White Paper: 3D reflection seismic investigation of segmentation of axial melt and hydrothermal venting at the Endeavour segment of the Juan de Fuca Ridge.

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The high temperature hydrothermal vent system of the Endeavour segment of the Juan de Fuca Ridge is arguably the most intensively studied of any along the global Mid-Ocean Ridge (MOR) system. Studies here have led to the discovery of the most extreme thermophiles on earth, existing at what may be the upper temperature limit for life. Much of what is currently known of hydrothermal vent macro-faunal ecology, and the nature of the subsurface biosphere at ridge systems comes from the long history of biological observations in the region. Available information on the architecture of hydrothermal fluid flow beneath the seafloor comes primarily from near bottom geophysical studies in the region and the best estimates of hydrothermal fluid fluxes from any MOR are from this site. Until recently, Endeavour was believed to be a type example vent system governed by fluids mining heat from cooling crustal rocks through downward propagation of a cracking front and along deep penetration faults. The large size of vent fields, their regular spacing, and high heat flux were all interpreted as evidence of long-term stable heat circulation attributed to a cracking front model of heat extraction. However, 2D multi-channel seismic data collected in 2002 detected a crustal magma body underlying all known Endeavour vent fields and led to the recognition that hydrothermal venting at this site is fundamentally fueled by a crustal magma reservoir and not by cooling deep crustal rocks as previously assumed.

The presence of a crustal magma body at Endeavour raises new questions regarding the origin and significance of spatial (and temporal) changes in the hydrothermal system observed at the seafloor. Along-axis variations are observed in other ridge properties including patterns of microseismicity within the shallow axial graben, the chemistry of seafloor lavas, and in the larger scale structure of the axial high. The existing 2D seismic reflection data for the region provide hints that the magma body at Endeavour may be segmented into multiple discrete lenses, similar to those discovered in the recent 3D seismic study of the EPR at 9°40-55'N. This fine-scale segmentation may play a key role in the observed variation in seafloor geological, biological and hydrothermal properties. To evaluate these relationships and further our understanding of the governing processes, 3D seismic imaging, now possible with the Langseth, would be needed. Such a study would provide detailed characterization of the crustal magmatic system and overlying crustal lid relevant for the broad range of scientific investigations underway in this region. The Endeavour site is one of the nodes of the CanNeptune cabled observatory and long-term observations and novel in situ experiments in this region are envisioned for the coming 30+ years. The hydrothermal-magmatic system at Axial Volcano, located ~200 km to the south, will be instrumented by the NSF funded Ocean Observatory Initiative and would also be an ideal target for a comparative 3D seismic characterization.