RAMAN SPECTROSCOPY OF NATUN BALIJAN L4 ORDINARY CHONDRITE. Bhaskar J. Saikias, G. Parthasarathy and Rashmi R. Borah, 1Department of Physics, A.D.P. College, India, 2Department of Physics, National Institute of Advanced Studies, IISc. Campus, Bengaluru, India, 3School of Natural Science and Engineering, National Institute of Advanced Studies, IISc. Campus, Bengaluru, India, 4Department of Physics, Nowgong College, India. (e-mail:vaskaradp@gmail.com)

Introduction: Meteorites are an important source of extraterrestrial matter, their chemical and physical characteristics, texture and internal structure contribute to our understanding of the birth and early history of our solar system. 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. 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 [11-20] and returned samples from the Stardust Mission [5]. In this paper we report Raman spectroscopic study of Natun Balijan L4 ordinary chondrite.

A single fall occurred on 5th June 2017 (04:30 pm IST) in Natun Balijan village of Sunpura, Sadiya (27°50'09"N; 95°51'34"E). According to the eye witness, a single stone was fallen in paddy field with a roaring sound and it formed an impact pet about 3.5 ft depth. The stone was fully covered with fusion crust and had well rounded edges and well developed regmaglypts on its surface (Fig. 1). The weight of the meteorite was 3kg and had specific gravity of about 3.4 g/cm³, typical of stony meteorites. The Natun Balijan meteorite fall represent the fifth ‘observed fall’ in North East India and it is the seventh meteorite of this region since 1846.

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. The Raman spectra were collected on bulk powdered meteorite samples using an Ar ion laser with a power of ~5 mW, which used an excitation source having wavelength 488 nm coupled with a Jobin-Yvon Horiba LabRam-HR Micro-Raman spectrometer equipped with an Olympus microscope with 10X, 50X and 100X objectives.

Result and Discussion: The Raman spectra of the sample shows (Fig. 2) two characteristics peaks of olivine at 819.95 cm⁻¹; 850.20 cm⁻¹ and three characteristic peaks of pyroxene at 335.34 cm⁻¹; 678.49 cm⁻¹ and 1004.50 cm⁻¹. The endmembers are responsible for these characteristics peak changes. The full width at half maximum (FWHM) of the peak is considered to be related to the degree of structural disorder of the crystal. The FWHM values of Natun Balijan L4 ordinary chondrite can be related to the degree of crystal structural disorder resulting from shock deformation. The measured FWHM averaged for the observed peaks for forsterites in the Natun Balijan L4 ordinary chondrite sample is 10.42 cm⁻¹ for the component at 819.95 cm⁻¹ and 27.28 cm⁻¹ for the component at 850.20 cm⁻¹. The well-crystallized terrestrial olivines have FWHM value 9.1 cm⁻¹ and 9.5 cm⁻¹ corresponding to the peak positions at 820 cm⁻¹ and 854 cm⁻¹. The observed FWHM values of Natun Balijan L4 ordinary chondrite are higher than those observed for well-crystallized terrestrial olivines. The FWHM value 34.3 cm⁻¹ for the pyroxene peak at 1004.50 cm⁻¹ of Natun Balijan L4 ordinary chondrite is higher than the well-crystallized terrestrial pyroxenes.

Fig.1 Photograph of Natun Balijan L4 ordinary chondrite.
Figure 3 displays different carbon phases observed in Raman spectra in between 1100–2000 cm\(^{-1}\). In general, the Raman spectra of nanodiamonds reveal two broad bands centred at 1326 cm\(^{-1}\) and 1590 cm\(^{-1}\). The first-order Raman band (F\(_{2g}\)) of diamond occurs at \(~1332\) cm\(^{-1}\) corresponds to carbon sp\(^3\) bonding (the main C–C bond vibration in diamond) and the band (E\(_{2g}\)) at \(~1590\) cm\(^{-1}\) is assigned to carbon sp\(^2\) bonding graphitic structures. The peaks exhibits in the Raman spectrum (Fig.3) at 1332 cm\(^{-1}\), 1351 cm\(^{-1}\) and 1588–1618 cm\(^{-1}\) attributed to diamond and graphite (D and G carbon bands), respectively. The peak intensity is generally used as a signature of crystalline quality. The relative intensities of these two bands reflect the degree of ordering. Depending on the degree of disordering and orientation of the graphite grain, a second band around 1350 cm\(^{-1}\) and a shoulder at 1620 cm\(^{-1}\) of lower intensity is present, which can be observed in the Raman spectrum of Natun Balijan L4 ordinary chondrite at 1348 cm\(^{-1}\) and 1618 cm\(^{-1}\). The relative intensities of the 1351 cm\(^{-1}\) and 1588 cm\(^{-1}\) peaks reflect the degree of ordering or disordering. The Raman peak position 1618 cm\(^{-1}\) is the evidence of disordered graphite in the Natun Balijan L4 ordinary chondrite (Fig. 3). The artificially produced chemical vapour deposited nanocrystalline diamonds exhibits two significant bands at 1150 cm\(^{-1}\) and 1450 cm\(^{-1}\). Similar peak at 1450 cm\(^{-1}\) is observed in Natun Balijan spectra. Therefore, it may be believed that the formation of nanodiamonds in Natun Balijan L4 ordinary chondrite is similar to this process (chemical vapour deposition).

Conclusion: In the Raman spectra, the diamond and graphite (D and G carbon bands) peaks correspondingly observed at 1332 cm\(^{-1}\), 1351 cm\(^{-1}\) and 1588–1618 cm\(^{-1}\). The peak intensity of these peaks reflects the degree of ordering. The Raman peak position 1618 cm\(^{-1}\) is the evidence of disordered graphite in the Natun Balijan L4 ordinary chondrite. The presence of 1450 cm\(^{-1}\) in Raman spectra indicates that the formation of nanodiamonds in Natun Balijan L4 ordinary chondrite is similar to the chemical vapour deposition process. The full wave at half maximum (FWHM) value 17.5 cm\(^{-1}\) reflects the shock metamorphism in the meteorite samples.