Nd-Sr-Hf-Pb Isotope Correlations in lavas from Lanai, Hawaii

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The extremes of Nd-Sr-Hf-Pb isotope compositions of shield-stage Hawaiian volcanoes are well documented in Koolau (relatively enriched isotopic signature) and Mauna Kea (relatively depleted isotopic signature). Koolau has much greater intravolcano isotopic variability than Mauna Kea. Based on an expanded data set for West Maui (Gaffney et al., this volume) and Lanai we show that this contrast in variability also holds for other volcanoes dominated by either the Koolau or Kea component.

We sampled several areas of Lanai to encompass the stratigraphically lowest and highest exposed flows. In three places we were able to collect short stratigraphic sections. Sample compositions span a significant part of the isotopic range of shield to late-shield lavas exposed in Hawaii. ε_{Nd} and ε_{Hf} range from –0.2 to +4.2 and +4.6 to +9.8, respectively, with no compositional gaps. The data are remarkably strongly correlated, with 18 of 20 samples within analytical error of the best-fit line. This correlation also holds for Nd-Sr isotope variation in which 21 of 24 acid-leached samples (including those of West et al., 1987) are within analytical error of a linear correlation.

$^{206}Pb/^{204}Pb$ (17.85 – 18.06) also correlates with Hf and Nd compositions. Although TIMS (Seattle) and MC-ICP-MS (Lyon) data for the same samples overlap within ana-lytical precision, correlated variation with $^{207}Pb/^{204}Pb$ is resolvable only by the higher precision data. In addition, when grouped by the stratigraphic section from which each sample was collected, each section describes just resolvable, subparallel linear trends in Pb isotope space.

The linear Hf-Nd trend implies little difference in endmember Hf/Nd ratios and simple binary mixing of two homogeneous sources. Linear extrapolation of the trend from ε_{Hf} of +9.8 (the most radiogenic Lanai sample) to +12.2 (the homogeneous average composition of Mauna Kea and West Maui) predicts a Nd isotope composition only 1 ε-unit lower than observed for Mauna Kea and West Maui. As observed in Mauna Kea (Abouchami et al., 2000), Lanai lavas also define multiple mixing lines in Pb isotope space that require binary mixing among more than just two components. Unlike Mauna Kea, however, mixing pairs may be associated with a stratigraphically discrete sequence of lavas.

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U-Pb SHRIMP dating of opals

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The applicability of U-Pb dating to uraniferous opal has been known for at least two decades (Ludwig *et al.*, 1980), but only recently has this technique been increasingly used in constraining the timing of surface processes (Neymark and Paces, 2000; Neymark et al, 2000; Ludwig and Paces, 2002). These studies revealed significant micro-scale variations of both U-Pb and U-series ages within the opal, emphasising a need for high spatial resolution analysis and driving subsequent attempts to use micro-analytical techniques for opal dating. Paces et al. (2000) presented results of the first successful application of SHRIMP for U-series analysis of opal. The aim of our study is to extend their work and develop analytical protocol for the U-Pb SHRIMP dating of opals.

U-series analysis of opal is relatively simple. Th/U ratios for unknowns are corrected using a ~2.2 Ma opal standard (Amelin and Neymark, 1999). This contains 800-1000 ppm of U, and has both $^{230}Th/^{238}U$ and $^{234}U/^{238}U$-activity ratios equal to one. Longer integration times (30-40 sec for less abundant isotopes and the background) and larger primary beams (15 to 50 nA) were used for these analyses, as compared to a standard zircon SHRIMP analysis, to improve the counting statistics. This had no visible effect on observed Th/U ratios; however, the longer sputtering using a stronger primary beam severely affected U/Pb ratios. It resulted in partial loss of conductivity at the end of a run and consequent drift of U/Pb ratios, which was unsupported by a change in UO/U ratios. To combat this problem intermediate run times and smaller primary beam currents (10-15 nA) were adopted.

Our U-Pb results for opals from both USA and Australia are comparable with the TIMS ages of these samples and support the potential for SHRIMP dating of opal.

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