

**A NOBLE GAS STUDY OF TWO STONES FROM THE ALMAHATA SITTA METEORITE.** U. Ott<sup>1</sup>, S. Herrmann<sup>1</sup>, P. M. Jenniskens<sup>2</sup> and M. Shaddad<sup>3</sup>, <sup>1</sup>Max-Planck-Institut für Chemie, Joh.-J.-Becher-Weg 27, D-55128 Mainz, Germany (uli.ott@mpic.de), <sup>2</sup>SETI Institute, 515 N. Whisman Road, Mountain View, CA 94043, USA, <sup>3</sup>Physics Department, University of Khartoum, Khartoum 11115, Sudan.

**Introduction:** A quite unique event happened on October 6, 2008 when the small asteroid TC3 was discovered by the automated Catalina Sky Survey telescope and subsequently impacted the Earth's surface over the desert of Northern Sudan [1]. Dedicated search in the area recovered a total of several hundred fragments that were assigned the meteorite name Almahata Sitta [2]. Almahata Sitta has been classified as an anomalous polymict ureilite [1, 2]. A special characteristic is the wide range of textures and albedoes for the individual fragments [3].

We report results for noble gases in two small samples (~ 15 mg) from two fragments, #1 and #47 of quite different appearance. #47 is dominated by olivine according to Mid-IR transmission spectra by [3] and is slightly terrestrially weathered [4].

**Experimental** Noble gases were analyzed by standard analytical techniques (e.g., [5]), with gas extraction in three temperature steps (600, 1000, 1800 °C).

**Cosmogenic gases:** Data for He and Ne are summarized in Table 1. <sup>3</sup>He and the Ne isotopes are essentially of pure cosmogenic origin, and unlike in other polymict ureilites [6], there is no evidence for presence of implanted solar wind gases.

	<sup>3</sup> He	<sup>4</sup> He	<sup>22</sup> Ne	<sup>20</sup> Ne/ <sup>22</sup> Ne	<sup>21</sup> Ne/ <sup>22</sup> Ne
#1	14.3 ± 0.4	118 ± 3	5.20 ± 0.07	0.8572 ± 0.0041	0.8959 ± 0.0051
#47	25.2 ± 0.5	230 ± 5	7.40 ± 0.11	1.0041 ± 0.0045	0.9278 ± 0.0057

Table 1. He and Ne results (abundances in 10<sup>-8</sup> cc/g).

Production rate systematics for ureilites is less well established than that for chondrites. For our calculations and in order to facilitate comparison with the literature data summarized in [6], we followed the approach of these authors, i.e. used the shielding correction derived for diogenites by [7]. Chemical compositions were taken from [8] and [9]; a few elements not available there were taken from the average ureilite abundances given by [6].

Nominal <sup>3</sup>He CRE ages derived in this manner are 8.8 Ma for fragment #1 and 15.1 Ma for #47. Corresponding ages based on <sup>21</sup>Ne are quite consistent with each other at 12.4 and 12.3 Ma. Apparently #1 has lost a significant fraction of cosmogenic He. This is also obvious in its position in the Bern-type plot of <sup>3</sup>He/<sup>21</sup>Ne<sub>cos</sub> vs. (<sup>22</sup>Ne/<sup>21</sup>Ne)<sub>cos</sub> shown in Fig. 1. The plot

also shows that #47 was irradiated in a rather shielded position in line with large meteoroid size.

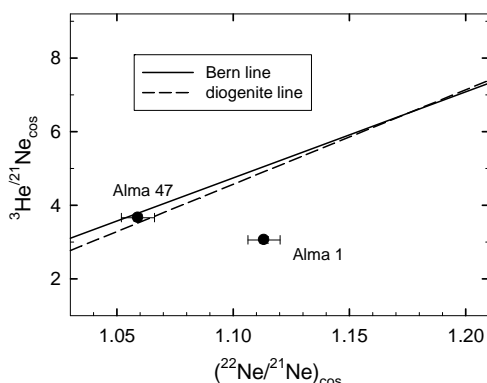


Fig. 1. Bern type plot of cosmogenic He and Ne. Shown are both the original Bern line [10] valid for chondritic meteorites as well as the relation derived for diogenites [7].

CRE ages based on <sup>21</sup>Ne and using the approach developed for ureilites by [11] are slightly higher at 13.2 and 14.2 Ma for #1 and #47, respectively. Cosmogenic <sup>38</sup>Ar is clearly visible in Alma #1 only, which has ~5x less trapped Ar than #47 (Table 2). A nominal exposure age based on Ar – again following [6] – is 8.4 Ma. Overall, the CRE age for Almahata Sitta is not unusual for an ureilite (Fig. 2).

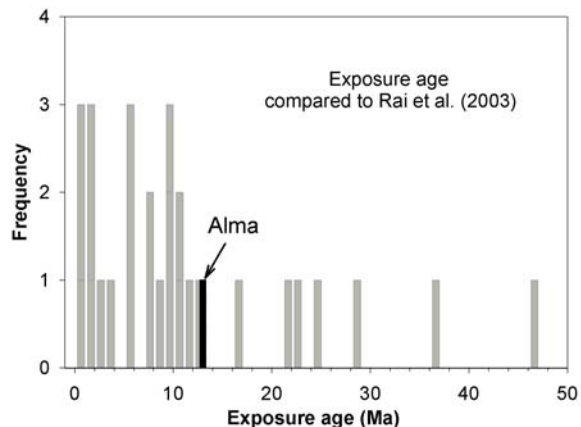


Fig. 2. CRE age of Almahata Sitta specimens compared with ureilite CRE ages compiled by [6].

**Trapped gases:** Both specimens, in particular #47, contain abundant trapped heavy noble gases (Table 2). Combined with the marginal only evidence for trapped He and Ne, this is characteristic for ureilites

(e.g., [6, 12]). Compared to other ureilites, Alma #1 lies in the lower abundance range, while #47 is comparably “average” (Fig. 3).

	$^{36}\text{Ar}$	$^{84}\text{Kr}$	$^{132}\text{Xe}$
#1	23.8 $\pm 0.6$	0.183 $\pm 0.006$	0.250 $\pm 0.007$
#47	115.4 $\pm 2.8$	2.399 $\pm 0.066$	1.936 $\pm 0.047$

Table 2. Abundances of  $^{36}\text{Ar}$ ,  $^{84}\text{Kr}$  and  $^{132}\text{Xe}$  in fragments of Almahata Sitta (units:  $10^{-8}\text{ cc/g}$ ).

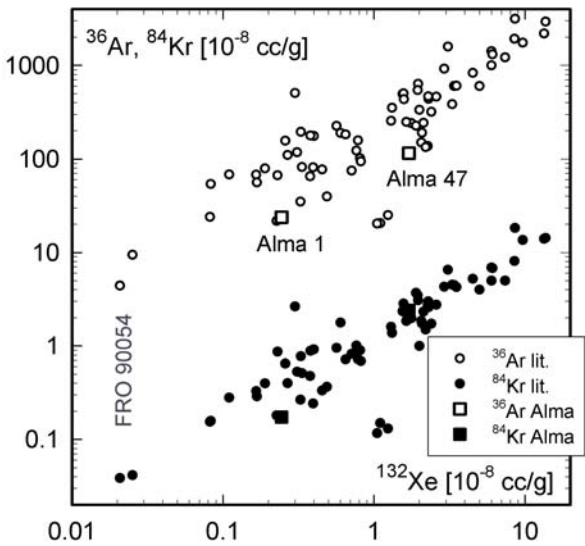


Fig. 3. Abundances of  $^{36}\text{Ar}$  and  $^{84}\text{Kr}$  vs.  $^{132}\text{Xe}$  abundance for Almahata Sitta #1 and #47 compared with literature data for ureilites.

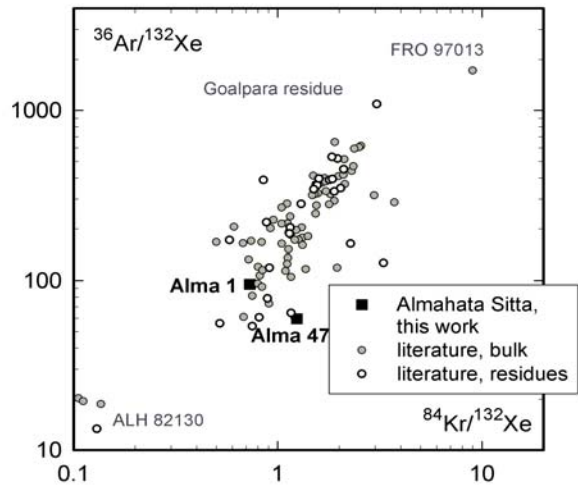


Fig. 4. Abundance ratio  $^{36}\text{Ar}/^{132}\text{Xe}$  vs.  $^{84}\text{Kr}/^{132}\text{Xe}$  in Almahata Sitta compared with literature data for bulk ureilites as well as chemical residues.

A further characteristic of trapped noble gases in ureilites is the large range in elemental abundance ratios. In a plot of  $^{36}\text{Ar}/^{132}\text{Xe}$  vs.  $^{84}\text{Kr}/^{132}\text{Xe}$  Almahata

Sitta #1 (ratios are 95 and 0.73, resp.) lies at the low end of the main population (i.e. not counting exceptional ALH 82130), while #47 (60 and 1.24) has a low Ar/Xe ratio, accompanied by comparably high Kr/Xe.

Trapped noble gases in ureilites bear resemblance in their elemental and isotopic abundance patterns to phase Q, the major carrier of noble gases in primitive carbonaceous and unequilibrated ordinary chondrites [6, 13, 14]. Xe isotopic compositions observed in ureilites appear to be quite uniform [6], and data for Almahata #47 are indeed similar to the average ureilite Xe of [12]. In contrast, our data for Almahata Sitta #1 indicate a small relative depletion of isotopes 131, 134 and 136 relative to  $^{132}\text{Xe}$  (Fig. 5). This will, however, require confirmation.

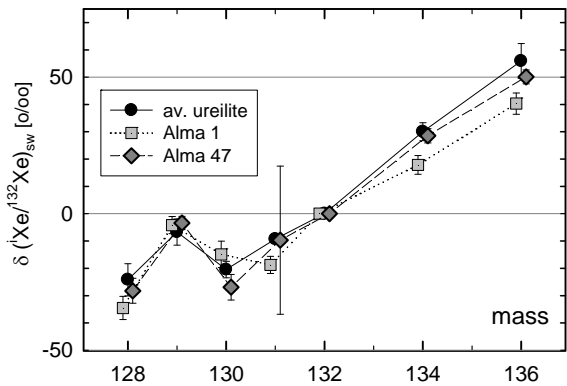


Fig. 5. Xe isotopic composition in Almahata Sitta samples compared with average ureilite Xe [12, 14]. Shown are deviations (in ‰) from solar wind Xe [15].

**References:** [1] Jenniskens P. et al. (2009) *Nature*, 458, 485-488. [2] Zolensky M. E. (2009) *Meteoritics & Planet. Sci.*, 44, A227. [3] Sandford S. A. et al. (2010), subm. to *Meteoritics & Planet. Sci.* [4] Zolensky M. E. (2009) priv. comm. [5] Schwenzer S. P. et al. (2007) *Meteoritics & Planet. Sci.*, 42, 387-412. [6] Rai V. K. et al. (2003) *Geochim. Cosmochim. Acta*, 67, 4435-4456. 869. [7] Eugster O. and Michel Th. (1995) *Geochim. Cosmochim. Acta*, 59, 177-199. [8] Friedrich J. M. et al. (2010) subm. to *Meteoritics & Planet. Sci.* [9] Welten K. C. et al. (2010) subm. to *Meteoritics & Planet. Sci.* [10] Eberhardt P. et al. (1966) *Zeitschrift f. Naturforschung*, 21a, 414-426. [11] Aylmer D. et al. (1990) *Geochim. Cosmochim. Acta*, 52, 1775-1784. [12] Göbel R. et al. (1978) *JGR*, 83, 855-867. [13] Busemann H. et al. (2000) *Meteoritics & Planet. Sci.*, 35, 949-973. [14] Ott U. (2002) in *Reviews in Mineralogy & Geochemistry Vol. 47*, 71-100. [15] Pepin R. O. et al. (1995) *Geochim. Cosmochim. Acta*, 59, 4997-5022.

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