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Mantle heterogeneity at a fast-spreading ridge revealed by crystal scale Pb-Nd isotopes in lower crustal gabbros

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The isotopic compositions of mid-oceanic ridge basalts (MORB) are commonly used to map the geochemical diversity of the upper mantle. However, MORBs have been homogenised by magma mixing prior to its eruption, and therefore does not faithfully capture the full heterogeneity of melts generated in its upper mantle source. To overcome this problem, we targeted cumulus minerals from gabbros and troctolites from the fast-spreading Hess Deep (East Pacific Rise) and performed the first coupled Pb-Nd isotope analysis of cumulus plagioclase to assess the isotopic heterogeneity of melts delivered to Earth's oceanic crust and hence that of the depleted upper mantle.

We characterised the major element distribution of 55 samples by SEM mapping to cover the full stratigraphic depth (>4000 m) of the Hess Deep oceanic crust. Of these, we selected 27 samples (covering the full range of textural types) for trace element (LA-ICPMS) and isotopic analysis. We then milled small volumes of selected primitive domains from cumulus plagioclase and clinopyroxene for Pb-Nd isotopic analyses by TIMS. These methods provide an integrated petrological and geochemical magmatic history through the oceanic crust.

We present the trace element and isotopic record through the Hess Deep oceanic crust and compare these to the whole-rock record from Hess Deep dykes and more widely along the length of the East Pacific Rise. Plagioclase and clinopyroxene $^{143}Nd/^{144}Nd$ values show limited variation and cover a similar range (0.51307 to 0.51322), which is largely within the precision of the measurements (±7-77 ppm 2SE). In contrast, plagioclase Pb isotopes show greater heterogeneity, extending far beyond analytical uncertainties ($^{208}Pb/^{204}Pb$ =17.70-18.09, $^{207}Pb/^{204}Pb$ =15.43-15.57, $^{206}Pb/^{204}Pb$ =37.42-37.68), validating the new coupled Pb-Nd isotopic approach. The Pb data do not vary systematically with depth but do show a range in $^{207}Pb/^{204}Pb$ beyond that of other single locations along the East Pacific Rise. Furthermore, the data show a departure in $^{207}Pb/^{204}Pb$ away from the NHRL and across the main trend of East Pacific Rise MORB that may indicate the involvement of an exotic mantle source previously unrecognised in EPR MORBs.