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Thermal metamorphism in type 3 Enstatite chondrites.

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Introduction:

Enstatite chondrites represent initial formation and metamorphism under highly reduced conditions. Like the other chondrite groups, the enstatite chondrites underwent various degrees of thermal metamorphism resulting in distinct petrologic types [1]. Type 3 chondrites are the least metamorphosed type among chondrite groups. For ordinary chondrites, Sears et al. [2] subdivided type 3 into ten finer divisions (type 3.0 through 3.9) using thermoluminescence (TL) sensitivity as an indicator of metamorphic grade. Subsequently, some mineralogical changes with increasing subtype have been identified [3]. An approach similar to that of [3] has been applied to enstatite chondrites [4]; however, a systematic understanding of metamorphic reactions has not been attained and metamorphic sub-types have not been established for enstatite chondrites. In this study, we examined 5 enstatite (EH3) chondrites in order to assess variations in texture and mineral compositions among the EH3 chondrites (ALHA81189, ALH84170, Sahara97096, Y-691, and PCA82518). We also compared these observations with EH4 (Indarch) and EH5 samples (St.Marks and LEW88180) to gain a broad perspective of metamorphism of EH chondrites.

Results and Discussion:

All of EH3 chondrites in this study are dominantly composed if FeO-poor pyroxene. Metallic and sulfide minerals occur as complex nodules which are composed of combinations of troilite, Fe-Ni metal, perryite, niningerite, djerfisherite, and daubreelite. Occasionally, oldhamite is also present.

ALHA81189 contains well-defined chondrules and chondrule fragments. Many chondrules are rimmed by silica or silica-rich rims in ALHA81189 and Y-691, whereas silica or silica-rich rims are not as abundant in ALH84170 and Sahara97096. In PCA82518, silica-rich rims were not identified. Instead, euhedral silica is observed inside chondrules.

Sulfide nodules are abundant in all EH3s. Sulfide/metal nodules in ALHA81189, ALH 84170 and Y-691 have sizes and shapes similar to silicate chondrules and are composed of combinations of troilite, kamacite, daubreelite, and niningerite. Generally, troilite and daubreelite occupy the cores of the spherules whereas kamacite usually occurs in the outer portions. Sulfides are more dispersed in PCA82518; the core-rim structure as described above is absent. In contrast, mixed sulfide/metal nodules are rare and sulfides tend to occur as dispersed crystals in Indarch (EH4), St. Marks (EH5) and LEW 88180 (EH5).

The Fa content of olivine, Fs content of pyroxene, and Ti and Cr contents in troilite show wide ranges of composition in the EH3 chondrites. Ti concentrations of troilite in ALHA81189 are lower than in the other EH3s, and those in PCA are the highest.

Based on the textural characteristics of EH3 chondrites, we can subdivide EH3s into 3 distinct groups: (1) Primitive, ALHA81189 and Y-691; (2) low degree of metamorphism, ALH84170 and Sahara 97096; moderately metamorphosed, PCA82518. This trend is supported by the chemical compositions of pyroxene and troilite; primitive EH3s have high Fs content in pyroxene and low Ti content in troilite, whereas metamorphosed EH3s have lower Fs content in pyroxene and higher Ti content in troilite. These results suggest that the reduction (lower f(O2)) occurred during thermal metamorphism [5].

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