Arsenic and Fluoride in Guanajuato Groundwaters, Mexico

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Toxic concentrations of arsenic (As) and fluoride (F) have been documented within the volcano-sedimentary aquifers of the Independence Basin in Guanajuato which lies on the northern edge of the Trans-Mexican-Volcanic-Belt. The geogenic sources of these contaminants, however, are unexplored. The distribution of As and F contamination in the major aquifers of the basin were determined from analyses of 24 water samples from five urban and rural areas. The mean As and F concentrations in the Cuenca Alto Rio Laja (CARL) aquifer were ~10 µg/L and ~0.5 mg/L, respectively. In contrast, the mean As and F concentrations in the Laguna Seca (LS) aquifer were ~44 µg/L and ~5.8 mg/L, respectively. The high sodium, alkalinity, and low calcium concentrations observed in both aquifers are typical for fractured acid volcanic geothermal systems. Additionally, elevated concentrations of boron, lithium, and groundwater temperature are indicators of geothermal origins which showed positive correlations with As (R^2 = 0.5, 0.7, and 0.6) and F (R^2 = 0.3, 0.7, and 0.5) concentrations. X-ray diffraction, petrographic, and elemental analysis revealed the country rocks of these aquifers are comprised of plagioclase, K-feldspar, quartz, biotite, calcite, volcanic glass, and fluorite with interstitial layers of pyroxene, amphibole, plagioclase, quartz, calcite, magnetite, and apatite. The release of As and F from the country rocks at 400 to ~500 m depths of each aquifer were determined through pH-adjusted batch reactors with groundwater from the recharge area of CARL with initial F of ~0.82 mg/L. Experiments at different pH revealed that at pH 5 the rocks of the CARL aquifer reduced F to ~0.68 mg/L and at a pH of 9, F concentrations increased to ~1.1 mg/L. Likely sorption explains the change in F concentrations with pH. The rocks of the LS aquifer released F at all three pH values as F-bearing minerals dissolved, limited by the common ion effect and ion exchange reactions. The minerals identified and the mechanisms observed in this work will aid future scientists to determine the sources and transport of As and F in similar volcano-sedimentary basins in central Mexico.