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Numerical modeling of the incorporation of mantle peridotites into continental crust during continental collision

Elena Sizova (1), Christoph Hauzenberger (1), Taras Gerya (2,3), Harald Fritz (1), and Shah Wali Faryad (4)

(1) Department of Earth Science, University of Graz, Graz, Austria (elena.sizova@uni-graz.at), (2) Institute of Geophysics, ETH-Zurich, Zurich, Switzerland, (3) Geology Department, Moscow State University, Moscow, Russia, (4) Institute of Petrology and Structural Geology, Charles University, Prague, Czech Republic

Formation of continental collision zones has been an important subject for numerical modeling during the last few decades. The main purpose for such models is to simulate exhumation of deeply subducted crustal material back to the surface. Although a big progress has been done already, the correlation of model results with the natural collision zones remains still a challenge due to the complexity of the natural orogens. A marker for the prevailed exhumation model could be not only the metamorphosed crustal rocks themselves, but also mantle-derived peridotites, which are widely distributed in all collisional zones. The correlation of the peridotite incorporation into the crust with a certain exhumation regime has been done theoretically based on the petrological-geochemical data of peridotites, but has never been explored so far with numerical thermomechanical modeling. For this purpose we have performed a series of 2D petrological–thermomechanical numerical experiments to investigate the fate of mantle peridotites incorporated into the continental crust at different collision scenarios. Based on the results of the numerical experiments most of the mantle peridotites representing xenoliths in the exhumed continental crust come originally from shallow mantle depths (40 – 60 km). They could be either peaked up during crustal exhumation along subduction channel or vertical crustal extrusion, or could be involved in the subduction process reaching in some cases ultrahigh-pressure conditions together with the felsic continental crust, and then exhumed to middle – upper crustal depths. The peridotites from deeper and hotter overriding mantle or even underlying asthenospheric mantle (up to 90 – 120 km depth and 1400 ºC) have been discovered so far only in the experiments with trans-lithospheric diapirism, where continental crust subducts deep into the mantle, undergoes partial melting, penetrates lithosphere – asthenosphere boundary, and due to high prescribed melt/fluid weakening rises vertically penetrating through the lithosphere of the overriding plate. Some eclogitic bodies formed from subducted oceanic basalts stacked initially in mantle wedge could be incorporated and found together with peridotites. None of the performed experiments allows oceanic lithospheric mantle to be involved into exhumation process. As a natural example, we discuss the peridotites from the granulites and gneisses of the Gföhl Unit in the Bohemian Massif. The Bohemian Massif is a well-preserved part of the Middle to Late Paleozoic Variscan Orogen in Europe with wide varieties of igneous and metamorphic rocks documenting both subduction and collisional events. Diverse types of the peridotites located in the Gföhl Unit showing a wide range of pressure – temperature parameters could be used as markers for the deep processes most likely including different exhumation mechanisms for the continental crust.