

Processes Controlling the Mobilization of Toxic Metals in Groundwater: The Interactions between Water, Rock, and Natural Organic Matter

“DUSEL offers a new and unprecedented opportunity for direct observation and direct experiments within the earth. These include addressing questions related to the protection and safe management of water resources for an expanding population to the effective restoration of contaminated ground water”—DUSEL Final Report.

Groundwater is a vital source of water for public supply, agriculture, and industry in the U.S. The occurrence of toxic trace metals in groundwater, however, is not uncommon. Of particular concern is arsenic, as high arsenic concentrations in groundwater have been documented in many areas of the United States. Within the last decade, parts of Maine, Michigan, Minnesota, South Dakota, Oklahoma, and Wisconsin have been found to have widespread arsenic concentrations exceeding 10 $\mu\text{g/L}$ in groundwater. In addition, as groundwater storage and recovery being accepted as an effective alternative to address water supply problems associated with rapidly increasing demand for drinking water, growing problems with the emergence of toxic metals, such as As, have been encountered. The current USEPA MCL for arsenic in drinking water, 50 $\mu\text{g/L}$, is under review after recognition of the risks of developing cancers (National Research Council, 1999). In 2000, the USEPA proposed a new, lower arsenic MCL of 5 $\mu\text{g/L}$ (U.S. Environmental Protection Agency, rev. June 2, 2000). Thus, a significant percentage of water supplies would be in violation under this proposal. Therefore, it is critical to gain a mechanistic understanding of the mechanisms controlling arsenic mobilization in the subsurface environment.

It has been reported that arsenic release from iron oxide appears to be the most common cause of widespread arsenic concentrations exceeding 10 $\mu\text{g/L}$ in ground water. Multiple geochemical conditions have been suggested to favor arsenic mobilization, including reactions of iron oxide with organic carbon. Notably, organic matter in groundwater plays important roles in controlling geochemical processes by acting as proton donors/acceptors and as pH buffers, and by participating in mineral dissolution/precipitation reactions. Dissolved and particulate organic matter may also influence the availability of nutrients and serve as a carbon substrate for microbially mediated reactions that mobilize arsenic. Numerous studies have recognized the importance of natural organic matter in the mobilization of metals and radionuclides. However, the mechanisms responsible for the transport or retention of organic molecules in the subsurface remain poorly understood.

Therefore, there is a critical need to investigate the interactions between water, rock, and natural organic matter, and their impact on the mobilization of arsenic and other toxic metals in subsurface environments, which will provide a much needed knowledge base to guide regulatory decision-making and water resources management strategies.