2025-2026 EOAS Colloquium Series

Anciently melt-depleted mantle resurfaces again at mid-ocean ridges

The convecting Earth mantle transports peridotite toward the surface, where it melts under mid-ocean ridges (MOR) and forms oceanic crust. This accounts for ca. 75% of today's volcanic activity. The return mass transport is at subduction zones where melt-depleted mantle, oceanic crust and sediment sinks into the mantle. Abyssal peridotites recovered from MOR are residual from the oceanic crust extraction, but their Hf isotopic compositions are vastly different from the basalts and require ancient melt depletion at MOR followed by the long-term (up to 3-4Ga) residence in the mantle.

Ultra-depleted peridotites have been documented at multiple localities, indicating their ubiquity in the sub-ridge mantle. Hence, melts from such ultra depleted peridotite influences mid-ocean ridge basalt compositions and variably melt- depleted sub-ridge peridotites should be considered when evaluating ridge depth variations. The large spectrum of Hf isotope ratios in abyssal peridotites, ranging to $\varepsilon Hf > 450$, confirms that the predicted variation of melt-depleted peridotites characterizes peridotites in the sub-ridge mantle.

The covariation between variable peridotite composition and density establishes a critical link between basalt chemistry and the thermochemical buoyancy forces that control mantle upwelling and basalt production rates under mid-ocean ridges or ocean islands. The Marion Rise at the southwest Indian Ridge is an example where ultra depleted peridotites are the likely cause for the shallow ridge depth.

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