# NOBLE GASES IN LEW88516 SHERGOTTITE: EVIDENCE FOR EXPOSURE AGE PAIRING WITH ALH77005.

D.D. Bogard and D.H. Garrison[1], NASA, Johnson Space Center, Houston, TX 77005 (1-also Lockheed-ESC)

LEW88516 contains excess amounts of radiogenic $^{40}Ar$ and $^{129}Xe$ that are slightly greater than those observed in ALH77005, but in the same relative proportion as much larger excesses observed in EET79001. Cosmogenic $^{3}He$ and $^{21}Ne$ abundances in LEW88516 are very similar to those for ALH77005 and are consistent with a common initiation of cosmic ray exposure ~2.8 Myr ago for four of the five shergottites. Exposure of these four shergottites could have been under different shielding in a common meteoroid, or in several objects.

*Introduction:* LEW88516, a 13 gram meteorite found in Antarctica, has recently been identified as a shergottite [1,2] and is the ninth member of the SNC group of meteorites which many believe to have been derived from Mars. Shock effects in LEW88516 are "ubiquitous and extreme", maskelynite is present, and the sample is "cut by veins of glass and vitrophyre" [2,3,4,5]. The petrology and chemical composition of LEW88516 are generally similar to ALH77005 and different from other SNC meteorites, which suggests possible pairing of these two meteorites [2]. However, modest differences between the two meteorites exist, including the fact that they were recovered about 500 miles apart.

*Noble Gas Abundances:* The isotopic abundances of noble gases were measured in two temperature extractions (450°C and 1600°C) of an 85 mg whole rock sample of LEW88516. The 450°C extraction released some adsorbed atmospheric gases, much of the radiogenic $^{4}He$ and cosmogenic $^{3}He$, and possibly a small amount of trapped gas. The 1600°C extraction released >97% of the total cosmogenic Ne and Ar. The isotopic composition of heavier Xe isotopes in the 1600°C extraction generally was within uncertainties of that for atmosphere and previous measurements of trapped Xe in EET79001 [6]. One exception is $^{129}Xe$, for which the measured $^{129}Xe/^{132}Xe$ ratio of $1.149 \pm 0.011$ is significantly higher than this ratio for atmospheric, AVCC, or solar components. Relative to atmospheric Xe composition, we calculate an excess $^{129}Xe$ abundance of $7 \times 10^{-12}$ $cm^3STP/g$ for LEW88516.

The total $^{40}Ar$ in LEW88516 was $5.93 \times 10^{-6}$ $cm^3STP/g$, of which 96.7% was released at 1600°C. The measured K concentrations of LEW88516 and ALH77005 are 199 ppm [5] and 230 ppm (JSC unpublished data), respectively. This K content for LEW88516 would have produced only ~$15 \times 10^{-8}$ $cm^3STP/g$ of radiogenic $^{40}Ar$ during the ~180 Myr Rb-Sr age determined for the other four shergottites [7], leaving an excess $^{40}Ar$ of $5.78 \times 10^{-6}$ $cm^3STP/g$. By analogy to the other shergottites [6], we attribute the excess $^{40}Ar$ and $^{129}Xe$ in LEW88516 to a shock-implanted, trapped component. The quantities of excess $^{40}Ar$ and $^{129}Xe$ in LEW88516 ($5.7 \times 10^{-6}$ and $7 \times 10^{-12}$ $cm^3STP/g$, respectively) are similar to excesses measured in ALH77005 ($1.2 \times 10^{-6}$ and $5 \times 10^{-12}$ $cm^3STP/g$, respectively) but are considerably less than excesses measured in shock-melt phases of EET79001 [6]. However, the excess $^{40}Ar/^{129}Xe$ ratio of $8 \times 10^{5}$ in LEW88516 is similar to the ratio of $12 \times 10^{5}$ found for several phases of EET79001. Thus, our sample of LEW88516 contained slightly greater amounts of a trapped, Martian-like component than did ALH77005.

*Cosmogenic Abundances & Exposure Ages:* The measured $^{21}Ne$ and $^{38}Ar$ were >99% and ~76% cosmogenic, respectively. We calculated abundances of the cosmogenic component using the lever rule and assumed end-member compositions of: trapped $^{21}Ne/^{22}Ne = 0.029$ and $^{36}Ar/^{38}Ar = 5.32$; and cosmogenic $^{21}Ne/^{22}Ne = 0.91$ and $^{36}Ar/^{38}Ar = 0.7$. The concentration of cosmogenic $^{38}Ar$ in LEW88516 ($2.5 \times 10^{-9}$ $cm^3STP/g$) is somewhat higher than that measured in ALH77005 ($1.8 \times 10^{-9}$ $cm^3STP/g$), even if we account for a higher measured Ca content for LEW88516 [5]. Cosmogenic $^{21}Ne$ and $^{3}He$ in LEW88516 are similar to those measured for ALH77005, but are different from those measured in other SNC meteorites, especially EET79001, Chassigny, and the nakhlites. Figure 1 is a plot of cosmogenic $^{3}He$ and $^{21}Ne$ concentrations against the cosmogenic $^{3}He/^{21}Ne$ ratio for all SNC meteorites. Except for the addition of LEW88516 data, it is reproduced from Figs. 10 and 11 of Bogard et al. [6]. Measured $^{21}Ne$ data have been corrected for differences in target element abundances by normalizing to the composition of ordinary chondrites [see 6]. These $^{21}Ne$ corrections were small (~3%) for LEW88516 and ALH77005, but amounted to a factor of ~2 for Shergotty and Zagami. No corrections were applied to $^{3}He$. The concentrations of cosmogenic He and Ne in SNC meteorites define three distinct groups: EET79001; Chassigny and the three nakhlites; and the remaining four shergottites. Using $^{21}Ne$ production rates given by [8], these three groups have distinctly different exposure ages of ~0.6 Myr, ~12 Myr, and ~2.8 Myr, respectively. Nishiizumi et al. [9] reported that the $^{10}Be$ exposure age for ALH77005 is $2.5 \pm 0.3$ Myr. Measured $^{10}Be$ activities and the prediction of a nearly constant $^{10}Be/^{21}Ne$ ratio as a function of

shielding for ordinary chondrite composition [10] can also be used to calculate exposure ages. From the $^{10}Be$ activity of 16.6 dpm/kg measured in LEW88516 [11] and the relationship given by [10], we calculate a $^{10}Be/^{21}Ne$ exposure age for LEW88516 of 3.0 Myr. The exposure age groupings of Fig. 1 are not significantly affected by the terrestrial ages determined from cosmogenic radionuclides, which are ALH77005 =0.19 Myr [12], EET79001 =0.012 Myr [13], and LEW88516 = <0.05 Myr [11].

*Shielding Groups:* The curves through the middle data sets of Fig. 1 define the expected variations in the cosmogenic composition due to cosmic ray shielding in a single body for a common exposure age and have been taken from the model of [14]. Analogous curves representing a greater exposure age could be passed through the Chassigny--nakhlite data. Thus, the variations observed in cosmogenic He and Ne among ALH77005, LEW88516, Shergotty, and Zagami could be explained as due to irradiation in a common object under conditions of different shielding for a period of 2.5-3.0 Myr. Similarly, variations among Chassigny and the three nakhlites be explained as due to irradiation in a common object for ~12 Myr under conditions of different shielding [6]. Lesser shielding is represented by larger $^{3}He/^{21}Ne$ ratios.

LEW88516 cosmogenic He and Ne data lie close to and probably within uncertainties of the ALH77005 data (Fig. 1). Similar $^{3}He/^{21}Ne$ and $^{10}Be$ indicate that LEW88516 and ALH77005 were irradiated under similar shielding. Because the chemical compositions of these two shergottites are not greatly different from that of ordinary chondrites, their cosmogenic $^{3}He/^{21}Ne$ ratios can probably be compared to shielding systematics in chondrites in order to estimate the amount of cosmic ray shielding. Thus, the relatively high $^{3}He/^{21}Ne$ ratios suggest irradiation within a few cm of the surface. The recovered ALH77005 specimen was 5-10 cm in diameter, and LEW88516 was only 1-2 cm. Furthermore, measurements of cosmic ray particle tracks indicate that <1 cm of ablation loss occurred for ALH77005 during atmospheric entry [15]. Thus, both LEW88516 and ALH77005 were exposed with minimal shielding to cosmic rays for an apparent common period of 2.5-3.0 Myr. Shergotty and Zagami could have been irradiated at somewhat greater depths in the same object. However, substantial compositional differences between LEW88516 and ALH77005 on the one hand and Shergotty and Zagami on the other might suggest that these four shergottites were exposed to cosmic ray irradiation within at least two objects. LEW88516 and ALH77005 could have been irradiated in a single object. However, different $^{36}Cl$ activities [11] and the significant distance between their recovery sites indicate that LEW88516 and ALH77005 fell to earth at different times, and thus existed as separate objects in space prior to their fall. In conclusion, it is likely that four of the five shergottites were ejected from their parent meteoroid by a common event ~2.8 Myr ago, but it is not clear whether most of their cosmic ray exposure occurred in a single object or in multiple objects.

*References:* [1] Mason, *Ant.Met. Newsletter 14:2*, 1991; [2] Lindstrom et al., *LPSC XXIII*, 1992; [3] Delaney, *Meteoritics 27*, p.213, 1992; [4] Harvey & McSween, *ibid*, p.231; [5] Dreibus et al., *ibid*, p.213; [6] Bogard et al., *G.C.A. 48*, p.1723, 1984; [7] Shih et al., *G.C.A. 46*, p.2323, 1982; Nyquist et al., *LPSC XVII*, p.624, 1986; [8] Eugster, *G.C.A. 52*, p.1649, 1988; [9] Nishiizumi et al., *G.C.A. 50*, p.1017, 1986; [10] Graf et al., *G.C.A. 54*, p.2521, 1990; [11] Nishiizumi et al., *Meteoritics 27*, p.270, 1992; [12] Schultz & Freundel, *Meteoritics 19*, p.310, 1984; [13] Jull & Donahue, *G.C.A. 52*, p.1309, 1988; [14] Nyquist, *LPSC XV*, p.613, 1984; [15] Bhandari et al, *G.C.A. 50*, p.1023, 1986.