EFFECT OF IONISING IRRADIATION ON THE D/H SIGNATURE OF HYDRATED SILICATES.

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Introduction: The question of the origin and the delivery of water on Earth is highly controvertial. Recent measurements of a terrestrial-like D/H signature in a Jupiter-family comet gave some support to the late delivery of cometary water on a dry Earth [1]. The detection of water vapor surrounding the T-Tauri star [2] and the likely direct detection of hydrous silicates in disks [3], conversely may support a wet-accretion scenario. In this context, if hydrous silicates are commonly observed in chondrites and could theoretically be formed before the accretion of the parent bodies [4], little is known about the pre-accretion history of such hydrated silicates. In particular, if ionizing irradiations have significant effects on the mineralogy and structure of silicates [5], the way such irradiation may shape the hydrogen isotopic signature of hydrated silicates is unknown. We performed preliminary irradiation experiments to address this question.

Methods: Two types of hydrated analogues were chosen. An amorphous hydrated SiO_2 thin film (400nm thick) was prepared by ionic deposition method on a silicon wafer. A commercial muscovite pellet (25µm thick) was used as a proxy for crystalline hydrous silicates. The ionizing excitation was obtained by electron irradiation in a scanning electron microscope (SEM) at energies ranging from 4 to 30 keV, at room temperature. The typical beam size was 50×50µm. After electron irradiation, the D/H signature was determined by nanoSIMS.

Results and discussion: Concerning the SiO_2 thin film irradiated at 4 keV, isotopic depth profiles were carried out. A large deviation from the initial isotopic signature of the film was found down to about 100 nm deep (up to δD=510±75‰). The magnitude of this fractionation depends on the deposited energy. The depth over which the profile was resolved corresponds to the theoretical penetration depth of electrons in SiO_2. A bulk deuterium enrichment was also measured in muscovite irradiated at 30 keV, up to δD=265±11‰. The crystalline structure of the muscovite is preserved over about 400 nm deep and fades below. Our results show that the irradiation of hydrated silicates leads to a significant D-enrichement of the solid residue at the level of several hundreds of permil. In addition, the amorphization of the irradiated material is not systematically observed. The kinetic or equilibrium nature of this isotopic redistribution is yet unclear but a isotopic distillation certainly occurs. Finally, our experimental conditions can be extrapolated to the irradiation conditions that prevailed in the early solar nebula. Hence, a systematic D-enrichment of the silicate residue can be produced in only a few thousand years.

References: [1] Hartogh P. et al. 2011. *Nature* 478:218–220. [2] Carr J. and Najita J. 2008. *Science* 319:1504–1506. [3] Morris M. et al. 2009. *Astrobiology* 9:965. [4] Ciesla F. et al. 2003. *Science* 299:549-552. [5] Carrez Ph. et al. 2002. *MAPS* 37:1615–1622.