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Melt and reaction effect to rheology of mafic granulte under wet condition, implication on strength of lower crust

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Understanding the rheological properties of the continental lower crust (CLC), particularly its response to water, is vital for comprehending various geodynamic processes within the Earth. In this study, two groups of clinopyroxene–plagioclase aggregates, which serve as representative samples of the CLC, were hot pressed in a Paterson gas-medium apparatus with “as is” and additional water. Subsequently, deformation tests were conducted on the hot-pressed samples in the same apparatus, under a confining pressure of 300 MPa, temperature of 1,173–1,423 K. Mechanical data revealed that axial stresses between 15–464 MPa and total accumulated finite strain values between 12%–20%. The resulting mechanical data were analyzed and fitted to a flow law, yielding a stress exponent (n) of 3.6±0.6 and activation energy (Q) of 504±85 kJ/mol for the “as is” samples, and n = 3.7±1.4 and Q = 347±48 kJ/mol for water-added samples. Microstructural observations revealed that the deformed samples exhibited a shape-preferred orientation (SPO) and crystallographic preferred orientation (CPO) with subgrain boundaries in coarse-grained domains, indicating that the primary deformation mechanism is dislocation creep. Additionally, the presence of melt, neoformed phases (olivine + orthopyroxene) and abundant fine-grained particles all show subsidiary dissolution-precipitation creep, and the subsidiary dissolution-precipitation creep played an important role under higher temperature and higher water content conditions. The overall reduction in average grain size resulted in deformation under the grain-size-sensitive creep regime, leading to a notable decrease in sample strength. Overall, these findings confirm the “jelly sandwich” concept of the continental lithosphere by showing that the lower crust is relatively weaker than the upper crust and uppermost mantle. This research has been supported by the National Natural Science Foundation of China (Grants No. 42472291).