

**COMPARATIVE INVESTIGATION OF ORGANIC COMPONENTS IN THE MURCHISON (CM2) AND KAINSAZ (CO3) CARBONACEOUS CHONDRITES.** M. A. Zaitsev<sup>1</sup>, M. V. Gerasimov<sup>1</sup>, E. N. Safonova<sup>1</sup>, M. A. Ivanova<sup>2</sup>, C. A. Lorenz<sup>2</sup>, A. V. Korochantsev<sup>2</sup>, Yu. P. Dikov<sup>3,1</sup>. <sup>1</sup>Space Research Institute of RAS, Profsoyuznaya St. 84/32, Moscow, 117997, Russia, [mgerasim@iki.rssi.ru](mailto:mgerasim@iki.rssi.ru); <sup>2</sup>Vernadsky Institute of Geochemistry, Kosygin St, 19, Moscow 119991, [meteorite2000@mail.ru](mailto:meteorite2000@mail.ru); <sup>3</sup>Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Staromonetnyi St. 35, Moscow, 119017, Russia.

**Introduction:** Organic compounds (OC) together with other volatile components can be indicators of nebular sources and parent-body processing of carbonaceous chondrites. Analytical methods for OC must be selected with due consideration, since OC are unstable and have a wide range of volatility. Pyrolytic gas chromatography-mass-spectrometry (Pyr-GC-MS) is one of the main methods used for OC analysis in meteorites. We applied Pyr-GC-MS analysis to analyze the bulk meteoritic material. Here we report preliminary results of a comparative study of organic components in the Murchison (CM2) and Kainsaz (CO3) meteorites. In the first step of this study, the aim was to compare OC of low and high metamorphosed carbonaceous chondrites. In the second step of the study, we attempted to compare OC in products of simulated hypervelocity high-temperature vaporization to investigate possible response of the OC pattern to impact processing.

**Analytical procedure and samples.** Pieces of Murchison and Kainsaz were obtained from the Russian Academy of Sciences. Samples were prepared for analysis by powdering selected portions of bulk meteorite material. Chemical components were extracted from the samples by thermo-desorption (at 460°C) and pyrolysis (at 900°C) in a flow of He and analyzed using a Chromatec Crystal 5000.2 chromatograph equipped with DSQ II quadrupole mass-spectrometry detector. Hypervelocity high-temperature vaporization was simulated using the standard laser pulse method [9].

**Results.** The thermo-desorption of both meteorites at 460°C showed a big variety of organic compounds. Among them we recognized cyclic and acyclic aliphatic hydrocarbons, up to C20, aromatic hydrocarbons, including benzene, naphthalene and their derivatives, unsaturated hydrocarbons, thiophene and alkylthiophenes, carbonyls, and nitriles. The CO<sub>2</sub> gas was also released. Relative abundances of the hydrocarbon components in each sample at thermo-desorption are almost similar (Fig. 1). However, unsaturated hydrocarbons are more abundant in Murchison (3.3%) than in Kainsaz (~1.0%). Carbonyls are present in large amounts in Kainsaz in comparison with Murchison. Organic sulfides and S-S disulfides that break down at low temperatures are present in Murchison and com-

pletely absent in Kainsaz analysis. We did not find any S-S bridge structures in Kainsaz.

The pyrolysis products appears to be material derived from the macromolecular compounds decomposition. We recognized CO<sub>2</sub>, benzenes, and alkanes for both meteorites, but the greater diversity of compounds was observed in Murchison – naphthalene derivatives, unsaturated hydrocarbons and nitrogen- and sulfur-bearing compounds (acetonitrile, methylmercaptan CH<sub>3</sub>SH and dimethyldisulfide CH<sub>3</sub>S-SCH<sub>3</sub>). During pyrolysis of Murchison, oleic acid nitrile is released. This certain specific compounds (e.g. cyanide compounds) might provide evidence for synthesis during pyrolysis.

OC from thermo-desorption of condensed products of Kainsaz, which have passed simulated hypervelocity high-temperature vaporization-condensation processing, in general was qualitatively similar to that of thermo-desorption of the bulk Kainsaz. The only, significant amount of acetonitrile, thiophenes, alkylthiophenes, and SO<sub>2</sub> was released. Further pyrolysis of the condensate (at 900°C) showed only release of CO<sub>2</sub>, SO<sub>2</sub> and benzene.

**Discussion.** Our data showed that the Murchison and Kainsaz material contain different sets of OC which were affected by heating events during the accretion history and/or parent body evolution. The estimated temperature of metamorphism is 96±65°C for Murchison and 453±29°C for Kainsaz [1]. It should be noted that the metamorphic temperature of Kainsaz is similar to the temperature of thermo-desorption in our experiment. As a whole, Murchison is one of the least-altered chondrites, recently reclassified by [2] as CM2.5. The aqueous alteration index (2.5 petrologic subtype), based on petrographic and mineralogical properties of the meteorite, indicates that the primary lithology of Murchison had experienced a relatively low and uniform degree of aqueous alteration.

The major portion of carbon in primitive chondritic meteorites is present as organic material. The bulk carbon content of Murchison (CM2) is ~2.2 wt% [3, 4]. Chondrites of CO3 group in average contain 0.45 wt% of carbon [3, 4]. Murchison contains 0.83 wt% of insoluble carbon, while Kainsaz contains 0.43 wt% [5]. This distribution of carbon forms suggests that the more highly metamorphosed meteorites contain mostly

insoluble OC. Our results support the idea that soluble compounds are generally more volatile than insoluble compounds and may have been lost due to thermal metamorphism of Kainsaz as it was shown in [6]. The difference between soluble and insoluble organics contents in CM2 and CO3 chondrites likely indicates modification of the insoluble OC structure during thermal alteration on the parent bodies.

In general, qualitative compositions of thermo-desorption products of Murchison and Kainsaz are quite similar (Fig. 1). The Kainsaz material after thermo-desorption at 460°C still contains benzene and alkylbenzenes but in less amount than that of Murchison. It could be an illustration of similar organic sources for both meteorites and medium temperature metamorphism of Kainsaz, which provided the loss of some OC. However, the Kainsaz thermo-desorbed OC are enriched in carbonyls (including acetone) and naphthalene compare to that of Murchison.

The more variable spectrum of the pyrolysis products of the Murchison seems to indicate the bigger variety of functional groups of macromolecular organic material, and also the less degree of material modification caused by thermal metamorphism.

Since Murchison underwent low-temperature metamorphism, its non-volatile organics could not have been formed on the Murchison parent body by carbonization of high-molecular-weight organics but rather must have been captured during accretion of the parent body from the nebula. This could indicate that non-volatile organic components in Murchison have a nebular origin. However, Murchison contains xenoliths with compositions similar to carbonaceous CO3 chondrites, specifically similar to Kainsaz [7]. Therefore a certain portion of the refractory OC in Murchison was formed by metamorphism of the CO3 parent body. In this case it is difficult to distinguish which OC have nebular origin or were formed by metamorphism without additional isotopic investigations.

Thermo-desorbed OC from the condensates, which were produced in the laser-induced evaporation experiments on Murchison and Kainsaz, contain all the same groups of organics as the original meteorites. There is a certain increase in nitrogen-bearing organics (acetonitrile), thiophene and alkylthiophenes, and unsaturated hydrocarbons and decrease in alkanes and PAHs. Further pyrolysis results mainly in the release of CO<sub>2</sub>, SO<sub>2</sub>, and benzene. Condensed material is deeply black and X-ray photo-electron spectroscopy shows that carbon is mainly bound as C-C. It consists mainly of nanometer-size condensed silicate particles which are formed in an expanding cooling vapor. New compounds are formed during condensation process involving various reaction paths with heterogeneous catalysis.

It was shown earlier [8] that nitrogen-bearing and other organic compounds are formed rather efficiently at high-temperature vaporization-condensation processes. Remarkable, that the forming pattern of OC during vaporization of meteorites contain many of OC which are present in the parent material. This circumstance does not contradict to the hypothesis that OC could be synthesized in an expanding vapor cloud after a high-temperature explosive event. Certain non-volatile organic and inorganic compounds found in the solar system objects (carbonaceous chondrites and comets) may be products of such a synthesis of material from nebular sources and also from material which had undergone processing on protoplanetary bodies.

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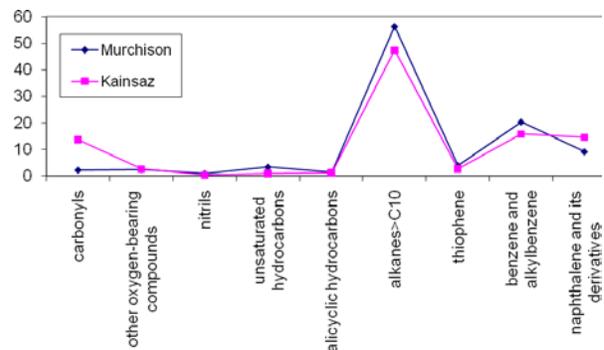


Fig. 1. Results of thermo-desorption of Murchison and Kainsaz (%).