Organic matter in carbonaceous chondrite lithologies of Almahata Sitta meteorite, a polymict ureilite

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The Almahata Sitta (AhS) meteorite is a brecciated, polymict ureilite that has originated from the near-earth asteroid 2008 TC3 which is classified as an F-type asteroid (a group in C complex) in spectroscopic taxonomy [1]. Carbonaceous chondritic lithologies AhS 671 and 91/91A have been characterized and contain phyllosilicates, bruennerite, dolomite, magnetite, fayalite, ilmenite, phosphates, pyrrhotite, and pentlandite [2]. These lithologies are breccias and enclose fragments of ureilitic olivine and pyroxene [2]. We investigated organic matter (OM) in AhS 671 and 91A with various methods including C and N elemental and isotopic analysis and FTIR for bulk samples (~100 μg), and microscopic analysis of their FIB sections using STXM/C-XANES and NanoSIMS.

AhS 671

The IR absorption spectrum of AhS 671 show phyllosilicates and carbonates consistent with mineralogical observations [2], and similar to the IR spectra of CI chondrites [3]. AhS 671 contains 3.9 ±0.22 wt.% of C and 0.19 ±0.02 wt.% of N with δ^{13}C = -3.8 ±0.7 ‰and δ^{15}N = 50.5 ±2.6 ‰. Its δ^{15}N and N/C ratio (0.042 ±0.002, atomic) is close to the values of insoluble organic matter (IOM) in the Tagish Lake meteorite [4]. Note that the N/C ratio of OM in AhS 671 would be higher than the value of the bulk sample since the bulk value includes carbonates.

C-XANES spectra of the organic-rich regions in the AhS 671 FIB section show large peaks at 285 eV assigned to aromatic carbon with no other specific features. Although, organic matter in AS 671 is highly aromatic, there is no 1s-σ^* exciton peak at 291.7 eV of graphene structures that is characteristic of thermally-metamorphosed meteorites [5]. Such characteristics are similar to the C-rich aggregate in the Zag clast [6]. The difference of their organic matter is related to morphology; Zag organics form large (over 10 μm) aggregates while those in AhS 671 are smaller and mixed with the matrix at the submicron scale. δ^{13}C and δ^{15}N obtained with NanoSIMS in C-rich areas are homogeneous with averages of 3 ±3 ‰ and 234 ±32 ‰, respectively. The δ^{15}N is higher than the bulk value and is close to the value of IOM of CR chondrites [7]. The δD value in C-rich areas is 988 ±59 ‰. It is similar to the value of IOM of CI and CM chondrites [7], but less than the value of CRs [7]. The N isotopes of organic matter in AhS 671 shows an isotopically heavier than ureilitic fragments of AhS (-53 to -94 ‰[8]) and rather close to the values of primitive carbonaceous chondrites. However, OM is dominated in aromatic structure without any sign of graphitization.

AhS 91A

Not like AhS 671, the IR absorption spectrum of AhS 91A show no sighs if phyllosilicates and carbonates. The C and N contents vary up to 4.8 wt.% and 0.056 wt.%, respectively, with the average δ^{13}C of -17 ±8

‰. It is consistent with the heterogeneous nature of AhS 91A. We could not obtain C-XANES due to low C contents in the FIB section of AhS 91A. We are going to analyze an additional FIB section since AhS 91A is highly heterogeneous.

Considering the molecular structure and the nitrogen isotope composition, the organic matter in AhS 671 is similar origin to the C-rich aggregate in the Zag clast [6], and thus perhaps related to D/P asteroids.

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