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Palaeomagnetic constraints on the evolution of the Atlantis Massif oceanic core complex (Mid-Atlantic Ridge, 30°N)

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Oceanic core complexes expose lower crustal and upper mantle rocks on the seafloor by tectonic unroofing in the footwalls of large-slip detachment faults. They represent a fundamental component of the seafloor spreading system at slow and ultraslow axes. One of the most extensively studied oceanic core complexes is Atlantis Massif, located at 30°N at the intersection of the Atlantis Transform Fault and the Mid Atlantic Ridge (MAR). The central dome of the massif exposes the corrugated detachment fault surface and was drilled during IODP Expedition 304/305 (Hole U1309D). This sampled a 1.4 km faulted and complexly layered footwall section dominated by gabbroic lithologies with minor ultramafic rocks.

Palaeomagnetic analyses demonstrate that the gabbroic sequences at Atlantis Massif carry highly stable remanent magnetizations that provide valuable information on the evolution of the section. Thermal demagnetization experiments recover high unblocking temperature components of reversed polarity (R1) throughout the gabbroic sequences. Correlation of structures observed on oriented borehole (FMS) images and those recorded on un-oriented core pieces allows reorientation of R1 remanences. The mean remanence direction in true geographic coordinates constrains the tectonic rotation experienced by the Atlantis Massif footwall, indicating a 46°±6° counterclockwise around a MAR-parallel horizontal axis trending 011°±6°. The detachment fault therefore initiated at a steep dip of >50° and then rotated flexurally to its present day low angle geometry (consistent with a 'rolling-hinge' model for detachment evolution).

In a number of intervals, the gabbros exhibit a complex remanence structure with the presence of additional intermediate temperature normal (N1) and lower temperature reversed (R2) polarity components, suggesting an extended period of remanence acquisition during different polarity intervals. Sharp break-points between different polarity components suggest that they were acquired by a thermal mechanism. There appears to be no correlation between remanence structure and either the igneous stratigraphy or the distribution of alteration in the core. Instead, the remanence data are consistent with a model in which the lower crustal section acquired magnetizations of different polarity during a protracted cooling history spanning two geomagnetic reversals. The crystallization age of the section (1.2 Ma; derived from Pb/U zircon dating) suggests that the R1 component was acquired during geomagnetic polarity chron C1r.2r, N1 during chron C1r.1n (Jaramillo) and R2 during chron C1r.1r. By considering the maximum time intervals available for acquisition of the N1 and R2 components and correcting laboratory unblocking temperatures accordingly, the data provide additional constraints on the thermal evolution of the Atlantis Massif footwall.