Mapping Global and Regional Correlations Between MORB Helium Isotopes and Seismic Wave Speeds

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The global mid-ocean ridge system stretches over 65,000 km and randomly samples the Earth's mantle. Compositional variations observed in mid-ocean ridge basalts reflect complex relationships between the thermal, compositional, and dynamical state of the mantle. In this study, we compare globally distributed ridge segment averaged helium isotopic compositions with shear-wave velocities, at both the global and regional scale. Our goal is to understand how temperature, composition and mantle flow control the distribution of helium isotopic compositions in basalts erupted at mid-ocean ridges.

The global dataset displays a strong correlation between helium isotopes and the underlying shear-wave velocities in the upper mantle with the most prominent correlations corresponding to depths between ~200 to 700 km. A similar, but less pronounced feature, is observed in the mid-mantle at depths of ~1000 to 1500 km. The exclusion of MORBs influenced by hotspots slightly reduces the magnitude of the global correlations observed between helium isotopes and shear-wave velocities in the upper mantle (though a statistically significant correlation still remains), while slightly intensifying the correlation at mid-mantle depths. Data grouped by individual ocean basin exhibit distinct geochemical-seismological correlations. Mid-ocean ridge basalts from the Atlantic and Indian oceans display similar features as the global correlation and dominate the global upper mantle correlations. However, in the Pacific Ocean, Globally the most dominant feature is a correlation between helium isotopes and shear-wave velocities at depths between ~750 to 1500 km. In the Atlantic, temperature appears to be the primary driver of helium isotope variability, even when influence from hotspots is removed. However, it still remains unclear what controls helium isotope variability in the Pacific.

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