Louisville seamount subduction: tracking mantle flow beneath the central Tonga-Kermadec arc

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Subduction of alkaline intraplate seamounts beneath a geochemically depleted mantle wedge provides a rare opportunity to study element recycling and mantle flow in some detail. One example of a seamount chain – oceanic arc collision is the ~2,600 km long Tonga-Kermadec arc, where midway the Cretaceous Louisville seamount chain subducts beneath the central Tonga-Kermadec arc system. Here subduction of a thin sediment package (~200 m) beneath oceanic lithosphere together with an aqueous fluid-dominated system allows to track geochemical signatures from the subducted Louisville seamounts and to better understand mantle flow geometry.

Geochemical analyses of recent lavas (<10 ka) from volcanic centers west of the contemporaneous Louisville-Tonga trench intersection (Monowai, 'U' and 'V') show elevated $^{206}Pb/^{204}Pb$, $^{208}Pb/^{204}Pb$ and to a lesser extend $^{87}Sr/^{86}Sr$ values but N-MORB-type compared to centers to the north and south (e.g. Turner et al., 1997; Haase et al., 2002; Timm et al., 2012) but mostly similar N-MORB-type ratios of fluid-immobile trace elements (e.g. La/Sm < 0.9).

This suggests that the observed geochemical anomaly above the subducted Louisville seamount chain is predominantly fluid-derived and hence different from other anomalies observed along the Tonga-Kermadec arc (e.g. Todd et al., 2011), interpreted to be pre-existing mantle heterogeneities.

Absolute pacific plate reconstructions indicates an anticlockwise rotation of the subducted Louisville seamount chain occurring in the chain older than oldest unsubducted Louisville seamount (~77 Ma old Osbourn seamount; Koppers et al., 2004) –a corollary to the westward kink of the Hawaii-Emperor seamount chain near the ~76 Ma old Detroit seamount (Duncan and Keller, 2004). If combined the geochemical anomaly and the geodynamic evidence is consistent with localized mainly fluid-derived input of Louisville material into partial mantle melts.

Finally, the combination of the geodynamic observation and estimates of the timing of fluid release from the subducting slab via U-series data (e.g. Bourdon et al., 1999; Caulfield et al., 2012) allows to determine the mantle flow geometry, which is primarily trench-normal mantle flow, although a slow southwards mantle flow of ~ 6cm/yr. is permissible (Timm et al., in press).

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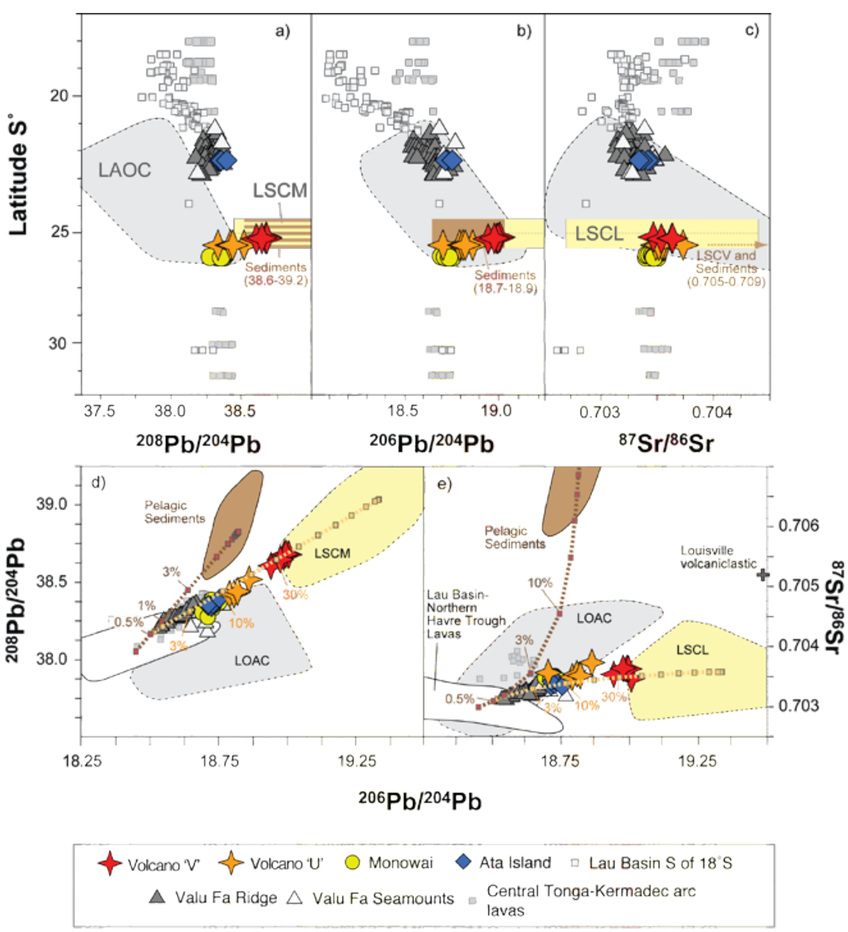

Figure 1. Pb and Sr isotope data, showing mixing calculations between the arc mantle and subducted Louisville material.