The leachability of ore metals in argillaceous rocks

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Most models for Sedex and MVT ore systems envisage that the ore metals were derived from shale basins, irrespective of whether the ore fluids represent the expulsion of basinal brines or convected sea water. A common suggestion is that the ore metals were leached from the iron oxide coating of red bed sand grains, and so places a lithological restriction on possibilities for the source regions for the metals. Considering that argillaceous rocks usually form the bulk of the sedimentary basins from which ore fluids are derived, a pertinent question is whether these rocks could be the major source for the ore metals. To investigate this question, forty core samples of marine argillaceous rocks along a transect across western Canada, that range in age from the present to the Mesoproterozoic and represent burial depths ranging from 1 m to 20 km, have been chemically analysed by a series of sequential selective leaches: ammonium acetate for metals adsorbed onto clays; sodium pyrophosphate for metals adsorbed onto organic matter; hydroxylamine for metals adsorbed onto oxides; hydrochloric acid for metals contained in carbonates and monosulphides; aqua regia for metals contained in acid-soluble silicates; and total dissolution. Starting materials and leach residues were also analysed for bulk chemistry and mineralogy. The contents of the metals that are commonly associated with Sedex and MVT ore deposits (Zn, Pb, Cu, Ba, Mn) range over two orders of magnitude. A major cause for variation of metal contents is dilution of argillaceous and carbonaceous matter by quartz and carbonates. There is not an obvious correlation between metal content and depth of burial.

The first three sequential leaches, which purportedly do not involve the destruction of host minerals but extract only the labile metal content, collectively leach on average 13% of the Zn, 33% of the Pb, 17% of the Cu, 10% of the Ba, 11% of the Fe and 22% of the Mn of the rocks. In terms of average amounts, this is Zn 20 ppm, Pb 8 ppm, Cu 6 ppm, Ba 68 ppm, Fe 3480 ppm and Mn 180 ppm. These quantities of labile metals are sufficient to give concentrations of > 100 ppm in pore fluids even at porosities as large as 20%. The availability of leachable metal in sedimentary basins is therefore not a limiting control on the generation of Sedex/MVT ore systems. More likely, the major limiting factor is the concentration of chloride in the pore fluid, which together with temperature, show good correlations with base metal content of pore fluids of sedimentary basins and of fluid inclusions of Sedex and MVT ore deposits.