

RAMAN SPECTROSCOPY OF KAMARGAON L6 ORDINARY CHONDRITE. Bhaskar J. Saikias¹, G. Parthasarathy² and Rashmi R. Borah³, ¹Department of Physics, A.D.P. College, India, ²National Geophysical Research Institute (CSIR-NGRI), Hyderabad, India, ³Department of Physics, Nowgong College, India. (e-mail:vaskaradp@gmail.com).

Introduction: Chondritic meteorites are the oldest and most primitive rocks in the solar system. Chondrites are stony meteorites that have not been modified due to melting or differentiation of the parent body. Chondrites are broadly ultramafic in composition, consisting largely of iron, magnesium silicon and oxygen. The ordinary chondrites are divided into three groups, viz. H-type which have high total Fe-contents, L-type having low total Fe-contents, and LL-type having very low metallic Fe relative to the total Fe, as well as low total Fe-contents [1]. The chemical distinction among the H, L, LL-group chondrites depends on the distribution of iron between metal and silicates. It has been established that there is no or very little compositional overlap among these H, L, and LL chondrites. The distinction between different chondrites is usually made on the basis of changes in ferrous, metallic, and total iron contents as well as in Fe/Ni ratios in the metal. In this paper we report spectroscopy, composition and mineralogy of Kamargaon meteorite.

A single stone fell from clear sky at the mustard oil cultivation field of the Bali-chapari village (26° 37' 56.99" N; 93° 46' 11.51" E), near Kamargaon town in Golaghat District of Assam, India, on 13th November 2015 at 12:00 hrs (Local time) with fireball and a tremendous sound [2]. A single piece of meteorite of weight 12.095 kg is recovered and preserved under the custodian of the local police station. The fusion crust (about 1mm of thickness) and the regmaglyphs are clearly visible on the surface of the meteorite. Though this meteorite fall has been described in a short note [2], to the best of our knowledge there are no previous detailed studies on Raman and infrared spectroscopic studies have been carried out. Raman spectroscopic technique is a very powerful in indentifying micro grains of shocked minerals in meteorite, which would be of great help in estimating shock pressure experienced by the meteorite.

Experimental: Raman spectra were collected on powdered bulk meteorite sample using a Ar⁺ excitation source having wavelength 488 nm, used with a power kept at 20μW (to avoid over-heating of the sample), coupled with a Jobin-Yvon Horiba LabRam-HR Micro Raman spectrometer equipped with an Olympus microscope with 50X objectives and a motorized x-y stage and using 1800 grooves/mm grating

and the spectral resolution is around 0.1 cm⁻¹ in the range from 100 to 3000 cm⁻¹. Spectra were generally collected with counting times ranging between 10 and 60 s. Quantitative mineral analyses were obtained using a JEOL JXA 8900 electron microprobe (EMPA) operated at 15 keV and a probe current of 15 nA. Natural and synthetic standards of well-known compositions were used as standards for wavelength dispersive spectrometry

Results and Discussion: The Figure 1 reveals clear Raman lines attribute to olivine in Kamargaon meteorite. The Raman bands in the region 400-800 cm⁻¹ are relatively weak as compare to their infrared counterparts. Raman peaks in the range 700-1100cm⁻¹ are attributed to the internal stretching vibrational modes of the SiO₄ tetrahedra. In this region, the renowned doublet is arising for the Si-O symmetric stretching bands appear at 813-823 and at 852-852 cm⁻¹, and a medium-wavenumber antisymmetric Si-O stretching band appears at 965-966 cm⁻¹ due to fosterite (F₀). The peaks of the 813-852 cm⁻¹ doublet is assigned to a mixed contribution of the symmetric (ν₁) and asymmetric (ν₃) stretching modes of Si-O_{nb} bonds (Non-Bridge Oxygen, NBO) in SiO₄ tetrahedra[3]. The Raman spectra of the sample indicates the characteristic doublet at 822.06 cm⁻¹ and 851.79 cm⁻¹ which is a result of the coupling between the symmetric (ν₁) and anti symmetric (ν₃) stretching modes of Si-O_{nb} bonds in SiO₄ tetrahedra of olivine [4]. This peak position may shift upwards as the values of F₀ increase [5]. The value F₀ of an olivine can be determined from the compositional results. The F₀ value of the meteorite is correspond to forsteritic olivines, with about 27.20% of Fe. The low wavenumber peak at 572.14 cm⁻¹ occurs due to the bridging oxygen (BO). The medium wavenumber peak at 916.92 cm⁻¹ is indicative of the polymerization. The peak 822.06 cm⁻¹ has a higher contribution of ν₃ (asymmetric mode) than the 851.79 cm⁻¹ peak. The relative peak height is a function of crystal orientation. Therefore, the systematic variations of the high-wavenumber Si-O bands are attributed to decreased distortion of SiO₄ tetrahedra. The full width at half maximum (FWHM) values of the ν₁ olivine band in the Raman spectra of L6 ordinary chondrites have been related to the degree of crystalstructural disorder resulting from shock deformation [6], and spans from 10 cm⁻¹ to 21 cm⁻¹ for

poorly shocked and strongly shocked meteorites respectively.

The observed FWHM value of the olivine Raman line at 822.06 cm^{-1} (ν_1) is $\sim 17\text{ cm}^{-1}$, which is identical to the strongly shock stage. The Raman spectral pattern of end-member chromite (Figure 2b) consists of a major broad peak near 684 cm^{-1} and a shoulder near 650 cm^{-1} . Other minor peaks are seen at 639 , ~ 615 , ~ 518 , ~ 478 and $\sim 432\text{ cm}^{-1}$. The strongest peak at 684 cm^{-1} is assigned to the A_{1g} mode and this feature presumably is generated by the bonds in $(\text{Cr}^{3+}, \text{Fe}^{3+}, \text{Al}^{3+})\text{O}_6$ octahedra. The trivalent ions lead to a more compact structure and a higher degree of covalency than those in Fe^{2+}O_4 tetrahedra [7]. The strong fluorescence at $400\text{--}520\text{ cm}^{-1}$ could hide the intense feldspar Raman bands at around 500 cm^{-1} . On the other hand, FeNi metal has no active modes for Raman spectroscopy and troilite is a weak Raman scatterer [7].

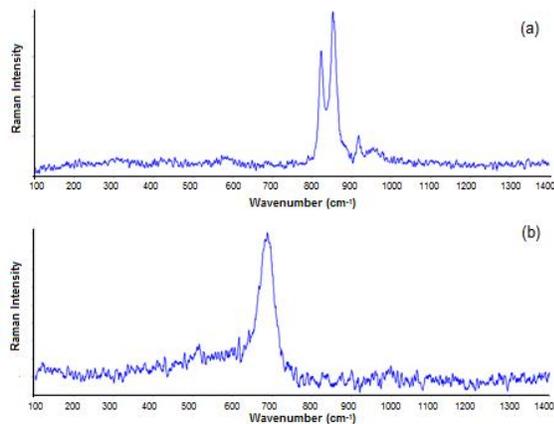


Figure 1. Raman spectra of olivine (a) and chromite (b) recorded in the spectral region 100-1400cm⁻¹ from different points of Kamargaon meteorite.

Table 1. Compositional analyses of olivines.

Oxides (wt%)	Kamargaon	Kaprada
SiO ₂	36.14±2.04	38.12
TiO ₂	0.00	0.00
Al ₂ O ₃	0.008±0.0	0.010
Cr ₂ O ₃	0.02±0.0	0.026
FeO	21.18±0.007	21.83
MnO	0.35±0.07	0.50
MgO	39.33±0.035	39.12
NiO	0.04	0.07
CaO	0.006	0.040
End members		
Fo	75.96	75.74
Fa	23.48	23.71
Tp	0.56	0.55

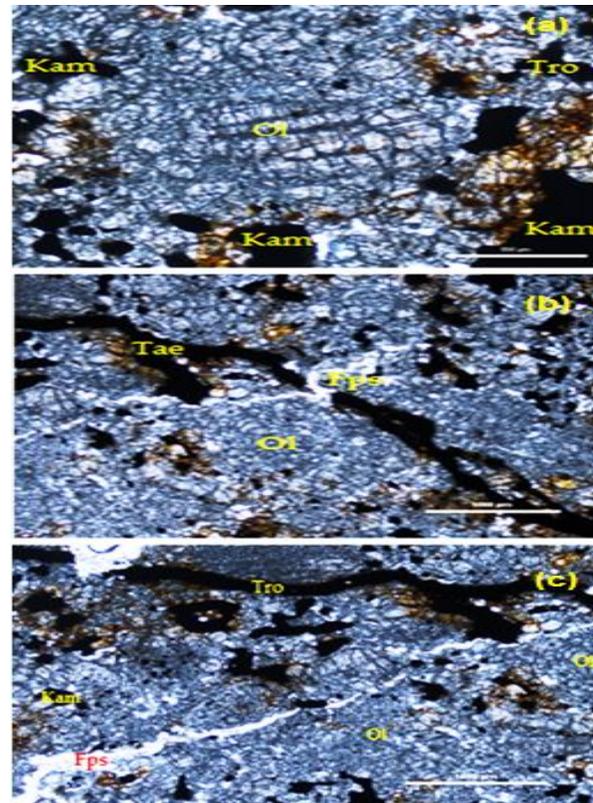


Figure 2. Thin section of Kamargaon meteorite, (a) The olivine (Ol) composition (Fo= 75.96 mol %; Fa=23.48 mol % and Tp= 0.56 mol %) and opaque metallic phases with kamacite (Kam) and sulfide phase troilite (Tro) with Ni less than 0.4 wt %, indicative of L6 type chondrite; (b) Olivine, with feldspar (Fps) secondary grains and opaque taenite (Tae) with Ni content of 22 % confirm that Kamargaon meteorite is L6 type ordinary chondrite; (c) Veins of feldspar and troilite exhibiting shock induced melt vein in the Kamargaon meteorite.

The EPMA data of olivine (Table 1) were compared with that of Kaprada [9]. The olivine concentrations are in excellent agreement with L6 type chondrite. The Raman spectroscopic analysis of the meteorite is consistent with the geochemical compositional analysis.

References: [1] Parthasarathy, G. and Sarmah, S. R. (2004) *Curr. Sci.* 86, 1366-1368 [2] Goswami et al. (2016). *Curr. Sci.* 110, 1894-1895. [3] Lam et al. (1990) *Am. Mineral.* 75, 109-119. [4] Saikia et al. (2016) 47 LPS. Abstract # 1799. [5] Chopelas, A. (1991) *Am. Mineral.* 76, 1101-1109. [6] Miyamoto M. and Ohsumi K. (1995) *Geophys. Res. Lett.* 22, 437-440. [7] Wang et al. (2004) *Am. Mineral.* 89, 665-680.