The chemical composition of the Earth

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The composition of the Earth is derived from ultramafic rocks, samples from the Earth's mantle in a variety of geologic settings [1]. The high Mg, Ni and PGE contents, chondritic Ni/Co ratios, unfractionated compatible refractory elements (Yb/SC), chondritic Na/Mn ratios etc. support a primitive mantle origin, affected only by core formation and loss of a small fraction of partial melt, which may have occurred before final accretion of the Earth [2,3]. From a detailed comparison with chondritic meteorites it is concluded that the bulk Earth composition is not CI chondritic (i.e. precisely solar) but has similarities to the chemical composition of the CV group of carbonaceous chondrites: (a) Enrichment of refractory elements, (b) bulk Earth Mg/Si ratio, assuming 7 % Si in the core, (c) similar patterns of moderately volatile elements as CV (d) depletion of Mn and other moderately volatile elements shortly after the first solids had formed in the solar nebula (based on ^{53}Cr). Despite chemical similarities Earth does not mach CV precisely: (a) Earth has excess Fe, (b) Earth is more depleted in volatiles than CV chondrites (d) the stable isotopic composition of several elements in the Earth is similar to ordinary chondrites and even closer to enstatite chondrites but different from carbonaceous chondrites [4]. However, enstatite chondrites have very different chemistry and are not good candidates for the Earth. It seems impossible to make the primitive upper mantle from a high Si, low Al source. As chemistry and stable isotopes are decoupled similarities of in stable isotopes have limited significance: Isotopically main group pallasites fit with the non-carbonaceous chondrites while Eagle Station pallasites are close to carbonaceous chondrites [4]. Considering chemistry and stable isotopes one has to conclude that Earth is made of a variety of chondritic meteorites, different from known groups of chondrites.

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The role of tephra diagenesis in the carbon cycle

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Most volcanoes are located close to the oceans. Hence a high proportion of the 10^{15} g/yr of tephra that is created by subaerial volcanism ends up in marine sediments, such that tephra comprises ~25% of Pacific Ocean sediments. In addition, individual massive explosive eruptions have covered large areas of the globe during Earth history. Given that fresh tephra is highly reactive when exposed to seawater it is important to consider the implications of this flux of material to the oceans.

We hypothesise that tephra deposition in the oceans may influence the ocean-atmosphere carbon cycle through the following mechanisms: (1) Leaching of tephra deposited in surface waters may cause increased productivity (and drawdown of atmospheric CO_2) via addition of nutrients to Fe-limited areas. (2) Deposition of tephra in sediments leads to rapid depletion of dissolved O_2 in pore waters, thus enhancing organic carbon preservation in underlying sediments. (3) After tephra deposition, bioturbation mixes the upper tephra surface with background sediments. Tephra contains reactive Fe phases that are known to complex organic carbon in non-volcanic sediments and enhance organic carbon preservation. (4) As the tephra layer is buried deeper, it moves into zones of CH_4 and alkalinity production. Alkalinity (and oxidised CH_4) diffuses into the overlying tephra where it encounters high dissolved Ca levels from Ca-Mg exchange during tephra diagene-sis, leading to precipitation of calcite cements that effectively sequester CO_2 produced from organic carbon and form a further barrier to downwards diffusion of oxidising species.

We review here the evidence supporting each of these processes and indicate times and places in Earth history when they have played a particularly important role.

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