COSMOCHEMISTRY AND SPECTRAL ANALYSIS – SULAGIRI METEORITE – **Aarthy R S[1] Sanjeevi S[1]**
1Department of Geology 2Department of Information Technology Anna University Chennai 600 025,
Tamil Nadu, India. 1rsaarthy_19@yahoo.co.in

Introduction : Meteorite fall (fresh sample) is rare to observe. Sulagiri is one such phenomenon that occurred in India in the year 2008. In this study an attempt has been made to understand mineralogy, chemical composition and reflectance spectra of Sulagiri meteorite. Meteor science is a valuable tool for gaining a better insight into the interplanetary material that reaches us [1]. 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.

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 [2]. 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).

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

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

Results : Mineralogy : Meteoritic samples collected from the impact site weigh 5g. Macroscopically (Fig. 2a and b) the exterior has light grey 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 3].

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. [4] first used the concentration of total iron to delineate chondrite groups. In this study meteorite cosmochemical analysis were carried out at NGRI and Table 1 provides the chemical data, 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 [5], 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.

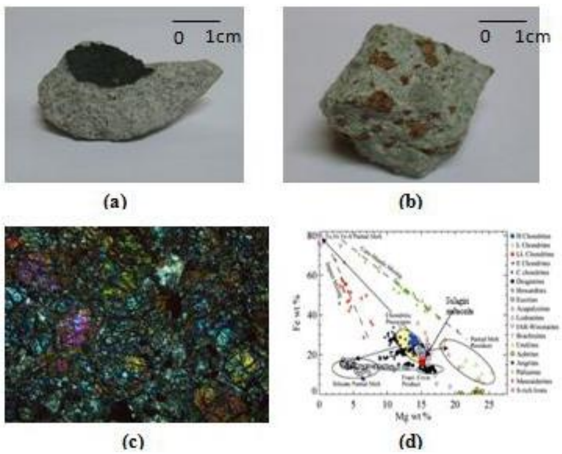


Figure 2(a,b) Photos of Sulagiri meteorite (c) thin section photo (d) Classification using Nittler et al 2004.

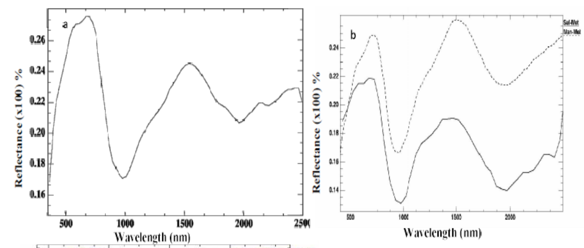
Table 1 Major oxides concentration (wt.%) of Sulagiri meteorite

It may be observed from the Table 1 and from the

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

Fig. 2d that the Sulagiri meteorite contains high iron (20%) than magnesium (15%) , falls in the LL meteorite category.

Spectral anaysis: 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 [6]. 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 [7,8] do lack a distinctive ~ 2 µm feature (Band II). The ~ 1 and ~ 2 µm features in pyroxenestend 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 [9,10]. These features in olivine and pyroxene are from electronic transitions due to Fe2+. Reflectance spectra of ordinary chondrites are known to show a 1000nm absorption band which is characteristic of 3d-electron transitions of Fe2+ 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)Si2O6), absorption 0.9-1.0 &1.8 – 2.2 µm, Olivine (Mg (Fe)SiO4 absorption1.1µm, plagioclase (CaAl2Si2O8) absorption 1.2µm, Troilites (FeS), Iron metal (Fe) : 800nm or 900nm.



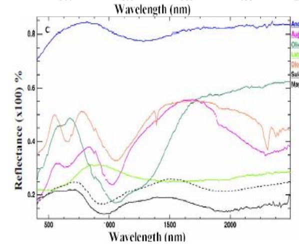


Fig.3 Spectra of meteorites
(a) Sulagiri
(b) Manbhoom
(c) mineral

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 11]. 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.

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