MEAN SPECIFIC HEAT CAPACITY OF MARS, MOONS AND ASTEROIDS.

M. Szurgot. Center of Mathematics and Physics, Technical University of Lodz, Al. Politechniki 11, 90 924 Lodz, Poland. E-mail: mszurgot@p.lodz.pl.

Introduction: Relationship between specific heat capacity $C_p$ and bulk density $d$ of meteorites has been recently established [1]. It can be used for estimation of specific heat capacities of meteorites and their parent bodies at room temperature. Taking into account the correction factor $f$ representing $C_p(T)$ dependence it is possible to estimate $C_p$ at any temperature using the equation $C_p(T) = fC_p(RT)$, where $C_p(RT)$ is a value of $C_p$ at room temperature ($f = 1$ at RT, $f < 1$ at low, and $f > 1$ at high temperatures). Knowing of $C_p$ and mass of the object $M$ gives a possibility to estimate heat capacity $C$ of any extraterrestrial object by the equation $C = M C_p$. Our recent calculations have shown that heat capacity $C$ of terrestrial planets is in the range of $10^{26} - 10^{24}$ J/K, asteroids $10^{24} - 10^{22}$ J/K, and of satellites $10^{18} - 10^{26}$ J/K at room temperature [2]. It seems to be evident that both quantities $C_p$ and $M$ should be known to determine $C$. The aim of the paper was to reveal the relationship between heat capacity and mass of extraterrestrial objects which can be applied for estimation of heat capacity $C$ using only $M$ value, and to determine the mean specific heat capacity of Mars and other terrestrial planets, moons, and asteroids at room temperature.

Results: An analysis of $C_p$ and $C$ values for asteroids, natural satellites and terrestrial planets [2] shows that $C$ increases with increasing mass $M$ of the object, and $C(M)$ dependence is linear. $C(M)$ relationship can be expressed by the equation

$$C = A \cdot M + B,$$

where constant $A$ is the slope of $C_p(M)$ dependence, and constant $B$ is the intercept. Constant $A$ plays the role of mean specific heat capacity ($A = C_{p\text{mean}}$). Our result show that for terrestrial planets $C_{p\text{mean}} = (542 \pm 90)$ J/(kg·K), for moons $C_{p\text{mean}} = (939 \pm 220)$ J/(kg·K), and for asteroids $C_{p\text{mean}} = (922 \pm 34)$ J/(kg·K) at room temperature. Constant $B$ is equal to: $(348 \pm 347) \cdot 10^{23}$ J/K, $(-124 \pm 184) \cdot 10^{23}$ J/K, and $(-0.086 \pm 0.109) \cdot 10^{23}$ J/K, for terrestrial planets, moons, and asteroids, respectively. It is seen that the mean specific heat capacity $C_{p\text{mean}}$ of terrestrial planets is determined by the material of cores (Fe-Ni, FeS) and by material of mantles (silicates), and $C_{p\text{mean}}$ of asteroids and moons is determined mainly by the material of mantles.

Mean values of specific heat capacity of Martian crust, mantle, core and the global Mars have been also determined. Calculations, based on $C_p(d)$ dependence [1], show that for $d_{\text{crust}} = 2.99$ g/cm$^3$, $d_{\text{mantle}} = 3.52$ g/cm$^3$, $d_{\text{core}} = 7.04$ g/cm$^3$, and $d_{\text{Mars}} = 3.94$ g/cm$^3$ we obtain: $C_{p\text{crust}} = 741$ J/(kg·K), $C_{p\text{mantle}} = 675$ J/(kg·K), $C_{p\text{core}} = 489$ J/(kg·K), $C_{p\text{Mars}} = 635$ J/(kg·K) at room temperature. The data reveal that the main contributor to the specific heat capacity of Mars is its mantle ($C_{p\text{mantle}}/C_{p\text{Mars}} \approx 0.77$), the core contribution is smaller ($C_{p\text{core}}/C_{p\text{Mars}} \approx 0.22$), and the crust contribution is very small ($C_{p\text{crust}}/C_{p\text{Mars}} \approx 0.01$).

Conclusions: Relationship between heat capacity and mass of extraterrestrial objects has been established, and applied for estimation of mean specific heat capacities of terrestrial planets, moons and asteroids. Mean specific heat capacity of Mars is determined by the material of its mantle.