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Unravelling the tectonic framework of the Musgrave Province, central Australia

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Abstract

The importance of the Musgrave Province in continental reconstructions of Proterozoic Australia is only beginning to be appreciated. The Mesoproterozoic Musgrave Province sits in a geographically central location within Australia and is bounded by older and more isotopically evolved regions including the Gawler Craton of South Australia and Arunta Region of the Northern Territory. Understanding the crustal growth and deformation mechanisms involved in the formation of the Musgrave Province, and also the nature of the basement that separates these tectonic elements, allows for greater insight into defining the timing and processes responsible for the amalgamation of Proterozoic Australia.

The ca. 1.60-1.54 Ga Musgravian Gneiss preserves geochemical and isotopic signatures related to ongoing arc-magmatism in an active margin between the North Australian and South Australian Cratons (NAC and SAC). Characteristic geochemical patterns of the Musgravian Gneiss include negative anomalies in Nb, Ti, and Y, and are accompanied by steep LREE patterns. Also characteristic of the Musgravian Gneiss is its juvenile Nd isotopic composition ($\varepsilon Nd_{1.55}$ values from –1.2 to +0.9). The juvenile isotopic signature of the Musgravian Gneiss separates it from the bounding comparitively isotopically evolved terranes of the Arunta Region and Gawler Craton. The geochemical and isotopic signatures of these early Mesoproterozoic felsic rocks have similarities with island arc systems involving residual Ti-bearing minerals and garnet.

Circa 1.40 Ga metasedimentary rocks of the eastern Musgrave Province also record vital evidence for determining Australia's location and fit within a global plate reconstruction context during the late Mesoproterozoic. U-Pb detrital zircon and Sm-Nd isotopic data from these metasedimentary rocks suggests a component of derivation from sources outside of the presently exposed Australian crust. Best fit matches come from rocks originating from eastern Laurentia. Detrital zircon ages range from Palaeoproterozoic to late Mesoproterozoic, constraining the maximum depositional age of the metasediments to approximately 1.40 Ga, similar to that of the Belt Supergroup in western Laurentia. The 1.49-1.36 Ga detrital zircons in the Musgrave metasediments are interpreted to have been derived from the voluminous A-type suites of Laurentia, as this time period represents a "magmatic gap" in Australia, with an extreme paucity of sources this age recognized. The metasedimentary rocks exhibit a range of Nd isotopic signatures, with ε_{Nd}(1.4 Ga) values ranging from –5.1 to 0.9, inconsistent with complete derivation from Australian sources, which are more isotopically evolved. The isotopically juvenile ca. 1.60-1.54 Ga Musgravian Gneiss is also an excellent candidate for the source of the abundant ca. 1.6-1.54 Ga detrital zircons within the lower sequences of the Belt Supergroup. If these interpretations are correct, they support a palaeogeographic reconstruction involving proximity of Australia and Laurentia during the pre-Rodinia Mesoproterozoic. This also increases the prospectivity of the eastern Musgrave Province to host a metamorphised equivalent of the massive Pb-Zn-Ag Sullivan deposit.

The geochemical and isotopic signatures recorded in mafic-ultramafic rocks can divulge important information regarding the state of the sub continental lithospheric mantle (SCLM). The voluminous cumulate mafic-ultramafic rocks of the ca. 1.08 Ga Giles Complex record geochemical and Nd-Sr isotopic compositions consistent with an enriched parental magma. Traverses across three layered intrusions, the Kalka, Ewarara, and Gosse Pile were geochemically and isotopically analysed. Whole rock samples display variably depleted to enriched LREE patterns when normalised to chondrite ($(La/Sm)_N$ = 0.43-4.72). Clinopyroxene separates display similar depleted to enriched LREE patterns ($(La/Sm)_N$ = 0.37-7.33) relative to a chondritic source. The cumulate rocks display isotopically evolved signatures (εNd ~-1.0 to –5.0 and εSr ~19.0 to 85.0). Using simple bulk mixing and AFC equations, the Nd-Sr data of the more radiogenic samples can be modelled by addition of ~10% average Musgrave crust to a primitive picritic source, without need for an enriched mantle signature. Shallow decompressional melting of an asthenospheric plume source beneath thinned Musgravian lithosphere is envisaged as a source for the parental picritic magma. A model involving early crustal contamination within feeder zones is favoured, and consequently explorers looking for Ni-Cu-Co sulphides should concentrate on locating these feeder zones.

Few absolute age constraints exist for the timing of the intracratonic Petermann Orogeny of the Musgrave Province. The Petermann Orogeny is responsible for much of the lithospheric architecture we see today within the Musgrave Province, uplifting and exhuming large parts along crustal scale E-W trending fault/shear systems. Isotopic and geochemical analysis of a suite of stratigraphic units within the Neoproterozoic to Cambrian Officer Basin to the immediate south indicate the development of a foreland architecture at ca. 600 Ma. An excursion in εNd values towards increasingly less negative values at this time is interpreted as representing a large influx of Musgrave derived sediments.

Understanding the nature of the basement separating the SAC from the NAC and WAC is vital in constructing models of the amalgamation of Proterozoic Australia. This region is poorly understood as it is overlain by the thick sedimentary cover of the Officer Basin. However, the Coompana Block is one place where basement is shallow enough to be intersected in drillcore.The previously geochronologically, geochemically, and isotopically uncharacterised granitic gneiss of the Coompana Block represents an important period of within-plate magmatism during a time of relative magmatic quiescence in the Australian Proterozoic. U-Pb LA-ICPMS dating of magmatic zircons provides an age of ca. 1.50 Ga, interpreted as the crystallisation age of the granite protolith. The samples have distinctive A-type chemistry characterised by high contents of Zr, Nb, Y, Ga, LREE with low Mg#, Sr, CaO and HREE. εNd values are high with respect to surrounding exposed crust of the Musgrave Province and Gawler Craton, and range from +1.2 to +3.3 at 1.5 Ga. The tectonic environment into which the granite was emplaced is also unclear, however one possibility is emplacement within an extensional environment represented by interlayered basalts and arenaceous sediments of the Coompana Block. Regardless, the granitic gneiss intersected in Mallabie 1 represents magmatic activity during the “Australian magmatic gap” of ca. 1.52-1.35 Ga, and is a possible source for detrital ca. 1.50 zircons found within sedimentary rocks of Tasmania and Antarctica, and metasedimentary rocks of the eastern Musgrave Province.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by any other person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Benjamin P. Wade

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