LATE NEBULAR CONDENSATES AND OTHER MATERIALS COLLECTED BY THE
METEORITE PARENT BODIES

Jan Hertogen, Marie-Josée Janssens, Herbert Palme, and Edward Anders
Enrico Fermi Institute, University of Chicago, Chicago, Illinois 60637

Meteorites are a biased sample of material in the asteroid belt. However, some brecciated meteorites carry strange xenoliths, and gas-rich regolith breccias, in particular, contain a representative sample of dust in the region of the meteorite parent bodies. Often these materials are too degraded for petrographic study, but can still be characterized by chemical techniques, such as those developed for identification of crater-forming bodies on the Earth and Moon.

We have analyzed 20 trace elements in a carbonaceous inclusion from the Krymka LL3 chondrite, and in light and dark portions of 3 gas-rich achondrites. The Krymka inclusion is a unique, volatile-rich material, probably a late nebular condensate ("mysterite"; 1,2). Among the 3 gas-rich meteorites, the howardites Jodzie and Kapoeta contain mainly C2 material, whereas the aubrite Khor Temiki contains a small, poorly defined meteoritic component resembling E-chondrites. The composition of dust in the inner solar system seems to vary with distance, from mainly C1 chondrites at the Moon (3,4) to mainly C2 chondrites at the howardite parent body (5,6) to E-chondrites at the aubrite parent body.

Krymka Inclusion. This inclusion, obtained through the courtesy of the late Dr. L.G. Kvasha, shows a slight but distinctive fractionation relative to C1 chondrites (Fig. 1).

The first 7, least volatile elements fall within the error bars of the C1 values (except for Re, which is enriched relative to C1's in nearly all chondrite classes). Of the next 8, lithophile and chalcophile volatiles, most are depleted by a factor of -0.7. (Exceptions are Zn, Cd, and Br, but the latter may be due to contamination.) Finally, among the 5 siderophiles, Sb and Ge (T_{cond} = 1100 - 900 K) are undepleted, whereas Ag, Bi, and Tl (T_{cond} = 900 - 400 K) are enriched by a factor of -1.6.

This enrichment of siderophile volatiles is the chief characteristic of "mysterite", a late condensate first postulated by Laul et al. (1) in Supuhee and Krymka, and later found in Supuhee as dark clasts (2,7,8).
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Now an inclusion having the properties of mysterite has been confirmed in Krymka as well. But as with Supuhee, the inclusion does not have the high Tl/Bi ratio that characterizes the bulk meteorites (see bulk Krymka points in Fig. 1). Another source must exist for the excess Tl, as discussed by Higuchi et al. (2).

Lewis et al. (9) have analyzed noble gases in a portion of the Krymka inclusion. Their data (Fig. 2) show that the inclusion contains much more gas than either bulk Krymka or Cl chondrites, but less gas (and a different pattern) than the HF, HCl-insoluble residue from Krymka, which accounts for most of the noble gases in the meteorite (10). The inclusion cannot simply be Krymka matrix, because as little as 2-3% of inclusion could account for all the Ne and Ar in the meteorite, and the matrix content of Krymka is surely higher than 10%. On the other hand, the inclusion resembles C3O chondrites such as Kainsaz (11) in its high Ar/Xe ratio, as evidenced by the flat pattern from Ar to Xe (Fig. 2). Kainsaz contains 30 vol. % matrix (12), and so Kainsaz matrix, among known materials, would seem to be the closest match to the Krymka inclusion. However, it is not rich enough in Ne, Bi, Tl, Cd, etc. Thus the Krymka inclusion apparently represents a unique lower-temperature condensate.

Gas-rich Achondrites. Of the 3 meteorites analyzed, the howardite Jodzie shows the largest enrichments in the dark portion (Fig. 3; the numbers above the bars are the abundance ratio dark/light). The net pattern closely resembles that of average C2 chondrites, except for the higher Re value and a slightly higher abundance of volatiles, which may imply a slight admixture of C1 material. This is hardly news, because Mazor and Anders (13) suggested 11 years ago that Jodzie contained C1 or C2 material, whereas Bunch (14) actually observed C2 fragments in Jodzie. Chou et al. (6) also concluded, from trace element data, that howardites contained C2 material, but did not acknowledge the earlier work.

The howardite Kaposka shows a similarly flat pattern, but with a lower
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ratio of volatiles to siderophiles. C2 chondrites must be an important component, as shown by Wilkening (5), but the low abundance of volatiles suggests contributions by other meteorite classes.

The aubrite Khor Temiki has only a small meteoritic component (0.3% Cl chondrite equivalent), but its pattern is quite distinctive, and matches that of E-chondrites rather than C2 chondrites. It is not surprising that enstatite chondrite dust is present on the enstatite achondrite parent body. But it is surprising that this dust dominates over the Cl-C2 mix that predominates on the Moon (3) and on the howardite and H-chondrite parent bodies (5,6). Apparently the aubrite parent body is situated in an isolated location, where locally produced E4 dust swamps the Cl-C2 mix from more distant, asteroidal and cometary sources. Of the 3 E-type asteroids proposed by Zellner et al. (15) as aubrite parent bodies, 434 Hungaria (a = 1.94 AU, well outside the main belt) would seem to be a more likely candidate on these grounds than 44 Nysa (2.42 AU) or 64 Angelina (2.68 AU).

References: