DERGAON (H 4-5) CHONDRITE: DIVERSE CHONDRULE MORPHLOGY AND EVIDENCES OF SHOCK INDUCED MELTING . D. Ray[1], S. Ghosh[1] and T.K. Goswami[2]. Physical Research Laboratory, Ahmedabad 380 009, India. [2]Department of Applied Geology, Dibrugarh University, Assam, India. E-mail: dwijesh@prl.res.in

Introduction: Dergaon chondrite shower (March, 2001) is one of the spectacular meteorite falls in Assam, Northeast India. Based on integrated data on petrology, bulk chemistry, oxygen isotopes, noble gas and cosmic ray track density Dergaon was assigned as H5 (S_{2-3}) ordinary chondrite [1]. Interestingly, low bulk K content (~ 340 ppm) in Dergaon as compared to mean K content of H chondrite (~786 ppm;[2]) is unique but not properly explained. Moreover, rich inventory of various chondrules in Dergaon chondrite was hitherto unreported. We, therefore, revisit Dergaon chondrite with an aim for a detailed petrological and chemical investigation, and finally propose a reasonable explanation for bulk K depletion.

Analytical Techniques: Mineral composition of chondrules and the matrix was carried out using EPMA (Cameca SX 100) with wavelength dispersive spectromer. Mineral phases were analysed using 15 keV accelerating voltage, 20 nA sample current with a focused beam. Natural and synthetic mineral standards were used for calibration. Data were corrected for absorption, fluorescence and atomic number effects based on the correction method [3].

Results: Dergaon chondrite is essentially a close-packed aggregate of a large variety of chondrules. Porphyritic olivine (PO) and cryptocystalline (C) chondrules are considerably large in contrast to small glassy (G) droplet chondrules. Larger clasts of radial pyroxene (RP) chondrule are most common while clasts of barred olivine (BO) and barred pyroxene (BP) chondrules are rarely present (Fig.1). Compound chondrules of sibling PO-PO, independent PO-RP and PO-BO types are often noted (Fig. 2). Chondrule- dominated Dergaon is reclassified to petrologic type 4-5 [4].

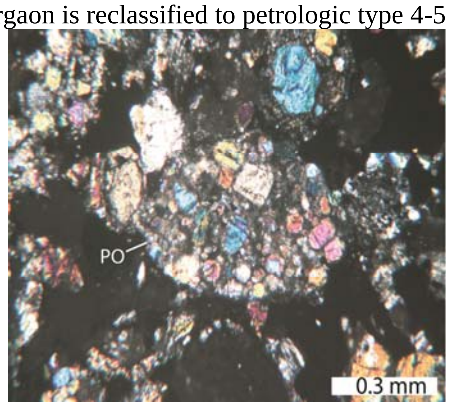

Fig. 1 Porphyritic olivine (PO) chondrule within glassy/ devitrified matrix

Chondrule petrography infers diverse mineralogy with variable olivine-pyroxene ratios, variable bulk FeO/ (FeO + MgO) composition (Type II) and igneous melt textures under both slow and fast cooling rate.

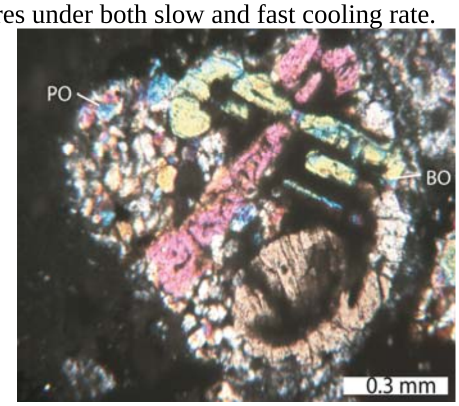

Fig. 2 Compound chondrule of independent Barred olivine (BO)-Porphyritic Olivine (PO) type

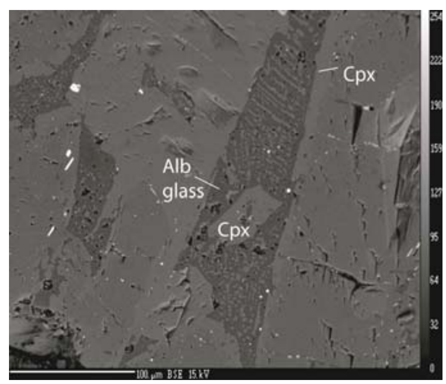

Fig. 3 Devitrification texture showing development of clinopyroxene (Cpx) crystallites in albitic glass

By contrast, chondrule mesostasis consists of translucent cryptocrystalline silicate assemblage and Fe-Ni metal dominated opaques.

Chondritic matrix is a fine grained disequilibrium mixture of silicates, oxides, Fe-Ni metals, sulphides and phosphates thermally reconstituted into a recrystallised aggregate. Two significant features of matrix are devitrification texture (Fig. 3) composed of octahedral sets of clinopyroxene crystallites ($En_{44.87}Fs_{6.59}Wo_{48.55}$) in a host of albitic glass ($An_{16.0}$) and shock- induced vesicular texture (Fig. 4) produced in diaplectic feldspar glass with low K- content ($An_{21.62}Ab_{75.86}Or_{2.52}$).

.

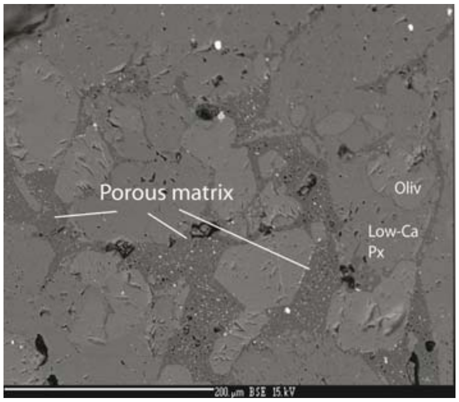

Fig. 4 Porous (or vesiculated) matrix of Degaon chondrite

Opaque-silicate ratio varies up to 18:82, while metal: troilite: chromite abundance ratio is 45: 45: 10. While the matrix is bimodal kamacite (mean Ni: 4.6 wt%, 6.0 wt%) bearing, chondrules are mainly taenite bearing (mean Ni: 12.23 wt%). In the shock- melt zone sulphur bearing metals (S: 0.21 – 0.78 wt%) and Ni bearing troilites (mean Ni: 35.7 wt%) are common

Our estimated equilibration temperature of Dergaon chondrite using coexisting olivine-chromite and ortho-pyroxene-clinopyroxene thermometers [5,6] yields a value 852.6°C. This higher temperature is not unusual in Dergaon H $_{4\text{-}5}$ chondrite because it shows evidence of reheating that produced shock melts of metal, troilite and to some extent silicates, as well. The lowering of at least 100°C is reasonably accepted due to post-shock reheating and therefore reduces the equilibration temperature to 765°C and it is comparable with mean estimate of 715°C for shock heated H5 chondrites [5].

Shock induced silicate melt vein (Fig. 5), hitherto unreported is one of the unique features in Dergaon chondrite. Furthermore, dense melt shows limited vesiculation due to post-shock cooling under low pressure. Interestingly, the olivine-dominated melt is more fayalitic (mean Fa: 39.9 mol%) as compared to chondritic mean olivine composition (Fa: 20.28 mol%) whereas the partly assimilated feldspathic glass is more anorthitic (An: 67.79 mol%) and contrasts with mean chondritic feldspar composition (An: 13.26 mol%). Troilite melt veins and its melt pockets are associated with Fe- Ni metal globules and droplets (Fig. 5).

Discussion: Dergaon H chondrite reports several significant observations that help to understand both nebular and asteroidal processes.

Dergaon chondrite is a classic example of H chondrite with high chondrule-matrix ratio. Accumulation of large varieties of chondrules including compound nature in volatile depleted, phosphate-bearing silicate matrix implies accretion of chondrules in an acidic aqueous environment with not much of transport.

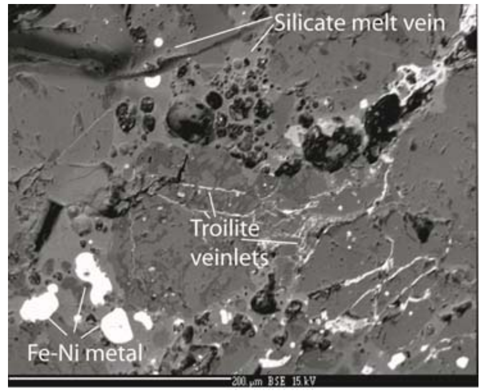

Fig. 5 Silicate melt vein in association with troilite veinlets and Fe- Ni metal droplets

Chondrule petrography infers their formation through impact melt fractionations from two different melt reservoirs. Furthermore, profusely vesiculated matrix of diaplectic plagioclase / maskelynite explains the loss of K due to shock during post-shock decompression stage under low pressure [7].

Two stage thermal histories in Dergaon chondrite clearly correspond to endogenic heat driven solid-state static diffusion and impact-shock induced dynamic thermal alterations. Longer duration static metamorphism at ~1 atmospheric pressure and ~765°C mean temperature accounts for textural integration and chemical homogenisation to petrologic type 4-5. By contrast, shock pressure (>45 GPa, 600°C) produces S_5 shock features like olivine mosaicism, diaplectic plagioclase, polycrystalline troilite. Peak shock metamorphism at ~ 75 GPa and above 950°C is furthermore responsible for locally developed shear melt silicate veins often associated with melt-quenched olivine crystallites, troilite-melt veins. Furthermore, presence of metal globules and vesicular texture in maskelynite suggests post-shock decompression stage under low pressure.

References: [1] Shukla P.N. et al (2005) *Met Planet Sci.* 40, 627-637. [2] Kallemeyn G.W. et al. (1989) *Geochim. Cosmocim. Acta* 53, 2747-2767. [3] Pouchon J. L. and Pichoir F. 1991. New York: Plenum Press. pp. 31–75. [4] Van Schmus W.R. and Wood J.A. (1967) *Geochim. Cosmochim. Acta* 31, 747- 765. [5] Wlotzka F. (2005) *Met. Planet. Sci*. 40, 1673—1702. [6] Lindsley D.H (1983) *Am. Mineral.* 68, 477-493. [7] Chen M and El Gorsey A. (2000) *Earth Planet. Sci. Lett.* 179, 489-502.