EXPERIMENTS WITH METEORITE "TSAREV": INSTALLATION FOR GATHERING AND REGISTERING VOLATILE COMPONENTS OF METEORITE SUBSTANCE

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Current research is related to one of the fundamental problems of the Earth sciences: estimating composition, mass, and properties of the original Earth atmosphere. The presence in the substance of ordinary chondritis of up to several percents of volatile matter allows us to assume that their decontamination and partial retention in a gas phase have facilitated forming the original atmosphere. The purpose of the present research is creating methods of separation and analysis of volatile matter of meteorites under the conditions similar to those during growth of a planet bombarded with chondritis. To this end, we carried out a number of laboratory experiments. The idea behind the experiments was that during heating of a meteorite sample, a volatile component will be emanating. The analysis of emanating gas will allow us to make certain conclusions about composition of an initial atmosphere within the framework of our conjecture. A fragment of the "Tsarev" meteorite has been chosen as an experimental sample. This meteorite has been chosen as a representative of the most common type of meteorites. The total mass of its fragments exceeds one ton.

For heating meteoritic substance, we have chosen microwave radiation. This way we have achieved internal energy release in a sample, and during our experiment the temperature on the surface was approximately the same as inside. Another important advantage of microwave radiation is a possibility of programmed "soft" heating to any desirable temperature. It allows us, in particular, to study the dependence of volatile composition on the temperature of a heated sample. A number of experiments were carried out; the gases emanated during heating the samples in the range of temperatures 150 ^{0} - 700 ^{0}C were analyzed.

The microwave generator generated an electromagnetic wave which propagated in a waveguide. The wavelength was 12 cm. Transmitted energy was adjusted with an attenuator and registered. The sample was put in the vacuum chamber. The chamber itself was placed inside a special short-circuited waveguide. The vacuum chamber, with the sample placed inside (fig.1), is a cylindrical pipe made of quartz glass. The diameter of the chamber was ~40 mm, length ~140 mm, volume~165 cm^3. In the chamber there are branch pipes and windows intended for air decompression and for taking gas samples for analysis, including measuring samples' temperature and pressure.

The construction of the waveguide section provides for balanced accommodation of the vacuum chamber in the electromagnetic field, allowing to input the required energy into the studied sample. At the same time, pressure sensors and an instrument measuring temperature are positioned outside of the waveguide and are not exposed to the influence of the electromagnetic field.

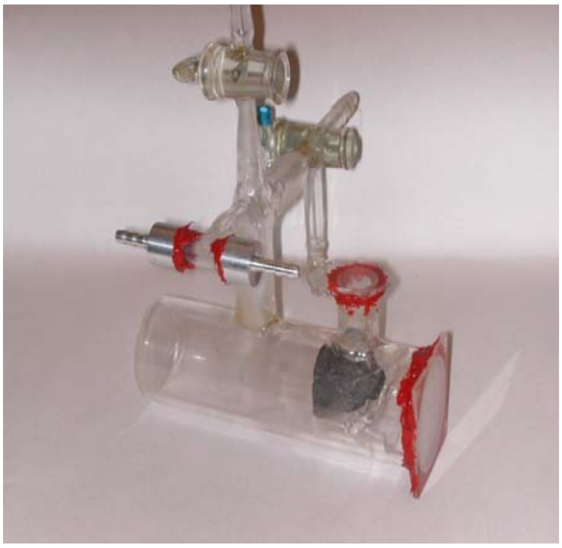

Fig.1. The vacuum chamber with the meteorite. Metallic cylinders – pressure sensors

The chamber prepared for the experiment with a sample was decompressed to up to ~ 10^{-3} torr. The gas emanated during heating fills the chamber and, if necessary, one or two gas reservoirs. The gas reservoir, after being filled at a certain temperature mode, was isolated from the vacuum chamber. Then the chamber was decompressed again, and the sample was again heated. As a result, gases emanated at different temperature modes have been collected.

The gas pressure in the vacuum chamber was measured by MOTOROLA gauges, of type MPX 5100A and MPX 5010D. The temperature of the surface of a sample was measured by an infra-red "Kelvin" thermometer. Since during the experiment the sample remains inside the chamber, for measuring its temperature a window closed by a flat fluorite plate 3 mm thick was provided. To avoid a gas discharge while the pressure is growing, the vacuum chamber was filled with xenon, which has rather high puncture resistance. Our measuring has shown that at xenon pressure of P = 100 mm Hg, a gas discharge during heating meteoritic substance does not occur.

On fig. 2, pressure and temperature during one of experiments are shown. The lowermost curve shows the recorded relative microwave power as a function of time.

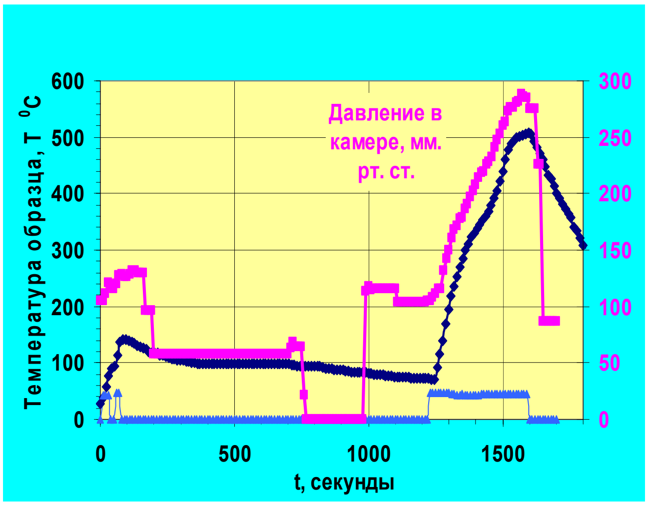

Fig.2. Temperature of sample (left scale) and gas pressure (right scale) in experiment 2

The first microwave heating lasted ~80 seconds (the bottom curve). It was accompanied by approximately linear growth of temperature (the curve in the middle) and pressure (the top curve, the right scale). After switching the microwave power off, the temperature began to fall exponentially. Sharply falling (approximately by the factor of 1/2) pressure after ~ 150 seconds is caused by connecting an empty reservoir of volume 125 cm^3. It lasted up to the 700th second. Zero pressure during the period from ~ 770 seconds up to ~ 980 seconds corresponds to the chamber decompression. The following sharp rise corresponds to the filling with xenon. Then - the second heating up to ~ 500 ^{0}C. The gases emanated in this experiment were subjected to the chromatographic analysis. The analysis was carried out on the chromatograph LHM - 8.3 with two columns on a katharometer. For measuring concentration of H_2, CO, CH_4, O_2, N_2, a column with molecular sieve was used. In the table, relative concentrations of the measured products are given.

T, °C	ΔP мм...	H_2	O_2	N_2	CH_4	CO	CO_2	Опыт №
140	30	1,3	0,06	0,2	0,18		1,1	2
170	20	2,5	0,1	0,3	1,25		0,45	3
270	170	13,0	4,3	23,6	0,16	8,3	2,1	1
330	160	32,2	1,8	6,9	0,40	10,8	2.1	1
500	170	18,8	0,02	0,45	0,56		3,4	2
700	200	26,0	0,3	0,9	2,2		6,9	3

Fig.3. The results of chromatographic analysis.
Dark cells – experiment without xenon.

Among the gases obtained in all experiments, molecular hydrogen has the biggest share. The presence of xenon in the experiments allows us to convert from relative molar concentration to absolute values. Thus, an estimation of the quantity of hydrogen emanated during the experiment №2 gives about $0.3\cdot10^{-4}$ mol or m ≈ 0.06 mg. The mass of a sample is M ~ 30 g. Thus, the ratio of m/M is ~10^{-6}. To obtain more detailed data, further research is needed.

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