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K. Nishiizumi, M.W. Caffee, A.J.T. Jull, S.E. Klandrud

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EXPOSURE HISTORY OF SHERGOTTITES DAR AL GANI 476/489/670/735 AND SAYH AL UHAYMIR 005. K. Nishiizumi[1], M. W. Caffee[2], A. J. T. Jull[3], and S. E. Klandrud[3]. [1]Space Sciences Laboratory, University of California, Berkeley, CA 94720-7450 (kuni@ssl.berkeley.edu), [2]CAMS, Lawrence Livermore National Laboratory, Livermore, CA 94550 (caffee1@llnl.gov), [3]NSF Arizona AMS Laboratory, University of Arizona, P.O. Box 210081, Tucson, AZ 85721 (jull@u.arizona.edu)

Introduction: Four basaltic shergottites, Dar al Gani (DaG) 476, 489, 670, and 735 were found in the Libyan Sahara [1-3]; two basaltic shergottites, Sayh al Uhaymir (SaU) 005 and 008 were found in Oman [4]. Recently SaU 051 was also recognized as a possible pair of SaU 005/008. Although the collection sites were different, the texture, bulk chemical compositions, and noble gas compositions of these shergottites are similar [e.g. 4]. However, cosmic-ray-produced noble gases alone cannot unambiguously constrain the irradiation history for these objects. From a combination of cosmogenic stable- and radionuclides, exposure histories, and ejection conditions from the hypothesized Martian parent body, and genetic relationships between the Martian meteorites can be determined. In addition to those nuclides produced by galactic cosmic rays (GCR) are those produced by solar cosmic rays (SCR). Radionuclides produced by SCRs reside in the uppermost few centimeters of extraterrestrial bodies and their presence in meteorites indicates the degree to which a meteorite has been ablated. Previous work shows ablation is less than 1-2 cm in at least three shergottites, ALH 77005, Shergotty, and EETA79001 [e. g. 5] and so it is possible some SCR signal may be observed in these meteorites. This suggests that the atmospheric entry velocity and/or entry angle of these shergottites is much lower than the velocity and/or entry angle of most ordinary chondrites. We report here preliminary results of cosmogenic nuclides, ^{14}C (half-life=5,730 yr), ^{36}Cl (3.01x10^5 yr), ^{26}Al (7.05x10^5 yr), and ^{10}Be (1.5x10^6 yr).

Experimental Procedures and Results: The total recovered mass of DaG 476/489/670/735 was 6,368 g and the total recovered mass of SaU 005/008/051 was 10,359 g.

^{10}Be, ^{26}Al, ^{36}Cl, and ^{41}Ca measurements. We received exterior and interior chips from DaG 476, 489, and 670 in order to investigate SCR effects. The distances between exterior and interior chips are about 30, 20, and 10-15 mm respectively. Only interior chips were obtained for DaG 735 and SaU 005. Weathering products were observed on the surface of the specimens, especially DaG 476, 489, and 670. The surfaces of DaG 735 and SaU 005 were cleaner than those of DaG 476, 489, and 670. To eliminate weathering products, each sample was etched twice with 0.2 N HNO_3 solution in an ultrasonic bath for 5-15 minutes. The weight loss was found to be 1.3-7.3%. Each sample was then dissolved in an HF-HNO_3 mixture along with Be and Al carriers. The concentrations of Mg, Al, Ca, Mn, and Fe in samples were determined by atomic absorption spectroscopy. The AMS measurements were performed at the Lawrence Livermore National Laboratory.

^{14}C measurements. Only interior samples were used for the ^{14}C measurements. The AMS measurements were performed at the University of Arizona NSF-AMS facility. Samples were pretreated with 100% H_3PO_4 to remove significant amounts carbonate weathering products, which are typical of meteorites recovered in this environment. The residue was then washed and dried before melting in a flow of oxygen to recover $^{14}CO_2$ in presence of a carrier. The ^{14}C concentrations in all four DaG meteorites were <0.5 dpm/kg meteorite using methods described by Jull *et al.* [6]. We estimate the saturated activity for shergottites with DaG chemical compositions to be 40-70 dpm/kg (4π). Depending on whether the object was exposed in 2π or 4π irradiation, we can constrain the terrestrial age to >34 or >37 kyr, respectively. Most recovered meteorites from the Libyan desert, indeed from most desert environments, have younger ages. Exceptions to this observation are Daraj 119, which was >35 kyr [7], and lunar meteorite DaG 262, which contained no cosmogenic ^{14}C.

Discussion: The preliminary radionuclide data are shown in Table 1. The quoted errors represent $\pm1\sigma$ AMS measurement error. The results for DaG 476 were reported earlier [8]. Measurements of ^{41}Ca and ^{14}C in SaU 005 are in progress. The ^{21}Ne concentrations are also shown in the table [1, 3, 9].

DaG 476/489/670/735. The ^{10}Be, ^{26}Al, and ^{36}Cl concentrations in four DaG meteorites are similar (8-13% variation from means). The lack of excess ^{26}Al in the exterior samples relative to the interior samples clearly shows there are no SCR effects on DaG 476, 489, and 670. Surface samples from ALH 77005 and Shergotty by contrast, have high ^{26}Al activities [5, 10]. The lack of SCR-produced ^{26}Al indicates that the ablation depths are more than a few cm for these three meteorites. Assuming the four DaG meteorites were a common fall, the preatmospheric radius was more than 11-12 cm. All the cosmogenic nuclides in the DaGs were produced exclusively by GCR. We have compared the measured cosmogenic nuclide concentrations to theoretical GCR production rate calculations using the LAHET Code System [11]. The radionuclide measurements suggest that all four DAGs are part of the same fall; additional ^{41}Ca results will provide an unambiguous test for this pairing. Using the method discussed in Nishiizumi *et al.* [8], the cosmic ray exposure condition was calculated as follows: 1) all cosmogenic nuclides were produced by a 4π exposure in space; 2) the preatmospheric radius was 15-20 cm; 3) the depths of our samples were 4-12 cm from preatmospheric surface; 4) DaG 670 and 735 were far to the outer edge and DaG 489 was far inside of the meteoroid. Under this shielding geometry, both the radionuclide and the cosmogenic ^{21}Ne yield exposure ages of 1.05±0.10 Myr. The terrestrial age is calculated to be 60±20 kyr. The DaG meteorites were ejected from the parent body 1.1±0.1 Myr ago. The ^{41}Ca measurements will constrain this result further.

SaU 005. The ^{10}Be, ^{26}Al, and ^{36}Cl concentrations in SaU 005 are nearly identical to those of DaG 476. The slightly lower ^{36}Cl in SaU 005 relative to DaG 476 is due to a lower Ca concentration in SaU 005. On the other hand, the ^{21}Ne concentration in SaU 005 is about 30% higher than that of DaG 476 [9]. Since ^{14}C and ^{41}Ca measurements in SaU 005 are not yet available, we cannot calculate a reliable terrestrial age and unambiguously constrain the shielding conditions. One possible scenario is that SaU 005 has a 100 kyr terrestrial age and a 1.0-1.1 Myr exposure age in a ~30 cm radius object. In this scenario the ejection age of SaU 005 is 1.1-1.2 Myr, the same as that of the DaGs. Fewer weathering products were found in SaU 005 [12] suggesting that SaU 005 has a shorter terrestrial age than that of the DaGs. Assuming a negligible terrestrial age for SaU 005, the meteoroid was as small as 10-15 cm in space and the exposure age is ~1.5 Myr; its ejection age is longer than that of the DaGs. If we assume SaU 005 has similar terrestrial age and shielding condition as DaG 476, the ^{21}Ne exposure age of SaU 005 is 30% longer than the exposure age obtained from radionuclides. One can speculate that SaU 005 was ejected by the same impact event but ejected from a shallower depth on the parent body so part of ^{21}Ne was produced on the parent body. Measurements of ^{14}C and ^{41}Ca are required to place limits on these possible scenarios.

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Table 1. Cosmogenic radionuclide concentration (dpm/kg meteorite) in DaG 476/489/670/735 and SaU 005 Martian meteorites.

	^{10}Be	^{26}Al	^{36}Cl	^{36}Cl*	^{41}Ca	^{14}C	^{21}Ne@
DaG 476 (interior)	8.87±0.28#	39.2±1.0#	9.65±0.41#	19.7±0.8	3.4±0.7#	<0.26#	0.26
DaG 476 (Rim)	8.58±0.28#	39.8±0.9#	9.28±0.36#	18.6±0.7	2.5±0.7#	-	-
DaG 489 (interior)	9.23±0.15	47.4±1.3	10.29±0.13	22.0±0.3		<0.39	0.292
DaG 489 (exterior)	9.55±0.17	46.8±1.3	9.93±0.15	19.9±0.3		-	-
DaG 670,03 (interior)	7.96±0.14	39.9±1.0	8.39±0.17	15.5±0.3		<0.33	
DaG 670,04 (exterior)	7.87±0.22	38.2±0.9	7.73±0.12	14.8±0.2		-	
DaG 735	7.93±0.13	35.6±0.9	7.21±0.12	15.4±0.3		<0.47	
Sayh al Uhaymir 005	8.53±0.19	39.5±0.9	8.86±0.23	20.5±0.5		-	0.324, 0.350

* dpm/kg (8Ca+Fe)
# [8], @ (10^{-8} cm^3 STP/g) [1, 3, 9]

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