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The long-term rheology of continental lithosphere: validating experimental data from real-scale observations and physically consistent models of geodynamic processes

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The lithosphere may exhibit elastic, brittle-plastic and viscous-ductile properties. Rock mechanics experiments infer that a large part of the long-term lithospheric strength may be supported in the visco(ductile)-elastic regime. Yet, rock mechanics data refer to very high strain rates (10 orders of magnitude faster than natural ones), small, often mono-mineral, rock samples, simple loading conditions and specific fluid contents. Therefore they cannot be univocally applied to aggregated rocks at real conditions, geological time and spatial scales without additional parameterization. The only adequate parameterization would be based on real-time and space scale observations of lithosphere deformation in-situ. On practice, such observations refer to indirect interpretations of various kinds of data. New, solid insights may be obtained from large-scale thermo-mechanical models that reproduce lithospheric behavior while fitting multi-disciplinary sets of large-scale geophysical and geological data. For oceans, Goetze and Evan's brittle-elastic-ductile yield strength envelopes were successfully validated by models of plate flexure that have yielded robust estimates for the integrated strength of the lithosphere (EET) through correlating the observed gravity and bathymetry. In continents, the uncertainties of flexural models and of other data are much stronger due to the complex structure and history of continental plates. We suggest that continental rheology can be assessed and validated from a direct physical approach. For that we explore, by numerical thermo-mechanical modeling, the implications of a weak and strong mantle for tectonic structural styles to show which experimental rheology data sets are more physically compatible with tectonic scale deformation. We therefore suggest a new approach allowing for validation of extrapolations of the experimental rock mechanics data. We show, in particular, that the evolution of most continental convergence zones appeal for generalized "Jelly-Sandwich" rheology (strong mantle and strong upper crust with various possibilities for the intermediate and lower crust), which parameters can be robustly constrained , for each particular geodynamic context, from coupled dynamic thermo-mechanical models.