



Geophysical Explorations for Landslides

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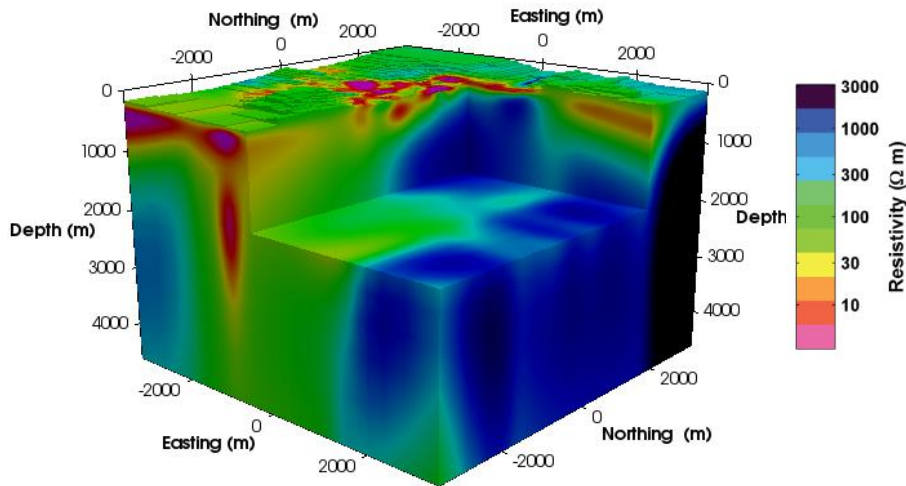
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**International Workshop on Landslide
Risk Assessment and Management
for ASEAN Member States
1 – 2 June 2017
NECTEC**

What is Geophysics? What are geophysicists doing?

We explore the deep Earth!



Fang's resistivity structure from magnetotelluric survey
(Amatyakul et al., 2016, Geothermics)

Subsurface
(Physical properties)

Physics measurement
(mostly at Earth's surface)



Geophysics

→ Workflow

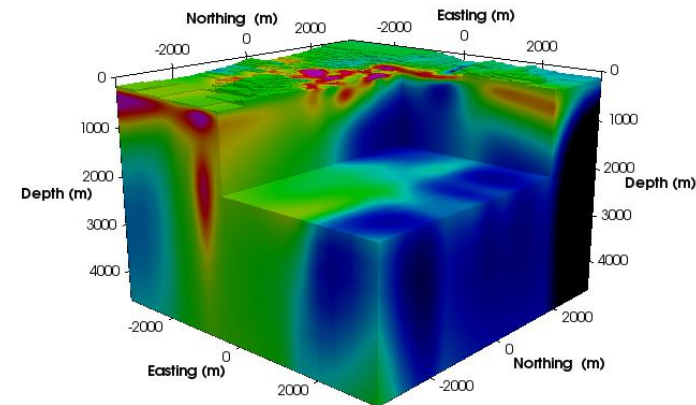
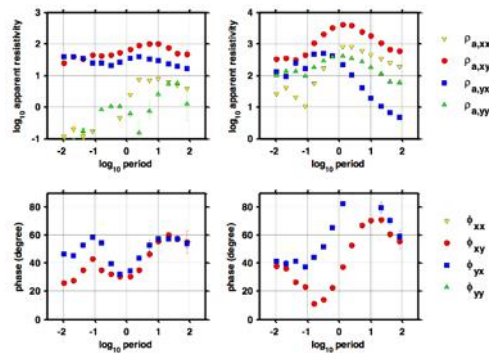
Physics + Mathematics
+ Computer Sciences

Data Acquisition

Data processing

Computational
modeling and
Inversion

Subsurface Model
(Physical properties)



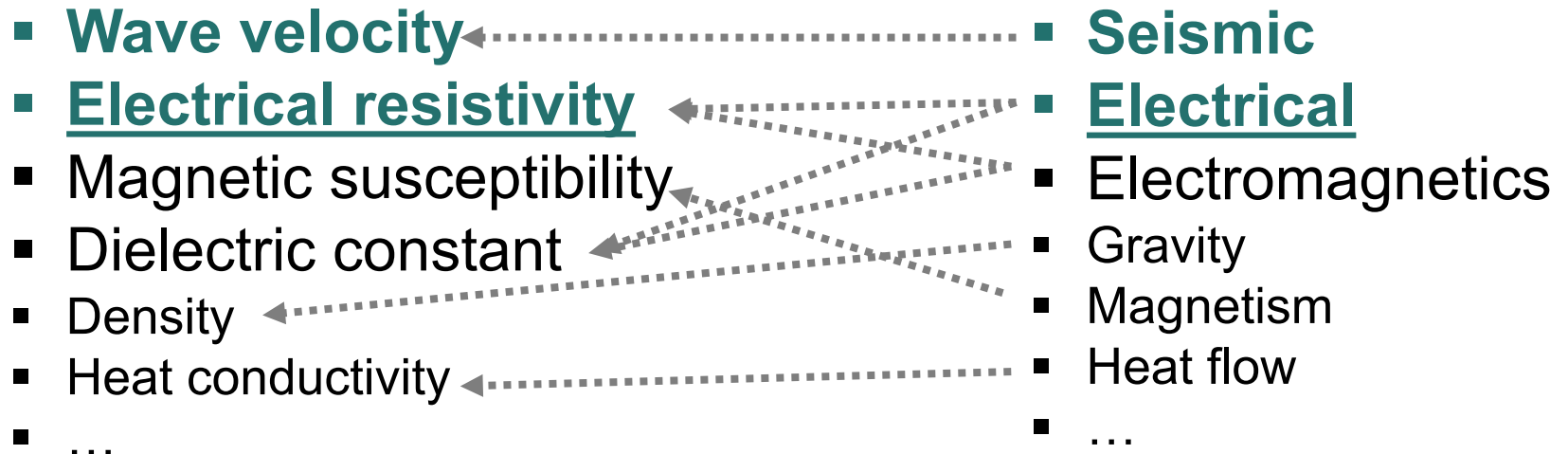
Geophysics

→ Methods / Techniques

Spatial distribution

Subsurface Model (Physical properties)

Exploration Techniques



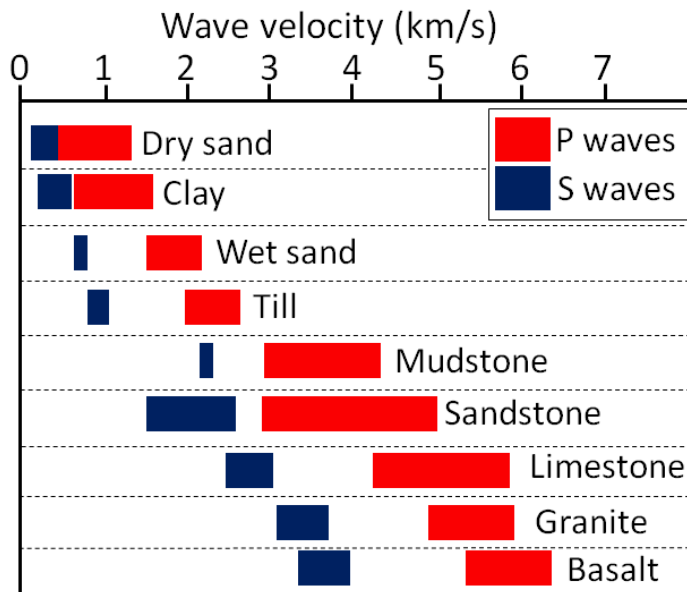
Geophysics

→ Methods / Techniques

Subsurface Model

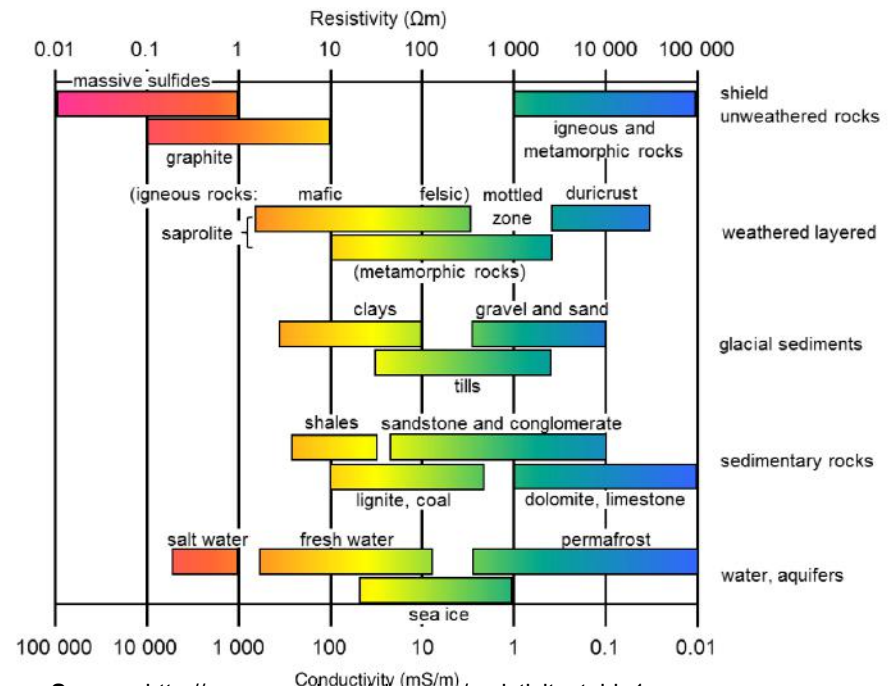
Rocks /
Geological Target

Wave velocity



Source: <https://opentextbc.ca/geology/chapter/9-1-understanding-earth-through-seismology/>

Electrical resistivity



Source: http://gpg.geosci.xyz/_images/resistivity_table1.png

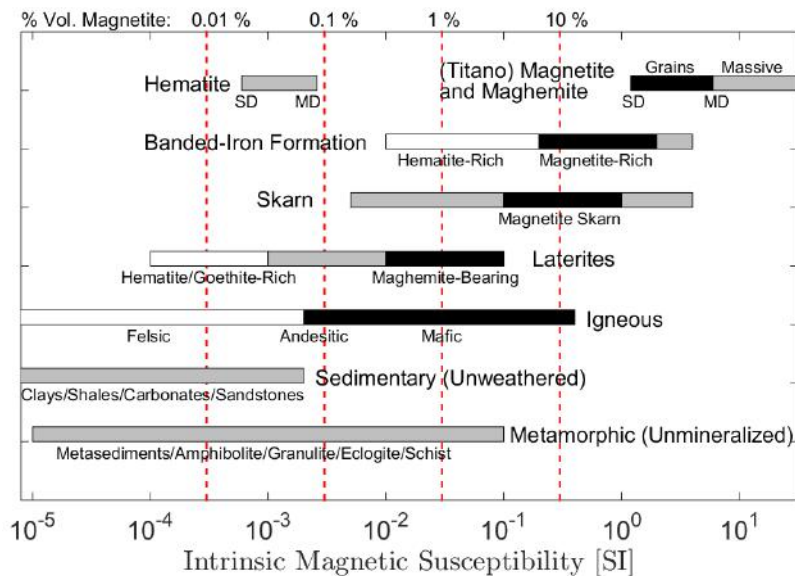
Geophysics

→ Methods / Techniques

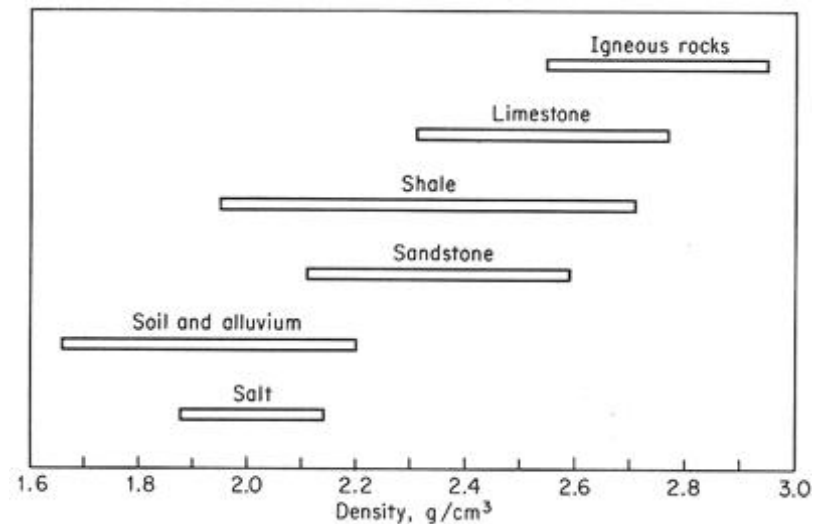
Subsurface Model

Rocks /
Geological Target

Magnetic susceptibility



Density



Source:

<https://www.eoas.ubc.ca/ubcgif/iag/foundations/properties/density.htm>

Source:

http://em.geosci.xyz/content/physical_properties/magnetic_permeability/magnetic_permeability_factors.html

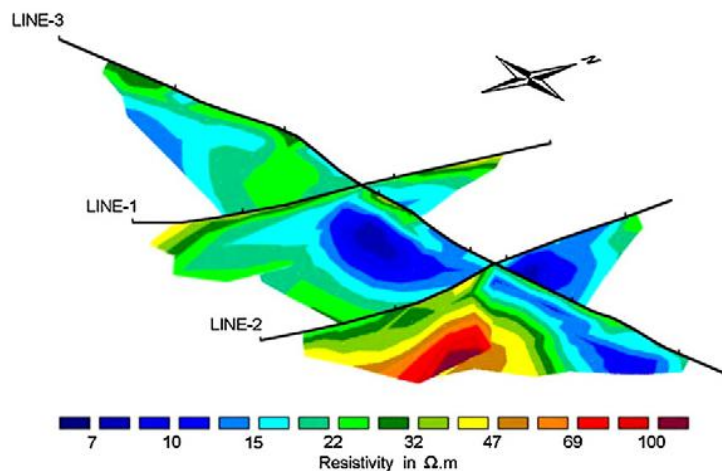
Geophysics



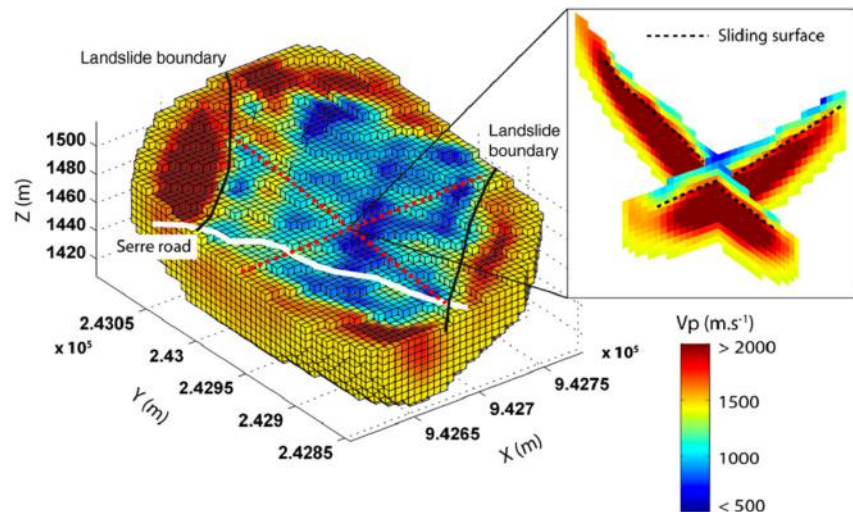
Landslides

“Imaging subsoil and beneath”

Electrical resistivity



Wave velocity



Geophysics

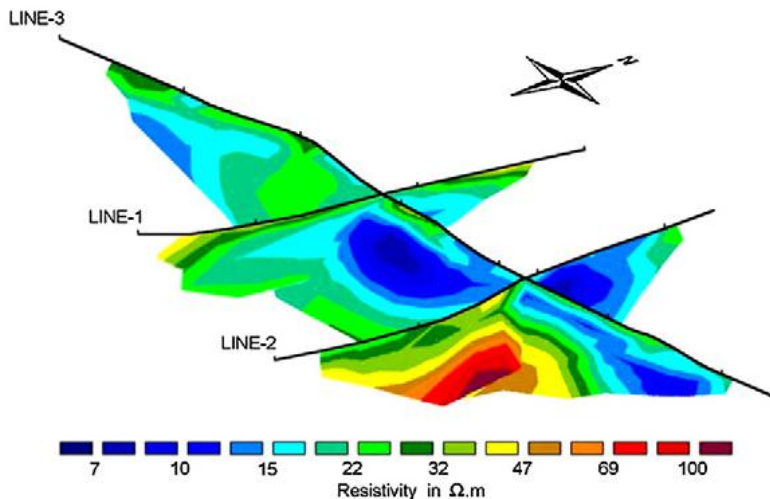


Landslides

“Imaging subsoil and beneath”

(DCR)

Electrical resistivity



3D DCR, Aydin (Turkey)

Source: Drahor et al., (2006)

Direct-current resistivity survey

- **Non-invasive** technique
- Provide **resistivity model**
- **Widely used** to study landslides
- **Linked** with
 - ✓ lithological,
 - ✓ hydrological and
 - ✓ geotechnicalcharacteristics of the landslides

Geophysics

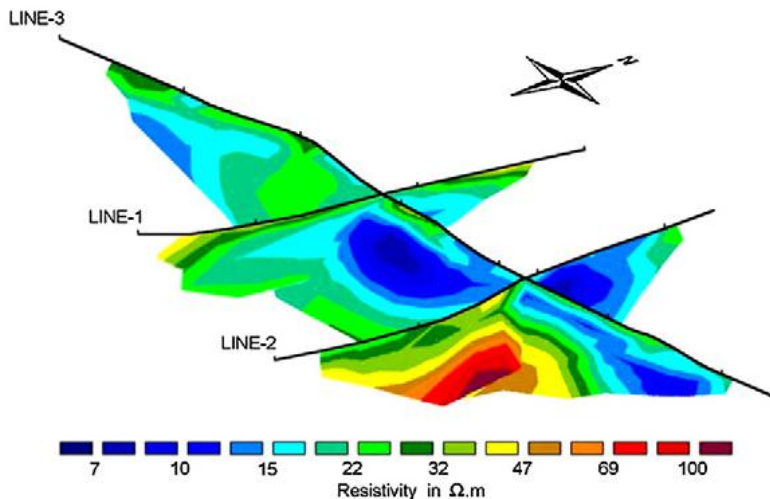


Landslides

“Imaging subsoil and beneath”

(DCR)

Electrical resistivity



Direct-current resistivity survey

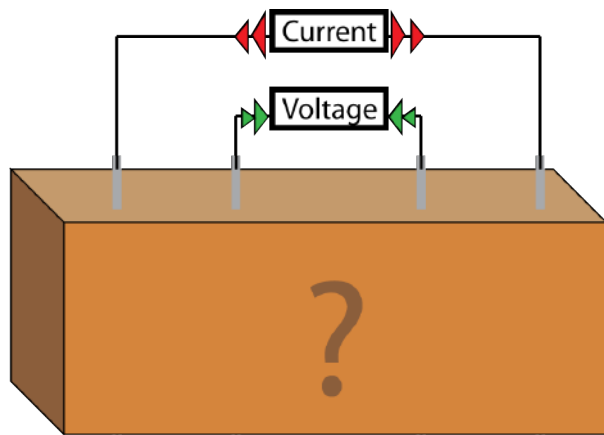
- Resistivity model reveals:
 - ✓ **Bedrock depth**
 - ✓ **Stratigraphic layers**
 - ✓ **Zones of saturation**
 - ✓ **Groundwater table**

3D DCR, Aydin (Turkey)

Source: Drahor et al., (2006)

DC Resistivity

Direct-current resistivity (DCR) method is a controlled-source electric geophysical method of imaging the earth's subsurface. DCR is generally used for a **shallow** application (< 1 km).



Ohm's law:

$$V = IR$$

Electrical resistivity:

$$R = K\rho$$

K = measurement factor

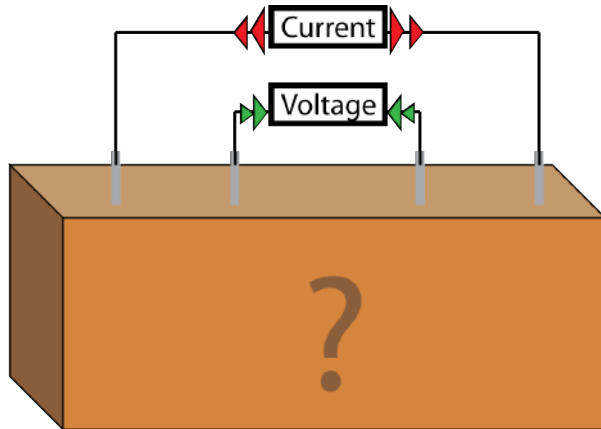
Injecting **I**
Measuring **V**

processing →

Apparent resistivity (ρ_a)

Resistivity model

DC Resistivity



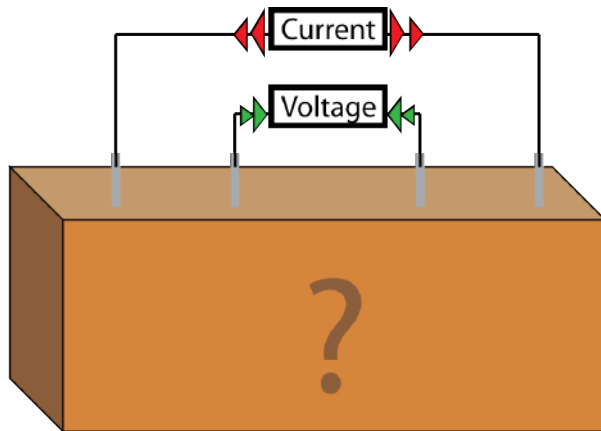
Injecting I
Measuring V

processing

Apparent resistivity (ρ_a)



DC Resistivity



Apparent resistivity (ρ_a)

Resistivity model

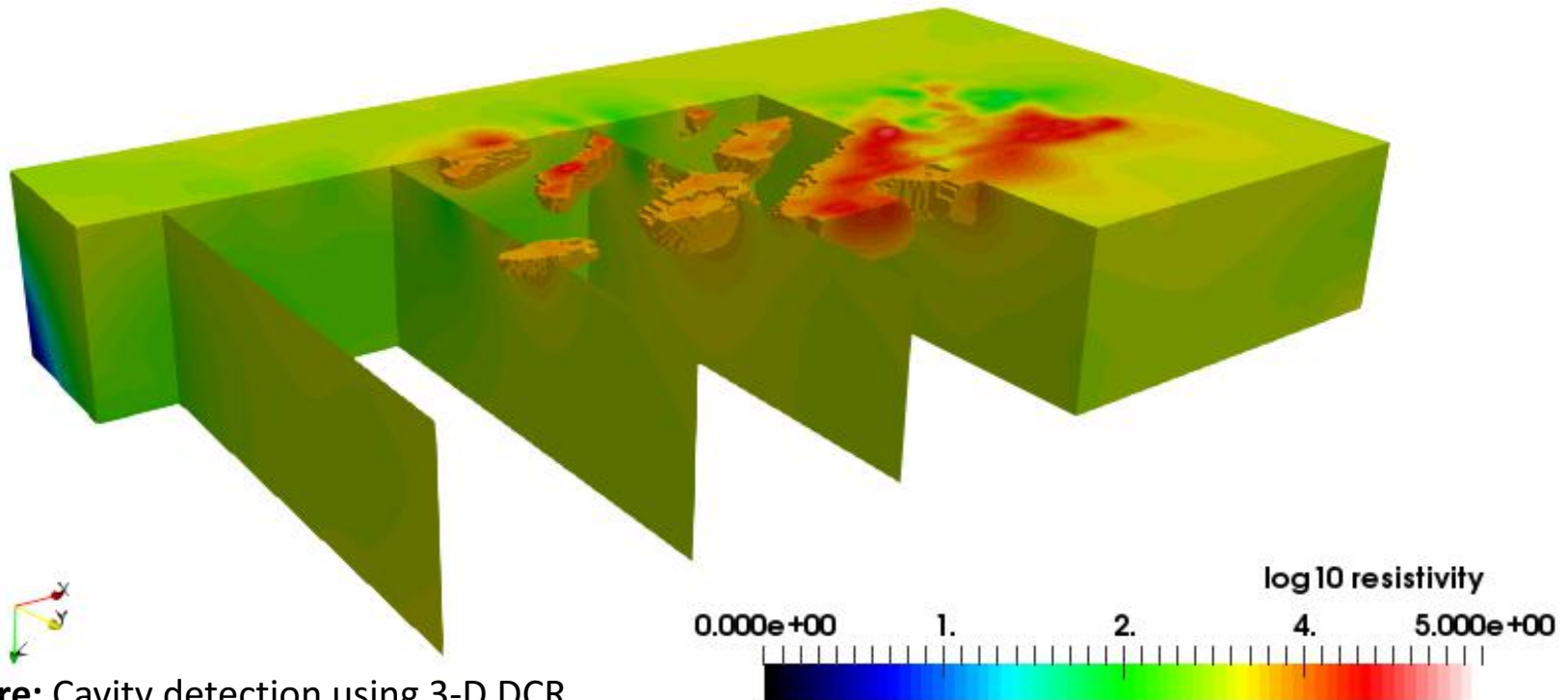
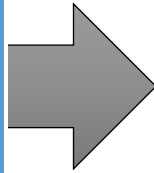


Figure: Cavity detection using 3-D DCR

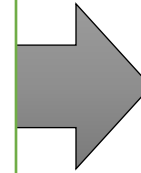
DC Resistivity



Data

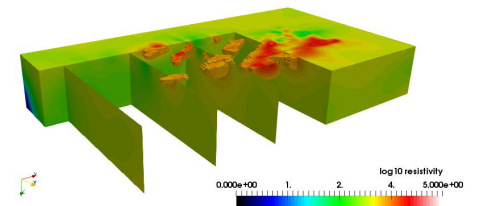


Inversion

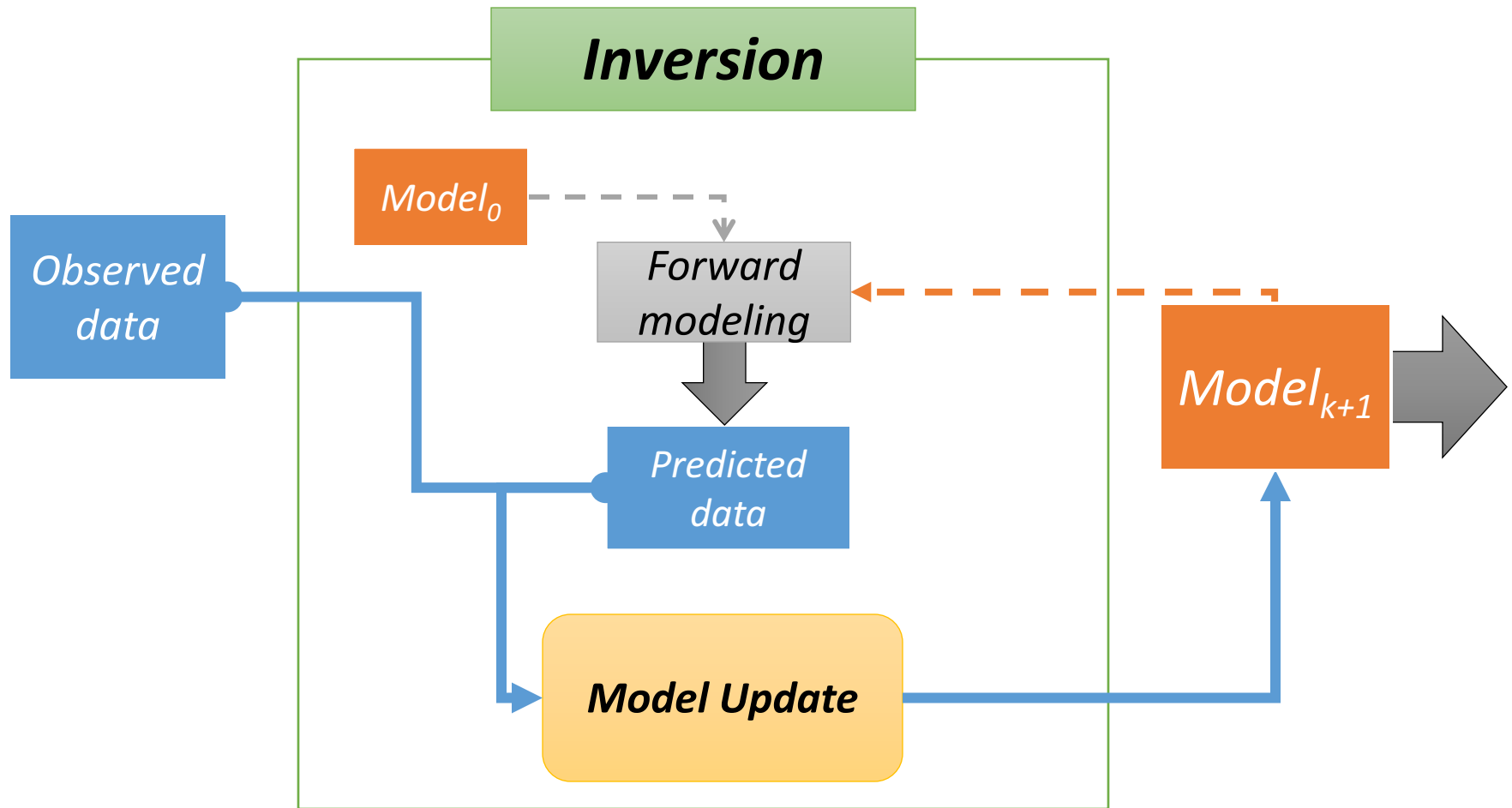


Model

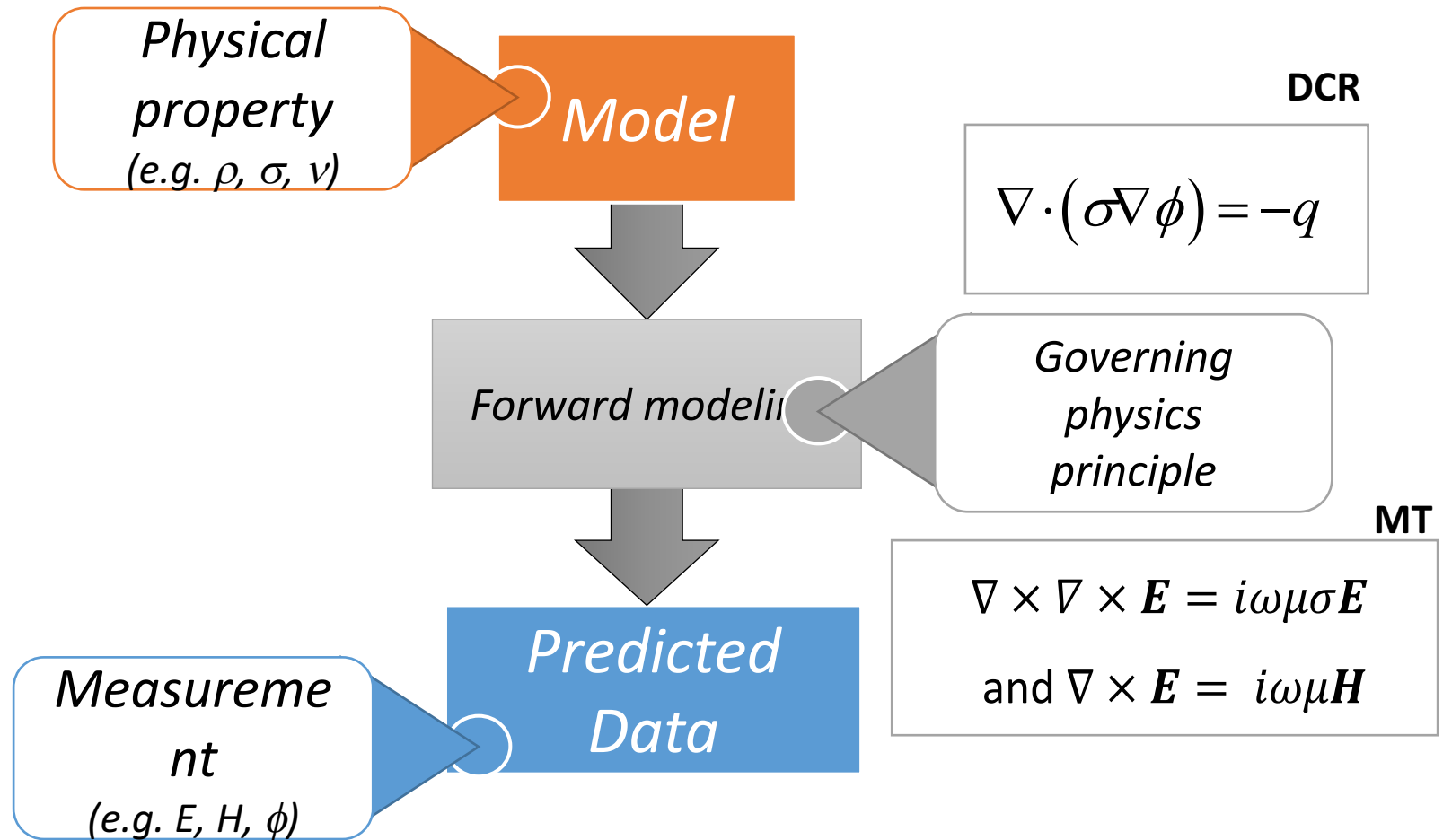
Mathematical
optimization



DC Resistivity



DC Resistivity



DC Resistivity

Inversion

Model

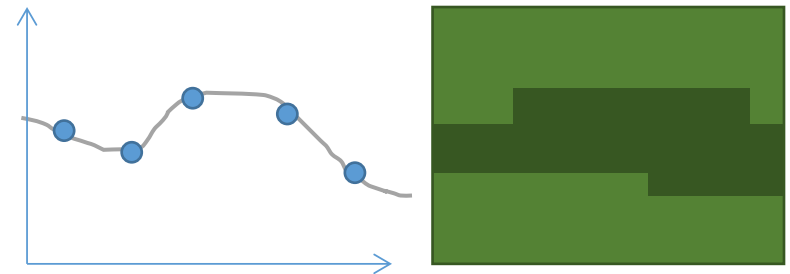
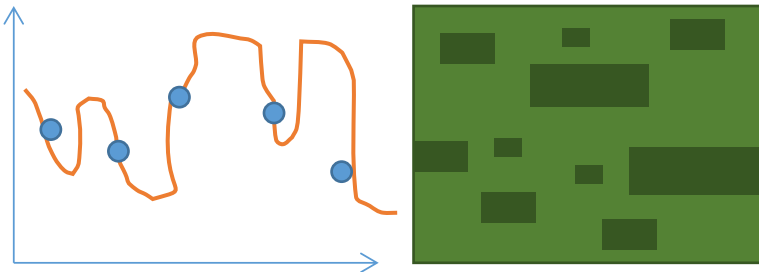
Fit

And

Constrained

Least-square

Smoothness constraint



DC Resistivity

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Physics of the Earth and Planetary Interiors

journal homepage: www.elsevier.com/locate/pepi



An efficient inversion for two-dimensional direct current resistivity surveys based on the hybrid finite difference–finite element method

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Case study

WSJointInv2D-MT-DCR: An efficient joint two-dimensional magnetotelluric and direct current resistivity inversion

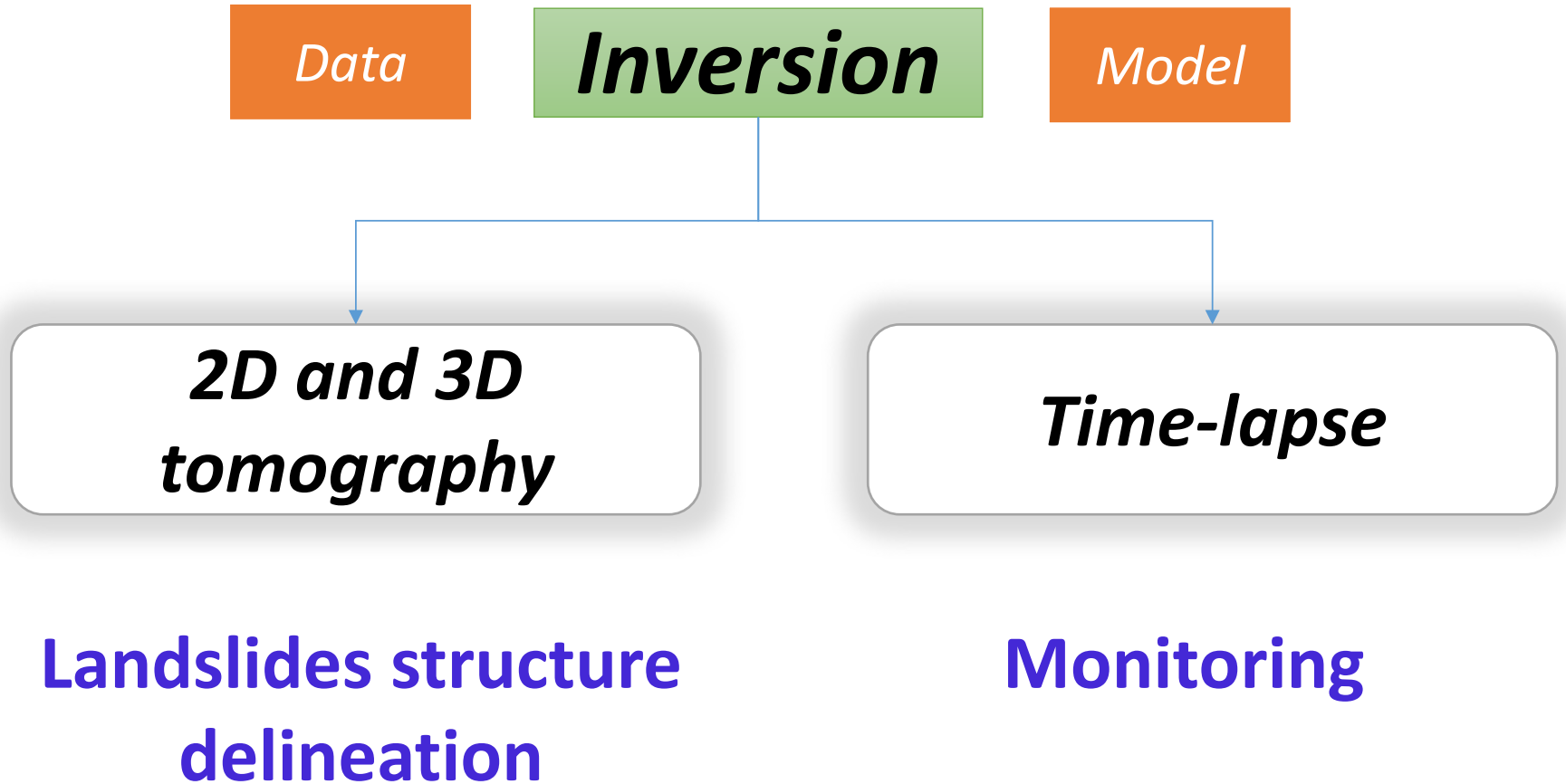
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DC Resistivity



Application: 2D DCR

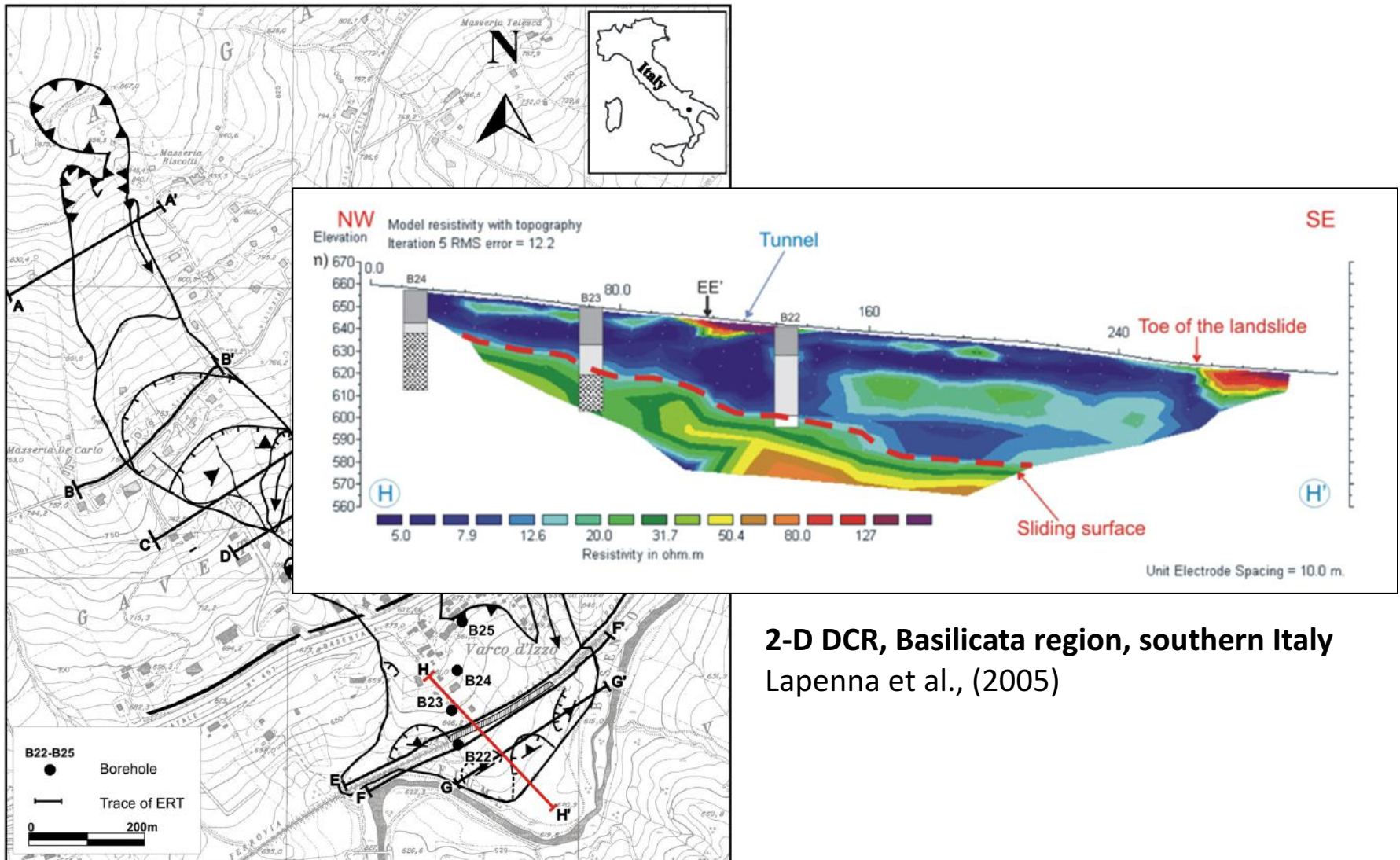


Fig. 2. Varco d'Izzo landslide (Basilicata region, southern Italy): identification of the sliding surface and definition of landslide shape by the comparison between the HH' 2D ERT and the stratigraphic data inferred from boreholes B22, B23 and B24 (redrawn from Lapenna et al., (2005)).

2-D DCR, Basilicata region, southern Italy
Lapenna et al., (2005)

Application: 3-D DCR

3-D DCR, Aydin (Turkey) Source: Drahor et al., (2006)

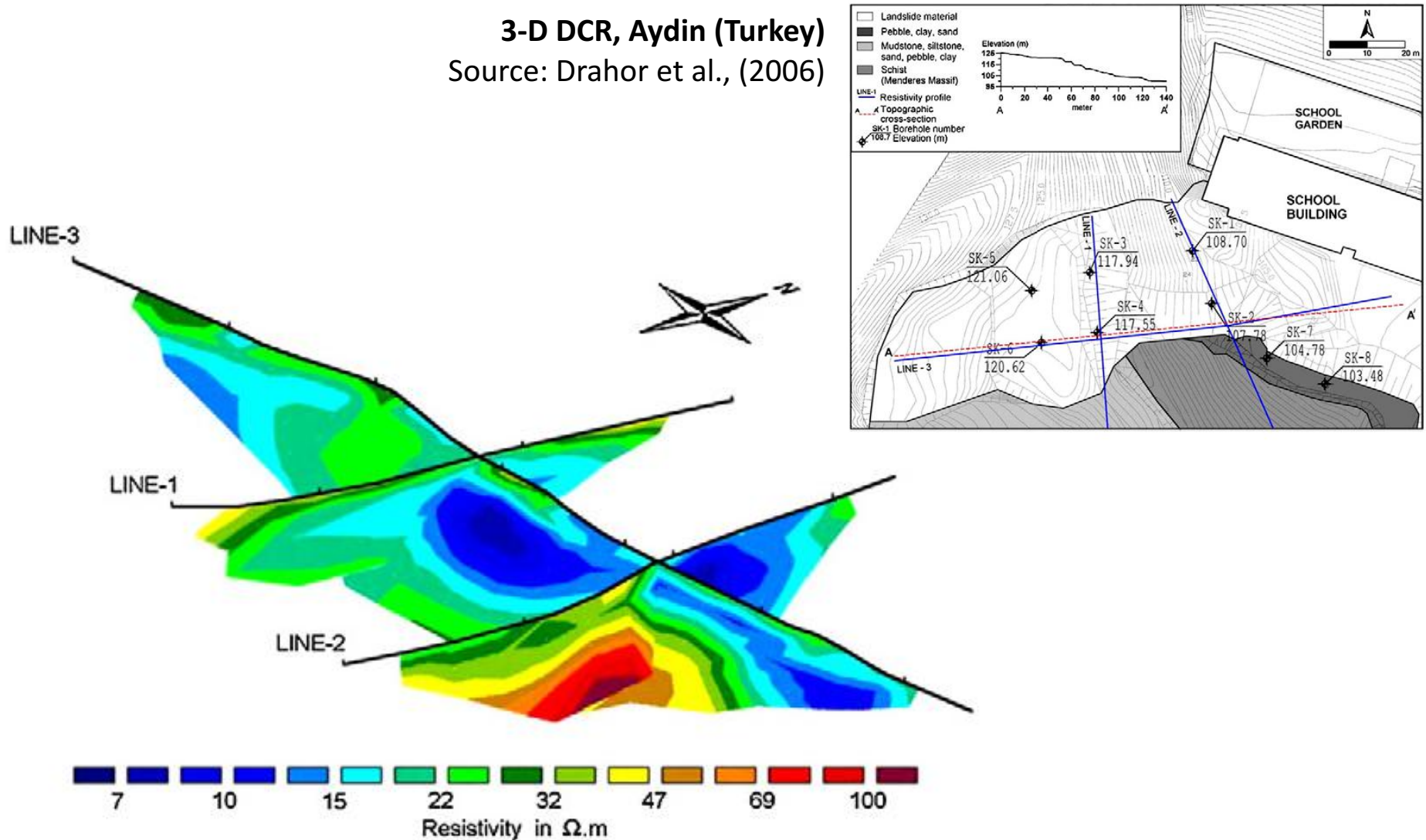


Fig. 5. Geological map of the Soke landslide area in the district of Aydin (Turkey) with location of measurement profiles. 3D fence diagram of the resistivity sections carried out on the landslide (redrawn from Drahor et al., (2006)).

Application: Joint DCR + Seismic

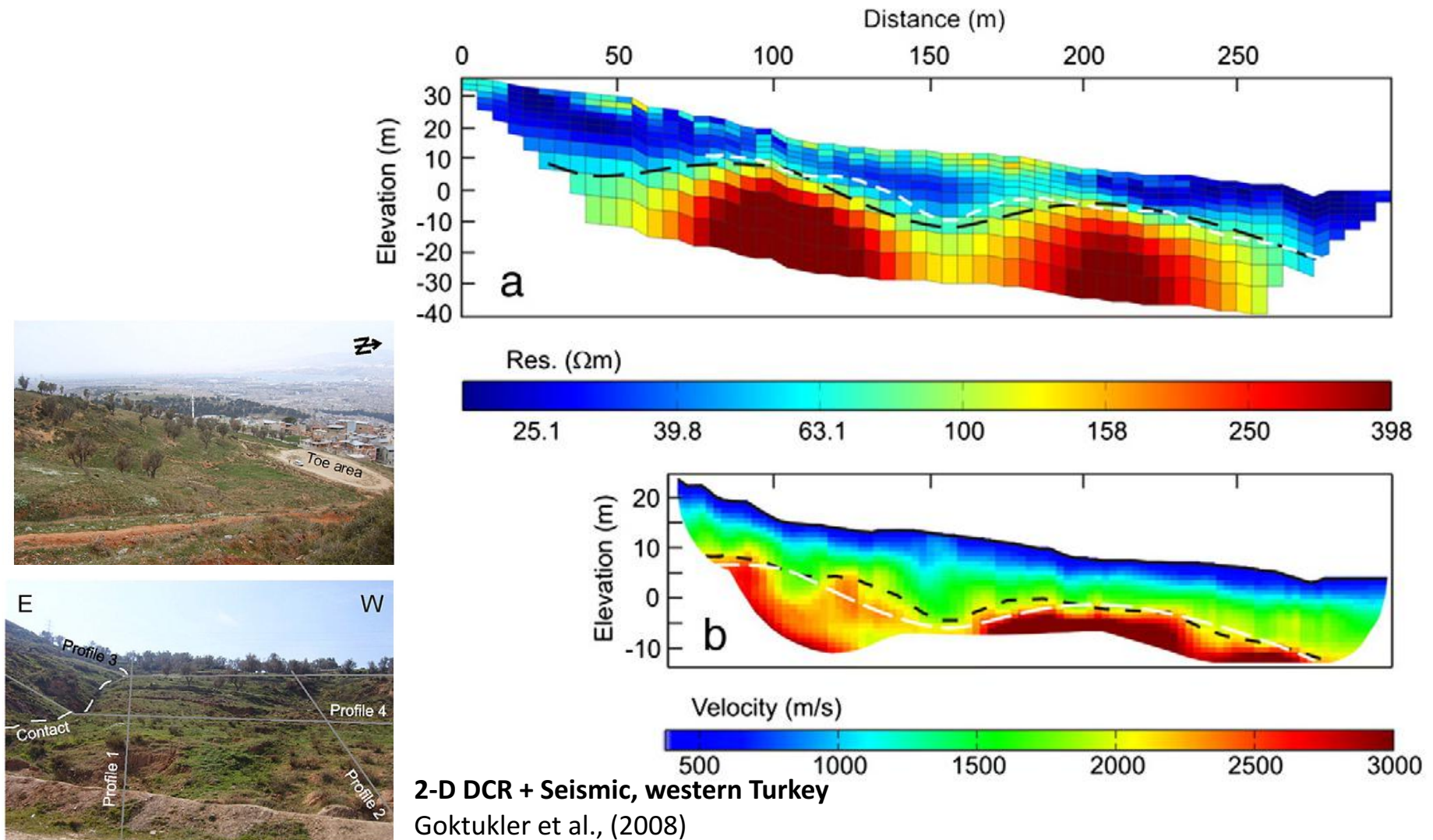
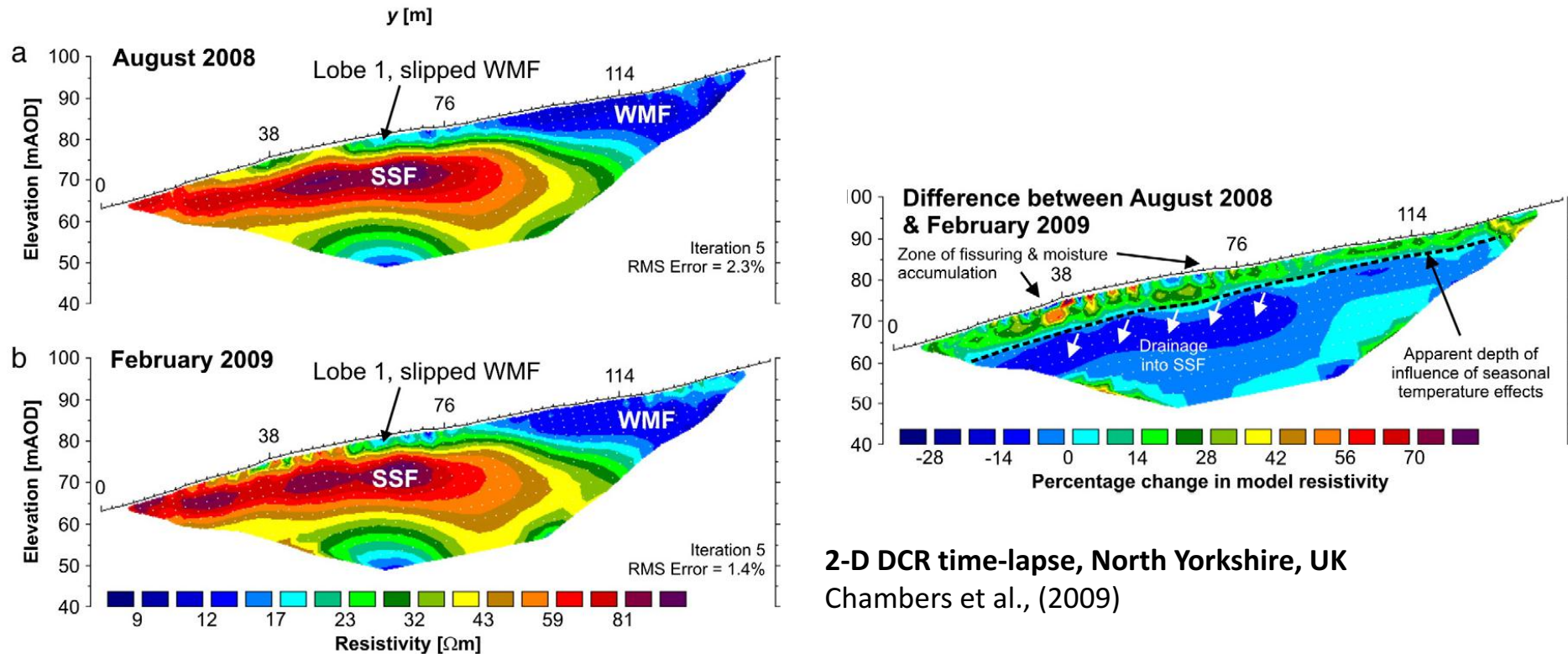


Fig. 3. (Top) A general view of the Altındağ landslide site, Izmir (western Turkey) with location of measurement profiles; (bottom) identification of the sliding surface by the comparison between 2D ERT and the seismic refraction tomography carried out along the profile 1 (redrawn from Göktürkler et al., (2008)).

Application: Time-lapse Inversion



2-D DCR time-lapse, North Yorkshire, UK
Chambers et al., (2009)

Fig. 6. Landslide in Malton site (North Yorkshire, UK): TI-ERT obtained by the ALERT (Kuras et al., 2009) data. (a) 2D ERT carried out on August 2008; (b) 2D ERT carried out on February 2009; (c) resulting differential resistivity image (after Chambers et al., (2009)).

Conclusion

Geophysics



Landslides

- ✓ Geophysical exploration reveal subsurface image.
- ✓ Electrical resistivity and seismic velocity directly links to landslides studies.
- ✓ Geophysical model can be related with petrophysical properties (water saturation).
- ✓ Integrated geophysical explorations is required to reduce interpretation ambiguity.
- ✓ Explorations can be designed according to the purpose of the studies (structural delineation and monitoring)
- ✓ Our research group can contribute both in data acquisition / software (inversion) / monitoring ideas

Thank you