

## Tracking Brines in Crustal Processes

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Brines play an important role in fluid processes at many levels in the crust, but especially in diagenetic and ore-forming processes in the upper crust. While many brines originate directly from evaporite-forming processes near the surface, others can arise as a result of removal of water from saline fluids through metamorphic hydration reactions, dissolution of deeply buried halite, or be exsolved from crystallising melt. Because brines can transport very large concentrations of many metals, understanding their origins is important for modelling ore genesis. They may also be significant in the lower crust, where low water activity brines can nevertheless permit significant mass transfer.

Most geochemical tracers of fluid-rock interaction are of little value for understanding rock-dominated crustal fluid processes, because they do not preserve a memory of a significant period of the fluid's history. Following the pioneering work of Bohlke and Irwin (1992), we have used the conservative halogen ratios, notably Br/Cl values, to distinguish different brine sources, measuring values in fluids leached from fluid inclusions in high-temperature rocks. To these, we have now added measurements of  $\delta^{37}\text{Cl}$  (Banks et al., in press). Sedimentary fluids can display a very wide range of Br/Cl, reflecting the consequences of precipitation or dissolution of halite, and thus bracket the range of possible magmatic and metamorphic fluid compositions. Preliminary results suggest that many sedimentary fluids preserved in fluid inclusions have  $\delta^{37}\text{Cl}$  in the range -1 to +1 per mil, irrespective of Br/Cl ratio, while magmatic fluids may have distinctive  $\delta^{37}\text{Cl}$  values, a few per mil heavier than those of most sedimentary brines.

The Capitan pluton, New Mexico, released hypersaline magmatic fluids that gave rise to Th-U-REE mineralisation (Campbell et al., 1995). In that study we showed that the salt had originated from evaporite deposits through which the pluton was emplaced, based on their low Br/Cl ratios. New  $\delta^{37}\text{Cl}$  determinations show a weak trend away from seawater values (close to 0), with a maximum of +1 per mil. In contrast, high-T ore fluids from SW England are less depleted in Br but many have distinct  $\delta^{37}\text{Cl}$  values near +2 to +3 per mil. This would appear to be a magmatic signature, although it is too early to know if it is universally applicable, and there is evidence of mixing with a Br-depleted brine composition. Some late, low-T ores are associated with quite distinct fluids having seawater characteristics, and appear to result from deep groundwater convection with no magmatic salt input.

Limited data from saline fluids trapped under extreme metamorphic conditions shows no obvious distinguishing characteristics, casting doubt on the ability of interactions between silicate rocks and fluids to change the halogen characteristics in a distinctive manner. It appears that magmatic processes and/or halite precipitation or dissolution are the main ways in which fluid halogen signatures can evolve.

Bohlke JK & Irwin JJ, *Geochim Cosmochim Acta*, **56**, 203-225, (1992).

Campbell AR, Banks DA, Phillips RS & Yardley BWD, *Econ. Geol.*, **90**, 1271-1287, (1995).