ON THE SPECIFIC HEAT CAPACITY AND THERMAL CAPACITY OF METEORITES.

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Introduction: Thermal properties of meteorites are important physical properties, that have not been intensively investigated [1-9]. In recent years we have studied specific heat capacity Cp of certain stony and iron meteorites [10], and specific heat capacity, thermal diffusivity and thermal conductivty of Morasko iron meteorities [11]. The aim of the paper was to determine and analyse specific heat and thermal capacities of chondrites, pallasites, mesosiderities, and iron meteorites at room temperature.

Methods: Measurements of specific heat capacity and bulk density of various samples of Brahin, Vaca Muerta, Allende, El Hammami, Gold Basin, Sahara 99471, DaG 610, Canyon Diablo, Gibeon, Sikhote Alin, Toluca and Morasko meteorites have been conducted at ambient conditions, at 297 K, in one atmosphere air. Bulk density of the samples d was determined by the Archimedean method, and specific heat capacity Cp by double-walled calorimeters and/or by differential scanning microcallorimeter DSC 605M produced by UNIPAN, as in previous our paper [11]. The relative errors of measurements of Cp are about 6% for traditional calorimeters, and 1% for density measurements.

Results and discussion: In Figure 1 dependence of Cp of meteorites on bulk density is presented. It is seen that heat capacity of chondrites at room temperature is in the range 480-930 J/kg.K, stony-iron meteorites represented by Brahin pallasites and Vaca Muerta mesosiderites in the range 470-530 J/kg.K, and of various iron meteorites is in the range 440-600 J/kg.K. The relationship between Cp and density of meteorites is evident, and it is seen also for stony-irons (Fig. 2).

Our results show that Cp(d) dependence is linear for stony- irons, and nonlinear for all group of meteorites.

Figure 2 shows also that the bulk density of various pieces of one and the same meteorite can vary significantly from sample to sample, density of Brahin between 4.6 and 5.3 g/cm^3, for example, and Vaca Muerta between 3.56 and 4.0 g/cm^3. Specific heat capacities of Brahin and Vaca Muerta meteorites reveal the same straight (Fig. 2).

It was established for terrestrial materials [12], that the thermal capacity (volumetric heat capacity, heat capacity per unit volume, Cp*d), is almost constant for solids at room temperature

$$Cp*d \approx 3x10^6 \text{ J/K.m}^3.$$

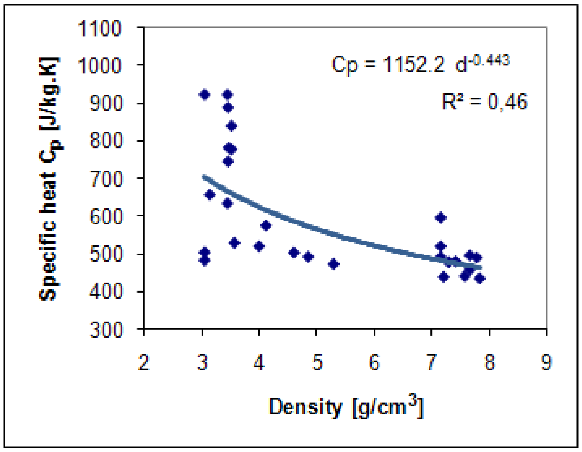

Fig. 1 Dependence of specific heat capacity Cp on bulk density of stony meteorites, stony-iron meteorites, and iron meteorites at room temperaure.

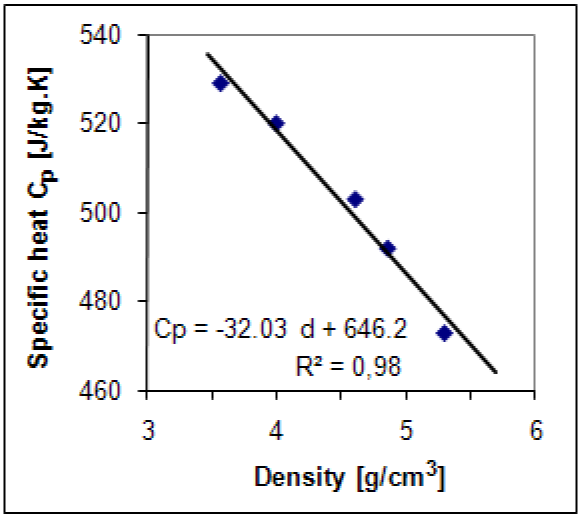

Fig. 2 Dependence of heat capacity Cp on bulk density of stony-iron meteorites (pallasite Brahin and Vaca Muerta mesosiderite) at room temperature. Each point represents an average of 15 measurements of Cp.

Figure 3 reveals distribution of values of thermal capacity for extraterrestrial matter at room temperature. The average value of Cp*d for all our meteorites is equal to (2.9±0.1) 10^6 J/K.m^3, and about 50% of the values are close to the average. These results show that the ratio of thermal conductivity and thermal diffusivity, equal to Cp*d, is close for meteorites, and for terrestrial materials. Comparison of values of Cp of meteorites and terrestrial materials reveals that specific heat capacity of iron meteorites and terrestrial metals based on iron, steels and iron alloys, are within the same range of values, and Cp of chondrites is within the same range of values as for most of terrestrial minerals and rocks.

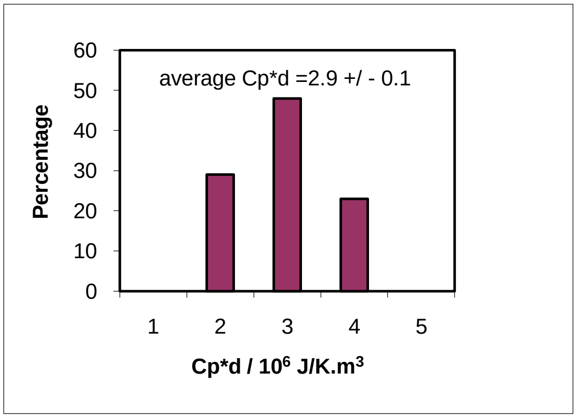

Fig. 3 Distribution of values of thermal capacity (volumetric heat capacity, Cp*density) for all studied meteorites. Note: thermal capacity for half of the meteorites is close to 2.9x10^6 J/K.m^3.

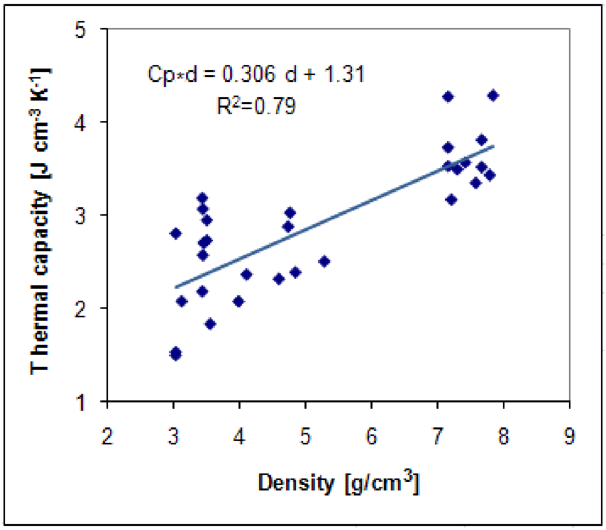

Fig. 4 Thermal capacity versus bulk density of meteorites at room temperature.

Our results show differences between various groups of meteorites. Figure 4 reveals that thermal capacity is a linear function of bulk density of meteorites. An analysis of the average values of thermal capacity of stony, and stony-irons show that they are nearly the same (2.5x10^6 J/K.m^3) and lower than the average value for all our meteorites (2.9x10^6 J/K.m^3), but the average volumetric heat capacity of irons is higher (3.6x10^6 J/K.m^3).

Waples and Waples established for a large number of terrestrial minerals and rocks that the mean value of thermal capacity of minerals is equal to 2.46x10^6 J/K.m^3 at room temperature, and that thermal capacity of low- and medium density minerals (with densities between 2 and 4 g/cm^3) increases with inceasing density from 1.7x10^6 J/K.m^3 (for 2 g/cm^3) to 3.0 x10^6 J/K.m^3 (for 4 g/cm^3), being about 2.7 x10^6 J/K.m^3 for 3.5 g/cm^3 [13]. Figure 4 reveals that thermal capacity of extraterrestrial rocks exhibits the same trend as terrestrial minerals but the values of thermal capacity of meteorites are somewhat smaller.

Conclusions: Specific heat capacities and thermal capacities of extraterrestrial rocks are similar to specific heat capacities and thermal capacities of terrestrial materials at room temperature. Relationships between specific heat capacity and bulk density of meteorites, and between thermal capacity and bulk density have been established which can be applied for evaluation of heat capacities of extraterrestrial objects.

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