KATOL METEORITE: A RARE SHOWER OF TROILITE-METAL NODULE BEARING SHOCK MELTED L6-7 CHONDRITE. D. Ray, S. Ghosh and S.V.S. Murty, PLANEX, Physical Research Laboratory, Ahmedabad 380009, India (dwijesh@prl.res.in).

Introduction: Katol meteorite shower (21°15'30"N, 78°35'30"E) during the afternoon of 22nd May, 2012 in Central India has gifted more than thirty (30) fragments with a total weight of ~13 kg. It has been classified as L6 ordinary chondrite [1]. Here we present an independent classification, using a sample from GSI repository and another that possesses one subrounded troilite- metal nodule (~2 cm across) in the silicate host (Fig. 1). Morphological signatures of atmospheric flight are well documented in the development of three different fusion crusts of variable colour, thickness and textures, large variety of regmaglypts and flow lines. Light gray, disseminated metal- sulphide specks bearing recrystallised silicate matrix with no discernible chondrule suggests its chondritic nature with high degree of chondrule- matrix integration. Anastomosing shock veins interconnected with black shining melt pockets imply a very high degree of shock metamorphism.

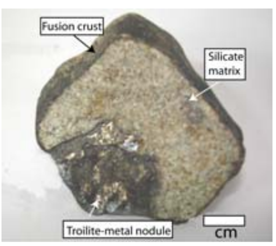

Fig. 1: Broken surface of Katol meteorite shows fusion crust, silicate matrix and troilite-metal nodule

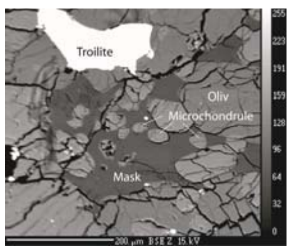

Fig. 2: Microchondrule (olivine) and large scale maskelynitisation (Mask) in silicate matrix

Textures and Mineral Chemistry

Silicate Matrix: Present work based on petrography and mineral chemistry (using EPMA) classifies Katol as L group Ordinary chondrite that shows a few microchondrules (Fig. 2) in transparent coarsely recrystallised aggregate of mainly olivine (Fa 24.8 ± 0.54, PMD: 1.77), low- Ca pyroxene (Fs 21.4 ± 0.48, PMD: 1.65) and nickel- free spongy troilite (mean Ni: 0.074 wt%). Other minor and accessory phases include secondary plagioclase ($An_{11.1}$), Fe- Ni metal (kamacite of Ni: 4.74 ± 1.87, Low- Ni taenite of Ni: 16.7 ± 2.2 and high Ni taenite of Ni: 30.2 ± 0.06), high- Ca pyroxene ($Wo_{44.3}$ $En_{46.5}$ $Fs_{9.2}$), merrilite and chromite (Cr# 0.91, Fe# 0.84). Olivine- dominated mineralogy, ~ 15 vol% (kamacite + taenite + troilite), high Wo- content (Wo:3.22 ± 0.65) of low- Ca pyroxene, good abundance of secondary plagioclase (>100 μm) which is largely transformed to maskelynite and coarse (up to ~50 μm), well crystallised grains of high- Ca pyroxene are all suggestive of extreme thermal metamorphism that corresponds to petrologic type beyond 6 but well within type 7 [2] (Fig. 3). Fe-Ni metal and troilte are generally present as discrete and composite grains except some localized melting at metal-troilite interface (Figs. 4,5).

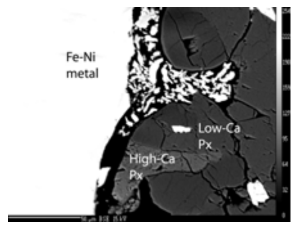

Fig. 3: Well crystalised high-Ca pyroxene (Px) coexisting with low-Ca Px in silicate matrix

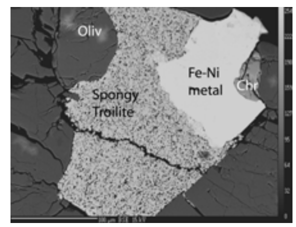

Fig. 4: Composite Fe-Ni metal-spongy troilite-chromite (Chr) grain in silicate matrix

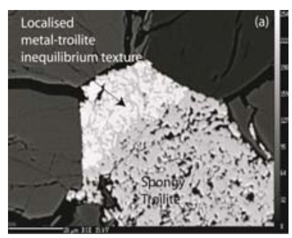

Fig. 5: Inequilibrium texture of troile and Fe-Ni metal in silicate matrix

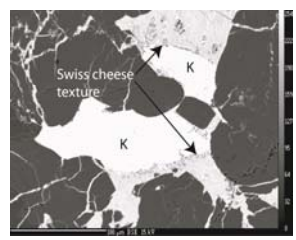

Fig. 6: Swiss cheese texture at troilite-Fe-Ni metal in SM nodule

Sulphide- metal (SM) nodule: SM nodule embedded in the chondritic matrix is, in fact, a shock- melt breccia which includes primarily troilite in frequent association with kamacite, olivine and low-Ca pyroxene fragments; maskelynite, taenite and chromite are other accessories. These silicates have no textural and compositional difference from those of chondritic matrix except some microchondrules. At least nine different textural modes of troilites are recognised in the SM nodule and majority of these are related to shock event [3]. These are swiss- cheese texture (Fig. 6), fizz troilite (Fig. 7), sheared troilite, immiscible droplets and globules of kamacite within troilite, shock- melt breccia (Fig. 8), troilite melt pocket, troilite as shock- melt veins with or without interconnected melt pockets, trolite clast as part of shock- melt breccia and finely disseminated troilite within the pulverised silicate matrix. Shock- melting of the SM nodule, because of liquid immiscibility on micron scale, accounts for Ni- rich troilites (Ni: 1.81wt%; S: 32.6 wt%), S- rich kamacites (S: 0.55 wt%; Ni: 6.18 wt%) and S- rich taenites (S: 0.64 wt%; Ni: 8.65 wt%).

Shock metamorphism: Katol silicates, despite extreme thermal metamorphism and intense shock metamorphism lack any evidence of whole- rock melting. Relict textures of planar fractures and planar deformation features in olivines (Fig. 9), large- scale maskelynitisation of plagioclase (Fig. 2), formation of in- situ breccia and displaced ejecta due to impact fracturing (Fig. 10), annealing of metal and finally metal- troilite inequilibrium texture (Fig. 5) suggest imprints of multiple shock events. In the SM nodule, troilite responded more intensely as compared to kamacite and taenite in the shock- induced melt forming process.

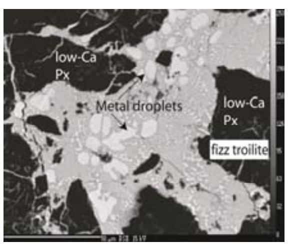

Fig. 7: Fe-Ni metal droplets and Fizz troilite in SM nodule

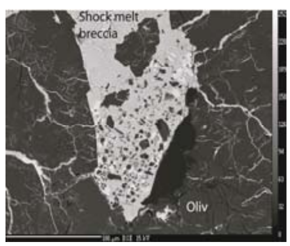

Fig. 8: Shock-melt breccia in SM nodule

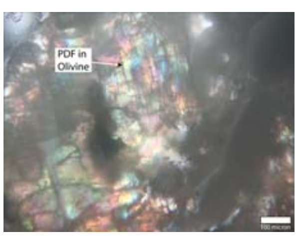

Fig. 9: Planar deformation feature (PDF) in olivine of silicate matrix

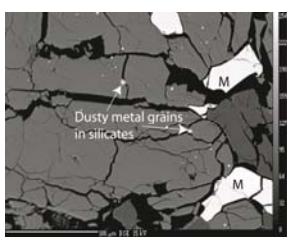

Fig. 10: In situ breccias due to impact fracturing of silicates and metal (M)

Discussion: Katol is unique due to its presence of troilite-metal nodule which is characterized by several shock-induced textures including melt breccias. Earlier reports exist on L- chondrites with nodules of only Fe-Ni metal, nodules of only troilites and metal- sulphide nodules [4,5,6]. Large metal / metal- sulphide nodules detached from ordinary chondrite parent bodies are also described [7].

We classify Katol as higly equilibrated and shock-melted L6-7 ordinary chondrite with a conspicuously large sulphide- rich Fe- Ni metal nodule which is envisaged to have been produced by shock impact and vaporisation [8]. Complete obliteration of the textural features like zoned taenite, monocrystalline kamacite, monocrystalline troilite related to early slow cooling event suggest post- shock minimum reheating temperature of ~ 650^{o}C. Post- shock temperature in Katol that generated metal- sulphide melt droplets, localised melting of Fe- Ni metal, troilite and silicates, specially transformation of feldspar to dense melt of maskelynite indicates ~950^{o}C [9]. Abundant metal- sulphide veins, rapidly solidified metal-troilite intergrowths suggest highest post-shock temperature must have reached Fe-FeS eutectic, 988°C [10]. Thus, Katol chondrite may be calibrated with metamorphic temperature of 900^{o}C- 950^{o}C that corresponds to S_{6-7} thermal metamorphism of the host chondrite. SM nodule of Katol refers to post- shock temperature of ~ 650^{o}C to 980^{o}C and ~ 90 GPa shock pressure.

Common texture and mineralogy of the silicates between chondritic matrix and SM nodule suggest an aggregation of the two from a single parent body but with two different environ of metal-sulphide formation. Metal and sulphides of the silicate matrix did not show any evidence of large scale impact wheras the formational process of the SM nodule involves impact melting up to metal-sulphide eutectic including intense fracturing and maskelynitisation of the silicates.

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References

[1] Meteoritical Bulletin (2014) *MAPS* (in preparation). [2] Hutchison R. (2004) Meteorities: a petrologic, chemical and isotopic synthesis. Camb. Univ Press, 506 pp. [3] Bennett M.E. and McSween Jr. H.Y. (1996) *MAPS 31*, 255-264. [4] Scott E.R.D. (1973) *GCA 37*, 2283-2294. [5] Rubin A.E. (1985) *Rev Geophys 23*, 277-300. [6] Scott E.R.D. (1982) *GCA 46*, 813-823. [7] Grossman J.N. (1994) *Meteoritics 29*, 100-143. [8] Rubin A.E. (1999) *JGR 104*, 30799-30804. [9] Heymann D. (1967) *Icarus 6*, 189- 221. [10] Rubin A.E. (2004) *GCA 68*, 673-689.