Phyllosilicate rich rims in Mukundpura meteorite: Implications for parent body aqueous alteration

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Introduction: Carbonaceous chondrites are of particular scientific significance because they retain an important record of a variety of early solar system processes, ranging from the formation of the earliest solids to low-temperature aqueous alteration. A broadly acknowledged and described phenomenon in the CM chondrites is the occurrence of fine-grained rims that encloses mineral grains, chondrules and inclusions. Fine-grained materials occur as rims around various coarse grained components, such as calcium aluminium rich inclusions (CAIs), chondrules and isolated mineral fragments, in CM, CV, CO and EC chondrites [1,2,3]. Fine-grained rims (FGRs) contain secondary minerals formed due to aqueous alteration of anhydrous precursor phases. However, the origin and modification of fine grained rim is poorly understood. Debate currently exists whether the alteration of fine grained rim occurred in nebular condition or in the parent body setting. Nevertheless, fine grained rim is important for shedding light on the chemistry and accretion history of chondritic material in the early solar system. In this study, we will discuss the evidences for accretion of dust and effects of secondary alteration in fine grained rims of Mukundpura meteorite, a recent fall in India. Mukundpura is a matrix rich meteorite and based on their mineralogical and geochemical analysis, it is assigned as CM2 or CM1/2.

Results and Discussions: The fine grained material in the Mukundpura meteorite (CM2) [4, 5] encloses different type of anhydrous mineral components including chondrules, isolated olivine grains, sparse calcium-aluminium rich inclusions (diopside and spinel) and magnetite rich aggregates. Chondrules occur in the size range of a few µm up to 1 mm and are dominantly FeO-poor porphyritic olivine (type IA) and olivine-pyroxene chondrules (type IAB). As a result of aqueous alteration in CM chondrite, the mesostasis of most of these chondrules has been altered to Mg-rich phyllosilicates. The fine grained rim appears continuous, phyllosilicate-rich and can clearly be distinguished from the enclosed objects and the meteorite matrix. Fine grained rims are homogeneous in composition and apparently less porous (compact) as compared to the highly porous matrix. The diameters of fine grained rim is positively correlated with the diameters of enclosed objects i.e. smaller objects are surrounded by thin layer of fine grained rim while larger objects are surrounded by broad, thick rims. The width of fine grained rims is observed to be in a range of 1.5µm to greater than 120 µm. The fine grained rim typically display sharp boundaries with the enclosed object while gradational or rather diffuse contacts are more common with the meteorite matrix. The outer edge of the rims is not necessarily rounded and smooth always, rather they are some-times angular or irregular.

Fine-grained rims shows similar textural features independent from the type of the enclosed object, through the different samples of Mukundpura meteorite. Apart from the single fine rained rims, it is observed that two layers of differing compositions have been enclosing some of the chondrules. This could be a result of internal layering within the rims. The layer forming outside/outer layer is usually found to be rich in magnetite and sulfides, thus appear brighter than internal layer which is lesser fine-grained and poor in FeO. The origin of this layering have been controversial that whether they formed during passage of chondrules through dust reservoirs of varying chemical compositions [2] or formed by a result of in situ aqueous alteration [6]. Fine grained rims often show radial cracks extending between object-rim and rim-matrix interfaces. Although, sometimes we have also found Fe, Ni sulfides or magnetites lying along with the boundaries of enclosed objects and their rims.

Electron microprobe analyses show that matrix and rims are overall homogeneous, however, rims are significantly depleted in Ca as compared to the matrix of the meteorite. This probably explains the absence of carbonate in the rims while preferentially precipitated in the matrix. However, the transport mechanism between enclosed object to matrix is least understood. Lack of fragmentation in fine grained rims indicates that their formation preceding to the accretion of meteorite body. Overall, the mode of occurrence, mineralogical, textural and chemical evidences are consistent with formation of FGR in the nebular condition and their modification is compatible with *in situ* aqueous alteration on the parent body. The study is still going on to further understand the origin and modification of fine grained rims in the Mukundpura meteorite.

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