CHONDRULE MORPHOLOGY, MINERALOGY, THERMAL METAMORPHISM AND SHOCK EXCURSION OF MAHADEVPUR CHONDRITE (H4/5). S. Rajpriye[1,2], S. Baliyan[2], D. Ray[2] and T. K. Goswami[3], [1]Indian Institute of Technology, Roorkee, Uttarakhand 247667, India (email: srajpriye@es.iitr.ac.in), [2]Physical Research Laboratory, Ahmedabad 380009, India, [3]Department of Applied Geology, Dibrugarh University, Assam 786004, India.

Introduction: Mahadevpur Chondrite fell at Mahadevpur near Namsai Town, Arunachal Pradesh, India (27°40′N, 95°47′E) on 21 February 2007 at 9:10 Indian Standard Time. The fall was witnessed by many people. The total known mass of meteorite is 70.5 kg and is the largest documented multiple fall of north-east India [1]. This meteorite is one of the four official meteorite falls in North-East India [2].

In this communication, we present morphology of different chondrules, mineral chemistry of phases and infer the shock-thermal history.

Analytical Techniques: A polished thick section of Mahadevpur was prepared for petrographic investigations and mineral chemistry.

BSE imaging and petrographic investigation was performed using JEOL JSM-IT300 Scanning Electron Microscope (20kV) equipped with Oxford Energy Dispersive X-ray spectrometry (EDS).

For determination of mineral composition, Cameca SX100 Electron Microprobe equipped with three vertical WDS was used with operating conditions: Acceleration voltage of 15kV and beam current of 15nA with PAP correction. Counting times for the elements were kept to 10-20s, except for Na, which was 7s to reduce any volatilization effect. Natural and synthetic mineral standards were used for calibration.

Results and Discussion: Mahadevpur contains a variety of chondrules which include Porphyritic Olivine (PO), Porphyritic Olivine Pyroxene (POP), Porphyritic Pyroxene (PP) and Barred Olivine (BO). The latter commonly occur as clast. The majority of the chondrules are porphyritic type.

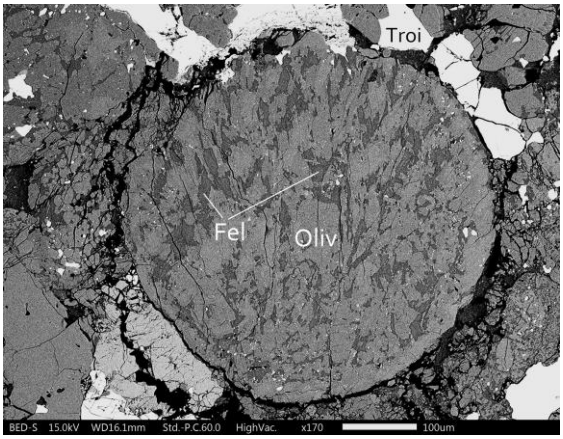

Figure 1. BSE image of Porphyritic Olivine (Oliv)-Pyroxene (POP) Chondrule. Troilite (Troi) and Fe-Ni is present along the boundary. Fel: Feldspar.

In concise, 30 distinct chondrules were identified and their diameter ranges from 0.13 mm to 0.7 mm, with a mean value of 0.44 mm. Chondrules with diffused outlines are more common and hard to delineate due to high chondrule-matrix integration of similar mineralogical composition. The common mineral phases of matrix include feldspar, Fe-Ni alloy, chromite and merrillite.

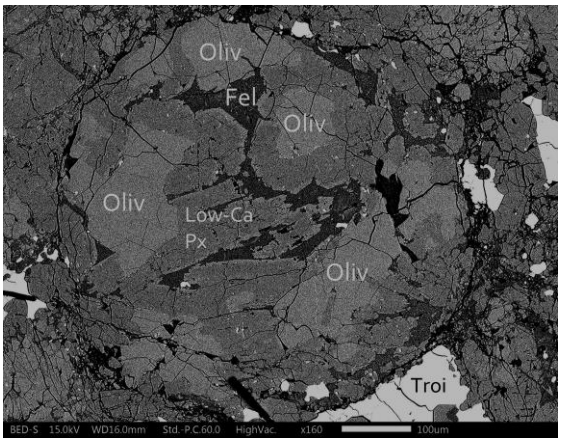

Figure 2. BSE image of Porphyritic Olivine (Oliv)-Pyroxene (Px) Chondrule (POP). Troilite (Troi) is common along the boundary.

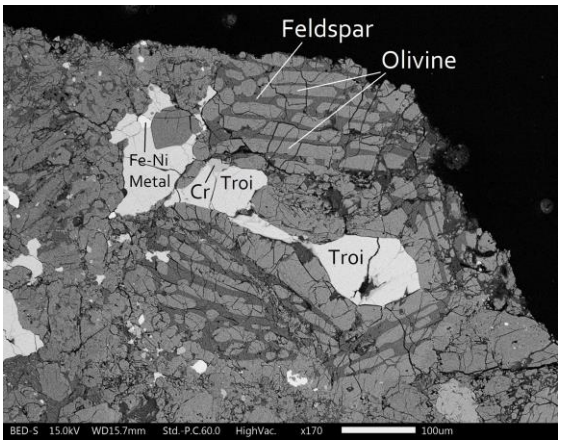

Figure 3. BSE image of Barred Olivine (BO) Chondrule, along with rare Chromite (Cr), Troilite (Troi) and Fe-Ni metal in the middle portion of chondrule.

Mineral phases provide the following compositions: Olivine (Fa: 19.6 ± 0.58), low-Ca Pyroxene $En_{81}Fs_{18}Wo_1$ (Ferrosilite ranges from 16.5-19.3, PMD is 0.44), Plagioclase $Ab_{76}Or_6An_{18}$ along

with Kamacite (Ni: 5.86 ± 0.88), Taenite (Ni: 40.09 ± 8.25), Troilite (S: 35.77 ± 0.55), Merrillite ($Ca_{11.25}Mg_{1.13}Na_{1.17}P_{4.29}O_{24}$) and Chromite (Cr# 0.87 and Fe# 0.85). The Fayalite and Ferrosilite content in Olivine and low-Ca Pyroxene fall well within the range of H chondrite.

Olivine in chondrules is largely homogenized and Per Mean Deviation (PMD) of Fayalite (0.44) suggesting for equilibrated type of chondrite [3].

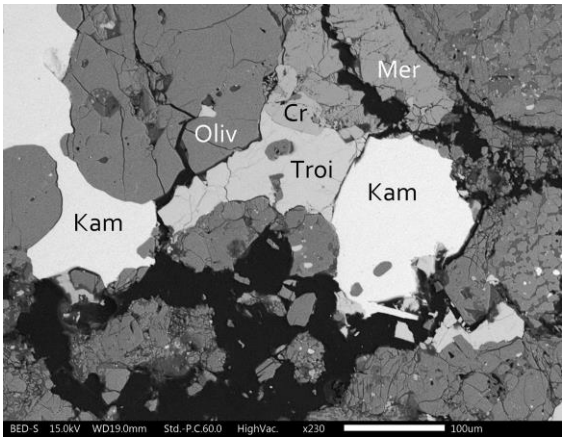

Figure 4. BSE image of matrix of Mahadevpur chondrite showing Merrillite (Mer), Chromite (Cr), Troilite (Troi) and Kamacite (Kam).

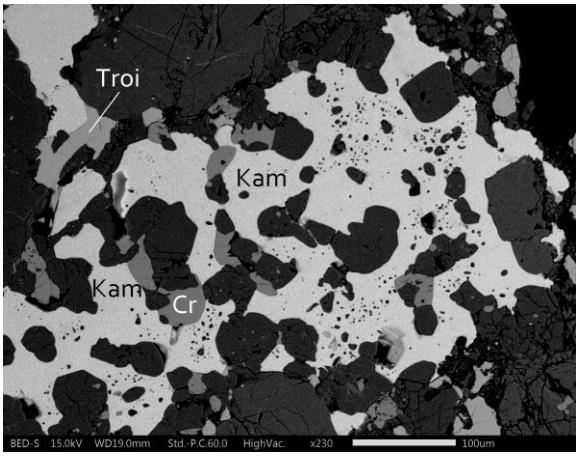

Figure 5. BSE image of matrix of Mahadevpur chondrite showing Chromite (Cr), Troilite (Troi) and Kamacite (Kam).

Thermal metamorphism in ordinary chondrite is common and heat sources for metamorphism are envisaged due to radioactive decay of short-lived radionuclides (^{26}Al and ^{60}Fe) [4]. The estimated mean equilibration temperature of thermal metamorphism yields 800°C and 699°C, respectively based on two-pyroxene thermometry and olivine-chromite thermometry [5,6]. The temperature difference between the two thermometers is ~100 °C, might be due to representation of "Closure Temperature" or the effect of post-shock reheating. The equilibration temperature estimated is well within the range for H4/5 chondrite (H4 mean is 707 ± 46°C, H5 mean is 703 ± 27°C) [5].

Shock Metamorphism: Fracturing of silicates especially the olivines are the most common shock induced feature in Mahadevpur chondrite. Maskelynites are also common. Locally shock melt veins and melt breccias are present. Numerous angular silicates appear to be transected and surrounded by metal-troilite intermix (Fig. 6). The shock features are also manifested by the presence of anastomosing shock-melt veins. The hairline fractures of olivines are also common and often likely to be crack-sealed by metal-sulphides. This study argues against the earlier studied shock stage (S1), rather locally shock stage could have attained up to S3/S4.

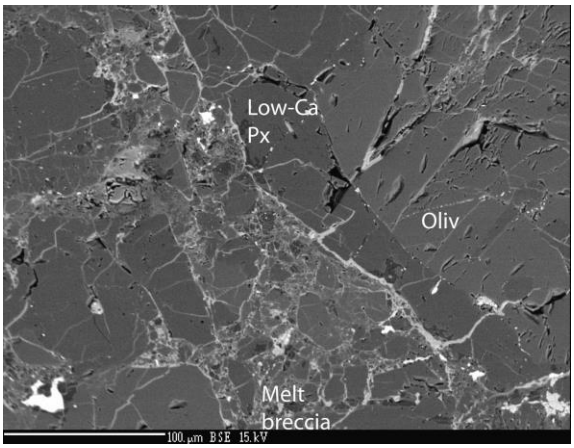

Figure 6. Impact-melt breccias texture of Mahadevpur. Oliv: Olivine; Low-Ca Px: Low calcium pyroxene.

References: [1] Weisberg et al. (2008). The Meteoritical Bulletin, No. 94, September 2008. *Meteoritics & Planet. Sci.*, *43*(9), 1551-1584. [2] Goswami, T.K. et al (2016) Meteorite fall at Komargaon, Assam, India. *Curr. Sci.*, 110, 1894-1895. [3] Murty, S.V.S. et al (2009), Jodia (L5) and Mahadevpur (H4/5): Two Recent Ordinary Chondrites Falls in India. 72nd Annual Meteoritical Society Meeting, No. 5058. [4] Huss, G. R., Rubin, A. E., & Grossman, J. N. (2006). Thermal metamorphism in chondrites. *Meteorites and the early solar system II*, 943, 567-586. [5] Wlotzka F. (2005) *Met. Planet. Sci.* 40, 1673— 1702. [6] Lindsley D.H (1983) *Am. Mineral.* 68, 477493.