# History of the Samoan plume inferred from relationships between Pb-isotopes and olivine composition

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## Geochemical Observations

Olivines Mg#'s of non-xenocrystic olivine phenocrysts in Samoan main-stage basalts (SMB) show strong positive correlation with the host rock $Pb^{206/204}$($R^2$=0.80). Furthermore, these two chemical tracers show systematic variation with decreasing distance from the active end of the hotspot track: Olivine Mg#'s in SMB increase ($R^2$=0.80) while whole rock $Pb^{206/204}$ becomes more radiogenic ($R^2$=0.86). Additionally, olivine Mg#'s in SMB exhibit a good correlation with mantle Bouger anomalies along the Samoan volcanic chain ($R^2$=0.52).

## Model: Variable Lithospheric Thickness

The transitive relationship in SMB's among olivine Mg#, whole rock $Pb^{206/204}$, and distance from the plume can be explained by invoking a wedge-shaped lithosphere that is progressively thinner near the plume, consistent with the observed geographic progression of mantle Bouger anomalies. At the inactive end of the hotspot track where the lithosphere is thicker, low olivine Mg#'s result from magmas that experience more olivine fractionation; near the active end of the hotspot track where melts are generated at shallower depths, olivine Mg#'s are higher because the magmas suffer less olivine fractionation. Although olivine Mg# variations can be modeled by melting a homogeneous upper-mantle source at different depths, the isotope variations require contributions from two isotopically distinct sources. We suggest that the plume interacted more with depleted MORB mantle (DMM) farther from the plume-end of the hotspot track where the lithosphere is thicker, driving the Pb to less radiogenic values. Near the plume-end of the hotspot track where the lithosphere is thinner, Pb isotopic values more closely reflect plume mantle source.

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# LA-ICP-MS: A mature technology?

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LA-ICP-MS combines the speed and flexibility of pulsed UV laser sampling with the detection capability of an ICP-MS, and now the precision of a MC-ICP-MS, allowing rapid, *in situ* determination of trace elements and isotope ratios in minerals. The major advances in the technique have derived from the progression to shorter laser wavelengths – 1064 nm to the current industry standards, 213 and 193 nm. Shorter UV wavelengths have a reduced optical penetration depth in transparent matrices. This results in more controlled ablation and generation of smaller particles that are more efficiently transported and ionised [1], particularly for ablation in He.

Critical to the development of the technique has been the robustness of non-matrix-matched calibration using synthetic glasses, resins and liquids (e.g., oils) with an internal standard to correct for ablation yield. However, the technique suffers one major problem - a dynamic, ablation-related fractionation between more and less volatile elements and isotopes. Fractionation compromises accurate elemental analyses where internal standard and analytes have different fractionation characteristics. It is a major limiting factor on the precision of U/Pb determinations. Ablation-related isotopic fractionation also imposes a major limitation on many in situ isotopic analyses; e.g., for Cu, biases of up to ca. 4 per mil have been determined (ca. half the natural variation).

It is now established that a large proportion of ablation-related fractionation occurs in the ICP due to differential volatilisation of elements/isotopes during incomplete vaporisation of particles <0.5 microns in diameter [1,2]. Techniques that efficiently filter large particles, with low losses of small particles [3], will be evaluated.

Use of short wavelength lasers, which minimise inter-matrix differences in fractionation, and appropriate calibration procedures allow accurate trace element analyses and sub 1% external precision (1 r.s.d.) on $^{206}Pb/^{238}U$ determinations in zircon. Using MC-ICP-MS, precise and accurate *in situ* isotope ratio determinations are leading to major developments in Hf, Os, Cu and Fe isotope geochemistry. Examples of trace element analysis of native Au, U-Pb zircon dating and Cu isotope measurements will demonstrate the strengths and limitations of the techniques.

Improvements in sample transport efficiency through further reduction in ablated particle size, and development of robust ICP's that deliver improved volatilisation efficiency will significantly improve precision and detection limits, and minimise analytical biases – a mature technology, at last?

## References

[1] Guillong, M., and Günther, D. (2002), J. Anal. At. Spectrom. 17, 831-837.
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[3] Jackson, S.E., and Günther, D. (2003), J. Anal. At. Spectrom. **18**, 205-212.