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Decoding thermal events before and during mantle xenolith extraction.

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Fragments of mantle materials extracted through volcanism (mantle xenoliths) are important source of information on lithospheric and asthenospheric mantle and their boundary region. We have been developing geobarometry for spinel peridotite xenoliths, which is crucial for reconstruction of the structures of thinner lithosphere, by exploiting geothermobarometers with weak but distinct pressure dependences as a useful depth estimator. In development of the geobarometry, we have noticed that thermal (and even ups-and-down) events on various time scales just before and during xenolith transportation is common in examined localities, which might be linked to the generation of the host magma that transported xenoliths themselves. This was pointed out long time ago by Irving (1976), who casted a doubt on the validity of paleogeotherms estimated by applying mineral equilibria to mantle xenoliths because of an inevitable genetic link between xenoliths and magma generation processes; chemical and thermal perturbation on “accidental fragments of the upper mantle” is inescapable not only during magmatic transport but also in generation of magmas in the vicinity of xenolith entrapment. There have been many studies on world xenolith localities arguing from diverse points of view that the lithospheric mantle underwent heating events.

In this paper, we will focus on thermal events just before and during xenolith extraction processes. We have picked up four xenolith localities for examination of the latest thermal events of xenoliths. They are Bou Ibalhatene maars in the Middle Atlas in Morrocco, Ichinomegata maar in northeast Japan, The Thumb in Colorado Plateau, and the Potrillo volcanic field in Rio Grande Rift. We found that they underwent longer heating event followed by shorter heating irrespective of their various tectonic environments. The former is inferred to have related to the host magma generation and its transportation through the lithospheric mantle, and the latter to extraction of xenoliths by the host magma. It is essential to carefully evaluate these events before application of the developing geobarometry, which must exploit subtle pressure dependence of geothermobarometers. Conversely, this gives depth variation of thermal history, which allows us to model the thermal events and dynamics took place around the lithosphere-asthenosphere boundary zone. We used geospeedometries based on kinetics of Mg-Fe exchange between olivine and spinel and Ca diffusion in olivine in contact with clinopyroxene. These two geospeedometries can cover slightly different time scale of thermal events, but is much shorter than temperature-sensitive components in pyroxenes, and allows us to correctly pin down appropriate mineral pairs and their location in grains and components for geobarometry.