

**ORGANIC COMPOUNDS IN MAHADEVPUR H4/5 AND NATUN BALIJAN L4 ORDINARY CHONDRITES BY RAMAN SPECTROSCOPY.** Bhaskar J. Saikia<sup>1</sup>, G. Parthasarathy<sup>2</sup> and Rashmi R. Borah<sup>3</sup>,  
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### 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. 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. Chondrites are stony meteorites that have not been modified due to melting or differentiation of the parent body. The primitive meteorites also contain abundant amounts (up to 1500 ppm) of nanodiamonds. The main formation process of the meteoritic nanodiamonds may be either in chemical vapor deposition or in shock origin. These nanocrystalline carbon materials (presolar grains) have to be considered amorphous or glassy carbon, and are either inorganic or consist of hydrogenated aromatic macromolecular organic carbon in the Raman spectroscopic literatures. Raman spectroscopy is a non-destructive technique that can yield information on the structural order of polyaromatic organic matter when applied at low laser power. Therefore, it is used to investigate insoluble organic matter from a range of chondritic meteorites, and a suite of interplanetary dust particles [1-2]. Raman analysis of insoluble organic matter have been already discussed by various authors in different meteorites [3-4], as well as of interplanetary dust particles and returned samples from the Stardust Mission [5].

### Experimental:

All the sample preparation was performed in ultra-clean conditions. To prevent from the environmental contaminations, such as mud, the sample was carefully checked by optical microscopy. To avoid surface contamination and the fusion crust we fragmented the

sample (~20 mg) and took only pieces coming from its interior. Raman spectra were collected on powdered bulk meteorite sample using a Ar<sup>+</sup> excitation source having wavelength 488 nm, used with a power kept at 20 μW (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<sup>-1</sup> in the range from 100 to 3000 cm<sup>-1</sup>. 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:

Figure 1 displays different carbon phases observed in Raman spectra in between 1100–2000 cm<sup>-1</sup>. The Raman spectra of the nanodiamonds exhibit two broad bands centered at 1326 cm<sup>-1</sup> and 1590 cm<sup>-1</sup>. The relative intensities of the 1334–1345 cm<sup>-1</sup> (I<sub>D</sub>) and 1591–1616 cm<sup>-1</sup> (I<sub>G</sub>) peaks and their peak widths, expressed as the FWHM reflect the degree of ordering. The first-order Raman band (F<sub>2g</sub>) of diamond occurs at ~1332 cm<sup>-1</sup> represents the main C–C bond vibration in diamond (carbon sp<sup>3</sup> bonding). The Raman band (E<sub>2g</sub>) at 1590 cm<sup>-1</sup> is assigned to carbon sp<sup>2</sup> bonding graphitic structures. The Raman spectrum of Mahadevpur shows peaks at 1334 cm<sup>-1</sup> and 1591–1619 cm<sup>-1</sup> attributed to diamond and graphite (D and G carbon bands), respectively. The peak intensity is generally used as a signature of crystalline quality. The peak intensities of these bands are relatively low, which indicates strong background fluorescence. This may be because of the amorphous nature of the sample or small grain size. In general, crystalline graphite can be identified by the dominance of the Raman band composed of merged peaks at around 1582 cm<sup>-1</sup> and 1588 cm<sup>-1</sup>, but owing to increasing disorder it moves to lower frequencies. Depending on the degree of disordering and orientation of the graphite grain, a second band around 1350 cm<sup>-1</sup> and a shoulder at 1620 cm<sup>-1</sup> of lower intensity is present. The shift of Raman peaks can also vary as a function of lattice stress, temperature and depends on the incident laser power.

Generally, the  $\sim 1350\text{ cm}^{-1}$  feature of the D band occurs because of Raman inactive  $A_{1g}$  mode, and it is activated only because of a finite crystal size. The presence of Raman peak at  $1351\text{ cm}^{-1}$  in Natun Balijan is indicative of fine-grained carbon. Measured FWHM for Mahadevpur and Natun Balijan as  $70\text{ cm}^{-1}$  and  $18\text{ cm}^{-1}$  respectively reflects the nature of shock metamorphism in the meteorite samples. Generally, FWHM  $10\text{--}120\text{ cm}^{-1}$  is characteristic for shock-induced diamonds. The diamond ( $I_D$ ) and graphite ( $I_G$ ) band intensity ratio are  $\sim 1.075$  and  $\sim 0.53$ , respectively, for Mahadevpur and Natun Balijan. The  $I_D/I_G$  ratio implies disordered graphite and glassy carbon, respectively, present in the Mahadevpur and Natun Balijan sample. The artificially produced chemical vapour deposited nanocrystalline diamonds exhibits two significant bands at  $1150\text{ cm}^{-1}$  and  $1450\text{ cm}^{-1}$ .

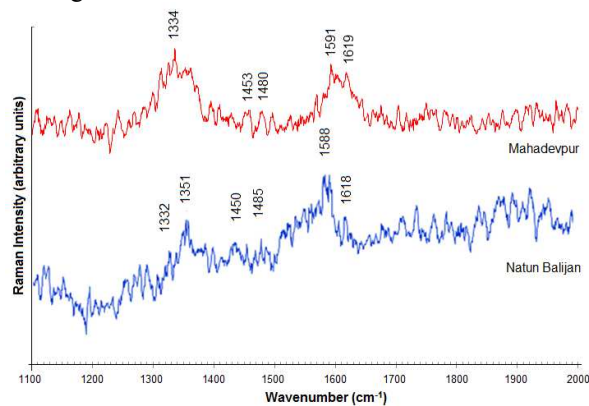


Fig.1. Raman spectrum of graphite nodule in Mahadevpur and Natun Balijan meteorite samples showing two peaks, at  $\sim 1332\text{--}1351\text{ cm}^{-1}$  and peak at  $\sim 1588\text{--}1618\text{ cm}^{-1}$ . The diamond peak appears around  $1331\text{ cm}^{-1}$

Similar peak at  $1450\text{ cm}^{-1}$  is observed in Natun Balijan spectra. Therefore, it may be believed that the formation of nanodiamonds in Natun Balijan is similar to this process (chemical vapour deposition). The Raman peak position around  $1616\text{ cm}^{-1}$  is also evidence of disordered graphite.

#### Conclusion:

In the Raman spectra, the diamond and graphite (D and G carbon bands) peaks correspondingly observed at  $1332\text{--}1351\text{ cm}^{-1}$  and  $1588\text{--}1619\text{ cm}^{-1}$  in Mahadevpur and Natun Balijan ordinary chondrites. The peak intensity of these peaks reflects the degree of ordering. The Raman peak position around  $1616\text{ cm}^{-1}$  is the evidence of disordered graphite in these meteorite samples. The peak appears at  $1332\text{--}1334\text{ cm}^{-1}$  is accepted for diamond. The Raman peak  $1450\text{ cm}^{-1}$  indicates that the formation of nanodiamonds in Natun Balijan is similar to the chemical vapour deposition process. The full wave at half maximum value  $18$  and  $70\text{ cm}^{-1}$  reflects the shock metamorphism in the meteorite samples. The diamond and graphite peaks intensity ratio  $\sim 1.075$  and  $\sim 0.53$  respectively indicates the disordered nature of graphite in Mahadevpur and Natun Balijan ordinary chondrites.

#### References:

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