pared to human samples. This may be the reason for undetectable level of platelet NE in rats. The increase in plasma NE and EPI observed in experimental diabetes as well as human subjects may be due to the increased output of sympathetic stimulation in both these cases. Previous studies have shown the involvement of sympathetic nervous system in elevating plasma NE and EPI in diabetic condition. The adrenal glands may also be involved in bringing about an increase in EPI[7]. Martin *et al.*[8,9] reported increased serotonin content in human and rat platelet in diabetic condition. Acute myocardial infarction showed a similar platelet 5-HT content[10]. There are also reports of altered NE, EPI and 5-HT in brain regions of diabetic rat models as well as humans[11].

The present study showed a decrease in platelet number in diabetic patients as well as in rat models which supports our earlier report on decreased number of platelets in diabetic rats[12]. The increased content of neurotransmitters observed in plasma and platelets may be similar to the increased sympathetic stimulation observed in our previous studies in pyridoxine-deficient animal models[13]. The increase in monoamine uptake by the platelets can be due to alteration of platelet membrane potential[14]. Kjeldsen *et al.*[15] have reported that a depletion of sodium in the diet can increase the monoamine uptake by the platelets. It appears that the changes in rat and human samples of plasma monoamines are correspondingly reflected in the platelet monoamines. Thus it is suggested that the platelets can be used for measuring the levels of NE, EPI and 5-HT in diabetic condition and the platelet content of these neurotransmitters is altered in untreated diabetes.

1. Seth, P. K. and Khanna, V. K., in *Lectures in Neurobiology* (eds Tandon, P. N., Bijlani, V. and Wadhwa, S.), 1991, vol. 3, pp. 60–72.
2. Rehavi, M., Weizmann, R., Weizmann, A., *Immunol. Biochem. Pathol.*, 1980, **100**, 569–583.
3. Alain, J., Andre, E., Lambert, W., St. Cubtacher, A. and Renold, A., *J. Clin. Invest.*, 1969, 2129–2331.
4. Arison, R. N., Caiccio, E. I., Glitzer, M. S., Cassaro, J. A. and Press, M. P., *Diabetes*, 1967, **16**, 51–56.
5. Steven, C., *Methods Enzymol.*, 1992, **215**, 181–200.
6. Paulose, C. S., Dakshinamurti, K., Packer, S. and Stephens, N. L., *Hypertension*, 1988, **11**, 387–391.
7. Kikuchi, N., Nanno, M. and Kurahachi, H., *Nippon Naibunpi Gakkai Zasshi*, 1988, **64**, 93–108.
8. Martin, F. J. and Ardegurde, M., *Biog. Amines*, 1995, **11**, 653–667.
9. Martin, F. J., Migvez, J. M., Aldegu, M. and Atierga, G., *Life Sci.*, 1995, **56**, 1807–1815.
10. Whaba, Z. and Solimen, K. F., *Experimentia*, 1988, 44, 742–746.
11. Zdravko, K., Melita, S., Zyratete, K. and Maja, R., *J. Neurochem.*, 1990, **54**, 143–146.
12. Naseema, A., Padayatti, P. S. and Paulose, C. S., *Curr. Sci.*, 1995, **69**, 461–463.
13. Paulose, C. S., Dakshinamurti, K., Subah, P. and Newman, L. S., *Hypertension*, 1988, **11**, 387–391.
14. Mahesh, C., Naveen, C., Sanjay, G., Mahima, V., Saxena, A. K., Aravind, K. and Kripa, *Indian J. Exp. Biol.*, 1993, **31**, 999–1001.
15. Kjeldsen, S. E., Weshtheim, A., Lande, K., Gjesdal, K. and Lere, *Hypertension*, 1988, **11**, 477–482.

ACKNOWLEDGEMENTS. This work was supported by a grant from DAE and DST, Govt. of India. PSP thanks CSIR for a fellowship.

Received 29 March 1996; revised accepted 13 December 1996

A Mössbauer spectroscopic study of the Pipliya-1 meteorite

K. L. Shrivastava, R. P. Tripathi* and V. K. Vaya

Department of Geology and *Department of Physics, JNV University, Jodhpur 342 005, India

A recently fallen stony type meteorite in Rajasthan namely Pipliya-1 meteorite has been investigated using Mössbauer spectroscopy at 300 K. The obtained Mössbauer parameters resemble pigeonite to a greater extent, among pyroxene. The ratio of Fe^{2+} inner doublet and Fe^{2+} outer doublet confirm the textural interpretations of the geothermal history of the pyroxene. Presence of a weak Fe^{3+} doublet is probably indicating the change in the oxidation state of Fe^{2+} in the meteroite itself because of shock phenomenon.

THE Pipliya-1 meteorite is one of the two Pipliya meteor showers fallen on 20 June 1996 at 20.30 h at village Pipliya Kalan (Lat. 26°2'5": Long 73°56'30"), Pali, Rajasthan, India. A preliminary study of the same has been reported recently[1]. In this paper the Mössbauer spectroscopic study of the Pipliya-1 meteorite is reported.

The Pipliya-1 meteorite has a glossy pitch black crust of nearly 500 μm thickness. Under the fused crust it has typical characters of a stony meteorite. The rock as a whole is a complex breccia consisting chiefly of two types of fragments (type A and type B, welded together), and a few xenoliths[1]. Type A is a fine-grained, gray rock while type B is a coarse-grained, grayish-white rock as reported[1]. The thin sections under petrological microscope reveal[1] that type A is composed of grains of pyroxene (65%), plagioclase (25%), opaque minerals (6%), and some xenoliths (4%). Type B is composed of pyroxenes (55%), plagioclase (40%) and opaque minerals (5%). Pyroxene is clinopyroxene of pale pink colour, nonpleochroic with moderate extinction angles.

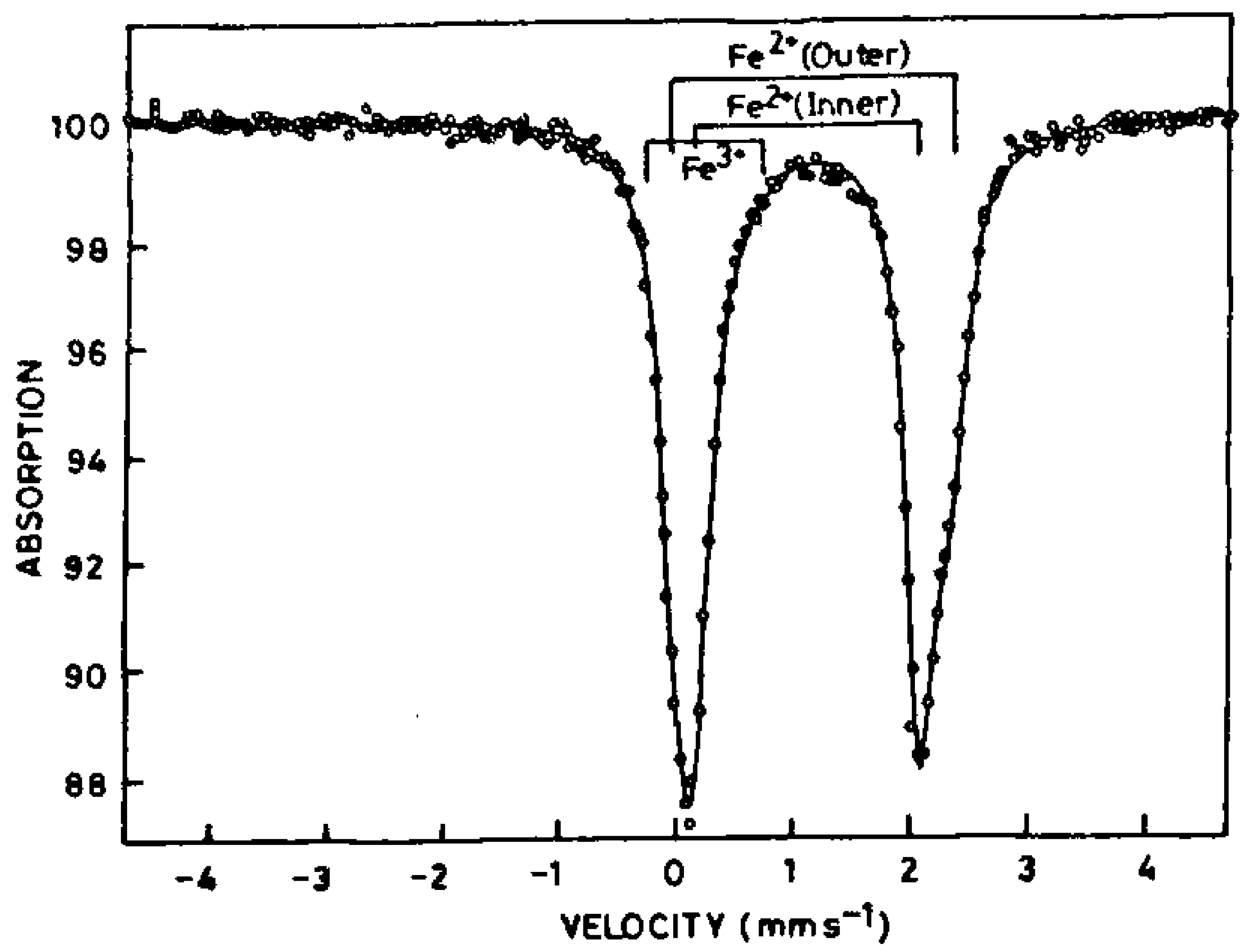

Figure 1. Mössbauer spectrum of rock type A of Pipliya-I meteorite at 300 K.

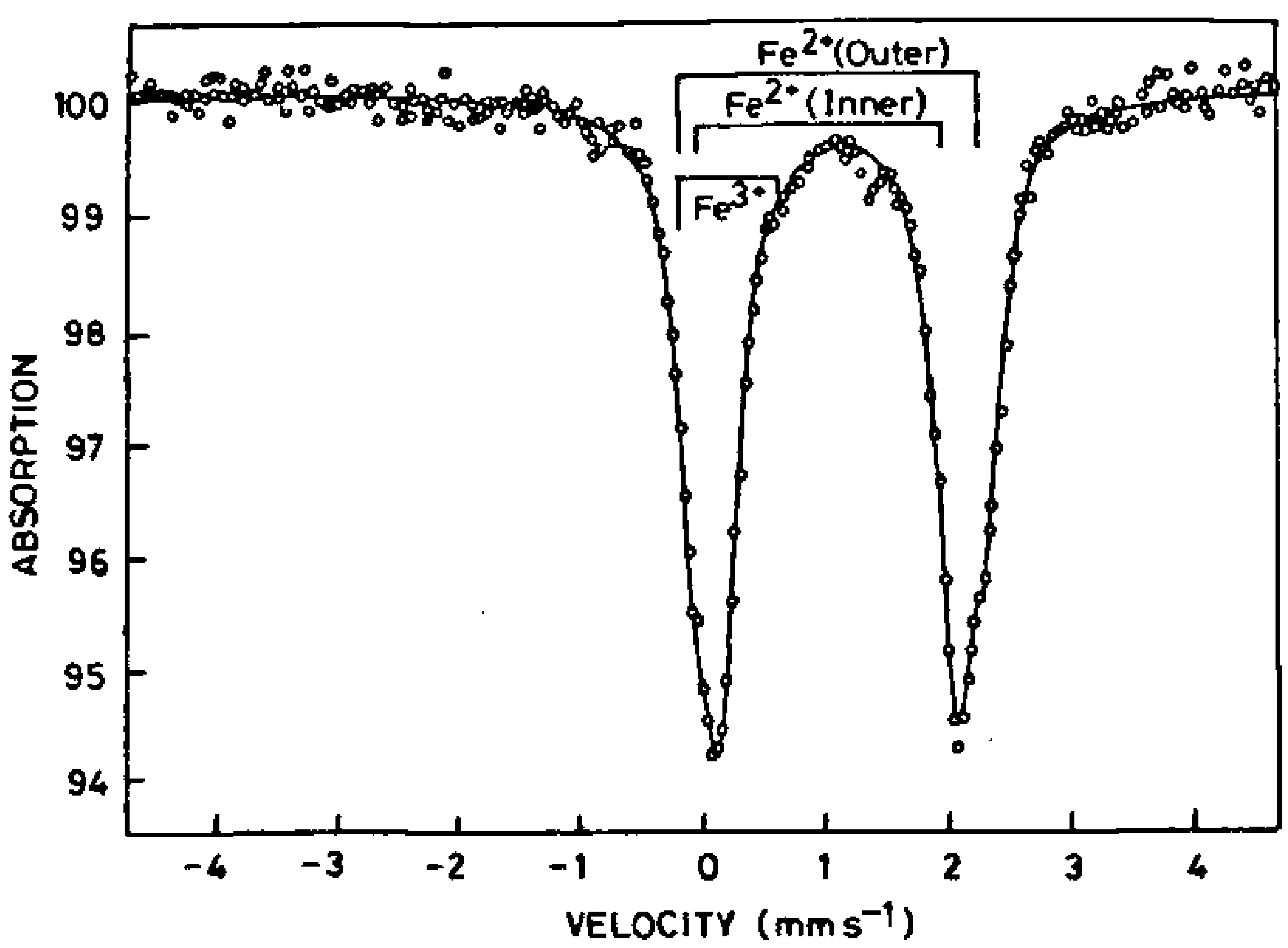

Figure 2. Mössbauer spectrum of rock type B of Pipliya-1 meteorite at 300 K.

The Mössbauer spectra for both type A and type B have been recorded at 300 K. The thin absorber was prepared by sandwiching fine powder in a sample holder of 2.5 cm diameter. A constant acceleration type Mössbauer spectrometer was used with 25 mCi, Co^{57} in Rh matrix source. All the spectra were computer fitted using a computer program given by Meerwal[2] with some modifications. This program assumes the spectrum to be the sum of Lorentzians. In the present study, the width and the intensity of the two halves of a quaderupole doublet were constrained to be equal. The various permutations and combinations were tried out and iterations were continued till minimum and acceptable χ^2 (goodness of fit parameter) was obtained. The solid

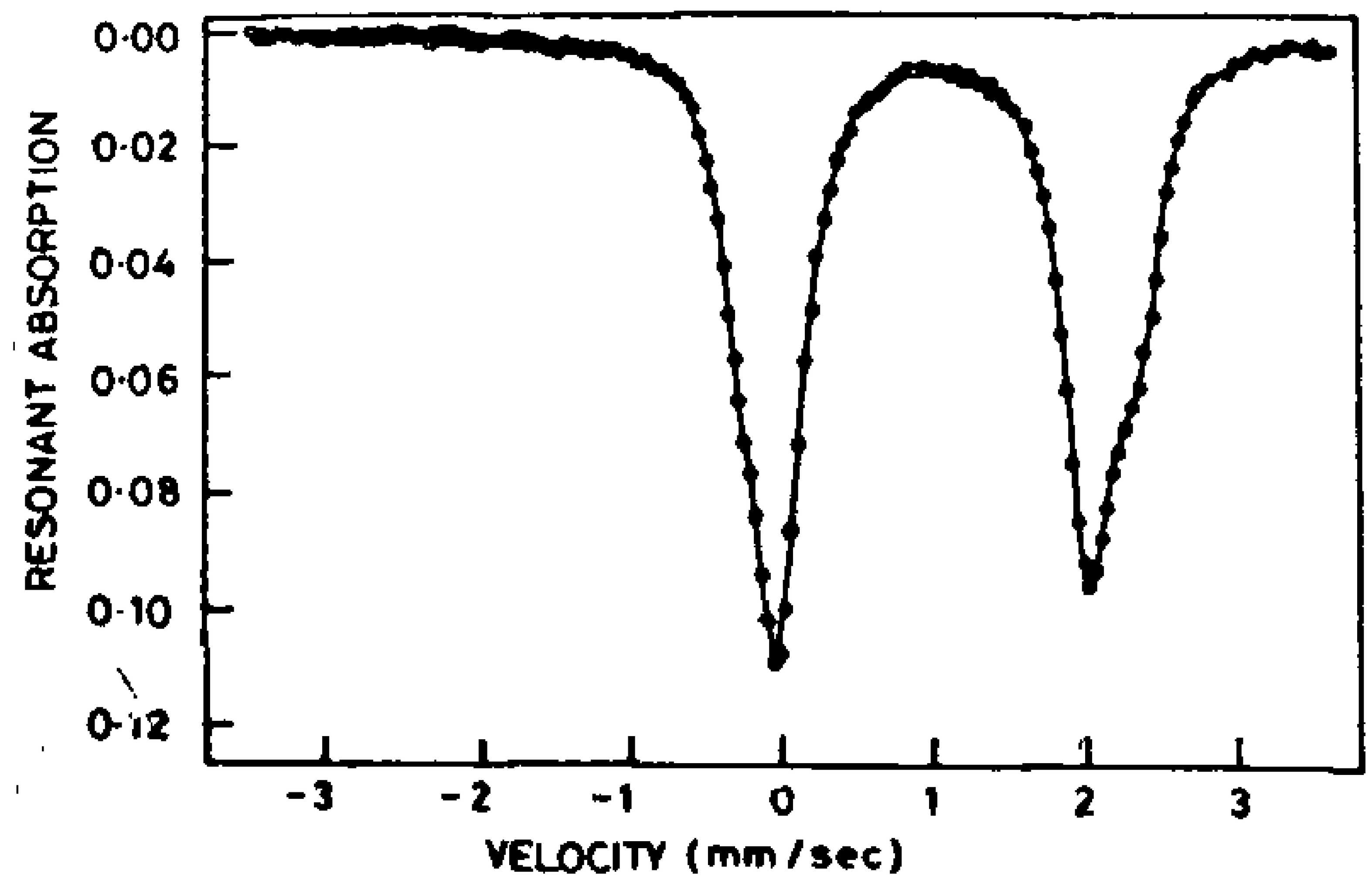

Figure 3. Resonant absorption spectrum of Fe^{57} (295 K) in pigeonite separated from a coarse-grained basalt of the Apollo 11 landing site at Mare Tranquillitatis (ref. 3).

lines in the spectra reported here, represent the computer-fitted curves and the dots are the experimental points. This IS (Isomer Shift) values are recorded with respect to the centroid of an α-iron foil. The positions of the individual doublets are marked on the spectrum.

Mössbauer spectrum of type A and type B rocks, constituting breccia of the Pipliya-1 meteorite is shown in Figure 1 and Figure 2. The Mössbauer parameters of the same are given in Table 1. The Mössbauer spectrum of a pigeonite sample obtained from a coarse-grained basalt of Appolo 11 landing site at Lunar is also given in Figure 3 for comparison[3]. The Mössbauer spectra of one terrestrial orthopyroxene (hypersthene) and one clinopyroxene (augite) are given in Figure 4 and Figure 5, respectively for comparison[4].

Several workers have reported the Mössbauer spectra of ortho and clino-pyroxenes[5-15]. The Mössbauer parameters of pyroxenes obtained by the earlier workers are presented in Table 2. In orthopyroxenes, the inner quadrupole doublet (which has smaller QS value) is attributed to Fe^{2+} in M2 site and outer quadrupole doublet is attributed to Fe^{2+} in the M1 site (which has larger QS value). On the other hand, the clinopyroxenes show their inner quadrupole doublet attributed to M1 site and the outer doublet to Fe^{2+} in M2 site. This is because in orthopyroxenes, the M2 site is more distorted than the M1 site, while in the clinopyroxenes M1 site is more distorted than the M2 site.

The Mössbauer spectra of Pipliya-1 meteorite samples show two intense quadrupole doublets but χ^2 values is significantly improved if a very weak doublet is also considered to be present in the fitting. The Mössbauer parameters for both the intense quadrupole doublets are characteristic of Fe^{2+} in high-spin state. On the other hand, a weak doublet indicates the presence of iron in Fe^{3+} state.

Table 1. Mössbauer parameters for Pipliya-1 meteorite at 300 K

Sample (meteorite)	Quadrupole split (QS) (mm s^{-1})	Isomer shift (IS) (mm s^{-1})	Line width (LW) (mm s^{-1})	Relative area (RA)	Doublet	Fe^{2+} inner / Fe^{2+} outer (Ratio)	χ^2 (per 243 degree of freedom)
Rock type A	1.94	1.09	0.34	71.77	Fe^{2+} doublet (inner)		
	0.93	0.26	0.32	5.25	Fe^{3+} doublet	$\frac{71.77}{21.98} = 3.28$	1.36
	2.40	1.13	0.29	21.98	Fe^{2+} doublet (outer)		
Rock type B	1.92	1.09	0.37	68.01	Fe^{2+} doublet (inner)		
	1.05	0.26	0.27	4.54	Fe^{3+} doublet	$\frac{68.01}{27.45} = 2.47$	1.42
	2.39	1.12	0.32	27.45	Fe^{2+} doublet (outer)		

Table 2. Mössbauer parameters reported for the pyroxenes

Pyroxene	Outer doublet IS (mm s^{-1})	Outer doublet QS (mm s^{-1})	Inner doublet IS (mm s^{-1})	Inner doublet QS (mm s^{-1})	Reference and remarks
Diospside	1.15	2.95	1.15	2.06	Ref. 4 (average of two samples)
Orthopyroxenes	1.16	2.57	1.14	2.04	Ref. 7 (average of seven samples)
Hypersthene	1.15	3.00	1.15	2.14	Ref. 4 (average of two samples)
Pigeonite	1.15	2.5	1.15	2.0	Ref. 3 (calculated from spectra of one Lunar sample)
Augite	1.12	2.72	1.10	2.11	Ref. 4 (one sample)

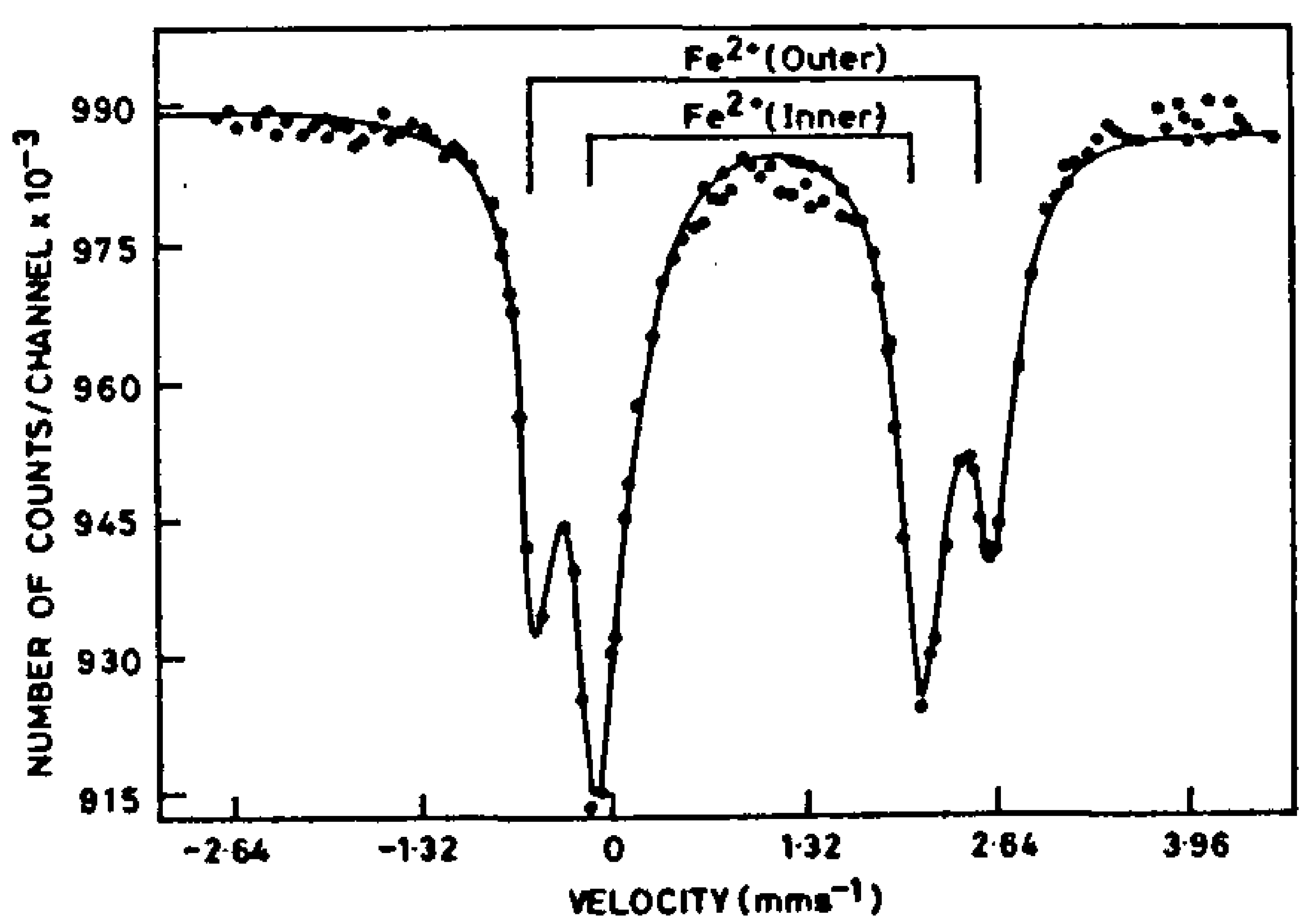

Figure 4. Mössbauer spectrum of terrestrial ordered hypersthene sample at 300 K (ref. 4).

The petrographic studies carried out earlier[1] indicated the presence of appreciable amount of clinopyroxenes in the Pipliya-1 meteorite samples. The Mössbauer parameters obtained in the present investigation (Table 1) also show those values which are characteristic of iron in clinopyroxenes. The large resonance absorption indicates the presence of higher concentration of iron in the sample, which is generally the case in pigeonite because it contains more $FeSiO_3$ component in solid solution. A comparison of the spectra obtained for the Pipliya-1 meteorite with the spectrum of Lunar sample[3] has been made. Both show pigeonite. Although there is no Fe^{3+} in Lunar basalt sample[3], both show similar line shape and Mössbauer parameters, which further strengthen the conclusion regarding the presence of pigeonite. Furthermore, Mössbauer parameters obtained presently (Table 1), do not tally with those reported for orthopyroxenes nor with those of other clinopyroxenes (Table 2).

As far as difference in the Mössbauer absorption in the meteorite samples is concerned, an observation can be made that the relative quantity of pyroxene is more in rock type A than rock type B. This observation is well within the limitation that the thickness of the absorbers for both the types was approximately the same.

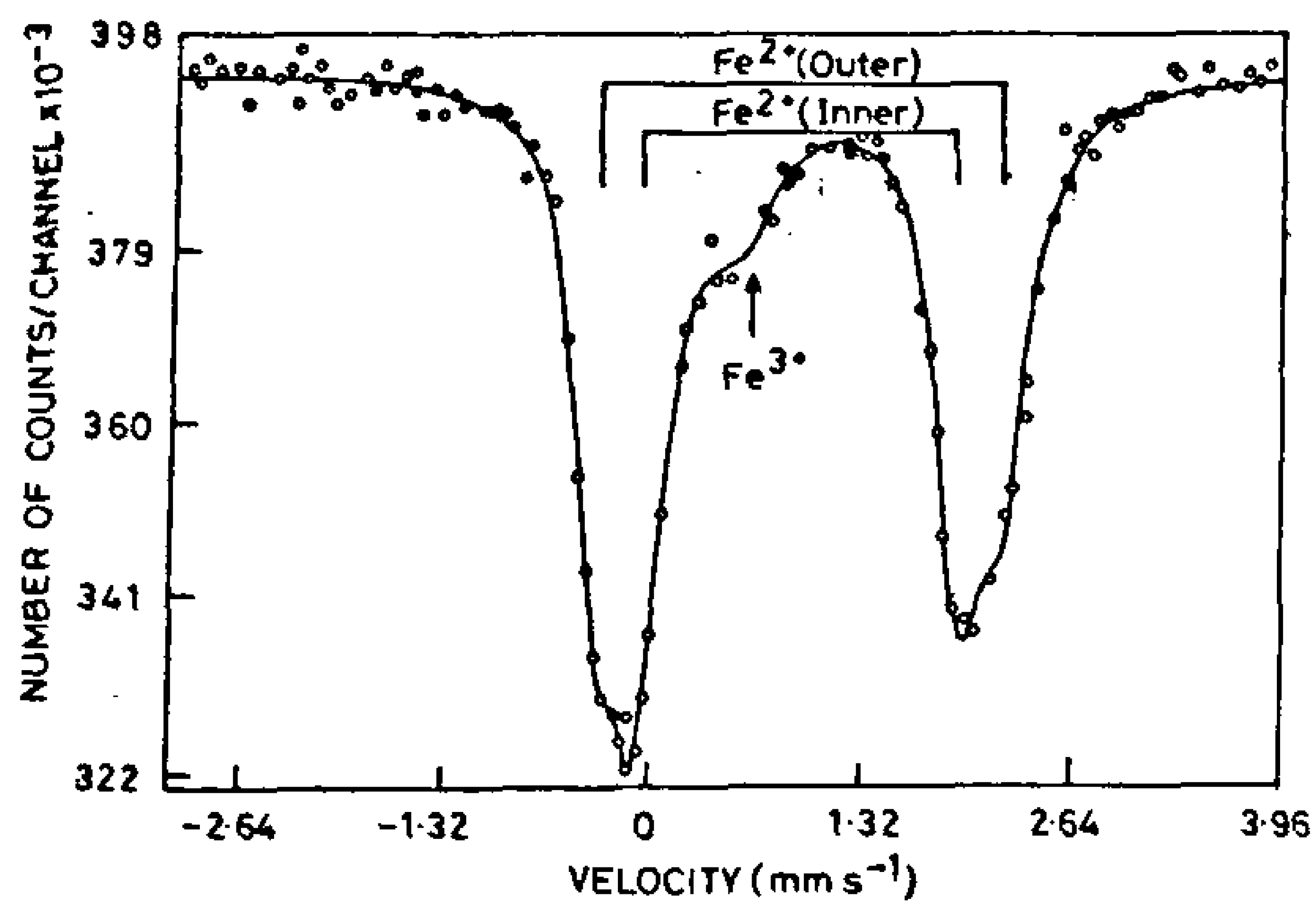

Figure 5. Mössbauer spectrum of terrestrial augite sample at 300 K (ref. 4).

assuming that the '*f*-fraction' (recoil free fraction) for pyroxenes in both the types is the same (which is generally the case).

The ratio of Fe^{2+} inner/Fe^{2+} outer is dependent on the geothermal history of the pyroxene[16]. Table 1 shows that the Fe^{2+} inner/Fe^{2+} outer ratio for rock type A is 3.28 and for rock type B is 2.47. It shows that rock type B has more equilibrium distribution and must have undergone slow cooling in comparison with the fast cooling of the rock type A. The conclusion is in accordance with the interpretation in the text.

The fine-grained texture of rock type A is evidence of fast cooling in comparison with the medium-to coarse-grained texture of rock type B showing slow cooling.

A Fe^{3+} doublet of weak intensity has been fitted in the Mössbauer spectra. This peak could have been due to the change in the oxidation state of Fe^{2+} in the meteorite itself because of shock phenomenon. However, this assignment should be considered with caution because the intensity of the doublet is quite weak.

1. Vaya, V. K., Mehta, D. S., Bafna, P. C., Sisodia, M. S. and Shrivastava, K. L., *Curr. Sci.*, 1996, **71**, 253–257.
2. Meerwal, E., *Comp. Phys. Commun.*, 1971, **9**, 117–128.
3. Hafner, S. S., in *Mössbauer Spectroscopy* (ed. Gonser, V.), Springer-Verlag, Berlin, 1975, pp. 167–199.
4. Tripathi, R. P., Unpublished Ph D thesis, Rajasthan University, Jaipur, 1978, p. 285.
5. Burnham, C. W., Ohashi, Y., Hafner, S. S. and Virgo, D., *Am. Mineral.*, 1971, **56**, 850–876.
6. Burnham, C. W., Clark, J. R., Papike, J. J. and Prewitt, C. T., *Z. Kristall.*, 1967, **125**, 109–119.
7. Bancroft, G. M., Burns, R. G. and Maddock, A. G., *Geochim. Cosmochim. Acta*, 1967, **31**, 2219–2246.
8. Yashito, M., Yonezo, M. and Yasuhiko, S., *Geochem. J.*, 1970, **4**, 15–26.
9. Bancroft, G. M., Burns, R. G. and Howie, R. A., *Nature*, 1967, **213**, 1221–1223.
10. Evans, B. J., Ghose, S. and Hafner, S., *J. Geol.*, 1967, **75**, 306–322.
11. Williams, P. G. L., Bancroft, G. M., Bown, M. G. and Turnock, A. G., *Nat. Phys. Sci.*, 1971, **230**, 149–151.
12. Shenoy, G. K., Kalvius, G. M. and Hafner, S. S., *J. Appl. Phys.*, 1969, **40**, 1314–1316.
13. Burns, R. G., *Mineralogical Application of Crystal Field Theory*, Cambridge University Press, 1970.
14. Bancroft, G. M., Burns, R. G. and Maddock, A. G., *Am. Mineral.*, 1967, **52**, 1009–1026.
15. Greaves, C., Burns, R. G. and Bancroft, G. M., *Nat. Phys. Sci.*, 1971, **229**, 60–71.
16. Saxena, S. K., *Thermodynamics of Rock Forming Crystalline Solutions*, Springer-Verlag, Berlin, 1973.

Received 29 August 1996; revised accepted 21 December 1996

Altruistic behaviour in *Dictyostelium discoideum* explained on the basis of individual selection

Daniella Atzmony*, Amotz Zahavi* and Vidyanand Nanjundiah**

*Institute for Nature Conservation Research, Tel-Aviv University, Tel-Aviv 69978, Israel.
**Center for Ecological Sciences and Developmental Biology and Genetics Laboratory, Indian Institute of Science, Bangalore 560 012, India

It is often argued that natural selection acting at the level of the individual may not be sufficient to explain the evolution of altruism. We suggest that before accepting such a point of view in any specific instance, the parsimonious course would be to examine all possible ways in which individual-level selection might act and rule out its sufficiency only when the postulated means for its action are either inherently improbable or experimentally disproven. As an illustration we propose an evolutionary model, based on the individual cell as the unit of selection, for the maintenance of 'altruistic' behaviour by pre-stalk cells in the social amoeba *Dictyostelium discoideum*.

EVOLUTION by natural selection proceeds via the accumulation of successive adaptations that serve to increase the reproductive fitness of an individual measured over its lifetime. Obviously, traits that appear to be detrimental to the fitness of an individual but advantageous to another individual – or to a group – are difficult to reconcile with this view of natural selection. It has been proposed that in order to explain the existence of such traits, one may need to invoke the action of selection at the group, meaning supra-individual, level. Group selection can work in two ways. It may operate directly, between groups[1], or indirectly, within groups – thereby superficially resembling individual selection –, when the groups contain individuals with a significant degree of