EXCESS 36S IN LAWRENCITE AND NITROGEN ISOTOPIC COMPOSITIONS OF SINOITE FROM ALMAHATA SITTA MS-17 EL3 CHONDRITE FRAGMENT. L. Feng1, A. El Goresy2, J. Zhang1, J. Hao1, M. Boyet1, and Y. Lin1, 1Key Laboratory of the Earth’s Deep Interior, Institute of Geology and Geophysics, Chinese Academy of Science, Beijing, China, Email: LinYT@mail.iggcas.ac.cn., 2Bayerisches Geoinstitut, Universität Bayreuth, 95447 Bayreuth, Germany, 3Université Blaise Pascal, Lab. Magmas et Volcans, UMR CNRS 6524, BP 10448, F-63000 Clermont-Ferrand, France.

Introduction: Almahata Sitta is an unique meteorite shower, the remnants of asteroid 2008 TC3 that was observed before it hit the Earth [1]. The meteorite is a breccia containing mainly ureltic lithologies with many chondritic clasts, and MS-17 fragment was first described as EL3/4 [2] and later as primitive EL3 [3].

The very fresh feature of MS-17 fragment promises preservation of lawrencite (FeCl2), the only known Cl-rich, S-poor condensate of the solar nebula, hence a key to determine the initial abundance of short-lived 36Cl (half life of 0.3 Ma) of the solar system. Excess 36S due to decay of 36Cl has been reported in sodalite [4] and wadalite [5], but both are the secondary alteration phases in Ca-, Al-rich inclusions (CAIs).

The MS-17 EL3 fragment also supplies with a good chance to clarify the origin of sinoite (Si2N2O) that was previously reported in equilibrated ELs [6-8]. The proposed formations of sinoite include condensation of the solar nebula [9], thermal metamorphism [10] and crystallization from alleged condensation of sunlight [11]. Observations of the sinoite-bearing assemblages, the occurrence of fluffy crystallite accretionary rims around metal nodules and absence of metal-sulfide eutectic textures in MS-17 EL3 chondrite fragment clearly indicate sequential condensation of sinoite and troilite, and against shock-induced melting.

Experimental: 32S, 33S, 34S, 36S and 37Cl of lawrencite were analyzed by the nanosIMS 50L at the Institute of Geology and Geophysics, Chinese Academy of Sciences. A primary Cs+ beam of ~2 pA was used, and the secondary S isotopes and 37Cl were counted with electron multipliers (EM) in multi-collection mode. Possible charging was compensated by using e-gun. The 33S peak was well resolved from 32S1H at a mass resolving power (MRP) of 6000 (CAMECA definition). Between analyses of lawrencite in different assemblages, troilite nearby (assuming a normal S isotopic composition) and synthetic FeCl3 deposited on purified Au foil were repeatedly measured as standards of S isotopes. Dead-time and background of each EM were corrected. The relative yield of Cl/S of lawrencite is unknown, instead, that of NIST glass of ~0.8 was applied.

Because of very low yield of CN- of sinoite, 14N16O and 15N16O were measured to determine the 15N/14N ratios. Interferences of 14N16O by 36Si, and 15N16O by 30Si1H and 14N17O can be well separated at MRP of ~9000. 14N16O was counted by FC and 15N16O by EM. Synthetic sinoite prepared from an equimolar mixture of Si3N4 and SiO2 at 1850°C [12] was used as the standard of N isotopes.

Results: Sulfur isotopic compositions were normalized to 34S, and the excesses of 36S were determined with Δ36S/34S=δ36S/34S+2×δ33S/32S. All analyses were plotted as 33S/34S vs 35Cl/34S in Fig. 1, with the error bars of 2σ. The synthetic FeCl3 has the highest 35Cl/34S ratios up to 1×106, with no significant excess of 36S. The synthetic FeCl3 analyses define a
detection limit of $^{36}\text{Cl}/^{35}\text{Cl}$ of $(2.9\pm0.4)\times10^{-7}$. Except for the analyses without $^{36}\text{S}$ excess, the other grains of lawrencite appear to cluster into three “isochron” lines (Fig. 1), with the inferred $^{36}\text{Cl}/^{35}\text{Cl}$ ratios of $(2.5\pm0.2)\times10^{-6}$, $(1.1\pm0.08)\times10^{-5}$ and $(0.94\pm0.08)\times10^{-4}$, respectively. It is noted that the higher Cl/S ratios of lawrencite the lower inferred $^{36}\text{Cl}/^{35}\text{Cl}$ ratios. In addition, the moderately weathered grains usually reveal small or no excess of $^{36}\text{S}$. It is possible that the S isotopic compositions of some lawrencite grains have been contaminated by the neighboring sulfides due to weathering. Hence, the highest $^{36}\text{Cl}/^{35}\text{Cl}$ ratio of $(0.94\pm0.08)\times10^{-4}$ can be referred to as the closest to the initial value of the solar system.

Relative to the atmosphere, the synthetic sinoite has $\delta^{15}\text{N}_{\text{air}}$ of $47.6\pm5.3\%$ (1SD, n=9), and five large sinoite grains from Almahata Sitta MS-17 fragment vary from (1SD) $8.3\pm6.3\%$ to $33.6\pm9.5\%$ with an average of $22.7\pm10\%$. We assume that the synthetic sinoite has a similar N isotopic composition of the atmosphere, because it was prepared at very high temperature under a N$_2$ pressure of 0.98MPa [12]. After the IMF corrected, the sinoite in MS-17 fragment has $\delta^{15}\text{N} = -24.9\pm15\%$.

**Discussion:** The analysis of more lawrencite grains from the new MS-17 section confirms the previous discovery of large excess of $^{36}\text{S}$ in this mineral [11]. The highest inferred $^{36}\text{Cl}/^{35}\text{Cl}$ ratio of $(0.94\pm0.08)\times10^{-4}$ can be referred to as the initial value of the solar nebula at the E-chondrite forming region, because lawrencite is a primary phase. Excess of $^{36}\text{S}$ was reported in sodalite [4] and wadalite [5] in CAIs from carbonaceous chondrites. After calibrating the time difference between CAI formation and alteration, the initial $^{36}\text{Cl}/^{35}\text{Cl}$ ratio of $>1.4\times10^{-6}$ at the C-chondrite forming region was calculated [4]. E-chondrites probably formed closer to the Sun than C-chondrites, because the former are much more reduced. In this case, the initial $^{36}\text{Cl}/^{35}\text{Cl}$ ratio of the solar nebula shows no increasing trend toward the Sun, arguing against irradiation of $^{36}\text{Cl}$ by the proto-Sun.

The $\delta^{15}\text{N}$ of sinoite measured in this study is consistent with the analysis of sinoite in a EL6 chondrite [-18\% to 3\%, 13], indicative of no significant fractionation of N isotopes during thermal metamorphism in the parent body. Our analysis is also consistent with bulk N isotopic composition of E-chondrites [14]. The similarity of N isotopic compositions between E-chondrites and the Earth is another line of evidence for contribution of an E-meteorite-like precursor during accretion of the Earth.

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![Fig. 1. $^{36}\text{S}/^{34}\text{S}$ vs $^{35}\text{Cl}/^{34}\text{S}$ plot of lawrencite from Almahata Sitta MS-17 EL3 fragment. Troilite (Tr) and synthetic FeCl$_3$ were standards of S isotopes. Error bars are in 2σ.](image)

**References:**