

AMORPHOUS SILICATES IN CARBONACEOUS AND ORDINARY CHONDRITES

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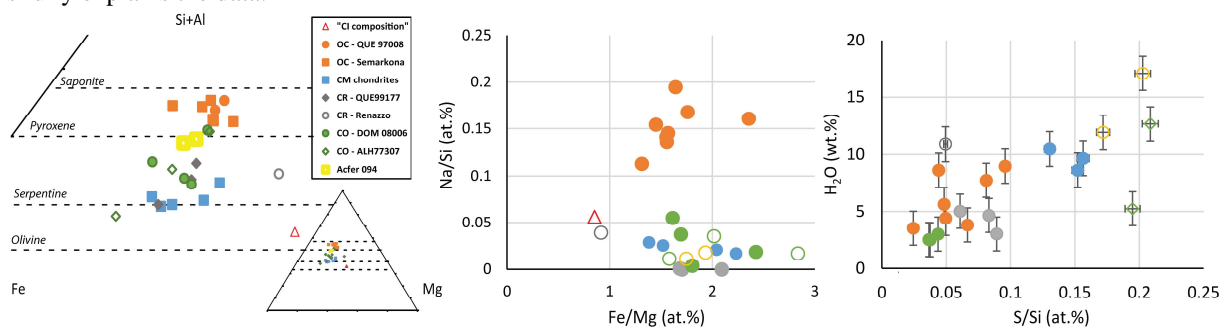
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Introduction: Amorphous silicate (AmS) is the major matrix constituent of pristine carbonaceous and ordinary chondrites [1,2]. Its origin and evolution is however difficult to assess, in part because of its nanometer size and the presence of embedded nano-sulfides that make it challenging to analyze. It has been proposed that AmS could originate directly from the primordial dust inherited from the molecular cloud. It shares similarities with GEMS (Glass Embedded with Metal and Sulfides) found in IDPs and UCAMMs. It could also have formed by metastable condensation from an unknown gas reservoir, which could be δ but is not necessarily δ related to chondrule formation. Alternatively, it has been suggested that AmS could be the parent body secondary alteration product of an unknown precursor. Here, we analyzed and compared the compositions of amorphous silicate in the most pristine chondrites of different petrologic groups in order to limit the effects of differential aqueous alteration and be able to test the different formation models.

Method: About 20 FIB sections from CR (QUE 99177 and Renazzo), CM (Paris, Y-791198 and QUE 97990), CO (DOM 08006 and ALH 77307), ordinary (Semarkona and QUE 97008) and Acfer 094 were extracted from either the rims or the matrix and analyzed by quantitative analytical TEM. In particular, we developed a method to measure and map the water content of amorphous silicate *in situ*. Using dedicated calibrations and home-made absorption correction routines, we reached an absolute precision of about ± 1.5 H₂O wt. %.

Results and discussion: AmS are found in all chondrite groups, but their association with other phases and their composition depend on the chondrite group. A major difference is observed between ordinary and carbonaceous chondrites. Compositions averaged per FIB section (see Figs.) indicate that the former are much richer in silicon ((Si+Al)/(Fe+Mg) ~ 1.18 vs. 0.8). Their Na/Si ratios are elevated and higher than in CC (~ 0.15 vs 0.03 at. %), in agreement with their bulk values. The Al/Si ratio is similar between OC and CC, ranging from 0.08 up to 0.22. The water content appears to be highly variable, and is not correlated with any of the major elements. However, we do observe a correlation with the S/Si ratio. Even at the FIB section scale, hyperspectral mapping reveals that AmS has a variable Fe/Mg ratio (50% variation, pixel size of ~ 100 nm), but has a more homogeneous (Si+Al)/(Fe+Mg) ratio (10% variation). The Mg/Si ratio is lower than the solar composition (in CC: 0.55 vs. 1.02 (bulk and CI)).

The AmS is by far the main matrix carrier of Mg and Si and it had been suggested that the matrix Mg/Si ratio could be complementary to that of chondrules [3]. However, no clear correlation between the AmS Mg/Si ratio and the chondrule content (of each meteorite group) is observed, which would have been expected if chemical fractionation had occurred. On the other hand, it has also been proposed that matrix could have a CI-like composition [4], but it does not seem to be the case either, as the matrix olivine (Mg/Si ratio of ~ 2) abundance is not high enough to compensate for the low Mg/Si ratio of the AmS. All chondrite groups share an AmS that was formed by a common process. However, AmS in OC is different from that in CC, which might exclude the idea of a disk-wide homogeneous dust of CI/interstellar origin. Using these constraints, we should be able to constrain if and how secondary processes have affected the AmS and evaluate the formation scenarios. So far, it might be that none of the usual models fully explains the data.



References: [1] Brearley. (1993) *Geochimica Cosmochimica acta* 57(7), 1521-1550. [2] Le Guillou et al., (2015). *Earth and Planetary Science Letters* 420, 162-173. [3] Hezel, D. C., & Palme, H. (2010). *Earth and Planetary Science Letters*, 294(1-2), 85-93. [4] Zanda, et al. (2018), in *Chondrules, Records of Protoplanetary Disk Processes*, 122-150.