Geophysical delineation of AMD in the Cradle of Humankind

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Acid mine drainage (AMD) and its effect on surface and groundwater resources in the Cradle of Humankind (COH) area near Krugersdorp is a pertinent and well-documented concern. In 2008, a water resources monitoring programme for the area was initiated and this contributed immensely to a better understanding of the AMD problem; for example, Figure 1 shows the inferred AMD footprint in the COH [1]. The Zwartkrans Compartment, which includes the Sterkfontein and Kromdraai sites, are characterised by high sulphate levels of more than 1000 mg SO_4/L in places. The complexity of the karst environment and the availability of a limited number of monitoring boreholes have contributed to the need to improve the lateral delineation of the contamination footprint.

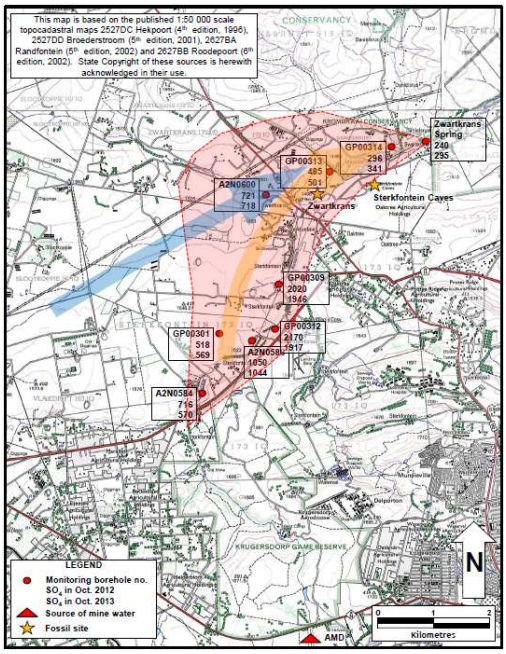

Figure 1: Inferred AMD footprint in COH

In 2015, A Water Research Commission (WRC) study was initiated to assess electrical resistance tomography (ERT) as a potential complementary tool to the ongoing borehole monitoring. Electrical resistivity is affected by a variety of properties including porosity, pore geometry, groundwater chemistry, mineral composition and rock/soil texture and the relatively contribution of these properties vary from site to site. Consequently, a 'snap-shot' ERT survey cannot be used to directly quantify groundwater contamination. To illustrate this, in the two selected ERT results (Figure 2), the blue zones represent the contaminated upper portions of the aquifer. Although the corresponding resistivity ranges inferred from these images are similar (10-50 Ωm), the sulphate levels differ appreciably (~660 mg/L at Pinnochio Farm and ~1770 mg/L at the Krugersdorp Game Reserve site).

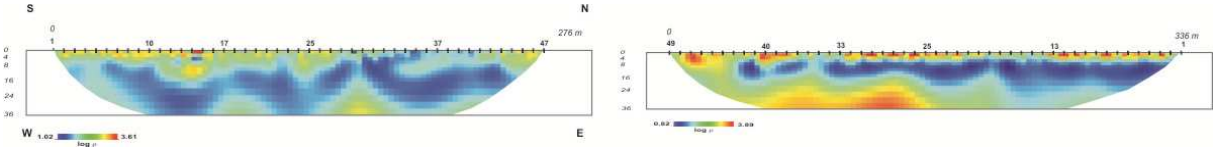

Figure 2: Selected ERT survey results: Pinnochio Farm (left); Krugersdorp Game Reserve (right)

A time-lapse ERT survey approach – see, for example, Hayley et al. [2] – is proposed to provide a more quantitative discriminating capability; by repeating surveys on a regular (annual) basis, subtle transient changes in the resistivity response could then be attributed primarily to changes in the groundwater contamination levels. If it proves successful, time-lapse ERT monitoring will provide a cost-effective alternative to expanding the existing network of monitoring boreholes in the COH area.

References:

[1] Hobbs P (2013) Surface water and groundwater resources monitoring, Cradle of Humankind World Heritage Site: CSIR, 1-47

[2] Hayley K et al. (2011) Journal of Applied Geophysics 75: 401–411