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The volatile (H_2O, C, N, noble gas) inventory of the Earth: geochemical and cosmochemical constraints

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The stable isotopes signatures of terrestrial nitrogen and hydrogen suggest strongly that most volatile elements on Earth originated from a cosmochemical reservoir that also sourced asteroidal bodies. In the Earth's mantle, a minor solar-like volatile component is present and best seen in the Ne (and possibly N and H) isotope composition(s) of mantle-derived rocks. Ne isotopes in minerals from mantle plume provinces discriminate against contribution of dust implanted with solar ions, and instead support trapping of volatile elements directly from the nebular gas.

The above geochemical compositions on one hand, and dynamical modelling of planetary formation on another hand, are consistent with the following scenario. Planetary embryos of the size of Mars accreted and differentiated in a few Ma, while the nebular gas was still present. Solar-like atmospheres were gravitationally bound and solar gases were dissolved in molten silicates, imposing reducing conditions that participated to metal segregation. Such conditions might have also permitted the trapping of minor amounts of solar, isotopically light, N and H. From different lines of evidence (K-Ar systematics of the bulk silicate Earth -BSE- and calibration of volatile elements to radiogenic ^{40}Ar, C/^{36}Ar ratios of carbonaceous chondrites, comparison of C/Zn, H_2O/Zn and N/Zn ratios between chondrites and Earth), the carbon and water contents of the BSE are set to $\sim$500 ppm C and 1,000-3,000 ppm H_2O. Such high contents (compared to those inferred from experimental petrology) suggest the occurrence of large, yet undocumented volatile reservoirs in the deep silicate Earth, and correspond to the contribution of 2$\pm$1% carbonaceous chondrite-type material. This contribution is larger than the so-called "late veneer" that supplied PGEs to the silicate Earth after core formation. Giant shocks that characterized the accretion of Earth (but not of Mars) did not completely dry up the proto-Earth. Major volatiles could have been supplied while terrestrial differentiation was on-going, thus playing a role for Earth's early evolution that needs to be assessed.