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A continuous structural characterisation of Atlantis Massif using an integrated analysis of oriented downhole imagery and logging data

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Continuous wireline logging data are invaluable when less than 100% of drilled core material is recovered. The data provide information on missing units, record the true depth of features and uniquely constrain spatial orientation. Only by fully integrating continuous, oriented logging data and discrete, finer-scale core data can we develop a complete structural interpretation for drill holes that is not limited by sampling bias.

Integrated Ocean Drilling Program (IODP) Expedition 304/305 sampled the Atlantis Massif oceanic core complex at the intersection between the Mid-Atlantic Ridge and the Atlantis Transform fault at 30ºN. Hole U1309D penetrated 1415.5m into the central dome of the massif, which exposes the corrugated detachment fault surface denuding the lower crust and upper mantle. The recovered section is dominated by gabbro compositions that are complexly faulted and layered on a variety of scales, reflecting the complicated interplay between magmatic and tectonic processes controlling the formation, evolution and deformation of oceanic crust at slow-spreading ridges.

The average core recovery at Atlantis Massif was 74%. Therefore, to augment and constrain structural interpretations based on limited core material, we used the Formation MicroScanner (FMS) wireline logging tool that measures microresistivity contrasts in the immediate vicinity of the borehole wall formation. The data are presented as an unwrapped image of the borehole cylinder, and inclined planar structural features that intersect the borehole, such as faults or veins, are shown as darker (more conductive) sinusoidal traces. The true dip and azimuth of these features can be calculated directly due to the inclusion of an accelerometer and magnetometer on the toolstring, which record the position and spatial orientation (with respect to magnetic north) of the tool within the borehole, respectively.

4324 distinct structural features have been identified in the FMS images between 97 and 1415mbsf (metres below sea floor). Distinctly different structural trends are seen across the five sub-units that are based on petrological and geochemical observations of the recovered core. In addition, variations in the borehole dimensions are used to define 115 zones of borehole breakout, with a cumulative extent of 434.76m (31% of the total drilled). Such regions often correspond to areas of poor recovery and are consequently poorly characterised using core samples. The extensive FMS-based structural database allows the variation in fracture networks and areas of weakness to be quantified at a high-resolution, leading to improved understanding of the hydrothermal fluid flow and melt pathways in the footwall section.