

Variability of Mauna Loa melt inclusions

P. Armienti¹ and D. Gasperini¹

Results presented by Sobolev *et al.*¹ focus on the wide range of trace element and Sr, Nd and Pb isotope composition shown by melt inclusions found in early-liquidus, high magnesian olivines of Mauna Loa lavas. Such geochemical features are related by the Authors to “*enormous mantle source heterogeneity*” due to contamination by 200-650-Myr-old sea-water, occurred before subduction and recycling of ancient oceanic crust in the source of Mauna Loa rocks.

Sobolev *et al.*¹ supplementary data set has been used to perform some tests with their high temperature (T>1310°C), low temperature (T<1310°C), adjacent inclusions, and ultra depleted mantle samples.

Projection of these data in the CaTs-Ol-Q-Di diagram from the Di vertex² reveals that all the melt inclusions lay on an Olivine Control Line, whereas most of literature data on Hawaiian primary melts³ (Mg#≥64) **are not** controlled by olivine fractionation only.

In Figure 1, melt inclusions and primary melts³ are plotted on the basis of their equilibrium olivine composition and MgO molar fraction and compared with results obtained by the Olivine-Maximum Fractionation model^{4,5} and literature primary lavas. Sobolev *et al.*¹ melt inclusions are perfectly fit by a fractionation line controlled by a Fe/Mg partition coefficient (Kd) of 0.26 (starting composition : 1435a¹), while Hawaiian picrites lay on a control line fitted by Kd=0.30. Kd values vary in the range of 0.25 to 0.38⁶ and are directly proportional to ambient pressure. This leads to the plain conclusion that the olivine melt inclusions analyzed by Sobolev *et al.*¹ are related to low pressure olivine fractionation (up to 14% for less magnesian olivines), while major element composition of Hawaiian picrites are controlled by high pressure cumulus processes.

In conclusion, major element variability of olivine melt inclusions in Mauna Loa lavas is here proved to be strictly related to olivine crystallization at inclusions' walls, at low pressure and decreasing temperature.

In so doing it is probably worth to interpret trace element and isotope variability in these olivine trapped liquids as the effect of disequilibrium (isotope) fractionation. In this respect, the accurate analytical work performed by Sobolev *et al.*¹ does not document the presence of a heterogeneous source, rather representing a tool to explore poorly documented aspects of magmatic crystallization that are controlled by the kinetics of liquid-solid phase transition^{7,8}.

Figure caption

Fig. 1: Comparison of melt inclusion¹ (MI) compositions with trends calculated with the Olivine-Maximum Fractionation model⁴. Melt inclusions and model results are reported as equilibrium olivine composition $[Fo_{ol}^l = (MgO^l / FeO^l) / (Kd_{FeO/MgO}^{Ol/l} + MgO^l / FeO^l)]$ and melt MgO molar fraction at progressive steps of olivine fractionation and Kd values of 0.33, 0.30 and 0.26. Literature compositions of olivine melt inclusions and primary lavas of Hawaiian archipelago (Georoc data base: <http://georoc.mpch-mainz.gwdg.de/Start.asp>) are reported for comparison. Compositions of the investigated melts¹ perfectly fit the olivine fractionation trend for Kd = 0.26, that is restricted to the lower pressure range of olivine fractionation. Composition of Hawaiian primary lavas is not controlled in general by olivine fractionation. Literature data on olivine melt inclusions span in a wide range of compositions that are controlled by olivine fractionation only into a limited extent, identifiable by small and “local” trends of some data subset.

The olivine maximum fractionation model computations are performed with a program that can be downloaded at the address:

<http://www.dst.unipi.it/claroline185/claroline/backends/download.php?url=L29sX21heF9mcl9tb2RlbC54bHM%3D&cidReset=true&cidReq=SFTETNA>

References:

1. Sobolev, A. V., Hofmann, A. W., Jochum, K. P., Kuzmin, D. V & Stoll, B. A young source for the Hawaiian plume. *Nature* 476, doi: 10.1038/nature10321 (2011)
2. Armienti, P. & Longo, P. Three-dimensional representation of geochemical data from a multidimensional compositional space. *Int. J. Geosc.* 2, 231-239 (2011).
3. Armienti, P., & Gasperini, D. Do We Really Need Mantle Components to Define Mantle Composition? *J. Petrol.* 48, 693-809 (2007).
4. Pearce, T. H. Olivine fractionation equations for basaltic and ultrabasic rocks. *Nature* 276, 771-774 (1978).
5. Armienti, P., Gasperini, D., Perinelli, C. & Putirka, K. D. A new model for estimating deep-level magma ascent rates from thermobarometry: an example from Mt. Etna, and implications for deep-seated magma dehydration. *Acta Vulcan.* 21, 145-158 (2009).
6. Ford, C. E., Russel D. G., Craven, J. A. & Fisk, M. R. Olivine-Liquid equilibria: temperature, pressure and composition dependence of the crystal/liquid cation partition coefficients for Mg, Fe²⁺, Ca and Mn. *J. Petrol.* 24 (3), 256-266 (1983).
7. Watson, E. B. & Müller, T. Non-equilibrium isotopic and elemental fractionation during diffusion-controlled crystal growth under static and dynamic conditions. *Chem. Geol.* 267, 111-124 (2009).
8. Spandler, C., O'Neill H. St. C. & Kamenetsky. Survival times of anomalous melt inclusions from element diffusion in olivine and chromite. *Nature* 447, doi: 10.1038/nature05759 (2007).

Nature Precedings - doi:10.1016/npre.2011.6582.1 - Posted 8 Nov 2011

