Geophysical Research Abstracts
Vol. 12, EGU2010-5928, 2010
EGU General Assembly 2010

Using garnet peridotites as tools to reconstruct paleo-geodynamic settings of fossil continental collision zones

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Orogenic garnet peridotites (metamorphic rocks containing the characteristic HP garnet-olivine mineral assemblage) form volumetrically minor, but important components of (ultra)high pressure (UHP) metamorphic terranes. Such terranes form along convergent plate margins where two adjacent plates collide and one of the plates is subducted below the other. After eduction back to the surface such fossil continental subduction/collision zones form the basic components of exposed (U)HP metamorphic terranes.

In the absence of significant amounts of tectonic overpressure (Vrijmoed et al., 2010), the discovery of diamond and majoritic garnet in (U)HP metamorphic terranes provide evidence that subduction of continental crust into the mantle was deep enough to reach the garnet stability field in the overlying mantle wedge above the subduction zone. Brueckner (1998) was the first author who noticed that garnet peridotite bodies, present in such mantle wedges, could be transferred during collision from the mantle wedge into the subducted continental crust. Subsequent buoyancy, most likely generated by slab break off of previously subducted oceanic crust, is the most likely candidate to enable the subducted continental crust and its garnet peridotite "cargo" to return back to (sub)crustal levels. During the latter process mantle wedge garnet peridotite may recrystallize (partly or completely) into what will be called here subduction zone garnet peridotite. Alternatively subduction zone garnet peridotite may be formed by prograde subduction of ultramafic protoliths (serpentinites, Fe-Ti peridotite) that may be present in subducting continental crust prior to subduction. Subdivision between these two basic types of orogenic garnet peridotites (mantle wedge - versus subduction zone peridotite) allows however that in mantle wedge garnet peridotite the subcontinental lithospheric mantle (SCLM) - versus crustal-incorporation processes can be identified which a.o. has lead to the recent recognition of a complete new, deep-seated, subcratonic, lithospheric mantle setting. In addition better characterization of SCLM processes in mantle wedge garnet peridotite will also allow for further subdivision of SCLM wedges into different subtypes that all may be present during collision in the hanging wall of a fossil collision/subduction system. In the following we will present the basic outlines of such a mantle wedge classification system.

A simple "conceptual" model will be presented that will allow orogenic mantle wedge garnet peridotite to be used as a tool to reconstruct the former paleo-geodynamic setting of the collision/subduction system. Using field, petrological, geochemical, geochronological and geothermobarometric criteria, all of which can be analysed directly in the mantle wedge garnet peridotite body itself, the model allows for discrimination between four different end-member types within the SCLM (equivalent to young/hot/dynamic- versus cold/old/static mantle in thick or thin garnet-olivine bearing mantle wedges). In addition our conceptual model is based on the fundamental assumption that all SCLM was once formed by rising, accretion and cooling of hot asthenospheric mantle. Note also that all mantle wedge end member types may become overprinted by the subduction zone type. The latter, when complete, may evidently erase all former mantle wedge evidences.

To test the applicability of our model we have applied the proposed mantle wedge classification system to well studied orogenic garnet peridotites of the Caledonian Orogeny in Scandinavia and the Triassic Sulu-Dabie Orogeny in China. Results will be presented.

References: Brueckner (1998). Geology 26, 631-634; Vrijmoed et al. (2010). Eur. J. Mineralogy.