Has non-destructive electrical tomographic imaging a role in heritage conservation?

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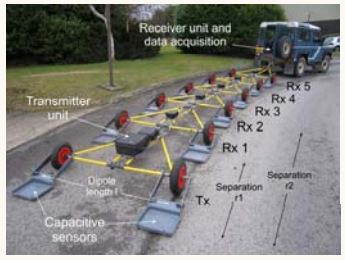
NATURAL ENVIRONMENT RESEARCH COUNCIL

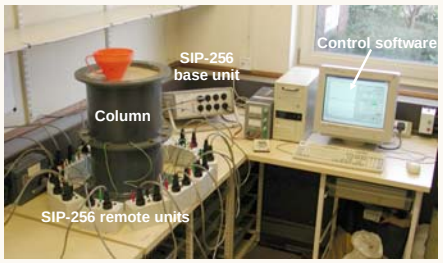
Outline of talk

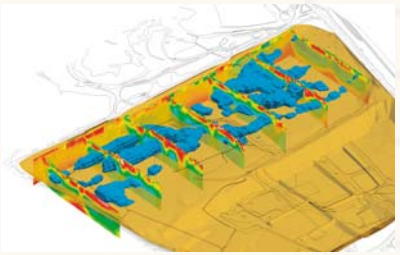
- Electrical imaging technologies under development by BGS
- Void detection (e.g: mineshafts, tunnels)
- Mapping of flow-paths (e.g: leachate, saltwater, contaminant plumes, electro-filtration)
- Remote real-time monitoring of vulnerable sites using wireless telemetry (GSM, GPRS, internet, satellite)
- Implications for the preservation of heritage buildings and sites

Geoelectrical Imaging Technologies

- Electrical Resistivity Tomography (ERT)
- Induced Polarisation Tomography (IPT)
- Complex Resistivity Tomography (CRT)
- Spectral Induced Polarisation Tomography (SIP)
- Capacitive Resistivity Imaging (CRI)
- Automated time-Lapse Electrical Resistivity Tomography (ALERT)
- Self-Potential Tomography (SPT)
- Electromagnetic Tomography (EMT)
- Radar Tomography (RT)

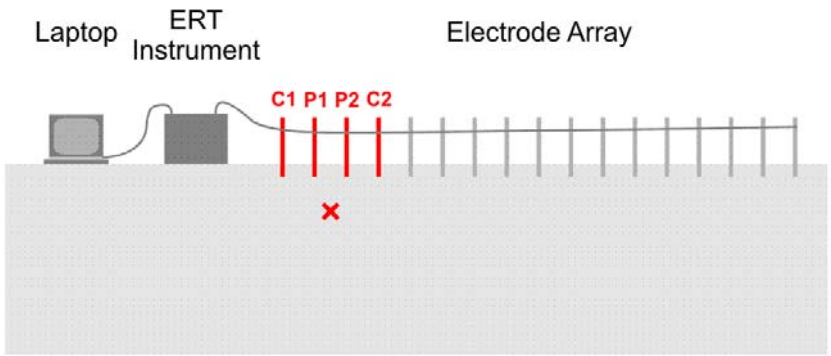






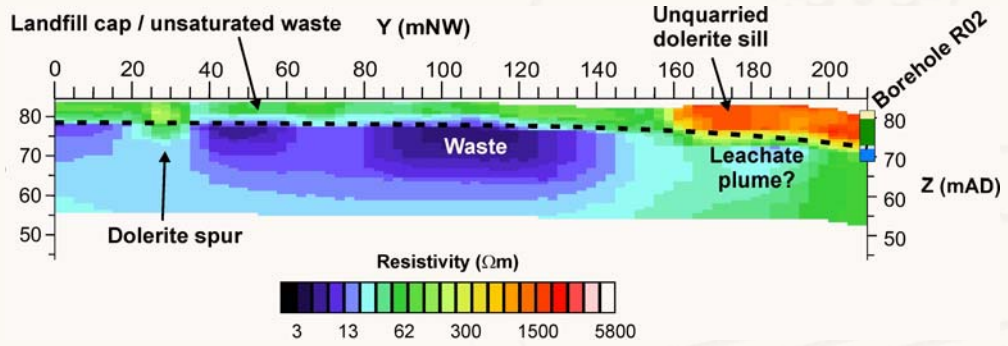
Static 2D and 3D ERT Surveys

Data Collection



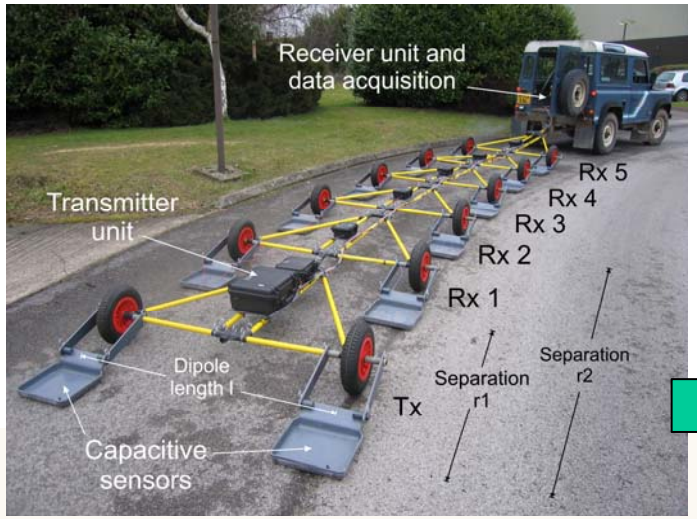
Data Inversion

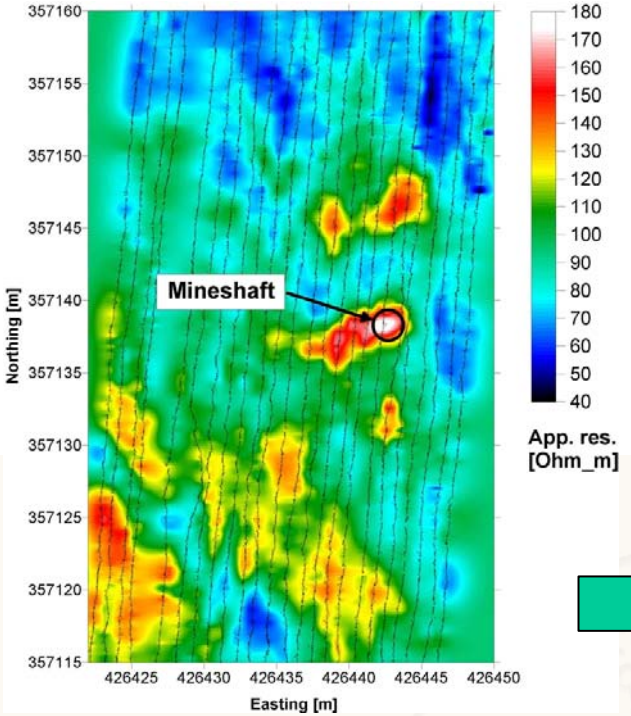
Electrical Image



Capacitive Resistivity Imaging (CRI)

Cavity Detection





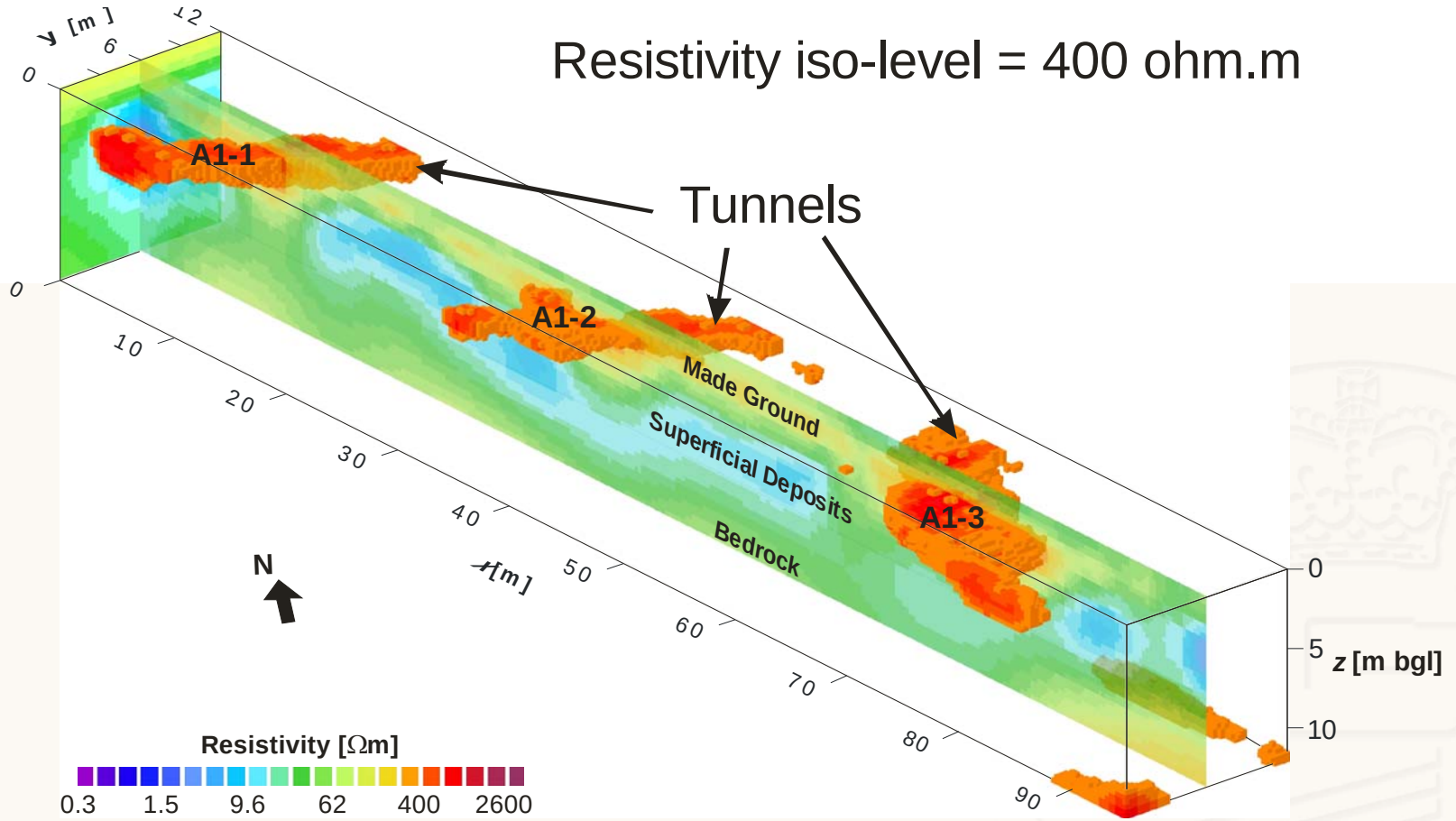
BGS-designed CRI prototype

- resistivity data sampled at 10 cm
- 1 m line spacing
- survey guided by RTKGPS navigation
- area of 80 m × 25 m covered in 5 hrs
- >100,000 data points captured

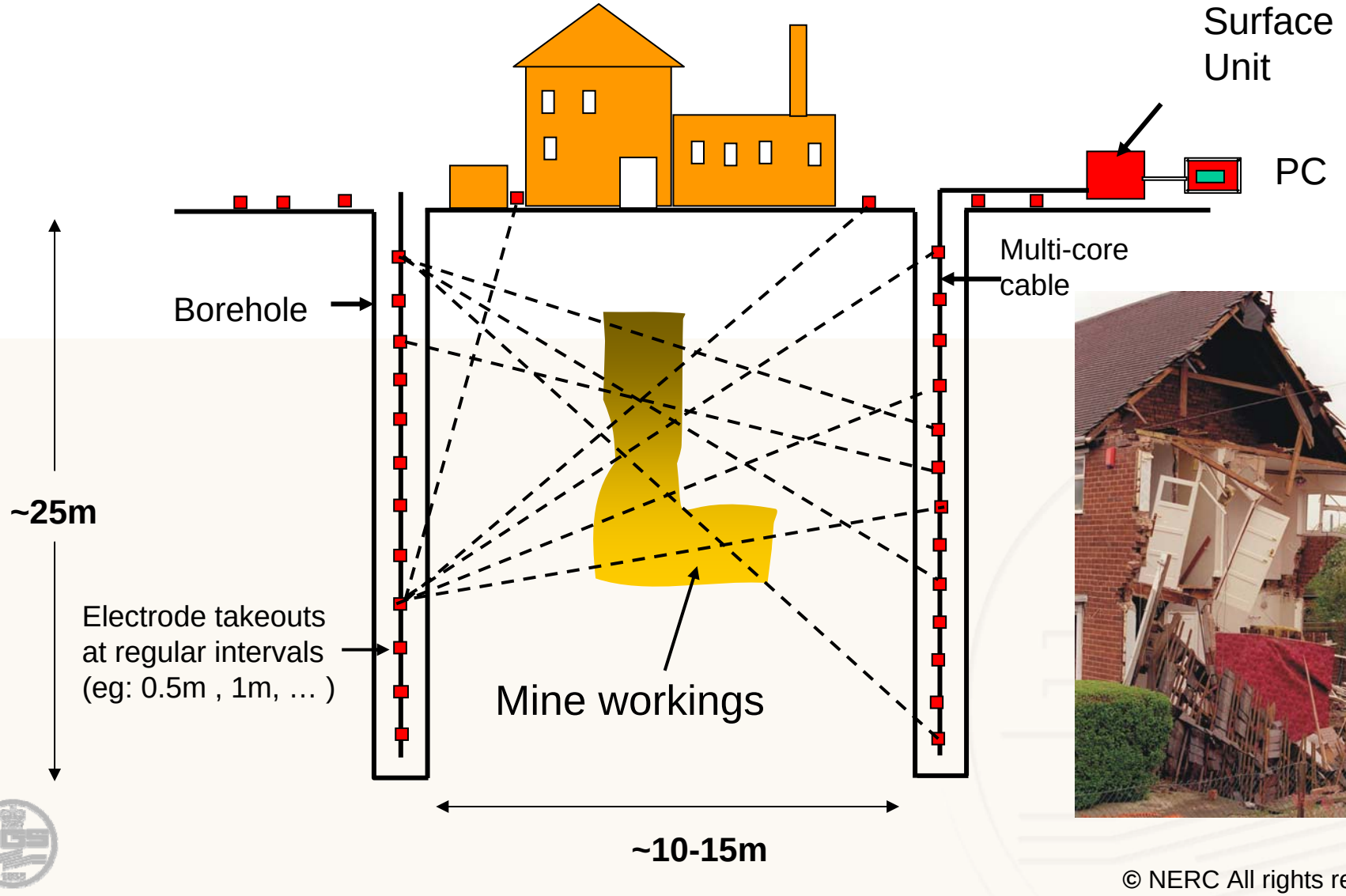
(US Patent granted)

Mineshaft 1m x 0.5m

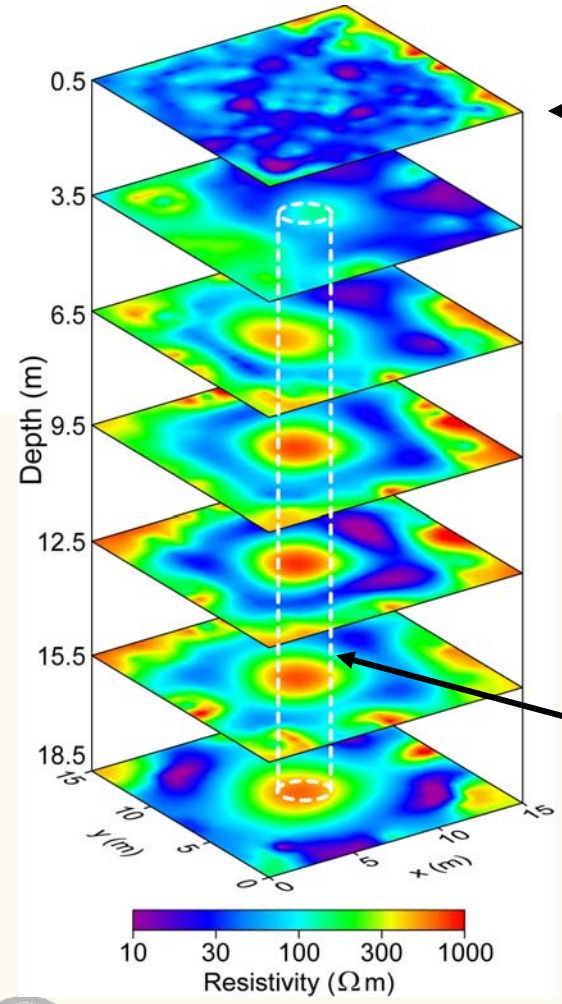
Detection of air-fill tunnels (Glasgow) by 3D ERT survey



Cross-hole Resistivity Tomography



Detection of air-filled shaft by cross-hole ERT

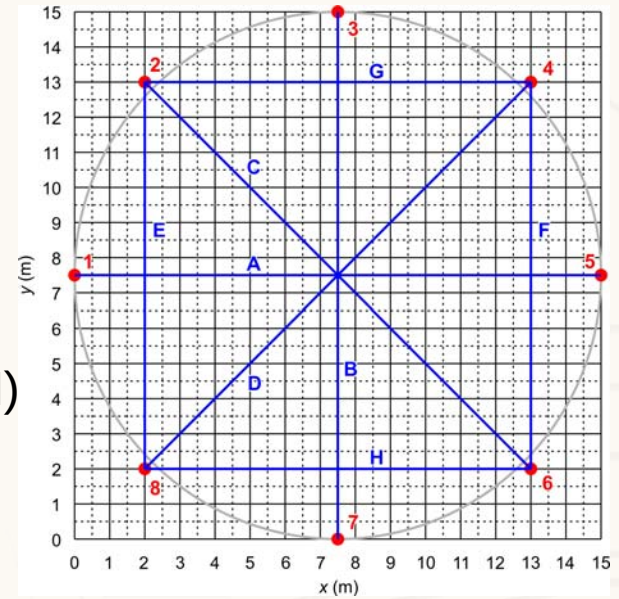


← Horizontal depth slices

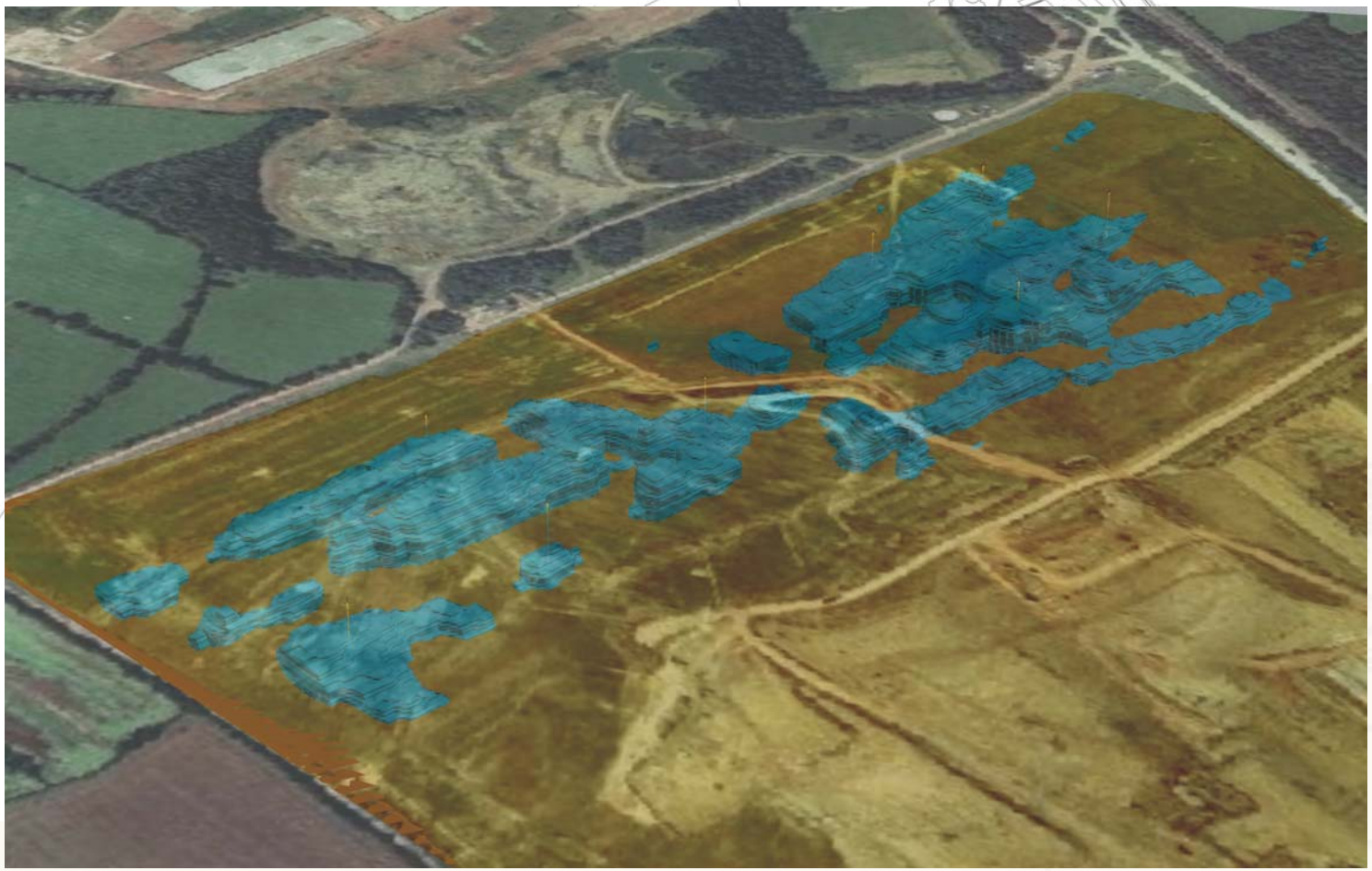
Detection was only possible using the new array optimization scheme.

Conventional cross-hole scanning failed to detect this shaft.

Shaft detected by 3D inversion of 8 Panels (A, B, C, D, E, F, G,H)



3D ERT Imaging of Commercial Landfill

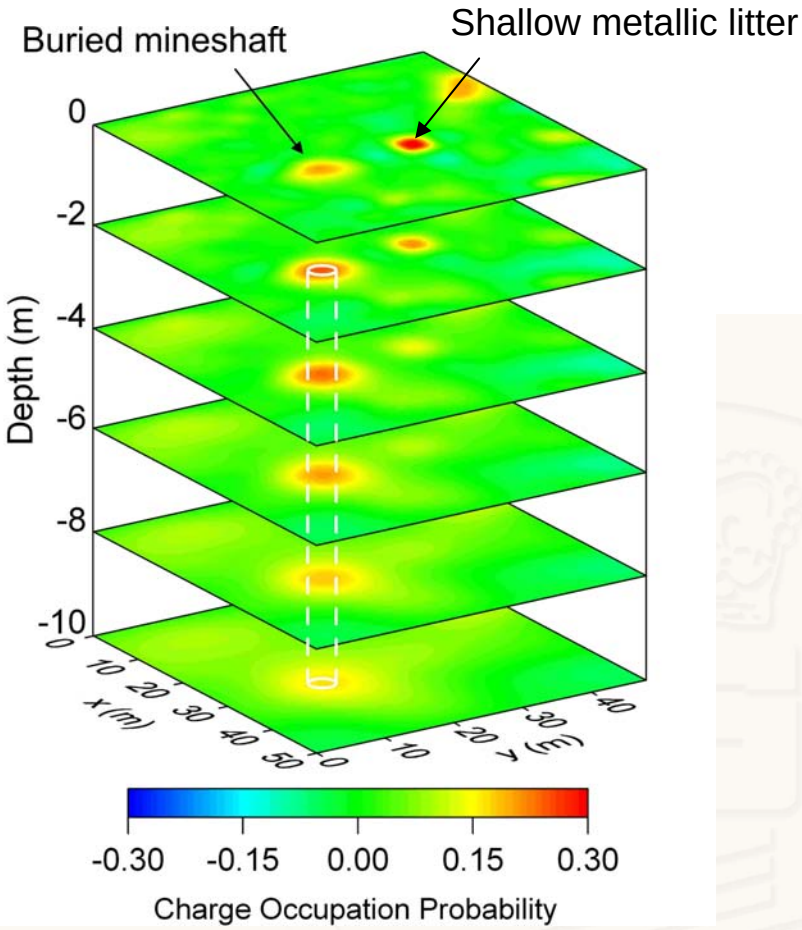


Resistivity iso-level = 4 ohm.m

Commercial landfill: 3D ERT survey to map the volumetric distribution of leachate (opaque blue). Leachate is re-circulated to further enhance the production of landfill gas, and subsequently the generation of electricity for the national grid

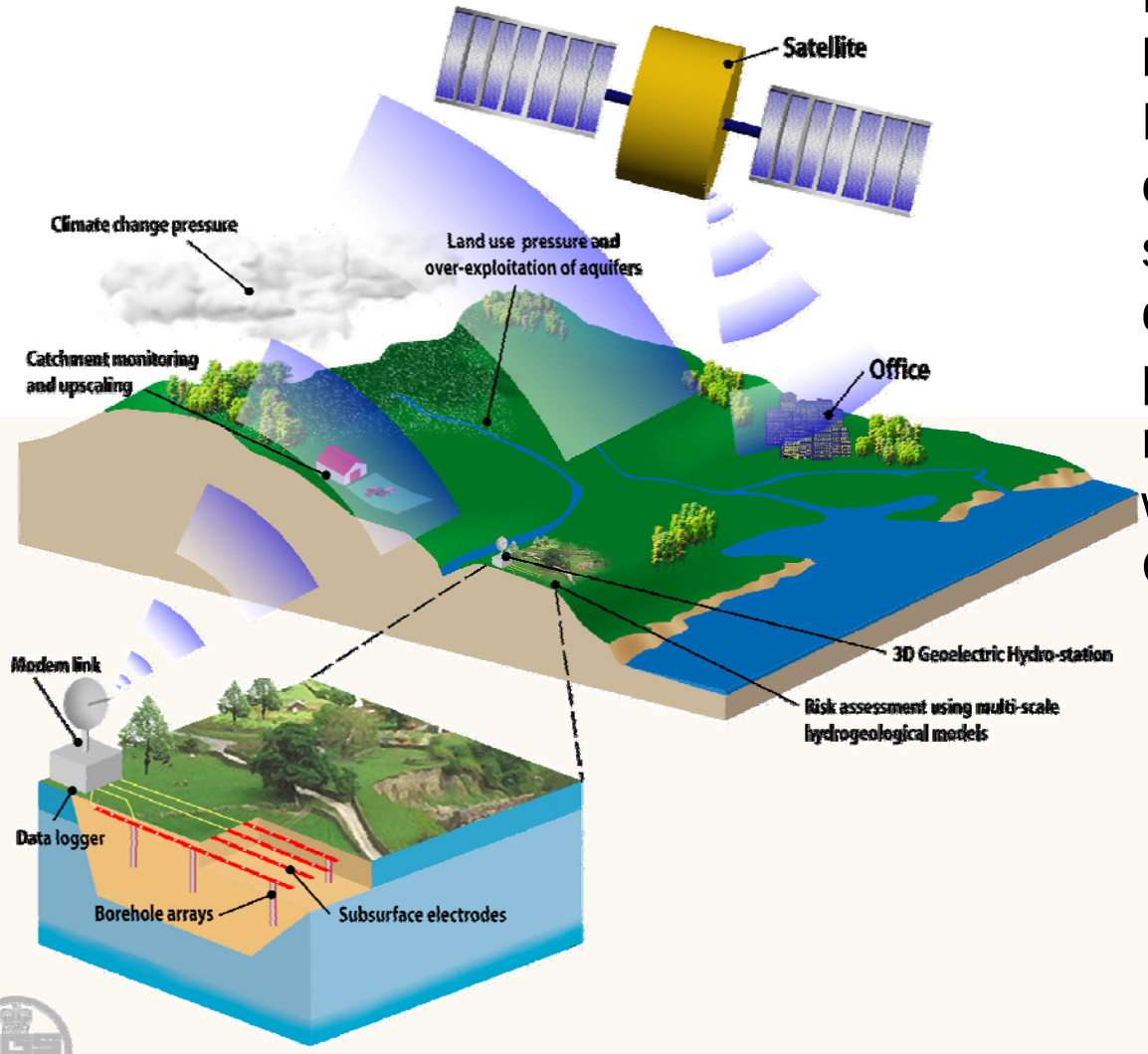
Electro-filtration in buried mineshaft detected by Self-Potential Tomography (SPT)

Abandoned Pewfall colliery



....no indication of shaft location, all surveys conducted "blind" on 50m grid

Dynamic Time-Lapse 2D, 3D ERT surveys (ALERT)



New sensor technology has been developed by BGS for the ***real-time*** electrical imaging of sensitive sites "on-demand" using permanent arrays and remote data capture by wireless telemetry (GSM, GPRS, internet, satellite)

- Contaminated land
- Water resources
- Geohazards
- Landfills
- Slope stability

ALERT installation in River Andarax, Almeria, Spain

Installation of ALERT system in trenches

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ALERT system Mk2

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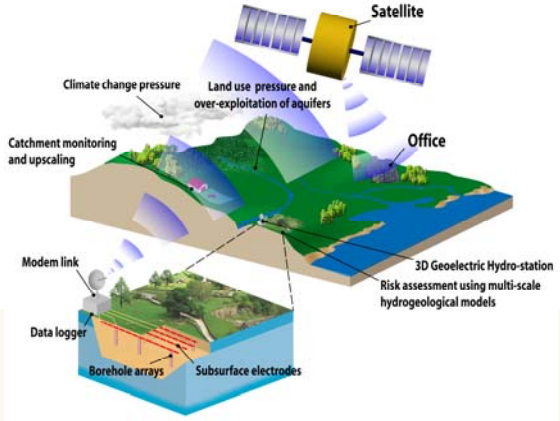

Telecommunications

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New servers in BGS

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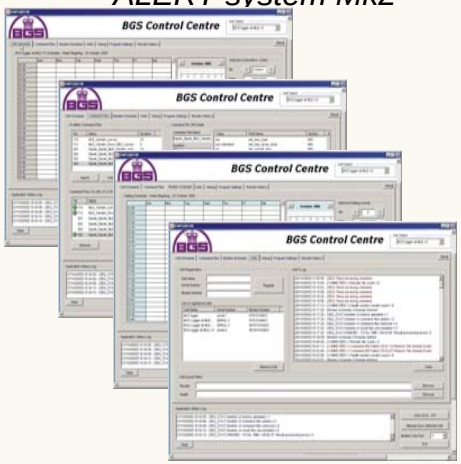

DBMS & Control Interface

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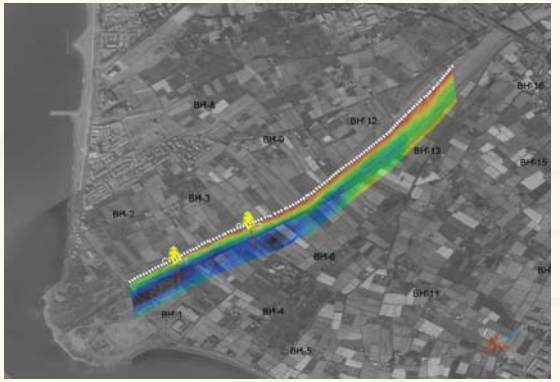
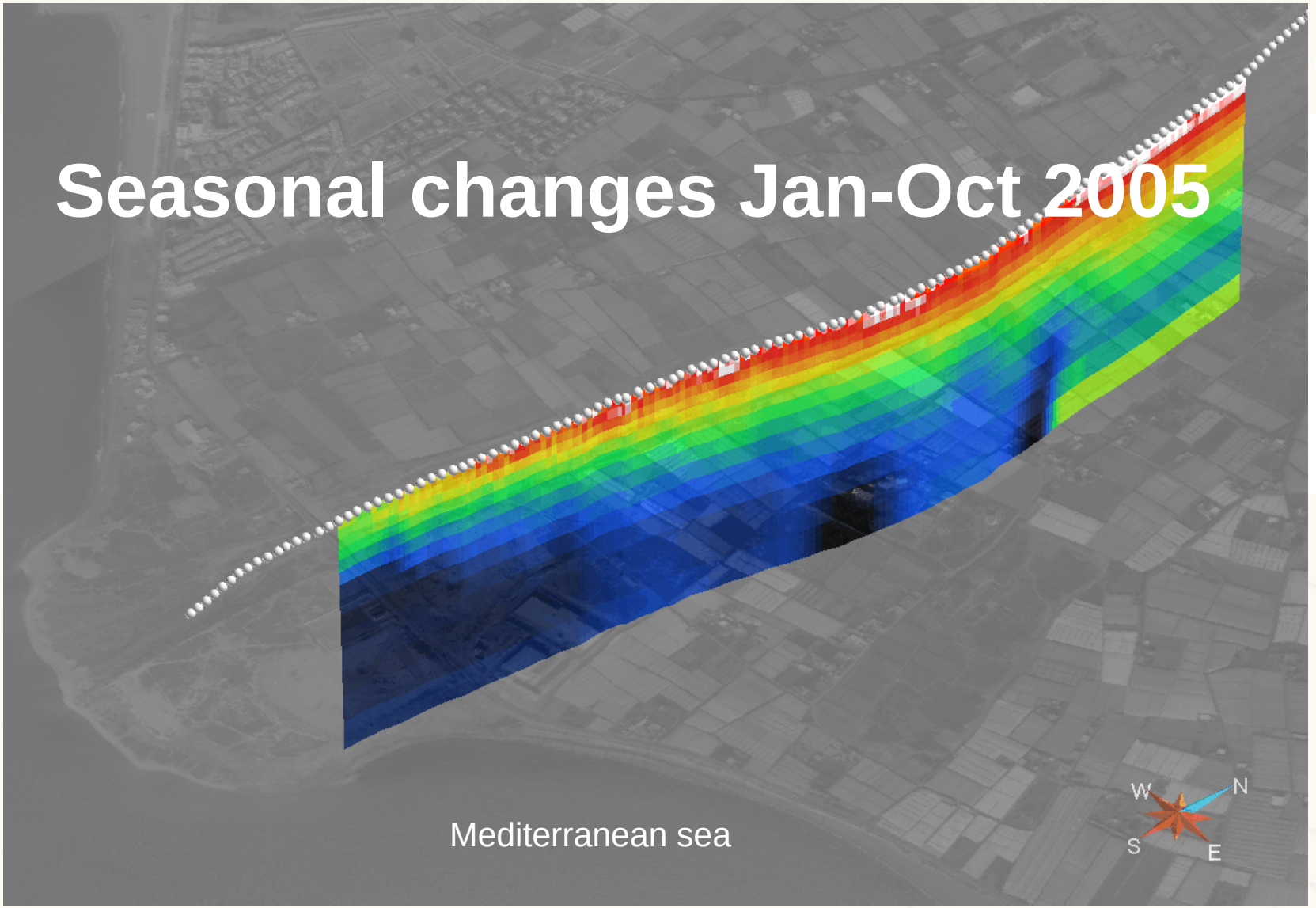
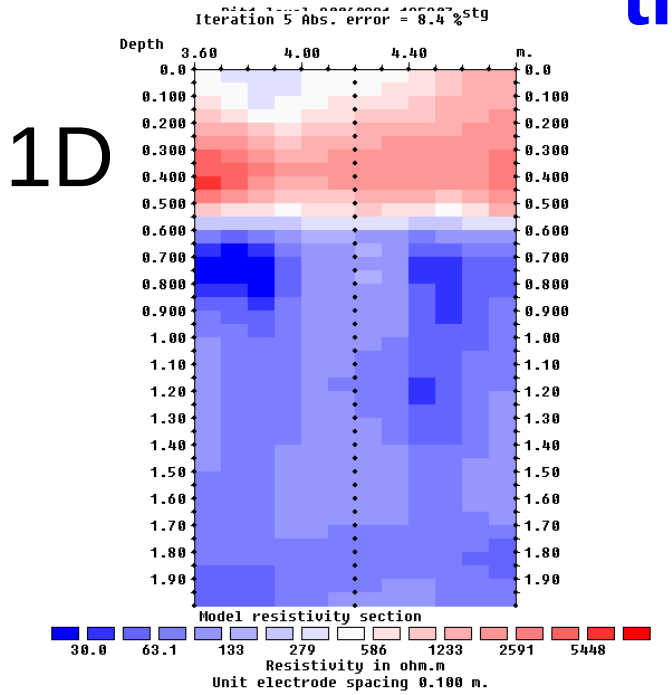


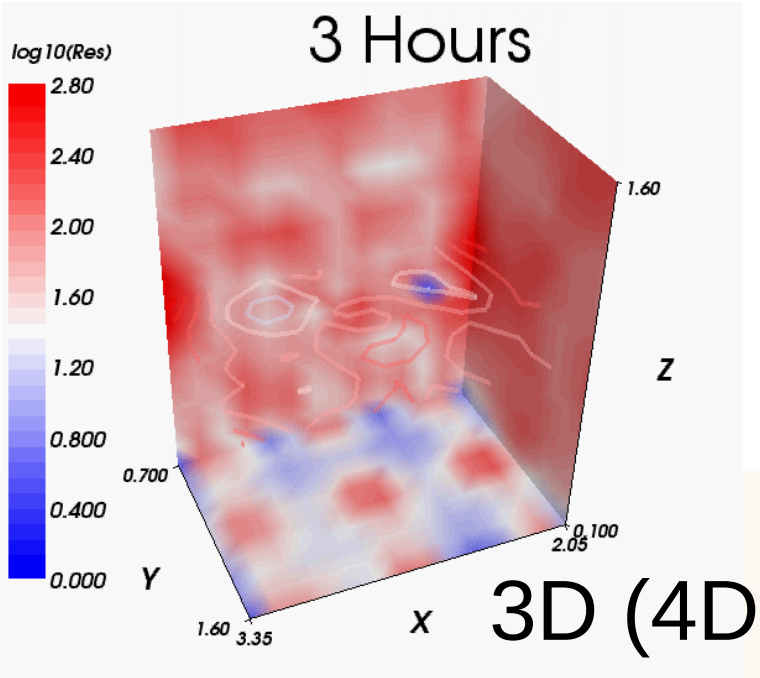
2D ERT image of saline intrusion, Almeria

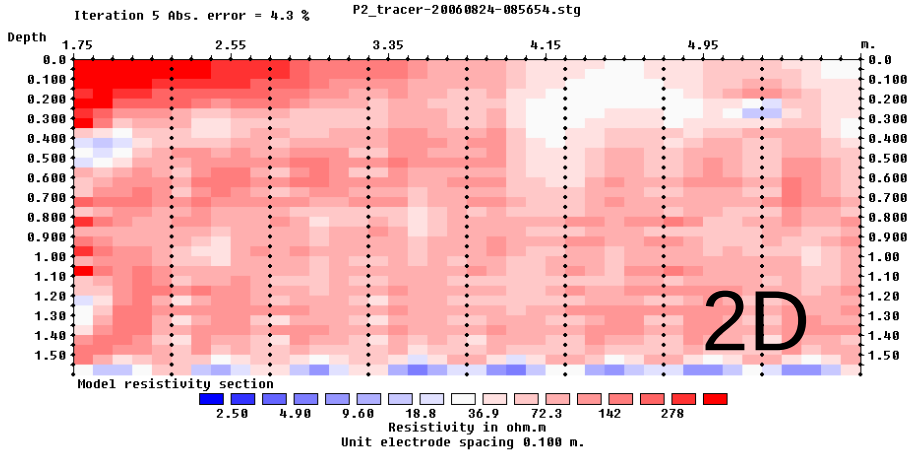
Seasonal changes Jan-Oct 2005

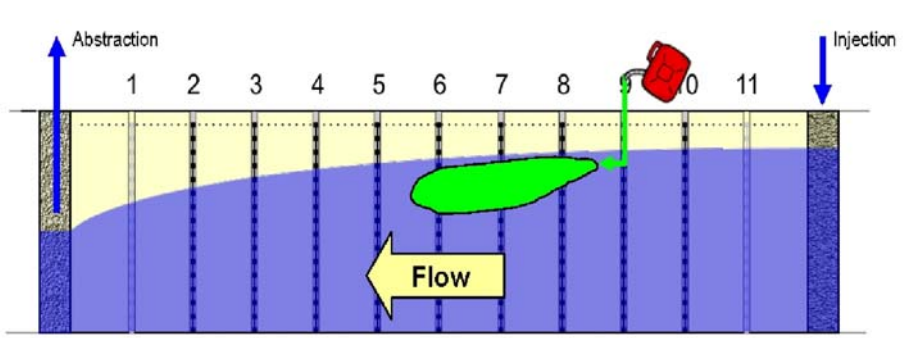


Real-time ALERT imaging of hydraulic tracer



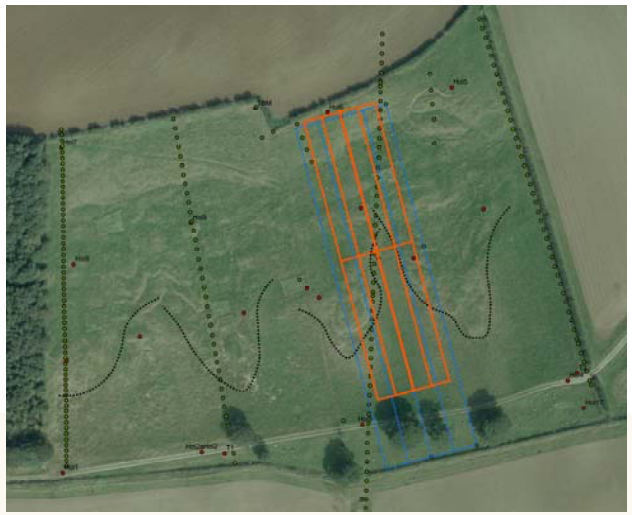


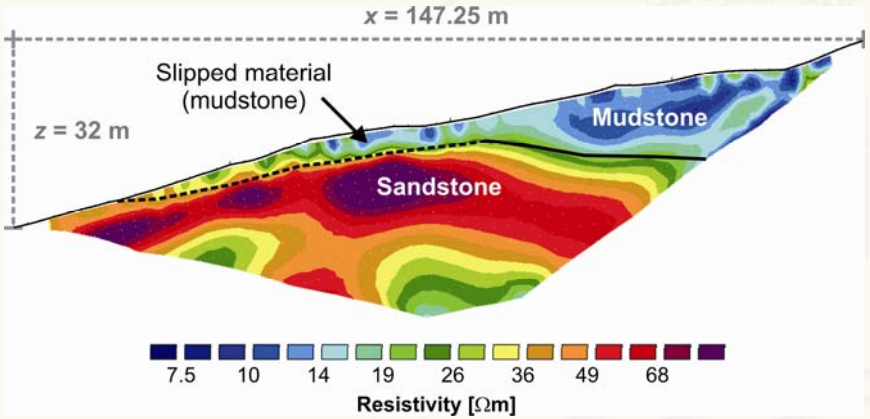




Landslip monitoring using time-lapse ALERT technology

- BGS-designed ALERT technology has been installed at an active landslide site to predict and track gravitational mass movement.
- Geoelectric property changes can be related to temporal changes in moisture content, infiltration, fluid flow, stress, deformation, or saturation levels and provide early warning of movement.
- The system is providing unprecedented sampling rates that would not be possible by manual repeat surveys.





Implications for heritage conservation

- Electrical imaging technologies are evolving rapidly.
- Rapid changes in climate and human activity are impacting on earth systems, and processes and our survey techniques need to meet this challenge.
- The same aggressive climatic actions and high human loadings (tourism) must be affecting ageing historic structures and sites
- ALERT and wireless telemetry offers the potential for both automated and *volumetric* temporal monitoring - thereby eliminating or reducing the need for expensive repeat inspections.
- Could ALERT-CRI technology be used as an early warning system to detect internal deterioration in heritage structures – before such effects become visible?