Pyrite is the key: Insights into ore forming processes at Bendigo, Australia using LA-ICPMS trace element and isotope methods

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Gold at Bendigo is hosted in quartz saddle reefs emplaced in a series of Ordovician turbidites. Pyrite growth occurs from sedimentation to late metamorphism, as later pyrite commonly nucleates from earlier generations; with careful petrography a near complete sequence of events can be shown. Pyrites were analysed on the LA-ICPMS at CODES to give quantitative element analyses and laser trace element maps; they were analysed at the University of Tasmania Stable Isotopes Lab, both conventionally and by *in situ* laser, and *in situ* at the SHRIMP II ion-probe ANU, Canberra to give sulfur isotope information. Examples of trace element maps can be seen in Large *et al*. [1].

Early diagenetic pyrite is defined as fine grained rounded or nodular aggregates comprised of intergrowths of acicular and fine cubic pyrite and marcasite. Later, metamorphic-hydrothermal pyrite is defined as euhedral and often internally zoned, in places overprinting the metamorphic fabric. Diagenenetic pyrite present in shale horizons exhibits a consistent association of elevated Bi, Ni, Cu, Mo, Ag, V and pb; with a higher Ag/Au ratio than demonstrated in metamorphic-hydrothermal pyrites. Metamorphic-hydrothermal pyrites tend to have a simpler trace element association, exemplified by a gold-arsenic relationship where the concentration of gold retained in the structure of the pyrite is directly proportional to the arsenic concentration. Pyrites located close to productive gold-reefs show Au-As rich rims.

Our sulfur isotope work demonstrates the presence of discrete populations of sulfur isotope ratios which may indicate the influence of a homogenization process. Pyrites in the sediments at Bendigo show a range of around (-15 to 15‰ δ34S) with pyrites in the reef exhibiting a range of (-1.5 to 2‰ δ34S)

[1] Large *et al*. (2009) *Econ. Geol*. **4**, 635–668.

Fe-Mg interdiffusion along dry grain boundaries in quartzites

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Experiments were conducted to study Fe-Mg interdiffusion along dry grain boundaries in which the diffusant is incompatible in the dominant matrix mineral. Two quartzites were synthesized for starting materials using a piston cylinder at high P-T conditions—one was a pure quartzite and another contained ~10% fayalite (Fe_2SiO_4) 'detector particles' dispersed along the grain boundaries. After synthesis experiments, the quartzites were cut into disks and polished. Diffusion experiments were conducted by sandwiching the pure quartzite between polished slabs of MgF_2 and fayalite-bearing quartzite. The only available pathway for Fe-Mg communication between the MgF_2 source and the fayalite detector particles was along the grain boundaries in the pure quartzite. The juxtaposition of the quartzite containing fayalite detector particles and the MgF_2 caused strong chemical potential gradients to develop within the intervening pure quartzite. After diffusion experiments, the diffusion couples were sectioned and the fayalite detector particles were analyzed for diffusant (i.e. MgO) using an electron microprobe. The MgO content of fayalite detector particles decreases with increasing distance from the quartzite interface. Transport of Mg across ~1 mm thick slabs of pure quartzite suggest minimum Fe-Mg interdiffusivities of $\sim 10^{-11}$ m^2/s at 1100°C. Pyroxene grains grew along the grain boundaries of the initially detector particle-free pure quartzite. The Fe and Mg contents of the pyroxene grains vary linearly throughout the intervening quartzite. A time series study shows that steady state interdiffusion is rapidly established and that pyroxene grains coarsen with increasing experimental duration.