Deep water recycling from early Earth to present-day

V. MAGNI[1]*, P. BOUILHOL[1] AND J. VAN HUNEN[1]

[1]Department of Earth Sciences, Durham University, Durham, UK

*Correspondence: valentina.magni@durham.ac.uk

The transport of water to large depths via subduction zones has a major impact on the Earth's volatile budget, on the chemical evolution of the Earth, and on the deep mantle composition and rheology. The amount of water that is retained in slabs and carried deep into the mantle is difficult to constrain for the present-day, and, arguably, even more so for early Earth conditions.

Here, we use a numerical tool that combines thermo-mechanical models with a thermodynamic database to examine slab dehydration for present-day and early Earth settings and its consequences for the deep water recycling throughout time. We parameterize the amount of water that can be carried deep into the mantle, W (x10^5 kg/m^2), as a function of subduction velocity v_s (cm/yr), slab age a (Myrs), and mantle potential temperature T_m (°C):

$$W = 1.06v_s + 0.14a - 0.023T_m + 17$$

We generally observe that a 1) 100°C increase in the mantle temperature, 2) ~15 Myr decrease of plate age, or 3) decrease in subduction velocity of ~2 cm/yr all have the same effect on the amount of water retained in the slab at depth, corresponding to a decrease of ~2.2x10^5 kg/m^2 of H_2O. We estimate that for present-day conditions ~26% of the global influx water, or 7x10^8 Tg/Myr of H_2O, is recycled into the mantle. Using a realistic distribution of subduction parameters, we illustrate that deep water recycling might still be possible in early Earth conditions, although its efficiency would generally decrease. Indeed, depending on the plate velocity model evolution we use, we find that 0.5-3.7x10^8 Tg/Myr of H_2O, or 3-13%, could still be recycled in the mantle at ages >2.8 Ga.