Meteoritics 28, 607–608 (1993)

From the Editors

The case of the not-so-missing sodium

Few topics in meteorite research have generated as much controversy as volatile loss from chondrules. The question goes straight to the heart of chondrite genesis. In the present issue of *Meteoritics*, Dean Lewis and his colleagues report on a new genre of experiments aimed at exploring volatile-loss from chondrules in atmospheres other than the canonical solar gas.

Larimer and Anders (1967) suggested that the main factor driving chondrite compositions and, therefore, responsible for the nine major chondrite groups, was the proportion of volatile-poor chondrules (metal and sulfide was also considered part of the high-temperature chondrule-mix) and volatile-rich matrix. A great many ramifications follow from this heroic suggestion, and a great many authors did not like the idea. Elements which did not fit a mixing pattern were no problem as they could be explained by partial loss during chondrule formation. But a serious blow for the idea was that, when pulled out of the meteorite, chondrules did not prove to be especially volatile-poor. In fact, their compositions were similar to that of the bulk rock, and this applied to oxygen isotope ratios too.

Thus was borne the idea that the chondrite compositions were fixed before chondrule formation and that chondrule formation itself was an interesting irrelevancy. Although the elemental abundance patterns in chondrites are driven by volatility, why should the thermal event not be nebula-wide cooling rather than chondrule heating? Why not make the chondrites from appropriate mixtures of condensation products?

But volatile-loss from chondrules has proved difficult to dismiss entirely. Laboratory experiments with silicate melts always result in considerable Na-loss. In their present paper, Lewis *et al.* also find that Na is lost very rapidly from their charges under normal circumstances. Of course, laboratory conditions can never entirely emulate Nature, which apparently found a way to prevent volatile-loss. Enhancing the oxygen fugacity over the cosmic value by many orders of magnitude, perhaps by increasing the dust-to-gas ratio, makes Na more refractory by stabilizing Na_2O. In the present issue, Lewis *et al.* perform the melting experiments in a Na-rich atmosphere, as if the chondrule being immersed in a clump of Na-rich grains, and find that not only is Na retained but actually increases as Na gas recondensed during the experiment.

Of course, hindsight is always 20/20 and much of the original controversy could have been avoided if the question had been deferred for 20 years. We now know that most chondrules have experienced metamorphism sufficient to alter the compositions of their chondrules, and we now know that chondrules come in a variety of classes (*e.g.* Sears *et al.*, 1992). There was no such thing as a single chondrule forming event, but the event took a variety of forms and intensities. If we look at the chondrules in Semarkona, probably the closest we have to unmetamorphosed material, 35% of the chondrules were totally melted and are volatile-poor. In short, the chondrules examined in the early work were largely from metamorphosed meteorites and excluded the volatile-poor chondrules.

We still do not know if the Anders-Larimer idea was essentially correct. It is clear that much of their discussion was over-simplified. On the other hand, we now know that many of battery of arguments used against their ideas were also over-simplified. Such is progress.

In the last few years, several chondrules have been found in Semarkona in which the Na concentrations are much higher in the outer regions of the chondrule glass than in the central regions. The normally inconspicuous effect stands out well during cathodoluminescence and thermoluminescence observations (Fig. 1). Additionally, a whole class of chondrules exists, called the A5 class, in which bulk Na concentrations are often higher than bulk chondrite values. To me, the most interesting aspect of Lewis *et al.'s* work is that they have found experimental evidence that Na recondenses into the chondrules on the timescales of their experiments. Recondensation is the favored way to explain the Na-zoning in the chondrule glass in Fig. 1 and the high bulk Na values of some A5 chondrules. Another important twist has been added to the chondrule formation story. We must now take into account the possibility that Na and the other volatile elements, once lost, may have recondensed into the chondrules.

Derek Sears
Editor

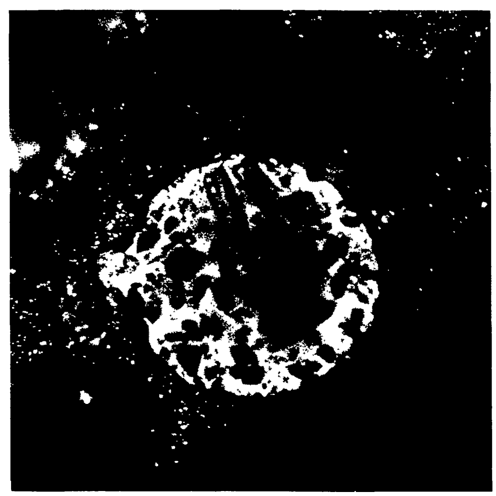

Fig. 1. The cathodoluminescence of a large group A1 chondrule in Semarkona (LL3.0). The higher Na content of the outer region of the chondrule glass, between the olivine grains, luminescences more brightly than the Na-poor region in the center (from Matsunami *et al.*, 1993).

REFERENCES

LARIMER J. W. AND ANDERS E. (1967) Chemical fractionations in meteorites. II. Abundance patterns and their interpretation. *Geochim. Cosmochim. Acta 31*, 1229–1370.

SEARS D. W. G., LU JIE, BENOIT P. H., DEHART J. M. AND LOFGREN G. E. (1992) A compositional classification scheme for chondrules. *Nature*, **357**, 207–210.

MATSUNAMI S., NINAGAWA K., NISHIMURA S., KUBONO N., YAMAOTO I., KOHATA M., WADA T., YAMASHITA Y., LU J., SEARS D. W. G. AND NISHIMURA H. (1993) Thermoluminescence and compositional zoning in the mesostasis of a Semarkona group A1 chondrule and new insights into the chondrule-forming process. *Geochim. Cosmochi. Acta* **57**, 2102–2110.