ABSTRACT

DISTRIBUTION OF NATURALLY OCCURRING ARSENIC IN GROUND WATER IN SOUTHEASTEN MICHIGAN

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In many parts of the "Thumb Area" of Michigan (southeastern Michigan), arsenic is present in ground water at concentrations that exceed the U.S. Environmental Protection Agency's retired maximum contaminant level (MCL), which was 50 micrograms per liter. With the recent reduction of the MCL to 10 micrograms per liter, many additional water supplies exceed the new MCL. Typically, ground water that exceeds the old MCL is from the Marshall Sandstone, although there are many areas where water from glacial or Pennsylvanian aquifers approaches or exceeds the new MCL.

Bulk rock samples of the Marshall Sandstone commonly have concentrations of arsenic that are about 10 ppm (parts per million), which is 5 times larger than the world-wide average for sandstones. Concentrations as large as 350 ppm have been measured in sandstones from areas of the Thumb. Pyrite is the only arsenic-bearing mineral known to be present in the Marshall Sandstone. Pyrite is ubiquitous in trace concentrations in the formation; in some sandstones pyrite constitutes as much as 20 percent, typically as pore occluding cement. Microprobe analyses of arsenic-bearing-pyrite grains show that arsenic is distributed heterogeneously, and arsenic concentrations as large as 7 weight percent have been measured. Large concentrations of arsenic are commonly associated with framboidal pyrite, but large concentrations of arsenic are also dispersed within massive pyrite cement. The Coldwater Shale (underlies the Marshall Sandstone) also contains large concentrations of arsenic (to 350 ppm), but relations of mineralogy to anomalous arsenic are unknown.

Authigenic pyrite formed during early-, mid-, and late-stages of mineral diagenesis. Early diagenetic pyrite forms coatings on detrital grains. Framboidal pyrite formed in the intermediate stages of diagenesis and precipitated on authigenic carbonate and chlorite, or on authigenic-quartz overgrowths. Late-stage pyrite encapsulates earlier framboidal pyrite grains in some cases.

Although the mineral source of arsenic in the Marshall Sandstone is known, the mechanism of arsenic release to ground water in unknown. The best working hypothesis is that oxidation of arsenic-bearing pyrite in glacial deposits (derived from rock fragments of the Marshall Sandstone and perhaps the Coldwater Shale) in the vadose zone is the major release mechanism. This explains the presence of arsenic in ground water in glacial and underlying bedrock aquifers. In situ release of arsenic in the Marshall Sandstone (bedrock aquifer) does not appear to be a significant process.