PETROCHEMICAL CHARACTERIZATION OF ADH IKOT AND KHAIRPUR ENSTATITE CHONDRITES (EC).

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Introduction: Enstatite chondrites (EC) comprise only 2% of the chondrites that fall on Earth, are among the most chemically reduced rocks known. Enstatite chondrites contain a variety of unusual minerals that can only form in extremely reducing conditions. All enstatite chondrites are dominantly composed of enstatite-rich chondrules and abundant grains of metal (metallic Fe-Ni) and sulfide minerals, with almost no iron oxides [1]. Detailed petrography, Electron Probe Micro Analysis (EPMA) and Scanning Electron Microscopy (SEM) have been carried out so far to characterize the internal textures, mineral compositions and thermal metamorphism of Adhi kot (EH4) and Khairpur (EL6) Enstatite chondrites.

Results and Interpretation: Adhi kot (EH4) enstatite chondrite is essentially composed of orthopyroxene + plagioclase + Fe-Ni metals (kamacite + taenite) + troilite + silica metal. The average chondrule's diameter is about 200µm to 500µm. Matrix is relatively less and coarse grained. Enstatite is the major silicate phase and shows porphyritic texture. The porphyritic pyroxene (PP) chondrules consist of enstatite ± albitic glass ± silica and opaque minerals (metals). Near end member enstatite (X_{Mg}=0.878-0.996), Si-bearing Fe-Ni metals (Si content ~ 3.5 wt.%), Mg-bearing troilite (Mg content ~ 3-12 wt.%) are the common mineral assemblages present in Adhi kot (EH4). Free silica grains (α-quartz) are also common in the matrix. Silica occurs as individual grains or within the interstices of enstatite grains, often mixed with albitic glass or plagioclase (X_{Ab}=0.86–0.92). It is also associated with metals and sulfides in some metal-sulfide nodules. Silica glass is also reported in the chondrule mesostasis. Sulfides and metals are major components, combingingly making up more than 40 vol.%. One of the characteristic features is the presence of wide variety of sulfides and metals like Fe-Ni metals (kamacite, taenite, awaruite, either Si bearing or Si free), troilite, oldhamite etc in Adhi kot (EH4). Sulfides and metals both occur within chondrules as inclusions, and outside chondrules as discrete grains, assemblages / cluster of grains and along cracks / fractures. The sulfide and metal chondrules are roughly irregular in shape having well-defined distinct boundaries. Chondrule sizes range from ~ 50 to 200µm, smaller than the silicate-rich chondrules (up to ~ 500µm). Metals occur in a variety of textural settings. Khairpur (EL6) enstatite chondrite is composed of orthopyroxene + olivine + plagioclase + clinopyroxene + Fe-Ni metals (kamacite and taenite) + troilite + magnetite + merrillite. The chondrules are essentially made of orthopyroxene and olivine ± plagioclase glass. The size of chondrules varies from 200 µm–1 mm (diameter). In Khairpur (EL6) the mineral chemical data of different textural variants of olivine ($Fa_{18-21}Fs_{79-82}$), orthopyroxene (clinoenstatite; X_{Mg}=0.81–0.83), clinopyroxene (augite to diopside; Wo_{45-46} En_{48} Fs_{5-6}) and plagioclase (albite to oligoclase; Ab_{81-86} An_{11-12} Or_{3-7}) suggests it is an equilibrated enstatite chondrite. Kamacite (Fe ~ 93-95% and Ni ~ 5-7%) and taenite (Fe ~ 59-66% and Ni ~ 34-41%) occur as equant and disseminated grains within matrix. In troilite, Fe and S vary from ~ 62-63 wt% and 36-37 wt% respectively. Troilite forms rim around silicate minerals (olivine and orthopyroxene). Calculated equilibration temperatures for a major mineral assemblage in enstatite chondrites range from 680 to 820°C (for Adhi kot and Khairpur). These temperatures are quite comparable to those estimated for ordinary chondrites from other mineralogical thermometers [2]. The calculated equilibration temperatures for Adhi kot (EH4) and Khairpur (EL6) fall into an interesting pattern. The temperatures increase from 680 to 820°C, and this may be correlated with increasing metamorphic grade, EH4 to EL6 [3].

Conclusion: The silicates, sulfides, and metal compositions in Adhi kot (EH4) and Khairpur (EL6) indicate highly reducing conditions in the solar nebula. Their mineralogy is very reduced, with nearly FeO-free enstatite as the dominant silicate phase, common free silica, Si-bearing kamacite and taenite, and in addition to Mg-bearing troilite, diverse sulfides largely unique to this clan such as oldhamite (CaS) as reported. Metals also occur as tiny (micron to submicron) blebs inside FeO-poor pyroxene, and appears to be formed as result of reduction. Metal-silicate intergrowth textures in which laths or euhedral crystals of enstatite are intergrown with Fe-Ni metals have also been observed. These textures have been interpreted to be the result of nebular condensation [4] whereas, more extensive survey of these intergrowths are argued that they were the products of impact melting [5]. This reduced mineralogy has suggested that these enstatite chondrites resulted from a condensation sequence in extreme reducing conditions [6,7].

References: [1] Weisberg M.K. and Kimura M (2012) *Chemie der Erde* 72:101–115. [2] Dutta A. and Bhattacharya A. (2017) *Unpublished Report of GSI* Field Season (FS) 2015-17. [3] Larimer J.W. and Buseck P.R. (1974) *Geochimica et Cosmochimica Acta* 38:471–477. [4] Weisberg M.K. et al. (1997) *LPSC XXVIII*, Abstract #1358. [5] Van Niekirk D. and Keil K. (2011) *Meteoritics and Planetary Science* 46:1487–1494. [6] Jacquet E. et al. (2015) *Meteoritics & Planetary Science* 50 (9):1624–1642. [7] Rubin A.E (1983) *Earth and Planetary Science Letters,* 64:201-212.