# Anatomy of the Hawaiian plume: Heterogeneity on many scales

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Tholeiitic magmas from the Hawaiian plume display a bewildering range of chemical and isotopic heterogeneities, with spatial scales ranging from micrometers to tens of kilometers. While some of the chemical variations are the result of progressive fractional melting processes, it is now clear that many of the chemical characteristics and all of the (radiogenic) isotope variations are tracking source heterogeneities. The smallest spatial scale is manifested by extreme chemical and isotopic differences between melt inclusions hosted by single olivine crystals and separated by only tens of micrometers (Sobolev et al., 2000). These observations indicate source heterogeneity of extreme amplitude and unknown, but probably small, spatial scale. Larger scales of source heterogeneity are evident from the Pb isotope stratigraphy of the 3000m drill core of the Hawaiian Scientific Drilling Project (HSDP-2). In addition to rapid oscillations of isotopic composition along specific mixing lines (in 206Pb/204Pb - 207Pb/204Pb - 208Pb/204Pb space), there are longer–wave-length changes, which can be related to the movement of the Pacific plate across the Hawaiian plume. Thus, 500 ka old Mauna Kea lavas appear to tap the same source composition as do present-day Kilauea lavas. The largest scale is evident from high-precision Pb isotope data and from certain trace element ratios (Sr/Nd, Sr/Zr, Zr/Y) in lavas from the two parallel lines of volcanoes, the “Loa trend” and “Kea trend.” The geochemical differences between these volcanoes are also evident from melt inclusion data, such as Nb/La and Sr/Ce ratios, which show distinct populations with little overlap, in spite of their extreme internal variability (see Sobolev et al., this meeting). These observations are not consistent with models of a concentrically zoned plume. Rather, they can be explained by a plume that is fed by a heterogeneous source at its base. The plume stem draws these heterogeneities out vertically, probably over hundreds of kilometers, causing extreme thinning and creating a spaghetti-like assemblage similar to the numerical model of Farnetani et al. (2002). The Loa and Kea trends represent a large-scale, lateral source heterogeneity, probably measuring several hundred kilometers in diameter, within the boundary layer where the plume originates.

## References

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# I-Xe ages and trapped Xe compositions

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I-Xe isochrons are mixing lines between a single trapped and a single iodine derived component. The slope of this line establishes initial iodine and hence the I-Xe age. One end of the isochron is fixed by the composition of the trapped Xe component, which should be representative of the Xe extant in the early solar system (Q-Xe or OC-Xe). Because the I/Xe ratio in the solar nebular was ~1, and the $^{129}$I/$^{127}$I was about $10^{-4}$, the $^{129}$Xe in trapped Xe cannot evolve in an open system. While it may be possible for Xe in a closed system with elevated I/Xe ratios to evolve producing trapped components with higher $^{129}$Xe/$^{130}$Xe ratios (Kennedy et al., 1988), trapped Xe compositions with *lower* (sub-planetary) $^{129}$Xe/$^{132}$Xe ratios seem unlikely. In general, isochron slopes (I-Xe ages) are much better constrained than end member (trapped Xe) compositions. High precision isochrons are required to convincingly constrain trapped compositions. Here we present new data and alternative explanations for sub-planetary trapped Xe.

I-Xe isochrons from 4 Allende CAIs and 6 Allende dark inclusions show two clustered groups of alteration ages, ~ 4 Ma apart, and a range of trapped Xe compositions, each determined with more precision than in previous studies (Swindle, 1998). By comparing irradiated and unirradiated samples, we confirm that the $^{128}$Xe/$^{132}$Xe ratios in the trapped components are identical to OC-Xe, but the isochrons often pass below OC-Xe, suggesting that the $^{129}$Xe/$^{132}$Xe ratios are lower than OC-Xe. We propose here, however, that it may not be the $^{129}$Xe that is anomalously low but the $^{128}$Xe (in irradiated samples) that is anomalously high, an alternative to the nebular chemical evolution model (Ozima et al., 2002). If $^{127}$I is intimately mixed with trapped xenon, it can result in a trapped Xe pseudo-component with an elevated $^{128}$Xe (after neutron irradiation). If this is true, it has important implications: a) similarly trapped, iodine can act much like an isotope of Xe, and b) trapping of iodine and Xe must have occurred late, after decay of most of the $^{129}$I, placing new constraints on the duration of aqueous alteration processes.

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## References

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