Geophysical Research Abstracts, Vol. 7, 02782, 2005
SRef-ID: 1607-7962/gra/EGU05-A-02782

Massive Quartz Veins – Insight in Crustal-Scale Fluid Flow along Faults

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Quartz veins can reach enormous sizes, over a million cubic meters in volume. Examples of such veins were studied near Poolamacca Station, western New South Wales (Australia), near Arkaroola (South Australia), and in the eastern Pyrenees (Spain). Such veins tend to occur in medium to high-grade rocks, but are themselves usually emplaced during retrograde metamorphism, typically at lower-greenschist facies conditions (around 250-300˚C). The quartz veins are commonly located at faults or distinct lithological boundaries, such as unconformities.

The highly localised precipitation of quartz is in contradiction to popularly used models of continuous percolation of fluids along faults. A fluid that percolates upwards through a fault zone would precipitate more quartz at deeper levels than at the shallow levels [1] where the massive quartz veins are commonly found. To avoid quartz precipitation during ascent of a fluid, the fluid must rise rapidly. Ascent of fluid batches in "mobile hydrofractures" [2] can explain the rapid ascent of fluids, which only precipitate their dissolved minerals at their emplacement level around the brittle-ductile transition. Fluid batches preferentially follow discontinuities within the crust, typically faults. Faults that served as pathways for mobile hydrofractures may show strong internal deformation, even when the displacement along the fault is minor. This deformation is not the result of fault movement, but of the catastrophic passage of fluids.

The massive quartz veins indicate that fluid transport is highly discontinuous, with periods of quiescence punctuated by sudden localised bursts of rapid fluid flow [3]. This nature of crustal-scale fluid flow should be incorporated into models if these are to correctly describe the transport of material within the crust, and the formation of many types of ore deposits.

[1] Connolly, J.A.D., 1997. Mid-crustal focussed fluid movement: thermal consequences and silica transport. In: B. Jamtveit, B. and B.W. Yardley (Editors), Fluid flow and transport in rocks. Chapman & Hall, London, pp. 235-250.

[2] Bons, P.D. 2001. The formation of large quartz veins by rapid ascent of fluids in mobile hydrofractures. Tectonophysics 336, 1-17.

[3] Bons, P.D. & van Milligen, B.P. 2001. A new experiment to model self-organized critical transport and accumulation of melt and hydrocarbons from their source rocks. Geology 29, 919-922.