# $^{10}$Be CONTENTS OF SNC METEORITES;

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Several authors have explored the possibility that the Shergottites, Nakhlites, and Chassigny came from Mars (e.g., 1-3). The spallogenic gas contents of the SNC meteorites have been used to constrain the sizes of the SNC's during the last few million years, to establish groupings independent of the geochemical ones and to estimate the likelihood of certain entries in the catalog of all conceivable passages from Mars to Earth (3-5).

Measurements of the radioactive, cosmogenic nuclides supplement the stable isotope data. The $^{26}$Al contents of six of the SNC meteorites are known but their interpretation is complicated by the sensitivity of the $^{26}$Al production rate to the bulk Al content, a property that varies more than tenfold among the SNC meteorites. In contrast, differences in chemical composition are expected to induce variations of less than 10% in the $^{10}$Be contents (6). Furthermore, the $^{10}$Be production rate, $P_{10}$, varies relatively little over the typical range of meteoroid sizes, i.e., in bodies with preatmospheric radii between 20 and 150 g/cm$^2$ although it does fall rapidly in larger bodies and rises in the interior of St-Severin-sized objects (7-11). The particular shielding dependence of $^{10}$Be makes the isotope a good probe of the irradiation conditions experienced by the SNC meteorites. We have measured the $^{10}$Be contents of all the members of the group by using the technique of accelerator mass spectrometry (9). The results appear in Table 1.

**Samples.** With the possible exception of Chassigny, the samples analyzed for $^{10}$Be come from the same meteorite fragments as those analyzed for the noble gases. The $^{26}$Al measurements for EETA 79001, ALHA 77005 and Nakhla also refer to the same fragments. The samples of EETA 79001 had been prepared by E. Jarosewich for other purposes. We used about 50 mg of meteorite for each $^{10}$Be determination.

**Adjustments for Chemical Composition.** To remove the effects of chemical composition from the $^{10}$Be and $^{21}$Ne data we multiplied each one by a chemical normalization factor, C, calculated according to the relation $C=P_{\mathrm{Shergotty}}/P_X$. The production rates were obtained from equations and composition data in the literature.

**$^{10}$Be Contents and Shielding.** The $^{10}$Be contents of Nakhla, Governador Valadares, Chassigny, and probably Lafayette, about 20 dpm/kg, exceed the values expected from irradiation of the surface of a large body. The $^{10}$Be data therefore do not support scenario III of Bogard et al. (5), one in which most of the $^{10}$Be in the SNC meteorites would have formed on the Martian surface; they resemble rather the $^{10}$Be contents found in many ordinary chondrites subjected to $4\Pi$ exposures. Judging from the calculations of Reedy (10), the meteorites named above orbited for several million years as bodies with radii less than 2 m or so.

**$^{10}$Be Exposure Ages.** The uncertainties of the $^{10}$Be contents lead to appreciable errors in the $^{10}$Be ages, $t_{10} = -1/\lambda \ln(1 - {}^{10}\mathrm{Be}/{}^{10}\mathrm{Be}_0)$, given in Table 1. Nonetheless, the $^{10}$Be ages are consistent with the $^{21}$Ne ages calculated assuming conventional, small-body production rates and short terrestrial ages for the finds. We believe that this concordance strengthens the case for at least 3 different irradiation ages for the SNC meteorites (5). Given the similar half-thicknesses of the $^{10}$Be and $^{21}$Ne production rates, the ratios of the $^{10}$Be and $^{21}$Ne contents do not appear consistent with common ages for any of the groups. In view of the general agreement between the $^{10}$Be and $^{21}$Ne ages it does not seem useful at this time to construct multiple-stage irradiation histories for the SNC meteorites.

REFERENCES 1) Wood, C.A. and Ashwal, L.D. (1981), Proc. 12 Lunar Planet. Sci. Conf., 1359-1375. 2) McSween, H.Y. and Stolper, E.M. (1980), Scientific American 242, 54-63. 3) Wasson, J.T. and Wetherill, G.W. (1979), in Asteroids (Ed. T. Gehrels) Univ. Arizona Press, Tucson, pp. 926-974; Wetherill, G.W. (1984), Meteoritics 19, 1-13. 4) Pepin, R.O. and Becker, R.H. (1984), Lunar Planet. Sci. 15, 637-8. 5) Bogard, D.D., Nyquist L.E. and Johnson, P. (1984), preprint. 6) Pal, D.K., Tuniz, C., Moniot, R.K., Savin, W., Kruse, T.H. and Herzog, G.F. (1984), in preparation. 7) Pal, D.K., Moniot, R.K., Kruse, T.H., Tuniz, C. and Herzog, G.F. (1982), Proc. 5th Int. Conf. Geochron. Cosmochron. Isotope Geol., Nikko Natl. Park, Japan. pp. 300-1. 8) Nishiizumi, K., Arnold, J.R., Elmore, D., Tubbs, L.E., Cole, G. and Newman, D. (1982), Lunar Planet. Sci. 13, 596-7. 9) Moniot, R.K., Kruse, T.H., Savin, W., Hall, G., Milazzo, T. and Herzog, G.F. (1982), Nucl. Inst. Meth. 203, 495-502. 10) Reedy, R.C. (1984), Lunar Planet. Sci. 15, 675-6. 11) Tuniz, C., Smith, C.M., Moniot, R.K., Savin, W., Kruse, T.H., Pal, D.K., Herzog, G.F. and Reedy, R.C. (1984), Geochim. Cosmochim. Acta, in press; Tuniz, C., Moniot, R.K., Savin, W., Kruse, T.H., Smith, C.M., Pal, D.K. and Herzog, G.F. (1984), 3rd Int. Symp. Accelerator Mass Spectrom. Zurich, Switzerland. Abstract. 12) Bogard, D.D., Cressy, Jr., P.J. (1973), Geochim. Cosmochim. Acta 37, 527-546. 13) Hohenberg, C.M., Marti, K., Podosek, F.A., Reedy, R.C. and Shirck, J.R. (1978), Proc. Lunar Sci. Conf., 9th, 2311-2344. 14) Hampel, W., Wanke, H., Hofmeister, H., Spettel, B. and Herzog, G.F. (1980), Geochim. Cosmochim. Acta 44, 539-547. 15) Heymann, D., Mazor, E., and Anders, E. (1968), Geochim. Cosmochim. Acta 32, 1241-1268. 16) Ganapathy, R. and Anders, E. (1969), Geochim. Cosmochim. Acta 33, 775-787. 17) Lancet, M.S. and Lancet, K. (1971), Meteoritics 6, 81-86. 18) Schultz, L. and Kruse, H. (1978), Nucl. Track Detection 2, 65-103.

Table 1. $^{10}$Be Contents of SNC Meteorites.

| Meteorite | ID$^{a}$ | $^{21}$Ne ($10^{-8}$cm$^{3}$STP/g) | Ref. | $C_{21}$ | $t_{21}{}^{b}$ (Ma) | $^{10}$Be (dpm/kg) | $C_{10}$ | $t_{10}{}^{b}$ (Ma) |
|---|---|---|---|---|---|---|---|---|
| Shergotty | U817 | 0.58 | 15 | 1.0 | 3.2 | 13±1.5 | 1 | 2.2 |
| Zagami | 01966,54 | 0.69 | 15 | 0.95 | 3.6 | 18.6±2.6 | 0.99 | 4.6 |
| ALHA 77005 | U/EJ | 0.75 | 5 | 0.56 | 2.3 | 15±3 | 0.95 | 2.6 |
| EETA 79001A | U/EJ | 0.14 | 4,5 | 0.78 | 0.6 | 7.8±1.1 | 0.96 | 1.0 |
| EETA 79001B | U/EJ | 0.12d | 5 | 1.06 | 0.7 | 8.5±1.1 | 0.99 | 1.2 |
| Nakhla | Me804 | 3.10 | 16 | 0.95 | 16.3 | 19.7±3.3 | 1.02 | >5c |
| Lafayette | Me2116 | 2.70 | 16 | 0.95 | 14.2 | 18.1±2.5 | 1.02 | >5c |
| Governador Valadares | LN | 2.10 | 5 | 1.0 | 11.7 | 25.6±3.6 | 1.03 | >5c |
| Chassigny | P2523 | 4.14 | 17,18 | 0.53 | 12.2 | 20.5±3.1 | 0.97 | >5c |

a) We thank the sample donors: LN=L. Nyquist (JSC); Me=E. Olsen (Field Museum); O=R. Hutchinson (Brit. Museum); U=E. Jarosewich (Smithsonian).

b) Assumes $P_{10}$=21.3 dpm/kg and $P_{21}$=0.18x$10^{-8}$cm$^{3}$STP/g-Ma in Shergotty. Uncertainties in $t_{10}$ range from 25 to 50%.

c) High gas and $^{10}$Be contents indicate unreliable $^{10}$Be age.

d) Considered doubtful by Bogard et al. (Ref. 5).