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Rheology of granulite at high temperatures and wet conditions

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Samples of natural granulite were deformed in a gas medium apparatus to evaluate the flow strength of the lower crust. The samples were collected at Wayaokou village, Huai'an, Hebei province, China. The sample consists of ∼52 vol % plagioclase, ∼40 vol % pyroxene, ∼3 vol % quartz, ∼5 vol % magnetite and ilmenite. Water content was ∼0.17±0.05wt% in the deformed samples. 40 creep tests were performed on 13 samples at 300 MPa confining pressure, temperatures of 900∼1200˚C, and strain rates between 3.13×10^{-6} ∼5×10^{-5}/s, resulting in axial stresses of 12∼764 MPa and the total strain up to 7.8-20.5%.

The sample strength decreased with increases in temperature and decreases in strain rate. The microstructural observations show that the granulite samples were deformed in semi-brittle region, with mainly dislocation glide with apparent intragranular microcracks at low temperatures of 900˚C-1000˚C. Based on the mechanical data , creep parameters were obtained with stress exponent n_{MT} of 5.7±0.1, activation energies Q_{MT} of 525±34kJ/mol, $logA_{MT}$ of 1.3, corresponding to grain boundary migration recrystallization at medium temperatures(MT) of 1050-1100˚C. The parameter of n_{HT} of 4.8 ± 0.1,Q_{HT} of 1392±63kJ/mol, $logA_{HT}$ of 37.5, corresponding to mainly grain boundary migration recrystallization accommodated with partial melting and metamorphic reaction characterized by neo-crystallization, forming-grained olivine at high temperatures(HT) of 1125 - 1150˚C. Partial melting at high temperature of 1125-1200˚C, which induced grain boundaries slip and diffusion, has a significant weakening effect on the rheology of granulite, with an estimated strain rate enhancement of 5 times at 1140-1150˚C by ∼2 vol% melt present at grain boundaries. This study was supported by the National Natural Science Foundation of China (41374184) and State key laboratory of Earthquake Dynamics (LED2013A05, LED2015A04).