AN ALMAHATA SITTA EL3 CLAST: A UNIQUE THERMAL HISTORY.

M. Kimura[1,2], M. K. Weisberg[3,4], A. Takaki[2], and N. Imae[1,5], [1]National Institute of Polar Research, Tokyo, Japan (kimura.makoto@nipr.ac.jp), [2]Ibaraki University, Mito, Japan, [3]Kingsborough College and Graduate School of the City University of New York, USA, [4]American Museum of Natural History, New York, USA, [5]SOKENDAI, Tokyo, Japan.

Almahata Sitta is a polymict breccia, consisting of many kinds of clasts. Here we present our mineralogical and petrological results on an EL3 clast, MS-177. This clast was already studied [1], and detailed condensation processes, especially of oldhamite, sinoite, and Fe-Ni metal, were clarified. Here we compare the results with another EL3 chondrite, Asuka (A) 881314 and others, and discuss the unique thermal history of this clast, especially on the parent body.

This clast shows typical type 3 chondritic texture, consisting of well-defined chondrules often with olivine, isolated silicate minerals, and opaque nodules. Although these components are typical of EL3 chondrites, the mineral abundances are different from the other EL3's [2]. Diopside is highly abundant. On the other hand, alabandite and oldhamite are not common, and perryite and daubreelite were not found. This clast shows shock-induced darkening, although no evidence of melting, such as shock melt veins, melt pockets, or eutectic intergrowth of Fe-Ni metal and troilite. These features are commonly observed in the heavily shocked EH3 chondrite Asuka (A) 10164 [3].

We identified low-Ca pyroxene by using an X-ray diffractometer after [4]. The X-ray diffraction peaks of 321 and 511 indices indicate that the pyroxenes are orthoenstatite, not clinoenstatite, in this clast. By using laser Raman microscopy, we identified the feldspar phase as albite, not kumdykolite. The silica phase is quartz, which is different from that in other EL3's [5]. Fe-Ni metals contain 0.3-0.6 wt.% P, and 6.4-8.2 Ni, higher than those in A-881314 (<0.2 and 4.5-7%) and other EL3's [2]. On the other hand, the Ni contents of schreibersites, 7.0-7.8 wt.%, are much lower than in those from A-881314 (22-50%). Troilites contain higher Cr (2.1-4.5 wt.%) and Mn (0.7-1.7) than those in A-881314 (0.2-1.0 and <0.1%). Only one keilite grain was found in a chondrule. An (Fe,Zn)S grain was found in a chondrule and this phase is identified as buseckite. Sinoite is present within Fe-Ni metal [1].

The texture of the MS-177 clast is similar to that of A-881314, but opaque mineral compositions indicate that the clast experienced a high-temperature event, 600-700°C, not inconsistent with [1]. This is supported by no evidence of partial melting, and the occurrence of quartz and absence of kumdykolite. The absence of clinoenstatite also supports the thermal conditions from the stability of orthoenstatite [6]. Low abundances of daubreelite and alabandite are explained by high concentrations of Cr and Mn in troilite, reflecting the high-temperature event. On the other hand, the high abundance of diopside can not be explained by the thermal event. Diopside may be primary and may have been abundant before accretion. A diopside-rich large chondrule was previously reported in the MAC 88136 EL3 [7]. Shock-induced heating for a short duration might explain this high-temperature event, as suggested by the survival of olivine and chondrules with clear outlines without any evidence of impact melting. No occurrence of high-pressure minerals indicates that the pressure conditions were low. The estimated temperatures and pressures were much lower than those, 3-10 GPa and 1000°C, for A-10164 which was partially melted by a shock event and contains the high-pressure phase coesite [3]. Thus, the thermal history of clast MS-177 is unique, differing from the high temperature and pressure conditions that formed A-10164, and the low-temperature conditions recorded in other EL3 chondrites [e.g., 8]. On the other hand, MS-177 may have partly experienced similar high-temperature conditions to ELb chondrites [9].

Acknowledgement: The sample of MS-177 was supplied by Prof. A. El Goresy.

References: [1] El Goresy A. et al. (2017) *Meteoritics & Planetary Science* 52:781-806. [2] Weisberg M. K. and Kimura M. (2012) *Chem. Erde* 72: 101-115. [3] Kimura M. et al. (2017) *Meteoritics & Planetary Science* 52:24-35. [4] Imae N. and Nakamuta Y. (2018) *Meteoritics & Planetary Science* 53:232-248. [5] Kimura M. et al. (2005) *Meteoritics & Planetary Science* 40: 855-867. [6] Smyth J. R. (1974) *American Mineralogist* 59: 345-352. [7] Weisberg M. K. et al. (2012) *The 75th Annual Meeting of the Meteoritical Society*, Abstract #5228. [8] Lin Y. and El Goresy A. (2002) *Meteoritics & Planetary Science* 37:577-599. [9] Weyrauch et al. (2018) *Meteoritics & Planetary Science* 53: 394-415.