

**EXPERIMENTAL INVESTIGATIONS OF METEORITIC SUBSTANCE
BY KNUDSEN EFFUSION MASS-SPECTROMETRIC METHOD.**

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Condensation and evaporation are important physical processes that formed meteorites at different stages of their complex evolution. The purpose of our work was to study the high-temperature evaporation process of the chondrite substances by the Knudsen effusion method. Experiments on evaporation of chondrites (Murchison CM, Krymka LL3), chondrules of Saratov chondrite (L6), CAIs Type A of Efremovka chondrite (CV) as well as on minerals: spinel, perovskite and wollastonite were carried out.

The Knudsen effusion method combined with mass spectrometry analysis of the vapor phase can be successfully used for physical-chemical study of the melt evaporation process. The method allowed us to obtain information about the forms of vapor components, their partial pressures and evaporation rates, the compositions of vapor and melt phases at various temperatures up to 2500 °C. It should be noted that the measurements of the partial pressure of melt components characterize the equilibrium state of the system. The vapor phase above the chondrite melt has a complex composition and contains monoatomic particles and simple molecules. Most oxides and oxide compounds in the melt thermally dissociate producing metal forms and oxygen in the vapor. For this reason metal forms (K, Na, Fe, Ni, Cr, Mg, Ca, Al), suboxide and oxide forms (PO, PO₂, SiO, TiO, TiO₂, AlO, Al₂O, Al₂O₂), as well as oxygen in atomic and molecular forms were observed in the vapor phase. Oxygen was the main component of vapor in the entire temperature range of the melt evaporation. The total oxygen content in the forms of O and O₂ at high temperatures (T > 2000 °C) was more than half of the vapor volume. The temperature sequence of the appearance of metallic, suboxide and oxide forms in vapors during evaporation of chondrites is mainly determined by the volatility of the individual oxide. The evaporative sequence can be arranged in the following temperature range: K > Na > Fe (FeO), Ni > SiO, Cr > Mg > Ca (CaO) > TiO, TiO₂ > Al, AlO, Al₂O (Al₂O₂). The brackets show the forms that are present in the vapor in small quantities. On the qualitative side, the forms of vapor components over the chondrite melts coincide with the vapor forms observed in case of the evaporation of the individual oxides. The composition of the evaporating melt depends on the temperature and evaporation time. As the temperature increases, the melt content of non-volatile oxides (CaO, TiO₂, Al₂O₃) increases; the content of moderately volatile oxides passes through the maximum values in the appropriate temperature range and mass losses.

In the experiment with the CAIs Type A of Efremovka chondrite we observed inversion of the volatility of SiO₂ and MgO, that is the most volatile MgO compared to the volatility of SiO₂. The results of the experiment clearly showed that in the field of high temperatures (T ≈ 1900 °C) the magnesium vapor was no longer observed, since it completely evaporated from the melt of the CAI melt. At the same time, silicon in the form of SiO was observed in the vapor along with vapors of refractory oxides – CaO and Al₂O₃, which indicates SiO₂ presence in the melt even at the final, high-temperature evaporation stage of the melt (T ≈ 2400 °C). Thermodynamic analysis of this volatility inversion showed that it is due to the acid-base melt factor [1], which, in turn, is determined by the concentration of CaO. The increasing the CaO concentration in the melt leads to an increase in the activity and, accordingly, the volatility of MgO and a decrease in the activity and, accordingly, the volatility of SiO₂ [2].

Complex forms of molecules were observed in the field of high evaporation temperatures of minerals – spinel, perovskite and wollastonite: MgAlO, CaSiO, CaSiO₂, CaTiO₃ [3]. The concentration of complex molecules in the vapor is small and does not exceed 1 % in total concentration. However, it is noted that the proportion of complex molecules increases with the increase of melt temperature. Thermodynamic analysis of the formation of complex molecules showed that they are formed not as a result of synthesis in the gas phase, but as a result of a heterogeneous reaction directly at the exit from the melt.

References: [1] Korzhinskii D. S. (1959) *Dokl. Akad. Nauk SSSR* 128:383–386. [2] Yakovlev O. I. et al. (2017) *Geochem. Int.* 55: 251–256. [3] Shornikov S. I. and Yakovlev O. I. (2015) *Geochem. Int.* 53:690–699.