VISCOSITY, DENSITY AND SURFACE TENSION OF IRON METEORITES MELTS UP TO 1800 ^{O}C

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Introduction: Iron meteorites and pallasites are considered to have undergone the stage of planetary differentiation and became self-contained in the process of distructing planetesimals by powerful impact events [1]. On the other hand, planetary cores of the planets which have survived (the Earth including) are believed to consist of liquid based on iron and convection of this metallic liquid produces a magnetic field [2]. A comprehensive understanding of this function, however, is hindered by the uncertainty as to the melt viscosity. Viscosity of molten iron meteorites is a very important thermophysical property which is crucial for understanding the chemical, thermal, and geomagnetic evolution of planets. This work presents experimental data on physical properties of meteorites' melts within the range of 1500 - 1800 ºC.

Samples and Methods: Fragments of the Sikhote-Alin IIAB, Chinga IVB-an, Dronino Iron-ung, Seymchan PMG meteorite are the objects of the study. In making investigations, a set of unique equipment designed for photometric measuring physical parameters of high-temperature metal samples' melts weighing 10 – 40 gr in electric furnaces within the temperature range of 20 - 2000 ºC [3] was used. The set ensures studying temperature dependences: kinematic viscosity ν(t), using non-contacting detection of the attenuation ratio δ in torsional swings of a crucible containing a sample, suspended on an elastic thread, as well as studying the surface tension σ(t) and density d(t), using image photometry of the "large sessile drop" contours of the sample under study.

Results and Discussion: The Sikhote-Alin molten meteorite (Fe ~ 5,7 % Ni) virtually doesn't have hysteresis *ν*(t) and is consistent with calibration based on pure iron. For example, at t = 1600 ^{o}C, ν values are 7.5 units. The Chinga meteorite melt (Fe ~ 17 % Ni) has ν of 5.5 units at t = 1600 ^{o}C . The specific feature of both Sikhote-Alin and Chinga sample melts is nonmonotonicity in heating and cooling. The data on ν(t) of the Dronino (Fe ~ 9 % Ni) meteorite sample containing sulfide inclusions (~10 vol. %) is indicative of maximal variability ν(t) in the temperature range presented – the ν melt values change almost twofold. The ν(t) data on the Seymchan PMG meteorite provides the greatest value as compared to other meteorites under investigation $(9.5 – 10.5)\cdot 10^{-7}$ m^2/c but in case of a significantly smaller difference of ν(t) values. Besides, ν(t) has a significant hysteresis and maximal nonuniformity both in heating and cooling. The peculiarities of ν(t) for it are admittedly attributed to heavy slagging and temperature difference in melting olivine and metallic fractions proper.

In making experiments on determining the surface tension σ(t) and density d(t), the Sikhote-Alin and Chinga meteorites' samples were melted without any slag as distinct from melting the Dronino meteorite and especially the Seymchan PMG meteorite which gave off slag in large quantities. It is necessary to point out that in accordance with the data provided by a large body of research and received, using various techniques the pure iron melt density d_{Fe} is 7.05 ± 0.15 gr/sm^3 when the temperature of the melt is close to the melting temperature $t_{пл}$. Absolute density values d_i of the meteorites' melts depend upon their chemical composition. However, due to the fact that all the samples are based on iron, it is the iron density d_{Fe} that the samples' density d_i is to be close to. In heating and cooling samples' melts, d(t) varies linearly from 7.0 gr/sm^3 to 6.8 gr/sm^3. Before crystallization, the d_i value was ~ 7.0 gr/sm^3. The σ(t) value of the Chinga meteorite melt varies starting from 1200 mJ/m^2, in heating it grows up to 1350 mJ/m^2, in cooling before crystallization, σ(t) is again 1200 mJ/m^2. The temperature dependences of σ(t) and d(t) for the Sikhote-Alin and Chinga meteorite melts are similar. In its absolute values the heat dependence σ(t) of the Sikhote-Alin melt sample is within the range of 1300 – 1500 mJ/m^2. The values of the surface tension σ(t) for the sample melt of the Dronino meteorite are the lowest and within the range of σ(t) = 900 - 1100 mJ/m^2. For the Seymchan PMG meteorite melt containing olivine inclusions, σ(t) appears nonmonotonic with a section of a steep rise during heating and a drop during cooling within the temperature range of 1550 - 1600 ^{o}C. In the absolute values its heat dependence is between the data related to sample melts of the Sikhote-Alin and Chinga meteorites.

Conclusion: For the first time, experimental data on the kinematic viscosity ν(t), surface tension σ(t) and density d(t) of iron meteorites' melts within the temperature range up to 1800 ºC has been obtained. The Ni and impurity phases' content in iron meteorites mostly affects ν(t) and σ(t) values. This methodology is not all that apparent in evaluating ν(t), σ(t), d(t) dependences for the purpose of studying pallasites and stone meteorites.

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