Electrical Resistivity Tomography Imaging of a Colloidal Silica Grout Injection

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Abstract: The U.S. Department of Energy (DOE) investigated the use of colloidal silica to create a viscous liquid barrier for *in situ* containment of radioactive waste. As part of this work, electrical resistivity tomography (ERT) was investigated for verification of the grout placement. ERT techniques for imaging viscous liquid barriers created using colloidal silica grout were field-tested following a barrier emplacement carried out in 1998 at Brookhaven National Laboratory (BNL) (Dailey, 1998). The results of this effort indicated ERT might be used to verify placement of the grout. In 1999, as part of the second phase of the demonstration in which a colloidal silica barrier was to be placed around a portion of the Brookhaven Linear Isotope Producer (BLIP) at BNL, a series of controlled injection experiments were completed on a laboratory scale at the MSE test facility in Butte, Montana. ERT was used to map one series of these injections in a sand tank designed to study the interaction between adjacent grout injections. The results of this investigation showed that ERT could be used to accurately map the extent of the colloidal silica grout during the injection process.

Sand Tank Construction: The sand tank used for this study is shown in Figure 1. It was constructed to visually verify the grout overlap for adjacent injections and for hydraulic conductivity testing in the overlap area. The sand tank was constructed of plywood and Plexiglas with injection manifolds on each side. It measured five feet tall, 3 feet wide and 1-foot deep. The bottom was lined with a sheet drain material to simulate gravity drainage by directing excess grout to drainage ports located in the bottom area of the test tank. Soil from the BLIP site was added to the tank and conditioned to simulate the 5% moisture content measured for the site soils and volumetrically compacted to 90% of the Standard Proctor for the soil. Electrodes were installed at 1-foot intervals along the sides and across the top of the tank for taking the electrical resistivity measurements.

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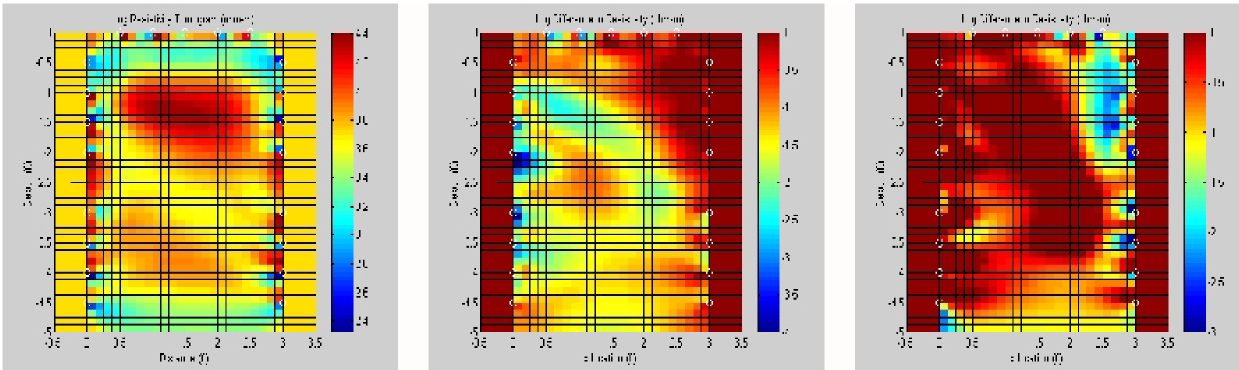
Figure 1. Sand Tank Used for Laboratory Test Injections

Electrical Resistivity Tomography Testing: Electrical resistivity measurements were obtained before and after each grout injection to determine if ERT could be used as an emplacement verification tool. Electrical resistivity tomography (ERT) data were acquired to determine the applicability of ERT imaging of the in situ grout injection process for future large-scale projects. The objective of the ERT monitoring was to delineate the extent of the grout in the tank after two grout bulb injections to determine grout bulb overlap.

The electrical resistivity of soil is primarily a function of the amount of interconnected (void) space in the soil, the amount of fluid in the void space, the salinity of the fluid, and to some degree the mineral composition of the soils. Clean, sandy soils saturated with fresh water generally have higher electrical resistivities than soils composed of sandy clays or sands saturated with salt water. To form a VLB, CS is activated with electrolyte solution (salt water). Therefore, the injection of grout should cause an observable decrease in the electrical resistivity of the soil, which is the basis for using ERT to monitor the grout injections.

Three ERT data sets were obtained over the course of grout injection into the tank. An initial data set was obtained prior to grouting to provide the baseline electrical resistivity values for the soil in the tank. A second set of ERT data was obtained after the first grout injection, and a third data set was collected after the second grout injection. The data were inverted, and estimates of the resistivity distribution across the sand tank were obtained for each of the three data sets.

To best observe the changes in electrical resistivity of the soil caused by the grout injections, the differences in the resistivity distributions between each successive injection were calculated and plotted (the resistivity values were plotted on a logarithmic scale to show order of magnitude changes). The pre-injection results are shown in Figure 2(a), while Figure 2(b) and Figure 2(c) show the results after the first and second grout injections, respectively.



(a) (b) (c)

Figure 2. ERT Results for the Pre-Injection (a), First Grout Injection (b), and the Second Grout Injection (c).

The difference between the resistivity distribution estimated after the first grout injection and the initial resistivity distribution is shown in Figure 2(b). A decrease in electrical resistivity (indicated by the yellow and green) is observed in the region where the grout was observed during injection.

The difference between the resistivity distributions estimated after both grout injections (Figure 2(c)) shows decreases in electrical resistivity where the second grout injection occurred (indicated by the lighter colors). Additionally, there is no change in the resistivity observed in the region where the first grout injection was made (as indicated by the darker reds).

The results suggest the ERT technique could be used to monitor CS grout injections to verify that successive grout injections intersect. Additional work may be required to implement this technique of monitoring the injection process in the field.

The project was funded by the U.S. Department of Energy National Energy Technology Laboratory under DOE Contract Number DE-AC22-96EW96405.