COSMOGENIC EFFECTS IN MBALE CHONDRITE, K.M.Suthar, C.J.Clement, S.V.S.Murty and N.Bhandari, Physical Research Laboratory, Navrangpura, Ahmedabad 380009, India.

We have measured cosmic ray tracks, noble gases and radioactive isotopes in one fragment of the Mbale (L5/6) meteorite shower in order to understand its exposure history. He and Ne exposure ages are 29 and 27 Ma respectively. Our results of track density, cosmogenic stable and radioactive isotopes suggest that Mbale had a simple one stage exposure, with a preatmospheric size R (≤35 cm).

Introduction : A large number of meteorite fragments weighing about 150 kg fell on August 14, 1992 in Uganda and has been described by Jenniskens et al [1]. A fragment weighing 700 g was kindly made available to us by Dr.Betlem and the following results have been obtained on this fragment.

Noble gas measurements and cosmic ray exposure ages : Isotopes of helium, neon, argon, krypton and xenon were measured in a 708.26 mg piece using a VG 1200 mass spectrometer. Table 1 gives the light noble gas data. He and Ne are almost purely cosmogenic.

Table 1 Light noble gases (10^{-8} cc STP/g) and isotope ratios in Mbale

^{4}He	^{22}Ne	^{36}Ar	$^{3}He_c$	$^{21}Ne_c$	3/4	20/22	21/22	$(22/21)_c$	38/36	40/36
367.6	9.11	1.41	45.9	7.97	0.125 ±.008	0.8869 ±.0084	0.8757 ±.0053	1.129 ±.007	0.8152 ±.0005	144.1 ±.4

Using ^{3}He and ^{21}Ne production rates of 1.6×10^{-8} cc STP/g Ma and 0.296×10^{-8} cc STP/g Ma following Eugster [2], we obtain exposure ages of 28.7 and 26.9 Ma respectively. The agreement between the ^{3}He and ^{21}Ne exposure ages suggests that there has been no He loss since Mbale started getting exposed to cosmic rays. This exposure age matches with the age cluster for L chondrites centered around 28 Ma found by Marti et al. [3]. The radiogenic ^{4}He ~129×10^{-8} yields a gas retention age of about 0.4 Ga. The K-Ar system also yields an age of 0.5 Ga (K=909 ppm [1]). Wasson et al. [4], in fact, found a peak at 0.4 - 0.5 Ga for the U-Th-He ages of L chondrites, signifying a major thermal event on a L-chondrite parent body. The low amount of trapped noble gas component [$(^{36}Ar)_{Trap.} = 0.73 \times 10^{-8}$ ccSTP/g) is consistent with the petrologic class of Mbale being L5/6. No neutron capture products are discernible at $^{80,82}Kr$ and ^{128}Xe respectively from Br and I, indicating that the sample analyzed comes from a shallow depth in a small body, which is consistent with the high observed NeR $(^{22}Ne/^{21}Ne)_c$ value of 1.129.

Track production rates : Five samples from different locations of this fragment were analyzed for cosmic ray VH tracks in the olivine grains using standard etching procedures [5]. The track densities ranged between 2.14 to 3.6 x 10^{5} tracks/cm^{2}. Normalising to pyroxenes and using the ^{21}Ne exposure age of 26.9 Ma, we obtain track production rates/Ma (TPM) of 1.6 and 2.7×10^{4}. This production rate corresponds to shielding depths in the range of 10.8 to 12.4 cm, based on the production rates given by [5].

COSMOGENIC EFFECTS IN MBALE, K.M.Suthar et al.

The data points in the TPM vs NeR diagram [6] lie in the region of meteorites with single stage cosmic ray exposure, indicating that Mbale had a simple exposure history. TPM and NeR both indicate about 11.6 cm shielding in a body of preatmospheric radius of ≤35 cm.

Cosmogenic radionuclides and modulation of galactic cosmic rays : Radionuclides ^{54}Mn, ^{22}Na, ^{60}Co and ^{26}Al were measured in this fragment by counting on a 100 cc Hyper Pure Ge γ-ray spectrometer located in a low level shield. ^{40}K was used as an internal gamma ray standard and the activity of different radionuclides was calculated using the procedure described elsewhere [7]. K value of 909 ppm as measured by Jenniskens et al [1] was used to obtain ^{40}K gamma ray efficiency. The results are given in Table 2.

Table 2 : Radioactivity at the time of fall of Mbale

Radioisotope	$t_{1/2}$	dpm/kg (1σ)
^{54}Mn	312.5 d	63±5
^{22}Na	2.602 y	77±3
^{60}Co	5.27 y	3.5±1
^{26}Al	7.16 x 10^5 y	65±5

These values are comparable to the reported values in other fragments [1]. The low value of ^{60}Co is consistent with small (~12 cm) shielding depth of this fragment. The ^{22}Na/^{26}Al was determined to be 1.18. The meteorite fell during the falling phase of solar cycle 22 and the ratio is close to the expected value calculated from the climax neutron monitor data following [7]. In summary all the cosmogenic effects i.e. tracks, rare gases and radionuclides show that Mbale had a simple one stage exposure history. TPM, NeR and ^{60}Co are consistent with a small preatmospheric size (R ≤35 cm) and the fragment measured here had small shielding depth (~12 cm). Some of these inferences were also made by [1,8].

References : [1] Jenniskens, P. et al. (1994) Meteoritics 29, 246-254; [2] Eugster, O. (1988) Geochim. Cosmochim Acta, 52, 1649-1662; [3] Marti, K. et al. (1992) Ann. Rev. EPS., 20, 221-243; [4] Wasson, J.T. et al. (1991) Meteoritics, 26, 161-167; [5] Bhandari, N. et al. (1980), Nuclear Tracks, 4, 213-262; [6] Bhandari, N. (1981) Proc. Ind. Acad. Sci., 90, 359-382; [7] Bhandari, N. et al. (1989) Meteoritics, 24, 29-34; [8] Pistorius, B. and Heusser, G. (1994, Meteoritics, 29, 519.