COMET NUCLEUS MATTER: SOME PREDICTIONS

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The first results of the dust analysis of comet Halley 1986 show that within a factor of two the average dust composition is chondritic for the major elements [1]. In other words, the ratios of nonvolatile elements in cometary dust and chondrites approach those of the Solar system (Sun, cosmic) [1], indicating the chemical primitivity of these materials. It was commonly anticipated that cometary matter would be chemically primitive and, although total conformity has not yet been attained, it can now be considered as directly proven (e.g. [2]). Here I suggest that if we know only that the cometary matter is chemically primitive, we can predict some of its characteristics.

The most studied of the chemically primitive materials are the chondrite meteorites. They are well known to be depleted in the most volatile elements (C, H, N) relative to the Sun (e.g. [3]). The carbonaceous chondrites (CC's) reveal the smallest depletions of C, H, and N and are considered to be chemically the most primitive ([4,5] and others). As one can see in **Fig. 1**, the groups of CCs are arrainged by volatile content to form a sequence from C, H, N–poor CO chondrites to C, H, N–rich CI chondrites. This sequence is proposed as a measure of chemical primitivity: the richer a chondritic material in C, H, N (i.e. the less deficit of volatiles relative to the Sun), the more chemically primitive it is. Since these elements all reveal a roughly uniform trend, any of them can be used as a measure of primitivity.

Based on this, and taking into account that for the dust of comet Halley the abundance of C has been deduced more certainly than H and N [1], one can compare that cometary dust with the other members of the primitivity sequence using the carbon abundance (**Fig. 2**). As one can see, it is the cometary matter that becomes now the chemically most primitive material in the proposed sequence.

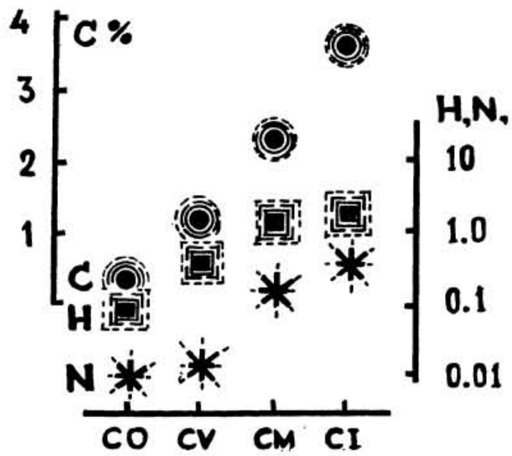

Fig. 1. C, H, and N contents in CC's groups. Data from [5,6] for C, [5] for H, and [7] for N (data from [6] not used becasue of the loss of H_2O released below 200°C).

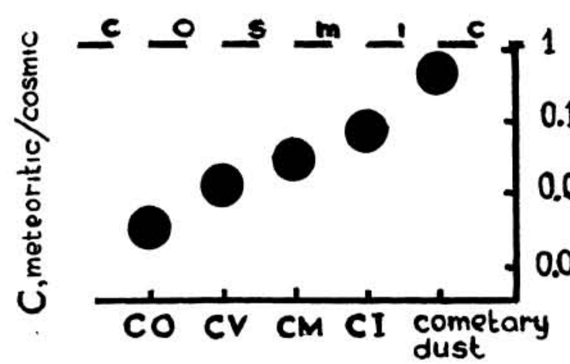

Fig. 2. C abundance in CC's groups and cometary dust relative to its cosmic abundance. Data from [5] for CCs, [1] for cometary dust, and [8] for cosmic abundance.

Note that this sequence was formed using widely known information, but as a result we have a sequence which becomes prognostic, if one assumes the validity of "linear" extrapolation. Following this extrapolation logic some properties of comet nucleus matter (CNM) can be predicted.

1. For all CCs the absolutely predominant form of carbon is organic matter [9,10]. So, the same should be true for CNM also.

2. For all CCs the organic matter exists in two analytical forms: largely hydrocarbon material (bitumen) that is extractable with organic solvents and macromolecular material (kerogen) that is insoluble in organic solvents, the first being more mobile and the last being closely associated with carbon–free minerals (at the submicron scale) [9,10]. So, both forms or organic matter could be in CNM too.

3. For all CCs bitumen is a minor, mainly aromatic, constituent [9,10,11]. But in the sequence from CO to CI chondrites the yield of bitumen slightly increases [9,10] (table). So, for CNM one should expect more abundant bitumen yield than in CCs.

4. For all CCs most of the organic matter is present as kerogen which consists essentially of a condensed, highly aromatic network [9–13]. However, in the sequence CO–CV–CM–CI the average d(002) interlayer spacing in kerogen increases [14,9] (table). It indicates that as the degree of ordering of the materials in the sequence decreases, the material becomes more and more amorphous.

5. If the terrestrial analogues of organic matter in CCs are selected using a complex of properties (but not by origin!) based on [15], the best ones would be high anthraxolite (e.g. shugite) for CO, CV and low anthraxolite–high kerite (e.g. impsonite) for CM, CI [16]. So, the terrestrial analogue to CNM could be approximately low kerite (e.g. albertite) and perhaps even asphaltite which, in contrast to previous forms, is almost completely extractable. Note that all these materials remain largely aromatic.

6. For all CCs the main host phases of hydrogen are both organic matter and hydrated minerals, largely phyllosilicates [10]. So, in CNM hydrogen should be present not only in organic matter and in water–ice, but also in phyllosilicates.

7. In the sequence from CO to CI the amount of high–temperature water–free minerals decreases, while the amount of mixed–layer phyllosilicates and the portion of noncrystalline material increases [5,10,17,18]. So, in CNM the high–temperature phases should be very scarce and the mixed–layer would be expected to be composed of poorly–ordered phyllosilicates rather than silicates.

	CO	CV	CM	CI	Ref.
Yield of bitumen, % (whole rock, hot extraction)	0,n	0,n	1–2	~2	[9]
Bulk kerogen, d(002), A.	3.5	3.5	3.6–3.7	3.8	[9,14]
Dominant matrix phases and matrix/refractory phases	pyroxene +olivine 34/61	pyroxene +olivine 42/54	phyllo- silicates 48/42	phyllo- silicates 99/1	[5,17]

This style of prediction and extrapolation could also be applied to present and future data analysis.

In summary, according to the above predictions, the main constituents of comet nucleus matter should be phyllosilicates, aromatic amorphous organic matter, and, evidently, water–ice*. If this is the case, the H_2O–gas observed in the coma (e.g. [19]) could be a product of, not only ice evaporation, but also dehydration at temperatures of ~100°C [20]; the very low albedo of the nucleus surface [21] could be explained by not only the crust of porous refractory material covering the icy nucleus [20], but also by the coating of dust particles by soot which could be a product of the incomplete combustion of organics or its recondensation (as it has be argued for the surface of Phobos [22]); at least the comet nucleus could be not only a "dirty snow–ball" (F.L. Whipple and many others), but a "fetid dirt–ball".

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*May be H_2O ice was present originally in CI's too? Just after its fall in 1864 Orgueil was soft and could be cut with a knife [10].