Geophysical Research Abstracts
Vol. 19, EGU2017-5901-1, 2017
EGU General Assembly 2017

Evaluation of thermobarometry for spinel lherzolite fragments in alkali basalts

Kazuhito Ozawa (1), Nasrrddine Youbi (2), Moulay Ahmed Boumehdi (2), Dan McKenzie (3), and Hiroko Nagahara (1)

(1) Department of Earth and Planetary Science, University of Tokyo, Tokyo, Japan (ozawa@eps.s.u-tokyo.ac.jp), (2) Geology Department, Cadi Ayyad University, Marrakesh, Morocco, (3) Bullard Labs of the Department of Earth Sciences, Cambridge University, UK

Geothermobarometry of solid fragments in kimberlite and alkali basalts, generally called "xenoliths", provides information on thermal and chemical structure of lithospheric and asthenospheric mantle, based on which various chemical, thermal, and rheological models of lithosphere have been constructed (e.g., Griffin et al., 2003; McKenzie et al., 2005; Ave Lallemant et al., 1980). Geothermobarometry for spinel-bearing peridotite fragments, which are frequently sampled from Phanerozoic provinces in various tectonic environments (Nixon and Davies, 1987), has essential difficulties, and it is usually believed that appropriated barometers do not exist for them (O'Reilly et al., 1997; Medaris et al., 1999). Ozawa et al. (2016; EGU) proposed a method of geothermobarometry for spinel lherzolite fragments. They applied the method to mantle fragments in alkali basalts from Bou Ibalhatene maars in the Middle Atlas in Morocco (Raffone et al. 2009; El Azzouzi et al., 2010; Witting et al., 2010; El Messbahi et al., 2015). Ozawa et al. (2016) obtained $\sim$0.5GPa pressure difference (1.5-2.0GPa) for $\sim$100°C variation in temperatures (950-1050°C). However, it is imperative to verify the results on the basis of completely independent data. There are three types of independent information: (1) time scale of solid fragment extraction, which may be provided by kinetics of reactions induced by heating and/or decompression during their entrapment in the host magma and transportation to the Earth's surface (Smith, 1999), (2) depth of the host basalt formation, which may be provided by the petrological and geochemical studies of the host basalts, and (3) lithosphere-asthenosphere boundary depths, which may be estimated by geophysical observations. Among which, (3) is shown to be consistent with the result in Ozawa et al. (2016). We here present that the estimated thermal structure just before the fragment extraction is fully supported by the information of (1) and (2).

Spera (1984) reviewed various method of estimation of ascent rate of mantle fragments in kimberlite and alkali basalt; one based on fluid dynamics of transportation of entrapped fragments by giving the maximum size and viscosity of magma as a minimum estimate (Spera, 1980) and the other by coupling depth of fragment residence before the entrapment in a magma and time scale of heating by the magma. The depth of entrapment, however, is the least known parameter for spinel lherzolite. Because of nearly adiabatic ascent of magmas loaded with solid fragments, all the fragments underwent the same heating and decompression history with difference in entrapment depth and thus heating duration, from which the depth of their residence just before the extraction may be estimated if ascent rate is known. Therefore, extent of chemical and textural modification induced by heating and decompression may provide independent test for pressure estimation. We have used several reactions for this purpose: (1) Mg-Fe exchange reaction between spinel and olivine (Ozawa, 1983; 1984), (2) Ca zoning in olivine (Takahashi, 1980), (3) partial dissolution of clinopyroxene, (4) partial dissolution of spinel, and (5) formation of melt frozen as glass, which is related to (3) and (4).

The depth of melt generation is constrained to be deeper than 70km by modeling the trace element compositions of the host magmas using the methods of McKenzie and O'Nions (1991) and data from El Azzouzi et al. (2010). The host magmas can be produced by melting the convecting upper mantle without requirement of any input from the continental lithosphere. This is consistent with the positive gravity anomalies in the NW Africa showing shallow upwelling in this region allowing decompressional melting owing to the thinner lithosphere in the Middle Atlas.