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The case for pre-depleted peridotites on Macquarie Island and similarities with peridotites from Leg 209

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Macquarie Island (Southern Ocean) is a fragment of young (Miocene) ocean crust and upper mantle formed at a slow-spreading ridge system, uplifted and currently exposed above sea-level. As such, it is unique in the world and it is generally considered as an important type-locality of oceanic crust and mantle.

The crustal rocks on the island have unusual compositions: N-MORB are rare, ultramafic cumulates, gabbros and most dykes were made from E-MORB magmas (La/Sm=1-5), and volcanic rocks are E-MORB to ultra-EMORB (La/Sm=2-8). Trace element compositions are strongly correlated with isotopic compositions, with very little overlap between gabbros (e.g., $\varepsilon\mathrm{Nd}^{(9Ma)}$=+7.8-9.3) and volcanics ($\varepsilon\mathrm{Nd}^{(9Ma)}$=+7.2-8.3). These compositions are consistent with the slow-spreading ridge setting, where degrees of melting in the underlying mantle are small and where there is a high proportion of melts from mantle heterogeneities with low melting points such as pyroxenites.

Peridotites on the island, however, are ultra-depleted harzburgites which can be modeled as residues of $>$20% of near-fractional melting. Clinopyroxene is rare, and all clinopyroxene present was either exsolved from orthopyroxene or was formed by late-stage melt-rock reactions. The peridotites have a very strong imprint of melt-consuming melt-rock reactions, melt percolation and sub-solidus re-equilibration, all in a thick ($>$10 km) thermal boundary layer. These sub-solidus processes occurred in the absence of any significant crystal-plastic deformation, as the peridotites have preserved high-temperature, asthenospheric' microstructures. The depleted character

of the peridotites is inconsistent with the slow-spreading ridge setting as well as with the enriched character of the overlying crust, and must indicate a *previous depletion event*. Nd isotope ratios reflect the composition of the late-stage percolating melts and give no information about the age of the depletion event. This leaves open the question whether the depletion event is young or ancient.

There is a striking similarity with the abyssal peridotites from the Fifteen-Twenty Fracture Zone at the Mid-Atlantic Ridge (ODP Leg 209; Seyler et al., 2007; Kelemen et al, 2007). At this site peridotites are also ultra-depleted, much more depleted than peridotites from nearby sites along the Mid-Atlantic and also much more depleted than expected from a slow-spreading setting. Also, the peridotites from this site show evidence for extensive melt-rock reactions and sub-solidus re-equilibration in an abnormally thick thermal boundary layer. Osmium isotope ratios of these abyssal peridotites are among the least radiogenic in young mantle rocks, and are consistent with an ancient (1-2 Ga) depletion history (Harvey et al., 2006).

The remarkable similarity between Macquarie Island and the Fifteen-Twenty Fracture Zone abyssal peridotites, both showing evidence for a previous (ancient?) depletion event, leads us to ask the question why pre-depleted peridotites are found (preserved) at slow-spreading ridges with abnormally thick thermal boundary layers, and what (if any) global significance they may have.