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# Linking chemical trends in ocean islands to the complex interaction between starting plumes and the core-mantle boundary

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Many features on the Earth's surface can be understood only through their connection with processes in Earth's deep interior. One example is the composition of ocean island basalts: It has been known for a long time that melt reaching the surface through intraplate volcanism reflects a different source composition than melt at mid-ocean ridges. More recent studies indicate that spatial geochemical patterns at ocean islands correspond to structures in the lowermost mantle inferred from seismic tomographic models. This suggests that hot, buoyant mantle plumes can carry chemical heterogeneities from the deep lower mantle toward the surface, providing a window to the composition of the lowermost mantle. The exact nature of this link remains an important open question in the Earth sciences.

To better understand the links between the Earth's surface and its deep interior, we consider the complex interaction between starting mantle plumes, thermal and/or chemical boundary layers at the base of the mantle and lower mantle flow. Using computational models, we show how chemical reservoirs present in the deep mantle may be sampled by hot mantle plumes. We take into account different processes that can introduce chemical heterogeneities in mantle plumes: On the one hand, viscous drag can lead to entrainment of ambient mantle material into starting plumes plumes. On the other hand, plume generation zones may be partially molten. Fractionation upon melting or freezing and the segregation of melt may introduce additional chemical heterogeneities into rising plumes.

We use high-resolution 3D geodynamic models with a realistic subduction history, plate geometries, and plate motions to identify a dynamically feasible mechanism for how rising hot material can inherit the lower-mantle geochemical structure despite variations in material density. If subducted slabs induce strong lower-mantle flow toward the edges of reservoirs of chemically dense material, where plumes rise, the pile-facing side of the plume preferentially samples material originating from the reservoir, and bilaterally asymmetric chemical zoning develops. By integrating thermodynamic models into our fluid dynamics computation, we show that if the base of the mantle is partially molten, chemical heterogeneities introduced by fractionation processes at the core-mantle boundary will be sampled by plume-generated melts at the Earth's surface.

Our results explain some of the observed geochemical trends of oceanic islands and provide insights into how these trends may originate.