A REAL SPACE ROSETTA STONE – THE ALMAHATA SITTA METEORITE. V.H. Hoffmann[1,2], M. Kaliwoda[3], R. Hochleitner[3], M. Funaki[4], S. Decker[5]. [1]Fac. Geosciences, Dep. Geo- and Environm. Sciences, Univ. München; [2]Dep. Geosciences, Univ. Tübingen; [3]Mineralogical State Collection, München, Germany; [4]Tokyo, Japan; [5]Meteorite Museum, Oberwesel, Germany.

Almahata Sitta meteorite – overview

The fall and discovery of numerous fragments of the Almahata Sitta meteorite in the desert of N Sudan has significantly deepened our knowledge concerning the formation, structure and life cycle of asteroids [1].

In contrast to earlier findings, Almahata Sitta - classified as a polymict ureilite - does not only contain small clasts of different meteorite lithologies but consists of individuals of a continuously growing number of different meteorites: various types of ureilites, numerous enstatite chondrites, a number of ordinary chondrites, even a carbonaceous chondrite (a Bencubbinite) and a unique and new meteorite lithology with an affinity to Rumuruti chondrites have been classified earlier [1] and partly investigated by magnetic means [2-4].

Despite the official information of about 2-3kg total mass (or even more?) existing, the major limitation for performing more detailed research on this unique material was the very limited access to these extraordinary samples.

Recently however, due to the efforts of one of our contributing authors (S.D.) a significant and growing number of new individuals of the Almahata Sitta meteorite could be made accessible for our projects: sample set MS-MU- 001–028.

Results and classification of Almahata Sitta MS-MU-001–011 have been reported in [1]. Amongst various types of ureilites and enstatite chondrites (see table 1-3), more fascinating new and unique meteorite individuals could be identified such as an enstatite achondrite or a trachyandesite [5-7]. It becomes obvious that the Almahata Sitta meteorite is unlike anything seen before.

Classification of meteorites by magnetic susceptibility (MS) is a well established method in the meantime [8-10]. A large set of Almahata Sitta samples was investigated and classified by MS [2-4,8], first results on the new sample set obtained by MS and Raman Spectroscopy (phase composition) have been reported in [11,12].

Figure 1 shows a statistical overview of all so far known and classified individuals of the Almahata Sitta meteorite fall. One can be sure that more different, new and unknown lithologies will be identified in future.
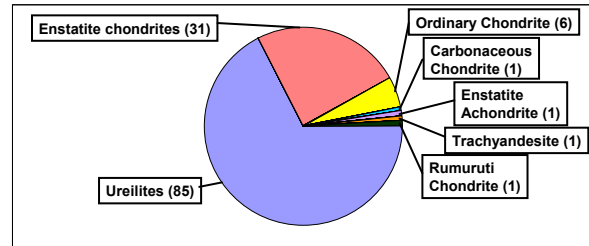

Fig. 1: Reported Almahata Sitta meteorite lithologies – overview (11/2015).

In the following we present magnetic susceptibility values and magnetic classification of the new sample set MS-MU 001-028.

Sample	Class.	MS and magnetic class.	
001	Ur - fg	4.93	Ureilite
002	EL 3	5.26	EL or EH
003	EL (brecc.)	5.43	EL or EH
004	Ur - fg, vgs	5.03 [Bart.]	Ureilite
005	Ur - cg	n. a.	
006	Ur - cg	n. a.	
007	EL 6	5.30 / 5.13	EL or EH
008	Ur - cg	n. a.	
009	EH 4/5	5.33	EL or EH
010	Ur - cg	n. a.	

Sample	Class.	MS and magnetic class.	
011	Trachy-Andesite	3.66/3.32/3.32	Unique
012	Ur (pla-ol-pyx)	5.37/4.99	Unique
013	H 5 (L/LL)	5.17/5.14	H 5
014	Ur - cg	4.90	Ureilite
015	EL 6	---	
016	Ur - cg	4.83	Ureilite
017	Ur - cg	5.20	Ureilite
018	Ur – fg metal rich	5.17/5.35	Unique
019	E-achondrite (metal rich)	5.46/5.38	Unique
020	Ur - cg	5.01	Ureilite

Sample	Class.	MS and magnetic class.	
021	Ureilite unique tex.	5.12	Ureilite
022	Ur - cg	5.02	Ureilite
023	EL 3	5.16	EL or EH
024	EL 6	5.29	EL or EH
025	Ur - fg	4.95	Ureilite
026	EL 6	5.21	EL or EH
027	Ur - fg	4.82	Ureilite
028	Ur variable tex.	4.95	Ureilite

Tab. 1a-c: Magnetic susceptibility of Almahata Sitta sample set MS-MU 001-028. Abbreviations: n.a.: not available; class.: classification [after 5-7]; MS − specific magnetic susceptibility: log MS in 10^{-9} m^3/kg; ur: ureilite, fg fine-grained, cg coarse grained, vgs variable grain size; tex.: texture. Errors in log MS values are +/- 0.02. [Bart.: value provided by R. Bartoschwitz 2015].

Some of the newly classified Almahata Sitta individuals are unique and the MS characteristics will be described in more detail:

(1) MS-MU-011, the first trachyandesite from the UPB; MS values of 3.66/3.32/3.32 which much lower than MS of all other Almahata Sitta individuals or ureilites investigated so far [8]. MS is in the range of Martian nakhlites, and is also typical for terrestrial intrusives.
(2) MS-MU-012 was classified as a unique unbrecciated olivine-pyroxene-plagioclase rich ureilite. MS values of 5.37/4.99 are one of the highest of all investigated Almahata Sitta individuals and all ureilites in general, in the range of severely shocked and brecciated ureilites.
(3) MS-MU-018 is a fine-grained ureilite with a high concentration of metal/sulfide and heavy shock. MS of 5.35/5.17 is in the range of MS-MU-012 and a few known severely shocked and brecciated ureilites.
(4) MS-MU-019 is an enstatite and metal rich achondrite (no aubrite), a likely unique type of meteorite (only NWA 8173/10271 may have similar characteristics). MS values of 5.46/5.38 are unique and much higher than for all reported aubrites (which are metal poor) or ungrouped enstatite achondrites.

It should be noted that the EL, EH and the petrographic enstatite chondrite types cannot be discriminated by magnetic susceptibility alone, additional magnetic parameters are required for that purpose.

Table 2a summarizes the MS values (average values of several samples each) of all known ureilite falls and (b) provides a statistical evaluation of the MS values of all investigated ureilite lithologies of the Almahata Sitta meteorite fall. h: high shock. In (b) MS values of the unique trachyandesite from UPB are given for comparison.

Sample	Source	MS
Novo Urei	[9]	4.96 +/- 0.09
	[10]	4.91 +/- 0.11
	This study	4.97 +/- 0.02
Haverö	[10]	5.13 +/- 0.03 h
	This study	5.16 +/- 0.02 h
Jalanash	This study	4.94 +/- 0.02
Dyalpur	[10]	4.90 +/- 0.08 h

Sample	Class.	MS
AS Ureilites (14)	Coarse-grained (cg)	4.80 +/- 0.03
AS Ureilites (7)	Fine-grained (fg) Various textures	4.96 +/- 0.03
AS Ureilite (1)	Pla-Ol-pyx	5.18 +/- 0.05
AS Ureilite (1)	Fg, metal-sulf. rich	5.26 +/- 0.03
Trachyandesite	AS, UPB	3.43 +/- 0.05

An evaluation of the MS values of the other AS lithologies will be published elsewhere.
The new Almahata Sitta sample set provides the scientific community with several unique and new meteorite lithologies: a real Rosetta Stone of Space!

References
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