COSMOGENIC Mn-53 IN METEORITES

Alexeev, V.A. and Lavrukhina, A.K.

V I.Vernadsky Institute of Geochemistry and Analytical Chemistry, USSR Academy of Sciences, Moscow, USSR

The distributions of the Mn-53 contents in 106 nonantarctic and 112 antarctic chondrites were analysed. A correlation analysis of these distributions showed that the correlation coefficient is a maximum ($r_{max}=0.75\pm 0.03$) when the histogram for antarctic chondrites is displaced by 40±8 dpm kg^{-1}Fe towards lower Mn-53 contents.

The distribution of Mn-53 saturated contents in nonantarctic ordinary chondrites was investigated as a function of their radiation age (T). It is found that the Mn-53 average content is higher by (21±9)% in H-chondrites with radiation age $T \leqslant 12$ Myr than in those with $T > 12$ Myr. This effect can be attributed to the fact that a considerable proportion of H-chondrites with $T \leqslant 12$ Myr originates from a comet or from the objects of Chiron like, with the orbits more inclined to the ecliptic plane and/or more extended, which caused their irradiation by cosmic rays of higher intensity. The greater proportion of such chondrites in the antarctic meteorites might cause the aforementioned higher Mn-53 content in the meteorites from Antarctica.

Studies of long-lived cosmogenic radionuclide Mn-53 ($t_{1/2}=3.7$ Myr) in meteorites can supply evidence on both the cosmic-ray intensity variation and the radiation history of these cosmic bodies. The direct counting of Mn-53 presents difficulties because of the soft K-radiation; also rather large amounts of precious material would be needed. Millard /1/ pointed out the possibility of converting Mn-53 into the γ-emitting Mn-54 by a neutron capture. The large cross- section affords much greater sensitivity for the determination of Mn-53.

We studied the different procedures on the Mn isolation from the meteoritic metal, found the optimal conditions of the irradiation, and determined the Mn-53 content in the iron meteorites and in the metal of chondrites. About 1 g of meteoritic metal along with the Mn carrier (5 mg) were dissolved in HNO_3. Pre- and post-irradiation chemical procedures were mainly similar to those reported by Imamura et al. /2/. The manganese was isolated by ion exchange procedures and then in the form MnO_2 was irradiated 1156 hours in the research reactor. Results of our measurements were published in /3,4/. This paper presents an analysis of data reported in the literature and authorss data on the Mn-53 content in ordinary chondrites.

The distributions of the Mn-53 contents in 106 nonantarctic and 112 antarctic chondrites were analysed (see Fig.1). A correlation analysis of these distributions showed that the correlation coefficient is a maximum ($r_{max}=0.75\pm0.03$), when the histogram for antarctic chondrites is displaced by 40+8 dpm kg^{-1}Fe towards lower Mn-53 contents (Fig.2). That is, the Mn-53 content in antarctic chondrites is higher, on the average, than in nonantarctic chondrites, in spite of higher earth age of the antarctic meteorites.

This fact can be explaned by several reasons: (a) antarctic meteorites have higher radiation ages; (b) antarctic meteorites were irradiated in space by cosmic rays of higher intensity due to, possibly, a higher extent or a larger inclination to the ecliptic plane of the orbits of these meteorites /5/.

The distribution of Mn-53 saturated contents in nonantarctic ordinary chondrites was investigated as a function of their radiation age. The equation:

$$A_{sat}=A_{meas}/(1-e^{-T.\ln 2/t}),$$

was used to calculate the saturated content of Mn-53 (A_{sat}). Here A_{meas} is measured content of Mn-53, t is half-life of Mn-53, and T is radiation age of meteorite. The radiation age of chondrites was determined from the cosmogenic ^{21}Ne content and its production rate (P_{21}). The P_{21} values were calculated according to relation proposed by Nishiizumi et al. /6/. The noble gas data are from the compilation by Schultz and Kruse /7/. When more than one analysis was available for a given meteorite, the average of the exposure ages was used. Ne-21 and Ne-22 concentrations were corrected for a trapped component, using a solar isotopic composition for the solar-gas bearing meteorites and atmospheric ratios for the rest of the analyses /8,9/.

The results for 56 H-chondrite are shown in Fig.3. It is found that the Mn-53 average content is higher by (21 ± 9)% in H-chondrites with radiation age $T \leq 12$ Myr years than in those with $T > 12$ Myr. A similar excess, though less pronounced, we observed for L- and LL-chondrites too. The analysis showed that this excess takes place both for the falls and for the finds, and is not due to the difference in meteorite mass distribution in different age groups. A similar, but less pronounced effect is noticed also for Al-26. The higher Mn-53 and Al-26 saturated contents in chondrites of low radiation age, especially in H-chondrites, can be attributed to the fact that a considerable proportion of meteorites with $T \leqslant 12$ Myr originates from a comet or from the objects of Chiron like, with the orbits more inclined to the ecliptic plane and/or more extended /10,11/, which caused their irradiation by cosmic rays of higher intensity. The greater proportion of such chondrites in the antarctic meteorites might cause the aforementioned higher Mn-53 content in the meteorites from Antarctica.

These data can supply the additional information for study of variations of galactic cosmic-rays intensity during the last ~10 Myr.

References

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Figure captions

Fig.1. Distributions of Mn-53 content in 112 antarctic (dashed line, the histrogram is hatched) and 106 nonantarctic (solid line) ordinary chondrites.

Fig.2. Correlation coefficient (r) of the distributions of Mn-53 contents in antarctic and nonantarctic chondrites as function of the histogram displacement (δ). Displacement of the antarctic chondrites histogram towards lower Mn-53 contents corresponds to the positive values of δ. The equation of the parabola was derived by the least sguares method and is of the form:

$$r=(71 \pm 4).10^{-2}+(22 \pm 3).10^{-4}\cdot\delta-(27 \pm 3).10^{-6}\cdot\delta^2$$

Analysis of this eguation showed that the maximum of the r (r_{max}=0.75) corresponds to the δ = 40 ± 8dpm$\cdot$kg^{-1} Fe.

Fig.3. Distributions of Mn-53 saturated contents as a function of radiation age in 56 nonantarctic H-chondrites. Hatched areas correspond to the average Mn-53 contents ($N \pm \sigma_{\bar{N}}$) for $T \leq 12$ and $T > 12$ Myr. The open circles stand for the finds, and the full for the falls.

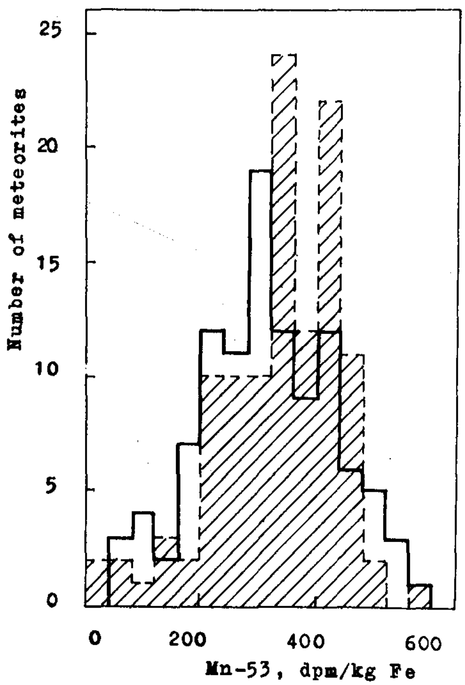

Fig. 1

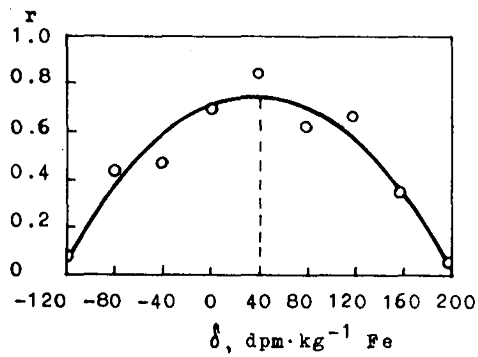

Fig. 2

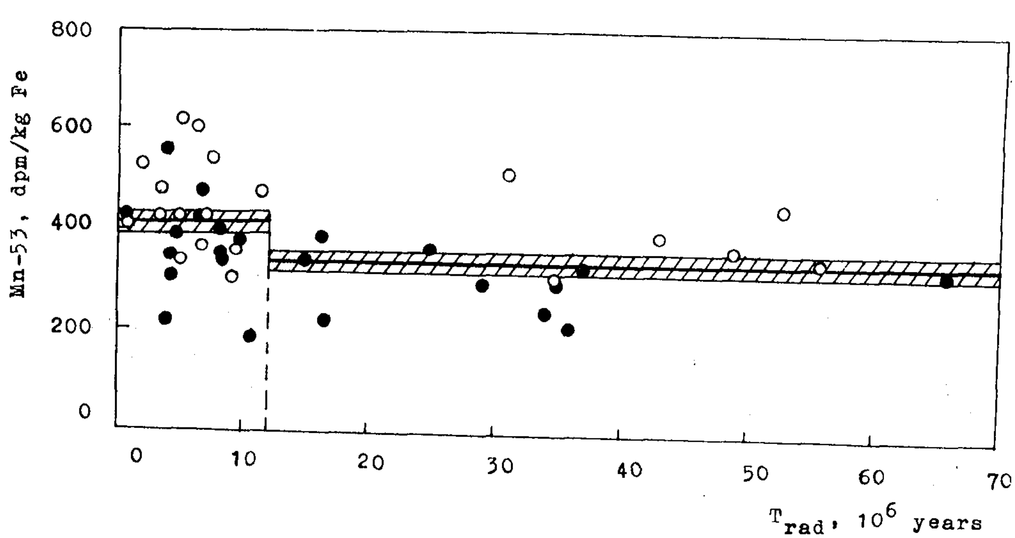

Fig. 3