What is the origin of OIB?

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OIB Characteristics.

Compositionally OIB lie between depleted MORB and enriched Continental crust. As shown in fig.1, the OIB field is skewed towards the enriched end of the continuum, suggesting an enriched component in its source. High radiogenic Osmium and primordial Helium levels in OIB help to constrain the origin of its source, and most importantly precludes its generation from the mixing between depleted upper mantle MORB source and enriched delaminated subcontinental lithospheric slab components.

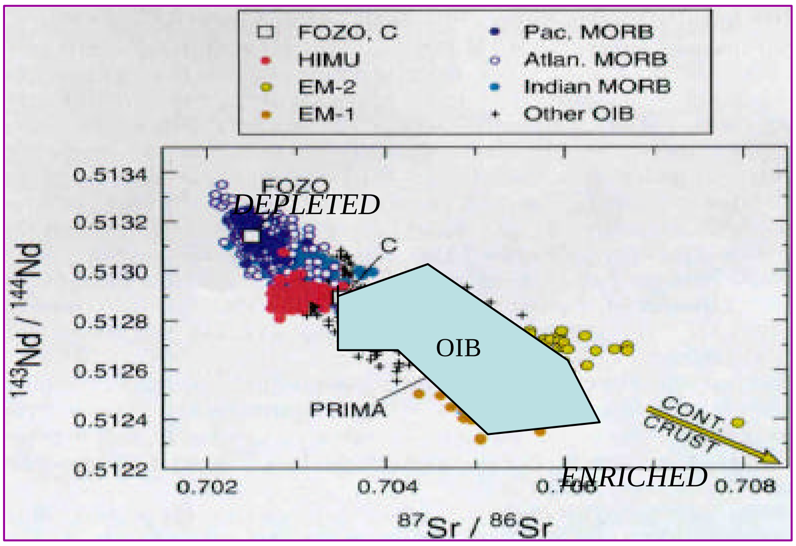

Fig.1 Sr/Nd isotope correlations Modified [Hofmann 1997.]

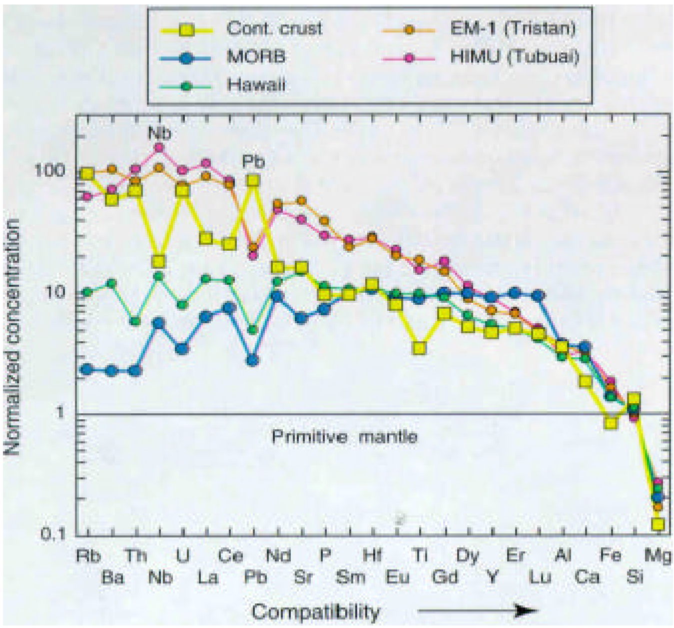

Fig.2 Incompatible element plots [Hofmann 1997.]

Melting of the OIB source– Implications for melt delivery mechanism.

Fig.2 illustrates that OIB are more enriched in the most incompatible elements (those furthest to the left) than MORB. Conventionally, on melting of a source rock the most incompatible elements preferentially partition into the initial small volume of melt formed. This melt can be said to be incompatible element enriched. As melting continues the volume of melt increases without any further input of incompatible elements. Subsequent melts are said to be incompatible element depleted. It is based on this principle that OIB are thought to represent smaller degree melts than MORB. However, emplacement of vast volumes of flood basalts, e.g. On Tong Java Plateau with 60×10^6 km^3 of material emplaced over a geologically short period of time (10Ma) requires efficient delivery of the melt produced.

The increased velocity of convection in a plume head, relative to that of the mantle, is a means by which the problem of reduced quantities of melt can be overcome.

Composite nature of OIB.

The heterogeneity displayed by OIB can be accounted for by a multi-component system comprising modern sediments (EM-2), recycled oceanic crust (HIMU), and oceanic lithosphere (EM-1), see fig.3 opposite. The convergence of these three components towards the FOZO (FOcal-ZOne) mantle component with elevated primordial helium (^{3}He) concentrations necessitates their reaching the deep mantle.

OIB provinces are arranged into 'arrays' based upon variation in isotope ratios. The diversity observed within a single province can be explained by the preferential sampling of one or more of the EM-1, EM-2 and HIMU components, but rarely all three. As illustrated over leaf, the examples of the Koolau and Kea trends from Hawaii show sampling of different parts of recycled subducted oceanic crust.

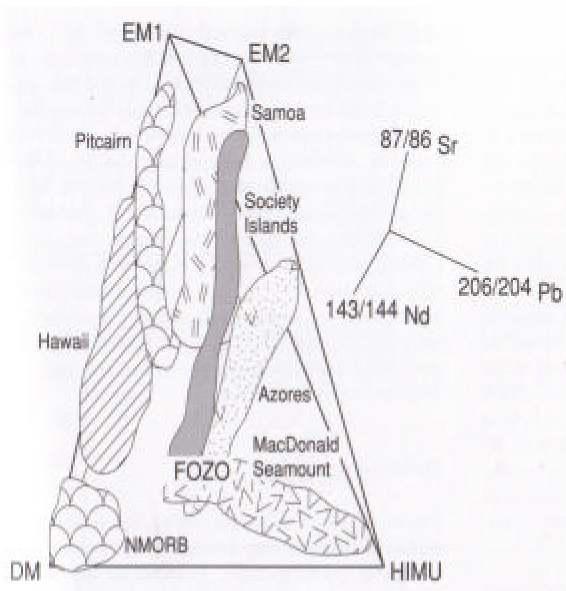

Fig3. 3D OIB endmembers [Condie 1997]

Recycling of Subducted oceanic crust.

Heterogeneity between the Koolau and Kea Hawaiian lavas provides evidence of sampling of different mantle components, see fig.4 adjacent. With high radiogenic Osmium and heavy Oxygen isotopes the Koolau endmember represents upper oceanic crust and modern sediments that have experienced little hydrothermal alteration and have acquired elevated ^{187}Os through decay of Remium naturally concentrated in oceanic crust. Thus the Koolau component represents mixing of EM-2 and HIMU.

Having unradiogenic Osmium and light Oxygen the Kea endmember is produced by melting of the recycled ultramafic lower crust and mantle lithosphere, EM-1, that has undergone ^{18}O removal through hydrothermal alteration.

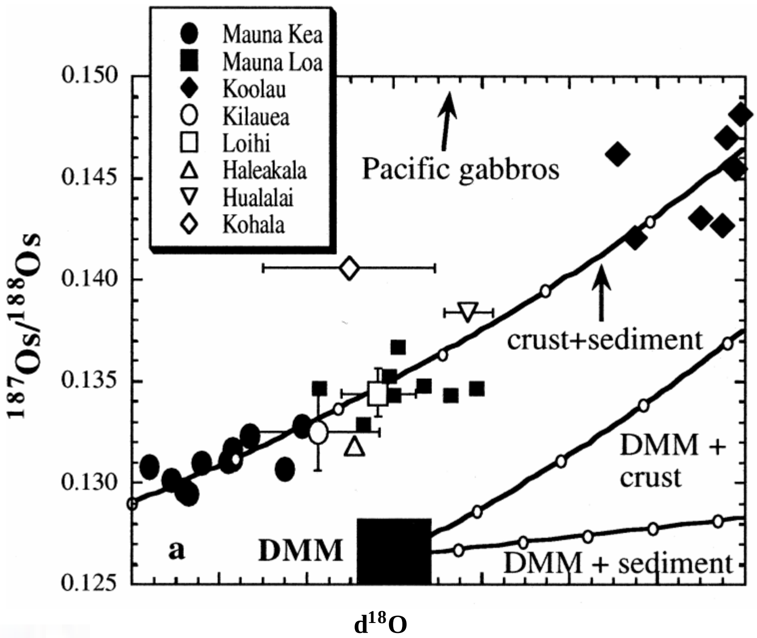

Fig.4 Koolau and Kea endmembers [Lassiter and Hauri 1997.

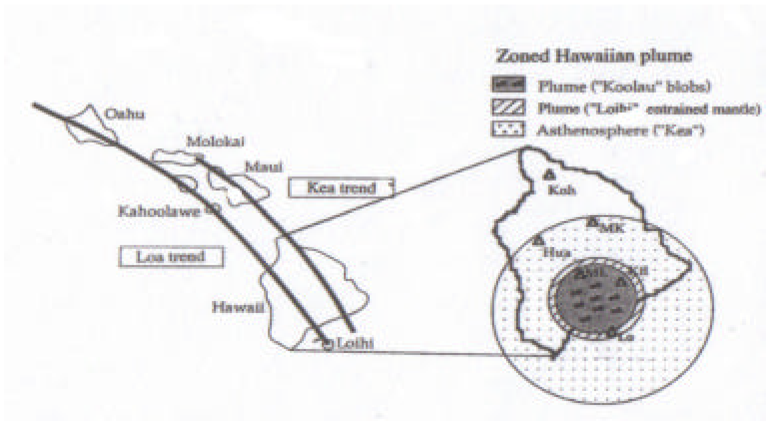

Fig.5 Concentrically zoned Hawaiian Plume model. [Hauri 1996]

Heterogeneous Plume model.

Major element correlation with isotopes is believed to account for major element variability in the mantle rather than differential partial melting for two reasons. Firstly, Mg#, a measure of the degree of partial melting, doesn't correlate with isotope values, and secondly, elevated ^{187}Os precludes melt-mantle interaction in the sub-oceanic lithosphere.

As shown in fig.5, Hauri 1996 calls upon an eclogite core to the Hawaiian plume, that on melting produces the spatially restricted high silica dacitic melts in the Koolau trend. Production of the Kea component with reduced silica contents is enabled through incorporation of surrounding asthenosphere.

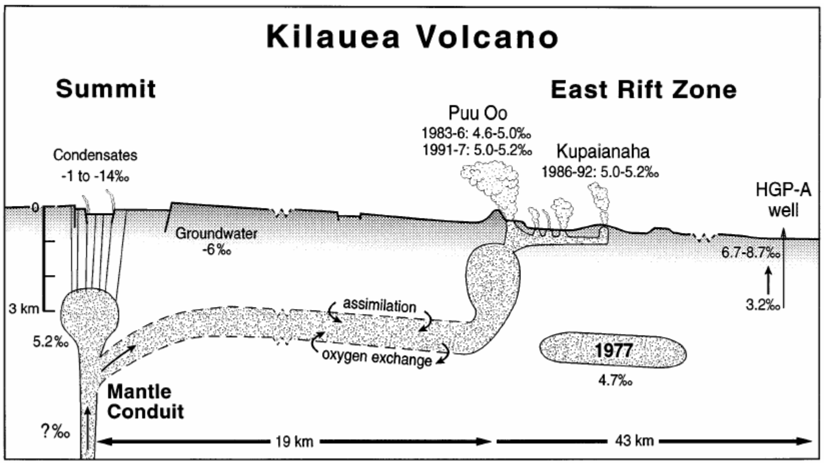

Fig.6 Wall rock assimilation– Kilauea Hawaii [Garcial 1998]

OIB Diversity.

Lavas of the Honolulu series contain a component that formed in the presence of residual amphibole (Class and Goldstein 1997), due to amphibole's sensitivity to heat, this component is restricted to the upper mantle. The pure OIB signature was lost through plume mixing with lithospheric oceanic mantle.

Fig.6 illustrates the process by which basic Kilauea plume derived magmas became altered through hydrothermal interaction with wall rocks during the period 1983-1986.

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