In situ Pb isotope ratios in melt inclusions from oceanic island basalts: Mangaia, a case study

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The study of oceanic basalts has provided unequivocal evidence for a chemically heterogeneous mantle[1]. However, the nature, distribution and scale of these heterogeneities remain problematic. The aggregation of melts on their way to the surface, and magma chamber processes previous to eruption, obscure the characteristics of the different mantle sources. Although trace and major element studies of melt inclusions from high Mg# olivine phenocrysts have proved to be useful in defining the composition of unaggregated melts[2], the uncertainty remains in distinguishing if they represent different extents of melting from a single source or if they originate from different source compositions. To address these problems, we have measured Pb isotopes in single melt inclusion by 1270 ionmicroprobe; we chose Mangaia Island as a case study, because its lavas are isotopically homogeneous and they represent one of the end-member mantle components (HIMU)[3].

Melt inclusions, in olivine and clinopyroxene phenocrysts (Mg# 86–89) from two primitive lavas from Mangaia are partially crystallized and ellipsoidal in shape (30 to 300 μm), indicative of their primary nature. Partially resorbed clinopyroxene inclusions in the olivine also occur. Some of the melt inclusions contain FeCuNi sulphide and MgFeCa carbonate globules. The $(La/Yb)_{CN}$ ratios in the inclusions range from ~5 to ~40.

In-run precision for the Pb isotopic measurements range from 0.4 to 1% (2σ), depending on the Pb content of the melt inclusion. Loihi glass 158-4* previously analysed by TIMS[4] was used as a standard during the period of measurement of the melt inclusions. The Pb content of the inclusions are roughly the same as the standard. The ion probe analyses reproduced the TIMS value within <0.2% standard errors (2σ n = 17). The fractionation per amu (<0.15%) was smaller than the inrun precision. No indication of interference or hidryde was found in the Pb measurement.

Ion microprobe analyses of Pb isotope ratios ($^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$) within single melt inclusion from one sample show large and systematic variations that overlap with the whole field for HIMU lavas (Mangaia, Tubuai and St. Helena islands). The $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ ratios range from 0.706 to 0.768 and from 1.840 to 1.940 respectively, which is much larger than the range observed in Mangaia lavas (0.726 to 0.735 and 1.869 to 1.883)[5]. Sulphide and carbonate globules, also analysed for Pb isotopes, have isotopic compositions typical of HIMU, suggesting a primary origin. No clear correlation was found between $(La/Yb)_{CN}$ ratios and Pb isotopic composition.

The rough linear trend produce by the melt inclusions from one sample in $^{207}Pb/^{206}Pb$ - $^{208}Pb/^{206}Pb$ space reproduce the trend defined by the HIMU islands, indicating that lavas from Mangaia do not derive from a single homogeneous mantle source and geochemical models should consider at least two mantle sources. The HIMU Pb isotopic composition of the carbonate globules in conjunction with their textures and composition provide direct evidence for a carbonated mantle source for the Austral Islands.

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References

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