A HUGE SINGLE DIAMOND IN ALMAHATA SITTA COARSE-GRAINED UREILITE M. Miyahara[1], E. Ohtani[1], A. El Goresy[2], Y.T. Lin[3], L. Feng[3], J.C. Zhang[3], P. Gillet[4], T. Nagase[1], J. Muto[1], M. Nishijima[5], [1]Department of Earth Sciences, Tohoku Univ., Sendai 980-8578, Japan, E-mail: miyahara@m.tohoku.ac.jp, [2]Bayerisches Geoinstitut, Universität Bayreuth, Bayreuth D-95440, Germany, [3]Key Laboratory of the Earth's Deep Interior, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China, [4]Ecole Polytechnique Fédérale de Lausanne Bâtiment CE Sation 1, Lausanne CH-1015, Switzerland, [5]Institute for Materials Research, Tohoku Univ., Sendai 980-8577, Japan.

Introduction: As is well known, ureilite contains diamond and graphite. There are three major models as a diamond formation mechanism in ureilite; i.e., 1) formation from a fluid or melt in the deep interior of an ureilite parent-body [e.g., 1], 2) formation through chemical vapor deposition (CVD)[e.g., 2] and 3) shock-induced transformation of graphite at the moment of planetesimal collision [e.g., 3]. Now, shock-induced transformation model is widely accepted. Almahata Sitta is the first meteorite that was observed and its trajectory was determined before the fall [4]. Almahata Sitta consists mainly of coarse- and fine-grained ureilites with less abundant chondritic clasts [5][6]. Most diamonds in ureilites studied previously are polycrystalline assemblages, and the individual single crystals are sub-microns in size. We found, at the first time, a huge single diamond crystal from one of Almahata Sitta coarse-grained ureilite samples. Here, we report the occurrence and nature of the unique diamond in the Almahata Sitta coarse-grained ureilite, and discuss its possible formation mechanism.

Experimental methods: We prepared several polished chip samples of Almahata Sitta coarse-grained ureilite MS-170 for this study. Euhedral grains of diamond were easily recognized in graphite matrix between silicate minerals under an optical microscope, both phases were confirmed with a laser micro-Raman spectroscopy (JASCO NRS-5100). The petrological and mineralogical textures were studied with a low-vacuum SEM (Hitachi S-3400N) without any coating. We determined the crystallographic orientation distribution of diamond using a EBSD system (HKL Technology Channel 5) attached to the low-vacuum SEM. Chemical compositions of the constituent minerals were determined with an EPMA (JEOL JXA-8800M). Some diamonds and graphites were observed with a TEM (JEOL JEM-2010). Isotope distribution images in diamond were taken with a NanoSIMS 50L. Samples for TEM observation and NanoSIMS measurement were prepared by a FIB system (JEOL JEM-9320FIB).

Results and discussion: The Almahata Sitta coarse-grained ureilite MS-170 consists mainly of olivine (Fa_{18-21}) and low-Ca pyroxene, with less abundant troilite, kamacite, magnetite, schreibersite and diamond-graphite assemblages. Olivine and low-Ca pyroxene around the diamond-graphite usually show the typical reduction texture of ureilites. Because of its hardness, diamond appears above the polished surface, easily seen under an optical microscope and SEM. The main diamond Raman band (T_2g phonon mode) stays within narrow range (1333.5 cm^{-1}, σ = 1.7, n = 53). High-magnification BSE images show that many diamonds (a dimension > ~2.0 μm) have hexahedron- or octahedron-like habits, which corresponds to idiomorphic {001} or {111} diamond, respectively, although not always idiomorphic. TEM images show that most diamonds are single crystals although now they are divided into several fragments along fractures or cleavages. SEM-EBSD analysis indicates that many diamond fragments have similar crystallographic orientation, implying that these fragments originated from one single crystal of diamond. Considering the SEM-EBSD analysis, a dimension of single crystal diamond is estimated to be ~100 μm or more. Unoriented graphite platelets exist between the diamonds. No specific crystallographic orientation between graphite and diamond could be found. The isotope distribution images show heterogeneous nitrogen abundances and $\delta^{13}C$ values ($\delta^{13}C = \{(^{13}C/^{12}C)_{Sample}/(^{13}C/^{12}C)_{PDB} - 1\} \times 1000$) among individual diamonds and even within grains. Some diamonds show sector zoning of nitrogen. Almahata Sitta is a less shocked ureilite (S0). The idiomorphic huge single diamond was not formed from graphite through martensitic phase transformation mechanism under high-pressure and -temperature conditions induced by dynamic events. The diamond would form under static conditions. CVD process and formation from a fluid or melt in the deep interior of an ureilite parent-body are likely scenarios for the huge single diamond formation. Additional NanoSIMS analysis and noble gas analysis are still on going to clarify its origin.

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