

## **OCCURRENCE AND DISTRIBUTION OF ARSENIC AND URANIUM IN THE POMPERAUG RIVER BASIN AQUIFER, WOODBURY, CONNECTICUT**

Craig J. Brown<sup>1,\*</sup> and Robert A. Zielinski<sup>2</sup>

1) U.S. Geological Survey, East Hartford, CT 06108, [cjbrown@usgs.gov](mailto:cjbrown@usgs.gov) (860) 291-6766

2) U.S. Geological Survey, Denver, CO 80225

The transport of anthropogenic and natural contaminants to public-supply wells (PSWs) is being studied in a glacial aquifer system in the Pomperaug River Basin of west-central Connecticut by the U.S. Geological Survey, as part of the National Water Quality Assessment (NAWQA) Program. One of the primary objectives of the study is to identify the source, distribution, and mobility of arsenic, uranium, and other trace elements of concern that could affect the quality of water in PSWs. A 22-well network of monitoring wells was installed and sampled along with the PSW in the modeled part of the aquifer that contributes ground water to the PSW. Trace elements were analyzed in grain coatings extracted from drill-core samples, and fission-track maps were produced from epoxy-mount thin sections of these samples to determine uranium distribution. Ground-water chemistry and solid-phase chemistry are used to determine the critical controls on trace-element concentrations in the water.

Stratified glacial deposits extend over an area of about 13 mi<sup>2</sup> in the Pomperaug River Basin and are the most productive sources of ground water for public supply. The stratified glacial deposits and till overlie a fault-bounded basin of Mesozoic-age rocks of arkosic sandstone, conglomerate, shale, and basalt (the Newark Terrane). Highlands to the east and west of the basin are composed of crystalline bedrock, including gneiss, granite gneiss, and schist of the Iapetus (Oceanic) Terrane. In the Pomperaug River Basin, as in much of New England, fractured bedrock aquifers and the valley-fill aquifer are hydraulically connected, although ground-water flow is generally much lower in fractured bedrock. Ground water moves from upland areas and the margins of the valley toward the Pomperaug River, lakes, and wetlands within the central part of the basin. Ground water in much of the stratified glacial aquifer is oxic, except in some parts where suboxic and anoxic conditions exist due to (1) the presence of sedimentary organic matter, (2) ground water in areas of discharge or in the underlying basal till or bedrock, and (3) areas of contamination by organic compounds. In these suboxic or anoxic waters, concentrations of dissolved oxygen typically are near or below detection levels, nitrate concentration is generally low or below detection levels, and dissolved iron and manganese concentrations can be high (>0.3 mg/L and >0.1 mg/L, respectively).

Dissolved (filtered) arsenic concentrations in the wells ranged from below the minimum reporting level (MRL) of 0.2 µg/L, to 5.8 µg/L; only five samples were above the MRL. The five samples with the highest dissolved arsenic concentrations had dissolved oxygen levels below 0.8 mg/L, and the two samples with the highest arsenic concentrations had very high dissolved iron levels (above 5 mg/L), indicating arsenic mobility under relatively anoxic conditions. A likely scenario is that sorbed arsenic is mobilized as the ferric oxyhydroxides dissolve under reducing conditions. The dissolved arsenic also may be higher in sediments that are derived from the underlying shales of the Newark Supergroup; both the Shuttle Meadow Formation and the East Berlin Formation can be sulfidic, and sulfides can sequester arsenic. The concentration of arsenic in the PSW was below the MRL.

Dissolved (filtered) uranium concentrations in the study area were low, ranging from below the MRL (0.2 mg/L) to 1.3 µg/L; only three samples were above the MRL. Uranium was highest in wells with low dissolved oxygen (<0.8 mg/L) despite the fact that uranium is more soluble under oxic conditions; this indicates that other factors are likely to control uranium concentration than solely dissolved oxygen. Uranium was highest in bedrock wells and generally highest in the deepest well of each cluster, indicating that the proximity to source material (bedrock) affects the dissolved uranium concentration. The concentration of uranium in the PSW was <0.2 µg/L. Activities of Ra-226 and Ra-228 were low (from <0.16 to 0.42 pCi/L and from <0.45 to 0.95 pCi/L, respectively) and are consistent with the uranium concentration data.

Ferric oxyhydroxide coatings on grains of glacial sediments, which can act as sites for sorption of arsenic or uranium, were extracted using acid solutions and analyzed for major and trace elements. Ferric-oxyhydroxide coatings extracted using 10 percent nitric acid yielded iron concentrations ranging from 2,100 to 2,300 mg/kg (mg of Fe per kg of bulk sediment). The extracted material also contained 0.09 to 0.38 mg/kg of uranium and 0.07 to 0.12 mg/kg of arsenic. Fission-track radiography of the stratified glacial deposits shows evidence of uranium associated with ferric oxyhydroxide grain coatings. Secondary iron oxides occur as oxidized parts of primary iron oxides, as hematite coatings and stains on other minerals, as a hematite-rich matrix of rock fragment grains, and as fracture-fill material. The distribution of uranium in the aquifer material infers the co-occurrence of uranium progeny such as radium, assuming that the sorbed uranium is not so recent that there is a limited build up of daughters by radioactive decay. Radon-222, which is derived from the decay of Ra-226, had activities in the glacial aquifer of the Pomperaug River Basin ranging from 580 to 2,200 pCi/L, exceeding the proposed MCL of 300 pCi/L in all five samples. High radon activities in ground water in the study area imply efficient emanation from surfaces containing the radium parent. The PSW sampled for this study had a radon activity of 1,100 pCi/L. Previous studies of radon in bedrock wells indicate that radon levels are high (from 3,000 to 650,000 pCi/L) in some of the crystalline rocks within the uplands part of the Pomperaug River Basin, including the Nonewaug granite and the Collinsville and Taine Mountain Formations. The short half-life of Rn-222 (3.8 days) precludes the possibility that the high activities seen in the stratified glacial deposits are derived from the upland bedrock aquifers, although the glacial deposits contain weathered minerals and rock fragments derived from bedrock. Some of the radon in the lower part of the glacial deposits could be from the underlying rocks of the Newark Supergroup, particularly the shales.

Despite the low concentrations of dissolved arsenic and uranium in the Pomperaug study area, it is important to understand the mechanisms related to their mobilization and transport. A similar terrane with slightly different conditions (pH, redox chemistry, source material) could result in very different behavior of natural contaminants and concentrations in PSWs. Sorption batch experiments will be performed on core samples from the study area to determine the effects of changes in pH on the sorption or desorption of arsenic and uranium.