

CHEMICAL EVOLUTION OF THE MATRIX OF SEMARKONA.

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Semarkona is one of the most primitive ordinary chondrites known. Semarkona and Krymka are classified as the only type-3.0 ordinary chondrites on the basis of texture, thermoluminescence, content of highly volatile elements and heterogeneity of silicates (1). Studies of chondrules from Semarkona (2,3) have confirmed the primitive nature of the meteorite. Even compared with chondrules in Chainpur (type 3.4), Semarkona chondrules show smoother CI-normalized abundance patterns and fewer elemental anomalies that cannot be related directly to nebular processes.

The fine-grained, opaque matrix of ordinary chondrites composes ~12 vol. %. Some workers have postulated that the matrix contains the bulk of the volatile elements in chondrites and that it has unfractionated amounts of all but the most volatile elements (4). Matrix is petrographically complex (5) and occurs in forms such as discrete lumps and chondrule rims. Previous studies that mainly relied on the electron microprobe to analyze matrix reported unusual compositions showing high Al/Ca and K/Na ratios. In one study (6), a large matrix lump from a type-3.7 chondrite, Allan Hills A77299, was analyzed by instrumental neutron activation analysis (INAA) and found to have a CI-like composition. I report here on INAA data for a suite of matrix samples separated from Semarkona.

The relative friability of Semarkona makes it an excellent candidate for disaggregation studies of unaltered components. A sample was obtained mainly for a study of its chondrules. During the course of separating ~175 chondrules, several samples of dark, fine-grained material, apparently rich in matrix, were also extracted. One of these was a large lump that yielded 4 subsamples ranging in mass from 0.2 to 2.1 mg. Another was taken from a thick (~300 μm) matrix-rim around a 7-mg porphyritic chondrule (also analyzed). Ten other samples, all of which appeared to be fragments of isolated lumps of matrix, ranged in mass from 0.2 to 0.7 mg. After INAA counting, polished mounts were prepared from each sample; these are currently being examined. Approximately 3 mg of the large lump remains for further study.

The matrix samples show a wide range of compositions, comparable in magnitude to the range shown by chondrules from Semarkona (2,3). Siderophile elements are especially variable. Petrographic examination revealed that this variability is at least partly caused by variations in modal amounts of coarse metal and sulfide. These phases are independent of fine-grained (<1 μm) sulfide (\pm metal \pm magnetite?) that is present in all matrix samples. Contamination by chondrule fragments does not contribute greatly to variation. As shown previously (5), individual lumps are relatively homogeneous. The four subsamples of the large lump are compositionally similar, but differ from the other samples in their Al/Ca, Na/K, Se/Fe and Ga/Ni ratios.

The matrix sample taken from the rim of a large chondrule shows no compositional relationship with its host chondrule. This matrix sample has a composition near the mean composition of all

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the samples of matrix lumps and is indistinguishable from them.

In Semarkona, average matrix composition is very different from that of the average chondrule. In matrix, nonvolatile lithophiles (Al, Ca, Sc, rare-earth elements, Mg, Cr, Mn) range from 0.8 to 1.0x the CI concentrations; in chondrules, the range is 1.8 to 2.2x CI. Matrix is enriched ~ 2 x CI in Na and K and >3 x CI in Cs; chondrules average ~ 1.4 x CI in Na and K, and have undetectable Cs (<1 x CI). All siderophiles (Ir, Os, Ni, Co, Fe, Au, As, Ga) are above CI levels in matrix and are <0.5 x CI in chondrules (except Fe ~ 0.6). The chalcophiles Se, Zn and Br are depleted in matrix relative to CI (0.9, 0.5, 0.6x CI, respectively) but are much higher than in chondrules (0.3, 0.04, 0.2x CI). A mass balance consisting of 12% matrix and 75% chondrules compared to bulk Semarkona indicates that these two fractions contain all the lithophile elements and Br. Chondrules contain ~ 90 % of the nonvolatile lithophiles and 60%-70% of the Na, K and Br. The remaining 13% of the mass, presumably rich in metal and sulfide, must account for $\sim 1/2$ of the total siderophile elements, Se and Zn.

The ubiquitous enrichments of Na, K, and Cs relative to other elements in matrix suggest that the matrix has scavenged volatile lithophiles lost during chondrule formation. These enrichments are not linked to any enrichments in Al, and thus are not due to differences in the amounts of feldspathic components. These data are in sharp contrast to microprobe data by this author and others that show correlations between Na and Al and anomalous enrichments of Al in Semarkona matrix. If we assume that chondrules and matrix initially had CI-like ratios of Na to refractory lithophiles, that relatively small amounts of refractories were vaporized, and that the accretion efficiencies of chondrules and matrix were equal, it appears that about 40% of the Na lost from chondrules recondensed onto matrix. A better assumption may be that all the Na recondensed onto matrix: then only 40% of the available matrix material accreted during the formation of Semarkona.

It is logical to assume that any other elements evaporated during chondrule melting also recondensed on matrix. However, volatile siderophiles such as Au and As show no enrichments relative to Ni in the matrices. The precursors of chondrules were probably metal poor; if the low amounts of siderophiles in chondrules were due to metal loss during melting, then volatilization followed by recondensation would have enriched matrix in these elements.

In ordinary chondrites, the fine-grained matrix is probably a mixture of solids that were never involved in chondrule formation (including coarse metal/sulfide grains) and recondensates from the vapor produced during chondrule melting. In Semarkona, chondrules were preferentially accreted relative to the matrix.

References: 1) Sears *et al.* (1980) *Nature* **287** 791-795. 2) Grossman and Wasson (1983) *GCA* **47** 759-771. 3) Grossman and Wasson (1985) *GCA*, in press. 4) Larimer and Anders (1967) *GCA* **31** 1239-1270. 5) Scott *et al.* (1984) *GCA* **48** 1741-1757. 6) Taylor *et al.* (1984) *LPS XV*, 848-849.