Giant impacts, late veneers and the gradual hydration of the earth's mantle by subduction

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The likelihood of one or more giant impact events occurring during the accretion of the Earth is very high [1,2], and most of these late-stage impact events impart enough energy to completely melt the silicate portion of the proto-Earth [3,4]. Despite the uncertain nature and composition of the terrestrial atmosphere immediately after such impacts, it seems inescapable that the Earth's mantle suffered a catastrophic loss of volatiles (including H_2O, CO_2 and noble gases) within the first 100 Ma of the planet's history.

For these volatile species, the subsequent evolution of the Earth's mantle has thus involved a gradual re-hydration from without, via the subduction of lithosphere altered by water from an exosphere whose existence has been dated to 4.4 Ga [5,6]. The estimated composition of this exosphere shows many similarities to a mass-fractionated proto-atmosphere mixed with volatiles released during impact degassing of a chondritic late veneer.

We will present the results of forward-modelling the evolution of volatiles in the Earth's interior via subduction hydration of an intially dry mantle, with an emphasis on H_2O. The model estimates the extent of (de)hydration of subducted hydrated lithosphere, and any associated isotopic (D/H) fractionations, based on studies of altered oceanic crust and Mariana arc magmas [7,8]. A defining characteristic of these models is the prediction of an initially high mantle viscosity, with gradual growth of a low-viscosity upper mantle due to the introduction of water at subduction zones. The fraction of the mantle that exchanges water with the exosphere thus grows with time, but the details of this growth depend on the extent of mixing between a hot, dry primordial mantle and a cooler and wet subduction-modified mantle. Nevertheless, virtually all conditions are expected to result in temporal shifts of the D/H ratios of the mantle and atmosphere that never reach steady-state, even over the age of the Earth.

References

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Determination of trace metal-nanoparticle assocations in contaminated riverine systems using analytical TEM

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Analytical electron microscopy (AEM) is being used to study the associations between trace metals and nanoparticulate material in riverine systems. Seven samples have been taken from the Clark Fork River system in western Montana, USA, over a distance of 200 river kilometers, and during normal summertime flow. This river is being used as a model site because it is contaminated with toxic trace metals (principally Pb, As, Zn, and Cu) from over 150 years of copper and silver mining activities, and it has been studied in great detail. All samples were digested and analyzed using Inductively Coupled Plamsa Mass Spectroscopy (ICPMS) to determine total metal concentrations and it was found that every sample contained significant amounts of at least two of the toxic metals of greatest interest. To date, extensive AEM analysis using an FEI Titan high resolution scanning/ transmission electron microscope (S/TEM) (equipped with EDS and EELS detectors) on one water sample has been performed. Grains of aragonite, titanium oxide and hematite, bearing Zn, Pb and As, respectively, have been identified. These particles range in size from 8 to 200 nm in diameter, show various stages of crystallinity, and are often heterogeneous even on a nanometer scale. The nanometer size range is important not only because grains this small represent a disproportionally large amount of surface area available in the biogeochemical system, but also because the properties of these materials are expected to be dramatically altered from larger grains of the same material. These property changes, along with a potential for increased activity, may have a large impact on the bioavailability and toxicity of trace metals in natural systems. Further sampling and AEM analysis of existing samples will lead to a better understanding of trace metals in riverine systems and how nanoparticles are likely influencing their fate and availability.