Halogen composition of the early Solar System inferred from meteoritic apatites

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The volatile halogens are important tracers in constraining Solar System processes, such as degassing, and as abundant anionic components in fluids they are also useful in deciphering fluid-rock interactions. So far, there is limited information about halogen ratios and the δ^{37}Cl isotope composition of planetary reservoirs, such as the chondritic reservoir, depleted Earth mantle or bulk silica Earth.

The halogen budget of individual meteorite samples appears dominantly controlled by apatites that preferentially incorporate halogens. To constrain the halogen budget of the early Solar System planetesimals we determined F, Cl, Br, and I concentrations, and the δ^{37}Cl of individual apatite grains in meteoritic materials - including ordinary and Rumuruti chondrites, primitive achondrites, eucrites, and iron meteorites. Phosphate grains were documented by SEM and their mineral chemistry was determined by EPMA. Halogen concentrations and δ^{37}Cl were determined using a Cameca IMS 1280 (NORDSIMS). Mass balance calculations were carried out to evaluate the potential of apatite to act as a probe for the halogen chemistry.

δ^{37}Cl values of different meteorite groups span a range from about -1 ‰ to +1 ‰ [1; this study]. We found an evolutionary trend in δ^{37}Cl from chondritic through differentiated material, with the latter probably being balanced by silicate-bearing iron meteorites, such as Campo del Cielo. This trend is also seen for F/Cl of apatites from different meteorite groups, which ranges from ~100 × 10^{-3} in chondritic material to ~32, 500 × 10^{-3} in differentiated meteorites. I/Cl range from ~0.6 × 10^{-6} to 6 × 10^{-6}, - except for eucrites, which have I/Cl two orders of magnitude higher. Br/Cl vary from ~0.02 × 10^{-3} in ordinary chondrites to ~1.7 × 10^{-3} in iron meteorites. This implies discernible variation of halogens among different meteorite groups but, compared to Earth's halogen reservoirs, a relatively homogeneous halogen composition for the early Solar System.

(1) Sharp *et al*. (2007) *Nature* **446**, 1062-1065.

Inherited ^{142}Nd anomalies in the Nuvvuagittuq supracrustal belt

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The short-lived ^{146}Sm-^{142}Nd chronometer is a sensitive tool to trace early silicate Earth differentiation. Mantle depletions prior to ~4.2 Ga are documented as positive ^{142}Nd anomalies in Eoarchean rocks [e.g. 1]. O'Neil *et al*. [2] reported evidence for an early enriched reservoir from negative ^{142}Nd anomalies in pre-3750 Ma rocks of the Nuvvuagittuq supracrustal belt (NSB) in Québec. These authors derived a ^{146}Sm-^{142}Nd isochron with a 4.28 Ga age and concluded that the NSB may be the oldest crust.

We present new coupled ^{147,146}Sm-^{143,142}Nd systematics for six different NSB lithotypes. Samples yield a range of ^{147}Sm/^{144}Nd ratios from about 0.07 to 0.17. Nd data were collected on a Triton (TIMS) at ETH; repeat measurements of the JNdi-1 standard yield an external precision of ±4 ppm (2 SD) for the ^{142}Nd/^{144}Nd ratio (n=39). We reproduced negative ^{142}Nd anomalies for sample powders reported in [2], and for a cummingtonite amphibolite from the mapped area in [3]. A mafic (tonalitic) gneiss and a quartz-biotite schist from an Inukjuak supracrustal enclave NE of the NSB show ^{142}Nd/^{144}Nd ratios lower than the terrestrial standard (ε^{142}Nd = -0.08 to -0.13). Taken together, these negative ^{142}Nd anomalies are uncorrelatable with ^{147}Sm/^{144}Nd for mafic or felsic lithologies and do not produce a ~4.28 Ga isochron as in [2]. In ^{147}Sm-^{143}Nd isochron diagrams our NSB whole rock samples define an array with an imprecise age of ~3.75 Ga similar to ages from U-Pb ion microprobe zircon geochronology [3]. Data indicate that the NSB rocks suffered a complex protracted history and that the Sm-Nd system is disturbed. We conclude that the absence of concordant ages in the ^{143}Nd-^{142}Nd system suggests that the negative ^{142}Nd anomalies were inherited from an early enriched reservoir and do not represent the age of the formation of the NSB rocks.

[1] Caro *et al*. (2006) *GCA* **70**, 164-191. [2] O'Neil *et al*. (2008) *Science* **321**, 1828-1831. [3] Cates and Mojzsis (2007) *EPSL* **255**, 9-21.