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High ^{3}He/^{4}He in the Deep Earth: Preservation of Primordial Mantle or Early Depletion?

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Several recent studies have highlighted how the highest ^{3}He/^{4}He basalts are as depleted as MORB. This is counter-intuitive and is inconsistent with the prevailing orthodoxy that considers the high ^{3}He/^{4}He reflects a lack of mantle degassing and depletion. Models fall into two general categories. Either the high ^{3}He/^{4}He-depleted mantle originates as a mix between unprocessed, primordial mantle and depleted mantle, or the primordial ^{3}He is present in a mantle reservoir that was depleted (and therefore partially degassed) early in Earth history and has remained isolated from further melting. Analysis of a newly collected suite of picrites from the early Tertiary basalt sequences on Baffin Island and West Greenland has now identified 23 samples with ^{3}He/^{4}He > 35 R_a (the highest value in recent volcanism). The significant peak of MORB-like ^{143}Nd/^{144}Nd observed in an earlier study (0.51298-0.51302; Stuart et al. 2003, Nature, 424, 57-59) remains, but it is now accompanied by eight lower values down to 0.51288. Crustal contamination cannot account for the unradiogenic Nd. The high La/Yb, positive ΔNb and low ^{143}Nd/^{144}Nd of several samples indicates that the high ^{3}He/^{4}He is present in basalts that are derived from a mantle source that is as enriched as the most enriched basalts from Iceland (Snaefelsnes) and the North Atlantic (Jan Mayen). We conclude that high ^{3}He/^{4}He is not uniquely associated with a depleted (high ^{143}Nd/^{144}Nd) mantle end-member that is common to deep mantle plumes. The data are consistent with the presence of primitive, primordial gas-rich heterogeneities in upwelling mantle at sites of intra-plate volcanism. The absence of the high ^{3}He/^{4}He-depleted component in upper mantle source of MORB suggests that the primitive mantle heterogeneities exist in the deep mantle.