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Simulation of Deformation, Fluid Flow, Heat Transfer, Species Transport, and Chemical Reactions in Hydrothermal Ore Systems

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Hydrothermal mineralization requires metal-bearing fluids to flow across gradients of pressure, temperature, or chemical concentration, or a combination of the above. Predicting the location of mineralization therefore requires an understanding of the hydraulic architecture of a fossil hydrothermal system in relation to thermal and deformation events, fluid pressure regimes, and the chemical composition of rocks and fluids. There is substantial need in the mineral exploration industry to understand the mechanical, thermal, and chemical controls on ore deposition, in order to find new deposits. Conceptual models are insufficient to gain a complete understanding of the complex interplay between these processes, but such models can provide input to quantitative, numerical models. Therefore we have developed a number of numerical schemes to investigate coupled deformation-fluid flow, deformation-fluid flow-thermal, and thermal-fluid flow-transport-reaction processes in three dimensions. These methods have been successfully applied on different scales to a number of hydrothermal ore deposit styles, such as Witwatersrand gold, unconformity-related uranium, lode gold, copper-lead-zinc-silver deposits, and Archean ophiolitic copper. We present examples of such simulations to illustrate the importance of coupling and feedback between processes in mineralized systems.