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2D or not 2D: Are two Dimensions enough to accurately model Convective Fluid Flow through Faults and surrounding Host Rocks?

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In many studies of water-rock interaction, convective fluid flow has been invoked to explain diagenetic processes or metal precipitation. Fluid convection in faults is increasingly recognized as an important mechanism for mass transport in hydrothermal systems, and there is often a close spatial relationship between major ore deposits and regional scale faults. Most numerical studies simulate free convection in 2D only. This is because fluid patterns are more easily recognised with less complicated geometries, less computational time is required, or because computer codes may be restricted to two dimensions.

Using the finite difference simulation tool SHEMAT, a series of numerical simulations of thermally driven fluid flow have been carried out to investigate the difference in the fluid flow patterns in 2D and 3D models for the same geological architecture. The results of this study show that 2D and 3D models of convection in hydrothermal systems produce significantly different results. In many cases 2D models represent an oversimplification, and conclusions reached from such investigations are likely to be irrelevant. In the case of planar high permeability regions, such as faults and permeable stratigraphic units extending along strike, 2D and 3D modelling outcomes vary significantly. Hence 3D models are absolutely essential to describe the flow field in these cases. However, 2D models of high permeability regions with close to radial or linear symmetries, such as damage zones between fault jogs or at fault intersections, give reasonable results in 2D.