THE PRE–ATMOSPHERIC SIZE OF MARTIAN METEORITES. O. Eugster, H. Busemann, and S. Lorenzetti, Physikalisches Institut, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland (eugster@phim.unibe.ch)

According to model calculations the upper limit of the radius of fragments ejected from Mars by asteroidal or cometary impact is about 2m, corresponding to a mass of about 100 tons [1]. In the present work we determined the lower limit of the pre-atmospheric size of martian meteorites based on the neutron flux induced by the comic-ray (CR) interaction with meteoritic matter.

We measured the Kr isotopic composition in eight martian meteorites. In all of them we observe effects induced by secondary cosmic-ray (CR) produced neutrons. Concentrations of neutron induced ^{80}Kr, $^{80}Kr_n$, are obtained from

$$^{80}Kr_n = {}^{83}Kr_c\,[(^{80}Kr/^{83}Kr)_c – (^{80}Kr/^{83}Kr)_s]. \qquad (1)$$

The index 'c' denotes cosmogenic Kr and 's' spallation Kr. For $(^{80}Kr/^{83}Kr)_s$ we adopt 0.765 [2]. The results are given in Table 1.

Table 1. Neutron induced $^{80}Kr_n$ ($10^{-12}cm^3STP/g$), Br concentration [6,7] (ppm), and CRE age, T (Ma).

Meteorite	$^{80}Kr_n$	Br	T
Los Angeles	0.98	0.7	3.04
QUE 94201	0.27	0.36	2.51
Shergotty	0.44	0.94	2.81
Zagami	0.24	0.79	3.15
Nakhla	0.99	4.05	10.8
Chassigny	0.44	0.12	11.3
ALH 84001	0.43	–	14.7
Sayh al Uhaymir 005	0.18	0.28	1.2

The production rate of $^{80}Kr_n$ is calculated from

$$P(^{80}Kr_n) = {}^{80}Kr_n/(Br \cdot T). \qquad (2)$$

The Br concentration and T are given in Table 1 and $P(^{80}Kr_n)$ in Table 2. Marti et al. [2] have shown that $^{80}Kr_n$ is produced by epithermal neutron capture of ^{79}Br in the energy range 30–300 eV. The neutron flux, ϕ_n, is then obtained from

$$\phi_n = P'(^{80}Kr_n)/\sigma_{79}, \qquad (3)$$

where $P'(^{80}Kr_n) = 2.33 \cdot 10^{-23} P(^{80}Kr_n)$ and has the dimension neutrons $cm^{-2}s^{-1}$. The resonance integral σ_{79} is $110 \cdot 10^{-24} cm^2$ [3]. Fig. 1 demonstrates the resulting neutron fluxes. They are shown in relation to the fluxes of > 5 MeV neutrons that were calculated based on cosmogenic ^{21}Ne [8].
Two scenarios are possible how the meteoritic material might have experienced the observed neutron fluxes: (a) during a pre–exposure to cosmic rays in the regolith before ejection from Mars, and (b) as a meteoroid during the transfer from Mars to Earth.

Table 2. Production rate $P(^{80}Kr_n)$ ($10^{-12}cm^3STP/g$, Ma), epithermal neutron flux ϕ_n (neutrons $cm^{-2}s^{-1}$), slowing down density q (neutrons $cm^{-3}s^{-1}$), and minimum pre-atmospheric radius R_{min} (cm).

Meteorite	$P(^{80}Kr_n)$	ϕ_n	q	R_{min}
Los Angeles	0.46	0.93	0.033	26
QUE 94201	0.30	0.61	0.021	24
Shergotty	0.17	0.35	0.012	23
Zagami	0.094	0.19	0.0067	23
Nakhla	0.023	0.047	0.0016	22
Chassigny	0.32	0.65	0.023	25
Sayh al Uhaymir 005	0.55	1.12	0.039	27

The neutron flux as a function of depth within the martian regolith has not been measured but Lingenfelter et al. [4] give these data for the lunar regolith. We show that scenario (a) can be excluded because the expected neutron fluxes in the meteoritic
material would be an order of magnitude higher than observed. For scenario (b) we obtain a slowing down density, q, for epithermal neutrons of

$$q = \phi_n \cdot \xi\Sigma_{tot}, \qquad (4)$$

where $\xi\Sigma_{tot} = 0.0354\ cm^{-1}$ for chondrites [5]. As the relevant element abundances in chondrites and martian meteorites are similar, this value is used here and we obtain

$$q = 0.0716\ P(^{80}Kr_n). \qquad (5)$$

Based on the calculations of Eberhardt et al. [5] minimum radii, R_{min}, are obtained:

$$R_{min} = R_o + aq, \qquad (6)$$

where R_o = 22 cm and a = 118 cm^4s. Fig. 1 shows the minimum pre–atmospheric radii as calculated from the measured q values.

The lower limit of the resulting radii (Table 2) is in the range of 22–27 cm. Taking the density of the martian meteorites into account we estimate the minimum pre–atmospheric masses to have been in the range of 150–270 kg.

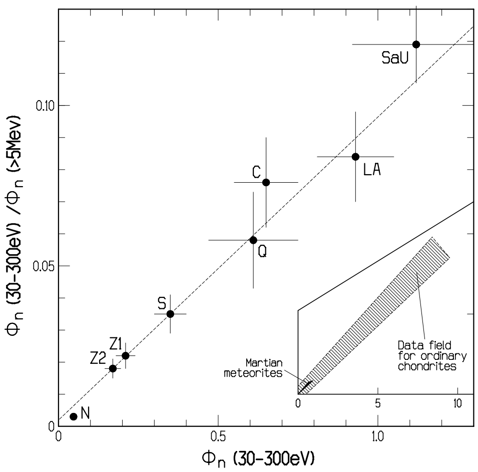

Fig. 1 Secondary neutron flux ratio for 30–300 eV neutrons (from ^{80}Kr) to >5 MeV neutrons (from ^{21}Ne) vs. flux of 30–300 eV neutrons in martian meteorites. LA, Los Angeles; C, Chassigny; Q, QUE 94201; S, Shergotty; Z, Zagami; N, Nakhla; SaU, Sayh al Uhaymir 005.

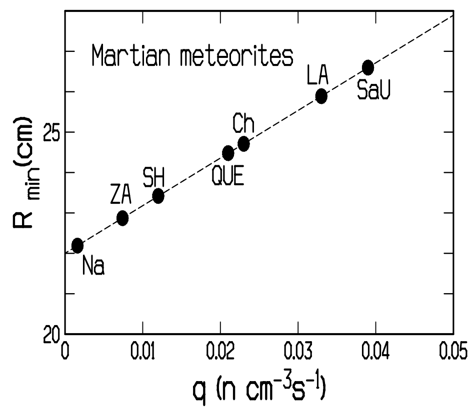

Fig. 2. Minimum pre–atmospheric radii of martian meteorites calculated from the measured slowing down densities q for epithermal CR produced neutrons. For meteorite names see caption to Fig. 1.

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