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Review

Magmatic ore deposits in mafic–ultramafic intrusions of the Giles Event, Western Australia

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ABSTRACT

More than 20 layered intrusions were emplaced at c. 1075 Ma across >100 000 km^2 in the Mesoproterozoic Musgrave Province of central Australia as part of the c. 1090–1040 Ma Giles Event of the Warakurna Large Igneous Province (LIP). Some of the intrusions, including Wingellina Hills, Pirntirri Mulari, The Wart, Ewarara, Kalka, Claude Hills, and Gosse Pile contain thick ultramafic segments comprising wehrlite, harzburgite, and websterite. Other intrusions, notably Hinckley Range, Michael Hills, and Murray Range, are essentially of olivine-gabbronoritic composition. Intrusions with substantial troctolitic portions comprise Morgan Range and Cavenagh Range, as well as the Bell Rock, Blackstone, and Jameson–Finlayson ranges which are tectonically dismembered blocks of an originally single intrusion, here named Mantamaru, with a strike length of >170 km and a width of >20 km, constituting one of the world's largest layered intrusions.

Over a time span of >200 my, the Musgrave Province was affected by near continuous high-temperature reworking under a primarily extensional regime. This began with the 1220–1150 Ma intracratonic Musgrave Orogeny, characterized by ponding of basalt at the base of the lithosphere, melting of lower crust, voluminous granite magmatism, and widespread and near-continuous, mid-crustal ultra-high-temperature (UHT) metamorphism. Direct ascent of basic magmas into the upper crust was inhibited by the ductile nature of the lower crust and the development of substantial crystal-rich magma storage chambers. In the period between c. 1150 and 1090 Ma magmatism ceased, possibly because the lower crust had become too refractory, but mid-crustal reworking was continuously recorded in the crystallization of zircon in anatectic melts. Renewed magmatism in the form of the Giles Event of the Warakurna LIP began at around 1090 Ma and was characterized by voluminous basic and felsic volcanic and intrusive rocks grouped into the Warakurna Supersuite. Of particular interest in the context of the present study are the Giles layered intrusions which were emplaced into localized extensional zones. Rifting, emplacement of the layered intrusions, and significant uplift all occurred between 1078 and 1075 Ma, but mantle-derived magmatism lasted for >50 m.y., with no time progressive geographical trend, suggesting that magmatism was unrelated to a deep mantle plume, but instead controlled by plate architecture.

The Giles layered intrusions and their immediate host rocks are considered to be prospective for (i) platinum-group element (PGE) reefs in the ultramafic–mafic transition zones of the intrusions, and in magnetite layers of their upper portions, (ii) Cu–Ni sulfide deposits hosted within magma feeder conduits of late basaltic pulses, (iii) vanadium in the lowermost magnetite layers of the most fractionated intrusions, (iv) apatite in unexposed magnetite layers towards the evolved top of some layered intrusions, (v) ilmenite as granular disseminated grains within the upper portions of the intrusions, (vi) iron in tectonically thickened magnetite layers or magnetite pipes of the upper portions of intrusions, (vii) gold and copper in the roof rocks and contact aureoles of the large intrusions, and (viii) lateritic nickel in weathered portions of olivine-rich ultramafic intrusions.

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1. Introduction

The Musgrave Province of central Australia hosts one of the most important clusters of mafic–ultramafic layered intrusions globally (Fig. 1), referred to as the Giles Complex (Daniels, 1974) or the Giles intrusions (Smithies et al., 2009). Together with broadly contemporaneous bimodal volcanism of the Bentley Supergroup and basic magmatism of the Warakurna Large Igneous Province (LIP) (Wingate et al., 2004), the Giles intrusions constitute the Warakurna Supersuite, formed during the c. 1090 to 1040 Ma Giles Event. The prospectivity of the Giles intrusions for magmatic ore deposits remains poorly understood. This is partly due to sparse exposure and because much of the study area belongs to the Ngaanyatjarra–Anangu Pitjantjatjara–Yankunytjatjara Central Reserve into which access is strictly regulated. However, the enormous volume of mafic igneous rocks and the remarkable size of some of the intrusions (up to several 1000 km^2) reflect a high flux of mantle derived magma and heat into the crust. This is considered to be favourable for the formation of magmatic and hydrothermal ore deposits. Two world-class deposits have been discovered so far, namely the Nebo–Babel magmatic Ni–Cu deposit (Seat et al., 2007, 2009) and the Wingellina Ni laterite deposit (Metals X Ltd, 2013). In the present paper we review the ore potential of the Giles intrusions and related mafic intrusive rocks of the Warakurna Supersuite.

2. Past work

Systematic geologic research on the Musgrave Province began with a mapping programme (at 1:250 000 scale) in the 1960s (Geological Survey of Western Australia — reported in Daniels, 1974), during which the Blackstone, Murray, and Morgan ranges, and parts of the Cavenagh and Jameson ranges, were mapped (see Fig. 1 for localities). Nesbitt and Talbot (1966) subsequently proposed that some of the layered intrusions are tectonised remnants of an originally much larger body. Other important early contributions on the layered

Fig. 1. Simplified geological map of the Musgrave Province, with mafic–ultramafic intrusions highlighted in bottom panel.
From Howard et al. (2011b).

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