Hydrothermal Alteration at the Hess Deep Rift

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Extensive field surveys by submersible and ROV, and ODP (Site 894) and IODP (Site U1415) drilling at the Hess Deep Rift have pieced together a complete composite section of young, fast-spreading crust formed at the East Pacific Rise. This comprehensive sampling provides a record of axial and near axial hydrothermal activity throughout the entire crustal section, and the localized effects of subsequent unroofing at the Hess Deep Rift.

Hydrothermal alteraton in the upper crust is largely focused in the sheeted dike complex, where dikes are variably altered to amphibole- or, locally, chlorite-dominated assemblages. There are no systematic variations in mineral assemblage or peak metamorphic temperature with depth, with temperatures >450° locally recorded throughout the dike section. The transition into the subjacent gabbroic sequence is complex, with hornfelsic regions marking magmatic instrusion into the dikes and the uppermost grabbros showing evidence for assimilation of hydrothermally altered dikes. A stepped temperature profile across the basal dikes and uppermost gabbros suggest these rocks record the conditions of a conductive boundary layer separating the magma-hydrothermal transition.

Incipient flow of hydothermal fluids along microfracture networks into the upper gabbroic sequence is marked by amphibole veinlets that record initial cracking at ≥700°C. Similar to the sheeted dike section, amphibole dominates the secondary assemblage, but the degree of alteration is less. Lower bulk rock Sr-isotopic compositions in the upper gabbros relative to the dike section suggest diminished fluid and heat fluxes associated with axial and near axial gabbroic alteration, relative to the dike section.

Evidence for early high temperature alteration is less common in the lower gabbros, although it may be manifest by non-hydrous phases that have not yet been characterized. Preliminary data suggest that incipient alteration occurred at slightly higher temperatures than in the upper gabbros. The more primitive compositions of the lower gabbros [1] leads to a different style of alteration, in response to the much greater abundance of olivine [2, 3].

[1] Gillis *et al* (2014), *Nature* ***505***, 204-207 [2] Marks *et al* (2014), Goldschmidt 2014 [3] McCaig *et al* (2014) Goldschmidt 2014