

Elemental Budget and Rheology of the Oceanic Lithosphere

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The compositions of the uppermost parts of subducting oceanic plates (sediments and altered crust) are relatively well known. However, the largest part of the downgoing slab, the lithospheric mantle (up to ~10 times the thickness of the oceanic crust), is not well defined. By virtue of its size and refractory nature, this may be the subducted material with the longest lifespan within the convecting mantle; also, ancient recycled lithosphere may be a source reservoir to modern ocean island volcanism. We present results constraining the chemical compositions of the entirety of subducting tectonic plates, and discuss consequences of variations in lithospheric composition (especially water) for the rheology of subducted plates.

We model profiles of chemical composition through average oceanic lithosphere, starting from the depth of melt initiation beneath a mid-ocean ridge up to the base of the oceanic crust. We treat melting as a near-fractional process and assume an initial asthenospheric composition equal to the “depleted MORB mantle” reservoir. A new generation of the MELTS thermodynamic melting model, pHMELTS [1], is employed; this melting model incorporates the effect of water on mantle melting. Partitioning of water in olivine is proportional to the square-root of water fugacity; partitioning of water into pyroxenes and garnet are in constant proportion to olivine (for example, $D^{\text{cpx/olivine}} = 10$). Potential temperature and water concentration in the upwelling mantle are determined from the melting trajectory with the best output for crustal thickness and composition. The results we obtain are depth profiles of major and trace element composition, water content, and modal abundances.

We are also in the process of deriving a working model for the rheology of the lithosphere by combining chemical profiles with three dimensional thermal models that incorporate conductive and advective heat transport. Viscosity estimates will be olivine-based calculations dependent on pressure, temperature and water content. This modelling effort provides a chemical and rheological baseline for seismic observations, deformation studies, mantle convection models, subduction zone dynamics dependent on mantle wedge compositions, and mass-balancing the silicate Earth.

References

[1] Asimow P.D., Dixon J.E. and Langmuir C.H. (2004) *Geochem. Geophys. Geosys.* **5** art. no. Q01E16