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THE FATE OF TRACE ELEMENTS IN ANTARCTIC MELTWATER POND ENVIRONMENTS

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When meltwater ponds in Antarctica refreeze each winter, dissolved ions become concentrated in residual water through a process of exclusion, and can ultimately form a basal brine beneath the ice layer. The potential exists for trace metals to also become enriched in these brines, to levels which could adversely affect microbial life. The concentrations of Cu, Pb, Zn, As, Cd, Ag, Mn and Fe have been measured in the summer water column, and winter ice and basal brines, in ponds near Bratina Island, and in ponds in the Wright and Victoria Valleys in Victoria Land. Matrix interference in the analysis of the highly saline brines was overcome by using matrix modified standards, and analysis in triplicate at various sample dilutions by both graphite furnace AAS (or hydride generation AAS for As) and ICP-MS or ICP AES (for Fe and Mn). Trace element concentrations in the basal brines were compared to those that would have been expected, had the trace element experienced a similar degree of enrichment to that observed for conservative major ions, such as Na and Cl. The geochemical model PHREEQC was used to assess the solubility of trace element-bearing mineral salts in the brine, and SEM/EDAX was used to detect trace element enrichment in the cyanobacterial mats and sediments at the base of the pond.

In the basal brines, relatively high concentrations of Mn (up to 6.5 mg/kg) and As (up to 0.7 mg/kg) were observed in some ponds. In over half of the ponds studied, all trace elements except Mn showed evidence of removal from the water column during brine formation. Modelling showed solid phases such as Pb-, Zn- and Cd-carbonate, Cu-hydroxy-carbonate and AgCl to be potentially stable in oxic brines. However, if conditions turn anoxic in winter (as indicated by the presence of H_2S in some brines) the precipitation of insoluble sulfide minerals could limit the solubility of all trace elements except Mn. In support of this hypothesis, in the cyanobacterial mats Pb enrichment was observed both in calcium carbonate layers and, together with As, in the zone of black sulphate-reducing bacteria at the base of the mat.