POSSIBLE SOURCES OF [H₂] TO [H₂O] ENRICHMENT AT EVAPORATION OF PARENT CHONDRITIC MATERIAL;

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One of the results obtained from thermodynamic simulation of recondensation of the source chondritic material (1,2) is that at 1500-1800 K it's possible to form iron-rich olivine by reaction between enstatite, metallic iron and water vapor in the case of $[H_2O]/[H_2] \approx 0.1$ (Fig. 1 in [2]). This could be reached if the gas depletion in hydrogen is 200-300 times relative to solar abundance. To get this range of depletion one needs some source material more rich in hydrogen than the carbonaceous CI material which is the richest in volatiles among chondrites. In the case of recondensation at impact heating and evaporation of colliding planetesimals composed of CI material (3), we obtain insufficiently high value of $[H_2]/[H_2O]$ ratio. In the present paper we consider some possible source materials and physical conditions necessary to reach gas composition with $[H_2]/[H_2O] \sim 10$ at high temperature.

Carbonaceous chondrites have mass ratio $H_2O/Si \approx 1.0 - 2.5$ at the bulk content of chondritic material $\approx 10 - 11$ mole/mole Si (for example [4]). Therefore, in order to get the gas with $[H_2O]/[H_2] \sim 0.1$ at evaporation of this material, it should be admixed with 10 mole H_2 per 1 mole Si or, equivalently, 1 mole hydrogen per 1 mole of bulk chondritic (CI) material.

The gas in the surrounding solar nebula (if not dissipated by the time of high-energy collisions) could be a source for hydrogen, but only in the case if the nebular pressure was higher than in the explosion cloud (3). The pressure near the central plane of the nebula in the formation region of the carbonaceous and ordinary chondrites ($R \sim 2$ AU) even at the early stage was higher than 10^{-5} bar (according to all current physical models of the solar nebula) and probably was $\sim 10^{-6}$ bar. These values are lower than the average pressures in the explosion cloud (3). Therefore, the necessary pressure relation could be reached only in a boundary layer between the explosion cloud and the surrounding gas of the nebula. But it's possible that the gas had already dissipated from the nebula at the time when high-velocity collisions occurred.

We'll consider another source of H_2 enrichment in the gas phase of the explosion cloud. The source could be related to a source material itself. Two possible mechanisms can be considered.

1) The material of carbonaceous chondrites contains significant amount of carbon and its compounds, including such volatile compounds as lower hydrocarbons, amino acids, carbon acids *et al.* There is evidence on significant loss of the volatile fraction of the organic component of chondrites during their fall onto the Earth and on the Earth's surface (5). It seems reasonable to suggest that the most of the mass of the volatile organic component has been lost from meteorites and their parent bodies at some stages

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of evolution or during the lifetime of the solar system. The temperature inside parent bodies of the carbonaceous chondrites could not be higher than 600-700 K in order for hydrosilicates, and in particular chlorite, to survive. But the temperature due to some internal or external heat sources could be well above T ~300-400 K, that is in the range 300-600 K. At these temperatures, volatile organic compounds should be more or less gradually destroyed and gaseous products of their decomposition would be lost from the surface of a body.

If the initial abundance of volatile fraction of organics was 2 orders of magnitude higher than observed in C chondrites, this fraction should supply 3-4 times higher content of carbon than in observed CI chondrites and yield H_2O/C ~1. On heating of such a parent material to $T > 1200$ K during an impact event, organic carbon had enough time to react with water released at decomposition of silicates:

$$C(org) + H_2O \rightarrow CO + H_2 \tag{1}$$

If the abundance of H_2O was a little higher than that of C, we obtain the ratio $[H_2O]/[H_2]$, necessary for formation of the iron-rich olivine. For example, at $H_2O/C = 1.2$ we obtain from reaction (1) $[H_2O]/[H_2] = 0.2$. Taking into account also some additional hydrogen released at decay of organic compounds with approximate $H/C \approx 2$ ratio, we obtain $[H_2O]/[H_2] \approx 0.1$.

2) There exists another possible source material which can produce $[H_2O]/[H_2]$ ≈ 0.1. at the impact evaporation process: it is comet-like material, but previously depleted in water. The data on the comet material (6) yield the ratio of carbon in organics to water ice approximately as 0.06/0.5 (by mass). When cometary-type bodies due to gas drag and/or gravitational perturbations appeared in the inner, warmer region of the early solar system, they lost water and other ices. Due to significant size of comet nuclei this loss could be not completed before a high-energy impact event. After release of ~80% of water from the cometary material, we obtain H_2O/C ~1. This ratio leads to $[H_2O]/[H_2]$ ~0.1 at high-temperature process according to Eq. 1.

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