A Mössbauer Spectroscopic study of Ordinary Chondrites

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Mössbauer spectroscopic studies of Ordinary chondrite shows that the main iron minerals in chondrites are Fe-Ni (Kamacite/Taenite), Troilite, Olivine and Pyroxene. Presence of these minerals can be characterized as a signatures of ordinary chondrites. Mössbauer absorption areas corresponding to different phases favour its classification as H ordinary chondrites.

Keywords: Mössbauer Spectroscopy, Ordinary Chondrites.

1. INTRODUCTION

Iron bearing minerals & phases from important constituents of a meteorite provide important clues and their origin or geothermal history [1]. Initial studies of meteorites revealed that relative distribution of iron bearing minerals show a characteristic pattern for a particular class of meteorite.

Ordinary chondrites (OC) are the most common type of meteorites. OC contains appreciable amount of iron in both metallic and silicate form. The metallic iron is present in the form of opaque minerals like Kamacite, Troilite, etc. and the silicates minerals like Olivine and Pyroxene. On the basis of distribution of different amount of metals and different amount of total iron. OC are further divided into three classes i.e. H, L, LL [2].

Identification and quantitative measurements of minerals are normally made using techniques such as Optical analysis, Inductively Coupled Plasma Mass spectroscopy [ICP-MS], Thermal Ionization Mass Spectrometry [TIMS], Secondary Ion Mass Spectrometry [SIMS], X-ray Diffraction [XRD], Electron Probe Micro Analyzer [EPMA], Instrumental Neutron Activation Analysis [INAA], Radio Chemical Neutron Activation Analysis [RNAA], Thermo luminescence and Mass Spectroscopic studies. Since the Mössbauer method has some unique advantage not found in other methods because no pre concentration or chemical treatment steps are necessary and 14.4 KeV γ-rays of ^{57}Fe will be transparent. This method is uniquely sensitive to small amount of iron in large amount of matrix materials as such as meteorites samples. Mössbauer Spectroscopy is highly useful technique to study iron bearing phases in various earth and planetary minerals. Meteorites are very complicated multiphases system where mechanical separation into individual minerals is generally not possible therefore a high quality analysis of iron bearing minerals in meteorites can be done using Mössbauer Spectroscopy. In this study we consider the result of some iron bearing minerals in meteorite sample using Mössbauer Spectroscopy [3].

These iron minerals can be easily characterized by ^{57}Fe Mössbauer Spectroscopy [4-6]. Many workers have this technique to characterize various iron bearing minerals in variety of meteorites including OC.

2. EXPERIMENTAL

The fragments were ground to fine powder and about 70mg was sandwiched between two transparent tapes to make one Mössbauer spectrum. The Mössbauer spectra of these powdered samples were recorded at 300^0K using a conventional constant acceleration Mössbauer spectrometer with ^{57}Co in Rh matrix as the gamma ray source.

Spectra were computer fitted using a least square routine and assuming each spectrum to be a Lorentzian functions. During the curve fitting the width and the intensity of the two halves of a quadrupole doublet were constrained to be equal. In the case of a sextant line widths of the outer, middle and inner pairs were constrained to be in the ratio 1.2:1.1:1.0. This ratio was chosen on the basis of pure iron spectra. The quality of the fit was judged from the value of χ^2 which was close to 1.0 per degree of freedom. The Isomer Shift (IS) were reported with respect to α-iron. The reported value of IS and quadrupole splitting (QS) have an accuracy of about 0.2 mms^{-1}, whereas the hyperfine magnetic field has an accuracy of about 0.2T. The absorption areas have an accuracy of about 5%.

2.1. Brief Description of the Meteorite under Study

On 21 February 2007 people in the bordering areas of lohit district of Arunachal Pradesh and Tinsukia District of Assam saw a large fireball in the northern sky at around 9:20 am. Within few seconds the fireball broke apart into several pieces with a Hugh airburst. The shattered fragments of the fireball fell on the earth surface in several places in that area. The meteorite fragments were reported from Mahadevpur, Gossain Gaon, Kothlaguri, podumoni, Mhaloni, Kopatani, Na Kathalguri and Pengeri of Arunachal Pradesh and Assam. Most of the fragments range from 2 to 5 kg in weight. People who collected the fragments broke them into smaller pieces and distributed among fellow villagers. The present fragment from which about 10 gm rock sample obtained by Mazumdar *et al.* was originally weighed around 2.5 kg fell over a residence belonged to Hasin Mech, pierced the roof of the house and got enmeshed in a blanket which was kept in a bag over a bed. This fragment was light grey in colour and porous. The fusion crust is apparent and of millimeter in thickness. Chondrules are noticeable with naked eye. Most chondrules are sub millimeter in size; few chondrules are seen to be larger than one millimeter. They named these chondrites as Mahadevpur chondrites. We obtained the small piece of this fragment of meteorite from professor Goswami for Mössbauer spectroscopic study.

3. RESULT AND DISCUSSION

The Mössbauer spectrum of Olivine generally consist of single quadrupole doublet with IS value centred around 1.13 mms^{-1} and QS value centred around 3.05 mms^{-1} as it is difficult to resolve two octahedral sites M1 and M2 in Mössbauer spectra of olivine due to almost similar parameters [7].

Troilite is a magnetically ordered mineral and shows a six line component in the Mössbauer spectrum, with magnetic hyperfine field of about 316 kOe. The magnetic hyperfine field for kamacite varies slightly with the Ni content but remains close to the pure iron value 330 kOe. For taenite the magnetic hyperfine field is around 311 kOe. The Mössbauer spectrum of Mahadevpur meteorite at room temperature is shown in Figure 1.

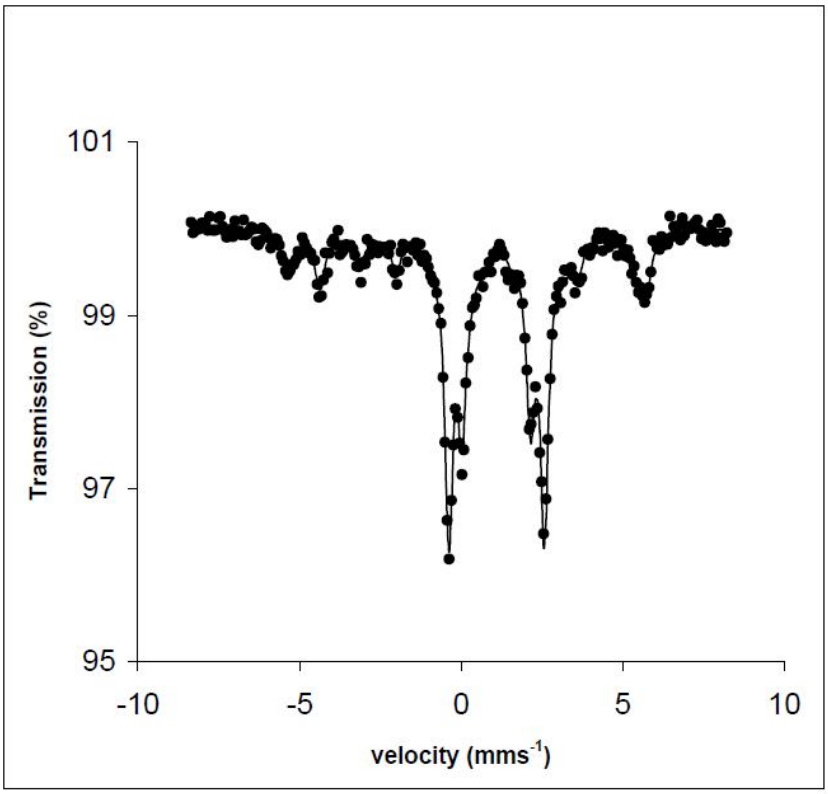

Fig. 1: Mössbauer spectrum of Mahadevpur meteorite at room temperature.

The Mössbauer parameters are shown in Table 1. From spectrum and Table 1 we can seen that Mahadevpur meteorite exhibit presence of characteristic minerals like olivine, pyroxene, troilite and kamacite as excepted for Ordinary Chondrites.

Table 1: Mössbauer parameters of Mahadevpur meteorite.

Meteorites	Spectrum	IS (mms^{-1})	QS (mms^{-1})	MHF (kOe)	Area (%)	Assigned Minerals
Mahadevpur	Doublet 1	1.11	2.95	-	37.24	Olivine
	Doublet 2	1.096	2.12	-	25.18	Pyroxene
	Sextet 1	0.81	-0.12	313	17.94	Troilite
	Sextet 2	-0.02	0.21	333	19.6	Kamacite

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