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CHEMICAL COMPOSITION OF METEORIC AND METEORITIC MATTER

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A comparison has been made of the data of Millman's (1972) work on the relative content of Na, Mg, Ca and Fe in Draconids (Giacobinids) with corresponding data for carbonaceous chondrites of type CI, CII, CIIIV, and CIIIO and ordinary chondrites of type H, L and LL. The correlation of values Fe/Mg, Na/Mg and Ca/Mg in Draconids agrees with their successive change in carbonaceous chondrites from CIIIV to CI. By its composition, meteoric substance is more distant from CIII than from CI. This result agrees with the idea that cometary matter condensed farther away from the sun and contains lighter volatile components, than CI chondrites.

The chemical composition of comets, or, to be more exact, of the nonvolatile component of their nuclei, is believed by some authors (Anders *et al.* 1973) to resemble that of CI carbonaceous chondrites, the type containing the relatively largest amount of volatiles - water, sulphur, carbon compounds, etc. Anders *et al.* (1973) regard this assumption as confirmed by the data of Millman, giving the results of the spectral analysis of the particles of the Draconids (Giacobinids). In his paper (Millman 1972) has established a similarity of relative Na, Mg, Ca, and Fe contents between the Draconids and the olivine-bronzite chondrites (type H).

But compared with chondrites, the meteor substance is richer in sodium; this also suggested by other studies, of meteor spectra (Saidov 1972) and of metal ions contained in the upper atmosphere in the period of meteor showers (Goldberg and Aikin 1973).

Millman (1972) assumes, after B. Mason, that H chondrites, for their part, resemble in composition the nonvolatile component of the carbonaceous chondrites. That is true in first approximation only, for carbonaceous chondrites generally differ from H chondrites in Mg and Ca content. Besides, H chondrites belong to ordinary chondrites, a grouping including two more types - L and LL. Carbonaceous chondrites, on the other hand, also comprise three types by their chemical composition - CI, CII, and CIII (Yavnel' 1973) that show the increase of volatile components at transition from CIII to CI. CIII chondrites subdivide into two subtypes - CIIIV and CIIIO, with the meteorites CI, CII, and CIIIV constituting the main sequence of carbonaceous chondrites (Yavnel' 1975).

Owing to the relatively high accuracy of analysis of meteoric particles (±2 - 8 percent), it is possible to compare their composition with that of the separate types of ordinary and carbonaceous chondrites. To this end, I converted the data of Millman (1972) to average ratios of Fe, Ca, Na content to

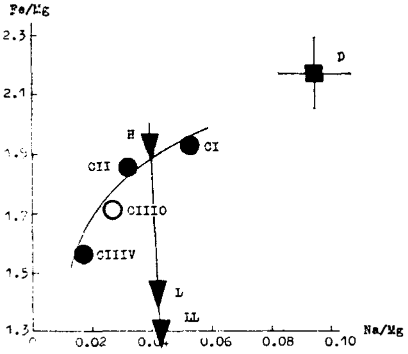
Mg content, and carried out a similar calculation of average values for chondrites on the basis of the latest survey of chemical composition of meteorites (Mason 1971), and for the carbonaceous chondrites CIIIV and CIIIO, on the basis of published data. The results are given in Table I.

TABLE I

RELATIVE (WEIGHT) CONTENTS OF Fe/Mg, Ca/Mg, AND Na/Mg IN DRACONIDS (D) AND IN VARIOUS TYPES OF CHONDRITES

Type	Fe/Mg	Ca/Mg	Na/Mg	Type	Fe/Mg	Ca/Mg	Na/Mg
D	2.17	0.086	0.095	CI	1.93	0.111	0.053
H	1.94	0.084	0.040	CII	1.86	0.114	0.032
L	1.44	0.084	0.042	CIIIV	1.56	0.124	0.017
LL	1.31	0.082	0.043	CIIIO	1.71	0.107	0.026

The comparison of the ratios must be indicative enough, since, according to Anders (1972) and to Yavnel' (1975), Fe, Ca, and Na belong to different cosmochemical groups of elements. Iron is a refractory siderophile element ; calcium, a refractory lithophile element; and sodium (in carbonaceous chondrites), a volatile lithophile one. As is seen from Table I, the meteor data do not coincide with any type of ordinary or carbonaceous chondrites, but warrant a judgment about the tendencies in the variation of the composition of chondrites and meteors.



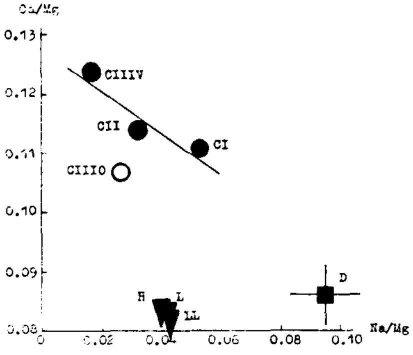


Figure 1. Relation Fe/Mg vs. Na/Mg in Draconids (D), ordinary (H, L, LL) and carbonaceous (CI, CII, CIIIV, CIIIO) chondrites.

Figure 2. Relation Ca/Mg vs. Na/Mg in Draconids (D), ordinary (H, L, LL) and carbonaceous (CI, CII, CIIIV, CIIIO) chondrites.

This is visualized by diagrams (Fig. 1 and 2), with the element ratios plotted on the axes. The Fe/Mg vs. Na/Mg curve reveals the different behavior of Fe and Na in ordinary and carbonaceous chondrites: with growing relative Fe content, the content of Na in ordinary chondrites slightly declines, while in carbonaceous chondrites it sharply increases. These data for the meteors correspond to the tendency observed in carbonaceous chondrites. The Ca/Mg vs. Na/Mg curve clearly shows a different behavior of sodium and calcium, which greatly differ in volatility, especially in carbonaceous chondrites. Again, the relative content of these elements in meteors looks rather like a continuation of their variation in carbonaceous chondrites at transition from CIIIV to CI. The comparison of the composition of the meteor substance and carbonaceous chondrites, therefore, shows that, by Fe/Mg, Na/Mg, and Ca/Mg ratios, the Draconids are even more distant from CIII than from CI carbonaceous chondrites.

In view of the connection between meteor streams (in particular, the Draconids) and comets, this result is consistent with the notion of the comet substance being richer in volatiles than CI chondrites, and also with my assumption (Yavnel' 1957) that beyond the bodies from which the carbonaceous chondrites originated, there could have been, nearer to Jupiter, the bodies from which the comets originated.

Certainly, for a comparison of composition of cometary substance with that of meteorites, the data of a spectral analysis of sun-grazing comets would be desirable. But a quantitative determination of chemical composition of comets from their spectra is no less difficult than for meteor spectra, so that usually only approximate estimates can be obtained. In particular, from spectroscopic study of comet Ikeya-Seki (1965f) (Preston 1967), Fe/Mg weight ratio is estimated to be larger than 2.9, which exceeds its value not only in chondrites, but also in Draconids (cf. Table I).

Yet, the comparison of the composition of meteorites and comets is essential for elucidating the source from which the former originated. Anders (1975) showed that a cometary genesis of carbonaceous chondrites is not confirmed by any argument other than their being of a similar composition with meteor substance. Other data - the abundance of gas-rich meteorites, including those not associated with the early irradiation in interplanetary space, and the occurrence of xenoliths (inclusions in meteoritic breccias) of an asteroidal origin - contrary to the hypothesis of formation of stone meteorites, including the carbonaceous chondrites, from comets.

Even the sole remaining argument, that of similar composition, is thus not confirmed, so that an asteroidal origin of all meteorite classes remains the most plausible hypothesis.

This paper confirms the results of my earlier study (Yavnel' 1974), to which it adds some extentions and revisions.

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DISCUSSION

MILLMAN: Yavnel' has drawn conclusions from my experimental values of meteoroid chemical composition which may not be warranted by the possible errors in these original data.