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Melt Supply, Crustal Structure, Tectonic Rifting, and Hydrothermal Venting at the Rainbow Area, 36°N MAR

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The MARINER (Mid-Atlantic Ridge INtegrated Experiments at Rainbow) seismic and geophysical mapping experiment was designed to examine the relationship between tectonic rifting, heat/melt supply, and oceanic core complex formation along the Mid-Atlantic Ridge at 36˚ N, the site of the Rainbow core complex and hydrothermal system. The 5-week experiment was carried out aboard the R/V M. G. Langseth in April-May 2013, and consisted of a 3D active-source seismic tomography experiment, a quasi-3D multi-channel seismic experiment, a 9-month seismicity study using seafloor instruments, dense acoustic mapping of the seafloor, gravity field mapping, and magnetic field mapping. During the tomography experiment, we deployed 46 ocean bottom seismometers in a grid pattern centered on Rainbow. Twenty-six seismic lines were carried out using the Langseth's 36-element source, generating 175,000 seismic records. Overall, the experiment extended across two sections of the Mid-Atlantic Ridge separated by the Rainbow core complex (an 80x105 sq. km area). MARINER seismic, gravity, bathymetry, and acoustic imagery data provide both broad and detailed views of the geologic and geophysical character of the ridge system, emphasizing the strong variability of ridge morphology, tectonics, and lava emplacement. The data indicate that the Rainbow area has been the site of low magma supply for over 1 Myr. The seismic tomography images reveal undulations in crustal structure and thickness across the Rainbow area, indicating temporal variations in melt supply, magmatic processes, and crustal construction. Patterns of seismic anisotropy, which arise from aligned cracks in the subsurface due to tension, suggest a broad semi-circular region of heavily cracked crust surrounding the Rainbow massif, that focuses upwards to a narrow chimney below the Rainbow vent field, potentially indicating the recharge and discharge zones for hydrothermal circulation. The current heat source for the vents may be a small melt lens intruded below the Rainbow massif (as suggested by reflection data), but the tomography does not indicate a significant magmatic system or high-temperature region beneath the Rainbow area. Only one area shows evidence for a ridge-centered high-temperature region at shallow depth, but it occurs beneath the southern ridge section and many kilometers south of the vent field.