The global chlorine cycle : Cl isotope constraints

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Due to its incompatible, soluble and volatile element chemical characteristics, chlorine is especially valuable in understanding the current and past evolution of the Earth (e.g., melting, recycling, degassing, differentiation). Comprehensive understanding of the Cl cycle may help constrain the origin of the oceans. Due to the large uncertainties in the estimated range of mantle Cl flux inputs and outputs, we present here the chlorine isotopic compositions of mantle and subducted materials as well as those in chondrites with the aim of better understanding the global Cl cycle.

Mantle, subduction and chondrites δ^{37}Cl:

Based on fresh N- and E- MORB samples affected by various degrees of assimilation of seawater-derived materials, we estimate that the mean upper mantle has δ^{37}Cl $\leq$ -1.9‰. Analyses on HP metaperidotites from the Alps suggest that no fractionation occurs during the Cl loss associated with the dehydration of serpentines throughout prograde subduction. Considering HP metaperidotites as suitable candidates for Cl transfer to the mantle, and excluding the possible contribution of sediments, we estimate the δ^{37}Cl in the subducted material to be $\geq$ -1.4‰. Various types of chondrites show relatively homogeneous δ^{37}Cl (-1.7 ± 0.4‰).

The global chlorine cycle:

The slight but significant difference between the δ^{37}Cl of recycled Cl and the upper mantle implies that the mantle δ^{37}Cl increased while the exosphere δ^{37}Cl decreased over geological time. Box modeling suggests that a large amount of Cl was already present in the early exosphere. This argues in favour of an early and catastrophic degassing of Cl from the mantle (however not sufficient to explain the δ^{37}Cl evolution) and/or a "late veneer" supply of Cl (i.e. heterogeneous accretion). Our data show evidence for: i/ a Cl depletion of the Earth by a factor of 15 to 20 relative to primitive chondrites; and ii/ a δ^{37}Cl contrast between the "Upper Earth" (i.e. exosphere + upper mantle; -0.3‰) and chondrites. This might be explained by a preferential loss of ^{35}Cl during Earth accretion and/or a supply of Cl with positive δ^{37}Cl.