicate melt contamination, postdepositional alteration or a minor difference in source composition, for example Ti-depletion.

## Conclusions

The komatiites at the Fisher East prospects in the Kurnalpi Terrane have characteristics favourable for hosting large nickel sulfide deposits — they were erupted in a high-flux, channelized flow field, are rich in high-MgO cumulate material, and show evidence of crustal contamination. They have a mineralization style,  $Al_2O_3/TiO_2$  ratios, incompatible trace element ratios, and volcanic facies comparable with komatiites of the Kalgoorlie Terrane. The prospectivity of these komatiites, coupled with known occurrences of nickel sulfides at Rosie and Windarra farther to the south, suggest the Kurnalpi–Burtville margin may be a prospective terrane margin, possibly analogous in style to the Norseman–Wiluna belt in the Kalgoorlie Terrane.

The new data provided in this study, together with small discoveries at Rosie, AK-47, and the existing deposit at Windarra, are testament to the potential of this region to host nickel systems. Large camp equivalents to those at Kambalda and the Agnew–Wiluna belt are currently elusive; however, exploration activity within the eastern terranes has historically been much less. Further work at multiple scales and involving new datasets, will be critical in unlocking the potential of the Kurnalpi–Burtville margin for komatiite-hosted nickel systems, and ultimately assessing whether this terrane can one day form a new nickel province in Western Australia.

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