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Oxygen isotopic composition as a fundamental reference marker in water-material chemical interaction.

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To understand the basic processes in water-material chemical interactions in nature it is common to use oxygen isotopic ratio as a reference marker. For this SMOW has been conventionally employed as a standard, but its validity as a universal reference in a whole solar system is currently in hot debate [e.g.1,2]. We urge that any cosmochemical study on water-material interaction in the early solar system (the objective of this session), either theoretical or experimental, must in the first place consider this fundamental constraint.

The latest report of GENESIS project [3,4,5] gave a convincing isotopic composition of oxygen in bulk solar wind (SW) sample collected on a concentrator. However, correction for putative isotopic fractionation between SW and the Sun is still needed to conclude the solar oxygen isotopic composition. Although a model-dependent and somehow circular argument on the fractionation process was suggested in the GENESIS report [5], a definitive examination of the isotopic fractionation is urgent. Here, we studied noble gas isotopic fractionation, and on the basis of the latter result, we discuss oxygen isotopic fractionation between SW and the Sun. Our result does not support the solar oxygen isotopic composition concluded from the GENESIS mission.

Firstly, we show that the average noble gas isotopic composition in the early solar system is represented by Q-noble gas in primitive meteorites, one of two major noble gas components (Q and SW) widely occurring in the early solar system. Next, we show that SW-noble gas was mass-dependently fractionated from Q-noble gas with a fractionation factor inversely proportional to a square root of mass ratio of isotope, namely in proportional to 1/(mi/mj)1/2, where mi and mj stand for the mass of isotope i and j. We note that the characteristic fractionation factor is the typical of a Rayleigh distillation type fractionation. If the noble gas isotopic fractionation factor concluded in this work were applied to the Genesis SW oxygen data, the corrected oxygen isotopic composition becomes much closer to the terrestrial oxygen than to those suggested in the GENESIS report [5], and therefore is contrary to a widely held view [1, 5] that the solar oxygen isotopic ratio is the same as CAI oxygen, but differs from the terrestrial oxygen. Besides the mass-dependent isotopic fractionation identified in the case of noble gas, additional mass-independent fractionation (MIF) may also be present, which we speculate attributable to the dissociation of CO in the lower solar photosphere [6,7].

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