Cosmogenic Radionuclide Contents of Antarctic Meteorites from Allan Hills Having High Natural Thermoluminescence; J. Mokos, S.Vogt, M. E. Lipschutz, Purdue University, West Lafayette, IN 47907.

Cosmic ray bombardment produces stable and radioactive nuclides, as well as thermoluminescence (TL). Concentrations of long-lived radionuclides have been measured in fifteen Antarctic H-chondrites with high TL levels. Sears et al.[1] studied these fifteen meteorites and postulated an unusual history. They noted that two have a young terrestrial age. We decided to examine their irradiation histories by measuring long-lived cosmogenic radionuclides in the fifteen H4-6 chondrites by accelerator mass spectrometry (AMS). The radionuclide concentration, TL data, and petrographic type, supports the idea that these meteorites originated from a single source with a unique orbital history.

Throughout their lifetime in space, meteorites are bombarded with cosmic rays. Radionuclides are produced from cosmic rays via high energy spallation and thermal neutron capture by various target nuclei in the chemical matrix.[2] Using AMS, these products can be studied to extract information about a meteorite's thermal history, origin, and the irradiation history of the constituent matrix. Natural TL provides similar historical information, but is also a sensitive indicator of perehelion and orbital changes.[3] Natural TL levels generally reflect the smallest perehelion experienced by the meteorite. Common meteorites with perehelia ≤ 1.0 A.U. exhibit low TL levels (1-80 krad) whereas those with perehelia > 1.0A.U. should have TL levels in the range of 80-200 krad.[3]

We have analyzed a group of fifteen H4-H6 chondrites recovered from the Allan Hills Main blue ice field of Antarctica. Previous studies indicate these chondrites exhibit high TL levels (> 100 krad) unusual by most meteorite standards.[1] ^{14}C analyses by Jull[1] reveal activities of 4.5 ± 0.5 dpm/kg and 35.3 ± 0.5 dpm/kg for two of the meteorites. This corresponding to notable young terrestrial ages of < 1300 and 2300 ± 1300 years, respectively. All AMS measurements were performed at Purdue's accelerator mass spectrometry facility. We determined ^{10}Be, ^{26}Al, and ^{36}Cl activities that range from 15.4 ± 0.4 - 18.4 ± 0.35 dpm/kg meteorite, 38.1 ± 1.18 - 58.0 ± 2.14 dpm/kg meteorite, and 18.4 ± 0.61 - 23.9 ± 0.60 dpm/kg metal, respectively. Figure 1, an unusual three-isotope plot, illustrates a positive linear correlation between long-lived radionuclides for fifteen H-chondrites, possessing high natural TL levels. This correlation differs markedly from Antarctic meteorites previously analyzed at Purdue.[4]

Sampling plays an important role when comparing these two populations. While the earlier sampling involved forty-three H-chondrites for which volatile trace elements had been determined by RNAA, our sample selection was based strictly on TL levels. Earlier sampling was selected to minimize both pairing and weathering for RNAA purposes. Prior data yield a correlation coefficient for H-chondrites of only 0.544 indicating a weak correlation (Fig.1). This is to be expected since the earlier sampling was purely random. Low ^{36}Cl data due to long terrestrial ages require a correction to results for the earlier sampling[4] (Fig.1). The high TL samples (Fig.1) show a strong statistical correlation with a 0.906 coefficient, corresponding to a p-value of $<<0.001$. These results demonstrate a relationship between natural TL and cosmogenic isotope abundance. These two parameters may be simultaneously used to determine the irradiation and orbital history these meteorites have experienced.

These meteorites may have originated from a single parent object despite differences in their petrographic type, H4-6. Radionuclide activities are all close to saturation values, indicating

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the parent meteoroid was relatively small in size. The radionuclide relationship shown in Figure 1 suggests a simple irradiation history, which also supports the notion of a relatively small sized object. In addition to saturated radionuclide concentrations, the unusually high TL levels are consistent with the suggestion that the meteorite suite experienced an orbital change from ≥ 1.1 A.U. to 1.0 A.U. within the last 10^5 years[1]: samples were irradiated at perihelia ≥ 1.1 A.U. and were unable to adjust TL levels to the warmer temperatures at 1.0 A.U. before entering the Earth's atmosphere. By comparing radionuclide concentration, TL data, petrographic type, geographic location, and terrestrial age, we conclude that these meteorites are fragments of a single parent object that has experienced an unusual orbital change over a short time period (< 10^5 years). It is also possible, based on the pattern of the recovery site that these meteorites may be part of a strewn field.[1]

Currently, AMS studies are underway to determine the ^{14}C content of each meteorite.

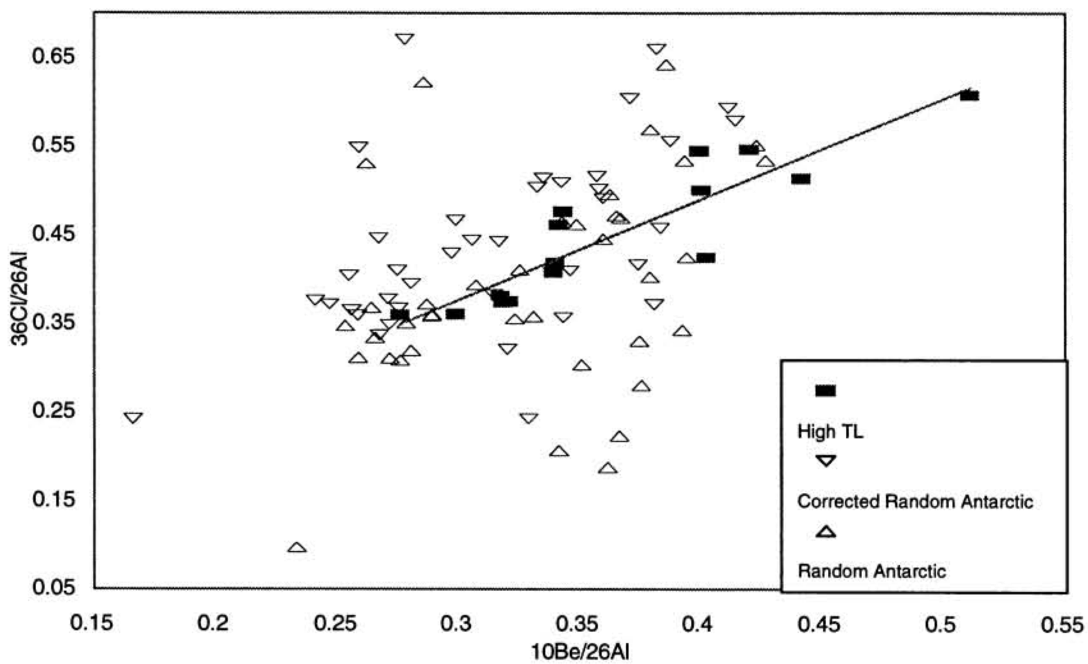

Figure 1. Randomly sampled Antarctic meteorites, analyzed by Michlovich et al., compared to high TL meteorites. ^{10}Be, ^{26}Al, and ^{36}Cl activities are significantly correlated among the H-chondrites exhibiting high TL.

References. . [1] P.H. Benoit, D.W.G. Sears; EPSL, 120, 463-471, 1993. [2] E.S. Michlovich et. al.; JGR, 99n11, 23,187 - 23,194, Nov.25, 1994. [3] P.H. Benoit, D.W.G. Sears; Icarus, 94, 311-325, 1991. [4]E.S. Michlovich, Ph.D. Thesis, Department of Physics, Purdue University, 1994.