Geophysical Research Abstracts
Vol. 13, EGU2011-6581, 2011
EGU General Assembly 2011

Rheological impact of partial melting on the subducting continental crust

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Partial melting textures were recognized in continental crust portions, buried in the Ultra High Pressure (UHP) eclogite facies during collision and then exhumed in the internal zones of mountain belts, like in the Western Gneiss Region (WGR), Norwegian Caledonides. The published pressure-temperature paths for WGR eclogites cross the wet solidus for granites at their pressure peak in the eclogite facies conditions. This apparent coincidence shows us that partial melting is thermodynamically possible at the maximum depth of burial of the WGR. No direct clues of partial melting at the metamorphic pressure peak in the WGR have been recognized yet and only few indirect evidences are reported from other UHP domains. However, partial melting in the UHP eclogite domain would have important rheological consequences for the continental crust rheology during its pressure-temperature history.

To constrain the relationship between melt compositions and partial melting conditions, a series of piston-cylinder experiments have been performed at ISTO Orléans, on natural samples from the Western Gneiss Region. The comparison of natural leucosomes from UHP and HP domains from the Western Gneiss Region with the results of published partial melting experiments on metapelites and melts from new experiments on Norwegian gneiss show that partial melting must have begun as soon as the very pressure peak of the buried Baltica continental slab. Natural leucosones are granitic to trondhjemitic in composition with Na-rich melts associated to UHP domains and early stages of extraction, according to textural relationships. Piston-cylinder melting experiments on a biotite and muscovite gneiss from Drage (WGR) at 2.5 GPa, 800/850°C and with 5-10 % of water show the production of melts from 800°C onward. The melts have a granitic composition, with a higher Na content at lower temperature and lower bulk water content reproducing known trends for experimental partial melting glasses. Garnets show a systematic overgrowth with a lower grossular content at higher temperature. Phengite breakdown enhances partial melting and leads to the production of large melt amounts (>40%). The experimental glasses compositions trend compares with the natural WGR leucosomes scatter, the early trondjhemitic natural melt being close to melts obtained under the lowermost experimental thermal gradients, similar to realistic continental subduction gradient. This implies that melts were produced all along the retrograde path of the WGR continental slab, beginning as early as the pressure peak.

The weakening effect of partial melting being considered as decisive from the first percentages of melt (corresponding to melt connectivity transition), it must have acted as a decoupling process of the continental crust and initiated its exhumation.

Keywords: Western Gneiss Region, partial melting, HP, piston-cylinder, melts