

MASS AND SPATIAL DISTRIBUTION OF CARBONACEOUS COMPONENT IN COMET HALLEY; M. Fomenkova, California Space Institute, UCSD, La Jolla, CA 92093-0216 and S. Chang, NASA Ames Research Center, MS 239-4, Moffett Field, CA 94035

Cometary grains containing large amounts of carbon and/or organic matter were discovered by in situ measurements of cometary dust composition during VEGA and GIOTTO fly-by missions [1]. In accordance with the classification [2] for the data of PUMA-1 and PUMA-2 mass-spectrometers onboard the VEGA spacecraft, particles with a ratio of C to any rock-forming element (Mg, Si, Fe, Ca etc.) >10 , were categorized as CHON. There are 464 such particles in PUMA-1 data and 51 in PUMA-2 data. Application of cluster analysis to these grains [3] revealed several distinct compositional classes, namely: [H,C,N,O], [H,C,N], [H,C], [H,C,O], [C,N], [C,O], [C,N,O] and [C]. Similar classes were identified among particles analyzed by PIA [4]. Also, about a third of all particles fell into groups [H] and [O] characterized by abundances of these elements beyond chemically reasonable limits.

The most numerous [H,C,N,O] particles are dominated by large grains $>10^{-13}$ g (Table) and distributed along the whole trajectory (Figure). They display variable H:C:N:O ratios and, most probably, are multicomponent mixtures. The [H,C,N] group is dominated by medium particles 10^{-15} - 10^{-13} g. Particles of this group are hypothesized [3] to contain nitrogen in aromatic heterocycles, or in amine, imine or nitrile substituents attached to basic hydrocarbon structures. Particles of the [H,C] group are uniformly distributed in all mass ranges and identified as mixtures of aliphatic and aromatic hydrocarbons alone or with carbon grains. The peak occurrence of [H,C,N] and [H,C] particles on the inbound leg of the VEGA-1's trajectory [about 3×10^4 km from the nucleus] appears to be shifted further from the nucleus than that of [H,C,N,O] particles. These shifts suggest possible transformations [H,C,N,O] \rightarrow [H,C,N] \rightarrow [H,C] caused by solar flux dependent factors. Alternatively, compositional asymmetry within the coma may reflect the heterogeneity of sources on the nucleus.

Another peak in occurrence of the [H,C,N,O], [H,C,N] and [H,C] particles and a peak in occurrence of the [H,C,O] particles [uniformly represented in all mass ranges] are centered near the closest approach. Possibly these particles readily decompose by evaporation after coming out of the nucleus, thus yielding formaldehyde and CO which appear to originate from a distributed source in the coma [5].

Particles of the [C, N] and [C,O] class are more abundant among small grains $<10^{-15}$ g while [C,N,O] particles are represented in all mass ranges. The small number of particles is insufficient for any further conclusions about mass or spatial distribution. These grains were tentatively identified as made up of polymers of cyanopolyynes and multicarbon monoxides, monomeric species of which were observed in the interstellar media [6].

[C]-particles strongly prevail among small grains. This is consistent with estimates of the sizes of circumstellar and interstellar carbon particles [7]. Mass loss from carbon stars may have contributed up to 50% of all matter injected into interstellar medium, and grains of interstellar origin are believed to represent a significant part of cometary dust [8]. These particles are the most abundant at the outermost segment of the trajectory and more or less uniformly distributed otherwise. The appearance of these particles does not seem to correlate with any other classes of CHON particles and they may represent a special population of cometary grains.

The majority of CHON particles was noted [3, 9] to contain a minor mineral component, although the ratio of carbon to these elements was very high. Only 40 spectra measured by PUMA-1 are "pure" CHON [9%] (the PUMA-2 data on minor elements are not reliable [3]). Almost all pure CHON grains were encountered before the closest approach (Figure). Particles with a total lack of rock-forming elements are not randomly scattered among all classes, but rather many of them are grouped together in a few clusters within [H,C,O] and [H,C,N,O] classes, the latter being chara-

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cterized by the lowest C/N ratio of about 3. In contrast, all particles of the [H,C,N], [C,N] and [C,N,O] group contain a minor mineral component and the C/N ratios vary from 8 to 50. Note that particles were combined into clusters according to the composition of their organic component while ignoring their mineral composition. Thus, the emerging correlation between composition of organic part and the lack of rock-forming elements in some groups is quite surprising.

Table. Mass distribution of different types of CHON particles. Percentages are relative to the total number of spectra in each mass range. PUMA-1 and PUMA-2 data.

mass range	H,C,N,O		H,C,N		H,C		H,C,O		C,N		C,O		C,N,O		C	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
<10 ⁻¹⁵ g	8	6	3	2	17	12	9	6	4	3	3	2	1	1	51	36
10 ⁻¹⁵ g - 10 ⁻¹³ g	41	19	28	13	18	8	15	7	5	2	1	<1	4	2	33	15
>10 ⁻¹³ g	52	33	11	7	13	8	4	2.5	1	1	-	-	3	2	16	10

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Figure. The distribution of CHON particles of different types along the trajectory of the VEGA-1 spacecraft. Data were averaged by 60-seconds moving window. Vertical lines show occurrence of "pure" CHON particles. At the closest approach the distance to the nucleus was about 8900 km.

