

Water and Organic matter D/H ratios in the solar system : a record of an irradiation of the nebula ?

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Water and organic molecules are intimately mixed in the primitive planetary objects of the solar system such as Meteorites, Comets, IDPs. In few rare examples, the D/H ratios of both water and organic matter (OM) have been measured independently in these objects. A critical review of these data is presented.

No systematic relations exist between the D/H ratio of water and OM as shown by the scattering of the data points in a diagram with (D/H)water vs. (D/H)OM. Several conclusions can be withdrawn from this observation : (1) the bulk D/H ratio of solar system objects are not governed by the relative proportion of water and OM (2) the relative intensity of a unique isotopic fractionation process cannot explained the solar system data (3) the "canonical" turbulent model developed for the protosolar nebula cannot account for this distribution.

A new interpretation for the origin of the deuterium enrichment in water and OM is proposed : the variation in the temperature at which the deuterium is concentrated in water and in OM via ion-molecule reactions may yield such an apparent scatter of the data. If correct, the origin of the deuterium enrichment in the solar system is linked to an early X-ray irradiation of the protosolar nebula, where ion-molecule reactions took place at the very surface of the disk.

The difficulty raised above by the point (3) needs to be quantitatively evaluated via new models of the protosolar nebula where ion-molecule reactions take place at the very surface of the disk.

Using the D/H ratio to trace the terrestrial water contamination in chondritic meteorites

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Issues : Several recent ion microprobe studies have reported the distribution of D/H ratios in extraterrestrial samples (SNC, Chondrites, IDPs). All these studies are subject to controversies because the effect of the terrestrial contamination on the D/H ratio has never been precisely quantified. Judging from literature discussions, two issues can be distinguished : (1) When an extraterrestrial sample exhibits a D/H ratio clearly out of the terrestrial range, what is the exact contribution of the terrestrial contamination on this D/H ratio ? (2) When in the terrestrial range, can we firmly assert that the initial indigenous water (or -OH) has a terrestrial-like D/H ratio or result exclusively from terrestrial contamination ? Here we report a detailed study of these problems (more than 650 individual determinations of D/H ratios were performed). The Semarkona meteorite has been analyzed with the CRPG 3f ion-microprobe. Samples were prepared using terrestrial and deuterium-rich water. All possible sources of contamination were considered and quantified.

Conclusions : In light of the large D/H variations observed in Semarkona (up to +5500‰), the problem of the terrestrial contamination can be ignored. To be precise, the sample preparation procedures involving liquid water (thick section, polishing, etc.) cause a water contamination of the sample ≈7% on average and a correction of - at maximum - 15% can be propagated on the measured D/H ratios.

Another contamination process may nevertheless take place and not being detected by our experiments : some clay minerals, whose isotopic composition cannot be changed after their formation (irreversible alteration reactions with atmospheric water vapour ?), have grown inside the rock during its stay in the Museum... This seems highly unlikely.