Paper Number: 4279

The rapid kinetics of fluid-catalyzed exsolution processes in hydrothermal systems

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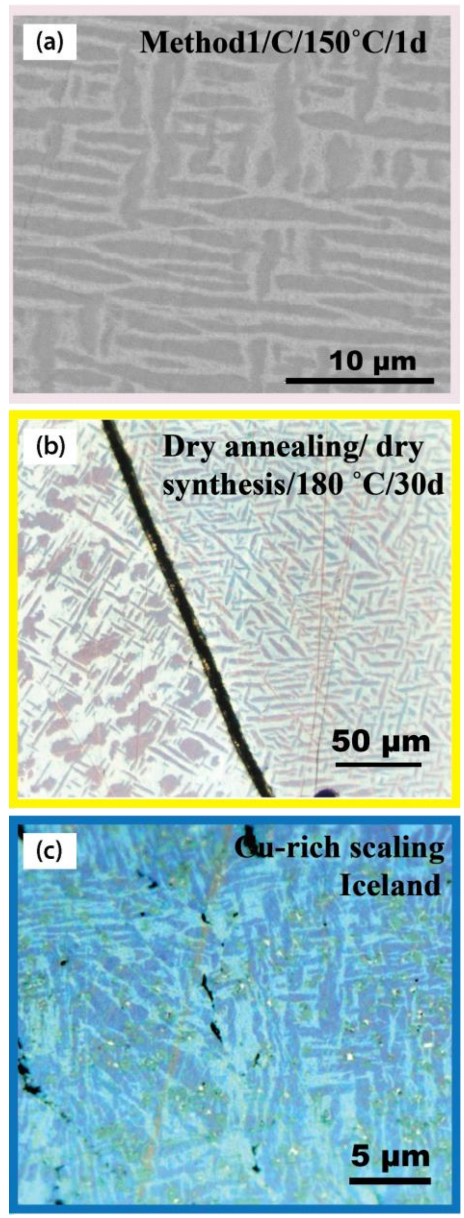

Exsolution is a process by which a homogeneous solid solution phase separates into two distinct phases. Exsolution is considered to be a solid-state process controlled by diffusion, and hence the width of the exsolution lamellae is expected to depend on the original crystal composition and the cooling rate. We have conducted experiments that reveal that exsolution can also be a fluid-driven process. Similar textures are obtained in dry and wet conditions, but for the fluid-driven case the kinetics of the exsolution reaction and the size of the lamellae depends on the porosity of the starting material and its thermal history.

In the case of synthetic bornite–digenite solid solutions, the kinetics of both dry [1] and fluid catalyzed unmixing into end-member components is very rapid. However, in the presence of water coarsening of the lamellae of *bornite* and *digenite* from the breakdown of a solid solution of composition $Bn_{87}Dg_{13}$ are readily observed after only 1 h of annealing at 150 °C (Fig. 1a), and full coarseness is reached after only 2 h. The kinetics of lamellae coarsening is 2,500 times faster than for similar solid solution compositions annealed under dry conditions (Fig. 1b). Our results indicate that the fluid within the open porous microstructure and at the grain boundaries plays an important role in driving the Ostwald ripening process, and it seems likely that the coarsening of the end-member products under these conditions is driven by fluid-enhanced grain boundary diffusion, a form of interface-coupled dissolution-reprecipitation reaction [2]. Such fluid-driven exsolution may be a major mode of reaction in ore systems, and are likely to affect oxide and silicate systems alike in the presence of aqueous fluids.

Figure 1: SEM images showing (a) the exsolution pattern after 1 day of hydrothermal annealing and (b) after 30 days of dry annealing (image from [1]). (c) Digenite occurs as graphic intergrowths with bornite as discrete exsolution lamellae, Cu-rich scales in the Reykjanes Geothermal System, Iceland (image from [3]).

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