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Geoelectrical monitoring to support the decommissioning of legacy silos at the Sellafield Site, UK

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A strategic priority for the UK's Nuclear Decommissioning Authority (NDA) is the reduction of risk and hazard across its estate of nuclear facilities. Legacy ponds and silos at the Sellafield Site in Cumbria, UK, pose the most significant technical challenges in this context. The safe emptying and decommissioning of the Magnox Swarf Storage Silos (MSSS) is one of the flagship projects that Sellafield Ltd (SL) are currently undertaking on behalf of the NDA.

There is an increased risk that leakage from the facility to ground may occur during planned waste retrievals. Part of the strategy to demonstrate control of silo liquor under normal and abnormal conditions is to employ electrical resistivity tomography (ERT) for the in-ground detection and volumetric monitoring of potential leakage plumes.

We report the results of a full-scale field trial, which used 4D ERT to monitor a controlled injection experiment at the MSSS site. The trial involved an initial period of baseline measurements, followed by multiple controlled injections of benign conductive simulants (saline tracer solution) into the vadose zone via shallow boreholes. The simulants were developed to replicate the likely properties of the silo liquors. Repeated ERT cross-borehole measurements before, during and after the injections were made in order to assess the information content of the ERT data with respect to the occurrence of the simulated leak and the fate of the resulting plume.

Absolute images of resistivity resolved the complex geological setting at the MSSS site, which comprises superficial deposits composed of an accumulation of Quaternary glacial material and post-glacial sands and gravel; these lie unconformably over Triassic sandstone bedrock. The complexity of the geology, combined with the presence of clay-rich sediments and the small contrasts in electrical properties expected at the site had cast initial doubts over the likelihood of a successful application of ERT at MSSS, particularly when compared with previous applications of ERT to nuclear waste management reported in the literature. Moreover, leak detection based on ERT is challenging in any circumstance as competing (but unrelated) processes are known to affect resistivity, including soil temperature variations, groundwater recharge, and electrical noise from plant operation and natural sources. However, our approach proved sufficiently sensitive and images of resistivity change relative to a baseline date have revealed likely pathways of simulant flow in the vadose zone and upper groundwater system; these were found to be compatible with historic contamination detected in sediment cores retrieved from the trial boreholes.

Future plans envisage the deployment of a permanent ERT monitoring system at MSSS in order to support the scheduled decommissioning work over the coming decades.