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Conducting a field-scale reactive transport experiment: logistics and lessons learned

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Full field-scale experiments on contaminant transport are quite rare in the literature for a variety of reasons, including inability to obtain permission, risk of environmental contamination, budget constraints, complication of logistics or lack of equipment or personnel. In particular, in the scope of radionuclide transport, there are few sites available which allow for injection of even stable isotopes or chemical analogues of their more toxic radioactive counterparts. In the Autumn of 2018, our group had a unique opportunity to conduct a field-scale reactive transport experiment investigating the mobility of radionuclide analogues in the presence of colloids through a fractured chalk flow path.

The purpose of the experiment was to study the effect of bentonite colloids on the mobility of Re, Cs, Ce and Sr through a fractured chalk aquifer in an industrial zone in the northwestern Negev Desert, Israel. A 100-L tracer solution containing known concentrations of each metal, the fluorescent dye uranine, and bentonite colloids was injected into an observation well, and a second observation well 47 m away was pumped at 8 L/min to create an artificial gradient throughout the full 8-day duration of the experiment. Samples were collected at depths of 10 and 20 m from the injection well and in parallel from the pumping well at regular intervals throughout the experiment. Each sample was subsequently divided into two samples while in the field: one aliquot of each sample was acidified for total metal concentration analysis, and one aliquot was immediately filtered through a 0.22 μm syringe filter to remove all particulate matter and determine the fraction of mobile metal as an aqueous species. After 5 days of pumping, a second injection of 500 mL tap water containing sodium naphthionate, a second fluorescent tracer, was injected to investigate the impact of changing the ionic strength. All metal concentrations were analyzed using ICP-MS, and ultimately breakthrough curves were used to determine the hydrological and geochemical parameters dictating the mobility of each metal in the site.

Planning such an experiment requires a considerable amount of logistics and effort. The experiment employed 19 staff members working around the clock to take measurements and collect samples. About 2000 test tubes and 1000 filters and syringes were used. Weather was a consideration; while the experiment was planned for the dry season to avoid damage to electrical equipment, a dust storm blew through the field site during the experiment, followed by light rain. These and other details are often overlooked in the final presentation of scientific data either in manuscripts or conferences, but they play an important role in determining the success of the experiment or even in explaining the observed results. This experiment can serve as a case study for how well-planned logistics, excellent technical support and well-trained staff cannot be overlooked in producing article-worthy field data.