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Elemental and Pb isotopic compositions for characterization of Madeira "HIMU" hotspot

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The Madeira Island (32º44'N; 16º58'W) and conjugated Desertas Islet, encircled by the -200m isobath, are considered to represent a single volcanic edifice formed by the Madeira mantle plume. The emerged rocks present ages ranging from 5.57 Ma (Ech-chakrouni, 2004) to 6200 years B.P. (Geldmacher et al., 2000).

The present study focuses on several volcanic sequences from the Shield Stage, covering a period from 5.57 Ma to 1.27 Ma ($^{40}Ar/^{39}Ar$ method). The objectives of the study are to revaluate relative contribution of the source components through high precision analyses of Pb isotopic ratios carried out using MC-ICP-MS (Hf and Nd isotopic analyses are in progress). A detailed trace element study will be combined to help for characterization of the main evolution stages of Madeira mantle plume, i.e. melting extent and magma flux rate evolution.

For each sample, about 300 mg of powder was leached with 6N HCl (cf. method of Weis et al., in press). Samples were then digested using sub-boiled HF-HNO3 in Savilex Teflon vials. After separation of Pb by chromatographic columns (Weis et al., in press), Pb isotopic compositions were analyzed on Nu Plasma MC-ICP-MS with Pb/Tl ratios of ~ 5, value of the Pb/Tl of the standards. During the analysis session, twenty analyses of the NBS981 Pb standard gave mean values of $^{208}Pb/^{204}Pb$ = 36.7186$\pm$63 (2SD), $^{207}Pb/^{204}Pb$ = 15.4978$\pm$24 (2SD) and $^{206}Pb/^{204}Pb$ = 16.9411$\pm$23 (2SD).

Our new results show positive correlation between $^{206}Pb/^{204}Pb$ (19.0573 – 19.5649) and $^{207}Pb/^{204}Pb$ (15.5329 – 15.5648) or $^{208}Pb/^{204}Pb$ (38.7479 – 39.3494). All the

data plot beneath the NHRL on the $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{204}Pb$ diagram. $\Delta 7/4$ varies from -2.0 to -6.4 while $\Delta 8/4$ ranges from +9.8 to -11.6. Desertas Islet samples show the most radiogenic Pb isotopic compositions together with the lowest incompatible elements enrichment of the whole sample set that includes Madeira Island samples formed by concomitant magmatic activity.

Geldmacher & Hoernle (2000) stated that, for Madeira/Desertas volcanic complex, all Pb isotope ratios become less radiogenic with decreasing age. Our study demonstrates that this tendency is common within specific volcanic sequences. However, the new isotopic compositions obtained on a rock sample with the most ancient age ever reported for Madeira (5.57 Ma) are the least radiogenic. This observation suggests a more complex evolution of the Madeira mantle source than previously proposed by Geldmacher & Hoernle (2000) or Mata et al. (1998). The complexity of Madeira/Desertas mantle source/mechanisms is also demonstrated by comparing the isotopic and trace element signatures of coeval rocks: the synchronous and closely spaced (20 km) Machico (3.15 to 2.66 Ma) and Curral das Freiras (4.32 to 2.33 Ma) sequences are characterized by different trends on the Th/Yb vs. La/Sm diagram. They also display different Zr/Hf (38.0 vs. 42.8, respectively) and $^{206}Pb/^{204}Pb$ ($\leq$19.276 vs. $\geq$19.2936) values suggesting an heterogeneous mantle source. In addition, the Machico sequence shows quite homogeneous isotopic compositions (e.g. $^{206}Pb/^{204}Pb$ = 19. 2393 to 19.2760) as well as, for relatively unfractionated magmas (Ni $<$ 150 ppm), a large range of Th/Yb ratios (1.9 to 4.8) indicative of occurrence of several distinct partial melting events (different F values).

Further Hf and Nd analyses are in progress and will help to define the most representative isotopic signature of the Madeira mantle plume and to better constrain the source heterogeneities.

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