A unified dependence of dislocation creep on water fugacity in clinopyroxene

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Clinopyroxene, a major rock-forming mineral in the lower crust and upper mantle, contributes significantly to the rheology of the lithosphere that dominates plate tectonics. A large number of studies have confirmed that cpx is the most 'hydrous' nominally anhydrous mineral (NAM) in the lower crust and upper mantle. Quantitative water weakening studies on cpx have been sparse and controversial. Under water-unsaturated conditions, a series of axial compression deformation experiments were carried out to investigate the effect of water on the rheology of cpx aggregates at a constant temperature of 1000 °C, confining pressure of 1.0 GPa, and strain rate of 5×10^{-5} s^{-1}. The flow strength of cpx aggregates decreases exponentially with the increase in the water content, corresponding to a water content exponent of 1.5 ± 0.15 or a water fugacity exponent of 1.7 ± 0.15. A unified water content exponent of 1.8 ± 0.15 is derived from all available data of cpx flow strength versus water content. The water weakening effect in cpx is higher than that for olivine (r = 0.33-1.25) and plagioclase ($r = 1.0 \pm 0.3$). The flow strength of cpx is similar to that of plagioclase but weaker than that of olivine in lithosphere where a wet condition should apply. Our new results imply a weak lower crust in the lithosphere and support the "jelly sandwich" continental lithosphere strength profile model.