

The vapour transport of metals: A view from the ivory tower of experimental geochemistry

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Although researchers have long considered vapour to be unimportant in the transport of metals in ore-forming hydrothermal systems, because of the vanishingly low volatility of most metals (their vapour pressure over the corresponding solids), there has been increasing evidence from fluid inclusion studies that metal solubility may be very much higher in the vapour than predicted. Indeed, the fluid inclusion evidence suggests that the vapour may play an important and even dominant role in the transport of metals in some magmatic hydrothermal systems. In order to resolve this conflict between observation and theory, we and several other research groups have been conducting experiments designed to measure the solubility of metals in the vapour and their partitioning between vapour and liquid. Solubility experiments in the system HCl-H₂O for a variety of metals, including Ag, Au, Cu, Mo and Sn, show that the transport capacity of the vapour is orders of magnitude higher than predicted by volatility data, but still very much lower than measured in vapour inclusions. Moreover, partition experiments for this and other chloride systems indicate that, except for As, the common ore metals prefer the vapour; Mo partitions preferentially into the vapour above 360°C. However, the addition of H₂S, which partitions strongly into vapour, has been shown to dramatically increase the solubility of Au in this phase and to lead to preferential partitioning of Cu and Au into the vapour over the liquid. These results and the observation that the experiments have been carried out at temperatures and vapour densities well below those at which vapour fluid inclusions containing high metal contents were trapped, suggests that high activities of sulphur-bearing species at relatively low fO_2 may permit vapour to transport appreciable quantities of chalcophile metals and thus play an important role in the formation of some deposits of these metals, notably those of Cu and Au.

The behaviour of Antimony in naturally impacted waters

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Antimony (Sb), a toxic, non-essential trace element, is generally considered to exhibit behaviour similar to arsenic (As) in freshwaters. The theory that the two behave in the same way is based upon both elements being metalloids that form oxyanions in aqueous systems, but the assumption has rarely been tested outside the laboratory. This is in part because Sb as an environmental contaminant has only recently begun to receive attention.

The Waikato River, New Zealand receives natural inputs of both Sb and As from geothermal areas as the river flows through the Taupo Volcanic Zone. Tuakau, a site in the lower reaches of the river, has been sampled monthly for two years in order to determine how geothermally-derived Sb behaves in its receiving environments, and to examine how Sb and As compare. Most of the time, the distribution of Sb mirrors that for As, but occasional divergences suggest that the two metalloids do not always behave in the same manner, or at the very least are subject to different external pressures.

Adsorption edges using suspended particulate matter (SPM) collected at Tuakau show that Sb behaves significantly more conservatively than As. Whereas the amount of As that adsorbs to SPM over 24 hours depends upon the season of collection, Sb exhibits no such variability. At pH greater than 5, no SbV adsorption was observed at all over 24 hours, and no significant binding occurred even after 10 days. There is evidence that SbIII species will adsorb to Tuakau SPM at pH 3-10, but as most, if not all, Sb in the lower Waikato River exists as SbV, such adsorption is unlikely to be important.

These results are in stark contrast to published Sb adsorption edges using surfaces such as mine derived soils or iron-oxides, which have shown significant binding for SbIII and SbV species. However such experiments have used sediments with effectively fresh surfaces, and therefore reflect what might happen in one-off events (such as flooding). SPM, having been already exposed to waters of mixed chemistry, is more reflective of material aqueous Sb species encounter while in solution and is therefore of greater relevance when determining Sb's eventual fate.