

THE ABUNDANCE AND DISTRIBUTION OF MODERATELY VOLATILE ELEMENTS IN SEMARKONA CHONDRULES. Jeffrey N. Grossman, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90024, USA.

A suite of 36 separated chondrules from the Semarkona (LL3.0) chondrite is being analyzed for major, minor, and trace elements, and petrologic properties. The surfaces of 7 chondrules were abraded off and analyzed. Our early results (1) agreed with the results from our previous study of the somewhat more equilibrated Chainpur (LL3.4) chondrite (2); most chondrules were produced by the sudden-melting of precursor grains that had formed in the solar nebula at a variety of temperatures. These precursor components, present in random amounts in the chondrules, were identified as 1) refractory metal, 2) non-refractory metal, 3) olivine- and refractory-rich, Fe-poor silicates, 4) pyroxene-rich, Fe-, Cr- and Mn-bearing silicates, and 5) a volatile lithophile component. It was not clear whether the volatile lithophiles were actually in their own precursor grains, or whether they covaried as the result of volatile loss during chondrule melting. We now present evidence that volatilization played an important role in determining the abundances of elements sited in fine-grained precursor materials, whereas abundances of other elements of similar volatility but located in coarse precursor grains were mainly affected by variations in the relative amounts of different precursors. The loss of volatiles from molten chondrule droplets seems to have been minor.

Figure 1 shows the relationship between Na and K in the chondrules. The data are corrected for the diluting effects of metal and sulfide. The host meteorite, Semarkona, has an essentially solar K/Na ratio, and plots near the middle of the chondrule distribution. Unlike Chainpur chondrules, Semarkona chondrules show an excellent K-Na correlation (>99% confidence). Figure 2 shows that K/Na tends to increase with increasing Na (and K) content; the two exceptions at low Na concentration have very low concentrations of both elements. This trend might be produced by the mixing of two precursor components with different K/Na ratios. However, a more plausible explanation is that samples with low K/Na ratios experienced volatilization during melting, preferentially depleting the more volatile element, K. Samples enriched in K may have scavenged the K-enriched alkalis volatilized out of low-alkali chondrules. This interpretation requires that the precursor materials of each chondrule have Na and K contents similar to whole rock Semarkona. In fact, this is a reasonable assumption since the alkalis probably condensed as coatings on the surface of Al-bearing grains; surficial Al may have been about equally available in coarser, refractory-rich and finer, volatile-rich grains. Elements mainly sited in the interiors of precursor grains were probably less homogeneously distributed.

According to this scenario, the abraded surfaces (especially of alkali-enriched chondrules) should show high K/Na ratios compared to the chondrule interiors. Five of seven showed K/Na ratio significantly higher than that in the whole chondrule, with only one ratio being $\approx 1.2X$ that in the whole chondrule. In most cases the absolute Na and K concentrations on the surfaces were higher than in the whole chondrules, but in all cases the amount of

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alkalis in the interiors exceeded the amount in the surface materials. This confirmed the results of our etching experiments on Chainpur chondrules; the loss of Na and K from molten chondrule droplets was minor. Alkali loss in low Na chondrules seems to have occurred as the result of those elements being flash volatilized from fine precursor grains or thin surface deposits.

Other moderately volatile elements behave differently than Na and K. Ge and Se both correlate well with siderophiles. Presumably, Ge was in the metal and Se in the FeS grains at the time of chondrule formation. Neither element correlates with Na, because metal and FeS were inhomogeneously distributed in the precursor material, but also because loss from the interiors of coarse grains was minor or negligible. Chondrule surfaces are strongly enriched in both siderophiles and Se, but do not have systematically high Ge/Ni or Se/Ni ratios as would be expected if volatilization followed by recondensation were important.

Bromine correlates with Se and seems to have condensed with sulfides. We note that the ionic radii of Br^- and Se^{2-} are nearly identical, and that sulfides are notoriously nonstoichiometric. Zinc is not correlated with any other element, including Se. Its abundances in Semarkona chondrules are low compared to those in Chainpur chondrules, although the whole-rock Zn concentration of $\sim 60 \mu\text{g/g}$ is normal for an ordinary chondrite. The Zn/Mg ratio in chondrules averages $\sim 15\%$ of the whole rock value, or $\sim 3\%$ of the solar ratio. Like siderophiles and chalcophiles, Zn concentrations are higher on the surfaces than in the interiors. Since the average chondrule shows only minor depletions in Na, K, and other moderately volatile elements, it appears that the very low concentrations of Zn were not the result of volatilization from molten chondrite droplets. It seems more probable that Zn was in the gas or in a very fine-grained volatile phase that evaporated during chondrule formation. Since most of the Zn was in the matrix when chondrite accumulation occurred, it is noteworthy that it shows little variation among the petrologic types.

References: 1) Grossman, J.N. and Wasson, J.T. (1981) LPS XII, 371.
2) Grossman, J.N. and Wasson, J.T. (1982) GCA, in press.

Figure 1:

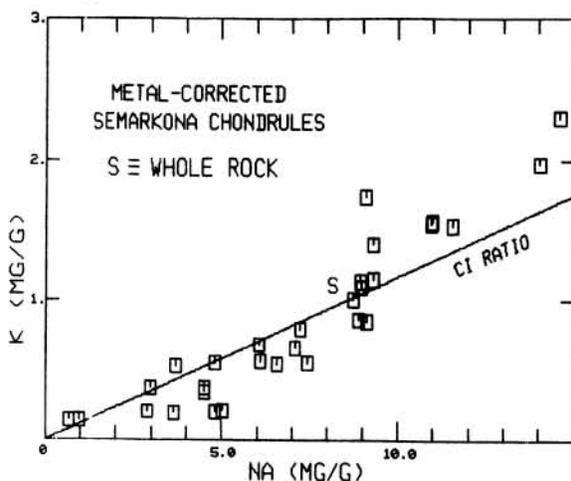


Figure 2:

