Collaborative Research (USC and UT): A Study of Naturally Occurring Decay-Series Isotopes as Quantitative Hydro-Geochemical Tracers

Teh-Lung Ku, University of Southern California
John F. McCarthy and Randall W. Gentry, University of Tennessee

PROJECT SUMMARY

Chemical transport in groundwater is often studied in the laboratory setting which may differ considerably from the natural settings in terms of heterogeneity of the sediment and the scales involved, both temporal and spatial. To assess the in-situ transport rates, this project makes use of the distributions of naturally occurring uranium- and thorium-series isotopes in an aquifer system. $^{238}$U and $^{232}$Th in rocks decay to stable isotopes of Pb through a series of intermediate daughters consisting of elements with diverse chemical properties and a wide range of decay mean lives. These decay-series isotopes enter groundwater as a result of water-rock interaction. Their abundance and ratios in groundwater evolve as the water passes through rock media, with resultant parent-daughter disequilibrium relationships providing quantitative constraints on subsurface geochemical reactions and transport processes on various time scales.

We will conduct this multi-tracer research in a regional aquifer system known as the Memphis aquifer at the Shelby County area in western Tennessee. In connection with the determination of groundwater recharge, it has been a research study site for interdisciplinary studies involving geochemistry, environmental tracers, numerical modeling and sediment analysis. We will collect groundwater from various locations and aquifer depths for isotopic measurements of $^{238}$U and $^{234}$U), thorium ($^{234}$Th, $^{230}$Th, $^{228}$Th, and $^{232}$Th), radium ($^{226}$Ra, $^{228}$Ra, and $^{224}$Ra), lead ($^{210}$Pb), polonium ($^{210}$Po) and radon ($^{222}$Rn). Measurements will also be made on aquifer solids and colloidal particles. Modeling the observed radioactive disequilibria in fluids and colloids will be attempted to quantify the kinetics of water-rock interactions (e.g., rates of adsorption/desorption and precipitation/dissolution) and their effects on chemical transport and subsurface flows. The model results, to be tested by the measured disequilibria in the sorbed phases of rocks, allow calibration of transport models developed from small-scale, natural, undisturbed flow system, and may reveal new processes that are not apparent in laboratory studies or field manipulation experiments. It is anticipated that the research will provide new insights into the colloidal associations of radioisotopes in groundwater. Through an enhanced understanding of long-term subsurface contaminant transport, the research has the practical benefit of strengthening the scientific basis for risk assessment and management of nuclear wastes stored in geologic systems.

Fund by the National Science Foundation, 2003-2006