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High Temperature and Pressure Deformation of Mafic Granulite: Implications for Strength of the Continental Lower Crust

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Recent years have seen many efforts and debates on the rheological properties of continental lower crust that is thought to be composed of mafic granulite. The controversy focuses on whether the lower crust is strong or weak mechanically when compared with the upper mantle and the upper crust. To solve this problem requires detailed knowledge of the rheological properties of mafic granulite. However, because of technical issues in experimental rock deformation, there are very few data on this problem. Here we report the rheology and fabrics of a reconstituted, fine-grained (32-53 μm) nominally dry (i.e., no hydrous mineral) mafic granulite (57% plagioclase + 24% clinopyroxene + 14% orthopyroxene + 5% opaque minerals, 0.16-0.28 wt.% H_2O) deformed at 1.1-1.2 GPa pressure in a modified Griggs-type deformation apparatus. The rheology of this mafic granulite can be described by the constitutive equation of

$$\dot{\varepsilon} = A\sigma^{3.2\pm0.4}\exp(-\frac{244\pm35kJ/mol}{RT})$$

where is in s^{-1}, σ in MPa, T in Kelvin and $A = 10^{-2.0\pm1.6}$ $MPa^{-3.2}s^{-1}$. Our results provide new experimental evidence in support of the "jelly sandwich" lithosphere strength model and imply that mafic granulite with a moderate amount of water (>0.05-0.08 wt.% H_2O) is likely to be a weak layer in the lithosphere. Both pyroxenes and plagioclase develop pronounced fabrics in responding to axial deformation. The deformation mechanism is dislocation creep with (100)[001], and (001)[100]/(010)[100] being the dominant slip systems for pyroxenes and plagioclase, respectively. The low strength of mafic granulite is ascribed largely to the significant weakening effect of dissolved water in pyroxenes and plagioclase. We hypothesize that a weak lower crust will decouple from the eclogitic lower crust or the upper mantle when they are subjected to deformation, lending a way for delamination of the dense lithosphere and crustal uplift. In addition, a low-viscosity lower crust could act as the avenue for lateral crustal flow, which in turn helps to maintain a low relief surface.

Key words: mafic granulite; continental lower crust; rheology; lattice preferred orientation

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