SHRIMP U-Pb ZIRCON DATING OF ARCHAEAN GREENSTONES FROM THE EASTERN GOLDFIELDS

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Summary - U-Pb zircon dates on 7 felsic volcanic rocks from the Eastern Goldfields are reported. Felsic volcaniclastic rocks from 5 localities within 3 tectonostratigraphic domains were deposited within 2673 - 2684 Ma. A dacite interleaved with komatiitic rocks of the Kalgoorlie Terrane has been dated at 2709 ±11 Ma and a felsic tuff interleaved with ultramafic rocks of the Bulong Complex in the Gindalbie Terrane was deposited at 2705 ±4 Ma. The new geochronological data indicate that the stratigraphic complexity observed within mapped tectonostratigraphic domains of the Eastern Goldfields greenstones is at least in part due to the rapid and localised deposition of felsic volcanic rocks in and adjacent to isolated volcanic centres in a tectonically highly active environment. A continental margin back-arc basin setting offers the closest modern analogous tectonic setting for the formation of the Eastern Goldfields granite-greenstone terranes.

INTRODUCTION

Mapping by the GSWA of the Eastern Goldfields greenstones has delineated a series of fault-bounded tectonostratigraphic domains (Swager et al., 1990, Swager, 1993). Within each of these domains, a relatively coherent regional stratigraphy can be established. In order to investigate relationships between adjacent domains and between greenstones and granitoids, a comprehensive programme of U-Pb zircon dating in the Eastern Goldfields, using the Perth Consortium SHRIMP (or Sensitive High-Resolution Ion MicroProbe), is currently in progress. This programme is in its early stages at the time of writing, with only 7 of an anticipated 25 dates completed.

THE KALGOORLIE TERRANE

In general terms, the Kalgoorlie Terrane stratigraphy consists of a lower basalt unit, an overlying unit dominated by ultramafic (komatiitic) and mafic flows, an upper basalt unit and an uppermost felsic volcanic and volcaniclastic unit commonly referred to as the Black Flag Group. A thick dacitic flow within the komatiite unit in the Boorara Domain was dated at 2709 ±11 Ma (all errors given are at 95% confidence), consistent with the date of 2692 ±4 Ma obtained by Claoué-Long et al. (1988) for the Kapai Slate overlying the komatiite. The deposition age of a felsic volcanic from the Black Flag Group in the Parker Domain was determined to be 2681 ±5 Ma. These data provide support for the concept of a relatively simple general stratigraphic sequence for the entire Kalgoorlie Terrane, but the inferred simple stratigraphic succession has been locally disrupted by the eruption of felsic volcanic rocks from isolated vents, both during and after the eruption of the komatiitic lavas. Deposition of the komatiite and Black Flag units of the Kalgoorlie Terrane stratigraphy occurred over a period of at least 12 Ma.

THE KURNALPI TERRANES

The Kurnalpi Terranes, to the east of the Kalgoorlie Terrane, have diverse and complex stratigraphic sequences comprised predominantly of basaltic and minor ultramafic units and proximal felsic volcaniclastic units. The lower part of the structural-stratigraphic column of the Gindalbie Terrane is dominated by a calc-alkaline association. The rocks of this association have yet to be reliably dated. They are structurally overlain by komatiitic flows of the Bulong Complex. A bimodal basalt-rhyolite sequence is in faulted contact with the underlying Bulong Complex.

A date of 2705 ±4 Ma has been determined for a felsic tuff interleaved with ultramafic rocks near the base of the Bulong Complex. This date is within error of the date of 2709 ±11 Ma obtained on a dacite interleaved with the komatiite unit from the Boorara Domain. The ultramafic rocks of the Bulong Complex may therefore be correlated with the komatiite unit of the Kalgoorlie Terrane. A date of 2683 ±3 Ma was obtained for a felsic tuff from the upper unit of the Gindalbie Terrane. A volcanic breccia containing black aphanitic clasts, sampled near

the Mount Monger Fault, was dated at 2675 ±3 Ma. Parts of the upper unit of the Gindalbie Terrane may therefore also be correlated with the Black Flag Group of the Kalgoorlie Terrane.

A date of 2684 ±3 Ma has been obtained from a thin rhyodacite unit at the base of a basalt sequence from the Kurnalpi Domain, located further to the east of the Gindalbie Terrane. Within the Mulgabbie Domain near the eastern margin of the exposed greenstones, a dacite separating basalt from an andesitic-basaltic sequence was dated at 2673 ±3 Ma. Despite the complex and diverse lithostratigraphic successions of these domains evident from field mapping, the geochronological data indicate that all of the domains from which dates have so far been obtained contain similar felsic volcaniclastic lithologies which were deposited synchronously at c. 2680 Ma.

FORMATION OF THE EASTERN GOLDFIELDS GRANITE-GREENSTONE TERRANES

Emplacement ages of 2690 - 2680 Ma for early (pre-D2) granitoids from the Eastern Goldfields (e.g. Hill et al. 1992) are similar to those obtained in this study for the felsic volcanics. Geochemical and Nd isotopic data suggest that the early granitoids and felsic volcanics were probably at least partly derived from similar sources and may have been cogenetic. The greenstone successions were therefore deposited during emplacement of at least some of the early granitoids, in a tectonically active environment.

The following evolutionary model of the formation of the Eastern Goldfields granite-greenstone terranes is consistent with the available field and geochronological constraints. At c. 2710 - 2690 Ma, asymmetric rifting, mainly along N - S-trending normal faults, of pre-existing granitic and gneissic crust resulted in the development of a series of adjacent basins, into which predominantly basaltic and ultramafic volcanics were deposited. Felsic volcaniclastic rocks were also erupted from a few isolated volcanic centres synchronously with the ultramafic volcanism. At c. 2685 Ma, felsic volcaniclastic rocks were erupted from numerous volcanic centres and early (pre-D2) granitoids were emplaced mainly as thick sheets into the base of the greenstone sequences. This was followed at c. 2670 - 2665 Ma by regional (D2) compression involving reactivation of early structures. Additional episodes of granitoid emplacement have been identified at c. 2665 - 2660 Ma and c. 2630 - 2600 Ma (Hill et al. 1992).

Tectonic models advocating the involvement of mantle plumes (e.g. Hill et al. 1992) cannot account for the compressional regime responsible for D2 structures and the volcanic rocks lack many of the diagnostic geochemical features found in the volcanic rocks of modern subduction zones. Furthermore, the field and geochronological data obtained so far also do not support currently popular tectonic models for the formation of the Eastern Goldfields granite-greenstone terranes by lateral accretion of "exotic" terranes or by accretion of a series of separate island arcs, although future work further to the west or east of the Eastern Goldfields greenstones may identify such terranes or arcs. On present evidence, a continental margin back-arc basin setting offers the closest modern analogous tectonic setting for the formation of the Eastern Goldfields granite-greenstone terrane. The Kalgoorlie greenstones are envisaged to have been deposited within a series of narrow back-arc rift basins formed along a continental margin and above an active subduction zone, which was then located to the east of the rift basins.

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