Erosion and fine fissuring detection in embankments using Geophysics

Workshop on seepage and instability in cohesionless soil – 31 Aug – 1st Sept 2017

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University of Strathclyde

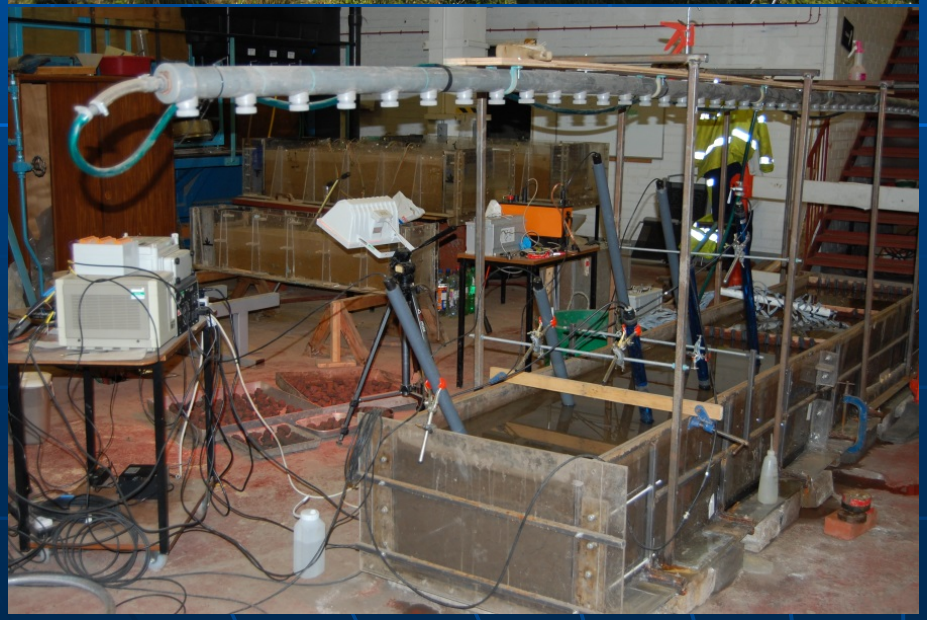
Flood and reservoir embankments

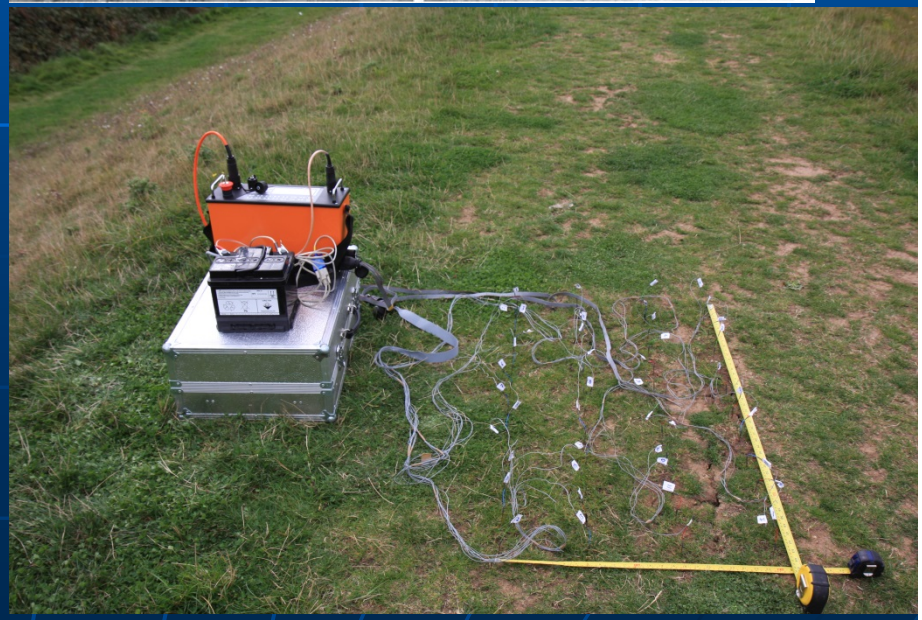
Geophysical assessment and Geotechnical monitoring

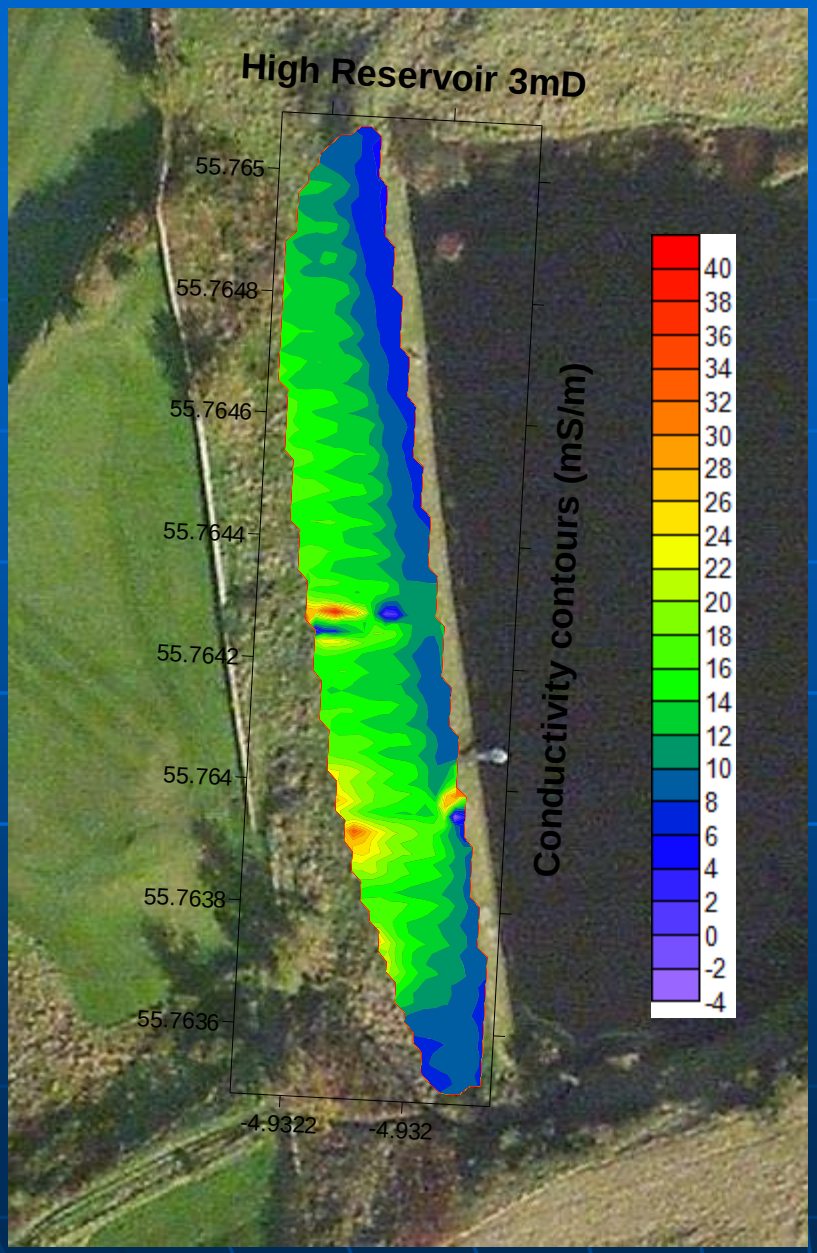
- Sea level change and extreme events
- Desiccation fissuring, piping, erosion = Major Risk
- Conductivity and resistivity mapping (related to zones of high/low moisture content) => Geotechnical weaknesses

- Modern 2020 – (£126k). Work Package 3, Task 3.5
- FP7-IAA MAGIC Industry- Academia (2013-1017)
- 2 IAA Impact Acceleration Account (Sept 2013-Sept 2014)
- FP7-IOF RISMAC (July 2011-July 2013)
- KTA emerging fund Strathclyde (Oct 2011-Oct 2012)
- 2 DTG scholarship (EPSRC) (Jan 2009-Jan2012)
- AXA research fund “environmental risks” (Jan 2010-June2011)
- ICE/Scottish Government (2008-2010)

Field and Laboratory applications







Electromagnetic survey for reservoir embankment Millport

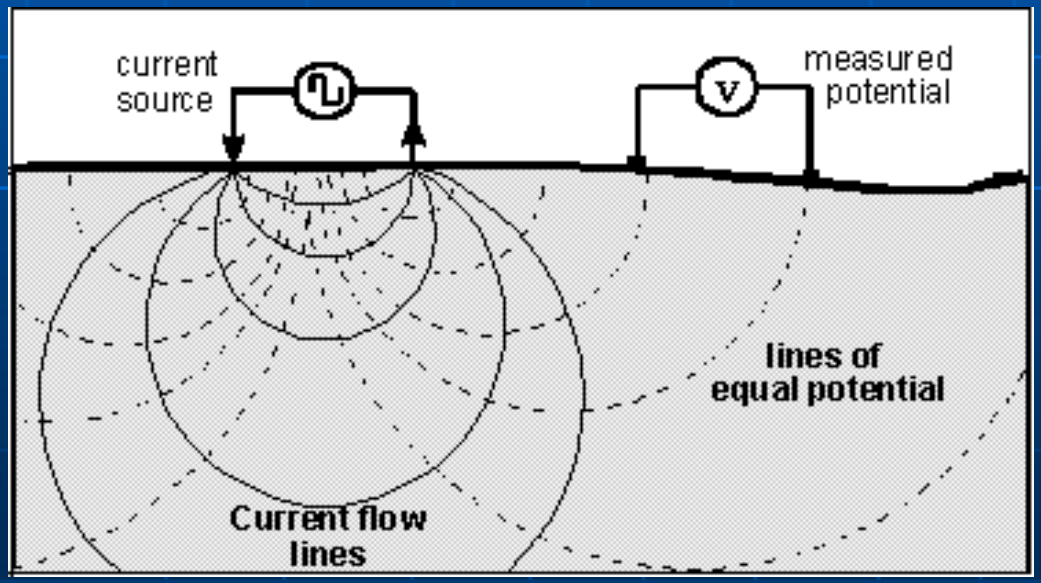
- Old drain pipe detection

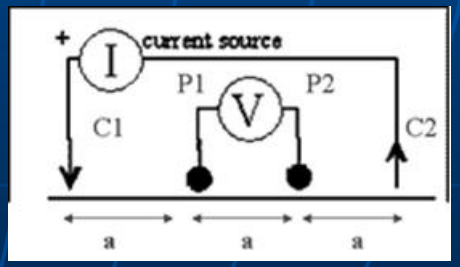
Outlet location confirmed

- Leak / seepage zone

Confirmed with self potential measurements

Resistivity Arrays Tomography





Wenner α array

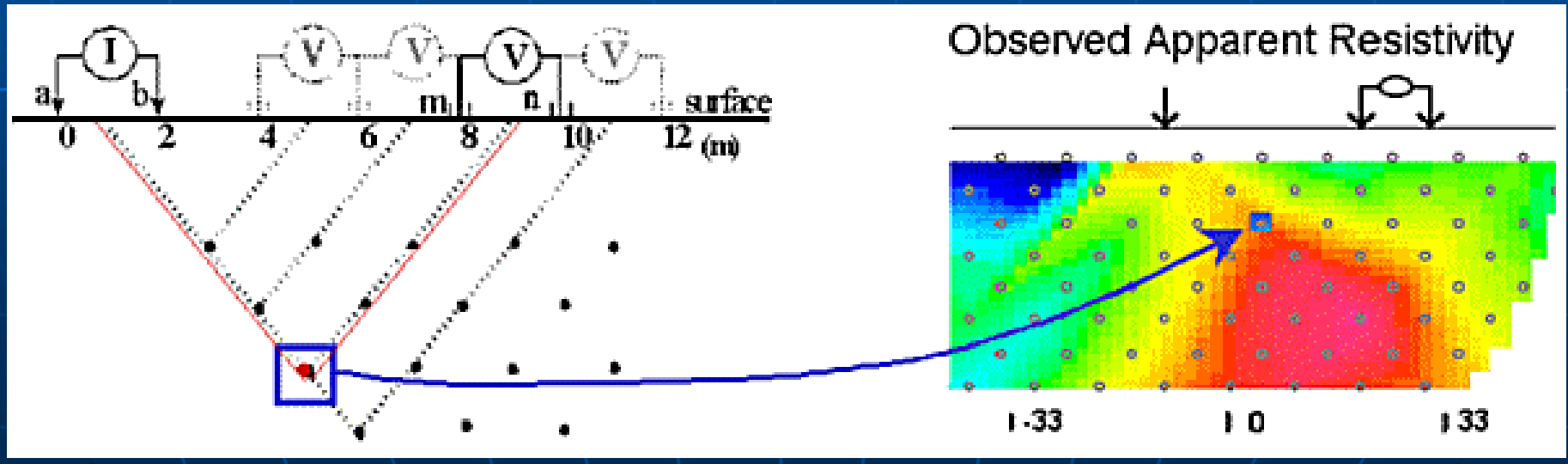
Use of Resistivity Arrays

- Mapping of the electrical properties of the ground

  - follow cracking evolution, or contaminant plume transport

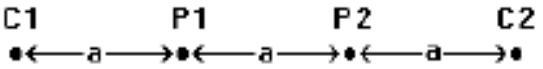
  - determine the precise location by colour contour and inversion model

    - Resistance = physical property
    - Resistivity of the soil = bulk property of material/flow



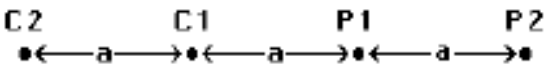
Types of Resistivity Arrays

a). Wenner Alpha



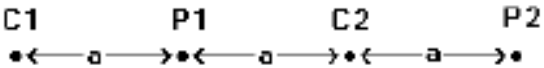
$k = 2 \pi a$

b). Wenner Beta



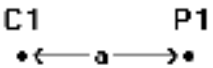
$k = 6 \pi a$

c). Wenner Gamma



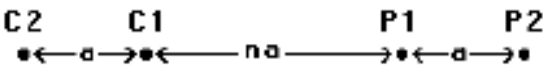
$k = 3 \pi a$

d). Pole - Pole



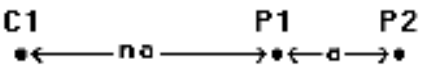
$k = 2 \pi a$

e). Dipole - Dipole



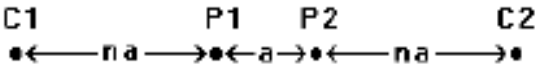
$k = \pi n(n+1)(n+2)a$

f). Pole - Dipole



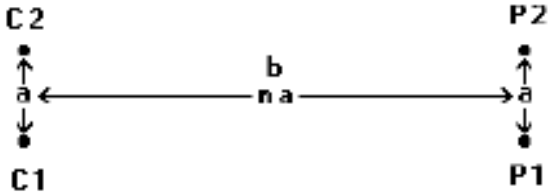
$k = 2 \pi n(n+1)a$

g). Wenner - Schlumberger



$k = \pi n(n+1)a$

h). Equatorial Dipole - Dipole



$b = na$

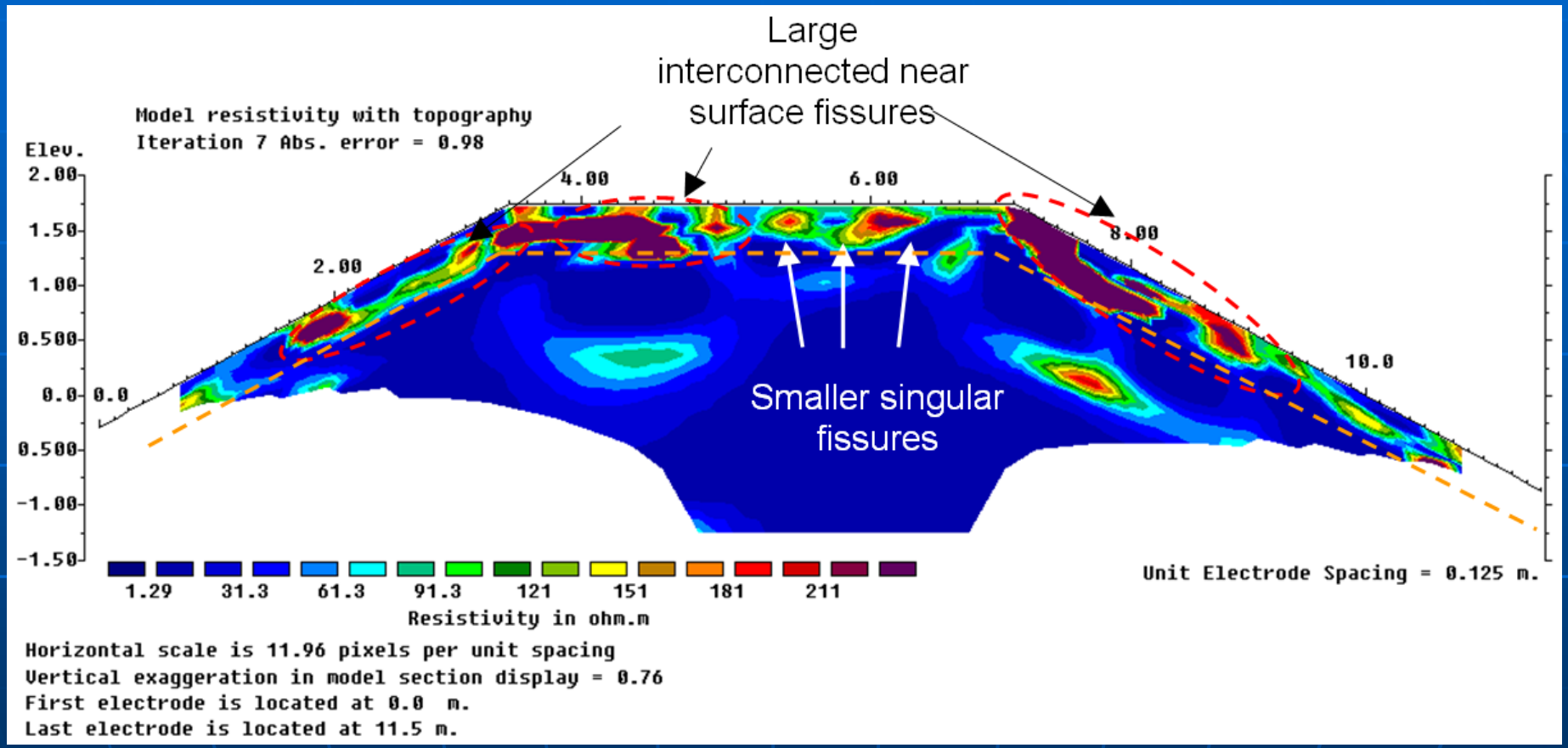
$k = 2 \pi bL/(L-b)$

$L = (a*a + b*b)^{0.5}$

k = Geometric Factor

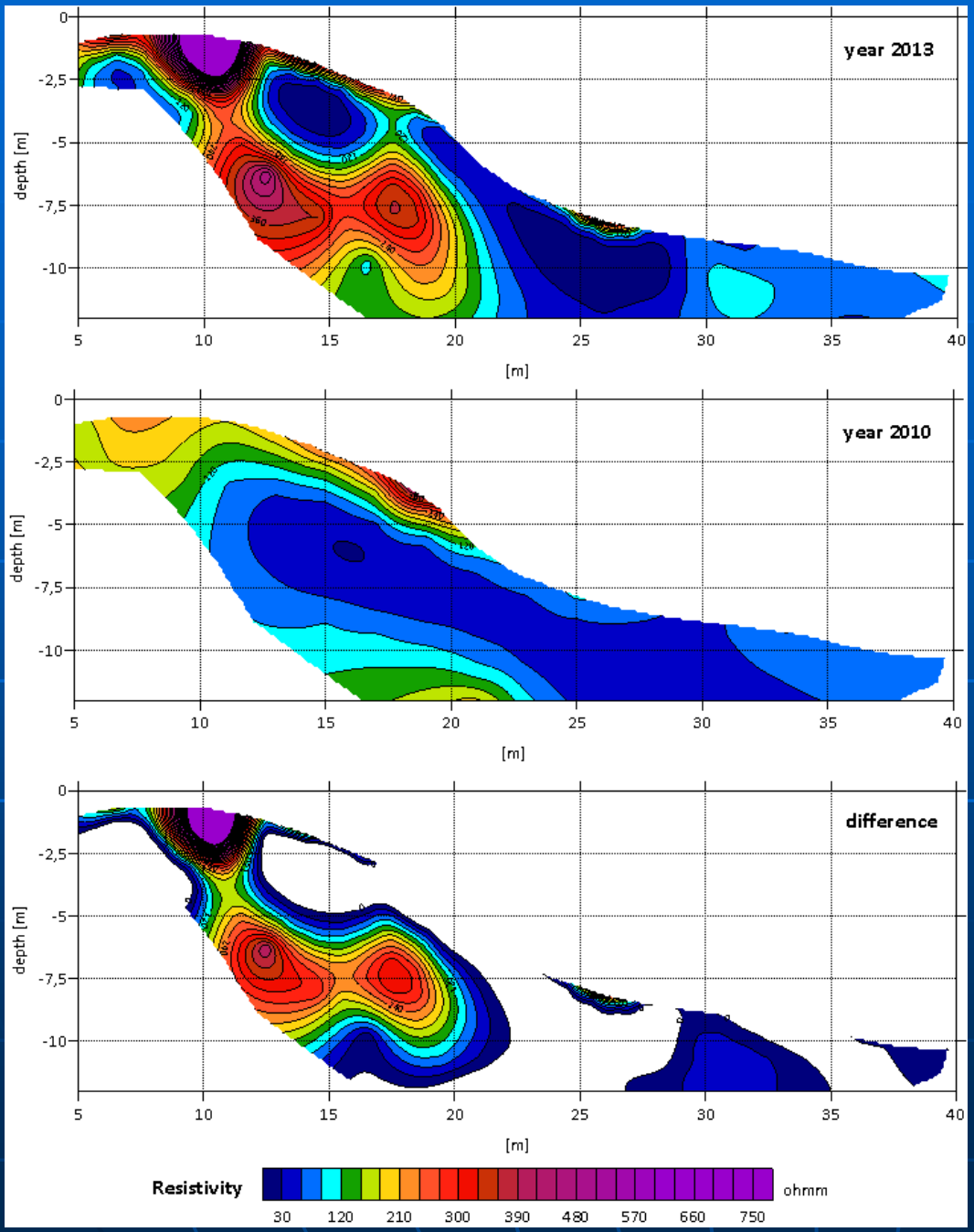
Loke (2001)

Flood embankment – 2D Field tomography



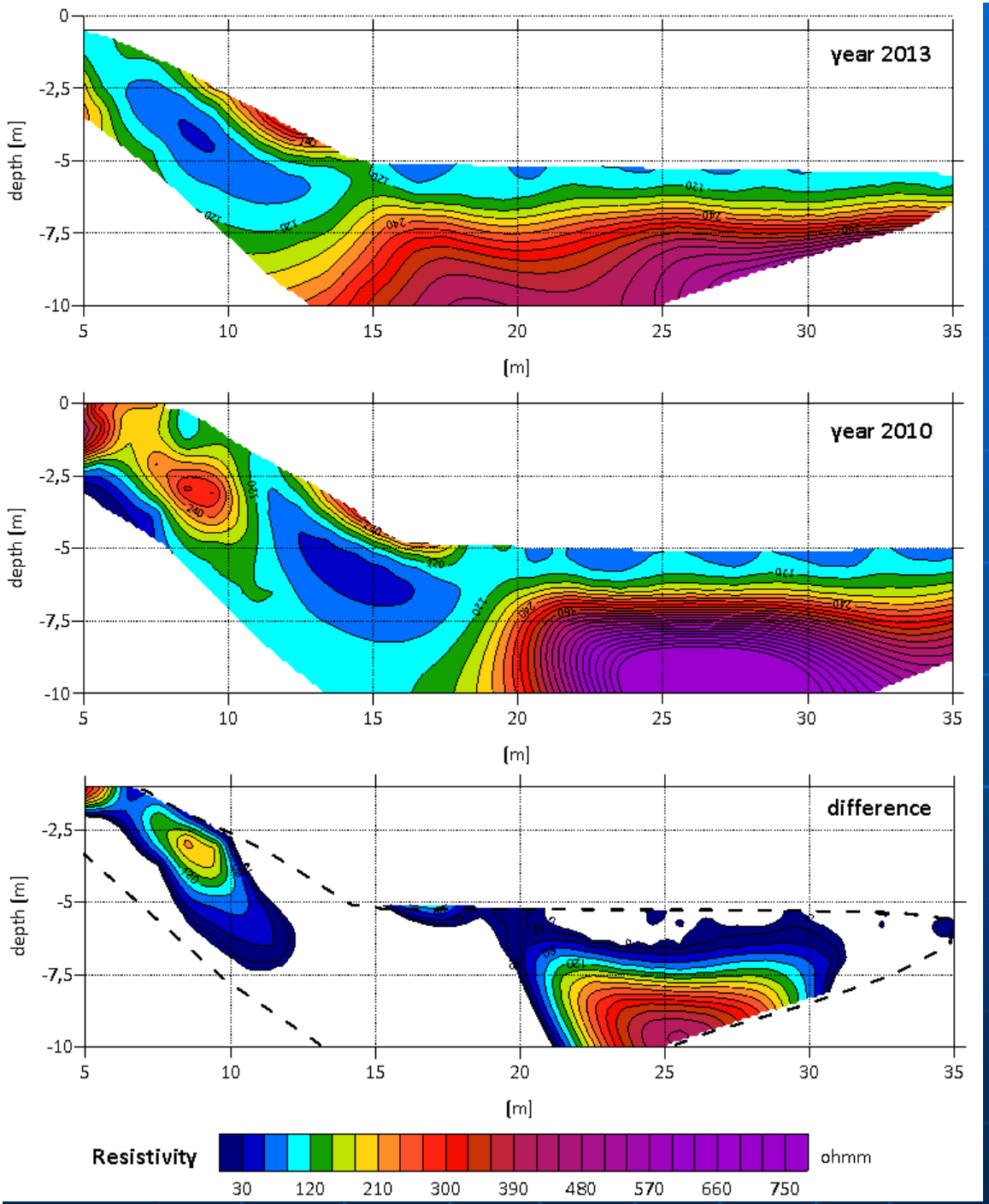
Cross section of flood embankment using resistivity arrays (Hull).

Flood embankment – Flood 2013 (Hull)



Electrical Resistivity Tomography on slope Velky Roch Czech Republic

Comparison – ERT 3 years time lapse Subtraction 1



Electrical Resistivity Tomography on Kardash slope Czech Republic

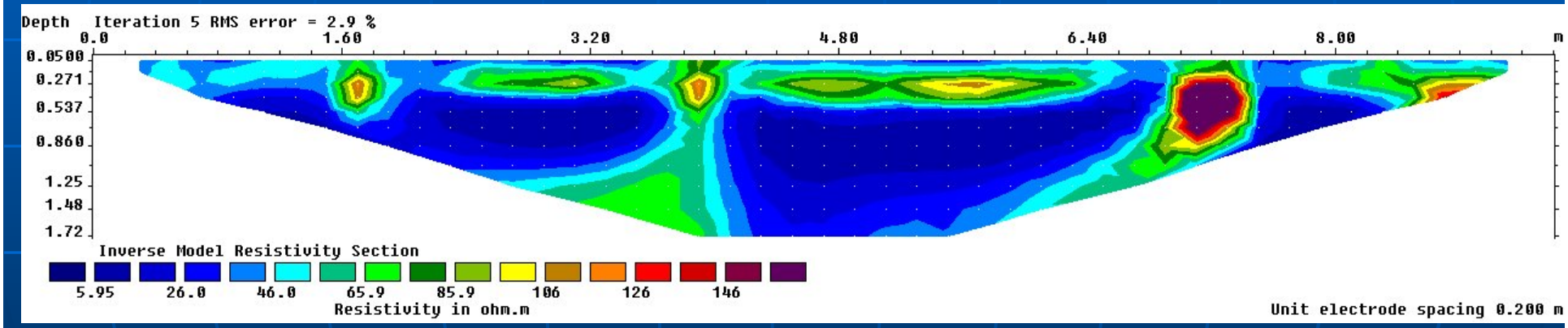
Comparison – ERT 3 years time lapse Subtraction 2

Flood embankments – 3D field tomography

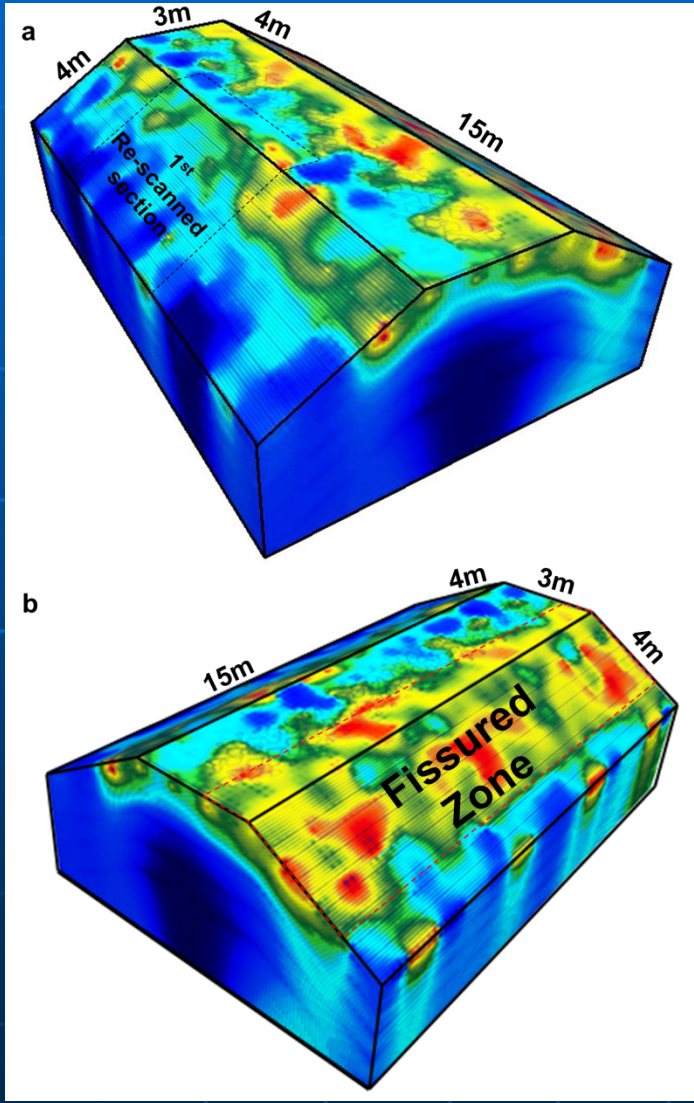
Digue Elite project - IRSTEA Aix en Provence

Flood embankments – 2D-3D field tomography
Digue Elite project - IRSTEA Aix en Provence

Fissuring detection on instrumented embankment (Clay + Lime)
with reduced scaled ERT array Schlumberger 20 cm spacing



Flood embankments Hull section
3D field tomography



New Inversion + Voxler
3D Resistivity Model

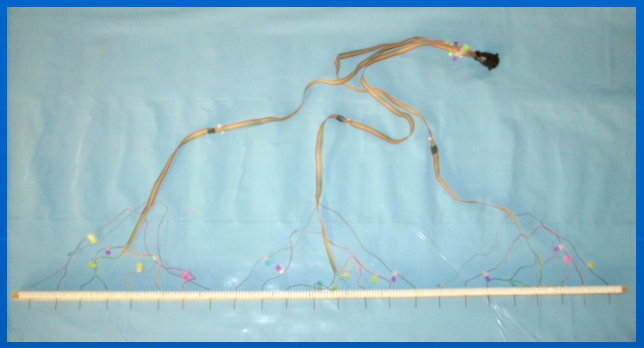
15 by 11m embankment section

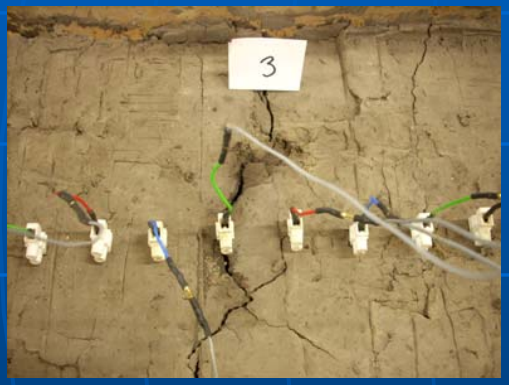
a) Outward Slope showing position of smaller scan

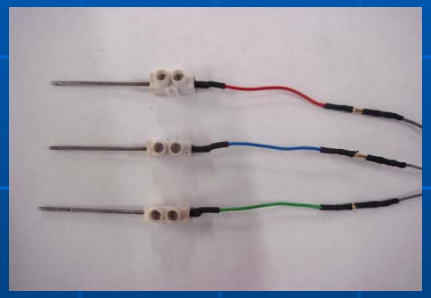
b) Landward slope showing position of fissured zone between crest and slope

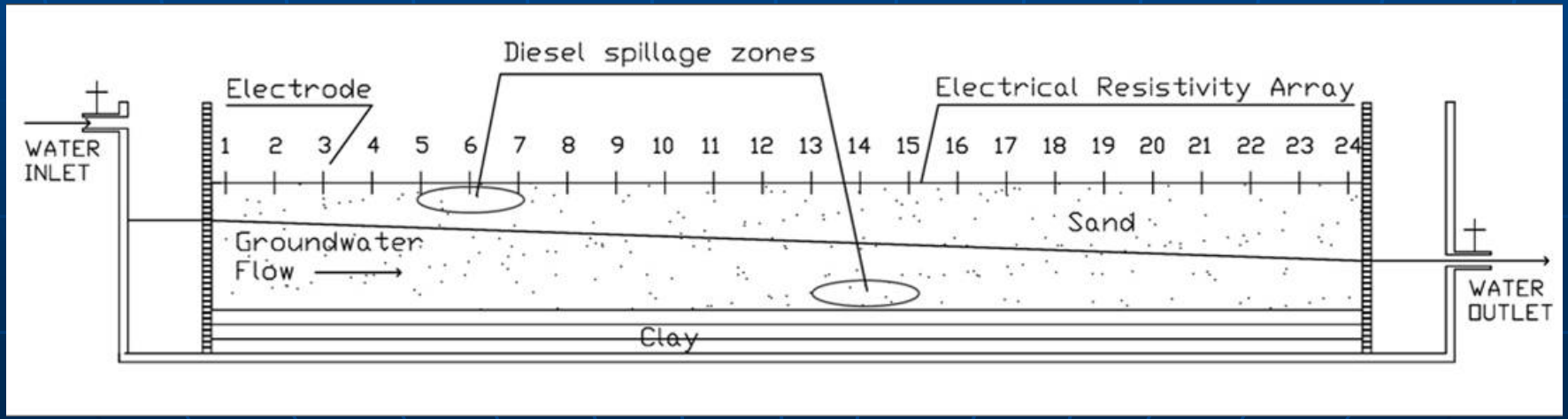
The colour contours after inversion indicate the zones of high resistivity corresponding to structural anomalies such as cavities of rocks.

Laboratory Miniature Geophysics

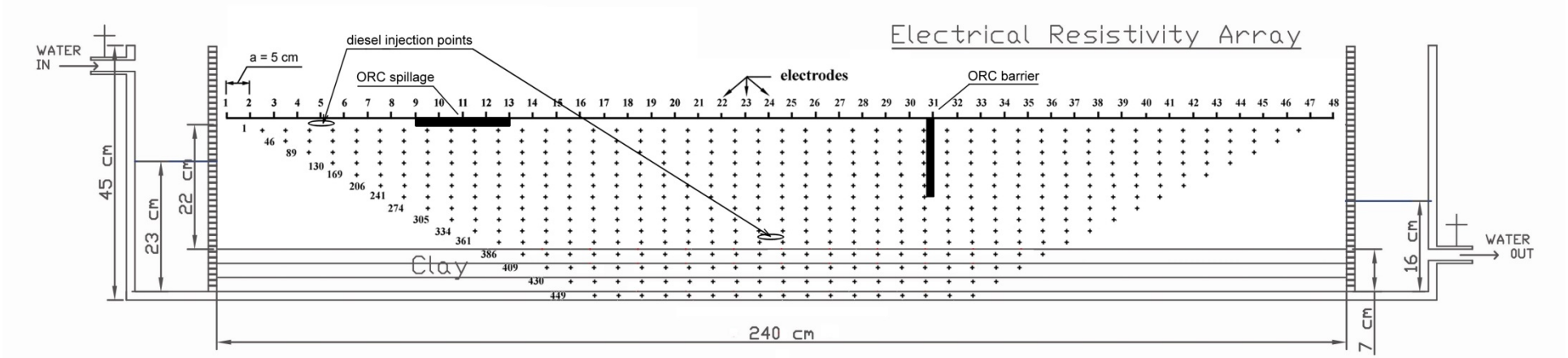


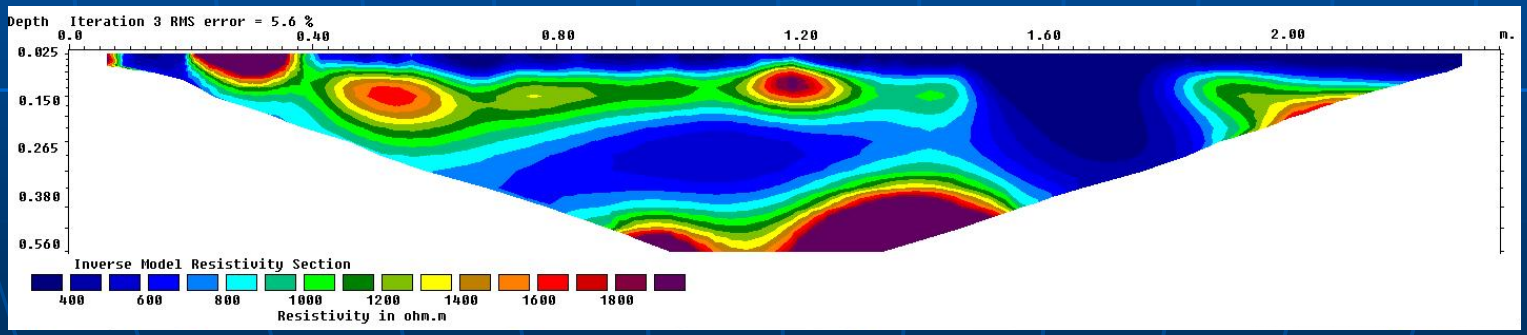






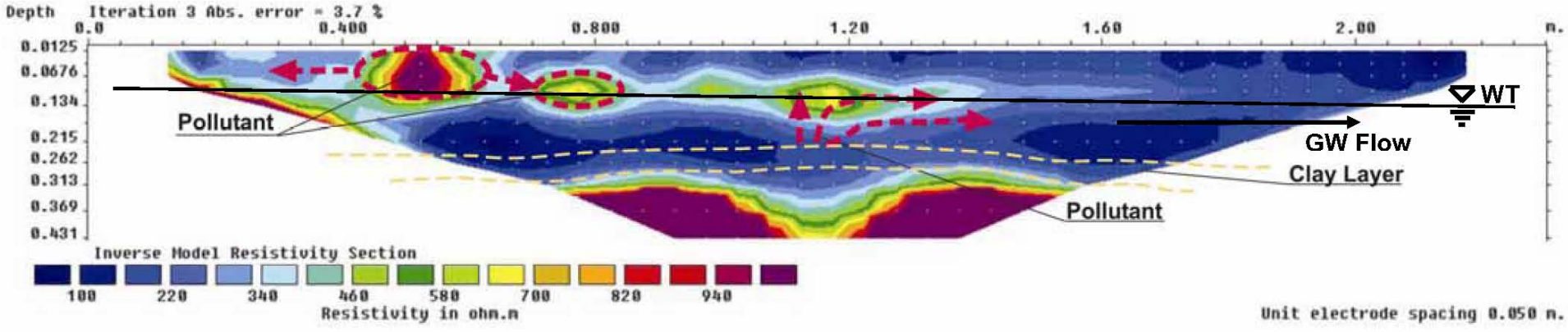
Miniature Geophysics
Diesel Migration in soil

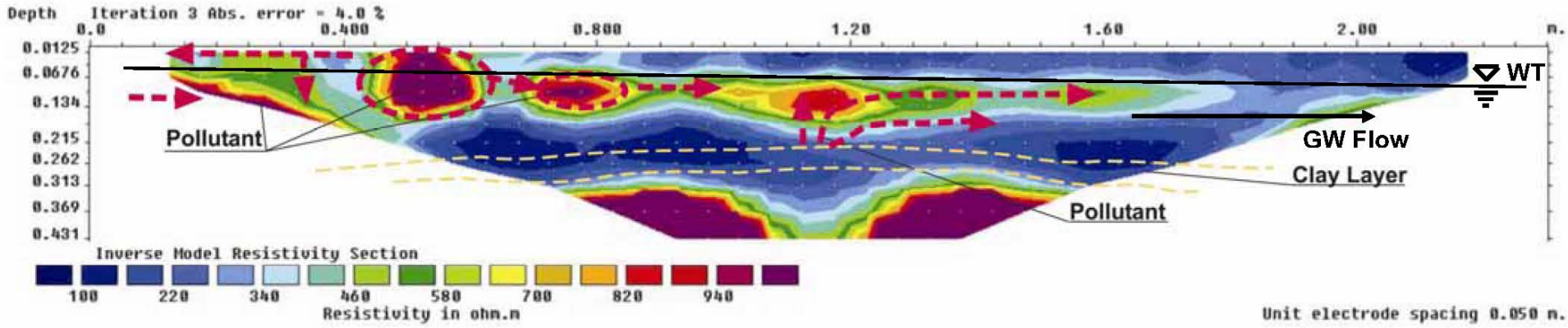




Environmental application

- Subsurface contaminant detection (Laboratory) Diesel and Tar.

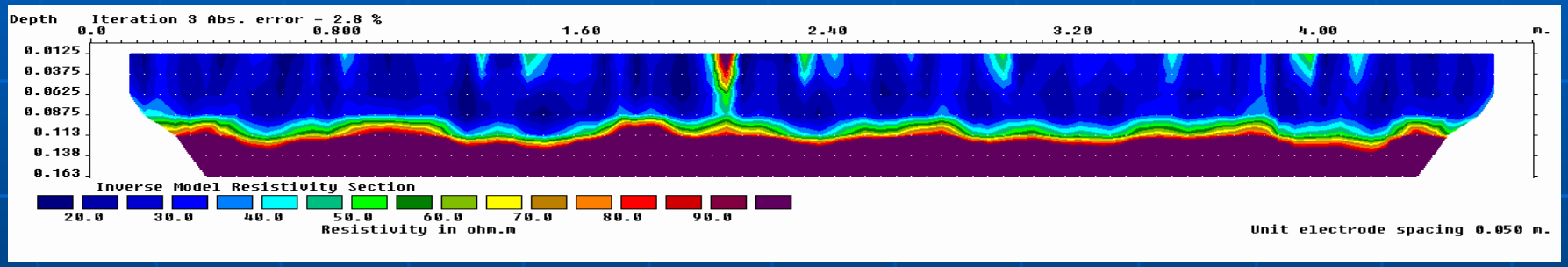




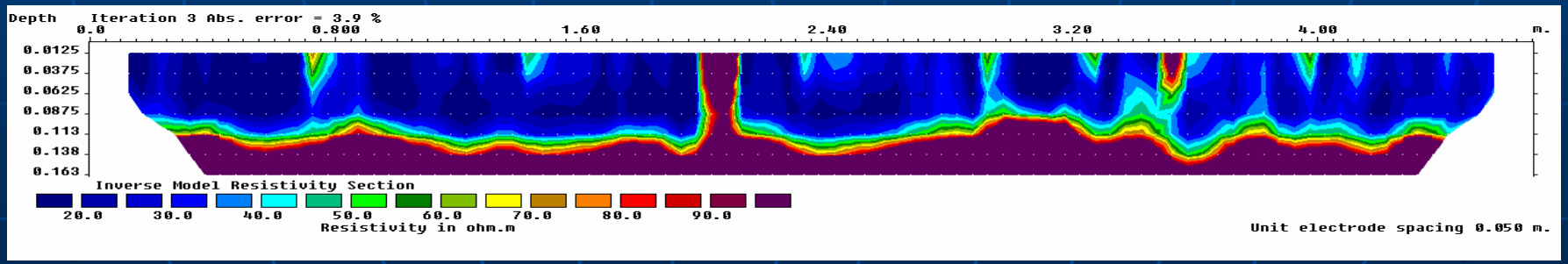
Geophysics – Laboratory Test miniature ERT

Preliminary results – geophysical scan on small desiccated model

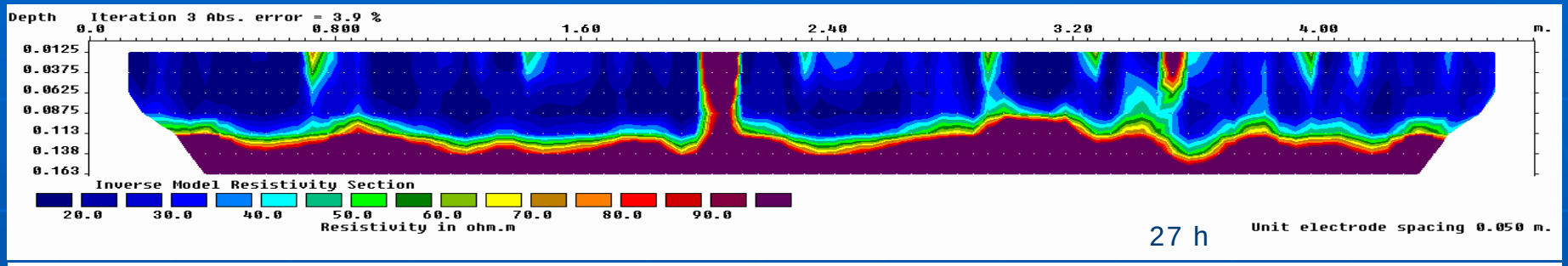
after 20 hours

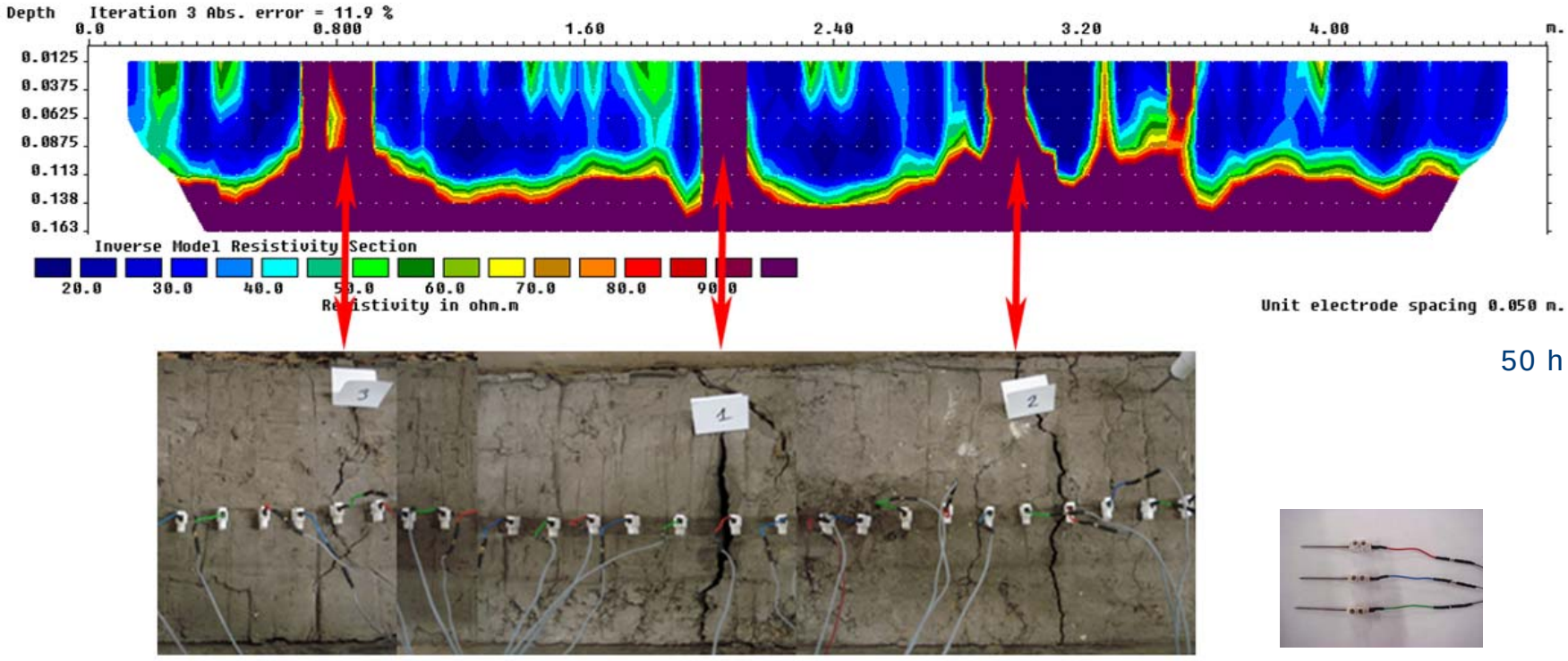


after 27 hours

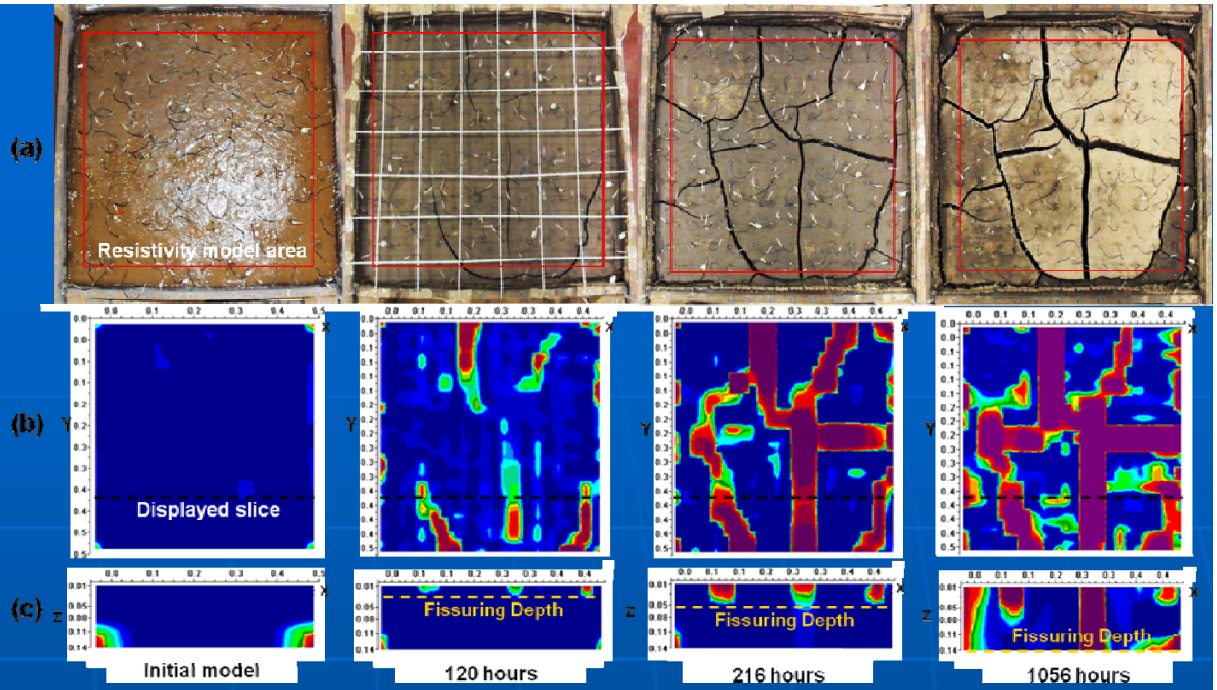


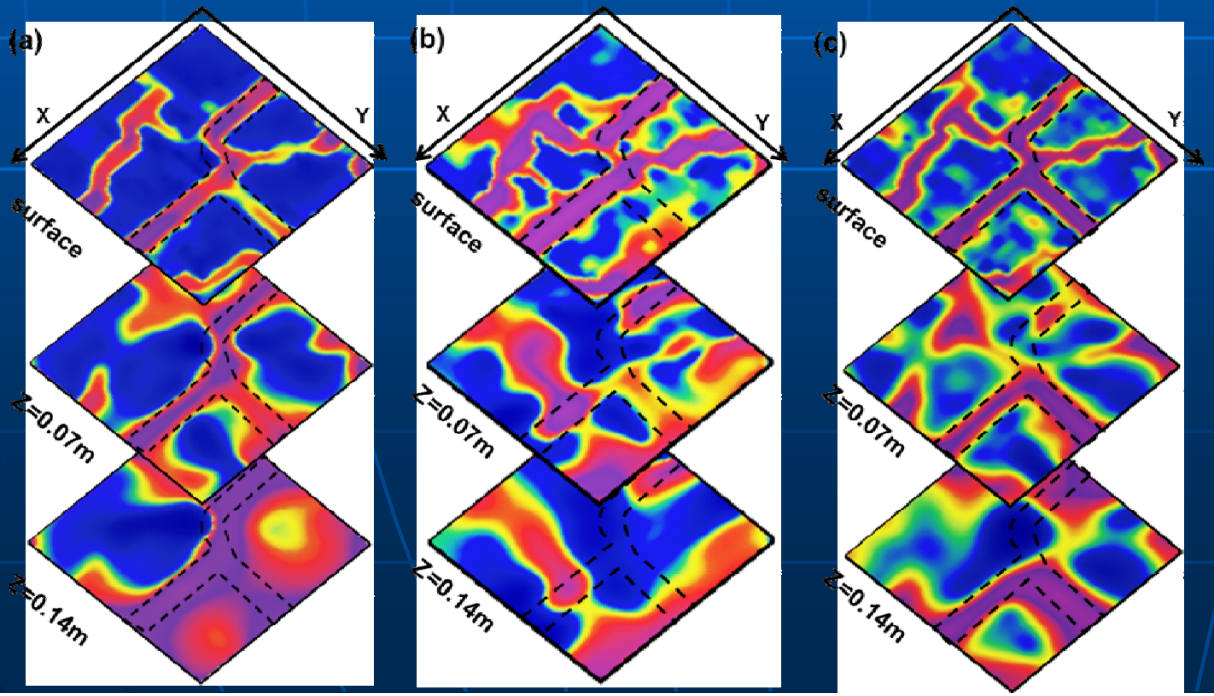
Laboratory Geophysics – Miniature resistivity arrays clay desiccation / cracking detection





Laboratory Miniature resistivity tomography 3D

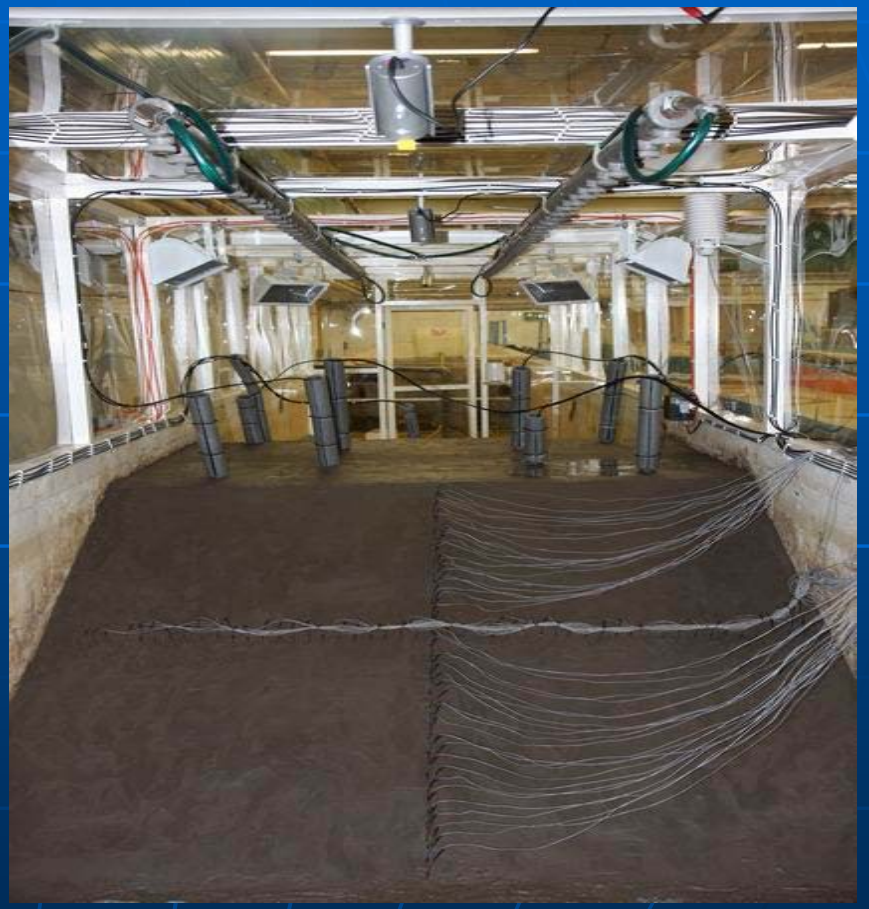




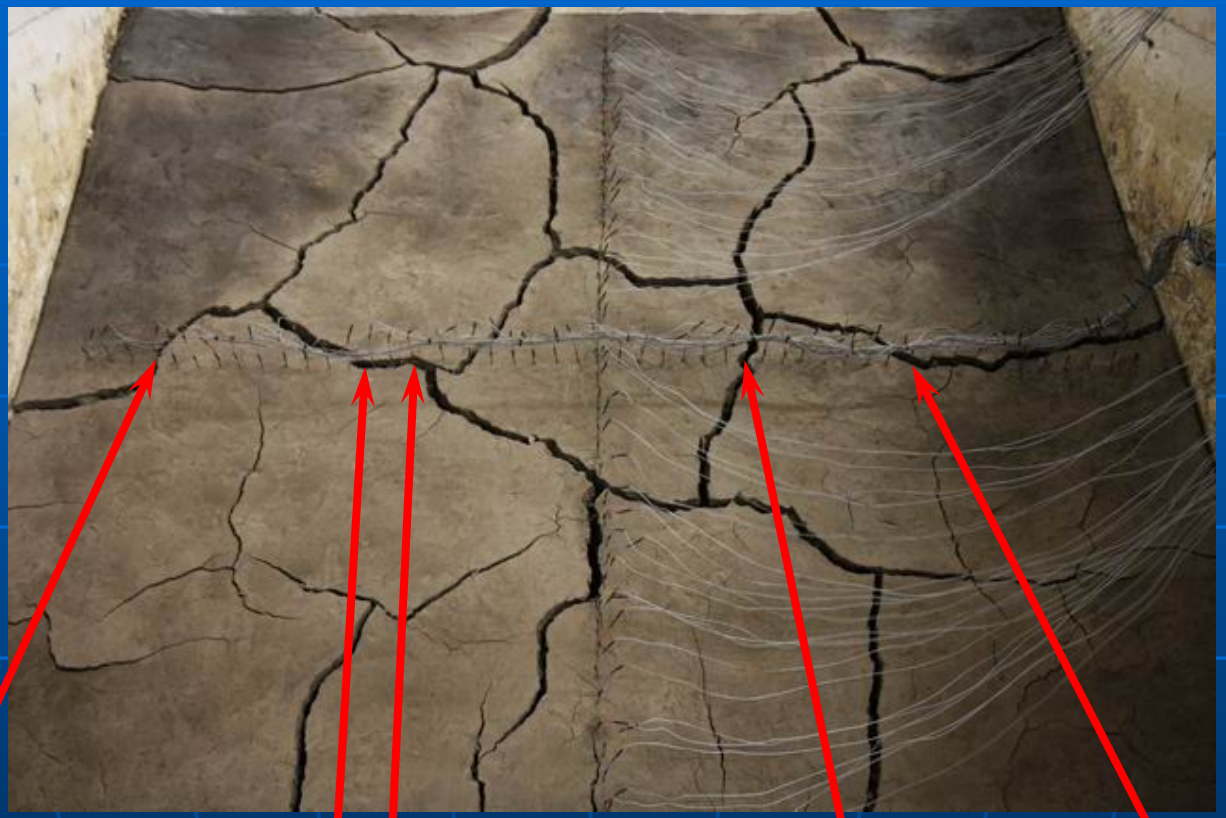
Using different arrays configurations

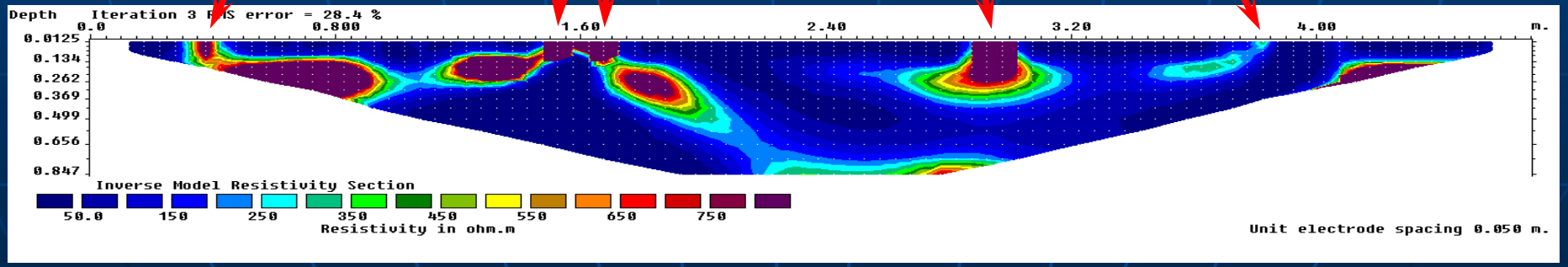
Macro-scale embankment model

Environmental chamber (Geotechnical and Geophysical sensors)



Laboratory macro-scale embankment model





Thank you for your attention