Geomechanical properties of submarine bedrock cliffs: controls on rock slope failures within the Whittard Canyon, Celtic Margin

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Large-scale mass wasting of slopes within submarine canyon environments is well-documented (e.g. Cunningham et al., 2005; Sultan et al., 2007; Lastras et al., 2009). However, at present research has almost exclusively focused upon unconsolidated, loose sediments that form the canyon head and flanks, and produce large slumps and turbidity currents that transport huge quantities of sediment to the canyon floor. This is perhaps due to the relative abundance of geophysical data which can be acquired from research vessels, enabling the detailed geomorphological mapping of large landslide scars and debris lobes at the base of slopes. In contrast, very few studies have previously attempted to assess bedrock rockwall behaviour within a submarine canyon, which could have significant implications for canyon evolutionary processes and, subsequently, regional geohazard assessments for offshore infrastructure. During the CODEMAP 2015 research cruise to the Whittard Canyon, Celtic Margin (funded by ERC Starting Grant 258482 and the NERC MAREMAP programme), a Remotely Operated Vehicle (ROV) gathered High Definition (HD) video footage of the canyon rockwalls over the course of more than 20 individual dives; this dataset was supplemented by rock samples collected during these dives and by shipboard geophysical datasets. The extremely high-resolution video footage revealed small-scale rockwall slope processes that would not have been visible if shipboard geophysical equipment was solely relied upon during the survey. Of particular interest was the apparent spalling failure of mudstone and chalk rockwalls, with fresh superficial "flaking" scars and an absence of sessile fauna indicating relatively recent mass-wasting activity. Extensive talus slopes, often consisting of coarse gravel, pebble and occasionally boulder-sized clasts, were observed at the foot of slopes impacted by spalling failures; this debris was rarely colonised by biological communities which could be an indicator of frequent rockfall events. It is suggested that hydrodynamic stresses could exacerbate the spalling process, and bio-erosion was noted on many of the walls prone to this form of rock slope failure (RSF). Undercutting of cliffs was noted, particularly in carbonate-rich lithologies, which resulted in the failure of large (>1 m) blocks from the overhanging ledge of resistant Fe-oxidised bedrock. Internal fracture networks impose a major control on the observed RSF processes, often resulting in cubic and tabular blocks (0.2-1.0 m scale) of bedrock toppling or sliding out of the cliff face. These discontinuity jointsets were evaluated and modes of failure (e.g. planar, toppling or wedge) were assessed against each lithology where structurally-controlled mass wasting was observed. The rock samples were sent to the British Geological Survey (BGS) geotechnical laboratory for testing in order to ascertain the tensile strengths of the different lithologies present within the canyon. By combining the ROV observations, discontinuity assessments and laboratory testing results, an understanding of the geomechanical properties of the bedrock can be obtained and linked with past and ongoing rock slope processes within the Whittard Canyon. These conclusions will have a wider implication for ongoing geomechanical processes within submarine canyons on a global scale.