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Externally pressurized microthermometry and its impact on fluid inclusion homogenization conditions in different host minerals

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Fluid inclusion (FI) serves as a geological record, providing the temperature, pressure, and composition (P–T–x) information of paleo-fluids. To reduce stretching and decrepitation of FIs during microthermometry, hydrothermal diamond-anvil cell (HDAC) can apply an external pressure (P_{ext}) to maintain isochoric condition. However, because the deformation resistance of FIs depends on multiple factors, such as host-mineral properties and inclusion's size, the impact of P_{ext} on the homogenization conditions of inclusions remains unknown. This uncertainty indirectly limits the accuracy of reconstructed P–T–x information. Here we conduct externally pressurized microthermometry on quartz, fluorite, and calcite-hosted brine inclusions using HDAC. Results show that homogenization temperatures (T_h) of brine inclusions generally increase as P_{ext} decreases. Compared with conventional microthermometry method, the T_h in fluorite-hosted brine inclusions can differ by up to ~13 °C. In contrast, the quartz- and calcite-hosted brine inclusions occur leakage during conventional microthermometry, and the smaller inclusions within a fluid inclusion assemblage are less prone to leakage. Leakage of brine inclusions occurs at pressure difference ($P_{inclusion}$ -P_{ext}) of ~200–220 MPa in quartz and ~94–133 MPa in calcite. Under pressurized conditions, the maximum T_h variation is 4 °C in quartz (P_{ext} from 250 MPa to 52 MPa) and 5 °C in calcite (P_{ext} from 148 MPa to 65 MPa). Notably, fluorite-hosted brine inclusions show a larger T_h response at smaller P_{ext} change compared to calcite, indicating weaker resistance to deformation. We infer that the fluorite-hosted inclusions are more prone to entering the plastic deformation regime and change shape due to reduced mechanical strength of fluorite at high temperature. In contrast, FIs within quartz and calcite mainly undergo elastic deformation during heating. These insights provide key experimental constraints to identify and correct non-isochoric error by conventional microthermometry.