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HYDROGEOCHEMISTRY OF GROUNDWATER IN ZACATECAS, MEXICO: A FOCUS ON ARSENIC, FLUORIDE AND URANIUM

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Groundwater is the main source for domestic drinking water supply, irrigation, and industrial activities in the semiarid region of Zacatecas in central Mexico. In this investigation, the main objective is to identify the connection between groundwater flow systems and As, F and U concentrations in the Calera aquifer. The aquifer is continuous from a fractured media (felsic volcanic rock) to a porous media (basin-fill sediments) with a composite thickness of >500 m.

Groundwater chemical composition allowed the identification of 3 groundwater flow systems: a) local flows, represented by shallow groundwater, hosted in basin-fill sediments with average temperatures of 18°C, pH (8.3), Eh (303 mV), variation in water types (Ca-SO_4/Na, Ca-SO_4, Na-SO_4, Ca/Mg-Cl and Na-Cl) affected by anthropogenic activities and low As (<0.05-10 mg/l), F (<0.1-0.8 mg/l) and U (<0.05-2.8 mg/l) concentrations, b) intermediate flows, identified in wells with depths of 100 to 200 m, with water circulating through the basin-fill sediments and the sequence of volcanic rocks (rhyolitic tuffs, rhyolites, ignimbrites and basalts), characterized by average temperatures of 24°C, pH (7.55), Eh (316 mV), water types Ca-HCO_3 and Mg/Ca-HCO_3, and concentrations of As (10-40 mg/l), F (0.80-1.50 mg/l) and U (2.8-5.2 mg/l), and c) regional flows, characterized by groundwater from wells with depths above 200 m, the water circulating mainly through the sequence of volcanic rocks (rhyolitic tuffs and rhyolites), temperatures up to 31.5°C, pH (7.75), Eh (333 mV), water types Mg/Ca-HCO_3 and Na-HCO_3, and higher concentrations of As (40-75 mg/l), F (1.5-5.7 mg/l) and U (5.2-8.7 mg/l).

Microscale characterization of granites, rhyolites and rhyolitic tuffs identified fluorapatite and topaz as potential sources for As, F and U. These minerals were found as microcrystals and embedded in a glassy matrix, together with textures such as devitrification and spherulitization marking the alteration of volcanic glass. Fluorite was found undersaturated in most groundwater samples, equilibrium conditions were identified for some samples from the regional system. The aerobic and oxidizing conditions prevailing in groundwater facilitate the presence of the stable oxy-anions $HAsO_4^{-2}$, $UO_2(CO_3)_2^{-2}$ and $UO_2(CO_3)_3^{-4}$, they are probably controlled by the interaction with oxi-hydroxide phases in the rock and basin-fill sediments.