

Microthermometric analysis of synthetic fluid inclusions in the hydrothermal diamond-anvil cell

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ABSTRACT

The hydrothermal diamond-anvil cell (HDAC) was employed as a pressurized fluid inclusion heating stage to determine temperatures of phase transitions in synthetic fluid inclusions in quartz. Using this technique, the common problem of decrepitation or stretching of inclusions having high internal pressures was eliminated.

Homogenization temperatures of pure H₂O synthetic inclusions determined in the HDAC are inversely related to the confining pressure exerted on the sample, suggesting a decrease in inclusion volume with increasing confining pressure. The very good reproducibility and reversibility of these experiments indicate that volume changes during heating under confining pressure in the HDAC are elastic in nature. However, results of microthermometric experiments in the HDAC indicate that the change in homogenization temperature is significantly larger than would be predicted by the equations of state for quartz and water. This difference reflects an additional component of volume change related to stress within the quartz host, causing displacement of the inclusion walls into the inclusion cavity, as predicted by theoretical models describing the behavior of inclusions in minerals.

Liquid-vapor homogenization temperatures [Th(L-V)] and halite dissolution temperatures (T_m halite) were determined for synthetic fluid inclusions in the ternary H₂O-NaCl-CO₂. The measured homogenization temperatures were regressed as a function of confining pressure at Th(L-V). The intersection of the Th(L-V)-confining pressure curve with an independently obtained *P-T* curve for the solvus of the same ternary composition provides the “correct” homogenization temperature, that is, the homogenization temperature corresponding to a confining pressure equal to the pressure on the solvus at that same temperature. This method for determining corrected Th(L-V) is based on the assumption that the effect of elastic stress on Th(L-V) approaches zero as the confining pressure approaches the internal pressure in the inclusion at homogenization. The Th(L-V) values at these intersection points were used to calculate lines of constant homogenization temperature (iso-Th lines). For a composition of H₂O + 40 wt% NaCl + 10 mol% CO₂, the iso-Th slopes decrease from about 53 bar/°C at Th(L-V) = 500 °C to 8.5 bar/°C for Th(L-V) = 650 °C. The halite dissolution temperature (in the presence of liquid and vapor) averages 342 °C (range ±6 °C) without recognizable pressure dependence. The slopes of iso-Th lines for a composition of H₂O + 20 wt% NaCl + 20 mol% CO₂ decrease from approximately 23 bar/°C at Th(L-V) = 475 °C to 6 bar/°C for Th(L-V) = 600 °C.

Using the HDAC technique, the high-pressure portion of the halite liquidus was redetermined for an H₂O-NaCl solution containing 40 wt% NaCl. These new measurements confirm the data of Bodnar (1994), which were obtained using a gas-flow heating stage at 1 atm confining pressure. This indicates that Bodnar’s (1994) observation of an essentially pressure independent liquidus at pressures ≥ 2 kbar is real and not a result of inclusion stretching.