# Geotectonics in the Gawler Craton: Constraints from geochemistry, U-Pb geochronology and Sm-Nd and Lu-Hf isotopes

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# Abstract

The southern Australian Mesoarchean to early Mesoproterozoic Gawler Craton holds a pivotal place in the architecture of Proterozoic Australia. Although in recent years a growing body of work has significantly improved our understanding of the tectonic evolution of the Gawler Craton, the lack of outcrop across large areas is an impediment to determining the tectonic framework. This study uses geochemical, geochronological (U-Pb zircon and monazite) and isotopic (Whole rock Sm-Nd and zircon Lu-Hf) data on samples mostly obtained from drill holes in regions of limited to non-existent outcrop to better delineate the tectonic setting of Proterozoic metasedimentary and igneous units in the western, central and northern Gawler Craton and the orogenic events which have affected them.

It is common practice in sedimentary provenance studies to use similarities in the detrital zircon age histograms from sedimentary systems to identify potential source regions, and therefore to make interpretations about paleogeographic settings. However, this method is limiting as the timing of zircon growth events is not a unique criterion of specific terrains. Nevertheless, these limitations can be overcome by employing additional isotopic data sets such as Sm - Nd and Lu - Hf that provide information on the crustal evolution of the source region. As an example, the age spectra of detrital zircons in Paleoproterozoic metasedimentary rocks in the eastern Gawler Craton in southern Australia are virtually identical to the dominant zircon growth timelines in adjacent older domains of the Gawler Craton, suggesting that it was the source region. However, the combination of bulk rock Nd and Hf zircon data suggest that the Gawler Craton is not a viable source region for the metasedimentary packages, despite the striking similarity between detrital zircon ages and zircon crystallisation events within the craton.

The western Gawler Craton occupies a key position in a number of Paleoproterozoic reconstruction models of Australia. Zircon and monazite U-Pb data obtained from drill holes in the Fowler Domain show that sedimentation occurred over the interval 1760 – 1700 Ma, closely followed by upper amphibolite to granulite-grade metamorphism and deformation in the interval 1690 – 1670 Ma. The timing of tectonism is synchronous with the Kimban Orogeny, which shaped the tectonic architecture in the eastern Gawler Craton. Detrital zircon ages indicate that sediment source regions for the metasedimentary rocks from the Fowler Domain are similar to other Paleoproterozoic basin systems in the northern and eastern Gawler Craton, suggesting the former existence of a large 1760 – 1700 Ma depositional system across what is now the South Australian Craton. Rather than a source dominated by Archean to early Paleoproterozoic rocks of the Gawler Craton, the source characteristics (age and isotopic composition) of the Paleoproterozoic basin system favour the North Australian Craton as a source. This suggests that the Gawler Craton and the North Australian Craton may have been part of a single lithospheric domain at around 1750-1700 Ma.

Data obtained from outcropping sedimentary sequences in the central craton indicate that the Gawler Craton shares basin formation time lines with the adjacent Curnamona Province, suggesting that they comprise a single lithospheric domain at the time of deposition. Detrital U-Pb zircon ages from the 1715 Ma Labyrinth Formation show similarities with 1760 – 1700 Ma basin systems in the western and northern Gawler Craton as well as the Curnamona Province, however, the Labyrinth Formation contains an isotopically evolved component consistent with input from the underlying Archean rocks in the central Gawler Craton. The overlying 1650 Ma Tarcoola Formation is isotopically more juvenile, and cannot simply be derived from erosion of the underlying sequences. Both the timing of basin development and the juvenile nature of the Tarcoola Formation is similar to units in the Curnamona Province as well as in northeastern Australia. This may suggest the presence of a large scale *ca* 1650 Ma juvenile basin system across eastern Proterozoic Australia.

U-Pb geochronology of orthogneisses intersected in drill holes in the unexposed northern Gawler Craton constrain the timing of magmatism to *ca* 1780 – 1750 Ma. These granitic rocks form basement to sedimentary successions that were deposited between *ca* 1740-1720 Ma, which have minimum depositional ages constrained by regional medium to high-grade metamorphism at *ca* 1730-1700 Ma, coincident with the Kimban Orogeny. The timing of magmatism and subsequent sedimentation and metamorphism is similar to that in the Arunta region of the southern North Australian Craton. This supports provenance links from metasedimentary units from the Fowler Domain of the western Gawler Craton with the Arunta region, and strengthens the paleogeographic connection between these two regions at *ca* 1780-1700 Ma.

Monazite geochronology from three drill holes in the northern Gawler Craton has revealed *ca* 1450 Ma timing for magmatism and high grade metamorphism. Elsewhere in the Gawler Craton this age corresponds to reactivation and cooling of crustal shear zones, as well as regional resetting of Rb-Sr isotopic systems. The sparse record of drill holes in the western Gawler Craton also intersect a pegmatite of this age as well as granitic rocks, suggesting the *ca* 1450 Ma thermal record may be more widespread than appreciated. Across Proterozoic Australia there is a diffuse but widespread record of *ca* 1450 Ma events that encompass granitic magmatism, regional cooling, isotopic resetting and basin development. The spatial scale of this record suggests it formed part of a larger system at that time which would have connected with eastern Proterozoic Australia. The most plausible paleogeographic connection is with southern and western Laurentia, which contains an extensive province characterised by felsic magmatism, localised deformation and regional cooling and isotopic resetting. In this case the *ca* 1450 Ma record in Australia provides an important paleogeographic constraint for Mesoproterozoic continental configurations.

# Declaration

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

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# Journal Articles

**Howard, K.E.**, Hand, M., Barovich, K.M., Payne, J.L., Cutts, K.A., Belousova, E.A., 2011. U-Pb zircon, zircon Hf and whole-rock Sm-Nd isotopic constraints on the evolution of Paleoproterozoic rocks in the northern Gawler Craton. *Australian Journal of Earth Sciences* **58**, 615-638.

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**Howard, K.E.**, Hand, M., Barovich, K., Belousova, E. A., 2010. Provenance of metasedimentary rocks in the western Gawler Craton: Geochemical, zircon U-Pb, Lu-Hf and whole rock Sm-Nd isotopic constraints. In: Quinn, C.D. & Daczko, N.R. (eds.) Abstracts of the Specialist Group in Tectonics and Structural Geology Conference, Port Macquarie. *Geological Society of Australia Abstracts* **97**, 35

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# Statement of Authorship

Much of the research presented in this thesis has been published in scientific journals. Bibliographic details are listed at the beginning of each chapter. The contribution of each author is described below.

**HOWARD, K.E. (Candidate)**
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**CUTTS, K.A.**
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