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# Plastic deformation of quartz and fluid inclusions: An experimental study

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Re-equilibration of fluid inclusions during hydrostatic experiments is a known phenomenon. However, little is known about the effects of plastic deformation on the preservation of fluid inclusions. To elucidate the behaviour of fluid inclusions during plastic deformation of their host crystals we have run a series of experiments using a Griggs-type piston-cylinder apparatus. Our samples are of natural $CO_2$–$H_2O$–NaCl inclusions in large, undeformed quartz single crystals.

The corresponding isochores span a range of pressures at 700 ˚C, the mean internal pressure being $\sim$600 MPa. Based on this information a first set of control experiments was conducted under hydrostatic conditions. The samples were placed at 700 ˚C and 500, 600 or 800 MPa (all within the $\alpha$-quartz field) for 16 hours, in order to induce static re-equilibration of the inclusions under internal under- or overpressure. At these conditions only one homogeneous phase is stable in the $CO_2$–$H_2O$–NaCl system. In each case, irreversible changes in the shape of the inclusions were observed, similar to those reported in the cited earlier studies.

A second set of experiments was conducted at 700 ˚C and 600 MPa and at 50 to 100 MPa deviatoric stress for 12 to 133 hours, leading to mean strain rates around $10^{-7}$ $s^{-1}$. Inclusions which have ruptured form new fluid inclusion trails. The cracks are healed. Most of the plastic deformation occurs in the direct vicinity of fluid inclusion planes. New shapes were observed, often with branches emanating from the inclusions, which are now elongated parallel to $\sigma 3$. Gas-free aqueous inclusions (homoge-

neous liquid at $T_{lab}$) were formed, close to but separate from relicts of the original inclusions. The relicts themselves have highly enriched gas contents ($\varphi_{car}$ up to 0.8), indicating partitioning of $H_2O$ and $CO_2$ from the originally homogeneous $CO_2$–$H_2O$–NaCl mixture into separate inclusions.

The observed ranges in textures, compositions and molar volumes of the inclusions in the latter experiments are remarkably similar to those in naturally deformed quartz in ductile shear zones and indicate an interplay of initially brittle deformation with the following plasticity.