Geoelectrical Surveys at the Oak Ridge Field Research Center

Oak Ridge ORFRC (Principal Investigator: André Revil)

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We performed a 3D resistivity survey and self-potential mapping at the Oak Ridge Field Research Center (ORFRC) to locate contaminant migration from the former waste disposal S3 ponds. The S3 area historically received liquid waste containing uranium and nitric acid, which has leached into the underlying groundwater. The pH of the contaminated groundwater is less than 4 and the electrical conductivity is very high, exceeding 5 S/m at several locations in the plume. The groundwater composition made it possible to detect zones of contaminant migration using electrical resistivity. A total of 17 resistivity profiles were collected along three sides and downgradient of the former S3 ponds. All but two profiles used an electrode spacing of 2 m with a total profile length of 126 m while the electrode spacing of the two 235 m long profiles was 5 m. The electrical conductivity of water samples collected from monitoring wells and inverted electrical conductivity at the same locations are correlated. The correlation provides evidence that ERT can be used to detect plumes with high total dissolved solids emanating from the former ponds. ERT measurements were also inverted to create a 3D resistivity model. Zones of low resistivity correspond to zones where contamination is observed. Time-lapse electrical resistivity measurements collected along one profile downgradient of the S3 ponds were inverted using a new time-lapse algorithm with an active time constrain approach to investigate the effect of infiltration on plume dilution and attenuation. Decreasing electrical resistivity was observed immediately after heavy rainfall and the greatest electrical resistivity was observed between May and September, which is the driest period during the year. Self-potential profiles were corrected for the presence of anthropogenic noise and provide further evidence for the location of the plumes.

In addition to the field measurements, we also investigated the petrophysical properties of saprolite core samples in the laboratory including complex conductivity and streaming potential coupling coefficients at different salinities and pH. Contaminated saprolite was neutralized in a separate column experiment. The results showed that complex conductivity was related to the pH and highlighted the large acidity accumulated in the sediments. The formation factor of saprolite samples measured in the laboratory was less than the formation factor estimated from field measurements. The difference is likely related to disturbance of the samples during sampling and repacking into columns. The electrical surface conductivity determined in the laboratory, on the other hand, corresponds to what was observed in the field and was related to the relative clay content of the samples. The background sample collected from the greatest depth (26 feet) contained more illite, smectite and chlorite than samples collected from 9 and 16 feet and also exhibited greater surface conductivity.