Experimental replacement of siderite by iron-sulfides

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Formation of pyrite via sulfidation of iron bearing minerals is an important process that can occur during ore deposition. Here we present an experimental study to investigate the replacement of Fe-carbonate (i.e., siderite) by Fe-sulfides.

Replacement experiments were performed in closed PTFE autoclaves at 200°C and vapor saturated pressure using natural siderite ($Fe_{90}(Mg,Mn)_{10}CO3$) and thioacytamite (CH_3CSNH_2) which breaks down upon heating to form H_2S. The formation of sulfides was studied as a function of reaction time, pH and H_2S concentration.

Reacted siderite shows different replacement textures depending mainly on H_2S concentration. Experiments with high starting H_2S concentrations (>0.25 molal) produce a complete replacement of siderite by either a dense mass of anhedral pyrite or euhedral pyrite crystals in a pyrrhotite matrix. At lower H_2S concentrations (0.01-0.1 molal) 3 different replacement zones can be observed: the outermost layer (few µm) is composed of µm sized pyrite that either occurs as euhedral, framboidal or spherical crytals; the second zone (20-70µm) consists of euhedral pyrrhotite crystals that form a highly porous network; the third zone is formed by euhedral magnetite surrounding the unaltered core of siderite. In experiments with low H_2S concentrations (<0.01) a thin pyrrhotite layer and a more pronounced magnetite layer can be found.

The observed replacement textures most likely result from a coupled dissolution-reprecipitation process mimicing the H_2S evolution of the experimental fluid. The firstly formed outer zone of pyrite consumes S from the fluid to such a degree that pyrrhotite is stabilised. Further depletion of S caused by formation of pyrrhotite leads to the stabilisation of magnetite.

The presented experimental study shows that sulfidation of siderite via replacement is an effective process to reduce H_2S activity in hydrothermal fluids and therefore enabling formation of pyritic ore deposits. Furthermore, the controlled precipitation of pyrite via a coupled dissolution-reprecipitation process can be utilised to study trace element partitioning between hydrothermal fluids and pyrite.