Stratigraphic associations in the Eastern Goldfields Superterrane

by

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Various stratigraphic schemes have been applied in the Eastern Goldfields Superterrane, but most have been locally focused, or have been hampered by an inadequate understanding of structural and chronostratigraphic relationships. With the recent completion of 1:100 000-scale outcrop mapping by GSWA and Geoscience Australia, it is now possible to use the large amount of geophysical, geochemical, and geochronological data that have been generated over the past thirty years to implement a systematic stratigraphic scheme across the Eastern Goldfields Superterrane. Much of the new data have been acquired through industry-sponsored research that includes the pmd*CRC, and AMIRA and MERIWA projects.

New datasets

A large amount of geophysical data has been acquired since the 1980s, beginning with high-quality aeromagnetic data, followed by gravity and seismic data and, more recently, magnetotelluric data. Recent structural studies using these data in conjunction with the evolving detailed mapping (Blewett and Czarnota, 2007) have allowed a more holistic understanding of the structural history of the Eastern Goldfields and, in particular, have emphasized the role of extensional tectonics in the development of stratigraphic successions.

High-resolution U–Pb zircon geochronology was first used in the Eastern Goldfields in the 1980s, and systematic dating commenced with the building of the Perth Consortium Sensitive high-resolution ion microprobe (SHRIMP) in the early 1990s. Since then, a large amount of SHRIMP data has been acquired through both government- and university-led mapping and research projects. These data have been used to constrain deformation events, to place the different types of granite magmatism in their temporal context, to date specific parts of the stratigraphy, and to determine the maximum depositional ages and provenance histories of sedimentary successions.

Stratigraphic issues

Early work by CSIRO recognized that the komatiite volcanism in the western part of the Eastern Goldfields Superterrane (formerly called the 'Norseman–Wiluna greenstone belt') was possibly attributable to a single event (Hill et al., 1995). SHRIMP dating subsequently demonstrated that this komatiite event likely took place during a short time interval at about 2704 Ma (Kositcin et al., 2008; Geological Survey of Western Australia, 2010). Building on the locally recognized stratigraphy at Kalgoorlie (Woodall, 1965), Swager et al. (1995) developed a regionally extensive stratigraphy for their 'Kalgoorlie Terrane' based on the interpretation that the komatiite unit can be used as a regional marker horizon. Subsequent mapping and geochronology, such as the work of Fiorentini et al. (2005) in the Agnew–Wiluna area, have supported this interpretation and provided a basis for the description of 'Kalgoorlie Terrane' stratigraphy between Norseman and Wiluna.

However, while the geochronology has largely validated the interpretation of the Norseman–Wiluna komatiite event, new levels of complexity have been introduced into the stratigraphic characterization of the greenstones of the Eastern Goldfields Superterrane by the confirmation that felsic volcanism across the region is diachronous and that different volcanic centres have distinctive age and geochemical characteristics (Barley et al., 2008a). It has also been shown that, although ultramafic volcanism to the east of the Norseman–Wiluna komatiite at Murrin Murrin also occurred at about 2700 Ma, there is a significantly older (c. 2800 Ma) komatiite succession farther to the east at Windarra (Kositcin et al., 2008). Ages of other ultramafic units east of the Norseman–Wiluna komatiite are not well established but associations within greenstone belts suggest that there are other instances of older komatiite.

New geochemistry, accompanied by locally detailed mapping and volcanological studies, on major felsic volcanic centres (Barley et al., 2008a) and mafic and ultramafic successions (Barley et al., 2008b) throughout the Eastern Goldfields has led to the recognition of sedimentary and volcanic rock associations with different ages and chemical characteristics. This in turn has resulted in the interpretation of a number of fault-bound terranes to the east of the original Kalgoorlie Terrane. Not all authors agree in detail on the criteria for assigning of components to the various terranes in all cases (Kositcin et al., 2008; Cassidy et al., 2006). However, new Sm–Nd datasets that show underlying mantle extraction ages across the Yilgarn Craton provide a strong basis for the broad subdivision of the terranes as they are presently understood (Champion and Cassidy, 2007). These studies are currently being supplemented by new Lu–Hf analytical work.

Recent studies (Krapež, 2008) have indicated a complex interplay between tectonic processes and the resulting

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Figure 1. View looking east from the summit of Mount Hunt across the Kalgoorlie mafic–ultramafic stratigraphy towards Serpentine Bay and Hannan Lake.

stratigraphic elements, for example the development of the so-called 'late basins'. It is likely that systematic compilation of mapping, geochemical, and geochronological data, together with an improved understanding of the structural and stratigraphic architecture, will demonstrate that the various terrane components have more complex internal structure than is presently recognized. For example, Tripp et al. (2007) have shown in the Kalgoorlie area that there are considerable facies variations across major faults, some of which were recognized as 'domain boundaries' by Swager et al. (1995). Thus, these faults may represent relatively early structures that have affected the basin development. Elsewhere, implementation of stratigraphy may highlight components of greenstone belts that appear to be out of context with the known geology of the terrane in which they occur. For example, the banded iron-formation and ultramafic rocks along the western side of the northern end of the Yandal greenstone belt (the Moilers Domain within the Kalgoorlie Terrane of Cassidy et al., 2006) may prove to be a fragment of an older terrane (e.g. the Youanmi Terrane to the west or the Burtville Terrane to the east).

Implications

A well-founded and formal application of stratigraphic concepts in the Eastern Goldfields is now possible and has the potential to bring fresh ideas to mineral exploration in the region. This is self-evident for nickel deposits where the distribution of the host komatiites, proximity to volcanic vents, and the nature of the rocks onto which komatiites were deposited, or into which they were intruded, are all important factors in determining exploration targets (Barnes, 2006). Similarly, for volcanogenic massive sulfide deposits, the mapping and characterization of the felsic volcanic complexes will assist in understanding known deposits, and in identifying areas worthy of further attention. While there are many factors that affect the distribution of gold deposits, recent work has shown that the recognition and characterization of sedimentary facies such as the sedimentary rocks of the Black Flag Group and those in the 'late-basin' successions are significant factors in the development of successful mineralization models (Squire et al., 2007; Hall, 2007).

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