LINKING SURFACE 3H TO 3H-3HE GROUNDWATER AGE BY GAS-LIQUID PHASE TRANSPORT MODELING

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The tritium and helium-3 (3H-3He) isotope groundwater age dating method provides a valuable tool for estimating groundwater residence times of 50 years or less. However, interpretation of 3H-3He data without consideration of unsaturated zone processes leads to difficulties. The negative effects of dispersivity and diffusivity on uncertainty of calculated 3H-3He groundwater ages are exaggerated without consideration of 3H dispersion and 3He gas partitioning in the unsaturated zone. Surface concentration of 3H inferred from 3H-3He age and 3H groundwater concentration will be underestimated without consideration of vadose zone residence time. To address these difficulties, a coupled gas-liquid phase transport model offers improved linking of surface water 3H activity to 3H-3He age in groundwater.

Importantly, the gas-liquid phase model includes simulation of 3H and 3He transport in the unsaturated zone, where 3He preferentially partitions into the gas phase. By doing so, the gas-liquid phase model confronts a recurring problem in 3H-3He age interpretation: assuming the 3H activity in surface water (generally inferred from IAEA precipitation records) is the same as the initial activity for the 3H-3He groundwater age dating chronometer. This problem arises because the 3H concentration history reaching the water table, the actual location of recharge to groundwater, can be significantly different than the 3H concentration history measured in surface water.

Conventional groundwater age interpretation of 3H-3He data from shallow irrigation wells in the San Joaquin Valley, California suggests 3H activities in recharging groundwater at the water table are higher than seen in precipitation for the calculated recharge year. Gas-liquid phase 3H and 3He modeling results, however, show that accounting for travel time and dispersion from transport through a 5-meter thick vadose zone completely resolves this unrealistic discrepancy and confirms the primary recharge source since agricultural development is irrigation return and not precipitation. In the larger realm of isotopic data interpretation, the gas-liquid phase transport modeling approach enables direct coupling of isotopic transport processes between atmospheric, surface water, vadose zone, and groundwater systems.

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