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Investigating intraplate orogenic controls on sediment production and transport through the Devonian-Carboniferous Drummond Basin, Australia: a multi-dating approach using detrital zircon, rutile and mica

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Sedimentary provenance studies can provide a finely-tuned record of sediment sourcing and tectonism where vertical provenance changes generally reflect either basin-forming tectonic processes or far-field orogeneses generating sediment that overwhelms local sediment supply. Basin-fill histories receiving extrabasinal sedimentation can provide valuable links between basins and tectonic processes operating in different parts of a continent. This study focuses on an example of a continental basin that was influenced by a far-field tectonic event causing a major provenance change.

The mid-Mississippian Drummond Basin (Queensland, Australia), preserves a thick (>5 km), large-volume (∼235,000 km3) succession of predominantly fluviatile, coarse-grained, cratonic-derived sandstones and conglomerates that define an abrupt, basin-wide provenance change supplanting initial rift-related intrabasinal volcanism and related sedimentation. Shifts in sandstone compositions are extreme, switching from Q28F19L53 to Q80F8L12 and where quartz changes from volcanic to plutonic varieties. Paleocurrent data, in combination with petrographic and facies analyses, indicate sediment supply from beyond the S/S-W basin margin, and require the transport of high loads of coarse-grained material to be maintained over an unusually long distance: ∼470 km along the basin axis, in addition to an unknown distance from the extrabasinal sources.

To understand the causes of the profound provenance change recorded in the basin, and to constrain the source terrain(s), a comprehensive detrital multi-dating study was undertaken. While many sedimentary provenance studies have been reliant on U-Pb detrital zircon dating, it has been increasingly recognised that this method alone cannot provide clarity on the source region of sedimentary rocks, as it only truly identifies the ultimate igneous source terrain, rather than immediate sedimentary or metamorphic sources. Here, utilising multiple techniques provides broad coverage of the closure temperature spectrum, from high-closure-temperature U-Pb zircon (∼900-1000oC), through moderate-temperature U-Pb rutile (∼500-600oC), to low-temperature 40Ar/39Ar systems in muscovite (300-400oC) and biotite (∼280-350oC). Twenty-nine samples were collected from different stratigraphic formations and multiple basin locations, allowing 4-D insights into the propagation of detrital mineral age signals across the basin. LA-ICP-MS U-Pb zircon dating was performed on 27 samples (2,544 analyses in total) and revealed a complex age pattern dominated by <440 Ma ages, as well as several older populations, notably of Pacific-Gondwanan and Grenvillean ages. To investigate potential metamorphic sources, 18 detrital rutile samples were analysed for a total of 1,431 analyses. Both concordant and discordant rutile data are dominated by Pacific-Gondwanan ages, with a minor ∼1547 Ma detrital population appearing mid-succession. 40Ar/39Ar detrital muscovite (2 samples) and biotite (1 sample) dating was undertaken and yielded 422-439 Ma ages which are interpreted to record the timing of the source terrain cooling/exhumation.

The multi-dating results reveal a broad, mixed source region, including a significant syn-depositional volcanic contribution (<360 Ma zircon population), igneous basement rocks to the S and W of the basin (older zircon populations; micas), recycled sedimentary rocks (Pacific-Gondwanan and Grenvillean zircons), and high-grade metapelitic rocks (rutile). The timing and nature of the provenance change recorded in the Drummond Basin are consistent with it being driven by the contemporaneous but far-field intraplate Alice Springs Orogeny of central Australia.