H_2O and CO_2 devolatilization in subduction zones: Implications for the global water and carbon cycles

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Subduction of sediments and altered oceanic crust functions as a major water and carbon sink. Upon subduction the water and carbon may be released by progressive metamorphic reactions. Quantification of the volatile release from subducting slabs is important to determine the provenance of volatiles that is released by the volcanic arc and to constrain the flux of water and carbon to the deeper mantle. In recent work we used a global set of high resolution thermal models of subduction zones to predict the flux of H_2O from the subducting slab [1] which provides a new estimate of the dehydration efficiency of the global subducting system. It is found that mineralogically bound water can pass efficiently through old and fast subduction zones (such as in the western Pacific) but that warm subduction zones (such as Cascadia) see nearly complete dehydration of the subducting slab. The top of the slab is sufficiently hot in all subduction zones that the upper crust dehydrates significantly. The degree and depth of dehydration is highly diverse and strongly depends on (p, T) and bulk rock composition. On average about one third of subducted H_2O reaches 240 km depth, carried principally and roughly equally in the gabbro and peridotite sections. The present-day global flux of H_2O to the deep mantle translates to an addition of about one ocean mass over the age of the Earth. We extend the slab devolatilization work to carbon by providing an update to Gorman *et al.* [2], who quantified the effects of free fluids on CO_2 release. We use the new high resolution and global set of models to provide higher resolution predictions for the provenance of CO_2 release to the mantle wedge.

[1] van Keken, Hacker, Syracuse, Abers, J. (2011) *Geophys. Res.* [2] Gorman *et al.* (2006) *Geochem. Geophys. Geosyst.*

Geology, age and origin of the oldest terrestrial rocks and minerals

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Earth's mineral and rock record extends back to an astonishing 4.4 Ga. The earliest history (4.4–4.03 Ga, 'The Hadean') is represented by zircon crystals and isotopic evidence from younger rocks of buried and/or vanished sources of this age [1, 2]. In the Archean, increasing amounts of crust are preserved from 4.03–3.5 Ga, but only as high-grade gneiss terrains with little primary sedimentary or volcanic material. Strangely, these rocks contain little or no evidence for meteorite bombardment at this time. Nevertheless, these remnants contain important clues to crust-forming processes and tantalising hints of the earliest biosphere. After 3.5 Ga, better-preserved crustal remnants yield more robust clues to early Earth processes and biosphere components.

Debate continues on the nature of early crust formation processes, specifically whether plate tectonics (of any kind) operated in early (or even middle) Earth history. Hadean crust may have been thick and basaltic, crystallised from a magma ocean and locally intrenally differentiated to form tonalite [3]. The early Archean was characterised by two types of crustal growth mechanisms, as on modern Earth [4]: 1) plateau formation over zones of upwelling mantle, forming thick welts of autochthonous crust affected by internal differentiation (e.g. East Pilbara Terrane, Pilbara Craton); 2) subduction-accretion in zones with voluminous arc-like magmatism and crustal imbrication (e.g. Western Greenland). By 3.1 Ga, modern-style (i.e. steep) subduction had commenced locally [5], and a significant proportion of the continental crust may have formed by 3.0 Ga, starting the supercontinent cycle.

[1] Wilde *et al.* (2001) *Nature* **409**, 175–178. [2] O'Neil *et al.* (2008) *Science* **321**, 1828–1831. [3] Kemp *et al.* (2010) *Earth Planet Sci. Lett.*296, 45–56. [4] Van Kranendonk (2011) *Am. J. Sci.* **310**, 1187–1209. [5] Smithies *et al.* (2005) *Earth Planet Sci. Lett.* **231**, 221–237.