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Impact of textural anisotropy on syn-kinematic partial melting of natural gneisses: an experimental approach.

Anne-Céline Ganzhorn (1,2), Pierre Trap (3), Laurent Arbaret (2), Rémi Champallier (2), Julien Fauconnier (1), Loic Labrousse (1), and Gaëlle Prouteau (2)

(1) Pierre et Marie Curie, ISTeP, Paris Cedex 05, France (anne-celine.ganzhorn@upmc.fr), (2) Université d'Orléans, ISTO, Orléans, France, (3) Université de Franche Comté, Besançon, France

Partial melting of continental crust is a strong weakening process controlling its rheological behavior and ductile flow of orogens. This strength weakening due to partial melting is commonly constrained experimentally on synthetic starting material with derived rheological law. Such analog starting materials are preferentially used because of their well-constrained composition to test the impact of melt fraction, melt viscosity and melt distribution upon rheology. In nature, incipient melting appears in particular locations where mineral and water contents are favorable, leading to stromatic migmatites with foliation-parallel leucosomes. In addition, leucosomes are commonly located in dilatants structural sites like boudin-necks, in pressure shadows, or in fractures within more competent layers of migmatites. The compositional layering is an important parameter controlling melt flow and rheological behavior of migmatite but has not been tackled experimentally for natural starting material. In this contribution we performed in-situ deformation experiments on natural rock samples in order to test the effect of initial gneissic layering on melt distribution, melt flow and rheological response. In-situ deformation experiments using a Paterson apparatus were performed on two partially melted natural gneissic rocks, named NOP1 & PX28. NOP1, sampled in the Western Gneiss Region (Norway), is biotite-muscovite bearing gneiss with a week foliation and no gneissic layering. PX28, sampled from the Sioule Valley series (French Massif Central), is a paragneiss with a very well pronounced layering with quartz-feldspar-rich and biotite-muscovite-rich layers. Experiments were conducted under pure shear condition at axial strain rate varying from 5*10-6 to 10-3 s-1. The main stress component was maintained perpendicular to the main plane of anisotropy. Confining pressure was 3 kbar and temperature ranges were 750°C and 850-900°C for NOP1 and PX28, respectively. For the 750°C experiments NOP1 was previously hydrated at room pressure and temperature. According to melt fraction, deformation of partially molten gneiss induced different strain patterns. For low melt fraction, at 750°C, deformation within the initially isotropic gneiss NOP1 is localized along large scales shear-zones oriented at about 60° from main stress component $\sigma 1$. In these zones quartz grains are broken and micas are sheared. Melt is present as thin film ($\geq$20 μm) at muscovite-quartz grain boundaries and intrudes quartz aggregates as injections parallel to $\sigma 1$. For higher melt fraction, at 850°C, deformation is homogeneously distributed.
In the layered gneiss PX28, deformation is partitioned between mica-rich and quartz-rich layers. For low melt fraction, at 850°C, numerous conjugate shear-bands crosscut mica-rich layers. Melt is present around muscovite grains and intrudes quartz grains in the favor of fractures. For high melt fractions, at 900°C, melt assisted creep within mica-rich layers is responsible for boudinage of the quartz-feldspar rich layers. Melt-induced veining assists the transport of melt toward inter-boudin zones. Finite strain pattern and melt distribution after deformation of PX28 attest for appearance of strong pressure gradients leading to efficient melt flow. The subsequent melt redistribution strongly enhance strain partitioning and strength weakening, as shown by differential stress vs. strain graphs.
Our experiments have successfully reproduced microstructures commonly observed in migmatitic gneisses like boudinage of less fertile layers. Comparison between non-layered and layered gneisses attest for strong influence of compositional anisotropies inherited from the protolith upon melt distribution and migmatite strength.