Geophysical Research Abstracts
Vol. 17, EGU2015-15008, 2015
EGU General Assembly 2015

Formation of lithospheric detachments: quantifying the mechanical effect of hydration reactions

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Many authors have published experimentally determined flow laws of rheologically important monophase aggregates and polyphase rocks. These laws provide good first order constraints on lithology-controlled lithospheric strength variations. However, since the whole range of mineralogical and chemical rock compositions cannot be experimentally tested, variations in reaction-controlled rock strength cannot be systematically and fully characterized.

We here present the results of a study coupling thermodynamical and Thermomechanical modelling aiming at predicting the mechanical impact of metamorphic reactions on the strength of the mantle during its exhumation in rifted zones.

Thermodynamic modelling is used for calculating the mineralogical composition of a typical peridotite as a function of pressure, temperature and water content. For a given P-T condition, the calculated modes and flow laws parameters for each phase constituting the paragenesis are then used as input of the Minimized Power Geometric model for predicting the polyphase aggregate strength. Hence, by considering P-T evolutions characteristic of exhumed mantle, we quantify the strength of the mantle as a function of pressure, temperature and hydration history in a rift zone. The mechanical impact of such metamorphic reactions and hydration is first quantified in 1D for three simplified hydration schemes and then introduced in preliminary 2D models which coupled fluid transfer to the thermodynamically derived rheological parameters. Schemes with limited hydratation are found to keep rocks in condition close to brittle ductile transition for a longer time and to permit more efficient mantle exhumation.