Do hydrothermal systems control detachment fault development?

A.M. MCCAIG*AND T. CASTELAIN

Institute of Geophysics and Tectonics, School of Earth and Environment, University of Leeds, LS2 9JT, UK (*correspondence a.mccaig@see.leeds.ac.uk)

Hydrothermal systems are generally seen as a response to magmatic events in the oceanic lithosphere. Here we suggest that on slow spreading ridges where magma supply is episodic, hydrothermal circulation may actively control tectonic styles and ridge crest morphology.

Large, long-lived black smoker systems on slow spreading ridge are often closely linked with detachment faults, and for the TAG field it has been suggested that a convex-upward fault controlled hydrothermal upflow leading to venting 4.5 km away from the ridge axis [1, 2]. The heat source for hydrothermal flow is thought to be gabbroic intrusions into the detachment footwall, 7 kmbsf and not directly beneath the TAG field[1].

Studies of exposed detachment faults suggest two endmember types; hot detachments (e.g. Atlantis Bank, SWIR) characterised by thick, high temperature (800-950 °C) gabbroic mylonite zones, and cold detachments characterised by talc-tremolite schists formed at black smoker temperatures and brittle rather than ductile deformation in gabbroic footwalls. Isotopic data suggests high fluid fluxes along cold detachment faults[2] but only limited flow through footwall gabbros. A simple 1-D thermal model shows that gabbros in the footwall of a detachment held at 400 °C by hydrothermal fluid will cool rapidly through the brittle-ductile transition (~750 °C), preventing the development of extensive mylonites. Hence the presence of vigorous hydrothermal circulation can profoundly affect crustal rheology.

The cold detachment model requires that the fault is already the locus of hydrothermal flow at the time the gabbro body is emplaced immediately beneath it. We suggest that initially, gabbro is intruded at intermediate depth in the hangingwall of a steep, low displacement axial valley fault. As the gabbro solidifies, the hydrothermal system mines down into it via a cracking front. The next gabbro is intruded into wet rocks and cannot rise so far. Eventually gabbro is intruded beneath the fault at 7 kmbsf. If magma is trapped below the fault it becomes kinematically favourable to switch to extensional faulting on a long-lived detachment as the main mode of plate separation.

[1] deMartin *et al*. (2007) *Geology* **35**, 711–714. [2] McCaig *et al*. (2007) *Geology* **35**, 935–938.

A magmatic record of Middle Archaean subduction

C.A MCCALLUM[1]* AND S.L HARLEY[1]

[1]University of Edinburgh, School of Geoscience, Grant Institute of Earth Science, The King's Buildings, West Mains Road, Edinburgh EH9 3JW(*correspondence: C.A.McCallum-2@sms.ed.ac.uk, Simon.Harley@ed.ac.uk)

The Torckler Tango Layered complex (TTLC) of the Rauer Group, East Antarctica, consists of a series of elongate mega-boudins that can be traced over a strike length of 7 km, enclosed within and intruded by homogeneous tonalitic orthogneisses. The TTLC has a whole rock geochemistry with distinctive high MgO (av. 15.8 wt%), high Mg# (av. 79.1) low TiO_2 (av.< 0.33 wt%), and high SiO_2 (av. 52.5 wt%). Despite extensive metamorphism (860-900°C, 0.7 GPa) into high grade pyroxene granulite the original igneous structures and layering features of the TTLC are remarkably well preserved. Metamorphic disturbance of isotopic and chemical signatures is minor, such that the whole rock chemistry of the TTLC is considered to reflect its protolith. Based on its systematic trace element ratios Ti/Zr vs. Zr (Ti/Zr ~34-59 at Zr ~15-40 ppm) and Cr vs. Mg# (Cr 70-3379 ppm, Mg# 76-86) the TTLC is similar in geochemistry to both modern and Late Archaean boninitic rocks. Magmatic zircons from the TTLC preserve distinctive HREE-enriched patterns consistent with their crystallisation from differentiated melts remaining after significant crystallisation of the boninitic magma. These zircons define an intrusive age for the complex of ca. 3300Ma. Whole rock Nd isotope ratios recalculated back to this age are consistent with a juvenile source for the primary magma. The mid-Archaean TTLC is therefore interpreted as the intrusive equivalent of a boninite, produced through the shallow melting of refractory mantle and indicative of the operation of subduction-like processes at ca. 3300 Ma.