# SEG 100 Conference: Celebrating a Century of Discovery

**S6**
**Structural Geology and Hydrothermal Ore Deposits**

Thomas Blenkinsop
School of Earth and Ocean Sciences, Cardiff University, Cardiff, United Kingdom

Strong structural controls on mineralization are characteristic of hydrothermal ore deposits. These arise because the permeabilities of crustal rocks are too low to allow deposit formation on realistic timescales unless rocks are deformed. A thorough structural investigation involves geometrical, kinematic (displacement and strain), dynamic (stress), and rheological analyses: each step can make important contributions to understanding hydrothermal mineralization. This review advocates a workflow based on these steps and introduces some recent relevant advances in structural geology. The focus is on gold, but most aspects apply to hydrothermal deposits in general.

Deformation zones and networks of deformation zones are the fundamental structures that control mineralization. Geometry relates orebody shape to controlling structures. Networks of deformation zones can be analyzed using topology to evaluate their connectivity and mineralizing potential. Kinematic analysis determines the locations of permeability creation and mineralization. Recent knowledge about shear zone kinematics has advanced significantly by taking into account variable amounts of pure and simple shear. These variations change likely directions of mineralization in predictable ways if the kinematics of the shear zones are known. A fresh appreciation that multiple orientations of deformation zones may form simultaneously and symmetrically about the principal strain axes has commensurate implications for orebody controls. Dynamic analysis is necessary for a mechanical understanding of deformation, fluid flow, and mineralization and for numerical modeling. Several important new tools for dynamic analysis are ready for application in exploration and mining. Rheology is the relationship between deformation (kinematics) and stress (dynamics): rheological contrasts are critical for the localization of many deposits.

Numerous hydrothermal gold deposits, especially the largest, have evidence for multiple mineralizing events that may be separated by tens to hundreds of millions of years. Reactivation of structures is common in these cases. A range of orientations of preexisting structures may be reactivated, given that they are weaker than intact rock.

Hydrothermal gold deposits form in contractional, strike-slip, and extensional tectonic settings. There may be great variations in the spatial scales over which a given stress regime applies, and stresses may change on rapid timescales, so that it is inadvisable to infer local tectonics from deposit-scale patterns and vice versa. It is essential to place mineralizing events within a complete geologic history in order to identify the effects of pre-, syn-, and postmineralizing structures on deposit geometry.

The mechanical conditions for various types of hydrothermal gold mineralization can be depicted on a failure mode diagram (Fig. 1). This diagram shows pore fluid pressure and differential stress, but recent rock mechanics experiments demonstrate that the intermediate stress is also a significant factor in failure. Adding detail to diagrams such as Figure 1 and appreciating the role of the full stress tensor are prime challenges for the future of ore deposit studies.

Fig. 1. Failure mode diagram showing fields of pore fluid pressure and differential stress for various types of hydrothermal gold mineralization.