LETTERS TO THE EDITOR

COSMIC RADIATION EFFECTS IN DHAJALA METEORITE

INVESTIGATIONS of recordable fossil track lengths in meteoritic minerals and in lunar rocks provided information on the charge composition of cosmic ray iron group and heavier nuclei[1–5] and on the spontaneous fission contribution from ^{238}U and extinct isotope of ^{244}Pu since the solidification of these extraterrestrial samples[6–8]. We report here results of fossil track studies of a fragment of the recently fallen Dhajala meteorite.

The Dhajala meteorite shower fell on 28th January 1976 at about 8·40 P.M. near Dhajala village (lat. 22° 22′ 40″ N, long. 71° 25′ 38″ E) of Gujarat State, India. Since then, detailed investigations[9–11] have been carried out to determine its preatmospheric radius, cosmic ray exposure age and ablation losses based on studies of cosmic ray tracks.

Our investigations are based on fossil tracks revealed in olivine crystals separated from a small fragment of this chondritic meteorite. The olivine crystals of size 300–700 μm were picked with tweezers under a stereomicroscope, mounted in epoxy resin and polished with 1 μm diamond paste. The samples were etched in WN solution[12] and examined under Olympus microscope using a magnification of 1500 × to reveal fossil tracks.

Fossil tracks were counted in four olivine crystals by using a calibrated 15 × eye-piece. The etched track lengths were recorded by measuring projected track lengths with a calibrated eye-piece scale and the depths by a fine focus knob. The fossil tracks recorded reveal a uniform distribution over the crystal surface. To estimate relative frequency distribution of short and long tracks, we sampled about 250 tracks. The track length distribution is shown by a histogram (Fig. 1). Most of the tracks are extremely dipping showing a directional effect during cosmic ray exposure of the meteorite. The results are summarized in Table I.

The fossil tracks recorded in Dhajala meteorite fragment conform to the behaviour expected of heavy primary cosmic rays of VH group. The positive identifying conditions are as follows :—

(a) a track length distribution peaked at short-lengths 10–15 μm depending on the mineral type,

(b) a significant directional anisotropy of tracks, and

(c) a rapid attenuation of track density with shielding depth of samples.

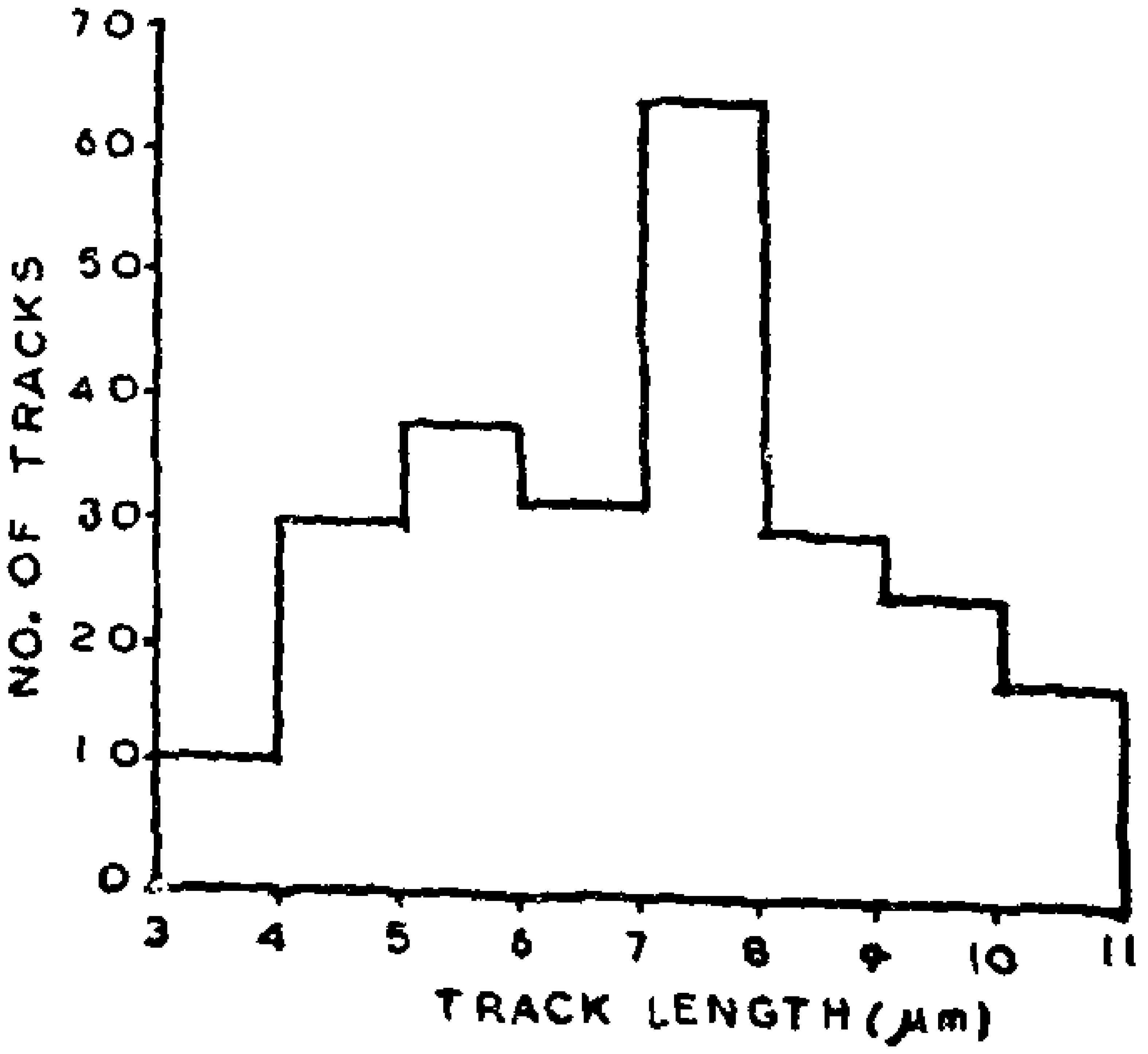

FIG. 1. Track length distribution of fossil tracks in olivine crystals.

TABLE I

Fossil track distribution in olivine crystals

Mineral sample	No. of tracks counted	Fossil track density × 10^5 cm^{-2}	Most probable track length (μm)
Olivine	215	8·5	
	422	9·4	7·5
	537	8·6	
	458	8·0	

Mean track density = 8·6 × 10^5 cm^{-2}.

Our track analysis conforms strictly to the conditions (a) and (b) and a comparison of our fossil track density with that reported by Bagolia *et al.*[11] establishes the validity of condition (c). The mean fossil track density in our fragment is found to be 8·6 × 10^5 cm^{-2} which establishes that this is one of the least ablated specimens. Assuming the cosmic ray exposure age of the Dhajala meteorite to be 7 m.y. and its preatmospheric radius as (38 ± 2) cm[11], the shielding depth of the sample is estimated to be 5·8 cm[13].

We have not found any evidence of V tracks or tracks longer than 12 μm as reported by Fleischer *et al.*[1,4] and Bhandari *et al.*[7] in the case of some other meteorites. Therefore, we eliminate high energy induced fission of heavy elements as possible source of fossil tracks in Dhajala meteorite. The spontaneous fission contribution of fossil tracks from ^{238}U and ^{244}Pu is estimated by Bhandari *et al.*[9] to be less than 3×10^{2} cm^{-2}.

On the basis of numerical calculations[8] the recordable range of iron group ions in olivine and pyroxene is predicted to be 10 μm on the average. Price *et al.*[14] determined the most probable track lengths of Fe ions in olivine from accelerator irradiations and from fossil tints (track in track) to be 13·0 μm and 9–11 μm respectively. We have neither taken recourse to tints, tincles or tots,[15] (methods to obtain total track lengths) nor applied any annealing correction but counted and measured lengths of only the normal surface tracks which are revealed by etching on the cleavage plane of the crystal. The most probable value of fossil surface track length observed in our analysis is 7·5 μm for olivine under normal etching conditions[12] which is consistent with the tracks belonging to the VH group of cosmic ray nuclei. Hence we conclude that the most predominant source of fossil tracks in Dhajala meteorite shower is the Fe group of cosmic rays.

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1. Fleischer, R. L., Price, P. B., Walker, R. M., Maurette, M. and Morgan, G., *Geophys. Res.*, 1967, **72**, 355.
2. —, Haines, E. L., Hanneman, R. E., Hart, H. R. Jr., Kasper, J. S., Lifshin, E., Woods, R. T. and Price, P. B., *Science*, 1970, **167**, 568.
3. Price, P. B., Rajan, R. S. and Tamhane, A. S., *Astrophys. J. Lett.*, 1968, **151**, 109.
4. Lal, D., Rajan, R. S. and Tamhane, A. S., *Nature*, 1969, **221**, 33.
5. —, Macdougall, D., Wilkening, L. and Arrhenius, G., *Proc. Apollo Sci. Conf.*, 1970, **3**, 2351.
6. Fleischer, R. L., Price, P. B. and Walker, R. M., *J. Geophys. Res.*, 1965, **70**, 2703.
7. Bhandari, N., Bhat, S. G., Lal, D., Rajgopalan, G., Tamhane, A. S. and Venkatavardan, V. S., *Nature*, 1971, **230**, 219.
8. Fleischer, R. L., Price, P. B., Walker, R. M. and Maurette, M., *J. Geophys. Res.*, 1967, **72**, 331.
9. Bhandari, N., Lal, D. and Trivedi, J. R., *Meteoritics*, 1976, **11**, 137.
10. —, N. and Ballabh, G. M., *Astron. Soc. India*, 1977, **5**, 69.
11. Bagolia, C., Doshi, N., Gupta, S. K., Kumar, S., Lal, D. and Trivedi, J. R., *Nucl. Track Det.*, 1977, **1**, 83.
12. Krishnaswami, S., Lal, D., Prabhu, N. and Tamhane, A. S., *Science*, 1971, **194**, 287.
13. Gupta, S. K. and Lal, D., *Nucl. Track Det.*, 1978, **2**, 37.
14. Price, P. B., Lal, D., Tamhane, A. S. and Perelygin, V. P., *Earth Planet. Sci. Lett.*, 1973, **19**, 377.
15. Lal, D., *Space Sci. Rev.*, 1969, **9**, 623.

SIMULTANEOUS DRIFT MEASUREMENTS BY SPACED RECEIVER TECHNIQUE AND BY BARIUM CLOUD RELEASE NEAR MAGNETIC EQUATOR

A SERIES of rocket borne barium cloud drift measurements were made over Thumba (dip. 0·6° S) during March 1968[1]. Horizontal E–W drift measurements in equatorial F-region by various techniques have been compared by Balsley[2] in his review on equatorial electric fields. In addition to these *in situ* measurements other techniques included in comparison are (1) drift measurements by spaced receiver technique at Thumba averaged over the period 1968–69[3] and at Ibadan during IGY[4], (2) drift measurements by incoherent scatter experiment at Jicamarca, (3) drift velocities derived from the sequential appearance of spread-F at a chain of ionosondes in Peru[5] and (4) from the spread-F ionogram synthesis work based on Huancayo ionosonde records[6].

Drift velocities by barium release experiment conducted at Thumba matched very well with the average spaced receiver drift velocities at Thumba and in close agreement with the velocities at Ibadan also be similar experiment even though the latter data belonged to different years and to different longitudes. The velocities by incoherent scatter method at Jicamarca showed however disagreement.

During the barium release experiments conducted at Thumba, the spaced receiver drift experiment was operated simultaneously and here we wish to compare the E–W drifts by this technique and by barium release technique. The spaced fading records have been analysed by similar fade method[7] and no N–S component was noticed on any of the barium release times. The drift was purely westward during the evening flights of 28th and 30th March (launch time 18·55 hr IST) and purely eastward on the morning flight of 31st March (launch time 05·37 hr IST). The E–W