Experimental re-equilibration of quartz-hosted H_2O-CO_2-NaCl inclusions under differential stress using a Griggs apparatus

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Little is known about the effects of plastic deformation on the properties of fluid inclusions within deforming host-crystals. Geochemical and petrologic investigations based on fluid inclusion analysis must therefore be confined to samples in which the host minerals are unstrained or at least contain strain-free domains. For want of a clear interpretative framework, the potentially useful information in inclusions within sheared hydrothermal veins and metamorphic rocks remains inaccessible.

To elucidate the basic behaviour of fluid inclusions during plastic deformation of their host crystals we are undertaking experiments using a Griggs-type piston-cylinder apparatus with weak salt as the solid confining medium. In addition to offering higher experimental pressures than conventional hydrothermal autoclaves pressurized by gas, the Griggs device permits experiments under deviatoric stress. A first series of experiments under hydrostatic conditions have been carried out on natural H_2O-CO_2-NaCl inclusions in large undeformed quartz crystals, obtained from orogenic gold-quartz veins at Brusson, NW Italy. Disks were cut from the samples at 45° to the crystallographic *c*-axis and polished such that their upper and lower faces were perfectly parallel.

Prior to the experiments numerous inclusions were mapped, photographed and analysed by microthermometry and Raman spectroscopy to determine their initial molar volumes and compositions. The corresponding fans of isochores were calculated to span a range of pressures at 700 °C, the mean internal pressure being approximately 600 MPa. The samples were therefore placed at 700 °C and 500, 600 and 800 MPa (all within the alpha-quartz field) for 16 hours, in order to induce re-equilibration of the inclusions under conditions of internal underpressure and internal overpressure. Following the experiments the inclusions were relocated and reanalysed. In each case, irreversible changes in the shape and composition of the inclusions were observed. Moreover, the initial variation in bulk molar volumes reduced considerably during the experiments, converging on the values expected for the externally imposed *P–T* conditions. The successful instrumental control attained in these hydrostatic re-equilibration runs is a necessary prerequisite for our on-going experiments involving deviatoric stress.

Feldspars of composition $K[(Al,Fe)Si_3O_8]$: Their growth and ordering behaviour

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K-feldspars in the system $K[AlSi_3O_8]$ - $K[FeSi_3O_8]$ have been synthesized hydrothermally from oxide mixes together with KOH solution at P_{H2O} = 1 kbar and T = 400 °C, 500 °C, and 600 °C to investigate their ordering behaviour, the extent of Al,Fe substitution, and the influence of oxygen fugacities on the run products.

In the Ni-NiO buffered runs Fe^{3+} was partly reduced to Fe^{2+}. Abundant growth of Fe-containing mica left the K-feldspar strongly depleted in Fe^{3+} relative to the starting material. In the Cu-Cu_2O runs with their larger oxygen fugacities, growth of delafossite ($Cu^{1+}Fe^{3+}O_2$) took up various amounts of Fe^{3+} resulting in Fe^{3+} contents of the K-feldspars ranging from 20 mol% to 100 mol%.

Considering the discontinuous character of the sanidine-microcline transition in both K-feldspar endmembers, a phase diagram has been calculated from known transition temperatures (480 °C and 704 °C, respectively) and known (7300 J/mol; Hovis, 1988) or derived transition enthalpies (11500 J/mol) yielding a narrow two-phase field separating (Al,Fe)-sanidine from (Al,Fe)-microcline. In the Al-rich part of the diagram, metastable monoclinic K-feldspar persisted in the stability field of microcline, whereas Fe-rich compositions attained the triclinic ordered state. No indication of a miscibility gap was detected.

Pure KAl-feldspars, even after long annealing, kept a high degree of disorder in agreement with predictions from the Mueller rate equation, when using an updated calibration of ln(Kd) vs. 1/T: -RTln(Kd) = 4047(668) - 1.80(47)*T + 10955(929)*Q.

Structural incorporation of Fe^{3+} leads to increasing order, the more so the lower the temperature of annealing. Following the ideas of Graham & Elphick (1991), this is interpreted as a consequence (i) of the proton concentration in the structure having a larger effect on Fe,Si than Al,Si interchanges and (ii) of solution-reprecipitation processes, dominating over solid state diffusion at increasing Fe contents. Solution-reprecipitation becomes the more effective the more the metastable monoclinic K(Al,Fe)-feldspars deviate from their field of stability.

References

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