The structure of silicate glasses: the thermophysical standpoint

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Establishing links between the structure and properties of silicate glasses and melts is a long-standing problem of special importance for tailoring industrial materials and for understanding quantitatively magmatic processes. In spite of the tremendous advances made during the last decade regarding the structure of the main entities present in glasses and melts, the way these determine physical properties is not well understood yet. Here, a series of examples will be taken to illustrate how one can gain insights from a reverse approach by using low-temperature heat capacities as structural probes. In addition to silicates, borosilicates and aluminosilicates, the vitreous oxides B_2O_3 and GeO_2 will also be considered. Below 70 K, the heat capacity of these glasses depends sensitively on the low-frequency part of the vibrational density of states. We will thus review use of such measurements to investigate medium-range order; attention will also be paid to the variation with composition of the boson peak and to the contrast between glasses and crystals with respect to low-frequency modes. Between 70 and 200 K the heat capacity is determined by oxygen coordination polyhedra, which allows short-range order to be probed for both the network-forming and modifying cations. Finally, we will discuss the intriguing similarity observed between the composition dependence of the low-temperature C_p of glasses and of the configurational heat capacity of liquids, with reference to the "strong" vs. "fragile" nature of melts.