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Testing Models for Three-Component Mantle Heterogeneity as Recorded in Compositions of Lavas from the Off-Axis 8°20' N Seamount Chain

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It has long been established that the northern East Pacific Rise (EPR) mantle is chemically and isotopically heterogeneous on small scales, invoking debate regarding how many components reside in the EPR mantle as well as how those components developed over time. Additionally, recent time-dependent mantle flow predictions from seismic tomography reveal a deep-seated mantle-wide upwelling beneath the EPR [1], further justifying the need to better constrain mantle sources feeding the EPR. The 8°20' N seamount chain has erupted extremely heterogeneous lavas over short (km) length scales (Figure 1), providing new constraints on near-EPR mantle heterogeneity. These lavas extend the compositional range of the northern EPR MORB and its adjacent seamounts to include about 70% of the variation in the oceanic mantle. For example, $\varepsilon_{Nd} = 3.6 – 11$ and $[La/Sm]_N$ = 0.30 to 2.85. In addition, $^3He/^4He$ ranges from 6.4 – 9.2 R_A, and is anti-correlated with $^{206}Pb/^{204}Pb$, spanning from 17.5 – 20.2 (Figure 2). Seamount compositions indicate the mantle beneath and near the EPR contains three components: 1) an incompatible element depleted (Nb/La < 1) isotopically depleted source ($^{206}Pb/^{204}Pb < 18.5$), 2) an incompatible element enriched (Nb/La > 1.5), isotopically enriched source, and 3) an incompatible element depleted (Nb/La < 0.8) HIMU source ($^{206}Pb/^{204}Pb > 20.1$). This small-scale heterogeneity results from an open-system exchange between the depleted upper mantle and ancient (possibly recycled and/or deeper) components. To investigate possible deep-mantle origins for EPR mantle heterogeneities, multi-stage melting and three-component source mixing model results are contextualized using tomography-based reconstructions of time-dependent mantle flowlines and particle tracks.

[1] Rowley, Forte, Rowan, Glisovic, Moucha, Grand, and Simmons (2016), Science Advances 12, 1-19.