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Hydrothermal alteration of the oceanic crust recorded by basaltic dykes at Atlantis Massif oceanic core complex, 30˚N Mid-Atlantic Ridge

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The Atlantis Massif oceanic core complex, located at the Mid-Atlantic Ridge at 30˚N, adjacent to the Atlantis Transform Fault, represents tectonically thinned and exhumed lithosphere, exposing rocks of the lower oceanic crust and the upper mantle.

During IODP Expeditions 304 and 305 we drilled c. 1400m of the lower crustal rocks, predominantly gabbros of a wide compositional range. Coarse grained basalts occur as dykes and sills of cm- to m-width throughout the cores, however predominantly in the upper 130 m. The dykes/ sills crosscut all other lithologies, indicating that they intruded the crust during a late evolutionary stage of the oceanic core complex.

The basalts are of normal tholeiitic MORB composition with slightly enriched FeO and TiO_2 contents and characterized by pervasive greenschist facies alteration. Whole rock and mineral geochemical data indicate that the degree of alteration decreases downhole but also across single dykes/ sills, from the centre towards the chilled margins.

Magnetic susceptibility measurements yielded high values for the basalts and conspicuous variation patterns in profiles across the basaltic dykes and sills. Often, the margins of the dykes/ sills tend to have high magnetic susceptibilities, whereas the interiors are not or only slightly magnetic. Bulk magnetic susceptibility and non-contact electrical conductivity seem to be both governed by magnetite and ilmenite. Petrographical observations show that euhedral Ti-magnetite crystals are more concentrated towards the margins of the dykes and sills whereas more skeletal crystals predominate in the centre.

Oxide microstructures indicate that most of the variation in magnetite content and structure is caused by hydrothermal alteration. Primary magmatic titano-magnetite, with ilmenite lamellae in magnetite, are intact in the least altered rocks. In contrast, in the rocks where most of the primary augite has been altered to actinolite, the magnetite in the primary Ti-magnetite grains had been consumed, leaving a skeleton of ilmenite lamellae. Relatively unaltered sections are characterized by high susceptibility, whereas the more altered sections coincide with regions of low susceptibility.

The close correspondence between logged magnetic susceptibility and fresh magnetite suggests that magnetic susceptibility can be a powerful proxy for magnetite and a strong indicator for hydrothermal alteration.