Acta Mineralogica-Petrographica, Abstract Series 2, Szeged, 2003

MELT AND FLUID INCLUSIONS IN DIOPSIDE-TITANITE VEINS, ARKAROOLA (SOUTH AUSTRALIA)

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Arkaroola is located in the northern Flinders Ranges, South Australia, and consist of Palaeo-Mesoproterozoic basement overlain by Neoproterozoic-Cambrian metasediments. The area underwent deformation and high T - low P metamorphism during the ~ 500 Ma Delamerian Orogeny. This was followed by a localised magmatic-hydrothermal event in the Late Ordovician (~ 440 Ma) (Elburg et al., 2003), with intrusion of a large I-S-type granitic batholith, formation of diopside-titanite veins and uranium mineralisation in the basement. The waning stages of this event are characterised by skarn formation and quartz-hematite mineralisation. The origin and evolution of the diopside-titanite veins is the main objective of this study.

The diopside-titanite veins consist of large (up to 60 cm long), often euhedral crystals of diopside with or without euhedral crystals of titanite (up to 20 cm diameter). The veins are up to 1.5 m wide and occur within Mesoproterozoic A-type granites. Both diopside and titanite belong to the same crystallisation event, and have grown into open space. The veins were partly brecciated before a second stage of mineralisation consisting of hematite-calcite-quartz.

Titanite contains several types of inclusions: (1) recrystallised melt inclusions (Fig.1a). These inclusions are filled with up to 90 vol.% solid phases including hematite, anhydrite, calcite, and quartz (as identified by micro-Raman laser probe). The remaining fluid is a highly saline aqueous solution. The inclusions occur in subparallel trails, typical for a secondary origin. They have a dark appearance and vary between 5 and 100 μm in diameter. The larger inclusions show indications of re-equilibration, exemplified by decrepitation textures. They have haloes and tails, which may extend for several 10's of μm. (2) three phase aqueous inclusions (Fig.1b). These inclusions contain a vapour bubble and a salt crystal, both approximately 10 vol.%. The consistency in phase ratio is indicative of homogeneous entrapment. They have a flat and irregular appearance and vary between 1 and 20 μm in their longest dimension. They occur as planar haloes around type 1 inclusions or in narrow trails. (3) single phase solid inclusions. They consist mainly of anhydrite or quartz crystals closely associated with type 1 inclusions.

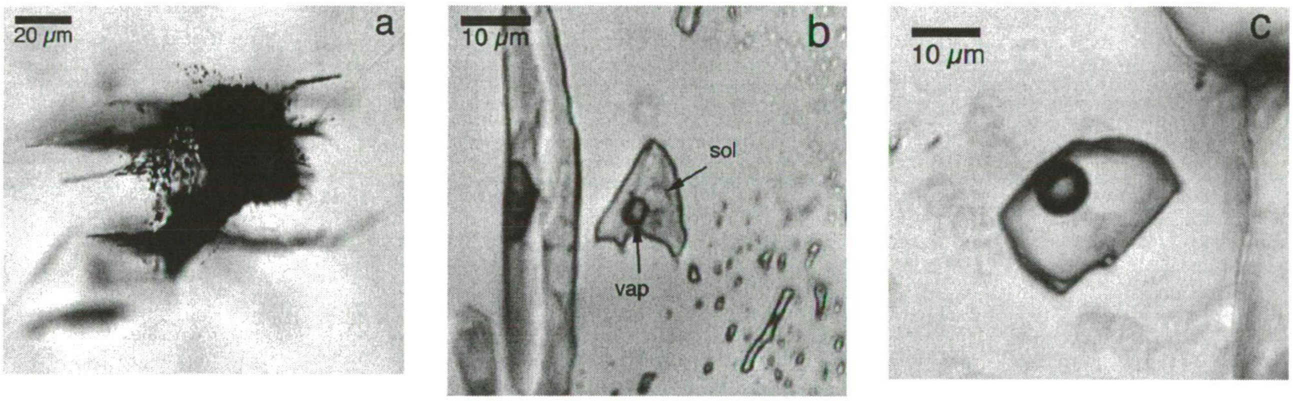

Fig.1. (a) Re-equilibrated secondary melt inclusion in titanite; **(b)** three-phase highly saline aqueous fluid inclusion in titanite; **(c)** aqueous inclusion in calcite.

The presence of a good cleavage prevents the preservation of inclusions in diopside, however, several highly elongated cavities are observed containing an aqueous solution and hematite crystals. These inclusion are not regarded as reliable for the interpretation of the origin of diopside.

The calcite occurs as bladed and coarse crystals, typical for a boiling hydrothermal system. The fluid inclusions have a primary character and contain an aqueous fluid with a ~10 vol.% vapour bubble (Fig.1c). They have regular shapes (negative crystal) and vary between 20 and 30 μm in diameter. Small euhedral single crystals of sulphate, hematite and diopside occur as solid inclusions.

Most fluid inclusions in quartz are homogeneous and consist of a saline aqueous fluid. They resemble the inclusions in calcite. Some contain a highly variable collection of accidentally trapped crystals, including 2 salt cubes, a complex sulphate phase, calcite, hematite, magnetite and pyrite.

The absence of primary fluid or melt inclusions in diopside and titanite prevents a conclusive interpretation of their origin, but we propose that they crystallised from an unusual pegmatite-like melt. Thermodynamic modelling will put additional constraints on the stability of this assemblage. The secondary melt inclusions in titanite may belong the same event as the macroscopic brecciation of the veins, resulting from forceful intrusion of overpressurised melt. A sudden decrease in pressure is evident from the decrepitation textures of those melt inclusions. An overpressure could have been maintained in a relatively closed system, and a relaxation to lithostatic or hydrostatic pressures by opening the system may have caused the sudden pressure release. Additionally, this pressure released caused boiling of the fluid-melt system, i.e. the separation of a highly saline aqueous fluid. The second mineralisation phase, including hematite, calcite and quartz occurred out of this fluid. The similarity in mineral assemblage between the melt inclusions in the titanite and the second mineralisation phase indicate that both melt and fluid belong to the same chemical system.

References

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