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Recent Magmatism on the Northern East Pacific Rise: Implications for Decadal Changes in Magma Chamber Composition and Relationships to Crustal Melt Distribution

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Detailed observations and fine-scale sampling of the northern East Pacific Rise (EPR) in the magmatically robust region around 9°50'N during the past 20 years, coupled with a recent eruption and 3D multichannel seismic studies in the region provide a unique opportunity to determine the relationships between recent magmatism and crustal structure. In particular, mapping, sampling and geochemical analysis of 2005-2006 lava flows that paved over lavas erupted in exactly the same location as a similar yet smaller eruption in 1991-1992 combined with repeat seismic surveys at this RIDGE2000 Integrated Study Site allow us to investigate the short-term temporal thermo-chemical changes in a fast-spreading mid-ocean ridge magmatic system, the spatial chemical variability in a single eruptive event, and how they relate to the distribution of melt in the underlying crust.

210Po-210Pb disequilibria in 16 samples indicate that the eruption occurred in pulses between June-July 2005 and January 2006 that also correspond to signals in the seismicity and changes in vent fluid temperature records. The 2005-06 lavas are typical N-MORB but are slightly more evolved than the 1991-92 lavas and exhibit some differences trace element characteristics. Lavas from the northern and southern limits of the 2005-06 eruption are more evolved than those erupted in the central portion of the fissure system, a pattern also observed in 1991-92 lavas indicating geochemical gradients are preserved over decadal time scales. In addition, some of the recent lavas record distinct parental melt compositions or evolutionary paths not observed in the main suite of 2005-06 lavas. This is consistent with mid-crustal magma lens segmentation into discrete lenses with along-strike dimensions of 5-10 km and suggests melt distribution in the axial magma chamber (AMC) remains intact on decadal timescales. Geochemical modeling indicates that the 2005-06 lavas likely represent differentiated residual liquids from the 1991-92 eruption that were modified by mixing of melts added from deeper in the crust but that those melts were not necessarily hotter, more primitive basalts as has been assumed in the past. Major element data indicate a role for moderately high pressure crystallization of parental magmas within the lower crust and/or mantle (2-4 kbar) and transport of differentiated melt from lower sills through the mush zone to the AMC via percolation or channel flow on a relatively rapid time scale ($\sim$1m/day).

Overall, geophysical and geochemical/petrologic data from the region indicate that: (1) the mantle source has limited compositional variation over the spatial extent of the eruption, (2) magmatic processes (e.g., fractional crystallization and magma mixing) that operate within the crystal mush zone and AMC occur on geologically short timescales (3) fine-scale geochemical variability is in part controlled by fine-scale melt lens segmentation, and (4) the 2005-2006 eruption was likely driven by AMC pressurization from persistent or episodic addition of magma from the crystal mush zone into the overlying sub-ridge melt lenses during the 13 yr repose period between the two eruptions.