Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 4, Issue, 11, pp.275-277, November, 2012

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

SULAGIRI METEORITE: MINERALOGY, COSMOCHEMISTRY AND SPECTRAL ANALYSIS

[1]Aarthy, R. S., [1]Sanjeevi, S. and [2]Vijayan, S.

[1]Department of Geology, Anna University Chennai 600 025, Tamil Nadu, India
[2]Department of Information Technology Anna University Chennai 600 025, Tamil Nadu, India

ARTICLE INFO

Article History:
Received 10th August, 2012
Received in revised form
23thSeptember, 2012
Accepted 19th October, 2012
Published online 23h November, 2012

Key words:
Meteorite, thin section,
Cosmochemistry,
Reflectance.

ABSTRACT

Our current knowledge on planetary bodies largely depends on remote sensing and rarely by samples investigation. Meteorite fall (fresh sample) is rare to observe. Sulagiri is one such phenomenon that occurred in India recently. In this study an attempt has been made to understand mineralogy, chemical composition and reflectance spectra of Sulagiri meteorite.

INTRODUCTION

Meteor science is a valuable tool for gaining a better insight into the interplanetary material that reaches us (Rodriguez et al., 2004). In the search for parent bodies for meteorites, asteroids have always seemed the logical solution. In particular, the S asteroid population has long been the center of the search for a connection with the ordinary chondrites due to their relative abundance to the asteroid population and the seemingly similar composition.In this study an attempt has been made to understand the spectra character of an ordinary chondrite meteorite also its mineral and chemical composition.

METHODOLOGY

Meteoritic samples were collected from impact site, thin section studies was carried out followed by cosmochemistric analysis. Spectra were obtained using spectroradiometer.

Study site

On 12th September 2008 around 8:30 hrs (Local time) the Sulagiri meteorite fell (12º40′00″N 78º02′00″E) in the Krishnagiri district of Tamil Nadu, India (Weisberg 2009). The location of the meteorite fall located ~200 km from Chennai. According to Geological Survey of India (GSI) seven pieces of the meteorite were collected, totaling ~110 kg, making Sulagiri, the largest meteorite fall so far in India. The fragments fell in several locations like Addagurikki, Rauthapalli, Gangapuram and A.Kottur Villages of Hosur Taluk in Krishnagiri District (Fig.1a-d).

***Corresponding author:** rsaarthy_19@yahoo.co.in

Meteorites were recovered by the Revenue authorities of Krishnagiri District and handed over to the authorities concerned at the Geological Survey of India, Chennai, for further research and analysis. However, very few samples were recovered by the villagers were used for this study.

Petrology

To identify the samples, petrography was studied in detail. These include megascopic, microscopic and geochemical analysis.

Spectroradiometery

Refers to the process to collect the reflectance spectra of any material (rocks, minerals etc), and this can be done in a laboratory or in the field. Often, a spectroradiometer is used for this purpose. This device measures the energy coming from an object as the function of wavelength. It is used primarily for the preparation of spectral reflectance curves for various objects including minerals and rocks.

Spectroradiometer

A handheld spectroradiometer was used in this study and it has the following specifications (Table 1). Spectroscopic data, have all wavelengths of interest obtained simultaneously.

RESULTS

Mineralogy

Meteoritic samples collected from the impact site weigh 5g. Macroscopically (Fig. 2a and b) the exterior has light grey

Fig.1. Field photographs of the impact sites (a) Attakurkki crater (b) Gangapuram crater (c) A. Kottur(d) Rathupalli

Table 1 Specifications of the spectroradiometer (Source: ASD 2005)

Parameters	Specifications
Spectral range	350-2500nm
Spectral Resolution	3 nm @ 700 nm; 8.5nm@1400nm; 6.5 nm @ 2100 nm
Sampling Interval	1.4 nm @ 350-1050 nm :2 nm @ 1000-2500 nm
Scanning Time	100 milliseconds
Detectors	One 512 element Si photodiode array 350-1000nm.TE cooled, graded index InGaAs photodiodes1000-2500 nm
Input	1.5 m fiber optic (25º field of view) Optional fore optics
Noise Equivalent Radiance (NEdL)	1.1 x 10^{-9} W/cm^2/nm/sr @700 nm. 2.2 x 10^{-9} W/cm^2/nm/sr @ 1400 nm. 4.0 x 10^{-9} W/cm^2/nm/sr @ 2100 nm
Weight	5.2 kg
Bands	979

coloured on broken surface, with black patch or burned surface that occurred when the meteorite entered the earth's atmosphere. This part of the sample helps the meteoritic origin. The grain size varies from 1cm to 1.5 cm, pyroxenes are pale coloured, olivines are brown coloured and few plagioclase feldspars can be readily recognized. The sample appears fresh as it was recovered immediately after the fall (hence no weathering).

The thin section (Fig. 2c) was prepared with the available facility (not in vacuum chamber) shows that the meteorite has dark matrix as ground mass with phenocrysts of mostly orthopyroxene and olivine. Clinopyroxenes are rare. Troilites (FeS) are more frequent than iron metal present in moderate amount. Feldspar grains are few and are clouded. Chondrules are poorly developed can be identified from the thin section. The chondrules are homogenized with coarse to moderately recrystallized matrix indicating high equilibrated petrographic type, based on the mineralogy and chemical composition the Sulagiri meteorite is classified to LL class and the metamorphic grade 6 with shock stage is S2 (similar to Murty 2009).

Cosmochemistry

To determine the chemical composition of minerals in the rock qualitatively or quantitatively the X-ray Fluorescence (XRF) instrument technique was used. Iron and magnesium are two of the most useful major elements to determine both meteorite groupings and geologic processes. Their concentrations within mafic silicates vary systematically throughout the solid solution series (fayalite to forsterite, enstatite to ferrosilite). Magnesium is partitioned solely into mafic silicates in most meteorites, while iron occupies a variety of valence states and occurs in mafic silicates, metal and sulfides. Urey and Craig (1953) first used the concentration of total iron to delineate chondrite groups. In this study meteorite cosmochemical analysis were carried out at NGRI and Table 2 provides the chemical data (Table 2), of the Sulagiri meteorite. The SiO_2 =36.74%, Fe = 20.11%, Mg = 15.59%, and low CaO= 2.55%, Al_2O_3 (0.80%). In order to understand the classification of the Sulagiri meteorite, a plot was made on classification diagram published in Nittler et al (2004), where the authors define the Chondritic meteorites exhibit a range of iron (~ 18-24 wt%) and magnesium (~ 8-16 wt%) concentrations. Ordinary chondrites exhibit a trend of decreasing magnesium with increasing iron in the order LL LH, although some scatter exists within these groups.

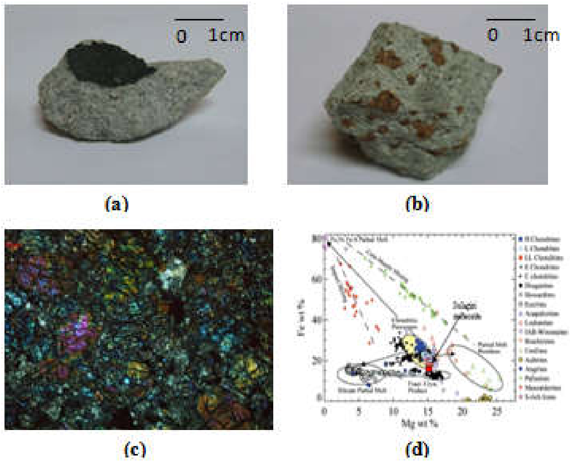

Figure 2(a,b) Photos of Sulagiri meteorite (c) thin section photo (d) Classification using Nittler et al 2004.

Table 2 Major oxides concentration (wt.%) of Sulagiri meteorite

Major oxides	wt (%)
SiO_2	36.74
Al_2O_3	0.8
Fe_2O_3	33.39
MgO	22.28
CaO	2.55
MnO	0.37
Na_2O	1.28
K_2O	0.12
TiO_2	0.16
P_2O_5	0.36

It may be observed from the Table 2 and from the Fig. 2d that the Sulagiri meteorite contains high iron (20%) than magnesium (15%) , falls in the LL meteorite category.

SPECTRAL ANAYSIS

Meteorite spectra

Spectrally, ordinary chondrites have features due to olivine and pyroxene. Even though ordinary chondrites contain significant amounts of metallic Fe, their spectra are not appreciably reddened (reflectances tending to increase with increasing wavelength) as found in other metallic Fe-rich meteorites (Burines et al 2000).

From the spectral curve (Fig 3) it may be observed that absorption for the Sulagiri meteorite occurs at olivine has three absorption bands that make up its feature centered near 1 µm. Pyroxenes tend to have features centered near 0.9–1.0 (Band I) and 1.9–2.0 µm (Band II), although some high-Ca pyroxenes (Adams 1975,Cloutis and Gaffey 1991) do lack a distinctive ~ 2 µm feature (Band II). The ~ 1 and ~ 2 µm features in pyroxenes tend to move to longer wavelengths with increasing Fe and/or Ca-contents. Besides composition, the shapes and depths of absorption bands are functions of other parameters such as particle size and temperature (Singer and Roush 1985; Hinrichs et al 1999). These features in olivine and pyroxene are from electronic transitions due to Fe^{2+}. Reflectance spectra of ordinary chondrites are known to show a 1000nm absorption band which is characteristic of 3d-electron transitions of Fe^{2+} ions in pyroxene and olivine (Fig. 3). Because ordinary chondrite types have each different modal an abundance of pyroxene and olivine, this 1000nm band feature can be used to distinguish them. The composition of Sulagiri meteorite is pyroxene ($Ca(Mg,Fe)Si_2O_6$), absorption 0.9-1.0 &1.8 – 2.2 µm,Olivine ($Mg (Fe)SiO_4$ absorption1.1µm, plagioclase ($CaAl_2Si_2O_8$) absorption 1.2µm, Troilites (FeS), Iron metal (Fe) : 800nm or 900nm.

CONCLUSION

The Sulagiri meteorite show the typical LL6 ordinary chondrite meterorite mineral and chemical composition. The spectra shows the sloping from 800nm while absorptions at 950 nm and 1900nm indicating sub-equal amounts of low-calcium pyroxene with olivine (as stated in Britt and Pieters 1988). There are absorption features in both the 1000nm and 2000nm regions suggest the presence of pyroxenes in all, the type 6 (LL6) chondrites show no indication of CPX. Other minerals such as plagioclase and olivine have absorption features in the 1000 nm region in the same range as the clinorhombicpyroxenes that are responsible for these numbers. This implies that using the laboratory spectral curve will be helpful in identification of meteorite type.

Acknowledgment

Authors thank NGRI for chemical analysis, and also DOS-PLANEX for funding.

REFERENCES

Adams, J.B. 1974. Visible and near-infrared diffuse reflectance spectra of pyroxenes as applied to remote sensing of solid objects in the solar system. JGR. Vol. 79, No.32.

Analytical Spectral Device, 2005. Manual. Colorado, USA.

Britt, D.T. and Pieters, C.M. 1988. Bull.Am.Ast.Soc.,Vol. 20, No. 863.

Burbine, T. H., McCoy, T. J., Meibom, A., Gladman, B. and Keil, K. 2000. Meteoritic parent bodies: Their number and identification. In Asteroids III, pp. 653-667.

Cloutis, E.A. and Gaffey, M. J. 1990. Pyroxene spectroscopy revisited: spectral- compositional correlations and relationships to geothermometry. J. Geophys. Res., pp. 22809–22826.

Hinrichs, J. L., Lucey, P. G., Robinson, M. S., Meibom, A. and Krot, A. N. 1999. Implications of temperature-dependent near-IR spectral properties of common minerals and meteorites for remote sensing of asteroids. Geophys. Res. Lett., Vol. 26, pp. 1661–1664.

Murty, S.V.S., Chattopadhyay, B., Goel, S., Mahajan, R.R., Shukla, P.N., Durga Prasad, K., Shukla, A.D., Krishnan, V., Nagarajan, K., Ghosh, J.B., Mondal, P.K. and Goswami, J.N. 2009. Sulagiri, the largest meteorite fall in India. 72nd Annual Meteoritical Society Meeting, No. 5060.

Nittler, L.R., McCoy, T J., Clark, P E., Murphy, M E., Trombka, J I. and Jarosewich, E. 2004. Bulk element compositions of meteorites: a guide for interpreting remote-sensing geochemical measurements of planets and asteroids. Antarct. Meteorite Res., Vol. 17, pp. 233-253.

Rodriguez, J. M. T., Llorca, J., and Fabregat, J.2004. Chemical abundances determined from meteor spectra II. Evidence for enlarged sodium abundances in meteoroids. Mon. Not. R. Astron. Soc. 348, pp. 802-810.

Singer, R. B. 1981. Near-infrared spectral reflectance of mineral mixtures: Systematic combinations of pyroxenes, olivine, and iron oxides. J. Geophys. Res., Vol. 86, pp. 7967-7982.

Urey, H. C. and Craig, H. 1953. The composition of the stone meteorites and the origin of the meteorites. Geochim. Cosmochim. Acta 4, pp. 36–82.

****