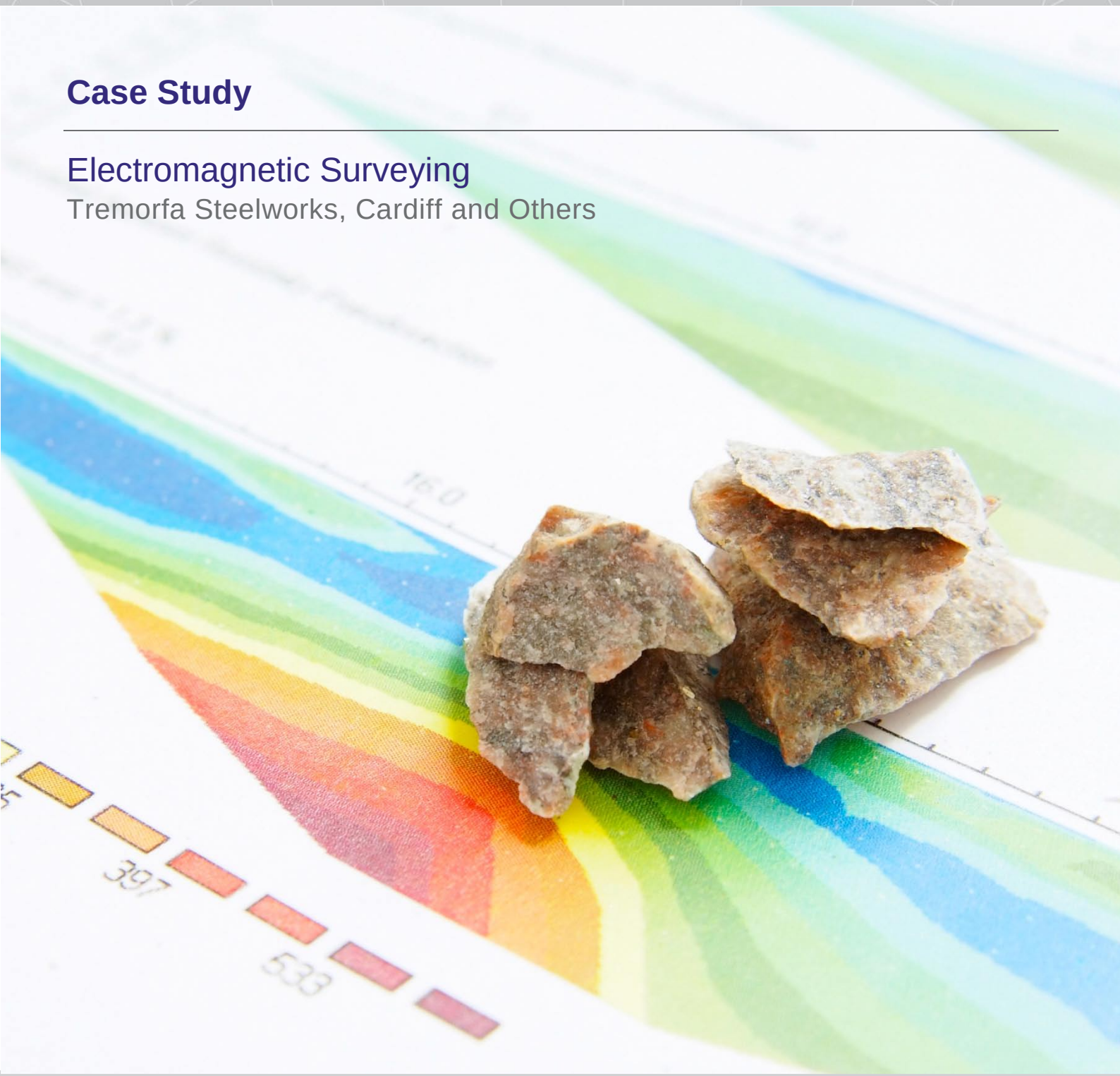
Case Study

Electromagnetic Surveying

Tremorfa Steelworks, Cardiff and Others



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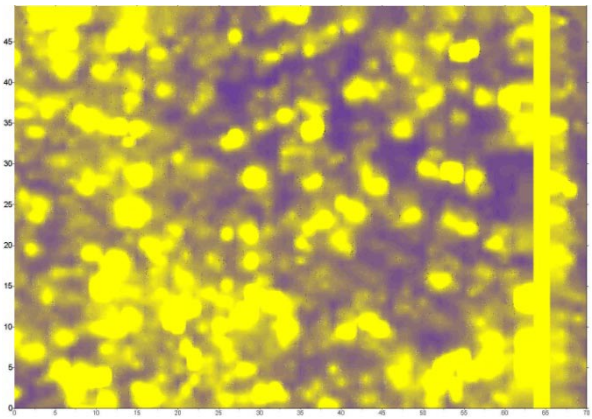
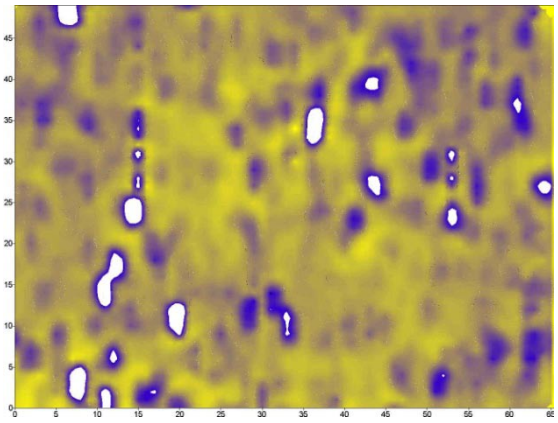
Electromagnetic surveying is a geophysical technique that maps the electrical conductivity of the ground without the need to insert probes. Instead, the instrument induces current to flow in the ground by generating an electromagnetic field at a transmitter coil. A second, receiver coil then measures the secondary field resulting from the flow of the induced current flow. Using this method, the conductivity of the ground directly beneath the instrument can be measured.

Sensing the conductivity of the ground is useful for many applications, but the Tremorfa Steelworks survey had an unusual objective: to sense the presence of metallic objects that might act as obstructions to a pile-driving scheme. Welsh Water proposed a major waste water treatment works at the site of the steelworks slag landfill together with a new sub-station to serve eastern Cardiff. The entire scheme was to be supported on piled foundations and the contractor wished to drive piles through the slag and the underlying soft ground to bedrock some 25m below ground level.

The slag landfill was known to have been a dumping ground for not only slag wastes but also fine flue dusts and large metallic lumps known as skulls. The piling contractor did not wish to hit obstructions and also needed to know where the piles would encounter fine dusts rather than slag. Geotechnology staff were invited to examine the site and the filling records to determine whether a geophysical method could be used to sense the presence of dusts and obstructions.



Steel slag, in its pure form has a very low electrical conductivity, in contrast to the flue dusts which have a high metal content and a correspondingly high conductivity. Skulls, being almost entirely ferrous metal have an extremely high conductivity, generating an even greater electrical contrast against slag. These observations led to the conclusion that electromagnetic methods would be



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the most appropriate method. Resistivity methods could also have been used (resistivity is inverse conductivity) but as resistivity methods require electrode placement the EM methods offered a much more rapid and hence cost effective survey.

Several EM instruments are available, each developed for inducing currents to flow at different depths. Two instruments were selected for this survey, the EM61 (top photograph) and the EM31 (second photograph). The EM61 has been developed as a high sensitivity metal detector with a depth penetration of 3m, whilst the EM31 is a ground conductivity mapping instrument with a depth penetration of 4 to 6m, depending on setup. A survey of the entire area was conducted with the EM31 to sense the position of flue dust masses and the area of piled foundations was surveyed with both the EM61 and EM31 to sense the presence of metallic objects to a depth of 6m. The third image shows the results of the high resolution shallow EM61 whilst the fourth image shows the results of the EM31, which has a deeper penetration but lower resolution. The EM61 displays metallic objects as yellow whilst the EM31 displays the metallic objects as blue and white. Using these maps the contractor repositioned a small number of piles and excavated the large metallic objects at the location of many of the piles.

The EM31 survey to sense flue dust was carried out on a 5m grid over the entire site area, and the results are shown below. Three areas of anomalously high conductivity were detected and the results of the intrusive investigation have been plotted to show the exceptional correlation between

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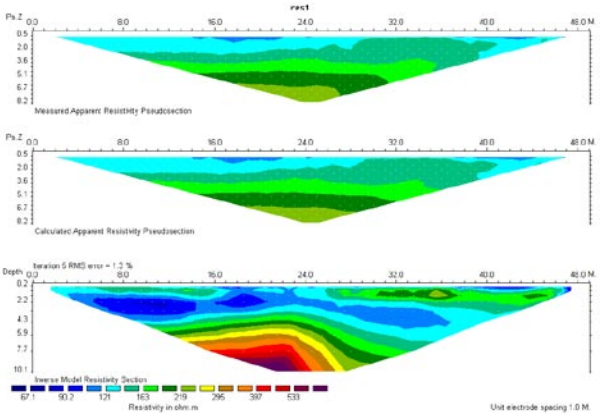

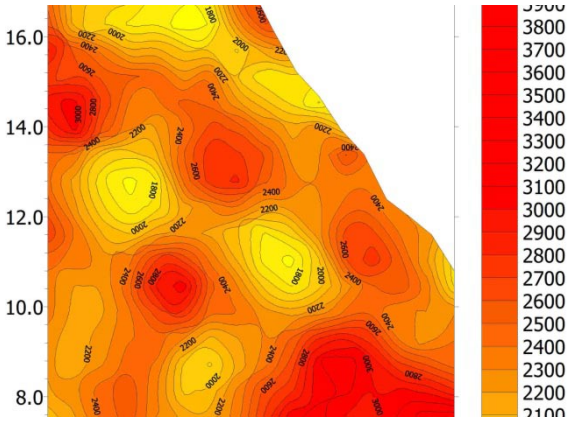

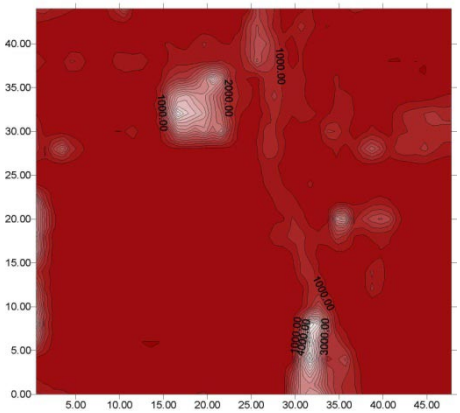

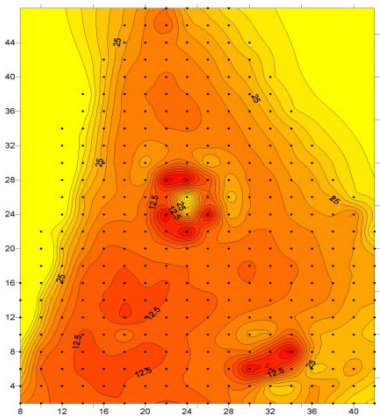

the geophysics and the presence of flue dust.

Having sensed the position of the flue dust disposal areas, a number of electrical resistivity tomography (ERT) sections were carried out to examine the vertical arrangement of the dust and slag. The top image opposite shows the results of the electrical imaging, clearly showing the low resistivity (high conductivity) dust in a layer between higher resistivity slag above and beneath.

Electromagnetic surveying is not restricted to the search for large buried metallic objects, though it's most common application is for sensing drums within contaminated land and buried ordnance. Wherever an electrical conductivity contrast might be expected, EM surveying can play a very helpful and cost effective role.

Shown opposite is an extract from a survey of the M4 interchange at Newport. Engineers wished to drive a tunnel beneath the carriageway, but anecdotal evidence suggested the road had been built on a piled raft because of very poor ground conditions. Not wishing to strike a pile with the tunnelling Geotechnology was invited to try anything that might sense whether the road was piled. EM61 was used (the first photograph was taken during this survey) and as the results show a regular pattern of high conductivity was revealed. The high spots correlated to the positions of pile caps beneath the road deck

Other uses for EM include the assessment of contaminated land, as shown on the third image on this page. An EM61 survey taking one day to complete has sensed the presence of a gasworks tar pit (square), a liquor storage tank and even the buried pipeline connecting the two.

The final image shows a coal mine shaft sensed with an EM31 (beneath the instrument on the second photograph). A brick lining has produced sufficient contrast to reveal the shafts position.