EXPOSURE HISTORIES OF LUNAR METEORITES MAC88104 AND MAC88105:

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Nine lunar meteorites have been found in Antarctica. The lunar meteorites are expected to have complex cosmic ray exposure histories. They have been exposed both at some depth on the moon (2π irradiation) before their ejection and as small bodies in space (4π irradiation) during transportation from the moon to the earth. Their terrestrial age can also be similar to other Antarctic meteorites. Measurement of cosmogenic nuclides can provide essential constraints for these ages and help to unravel the complex history of these objects [1]. This complexity requires measurement of three or more cosmogenic nuclides in the same sample.

The work reported here adds to the list of nuclides previously measured in these lunar meteorites. In particular we report studies of the recently distributed MAC 88104 and MAC 88105. Data for the cosmogenic nuclide ^{26}Al ($t_{1/2} = 7.05 \times 10^5$ years) are given in Table 1. Our ^{26}Al concentrations in the both meteorites are in good agreement with non-destructive measurement by the Battelle group [2]. We expect ^{10}Be (1.5×10^6 years) and ^{36}Cl (3.01×10^5 years) results for aliquot samples to be available at the conference. Table 1 also lists new ^{10}Be and ^{36}Cl data for Yamato 86032. ^{53}Mn (3.7×10^6 years) was measured by neutron activation in Y-791197, 82192, and 82193 and data are shown in the table. The table also includes previous measurements of cosmogenic radionuclides in lunar meteorites [2, 3, 4]. ^{10}Be, ^{26}Al, and ^{36}Cl were measured by AMS (accelerator mass spectrometry) [5, 6, 7].

Although only the ^{26}Al results are available at this writing for MAC 88104 and 88105, in addition to an undetectable amount of ^{14}C [8], some interesting features can be found. These two objects have almost identical ^{26}Al concentrations indicating that they are from the same fall. The very low ^{26}Al concentrations in the meteorites indicate that (1) the meteorites were ejected from depths of $\geq$400 g/cm^2 or deeper in the moon, and (2) the transition time from the moon to the earth was less than 0.1 million years, assuming they traveled as moderate size bodies. Both conclusions require the assumption of a short terrestrial age, meaning that ^{26}Al has not decayed significantly since fall, although the undetectable amount of ^{14}C suggests more than 30,000 years terrestrial age. MAC 88105,19 was located at the surface of the recovered object and contained glassy material. MAC 88105,25 was located near the center of the meteorite and the distance between the two samples was about 4.5 cm. ^{26}Al production by galactic cosmic rays increases with depth in an object of this size. The somewhat higher concentration of ^{26}Al in the surface sample may indicate an solar cosmic ray contribution to the activity. In this case, the meteorite was ejected from very deep (over a few meters) in the moon and the ^{26}Al was produced in space during the 0.1 million years travel to earth. Measurements of other nuclides such as ^{41}Ca, ^{10}Be, ^{53}Mn, and noble gas are required to constrain the history.

The important thing is that at least three completely distinct ejections and transition times have been observed for the lunar meteorites so far studied. It is interesting to compare these facts and theoretical studies [9, 10, 11]

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Table 1. Concentration of Cosmogenic Radionuclides in Lunar Meteorites

Meteorite	^{36}Cl (dpm/kgFe+6Ca)	^{26}Al (dpm/kg meteorite)	^{10}Be (dpm/kg meteorite)	^{53}Mn (dpm/kg Fe)
ALHA81005,16	12.83±0.64[a)]	41.3 ± 4[a)]	6.33±0.25[a)]	176±12[a)]
ALHA81005		46 ± 3[b)]	4.1 ± 0.5[b)]	
MAC 88104,9		16.1 ± 1.0		
MAC 88105,19		20.3 ± 1.2		
MAC 88105,25		16.0 ± 1.0		
MAC 88105		19.5 ± 2.6[c)]		
Y-791197,75	17.88±1.25[a)]	85.1± 8.5[a)]	11.61±0.46[a)]	249±18
Y-82192,73	25.21±1.50[a)]	106.6±7.5[a)]	23.96±1.20[a)]	327±24
Y-82193,101	25.92±0.91[a)]	138.9±9.7[a)]	20.10±1.00[a)]	320±22
Y-86032,55	25.01±0.75		21.47±0.86	

[a)] Nishiizumi et al. (1986)
[b)] Tuniz et al. (1983)
[c)] Wacker (1989)