PRAMANA
— journal of
physics

Vol. 60, No. 1
January 2003
pp. 47–52

Spectroscopic investigation of the Dergaon meteorite with reference to 10 μm and 20 μm bands

A GOHAIN BARUA[1,*], B R BORUAH[1], S BHATTACHARYYA[2] and G D BARUAH[2]
[1]Department of Physics, Gauhati University, Guwahati 781 014, India
[2]Department of Physics, Dibrugarh University, Dibrugarh 786 004, India
[*]Email: agohainbarua@yahoo.com

MS received 6 April 2002; revised 16 August 2002

Abstract. Analysis of a part of the meteorite which fell at Dergaon (India) on March 2, 16.40 local time (2001) is presented with the help of FTIR, absorption and atomic spectra. The FTIR spectrum exhibits prominent absorption bands in the region 800–1100 cm^{-1}, originating from the valence vibration of SiO_4, a basic component of the silicate lattice.

Keywords. Dergaon meteorite; olivine; interstellar dust.

PACS Nos 96.50.Mt; 33.20.Ea; 32.30.Jc

1. Introduction

In terms of physical and chemical compositions, meteorites fall into three broad classes [1]. These are: irons, stones and stony-irons. The irons are about 90% iron and 9% nickel with a trace of other elements. The stones are composed of light silicate materials, and when examined under a microscope many stones are seen to contain silicate spheres of a few millimeter size. These are known as chondrules embedded in a smooth matrix. These stones are known as chondrites. Chondrites contain small round masses of olivine or pyroxine. Stony-iron meteorites represent a hybrid between iron and the stones, and commonly exhibit small stone pieces set in iron. There is one peculiar type of chondrite known as carbonaceous chondrite. Chondrites in these meteorites are embedded in materials that contain a considerable amount of carbon compound compared to other stony chondrites. Meteors are natural physical agents leading to stratospheric ozone perturbations. High velocity meteoric debris heats the upper atmosphere by friction generating NO_x. Rare large meteors, such as Tunguska (Russia, 1908), may cause ~10% of O_3 depletions; smaller, more common, meteorites have little effect on O_3.

The Dergaon meteorite (Dergaon, Assam, India, 26°41′ N, 93°52′ E), which reportedly [2] fell at Dergaon on March 2, 16.40 local time (2001), belongs to the third category of meteorites, that is, a hybrid between iron and stony meteorites. The aim of the present investigation is to analyze the FTIR spectra of the sample with reference to the 10 μm and

20 μm bands. It is worthwhile to note that the wide absorption bands at these middle infrared wavelengths detected in interstellar space are thought to be the valence vibrations or deformation vibrations of the SiO_4 tetrahedrons in silicates, occurring probably as components of the interstellar dust [3–5]. It is also worthwhile to examine the visible absorption spectrum of the meteorite sample. Several diffused absorption bands have been observed at various regions in the visible sector of the spectrum. Wilson [6] has listed the bands at 4430 Å, 4760 Å, 4890 Å and 6180 Å. These bands are not yet precisely identified, but they are believed to be of silicate origin. Many scientists are inclined to believe that these diffuse bands and lines are derived from absorbers which are in the interstellar dust particles. A number of authors have suggested that at least the wide bands are derived from transition metal ions, incorporated in lattices of interstellar silicate particles [3].

2. Experimental

The sample of the meteorite used for experiments is shown in figure 1. Using the conventional method, the density is estimated to be around 4. One part of the sample is crushed into fine powder, and the iron part is removed with the help of a magnet. The remaining part, consisting of stones, is used for obtaining atomic spectra under arc excitation, absorption spectrum and FTIR spectrum. The atomic spectra of the sample are obtained for different electrodes of carbon and copper with iron being used as the standard. The excitation condition for the arc is 220 V dc with 3 A current. The spectra are recorded on a Medium Quartz Spectrograph and also on a Large Quartz Spectrograph. It is observed that during the process of excitation, the powdered sample kept inside the cavity of the electrode melts down and assumes a spherical shape similar to a liquid drop. The liquid drop solidifies after some minutes and it can be separated from the cavity. The absorption spectrum of the powdered sample is recorded on a Glass Spectrograph. The source of the continuum radiation used for the purpose is a 1000 W halogen lamp. The finely powdered sample is kept between two firmly held glass plates. The optical path is about 0.5 mm. By mounting the sample plates in front of the slit, one can clearly observe the extinction of the blue and green sector of the spectrum with substantial reduction of intensity of the red sector. The FTIR spectrum is recorded in the middle infrared region by a sophisticated computer-controlled FTIR 2000 Perkin Elmer with helium–neon laser as the reference. KBr pellet is used as the sample.

Figure 1. A piece of the Dergaon meteorite.

3. Results and discussion

The atomic spectra of the powdered sample have revealed the presence of iron, magnesium, calcium and silicon. The presence of iron is easily understood, as the sample is attracted by a magnet. One of the characteristic features of the sample is the formation of a tiny spherical object after the sample melts, when placed in the arc cavity, at the arc temperature of the order of $\sim$4000 K. Using the same standard method, the density of the newly formed object is estimated to be slightly higher than the original one ($\sim$4). The present laboratory experiment with an arc is expected to throw some light on the general problem of meteor entry. Current science and technology is involved in designing vehicles to enter planetary atmosphere at velocities comparable to those of the meteors.

The absorption spectrum of the powdered sample in the visible region indicates weak broad absorption band at 6150 Å. The blue sector of the spectrum is completely absorbed. The weak absorption band at 6150 Å is due to silicate.

The FTIR spectrum, as shown in figure 2, reveals a large number of absorption bands. The group of bands in the region 400–700 cm^{-1} and in the region 800–1150 cm^{-1} are designated as 20 μm and 10 μm bands, respectively. Table 1 gives a comparison of these bands with olivine and figure 3 [7] shows the spectra of the 20 μm and 10 μm bands in all the silicates including olivine. The strong bands in the range 800–1150 cm^{-1} are due to Si–O stretching, while the equally strong bands in the region 400–700 cm^{-1} are identified as Si–O–Si bending vibrations. It may be noted that in the Si–O stretching region, there are three strong absorption bands at 885, 974 and 1061 cm^{-1} with decreasing intensities. These

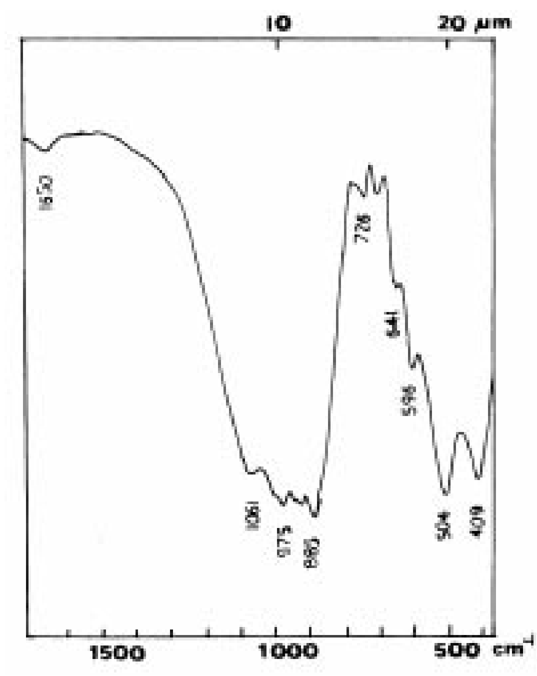

Figure 2. FTIR spectrum of the Dergaon meteorite, showing the 10 μm and 20 μm bands.

Table 1. FTIR spectra of the meteorite and a comparison with the 10 μm (1000 cm^{-1}) and 20 μm (500 cm^{-1}) bands of olivine (s = strong, ms = medium strong, w = weak, sh = shoulder).

	Meteorite sample		Olivine		
Band position (μm)	Wave number (cm^{-1})	Intensity	Wave number (cm^{-1})	Intensity	Assignment
	409	(s)	450	(s)	Si–O–Si bending
	504	(s)	534	(s)	
20	537	(sh)			
	596	(ms)			
	641	(ms)	630	(ms)	
	685	(w)			
	842	(sh)			
	885	(s)	850	(s)	
	925	(ms)	910	(s)	Si–O stretching
10	974	(ms)			
	1061	(ms)	1030	(w)	
	1123	(sh)	1100	(w)	
	1650	(w)			

bands are identical to the bands at 850, 910 and 1030 cm^{-1} due to olivine. For the reference purpose, the 10 μm and 20 μm band systems for 12 known silicates are shown in figure 3, and it is seen that the characteristic frequencies slightly differ but the relative intensities vary from one silicate to another. Thus, it is the relative intensity pattern which helps us to identify the particular silicate component in the meteorite sample. The 20 μm band systems, comprising the bands at 409, 504, 596 and 641 cm^{-1}, are also identical to the bands at 450, 534 and 630 cm^{-1} due to olivine. The presence of a moderately strong band at 1650 cm^{-1} is attributed to the H–O–H bending vibration.

4. Conclusion

The present investigation of the meteorite sample reveals a few characteristic features which may be of some importance in context with interstellar dust presumably consisting of silicate particles. It should be noted that the 20 μm and 10 μm bands have already been observed in interstellar space. Similarly, the visible absorption bands at 4430, 4760, 4890 and 6180 Å are yet to be fully identified. The band at 6150 Å would seem to characterize silicate.

Acknowledgments

Samples for this investigation have been provided by K Duorah (Department of Physics, Gauhati University, Guwahati, India), principal investigator of the ISRO-sponsored project

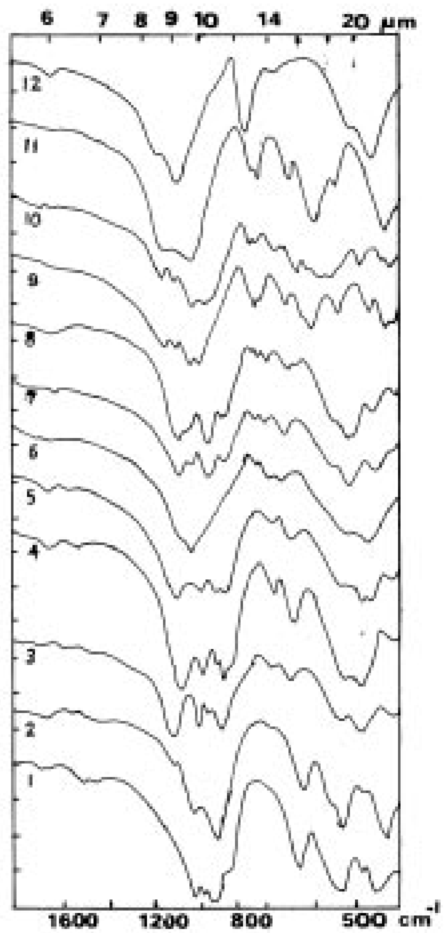

Figure 3. IR spectra of different silicates, according to ref. [7]; 1 = forsterite, 2 = olivine, 3 = diopside, 4 = hedenbergite, 5 = augite, 6 = enstatite, 7 = bronzite, 8 = hypersthene, 9 = albite, 10 = anorthite, 11 = orthoclase, 12 = quartz.

'Studies on Dergaon Meteorites'. IR spectra of different silicates (ref. [7]) have been provided by A N Neog (Regional Research Laboratory, Jorhat, India). Both are thankfully acknowledged.

References

[1] Zeilik Michael, *Astronomy of the evolving universe* (Wiley, 1988) p. 236
[2] Meteoritical Bulletin, No. 85, A295 (2001)
[3] R F Knacke, J E Gaustad, F C Gillett and W A Stain, *Astrophys. J.* **155**, L189 (1969)
[4] J A Hackwell, R D Gehrz and N J Wolf, *Nature* **227**, 822 (1970)

[5] J Dorchner, *Astra. Nachr.* **292**, 107 (1970) (in German)
[6] R Wilson, *Astrophys. J.* **128**, 57 (1958)
[7] A N Neog, *Investigation of some silicate minerals with special emphasis on 10 μm–20 μm band*, Ph.D. thesis, Dibrugarh University (1997) p. 299