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North Atlantic Margins: Case studies of Magmatic Continental Breakup

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Continental breakup between Europe and Greenland was accompanied by the rapid eruption of the > 1 million cubic kilometres of extruded basalts forming North Atlantic Igneous Province. With episodes of extension in the region dating back to the Devonian, rifting finally proceeded to full breakup and oceanic spreading in the Paleocene. Flood basalt units flowed up to 150 km over pre-existing sedimentary basins, discrete volcanic centres formed and intrusion into the thinned continental crust occurred. Marine seismic investigations utilising industry-leading seismic reflection imaging technologies and large deployments of ocean bottom seismometers across the Faroes and Hatton Bank margins have been used to better resolve margin structure and composition, improving our understanding of breakup processes. Seismic reflection imaging reveals sub-aerial and submarine seaward-dipping reflector sequences tracking the interplay of uplift (transient and permanent), crustal loading through extrusion and ongoing extension. Lower crustal reflectors, cross-cutting the continental fabric and interpreted as intrusions, are observed within the narrow continent-ocean transition. P-wave tomography of wide-angle reflections and refractions, recorded to offsets of up to ~200 km, reveals unusually thick oceanic crust with lower crustal velocities in excess of those expected for MORB compositions. High P-wave velocities are attributed to magnesium-rich compositions which, combined with the large oceanic crustal thickness, would be consistent with an elevated mantle temperature (~150°C higher than 'normal') at the time of breakup. Vp/Vs ratios derived from tomography of converted shear wave phases also support high magnesium melt composition. P-wave velocities and Vp/Vs ratios across the continent-ocean transition show a mixing trend between magnesium-rich gabbroic compositions (100% for oceanic crust) and compositions consistent with the Lewisian gneiss basement or Early Proterozoic metamorphic basement of the Faroes and Hatton Bank areas respectively. Sedimentary units forming a low velocity zone beneath the flood basalts across the Faroe Ridge and into the Faroe-Shetland Trough are hypothesised to represent Paleocene sedimentary rock emplaced as transient thermal uplift across the nascent rift zone led to increased weathering and clastic sediment transport from Greenland.