ASTEROID 2008 TC_3 – ALMAHATA SITTA: NOT ONLY A UREILITIC METEORITE, BUT A BRECCIA CONTAINING MANY DIFFERENT ACHONDRITIC AND CHONDRITIC LITHOLOGIES.

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Introduction: Asteroid 2008 TC3 was the first asteroid detected in space and impacting the Earth in the Nubian Desert of northern Sudan October 7, 2008. Hundreds of mostly small fragments were recovered. The meteorite called Almahata Sitta was classified as a polymict ureilite [1]. We have studied 31 small pieces from different fragments collected in the Almahata Sitta strewn field and found a large number of different lithologies. Since all are extremely fresh and unweathered we are convinced that most, if not all belong to the Almahata Sitta meteorite fall.

Results:

Cosmogenic radioisotopes: Cosmogenic isotopes were measured by means of γ-ray spectroscopy in two chondritic fragments (MS-D and MS-CH) of the Almahata Sitta strewn field. The detection of ^{46}Sc (half life: 83.8d) in MS-CH, of ^{54}Mn (half life: 312.2d) and ^{57}Co (half life: 271.8d) in both samples clearly indicates that these fragments result from a very recent meteorite fall consistent with the Almahata Sitta fall 14 months ago.

Mineralgy: The mineralogy and texture of all fragments were studied by light and electron optical microscopy. A JEOL 6610-LV electron microscope was used to resolve the fine-grained textures and to analyze the mineral constituents using the EDS attached (INCA; Oxford Instruments). The fragments can be characterized as follows. Details on some fragments are also given by Horstmann and Bischoff [2]. Please note that the following statistic may not be representative of the real distribution of collected fragments:

7 ultra-fine-grained ureilites: These fragments are mineralogically similar to those described by Jenniskens et al. [1], but vary in mineral composition from fragment to fragment. Some have a mean olivine composition of ~Fa_{12} (e.g., MS-1, MS-152) whereas others can have mean olivine compositions between ~Fa_3 (e.g., MS-154) and ~Fa_{18} (e.g., MS-161). One fragment mainly having olivine of $Fa_{12\text{-}14}$ includes a highly reduced clast with ~Fa_1 olivine (Fig. 1a).

10 coarse-grained ureilites: Based on texture and mineral compositions these ureilitic fragments belong to at least five different lithologies of the parent body. (Figs. 1b-d).

10 enstatite chondrites: Due to differences in texture, mineralogy, and mineral compositions these fragments represent at least six different enstatite chondrites (EH3 (MS-14), EL3/4 (MS-17), EL6 breccia (MS-D), EH5, shock-darkened EH4/5 (MS-13) chondrites etc.).

2 H-group ordinary chondrites: The H5 (MS-151) and H5/6 (MS-11) chondrites have different compositions of olivine and pyroxene (~$Fs_{17.5}$; ~$Fa_{20.5}$ and ~Fs_{14}; ~$Fa_{16.5}$, respectively).

1 unique chondrite (MS-CH): This is a type 3.8±0.1 chondrite with a chondrule/matrix ratio of about 1.5 (Fig. 1f). Olivine is mainly $Fa_{35\text{-}37}$. Since the rock has a considerable abundance of mainly Ni-rich metal (Ni: ~38.5 wt%; Co: ~2 wt%) a relationship to CK- and R-chondrites can be ruled out (see [2] for details).

1 sulfide-metal assemblage: One fragment (MS-158) is dominated by a sulfide-metal assemblage (Fig. 1e) having an area of fine-grained ureilitic lithology attached. Highly reduced olivine is found in silicate inclusions within the sulfide-metal intergrowth.

Discussion: We are convinced that most, if not all different lithologies belong to the Almahata Sitta meteorite fall. The main reasons are: (a) detection of the short and medium short lived cosmogenic nuclides ^{46}Sc, ^{57}Co, and ^{54}Mn. (b) Preliminary studies show that at least two fragments contain two different lithologies. (c) Among the fragments at least 6 different E chondrite lithologies were detected. Enstatite chondrites are relatively rare and such a high number of fresh E-chondrite meteorite falls in just one small area is unrealistic. (d) The discovery of several new unique meteorite fragments (having so far unknown textures and mineralogy) in a small area is only conceivable with a break-up of a polymict asteroid.

The study of breccias is extremely important to reveal information on the evolution of asteroidal parent bodies [3]. Thus, after the polymict breccia Kaidun [4] Almahata Sitta is a new extraordinary breccia for future studies.

Asteroid 2008 TC_3 was classified as a F-class asteroid, although ureilites were initially thought to derive from S-class asteroids [1]. Based on these findings the reflectance spectrum of asteroid 2008 TC_3 has to be evaluated in a new light.

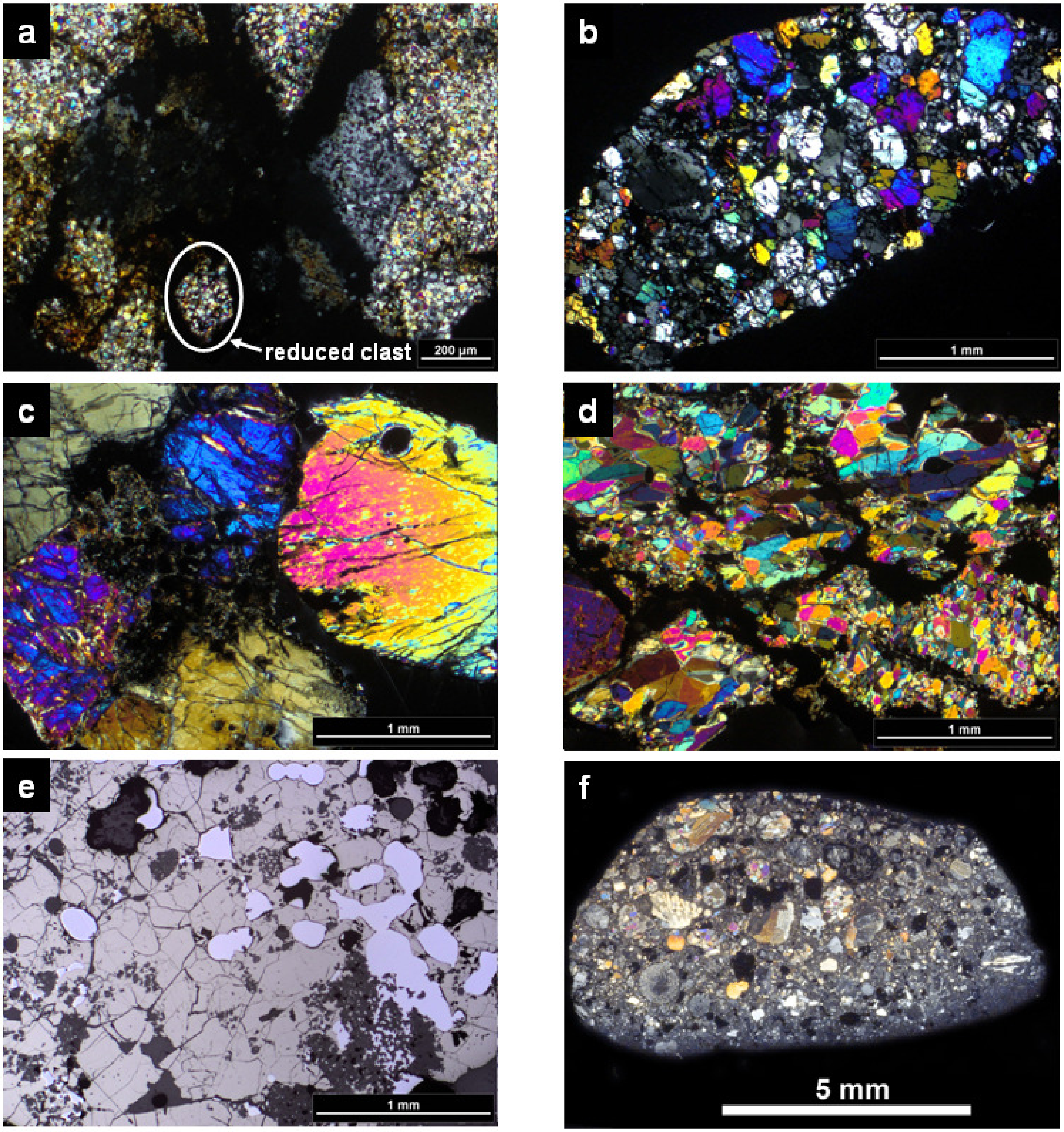

Figure 1: Photomicrographs in transmitted (crossed polarizers; (a)-(d), (f)) and reflected (e) light: (a) Fragment MS-152 is a fine-grained, ureilitic object containing a reduced clast; Figs. (b)-(d) show some coarse-grained ureilites with different textures: (b) MS-153; (c) MS-160; (d) MS-171; (e) the sulfide-metal portion of fragment MS-158 includes highly reduced olivines in the silicate-rich areas (grey) and holes (black); (f) the unique chondrite fragment MS-CH.

References:

[1] Jenniskens P. et al. (2009) *Nature, 458,* 485-488. [2] Horstmann M. and Bischoff A. (2010) *LPSC 41, this issue*. [3] Bischoff et al. (2006) MESS II, 679-712, Univ. of Arizona, Tucson. [4] Zolensky M. and Ivanov A. (2003) *Chem. Erde 63*, 185-246.