MURCHISON AND CHELYABINSK VOLATILES BY STEPWISE HEATING: PRELIMINARY ANALYTICAL RESULTS

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Introduction: Asteroids and comets can be considered as the source of gases and water for the atmospheres of planets and the hydrosphere of the early Earth. The organic compounds (OC) they contained were probably the basis for the biosphere of our planet. It is known that CI and CM carbonaceous chondrites contain 2.7-5.2 wt.% of C, 0.12-0.18% N, 0.6-0.8% H, and most of the OC spectrum known on Earth [1]. Meteorites also contain bound water (5-7 wt.%), a constituent of phyllosilicates [2].

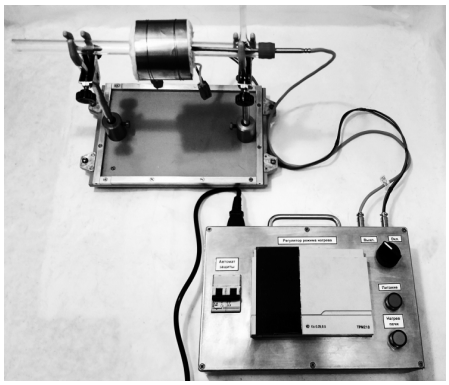

Fig. 1 Furnace for heating small samples

Methods: Preliminary results for the composition of OC isolated from the Murchison meteorite (CM2) were obtained using the on-line Pyr-GC/MS setup described in [3]. We performed two-stage pyrolysis of 10 mg of the powdered meteorite bulk material under helium flow (460°C, 15 min → 900°C, 10 min). Released volatiles were collected at liquid N_2 temperature and desorbed into a chromatographic system by pulse heating of the cryogenic trap. Further experiments were carried out with powdered Chelyabinsk meteorite material (LL5) with the furnace shown in Fig. 1, providing stepwise heating of samples from 50°C to 850°C in an He atmosphere. A CrystalLux 4000M gas chromatograph was used to analyze the gas phase after heating of the samples.

Results: The low temperature pyrolysis of Murchison (460°C) gave a wide variety of OC: cyclic and acyclic aliphatic hydrocarbons (up to C_{20}), aromatic hydrocarbons including benzene, naphthalene and their derivatives, unsaturated hydrocarbons, thiophene and alkyl thiophenes, carbonyl compounds, and nitriles. Inorganic CO_2 gas was also released. A portion of the released OC was desorbed in the free state from the meteorite while other parts appeared to be products of thermal destruction of a high-molecular-weight organic substance and low-molecular-weight thermolabile compounds. The high-temperature pyrolysis products (900°C) included CO_2, alkanes, benzene, naphthalene, and their derivatives, N- (acetonitrile) and S-containing compounds (methylmercaptane and dimethyldisulfide – the products of thermal destruction of organic sulfides and disulfides). These products are mainly derived from the decomposition of macromolecular compounds.

Chelyabinsk high-temperature heating products (850°C) included H_2, CO_2, N_2, CH_4, H_2S, CO and H_2O.

Summary: During formation of the Earth, gases and OC similar to the substances we observed in our experiments could be released from meteorites by impact events and subsequent processes, and become part of the nascent atmosphere and hydrosphere [4]. The hypothesis that C and H in these spheres of the Earth come from source material similar to carbonaceous chondrites is supported by the isotopic composition of volatile elements in meteorites [5].

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