Deep Earth Volatiles Cycle:
processes, fluxes and deep mantle metasomatization

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The exchange of volatiles (water -as hydrogen-, carbon, nitrogen, noble gases, halogens and sulphur) between the Earth's surface and its interior controls on the long-term the composition of the atmosphere and hydrosphere, thus affecting climate and the biosphere. Degassing of the mantle occurs principally at divergent plate boundaries and at volcanic centres via magmatic processes, while extensive recycling of volatiles in the mantle occurs via subduction of metasomatized, volatiles-rich oceanic plates (*Faccenda et al., 2009, 2012*).

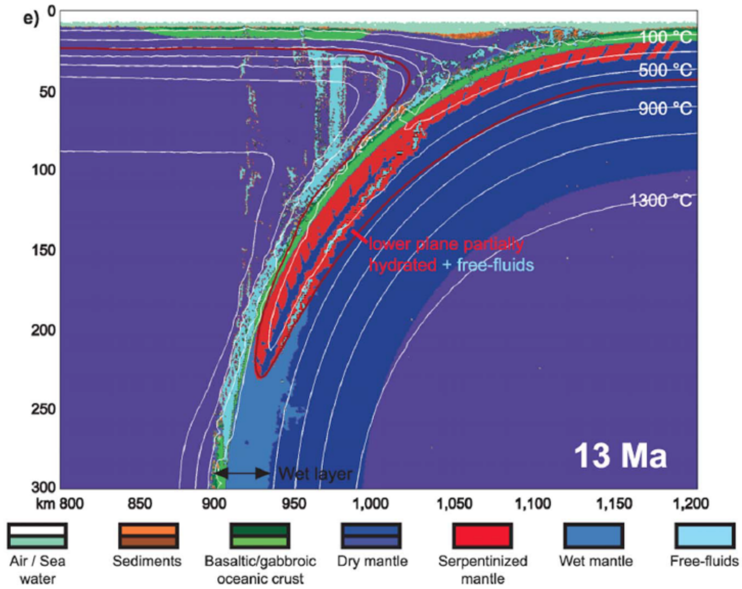

Figure 1 – Numerical modelling of slab hydration at the trench outer-rise due to bending-related faulting and subsequent dehydration at upper mantle depths. From (Faccenda et al. 2012)

On the other hand, the distribution of volatiles within the Earth's mantle – the largest volatiles reservoir – has profound implications on the dynamics and the evolution of our planet, as small quantities of volatiles strongly affect the physical properties of rocks (viscosity, density, seismic wave velocities, electrical conductivity). Yet, our understanding of the deep-Earth volatiles cycle is crude, as several uncertainties remain relative to, for example, the storage of different volatile species within oceanic plates at the surface and the subsequent devolatilization of subducted slabs at different mantle depths (Fig. 1 shows a simplified simulation of the water cycle in the shallow mantle). Furthermore, it is poorly understood which are the implications of a deep (>300 km) mantle metasomatization that potentially could cause the formation of magma (Fig. 2) and diamonds at depth, and related volcanism and diamonds deposits at the surface. Another aspect which deserves more attention is related to those volcanic processes that generate strong mantle degassing events and that can lead to either short or long periods of sustained climate changes with catastrophic effects for life at the Earth's surface.

Numerical modelling can provide insights on the long-term fluxes and processes associated with the volatile cycling and distribution on Earth. This research project will make use of cutting-edge numerical methods which simultaneously reproduce the petrological-thermomechanical behaviour of fluid-rock systems (e.g., *Faccenda et al., 2009, 2012; Faccenda, 2014*), with the aim of improving our understanding of processes related to volatile recycling, deep metasomatization of the mantle and its subsequent degassing through magmatic events.

The research project provides a unique opportunity for successful candidates to combine different fields of the Earth's sciences, from petrology to geochemistry, to geodynamics and numerical methods.

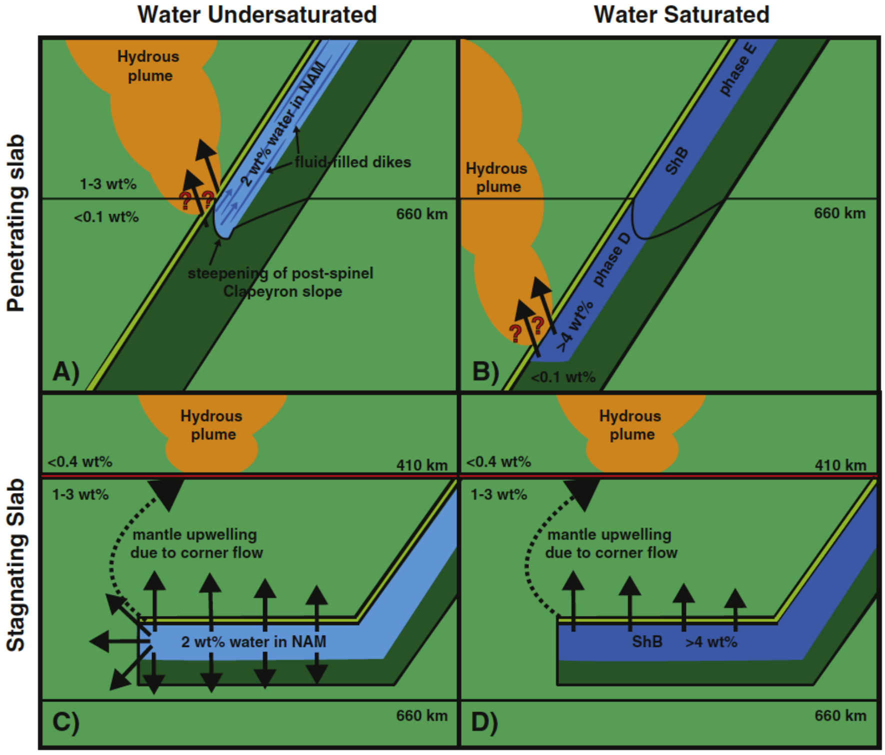

Figure 2 – Hypothetical models of deep slab mantle dehydration in H_2O-undersaturated and H_2O-saturated conditions for penetrating and stagnating slabs. Dark blue is hydrated mantle, light blue is wet mantle. Red indicates partially molten mantle, while orange is representative of upwelling hydrous plumes. Light and dark green are the ambient and lithospheric mantle. NAM are nominally anhydrous minerals. Phase E, ShB, D are deep hydrous phases. Values in wt. % indicate mantle water contents. From (Faccenda, 2014).

Available financial resources: *Fondi DOR Faccenda 2016*

References

Faccenda M. Water in the slab: a trilogy. Tectonophys. 614, 1-30 (2014).

Faccenda M., T. V. Gerya, N. S. Mancktelow, and L. Moresi (2012), Fluid flow during slab unbending and dehydration: Implications for intermediate-depth seismicity, slab weakening and deep water recycling, Geochem. Geophys. Geosyst., 13, Q01010, doi:10.1029/2011GC003860

Faccenda M., Gerya, T.V., Burlini L. Deep slab hydration induced by bending-related variation of the tectonic pressure. Nat. Geosci. 2, 790-793 (2009).