

Oxygen isotopic composition of solar wind implanted in lunar soil: a ^{16}O -rich protosolar nebula

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Oxygen is the most abundant element constituting the planetary materials of the inner solar system. Understanding the origin and formation processes of rocks and water, the O-bearing building blocks of our planets, is indispensable in describing how our planetary system had formed. Classically it was considered that rocks and water were produced from a hot and homogenous solar gas through equilibrium condensation processes. However, numbers of studies in the past three decades on meteorites showed that their formation processes are not that simple. The most typical case suggesting the complexity is demonstrated by the dispersion in composition of the three O isotopes (^{16}O , ^{17}O and ^{18}O) among bulk meteorites and specific parts of meteorites in a non mass-dependent manner.

The discovery of strong ^{16}O enrichments in Ca-Al-rich inclusions from carbonaceous chondrites [1] was followed in the last 30 years by a systematic search for non mass-dependant oxygen isotopic anomalies in all available solar system rocks [e.g. 2]. The picture which emerged from these studies is that most of the chondritic and achondritic meteorites as well as Earth and Mars have variable bulk oxygen isotopic compositions which cannot be derived one from others by "normal" chemical and physical processes obeying mass dependent fractionation laws. The mass dependence of rate constants and equilibrium constants of most chemical/physical processes dictates that the abundance ratios of the three stable oxygen isotopes in all solar system objects should be related by a law which can be described by the approximated equation $\delta^{17}\text{O} = 0.52 \times \delta^{18}\text{O}$ (the terrestrial fractionation line), in which $\delta^{17}\text{O}$ and $\delta^{18}\text{O}$ represent the $^{17}\text{O}/^{16}\text{O}$ and $^{18}\text{O}/^{16}\text{O}$ ratios expressed in delta notation relative to the terrestrial standard. The fact that the oxygen isotopic composition of most meteorites are distributed on both sides of this line has been interpreted as reflecting either (i) the presence in the solar accretion disk of grains and gas which differed in their relative ^{16}O contents because of different nucleosynthetic origins and which were mixed in various proportions [1,2] or (ii) the occurrence in the early solar system of peculiar reactions in the gas phase which would not obey the mass fractionation laws [3,4].

In this talk, one fundamental data will be presented, which is central to this issue and owes the key role in deciphering the problem. Using the successful technique we have previously applied for identification of the solar composition of N [5] and C [6] from lunar samples, we provide the O isotopic composition of the present Sun [7], which must be essentially the same with those of the proto-Sun and the protosolar nebula. We conclude that the solar gas, compared to the terrestrial composition, is significantly enriched in ^{16}O . Our conclusion suggests that bulk of O in Earth, Mars, Moon and meteorites, depleted in ^{16}O , must have originated from precursors which were produced by "specific reaction pathways", as recently proposed [e.g. 4,8,9], and were never isotopically equilibrated with the protosolar nebular gas.

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