# Lithosphere-asthenosphere boundary (LAB) as mechanical boundary layer based on mineral and rock physics

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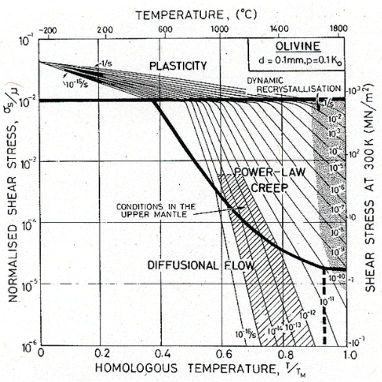
LAB is well known to be a thermal boundary that develops as the upper mantle cools in the divergent flow moving away from the mid-ocean ridge. In the oceanic setting the upper mantle separates into the cool lithosphere above, which increases in thickness with age, and warmer asthenosphere subject to convection below. The lower boundary of cool oceanic lithosphere is defined by an isotherm at some critical temperature (Tc). The more rigid mechanical behaviour of the oceanic lithosphere is caused by the reduced plastic flow of olivine at the strain rates imposed by mantle convection at temperatures below Tc. The situation underneath the continents is more complex due to the long thermal and chemical evolution of the Earth's lithosphere and less well-known distribution of temperature with time. In addition the lithosphere boundary has significant topography under shield areas, implying perhaps PT variations long the LAB. In this presentation I will take the point of view that the first order control on the LAB beneath continents is the low-temperature plasticity of olivine. Low-temperature plasticity has many characteristics that are different to the high-temperature plasticity associated with mantle flow in the asthenosphere. The plastic strain-rate of polycrystalline rock is influenced by temperature, pressure, grain-size, chemical activity (hydrogen, …), grain-boundary properties (melts films) and mineral composition, any combination of these parameters would create a strain-rate discontinuity at LAB.




In low-temperature plasticity the mechanism is no longer controlled by climb of dislocations as in power-law creep, instead it is the Peierls stress associated with crystal's atomic structure. The constitutive strain-rate equation of low-temperature plasticity has lower temperature and stress sensitivity than power-law (e.g. deformation map for olivine from Frost and Ashby). High-temperature creep is often assumed to be steady-state with statistically homogeneous microstructure that does not evolve with strain. In contrast, low-temperature plasticity is more likely to belong to the class of behaviour called "deformation gradient plasticity" in materials science, with heterogeneous micro-structure with well-defined length scale. To maintain the mechanical coupling between the lithosphere and the lower viscosity asthenosphere seems to imply a deformation gradient at LAB. Low-temperature plasticity is typically a localising type of deformation with a strain-rate sensitivity close to “power-law break-down” is certainly compatible with a deformation gradient. I will review recent findings from material and earth sciences on low-temperature plasticity and explore the implications for mantle rheology and the development of crystal-preferred orientation (CPO) of olivine at the conditions of LAB. I will summarize the global findings for the seismic anisotropy beneath continents, the possible origins of the Lehmann discontinuity and seismic detection of the LAB region. Although seismic velocity only gives us an instantaneous picture of the Earth interior, it will be argued that seismic anisotropy gives us information over a more integrated time-scale. The development of CPO in mantle requires finite deformation, which would require several million years to develop.