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Mechanical thickness of the lithosphere and its relation to its seismic, rheological and thermal structure

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The outermost layers of the Earth form a mechanical boundary layer that supports geological loads on long times-scales. The layer is 1.5-2 times thinner than "the seismic", "thermal" or "chemical" lithosphere and its thickness strongly depends on both its temperature and rheological structure. Although the rheology of the lithosphere is still poorly known, it is possible to establish direct links between the mechanical, seismic and thermal lithosphere. This provides an important constraint on lithosphere structure since the thickness of the mechanical lithosphere can be derived independently of other layers, from observations of flexural isostasy, thermo-mechanical modelling and yield strength envelope considerations. We explore here possible relationships between the seismic, thermal and mechanical thickness of the lithosphere in oceanic as well as the more complex continental lithosphere. In oceanic lithosphere, the mechanical thickness corresponds to the observed equivalent elastic thickness (EET) multiplied by a factor of 1.1-1.5. In continents, a similar relationship applies for young hot lithosphere (i.e. thermo-tectonic age $<$ 150 Myr) and cratons (age $>$ 700 Myr), but not for plates aged from $\sim$150 to $\sim$700 Myr where the depth to the bottom of the mechanical lithosphere is approximately equal to the crustal thickness PLUS the EET multiplied by a factor of 1.2-1.5. In cratons, the mechanical thickness follows roughly the same rule as for the oceanic lithosphere. It total, it varies from about 50-90 km in young continental plates to 150-175 km in oldest plates. Comparisons of the EET in oceans and continents with the seismic thickness indicate a systematic relationship between the two thicknesses. However, no correlation exists between the EET and seismogenic layer thickness. Thermo-mechanical models provide additional insights on lithosphere thickness: testing mechanical stability of different lithospheres allows us to establish mechanical parameters that are compatible with the longevity and integrity of lithospheric plates, in particular, cratons.