



Thermobarometry for spinel lherzolite xenoliths in alkali basalts

Kazuhito Ozawa (1), Nasrddine Youbi (2), Moulay Ahmed Boumehdi (2), and Hiroko Nagahara (1)

(1) Department of Earth and Planetary Science, University of Tokyo, Tokyo, Japan, (2) Geology Department, Cadi Ayyad University, Marrakesh, Morocco

Application of geothermobarometers to peridotite xenoliths has been providing very useful information on thermal and chemical structure of lithospheric or asthenospheric mantle at the time of almost instantaneous sampling by the host magmas, based on which various thermal (e.g., McKenzie et al., 2005), chemical (e.g., Griffin et al., 2003), and rheological (e.g., Ave Lallemand et al., 1980) models of lithosphere have been constructed. Geothermobarometry for garnet or plagioclase-bearing lithologies provide accurate pressure estimation, but this is not the case for the spinel peridotites, which are frequently sampled from Phanerozoic provinces in various tectonic environments (Nixon and Davies, 1987). There are several geobarometers proposed for spinel lherzolite, such as single pyroxene geothermobarometer (Mercier, 1980) and geothermobarometer based on Ca exchange between olivine and clinopyroxene (Köhler and Brey, 1990), but they have essential problems and it is usually believed that appropriated barometers do not exist for spinel lherzolites (O'Reilly et al., 1997; Medaris et al., 1999). It is thus imperative to develop reliable barometry for spinel peridotite xenoliths.

We have developed barometry for spinel peridotite xenoliths by exploiting small differences in pressure dependence in relevant reactions, whose calibration was made through careful evaluation of volume changes of the reactions. This is augmented with higher levels of care in application of barometer by choosing mineral domains and their chemical components that are in equilibrium as close as possible. This is necessary because such barometry is very sensitive to changes in chemical composition induced by transient state of the system possibly owing to pressure and temperature changes as well as chemical modification, forming chemical heterogeneity or zoning frequently reported from various mantle xenoliths (Smith, 1999). Thus very careful treatment of heterogeneity, which might be trivial for geothermobarometry based on reactions with large and distinct volume changes, is necessary. Specification of mineral domains and their components representing the thermal state of the mantle just before xenolith extraction is one of the major tasks for the establishment of reliable geothermobarometry for spinel lherzolite xenoliths. Systematic variations of such mineralogical information among xenoliths transported by a single volcanic eruption guarantees proper estimation of a mantle geotherm.

For the development of such geobarometry, it is important to choose appropriate xenolith locality, where previous studies provide enough information and where many xenolith samples are available for extending a range of derivation depth. Spinel lherzolite xenoliths in alkali basalts from Bou Ibalhatene maars in the Middle Atlas in Morocco are suitable study target. Geochemical, geochronological, petrological, and rheological aspects of the spinel lherzolite xenoliths have been studied (Raffone et al. 2009; El Messbahi et al., 2015; Witting et al., 2010; El Azzouzi et al., 2010), which show that they represent fragments of the lithospheric mantle formed and modified since 1.7Ga before their extraction from Miocene to recent. We have pinpointed portions of minerals in the xenolith samples and their components representing condition just before their entrapment in magmas, on which appropriate geothermobarometers are applied and detected ~ 0.5 GPa pressure difference (1.5-2.0GPa) for $\sim 100^\circ\text{C}$ variation in temperatures (950-1050°C).