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Ancient heterogeneities at the bottom of the Earth's Mantle?

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There is a clear record of ancient differentiation events in the Earth based on short-lived radioactivities (e.g. ^{129}I, ^{182}Hf, ^{146}Sm) and the corresponding events must have taken place during the Hadean era (4.56-4.0 Ga). Deciphering the heritage left by these events will prove crucial for understanding the present-day mantle dynamics. In particular, if dense or chemically distinct layers are stored at the bottom of the mantle, they may have a long-term effect on mantle convection. If the mantle evolved by magma ocean crystallization [1], the question is whether there is a preserved record of this early event. It has been suggested that an early differentiated crust had sunk to the bottom of the mantle as suggested from ^{142}Nd differences between the Earth and chondrite reference material [2].

This suggestion can be questioned because: (1) Chondrites themselves are not homogeneous with respect to their ^{146}Sm-^{142}Nd systematics and it cannot be proven that chondrites represent the exact parent material to the Earth, as for example the Earth itself is not identical to chondrites in its oxygen isotopes. (2) The early-formed crust has been argued to be granitic [3] rather than basaltic, which makes it to hard to stabilize in a boundary layer. (3) The requirement for a hidden reservoir, while being attractive needs to be quantified. We have estimated the composition of the hidden reservoir proposed in [2] and as it is extremely distinct with respect to its ^{142}Nd composition, it cannot contribute to more than 0.5% in mass to the source of hotspot material. If the early-formed dense crust is stored near the core-mantle boundary, there will be some leakage by entrainment. Jellinek and Manga [4] have shown that rising plumes are predicted to entrain up to 5-10 km of a dense layer located below a starting plume. Based on the maximum radius of mantle plumes determined in [5], the fraction of entrained

material represents at least a few %, which should be easily detectable in terms of Nd isotope signature. Nevertheless, no such isotope anomalies has been detected in any mantle-derived material [6]. It is perhaps safer to conclude that the Hadean crust has been re-mixed in the mantle as the only ^{142}Nd heterogeneities were found in ancient continental crust but not in mantle-derived material.

[1] Caro et al. (2005) Nature 436, 246-249, [2] Boyet and Carlson (2003) Science 309 576-581, [3] Harrison et al. (2005) Science 310, 1947-1950 [4] Jellinek and Manga (2002) Nature 418, 760-763, [5] Bourdon et al. (2006) Nature 444, 713-717 , [6] Caro et al. (2006) Geochim. Cosmochim. Acta 70, 164-191.