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A COMPLEX EXPOSURE HISTORY OF THE GOLD BASIN L4-CHONDRITE SHOWER FROM COSMOGENIC RADIONUCLIDES AND NOBLE GASES.

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Introduction: Gold Basin is a large L4 chondrite shower, that was recently discovered in the Mojave Desert, Arizona [1]. Based on ^{10}Be and ^{14}C concentrations in several fragments, the pre-atmospheric radius of this shower was estimated to be 3-4 meters [2]. Among chondrites, Gold Basin is one of the largest, thus providing a unique opportunity for comparing measured cosmogenic nuclide concentrations with model calculations for large objects. Noble gas measurements combined with ^{10}Be data of most Gold Basin samples suggest a single-stage exposure of 15-30 Myr, although a few samples may require a complex exposure history [3]. We selected eight samples of the Gold Basin shower that were analyzed for noble gases; these samples represent a wide range of shielding depths.

Experimental procedures: Samples of 2-3 g were gently crushed in an agate mortar and metal was separated with a magnet. The metal was cleaned several times in a ultrasonic bath with 0.2N HCl and once with concentrated HF to remove attached troilite and silicates, respectively. After adding carrier solutions containing 1-2 mg of Be, Al and Ca and 3-5 mg of Cl, metal samples of 20-100 mg were dissolved in 1.5N HNO_3. After dissolution, aliquots were taken for chemical analysis by atomic absorption spectroscopy. Measured concentrations of Mg in the dissolved metal samples correspond to silicate contaminations of ≤0.2 wt%. The silicate fraction was homogenized and samples of ~100 mg were dissolved with ~3 mg of Be and Cl carriers in a mixture of concentrated HF/HNO_3. Further sample preparation was done as described in [4]. All radionuclide concentrations were measured by accelerator mass spectrometry (AMS) at the Lawrence Livermore National Laboratory.

Model calculations: We used the LAHET Code System to calculate primary and secondary particle fluxes in cosmic-ray irradiated L-chondrites with radii of 100-500 cm [5]. Using these fluxes and previously evaluated cross sections we calculated the production rates of spallation produced ^{10}Be, ^{26}Al and ^{36}Cl in metal and stone fractions.

Results and Discussion:. Result of five samples are given in Table 1; measurements of other samples are in progress and will be presented at the meeting.

Terrestrial age. Previous measurements of ^{14}C and ^{10}Be indicate a terrestrial age of 15±1 kyr [2]. Although ^{36}Cl is less sensitive on this time scale, we determined a terrestrial age based on the ^{36}Cl/^{10}Be pair [6]. The ^{36}Cl/^{10}Be method gives a terrestrial age of 60±30 kyr, less precise, but consistent with the age based on the ^{14}C/^{10}Be pair. Accordingly, we conclude that the radionuclide data alone are consistent with a simple exposure of at least 7 Myr in a large object.

Pre-atmospheric size. The measured values of ^{10}Be in the metal and stone fraction are plotted vs. calculated production rates for L-chondrites with radii of 120 and 200 cm.

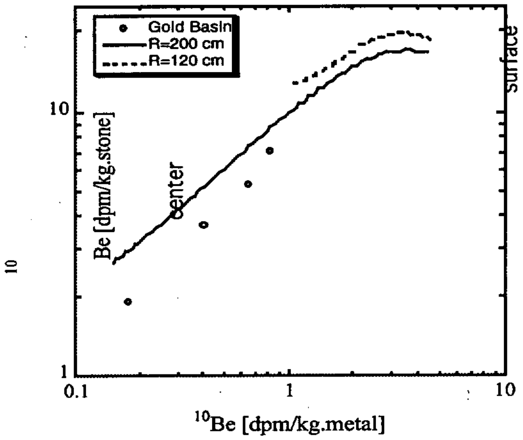

Fig. 1 Comparison of measured ^{10}Be saturation values in stone and metal fraction of the Gold Basin shower with calculated production rates for chondrites with preatmospheric radii of 120 and 200 cm.

Figure 1 confirms that the Gold Basin shower was derived from an object having a radius larger than 2 m. Calculations for radii of 3-5 m will be presented at the meeting to obtain a better constraint of the pre-atmospheric size of the Gold Basin meteoroid.

Shielding depth. The production of ^{36}Cl in the stone fraction is a combination of spallation (from Fe, Ca and K) and neutron-capture (from ^{35}Cl). The spallation component can be estimated from measured concentrations of ^{36}Cl in the metal and of Fe and Ca in the stone fraction. In order to estimate the contribution from Ca we derived the $P^{36}(Ca)/P^{36}(Fe)$ ratio from the ^{10}Be(stone)/^{10}Be(metal) ratio according to Eq. 2 in [7]. $P^{36}(Ca)/P^{36}(Fe)$ varies from 18 to 21 in the four Gold Basin samples. This gives ^{36}Cl spallation contributions of 0.5-2.0 dpm/kg, relative to measured ^{36}Cl concentrations of 5.4-12.9 dpm/kg. The neutron-capture ^{36}Cl component decreases with increasing shielding from ~11 dpm/kg in UA285 to ~5 dpm/kg in UA639. This

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indicates that all four samples came from a depth of at at least 50 cm, whereas the low ^{10}Be concentrations in UA639 indicate a depth close to 200 cm (Fig. 1).

Exposure age. Wieler et al. [3] reported ^{10}Be-^{21}Ne exposure ages between 15 and 30 Myr with a note that some samples may require a complex exposure history. Now, the ^{10}Be and ^{21}Ne concentrations seem to cluster in two groups (Fig. 2). The possibility of two separate showers is highly unlikely, since the ^{14}C-^{10}Be ages of samples from the two groups are identical [2]. Most samples show a relatively constant ^{21}Ne/^{10}Be ratio of ~72 at/at, whereas the remaining four samples (UA263, 274, 300 and 682) show excesses of ^{21}Ne, up to a factor of 2. The majority of samples are consistent with a single-stage exposure of 19±3 Myr, assuming a P(^{10}Be)/P(^{21}Ne) production ratio of 0.12±0.02, which is intermediate between Graf's value of 0.14 [8] and Leya's lowest value of 0.10 [9].

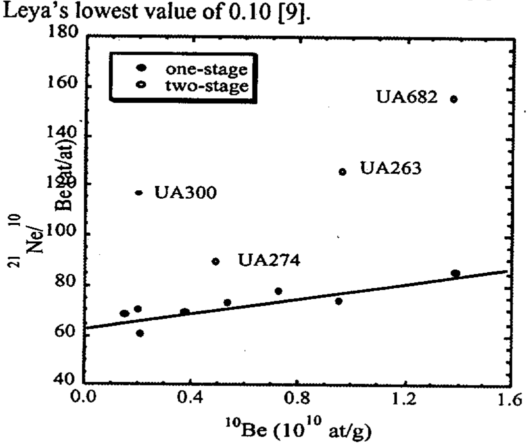

Fig. 2. The ^{21}Ne/^{10}Be ratio as a function of shielding in Gold Basin samples. ^{10}Be data are from [2] and this work, ^{21}Ne data are from [3] and this work. Full circles represent samples without a recognizable ^{21}Ne contribution from a first exposure stage, open circles do show excess ^{21}Ne due to a previous exposure. The solid line is a least-squares fit through the full circles.

The most likely explanation is that the radionuclides of all samples and the ^{21}Ne of most samples reflect exposure conditions during the second stage of 19 Myr, whereas the excesses of ^{21}Ne in UA263, 274, 300 and 682 are due to a previous exposure, most likely on the L-chondrite parent body. Apparently, these four samples (and especially UA682) were closer to the surface of the parent body than any of the other samples measured in our study, which is quite plausible due to the large size (3-4 m radius) of the Gold Basin meteoroid. The depth of burial is still unknown, but based on the ^{21}Ne excesses, the duration of the first-stage exposure must be at least 20 Myr. In the second stage, the samples with the highest ^{21}Ne production from the first stage are close to the surface of the meteoroid, whereas the samples with the lowest (or no) ^{21}Ne from the first stage, are closer to the center or on the opposite side of the meteoroid.

Conclusions: Measurements of cosmogenic radionuclides in both metal and stone fractions of the Gold Basin shower confirm a large pre-atmospheric radius (>200 cm), and a wide range of shielding depths (50-200 cm). Further calculations for objects larger than 200 cm are necessary to further constrain the pre-atmospheric size of Gold Basin.

In combination with the ^{21}Ne concentrations we conclude a two-stage exposure history for the Gold Basin shower. In the first stage the top part of the later excavated Gold Basin meteoroid was exposed close enough to the surface of the parent-body to acquire significant amounts of ^{21}Ne in a few of our samples, whereas other samples were shielded too deep. In the second stage, Gold Basin, was exposed as an object of 3-4 m in radius. From the noble gases and radionuclides, we can reconstruct the location of the samples during the first and second-stage exposures.

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Table 1. Concentrations of cosmogenic ^{21}Ne (in 10^{-8} cm^3 STP/g) in bulk and radiounclides (in dpm/kg) in metal and stone fraction of Gold Basin samples.

Sample	^{21}Ne(cos)	^{10}Be(sto)	^{10}Be(met)	^{26}Al(sto)	^{26}Al(met)	^{36}Cl(sto)	^{36}Cl(met)
GB-UA285	2.10±0.10	7.02±0.14	0.82±0.02	23.7±0.6	0.58±0.02	12.9±0.2	4.23±0.05
GB-UA418	1.47±0.14	5.19±0.10	0.65±0.01	17.1±0.4	0.46±0.02	8.0±0.1	3.26±0.05
GB-UA426	0.98±0.05	3.67±0.07	0.40±0.01	12.7±0.3	0.29±0.02	6.6±0.1	2.06±0.03
GB-UA639	0.51±0.03	1.88±0.04	0.18±0.01	6.5±0.2	0.12±0.01	5.4±0.1	1.02±0.03
GB-UA682	7.98±0.37	12.7±0.22	-	41.0±1.0	-	-	-