Recycled depleted lithosphere in the enriched mantle?

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Mid-ocean ridges create ten cubic kilometers of oceanic crust each year. Most of this material is subducted back into the mantle. Assuming spreading rates are constant this means that over the age of the Earth a volume equivalent to 90% of the whole mantle has been subducted as basaltic crust and accompanying depleted lithosphere. The question therefore is not are there signs of ancient subduction, but how do we recognize recycling in, most likely, every rock on the Earth's surface. Here we examine data for three oceanic volcanic chains, Hawai'i, Samoa and Walvis Ridge, that are argued to contain a significant recycled component.

Hofmann and White [1] proposed that the enriched mantle components find their origin in recycled crustal material and this theory had found wide acceptance. However, our recent Hf-isotope data in combination with Nd- and Pb-isotopes and trace element variations shows that in detail many variations are not consistent with the origin of the enriched endmembers being related solely to recycled crustal materials.

Hf-isotopes on the enriched basalts from the Koolau volcano on Hawaii have shown that the enriched Koolau endmember contains an ancient depleted lithosphere component and indicate that a recycled crustal component is not a dominant component. The existence of this depleted component in the Hawaiian plume is confirmed by the Os-Hf and Nd-Hf isotope variations in the peridotite and pyroxenite xenoliths respectively. Hf-isotopes on Samoan basalts (EMII endmember) have confirmed the presence of depleted lithosphere in the source and the combined trace element and isotope variation also shows the recycling of crustal material is not the dominant process causing enriched mantle signatures. Walvis Ridge is the "type" locality for Enriched Mantle I compositions, which is argued to originate from pelagic sediment. Characteristic for pelagic sediment contribution is a shallow slope on a Hf-Nd isotope correlation diagram. However, Walvis forms one the steepest slopes being inconsistent with pelagic sediments. Isotopic and trace element characteristics of the Walvis Ridge basalts are well correlated with low epsilon-Hf basalts showing low Sm/Hf, high Ce/Yb, high U/Th and high La/Nb, and point to mantle metasomatism for a large part of the isotopic and trace element variability.

References

[1] Hofmann A.W. and White W.M. (1982) Nature, **295**, 363.