High-Precision Adiabatic Calorimetry Investigation of Ice Premelting in Porous Media

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The present work is devoted to highly precise adiabatic calorimetry measurements of the temperature dependence of the heat capacity of frozen water in bulk and various granular porous media, in the vicinity of the standard melting temperature of bulk ice (T_m = 273.15K). Directly measured values were temperature and amount of heat (enthalpy) embedded into a measuring cell under its heating. Two fractions of a quartz powder prepared by its separation on a vibrating shaker were used as the porous media. The characteristic grain size of the coarse-grained fraction was about 90-100 microns. The grain size of the fine-grained fraction was about 5-8 microns. In both fractions the measurements were carried out at several saturations of the porous media by the water. In all investigated cases, including measurements in bulk, the effect of ice premelting was observed. The common factor for all cases was that the temperature dependence of the heat capacity of frozen water includes two terms, one of which, proportional t^(-4/3), is connected to interface melting of ice due to the Van der Waals forces, whereas the second, proportional t^(-3), connected to curvature melting of ice due to the Kelvin's effect. Here $t = (T_m - T)/ T_m$ is the dimensionless temperature deviation from the standard melting temperature of bulk ice. We found the ratio of coefficients at each of the specified terms appears the same in all cases investigated in the work. Presence of effect of premelting in bulk sample is caused, most likely, by polycrystallinity of the ice. The contribution to the heat capacity connected to interface (grain boundary) melting in this case is on the limit of accuracy and, accordingly, cannot be reliably identified.

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