GALACTIC-COSMIC-RAY EXPOSURE HISTORIES OF THE ANTARCTIC SHERGOTTITE EETA 79001. R. O. Pepin and R. H. Becker, School of Physics and Astronomy, University of Minnesota, Minneapolis, Minnesota 55455.

A martian origin for the SNC meteorites is supported by chronologic, petrologic and chemical arguments(1) and, for the shergottite EETA 79001, by direct comparison of trapped noble gas and nitrogen elemental and isotopic abundances with Viking measurements of Mars' atmospheric composition(2,3). However, there remains a troublesome dynamical problem in ejecting appropriate fragments, particularly of decameter size, from Mars by impact(4). If ejection of the shergottites occurred at their $\sim$180m.y. shock age(2) the fragments must have been large enough($\gtrsim$15m) to account for their much shorter cosmic ray exposure ages by deep shielding for most of their space lifetimes. An alternative is small ($\lesssim$1m) fragment ejection and transit in times given directly by the exposure ages(5). In this case the shergottite meteorites were most probably ejected in one event, since all four carry the 180m.y. shock signature which presumably would have been left by a previous impact in only a small fraction of the martian surface. All shergottites being captured now by the earth should therefore have the same residence time in space. A problem here is that while exposure ages of three of them do cluster, near $\sim$2.5m.y.(1,6), that of EETA 79001 appears to be <1m.y. assuming comparable shielding conditions(3,6). The question is whether deeper shielding for EETA 79001 can account for its low apparent age.

We have calculated exposure histories of 79001,34 (A-lithology) from measured spallation abundances {^{3}He=84.7 ± 2.55 x 10^{-10}, ^{21}Ne=11.1 ± 1.0 x 10^{-10}, ^{38}Ar=5 ± 1 x 10^{-10}, ^{78}Kr=2.9 ± 1.4 x 10^{-14}, ^{126}Xe=1.9 ± 0.5 x 10^{-14}, all in ccSTP/g(3)} and Reedy's GCR production rates in spherical bodies(7). Comparison of $(^{3}He/^{21}Ne)_{meas}$ with Reedy's production rate ratios for various depths in spheres of radius R (Fig. 1) restricts single-stage exposure to the shallow depths($\lesssim$80 g/cm^2) and short durations($\sim$0.4-0.9m.y.) shown in Table 1. Measured ^{38}Ar/^{21}Ne and ^{78}Kr/^{21}Ne are too uncertain to confirm or narrow these constraints, but are consistent with them. Ages from ^{126}Xe are roughly a factor 3 higher, but are within 2σ of the $\overline{T}$ values in Table 1.

These results are incompatible with production of spallation gases in 79001,34 under substantial shielding during a single-stage, $\sim$2.5m.y. GCR irradiation. A two-stage exposure, for $\sim$2m.y. at $\sim$2m depth in a $\sim$6-7m diameter body followed by collisional fragmentation and subsequent exposure for $\sim$0.4m.y. as an EETA 79001-size fragment, satisfies the Fig. 1 constraints but now requires a relatively large body among the shergottite fragments ejected $\sim$2.5m.y. ago. A strictly small body hypothesis would appear to require one of two scenarios: (a) two impacts capable of ejecting fragments, at $\sim$2.5 and $\sim$0.5m.y. ago, into shergottite country rock metamorphosed $\sim$180m.y. ago; or (b) ejection of all four recovered shergottites at $\sim$2.5m.y. in one event, but with orbital evolution of the ejecta such that one fragment was captured quickly (after space exposure of $\sim$0.5m.y.) by the earth. Scenario (b) predicts a very high ($\sim$2m.y.)terrestrial residence age for EETA 79001, about three times longer than the maximum terrestrial ages found so far in measurements on a small fraction of the antarctic collection(8). Such long-term preservation in the ice cap environment might not be improbable; in any case, the possibility can be tested directly for this meteorite.

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GCR EXPOSURE HISTORIES OF EETA 79001

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Table 1. Ranges of allowed shielding depths d and exposure ages T for single-stage GCR irradiation of EETA 79001,34 in spherical bodies of radius R. The R-d pairs ≳1000-6, 35-35, ≳1000-23 and 80-80 are corner coordinates of the field defined by the measured $^{3}He/^{21}Ne$ ratio of 7.63 ± 0.72 in Fig. 1. Values of d and T for R = 150 g/cm^2 represent the $\pm 1\sigma$ range of possible exposure histories for 79001,34 in a 1m diameter parent body. Ages calculated from Reedy's production rates with 79001-A chemistry(7); $\pm 1\sigma$ errors, including uncertainties in measured spallation abundances, production rates, and chemical composition, are ∿20% for T_3 and T_{21}, 30% for T_{38}, and 55% for T_{78}.

$^{3}He/^{21}Ne$	R (g/cm^2)	d (g/cm^2)	T_3 (m.y.)	T_{21} (m.y.)	T_{38} (m.y.)	T_{78} (m.y.)	$\overline{T}$ (m.y.)
8.35	≳1000	6	.84	.94	1.00	.73	.89 ± .14
(+1σ)	150	11	.54	.58	.63	.47	.56 ± .08
	35	35	.42	.46	.49	.36	.44 ± .06
7.63	≳1000	13	.84	.86	.90	.73	.85 ± .08
	150	21	.53	.52	.55	.46	.53 ± .05
	50	50	.42	.42	.44	.36	.42 ± .04
6.91	≳1000	23	.85	.79	.81	.74	.81 ± .06
(-1σ)	150	38	.53	.47	.48	.45	.49 ± .04
	80	80	.44	.40	.44	.38	.42 ± .03