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Variable depletion signatures in the oceanic upper mantle

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Melt depleted residual peridotites develop extremely radiogenic Hf-Nd isotope ratios over geologic time periods (10^8-10^9 years), because the parent-daughter ratios Sm/Nd and Lu/Hf increase dramatically with the extent of melt extracted. However, the great majority of the global abyssal peridotites plot in the field defined by global MORBs in Nd-Hf isotope diagrams, and only locally show Hf isotope ratios much higher than those in ridge basalts. Here, we report new Hf-Nd isotope data on mantle peridotites exposed at the Doldrums Fracture Zone at the Mid Atlantic Ridge (7-8° N). These peridotites reveal mantle isotopic heterogeneity on a kilometre-scale. The investigated peridotites can be grouped into residual peridotites and melt-modified (refertilized) samples. The refertilized peridotites preserve highly radiogenic Hf values (ƐHf up to 101) associated with MORB-like Nd isotopes (ƐNd up to 12), reflecting partial resetting of ancient highly depleted mantle by recent melt-rock interaction. The residual peridotites, on the other hand, have Nd-Hf isotope ratios similar to the local MORB (ƐNd = 7-12 and ƐHf =12-19), despite a very depleted incompatible element compositions. The residual peridotites thus most likely reflect highly depleted mantle that has been entirely reset by reaction with extracted or trapped melts during prior melting events, and hence developed with only modest incompatible element depletion until recent melting at the Mid Atlantic ridge axis, which led to the observed strong incompatible element depletion. The kilometre-scale association of such isotopically heterogeneous domains suggests that the upper mantle exposed in this portion of Atlantic formed by a combination of ancient melting and melt-rock reaction processes, preceding its renewed melting and variable extent of reaction with migrating below the present-day Mid Atlantic ridge axis.