

Electrical conductivity of the serpentinised mantle and fluid flow in subduction zones

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In the mantle wedge of subduction zones, electromagnetic profiles reveal high electrical-conductivity bodies. In hot areas ($> 700^{\circ}\text{C}$), water released by dehydration of the slab induces melting of the mantle under volcanic arcs that can explain the observed high conductivities. In the cold ($<700^{\circ}\text{C}$) melt-free fore-arc mantle wedge, fluid water migrates and causes serpentinisation detected as low seismic wave velocities in the mantle wedge. High conductivities in the serpentinized wedge may picture serpentinisation or instantaneous fluid flow depending on serpentine electrical conductivity. We measured the electrical conductivities of three natural serpentine samples from subduction zone context using complex impedance measurements, and find they have low electrical conductivities ($< 10^{-4} \text{ S. m}^{-1}$) similar to those of dry mantle minerals below 700°C . Because of the negligible conductivity of serpentine, electrical conductivity in the hydrated mantle wedge is only sensitive to the fluid content and salinity, not to serpentinisation. A small fraction (*ca.* 1% in volume) of connective high-salinity fluids accounts for the highest observed conductivities. The low-salinity fluids ($\leq 0.1 \text{ m}$) released by slab dehydration evolve towards high-salinity ($\geq 1 \text{ m}$) fluids during progressive serpentinisation of the mantle wedge. These fluids can mix with arc magmas at depths and account for high chlorine/water ratios in arc lavas.

Modelling vertical stable isotope and elemental distributions in the upper ocean

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The stable isotope compositions of elements dissolved in seawater are a valuable source of information on ocean biogeochemistry. Depth profiles of elemental ratios and isotope compositions often show large vertical gradients near the surface due to the uptake and fractionation by biota in the surface ocean. However, interpretations of observed distributions are often based on overly simplistic models of the fractionation behaviour, such as the Rayleigh equation [1], which ignore dynamic mixing in the oceans. The processes governing the spatial and chemical gradients do not fit the fundamental assumptions underlying Rayleigh-type behaviour. In order to more effectively describe the processes governing the depth profiles we argue that simple one-dimensional advection-diffusion-reaction (1-D ADR) models should be applied. These models incorporate the interaction between biogeochemical cycling and physical redistribution, and thus help to realise the true potential of stable isotopic tracers to quantify biogeochemical cycling.

Applications of our models to stable isotope variations in the upper ocean demonstrate that, within the thermocline, elemental concentration gradients and isotope distributions are strongly affected by physical mixing processes. The biological cycling, however, controls the composition of the surface mixed layer. Our models provide a combined physical-biological framework for the interpretation of novel metal stable isotope variations currently being determined. It is apparent from the models that estimations of the fractionation factors derived using the Rayleigh equation will systematically underestimate the true values; the degree of underestimation depending upon the relative importance of mixing. We show how our models can be applied to published datasets.

[1] Rayleigh (1902) On the distillation of binary mixtures. *Phil. Mag.* **4**, 521.