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Low lithospheric effective strength is indicated by global convection simulations with self-consistent plate tectonics

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During the last 20 years it has become routine to simulate plate tectonics in global mantle convection models using a combination of strongly temperature-dependent viscosity and plastic yielding, parameterised using either a yield stress or friction coefficient. Such models are successful in explaining some of the major global characteristics of plate tectonics including the oceanic age-area distribution (Coltice et al., 2012 Science) and the plate size distribution (Mallard et al., 2016 Nature).

However, a major problem with such models is that the values of yield stress or friction coefficient needed to obtain plate-tectonic-like behaviour are a factor of 5-10 lower than those measured in laboratory experiments. Specifically, yield stresses in the range 30-100 MPa or friction coefficients of around 0.05 are commonly required - higher values lead to a stagnant lid.

Several physical complexities have been found to reduce this gap between numerical and laboratory findings, facilitating plate tectonics for higher values of yield stress. These include the presence of continents (Rolf et al., 2011 GRL), the presence of laterally-varying crust formed by partial melting (Lourenco et al., 2016 EPSL), the presence of weak hydrated crust in the subduction channel (Gerya et al 2008 Geology; Crameri et al., 2012 GRL) and abundant igneous intrusion (Lourenco, 2017 PhD Thesis). Nevertheless there is still a large gap and another explanation for the effective weakness of the lithosphere is required.