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Fluid-controlled rheological responses during intraplate orogeny

Tom Raimondo (1), Daniel Howlett (2), Martin Hand (2), and Chris Clark (3)

(1) School of Natural and Built Environments, University of South Australia, Adelaide, Australia (tom.raimondo@unisa.edu.au), (2) School of Physical Sciences, University of Adelaide, Adelaide, Australia, (3) Department of Applied Geology, Curtin University, Perth, Australia

The intraplate Alice Springs Orogen, central Australia, is characterised by fluid-rock systems that systematically vary in their depth, structural style, fluid sources and magnitude of rehydration and reworking. Discrete metre-scale cataclastic faults in the northwestern Reynolds–Anmatjira Ranges progress into ten- to hundred metre-scale metasomatised shear zones at the southeastern margin of this terrane, associated with low δ^{18}O and δD values indicative of a meteoric fluid source. Continuing along strike to the southeast, these structures are succeeded by kilometre-scale schist belts transecting Palaeoproterozoic granulites in the Strangways Metamorphic Complex, followed by a $\sim$7500 km^2 zone of pervasive Palaeozoic amphibolite facies retrogression and voluminous partial melting in the Harts Range and Entia Gneiss Complex further east. Strongly deformed outcrops of the basal sedimentary unit of the Amadeus Basin (Heavitree Quartzite) are preserved in these areas, and discrete shifts to elevated δ^{18}O values suggest that shear zones of the Strangways Metamorphic Complex contain fluids sourced from its prograde dewatering.

Intriguingly, despite being part of a laterally-continuous, anastomosing shear belt that forms the dominant structural network of the Alice Springs Orogen, the fluid-rock systems described above appear to be diachronous. Garnet Sm-Nd and monazite U-Pb geochronology from garnet-staurolite-biotite-muscovite-quartz $\pm$ kyanite $\pm$ sillimanite schists of the Strangways Metamorphic Complex indicate metamorphic ages of *ca* 445 Ma, *ca* 380 Ma, *ca* 360 Ma and *ca* 330 Ma, spanning approximately 120 Myr of fluid-rock interaction and partial melting. *P*–*T* evolutions constrained by petrography, EPMA X-ray maps and calculated pseudosections also demonstrate multiple prograde thermal cycles across this interval, while field relationships indicate the reactivation of contractional structures by overprinting extensional ultramylonites, attesting to a prolonged and episodic history of fluid-driven metamorphism and deformation. The Alice Springs Orogen therefore represents a remarkable natural laboratory to investigate the contribution of metasomatic processes to intraplate orogenesis through space and time.

We explore the possibility that the fluid-rock interaction history of this intraplate orogenic event had a profound impact on its structural/metamorphic expression, and by inference the rheological response of the lithosphere. In particular, we suggest that the spatial and temporal evolution of Alice Springs shear zones may be linked to the availability of fluids in the deep crust and their effects on lithospheric strength through processes such as hydration and reaction softening. Far from being a purely local phenomena, therefore, deep crustal metasomatism had a profound impact on the dynamics of basement reactivation, acting in concert with other factors such as regionally elevated heat production to critically reduce the long-term strength of intraplate lithosphere and provide impetus for large-scale reworking.