Preprint
UCRL-JC-137141

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This article was submitted to
31st Lunar and Planetary Science Conference
Houston, TX
March 13-17, 2000

U.S. Department of Energy

Lawrence Livermore National Laboratory

January 14, 2000

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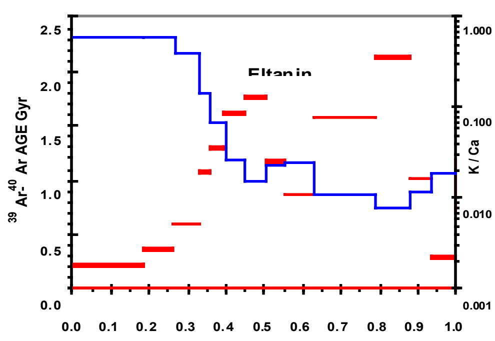
Abstract: A 1.5 cm long, 1.2 g specimen of the Eltanin meteorite was found at 10.97 m depth in Polarstern piston core PS2704-1 [Kyte, 2000 #4486]. The early studies indicated that the small fragments of the Eltanin meteorite was debris from a km-sized asteroid which impacted into the deep-ocean basin [Kyte, 1985 #2195; Gersonde, 1997 #4030]. In this study, we measured ^{39}Ar-^{40}Ar age, noble gases, and cosmogenic radionuclides in splits of specimen as a part of consortium studies of Eltanin meteorite. We concluded that the specimen was about 3 m deep from the asteroid surface. The exposure age of the Eltanin asteroid was about 20 Myr.

^{39}Ar-^{40}Ar Age: A 45 mg sample of Eltanin was neutron irradiated to determine its ^{39}Ar-^{40}Ar age (Fig.1). The first ~35% of the ^{39}Ar release suggests K contamination (high K/Ca ratio) and major diffusion loss of ^{40}Ar. Most of the Ar was released in a broad peak over 850-1300^{O}C, where the measured Ar-Ar ages scatter considerably and are all less than ~2 Gyr. Thus, all Eltanin phases have been extensively degassed of ^{40}Ar, either by terrestrial weathering or by impact prior to falling on earth or during impact with the earth. The measured [Cl] concentration of our sample (determined using ^{38}Ar) was <10 ppm, so significant contamination by seawater is not indicated.

Figure 1. ^{39}Ar-^{40}Ar ages and the K/Ca ratio as a function of fraction of ^{39}Ar released



Cosmogenic and Trapped Noble Gases: Noble gases were extracted in three temperature steps (500, 750, and 1550˚C) from a separate 22.5 mg sample of Eltanin and analyzed on a different mass spectrometer (Table 1). ^{3}He signals were at blank levels, and the values given in Table 1 are upper limits. The ^{4}He concentration, however, is comparable to that observed in some other mesosiderites [Schultz, 1989 #1516]. Neon and Ar are primarily released at the highest extraction temperature, which suggests that terrestrial noble gases do not constitute a significant portion of the totals. The $^{20}Ne/^{22}Ne$ ratio decreases from 12.45 at 500˚C to 11.23 at 1550˚C. These ratios are higher than the atmospheric ratio of 9.81 and indicate the presence of solar wind or SEP Ne. It is not clear how this solar Ne was introduced into Eltanin.

Table 1. Noble gases in Eltanin (10^{-9} cm^{3} STP/g)

Isotope	500˚C	750˚C	1550˚C	Total
^{3}He	0.07	0.07	0.07	0.22
^{4}He	1100	2800	650	4600
^{20}Ne	2.4	2.5	19.6	24.5
^{21}Ne	0.004	0.003	0.175	0.182
^{22}Ne	0.19	0.22	1.74	2.16
$^{21}Ne_c$	~0	~0	0.13	0.13
^{36}Ar	1.48	0.76	12.0	14.3
^{38}Ar	0.37	0.17	2.38	2.92
^{40}Ar	654	475	2717	3846
$^{38}Ar_c$	0.10	0.03	0.14	0.27
^{132}Xe	n.m.	n.m.	0.02	0.02
$^{129}Xe/^{132}Xe$				1.08±0.10

Eltanin contains cosmogenic ^{21}Ne and ^{38}Ar (Table 1).. These concentrations were calculated assuming two component mixtures with trapped $^{21}Ne/^{22}Ne$= 0.029 and $^{36}Ar/^{38}Ar$ =5.32, and cosmogenic $(^{21}Ne/^{22}Ne)_c$ =0.9 and $(^{36}Ar/^{38}Ar)_c$ =0.67. Only the 1550˚C extraction released significant amounts of cosmogenic ^{21}Ne Calculation of cosmogenic ^{38}Ar at each temperature is sensitive to the choice of trapped $^{36}Ar/^{38}Ar$, and the values in Table 1 are rather uncertain. The low temperature release of cosmogenic $^{38}Ar_c$ may derive from oxidized metal, as little metal phase remains in Eltanin. The $^{129}Xe/^{132}Xe$ ratio at 1550˚C is slightly higher than, but within uncertainty the same as, this ratio in terrestrial Xe. The low $(^{3}He/^{21}Ne)_c$ ratio suggests that more than 50 % of ^{3}He has been lost from Eltanin.

Cosmogenic radionuclides: Two small pieces of the Eltanin meteorite were leached by chemical means to remove possible surface contamination of meteoric (atmospheric) ^{10}Be. The sample was first leached with 0.2 N HNO_3 in an ultrasonic bath for 5 min. The sample was subsequently leached with 1.5 N HNO_3 in an ultrasonic bath for 10 min. Following these leaches the meteorite was rinsed with deionized water and ethanol in an ultrasonic bath. Finally, 33.2 mg of Eltanin was dissolved with an HF/HNO_3 mixture in conjunction with Be and Mn carriers. After taking aliquots for chemical analysis, the Be, Al, and Mn were separated and purified. The ^{10}Be and ^{26}Al in the dissolved Eltanin as well as leaching solutions were measured at LLNL-AMS facility. The results are shown in the table 2.

The observed activities, 0.186±0.003 dpm^{10}Be/kg and 0.041 dpm^{26}Al/kg are corrected to the time of fall using a terrestrial age of 2.15 Myr [Gersonde, 1997 #4030]. At the time of the fall the ^{10}Be and ^{26}Al activities were 0.50±0.01 dpm^{10}Be/kg and 0.34±0.08 dpm^{26}Al/kg. Relative to the ^{26}Al activity, the ^{10}Be activity is much higher than would be expected. Assuming an average Eltanin chemical composition and a relatively heavily shielded 2π exposure, the production rate ratio of ^{26}Al/^{10}Be is ~6. In contrast to *in-situ* production, the production rate ratio of ^{26}Al/^{10}Be in the atmosphere (meteoric) is ~0.005. Our measurements are consistent with the presence of meteoric ^{10}Be contamination in Eltanin that was not removed by the chemical leaching. Since the production of meteoric ^{26}Al is negligible, the observed ^{26}Al in the Eltanin was produced *in-situ*. The concentration of meteoric ^{10}Be contamination is $5x10^8$ atom/g, an amount typical for ^{10}Be concentration in deep-sea sediments.

Table 2. Cosmogenic radionuclides in Eltanin

	Eltanin	Leaching-1	Leaching-2
Mass (mg)	33.23		
^{10}Be (10^6atom)	7.04±0.12	0.03±0.02	0.16±0.02
^{26}Al (10^6atom)	0.73±0.17	0.00±0.06	0.00±0.04
^{10}Be (dpm/kg)	0.186±0.003		
^{26}Al (dpm/kg)	0.041±0.009		
^{10}Be (dpm/kg)*	0.50±0.01		
^{26}Al (dpm/kg)*	0.34±0.08		

* After 2.15 Myr terrestrial age correction

Exposure history: Utilizing the production rate systematics of ^{26}Al produced on the lunar surface [Reedy, 1995 #4229], we conclude that this particular Eltanin sample was exposed to cosmic rays while shielded by 1050 ± 50 g/cm^2 of material, *i.e.* at a depth of ~3 m in the Eltanin asteroid. At such large depths cosmogenic production rates are much smaller than those for typical meteorites. The fragments of Eltanin meteorite in our collection were presumably spalled during atmospheric passage from the near surface of the Eltanin asteroid, which was a km-size in diameter [Gersonde, 1997 #4030]. Using the shielding information determined from the ^{26}Al measurements, it is possible to determine the ^{21}Ne production rate. We assumed that the production rates of ^{21}Ne and ^{26}Al at the depth of 1050 g/cm^2 in Eltanin chemical composition are approximately the same [Reedy, 1995 #4229, Masarik (priv. comm)]. The exposure age of the Eltanin asteroid is accordingly calculated to be ~20 Myr, based on the cosmogenic ^{21}Ne concentration of $1.3x10^{-10}$ cm^{3}STP/g and 0.34 dpm^{26}Al/kg at the time of fall. Although mineralogy of the Eltanin specimens show similarity of HED meteorites, Kyte *et al* [Kyte, 2000 #4486] concluded that the Eltanin is related to the mesosiderite rather than the HED. On the other hand, the ~20 Myr exposure age of the Eltanin asteroid coincides with the exposure age peak of the HEDs [Eugster, 1995 #3585]. Measurement of ^{53}Mn will constrain the exposure history of the Eltanin asteroid.

Acknowledgement We wish to thank Alfred Wegener Institüt für Polar und Meeresforschung, Bremerhaven, Germany for providing the sample of Eltanin meteorite. This work was supported by NASA grant NAG5-4992, RTOP-344-31-30-01, and under the auspices of the D.O.E. by LLNL under contract W-7405-ENG-48.

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