

Heat capacity and entropy of MgSiO_3 and Mg_2SiO_4 glasses

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Melting of the material in the crust and mantle of the Earth is one of the principal processes of this geologically living planet. The two most common rock types of the crust – granite and basalt – both originate from molten silicate liquids generated in depth.

In this work, we have measured the thermophysical (heat capacity, C_p , and entropy, S^0) properties of two glasses with composition relevant to basic and ultrabasic rocks. The glasses correspond in their composition to the minerals enstatite (MgSiO_3) and forsterite (Mg_2SiO_4). The thermophysical properties were measured with a commercial PPMS system in the temperature range 5 - 300 K on ~ 25 mg samples prepared by levitation and containerless quenching techniques. In combination with high-temperature DSC C_p measurements, our data have the potential for constructing a complete thermodynamic dataset for glasses and liquids of enstatite- and forsterite-composition.

The entropy of the MgSiO_3 glass at 298.15 K was calculated as 73.0 J/(mol·K) and the heat capacity at this temperature is 80.2 J/(mol·K). The entropy of the Mg_2SiO_4 glass at 298.15 K is 105.6 J/(mol·K) and the heat capacity is 118.8 J/(mol·K). None of these entropy values includes the configurational contribution which cannot be estimated from our low-temperature calorimetry data alone.

The C_p curves for both glasses display a pronounced “boson” peak at low temperatures (< 150 K), i.e., a pronounced positive difference of the $C_p(\text{glass}) - C_p(\text{crystal})$ value. Although this peak has been assigned simply to a variable coordination number of cations in glasses, it seems more likely that it is due to the presence of low-frequency modes in the relatively open framework of the glasses. The origin and cause of this difference will be discussed in further detail in a separate contribution.

Unusually high trace element abundances in residual peridotites: Implications for mantle-melt interactions at a Mid Oceanic Ridge

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We report unusually high trace element concentrations in clinopyroxene (CPX) and extremely high whole rock trace element abundances of a set of unmetasomatized peridotites from a ~2m high peridotite-gabbro section from the Horoman Peridotite Complex, Japan. Trace elements exceeding Primitive Mantle values suggest a fertilization event by addition of a melt producing a highly fertile peridotite suit. Gabbros represent added melts having higher Cr_2O_3 than both Type I [TiO_2 and rare earth elements (REE) rich] & II (Cr_2O_3 rich with distinct positive Sr & Eu anomalies) gabbros (Takazawa *et al.*, 1999), whereas TiO_2 and REE contents are lower than Type I but greater than Type II. Mineral textures preserved in the peridotites support melt interaction and bulk rock trace elements can be successfully modelled by a gabbro-peridotite binary mixing process. Absence of metasomatic evidence and arc signature in these samples clearly rules out the occurrence of melt interaction at a subduction zone. Highly depleted light REE patterns of both CPX and bulk peridotites and occurrence of two pyroxene spinel symplectites imply the peridotites are residues of polybaric melt extraction started from the garnet field. Thus, we propose these peridotites were intruded by magma and consequently melt-rock interaction occurred under mid ocean ridge tectonic setting. Intruded melts were then frozen as gabbros within the residual peridotites during decompression to the spinel facies conditions, eliminating any chance for melt-driven metasomatism. Subsequently, rocks were incorporated into a subduction zone setting and undergone deformation with extreme stretching and folding in H_2O bearing wedge-mantle forming millimetre to meter scale layering (Yoshikawa and Nakamura, 2000).

References

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