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Operations and Initial Results from IODP Expedition 396: Mid-Norwegian Continental Margin Magmatism and Paleoclimate

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The NE Atlantic conjugate volcanic rifted margins are characterized by extensive breakup-related magmatism recorded by basalt flows, volcanogenic sediments, magmatic underplates, and intrusive complexes in sedimentary basins and the crust. Onset of this voluminous magmatism is concomitant with the global hot-house climate in the Paleogene, and the injection of magma into organic-rich sedimentary basins is a proposed mechanism for triggering short-term global warming during the Paleocene-Eocene Thermal Maximum (PETM, ~56 Ma).

The aims of IODP Exp. 396 (August-September 2021) were to drill three transects on the mid-Norwegian continental margin to sample 1) hydrothermal vent complexes formed by eruption of hot fluids and sediments above sill intrusions (Modgunn Transect), 2) Paleogene sediments, with particular focus on the Paleocene-Eocene transition (Mimir Transect), and 3) basalt and sub-basalt sequences across the volcanic rifted margin and the initial oceanic crust (Basement Transect). A total of 21 boreholes were drilled, successfully coring all nine primary and one alternate sites. A comprehensive suite of wireline logs was collected in eight boreholes. Most of the sites were located on industry-standard 3D seismic reflection data, whereas additional high-resolution 2D and 3D P-Cable site survey data were acquired across six sites which were highly useful during the Mimir and Modgunn transect drilling. In total, more than 2000 m of core were recovered during 48 days of operations, including more than 350 m of basalt, 15 m of granite, and 900 m of late Paleocene to early Eocene sediments. Drilling was done using a combination of RCB, XCB, and APC drill bits, commonly with half-advances (c. 5 m) to optimize core recovery. Particularly high recovery (almost 100%) was obtained by half-length APC coring of Eocene sediments in two holes on the outer Vøring Margin, whereas basaltic basement recovery was above 60% in seven holes.

Expedition 396 probed the key elements of a typical volcanic rifted margin and the associated sedimentary archive. Of particular importance is the Modgunn Transect, where we drilled five holes through the upper part of a hydrothermal vent complex with a very expanded Paleocene-Eocene Thermal Maximum (PETM) interval dominated by biogenic ooze and volcanic ash deposits.

The expedition also recovered an unprecedented suite of basalt cores across a volcanic rifted margin, including both subaerial and deep marine sheet flows with inter-lava sediments and spectacular shallow marine pillow basalts and hyaloclastites, as well as high-resolution interstitial water samples to assess sediment diagenesis and fluid migration in the region. Lastly, we recovered the first cores of sub-basalt granitic igneous rocks and upper Paleocene sediments along the mid-Norwegian continental margin. Collectively, this unique sample archive offers unprecedented insight on tectonomagmatic processes in the NE Atlantic, and links to rapid climate evolution across the Cenozoic.