The heterogeneous Icelandic plume: constraints from Pb isotopes and trace element ratios

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 Although the volcanic rocks of Iceland have been the subject of numerous geochemical investigations, none has included both Pb isotopes and precisely determined trace-element ratios. This combination, when used together with existing petrological and geochemical data, has the potential to provide strong constraints on the composition and origin of the Iceland plume, the manner in which it interacted with surrounding mantle, and the way in which it melted.

We report here measurements on well documented (Hémond et al. 1988, 1993) mafic volcanic rocks from all parts of the island. Compositions range from picrite to alkali basalt and include the most common olivine and quartz tholeiites. Extended trace-element patterns show a wide range, from strong depletion of incompatible elements ((La/Sm)\textsubscript{N}=0.5) in the picrites, to moderate enrichment ((La/Sm)\textsubscript{N}=2.7) in the alkali basalts. Pb/\textsuperscript{206}Pb ratios vary from 18.0 in picrites to 19.2 in alkali basalts. These ratios correlate with both \textsuperscript{87}Sr/\textsuperscript{86}Sr and \textsuperscript{206}Pb/\textsuperscript{204}Pb and with Ce/Pb which is as low as 10.7 in picrites and as high as 46.8 in alkali basalts. In addition, Ce/Pb correlates both with Sm/Hf and with the size of positive Sr and Ba anomalies which are large and conspicuous in the picrites. In contrast with the strong correlation between chemical composition and rock type, there is no systematic relationship between isotopic or trace-element ratios and the geographic position of the samples. Correlations are also observed between Ce/Pb, Sr/Nd, Sm/Hf and \(\delta^{18}\)O which ranges from +3%o in the alkali basalts to +6%o in the picrites.

Even though some of the trace-element characteristics can be attributed to extreme fractionation during melting (Elliott et al., 1991), most of the variations that we report here cannot. The mantle-like \(\delta^{18}\)O of the picrites argues against an hydrothermal origin for the positive Sr and Ba anomalies and rules out an important role for interaction of magmas with the present Icelandic crust. Correlations between isotopic compositions and ratios such as Sr/Nd, Sm/
would therefore be the first clear example of differential melting of the various parts of a recycled oceanic crust within the mantle.

Both the Reykjanes Ridge Southwest of Iceland and the Kolbeinsey ridge to the North have isotopic compositions intermediate between that of North Atlantic depleted mantle and that of the Iceland plume. This provides evidence that the mantle is contaminated by the Icelandic plume on both sides of the island, and not only to the South.

References