

## The record of hydrothermal alteration in the lower oceanic crust sampled by Oman Drilling Project Holes GT1A and GT2A

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Hydrothermal circulation is a fundamental Earth process that is responsible for the cooling of newly formed ocean crust at mid ocean ridges and imparts a chemical signature on both the crust and the oceans. Recent studies highlight the requirement for deep hydrothermal circulation in the lower crust, but the critical samples necessary to resolve the nature of this deep hydrothermal system are poorly sampled in the ocean basins. The Oman Drilling Project successfully cored 3 boreholes into the lower crust of the Semail ophiolite (Holes GT1A layered gabbros, GT2A foliated gabbros and GT3A dike/gabbro transition). These boreholes have exceptionally high recovery (~100%) and have been characterised using both traditional and novel core description methods. These cores provide a timely and important opportunity to quantitatively characterise the hydrothermal system in the lower oceanic crust.

Hydrothermal alteration in Holes GT1A and GT2A is ubiquitous and manifests as secondary minerals replacing primary igneous phases and secondary minerals precipitated in hydrothermal veins and hydrothermal fault zones. Hydrothermal alteration of the host rock was classified as either background, halos, patches or deformation related. Hydrothermal veins were individually logged and cross cutting relationships were recorded to determine the relative timing of hydrothermal alteration. The total alteration intensity in Hole GT1A ranges between 10 -100%, with a mean alteration intensity of 60%, and shows no overall trend downhole. However, there are discrete depth intervals (on the scale of 30 -100 m) where the total alteration intensity increases with depth. Alteration assemblages are dominated by chlorite + albite + amphibole, with variable abundances of epidote, clinozoisite and quartz. Hole GT1A intersected several hydrothermal fault zones, these range from 2-3 cm up to >1m in size and are associated with more complex secondary mineral assemblages. Hydrothermal veins are abundant throughout Hole GT1A, with a mean density of 37 vein/m. Alteration intensity in Hole GT2A ranges between 6-100%, with a mean alteration intensity of 45%, and is highly variable downhole. Alteration halos and patches are slightly more abundant in Hole GT2A than in Hole GT1A. The secondary mineral assemblage is similar to Hole GT1A, but Hole GT2A has higher abundances of epidote, clinozoisite, quartz, laumontite and iron-oxhydroxides. Vein density in Hole GT2A is 61 veins/m. In both holes, cross cutting vein relationships indicate a relative timing from earliest to latest of: amphibole; epidote + zoisite + quartz; chlorite + prehnite + quartz, calcite-laumontite-anhydrite; gypsum.

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