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Experimental study of continental crust partial melting: rheological and microstructure effects.

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Deformation on the orogen-scales involves localization due to weakening, and partial melting of the continental crust is one of the most important weakening agent. In order to understand the causes of melt-induced weakening and the way melt moves through an anisotropic medium (generally consisting of a foliation and/or layering) we conducted a series of high-pressure experiments to deform partially molten, crustal-like materials and compare the experimental microstructures with those of natural migmatites. Deformation experiments were performed in simple shear mode in a Griggs-type apparatus. The starting material consists of 90% quartz powder (crushed Fontainebleau sandstone; 10 to 20 μm grain size) and 10% biotite powder (50 to 100 μm grain size). In order to control the amount of melt, 5% to 10% of haplogranitic glass (HPG) were added to the starting material. Experiments were performed in the biotite stability field, but above the HPG transition temperature (1 GPa confining pressure, temperature between 700°C and 900°C). Deformation took place at a strain rate of 10-5 s-1,to a finite shear strain of up to $\gamma \approx 4$. Our first results show the following features: (1) The presence of melt weakens the sample only during the first increments of deformation (below $\gamma \approx 2$) compared to experiments without glass. (2) Small amounts of weak phase (5% HPG or 10% biotite) result in the nucleation of shear bands which localize deformation. (3) Larger amounts of melt (10% HPG) are associated with weakening by a factor of 3 compared to 5% melt samples, accompanied by a more homogeneously distributed deformation and absence of shear bands. The increase from 5 to 10% HPG changes the microstructures from dominant crystal plasticity of quartz to microstructures indicating grain boundary sliding. (4) Surprisingly, the weakening caused by 5% HPG in a pure quartz sample at 800°C (i.e. 5% melt) is very similar to the weakening effect of 10% biotite (after $\gamma \approx 2$) without melt. Further experiments and quantitative analysis of microtextures is under progress. Natural migmatites from the Western Gneiss Region and Vestranden Gneiss Complex (western Norway) will be use as natural references.