

ATMOSPHERIC FRAGMENTATION OF THE GOLD BASIN METEOROID AS CONSTRAINED FROM COSMOGENIC NUCLIDES. K. C. Welten¹, D. J. Hillegonds², A. J. T. Jull³ and D. A. Kring⁴, ¹Space Sciences Laboratory, University of California, Berkeley, CA 94720-7450, USA, (kcwelten@uclink4.berkeley.edu), ²Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, Livermore, CA 94450, USA, ³NSF Arizona Accelerator Mass Spectrometry facility, University of Arizona, Tucson, AZ 85721, USA. ⁴Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA.

Introduction: Since the discovery of the Gold Basin L4 chondrite shower almost ten years ago in the northwestern corner of Arizona, many thousands of L-chondrite specimens have been recovered from an area of ~22 km long and ~10 km wide. Concentrations of cosmogenic ¹⁴C and ¹⁰Be in a number of these samples indicated a terrestrial age of ~15,000 years and a large pre-atmospheric size [1]. Additional measurements of cosmogenic ¹⁰Be, ²⁶Al, ³⁶Cl and ⁴¹Ca in the metal and stone fractions of fifteen Gold Basin samples constrained the pre-atmospheric radius to 3-5 m [2]. This implies that Gold Basin is by far the largest stone meteorite in the present meteorite collection, providing us with an opportunity to study the fragmentation process of a large chondritic object during atmospheric entry. Knowledge about the fragmentation process provides information about the mechanical strength of large meteoroids, which is important for the evaluation of future hazards of small asteroid impacts on Earth and possible defensive scenarios to avoid those impacts.

The previously selected Gold Basin samples did not show a correlation between location of find and estimated depths of 5 to 170 cm in the meteoroid [2]. However, these samples came from a relatively small area, corresponding to ~10% of the known strewnfield area. In this work we present cosmogenic nuclide data on fifteen additional samples from the Gold Basin area. We verified pairing, estimated the depth of each sample in the meteoroid and evaluated the possible correlation (or lack thereof) between sample depth and location of find in the strewnfield.

Samples. Eleven of the fifteen samples are well documented finds by the University of Arizona meteorite recovery team. Three of these samples are from the northern edge of the strewnfield, whereas three others are from the southern edge (Fig. 1). In addition, we selected three of the ~20 samples that were classified by A. Rubin (unpublished data) as L6 chondrites and are informally known as Hualapai Wash (HW) xxx samples. Although the find locations of these L6 chondrites are inside the Gold Basin strewnfield, HW 001 (L6) was initially recognized as an independent fall [3]. We measured the concentrations of cosmogenic ¹⁰Be, ²⁶Al and ⁴¹Ca in ten samples and of ¹⁴C and ¹⁰Be in five samples.

Results and discussion. The concentrations of ¹⁴C, ¹⁰Be, ²⁶Al and ⁴¹Ca are in the same range as

those of previously measured Gold Basin samples. In addition, the new specimens show the same correlation between ¹⁴C and ¹⁰Be and between ⁴¹Ca and ¹⁰Be as previously studied Gold Basin samples [1,2], providing strong evidence that all samples came from the same large pre-atmospheric object. This implies that the three HW L6 chondrites are not an independent fall, but are part of the Gold Basin shower, which apparently is an L4-6 chondrite breccia instead of a regular L4 chondrite. This conclusion confirms the brecciated nature of Gold Basin reported in [1].

We estimated the depth of each sample from the measured ¹⁰Be concentrations and the theoretical depth profile of ¹⁰Be, which was calculated using the LCS model, assuming a pre-atmospheric radius of 5 m [2]. The samples measured in this work yield shielding depths ranging from ~10 cm to ~135 cm, whereas the two most shielded Gold Basin samples analyzed so far came from depths of ~175 cm [2]. We now have depth estimates for ~40 Gold Basin specimens, 31 of which the location of find is well known. Figure 1 shows that there is no correlation between shielding depth in the meteoroid and find location. This observation is consistent with a single atmospheric fragmentation event, as was also concluded from the smooth mass distribution [1].

However, due to the long terrestrial age (15 kyr) and the mountainous terrain in which the Gold Basin shower landed, it seems unlikely that the full extent of the original strewnfield has been mapped yet [1]. This hypothesis is supported by the lack of correlation between recovered mass and location of find in the strewnfield. We also note that the largest specimen of the Gold Basin shower (HW 010) is only ~2.5 kg, whereas most large stony meteoroids yield one or more fragments larger than 100 kg. It is thus not unlikely that a large fragment of the Gold Basin meteoroid survived the main fragmentation event and landed (in one or more pieces) outside the presently known strewnfield.

Moreover, considering the large pre-atmospheric radius (3-5 m) and the many Gold Basin samples analyzed, it seems curious that none of the samples came from a pre-atmospheric depth >2 m. If we assume a radius of 3 m for the Gold Basin meteoroid, and a single fragmentation event producing thousands of small fragments, then the probability is ~25% that out of 35-40 randomly selected samples,

none are from a depth of >2 m. However, if the meteoroid was 4-5 m in radius, as seems more consistent with the neutron-capture ^{41}Ca results [2], then the random probability to find no interior samples is $<1\%$. This low probability either suggests that the pre-atmospheric size of 4-5 m (based on ^{41}Ca) was overestimated or that the present strewnfield is not a representative sample of the entire meteoroid, but is biased towards the outer part. The second explanation suggests that a large interior fragment of the Gold Basin meteoroid survived the initial fragmentation and landed (in one or several pieces) outside the presently known strewnfield. This scenario is similar to the two-stage fragmentation proposed for the Mocs

L chondrite shower [4,5], where the most shielded fragments were found up to ~ 10 km from the center of the strewnfield.

Conclusions. The radionuclide results in fifteen new L chondrite specimens from the Gold Basin area indicate that all samples are part of the same shower, which should be classified as an L4-6 chondrite breccia. All 40 Gold Basin samples analyzed so far came from shielding depths of less than ~ 2 m in the pre-atmospheric object and show no relationship between find location and depth. This lack of correlation is consistent with a single fragmentation event.

The lack of samples from depths >2 m could either indicate that the radius of the meteoroid was not much larger than 3 m, or that a large interior fragment of an object 4-5 m in radius survived the initial atmospheric fragmentation event and landed (in one or more pieces) outside the boundaries of the presently known strewnfield.

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Fig. 1. Relationship between estimated shielding depth in the Gold Basin meteoroid and location of find in the strewnfield, of which the presently known boundaries are indicated by the dashed line. The strewnfield is ~ 22 km long and ~ 10 km wide, but the quasi-elliptical shape is not necessarily due to the fragmentation process, but seems constrained by the local geography [1]. The samples previously analyzed [1,2] all came from a relatively small part (~ 14 km²) of the strewnfield. The new samples, including LPL 1068-1072 and LPL 1074, provide a better sampling of the strewnfield, but still show no relationship between depth in the meteoroid and location of find

