



UNIVERSITÀ  
DI PISA

# Elements of Geophysics

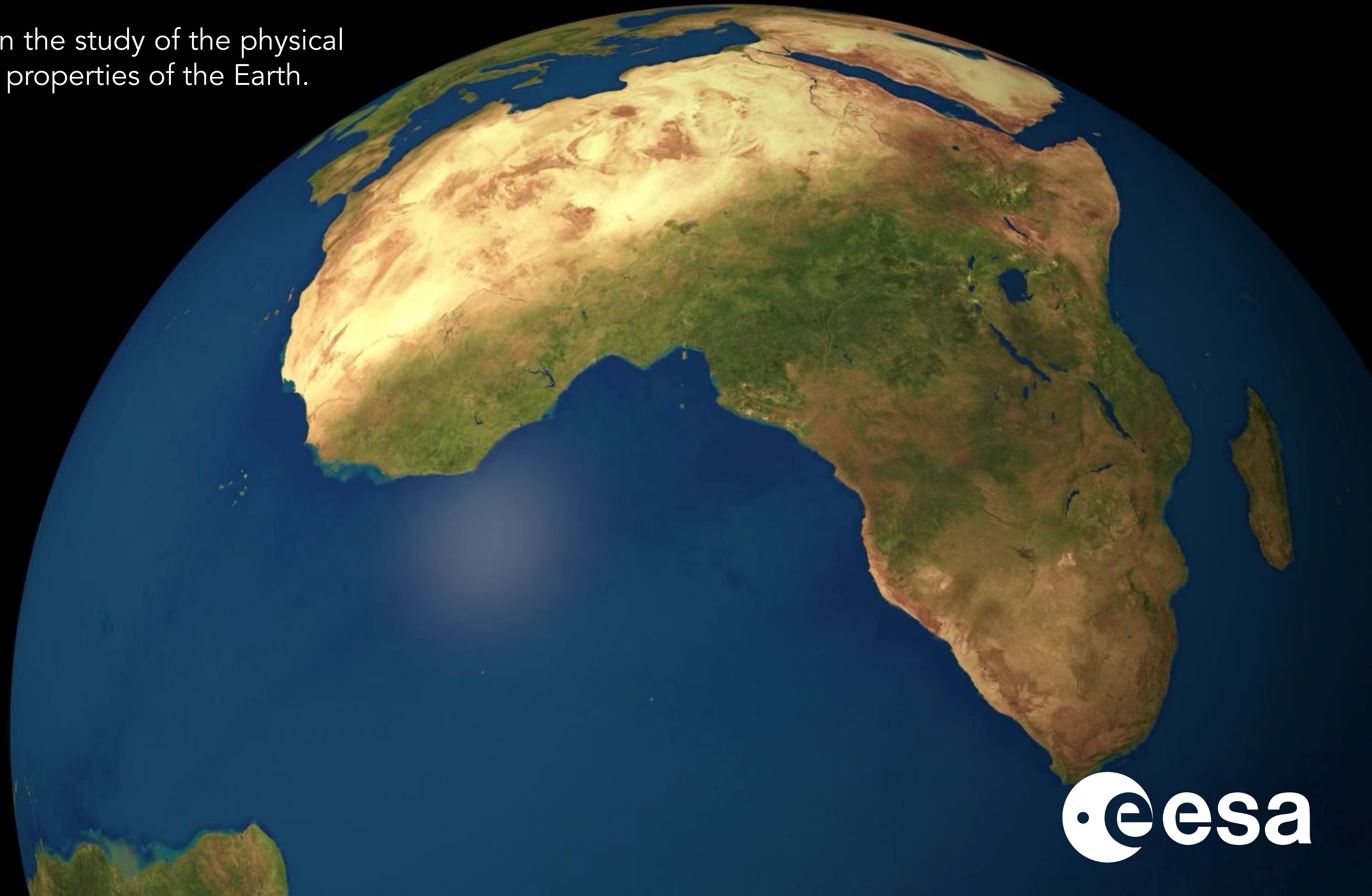
Instructor  
Mattia Aleardi

[mattia.aleardi@unipi.it](mailto:mattia.aleardi@unipi.it)



# Geophysics is.....

The science focusing on the study of the physical processes and physical properties of the Earth.





# Geophysical methods

Geophysics combines principles of physics with knowledge of geology, engineering and digital signal processing to study and characterize the Earth's subsurface (from few meters to thousands of kilometers) and its physical properties.

Geophysical methods: seismic, gravitational, magnetic, electrical and electromagnetic methods

Geophysics is used in many applications, to name just a few:

Earthquake seismology

Vulcanology

Landslides characterization and monitoring

Mining

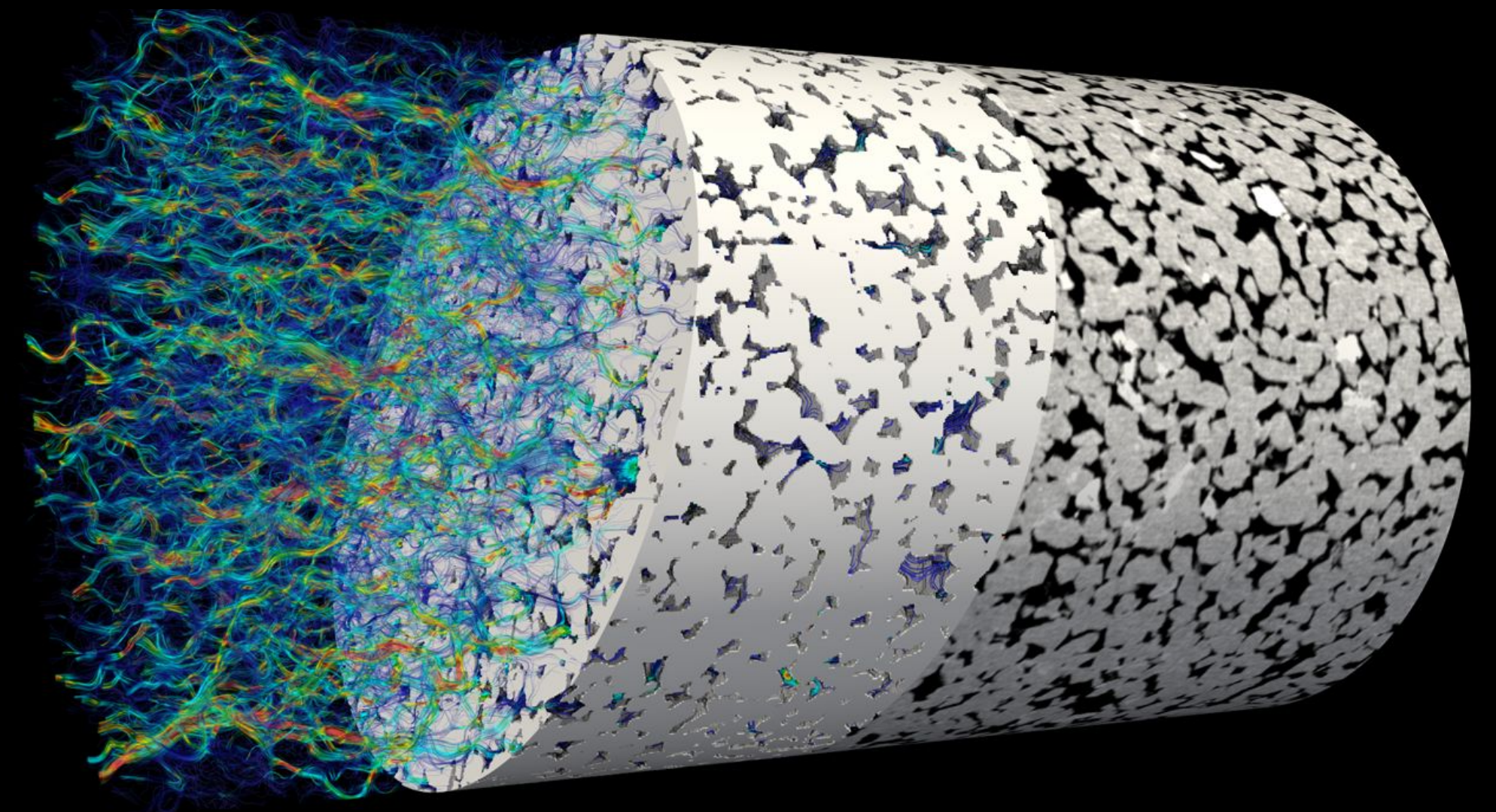
Environmental monitoring of pollutants

Engineering

Archaeology

Exploration for natural resources (e.g. Geothermal Energy)

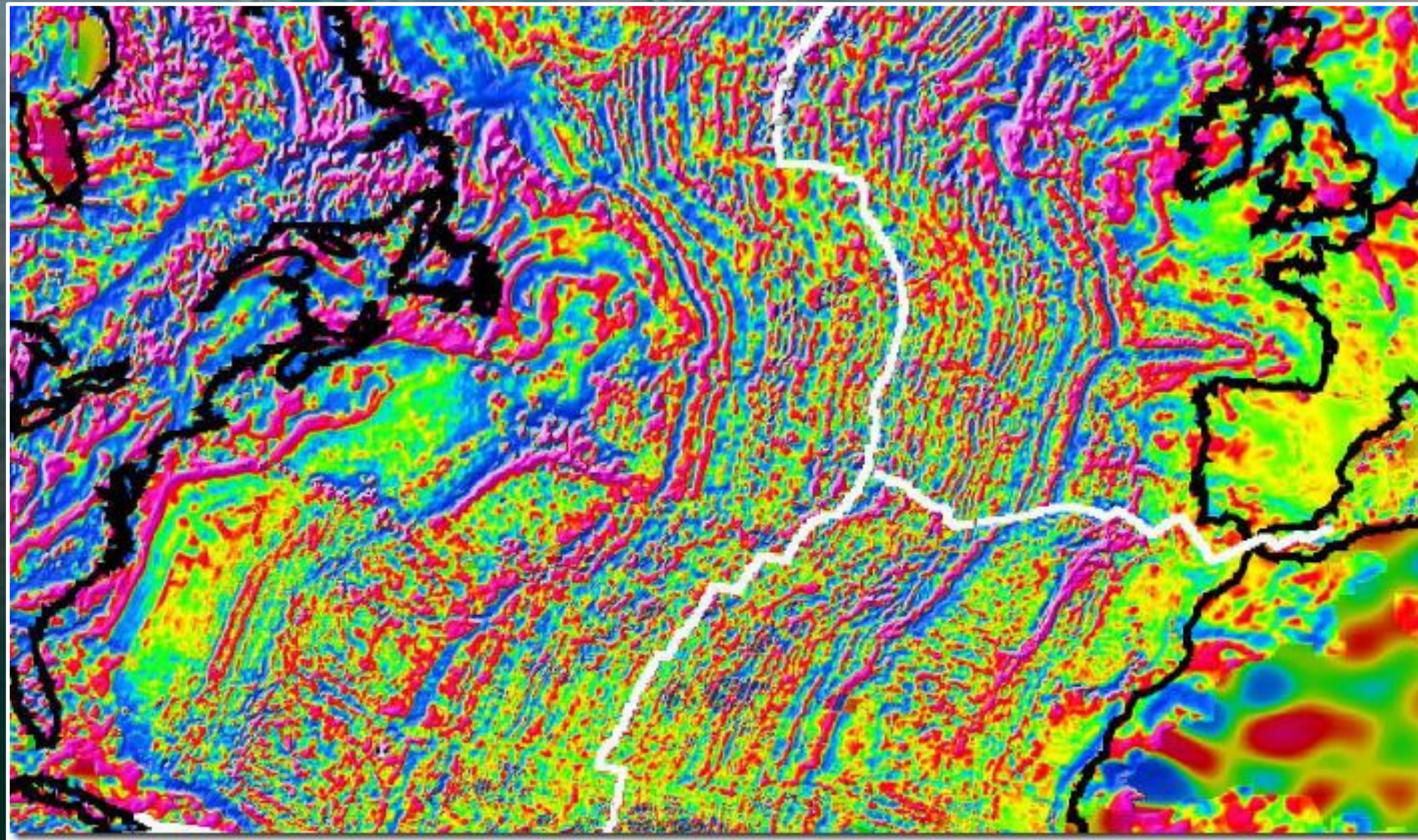
Monitoring industrial operations (e.g. CO2





# Geophysics: Magnetic method

## Plate tectonics



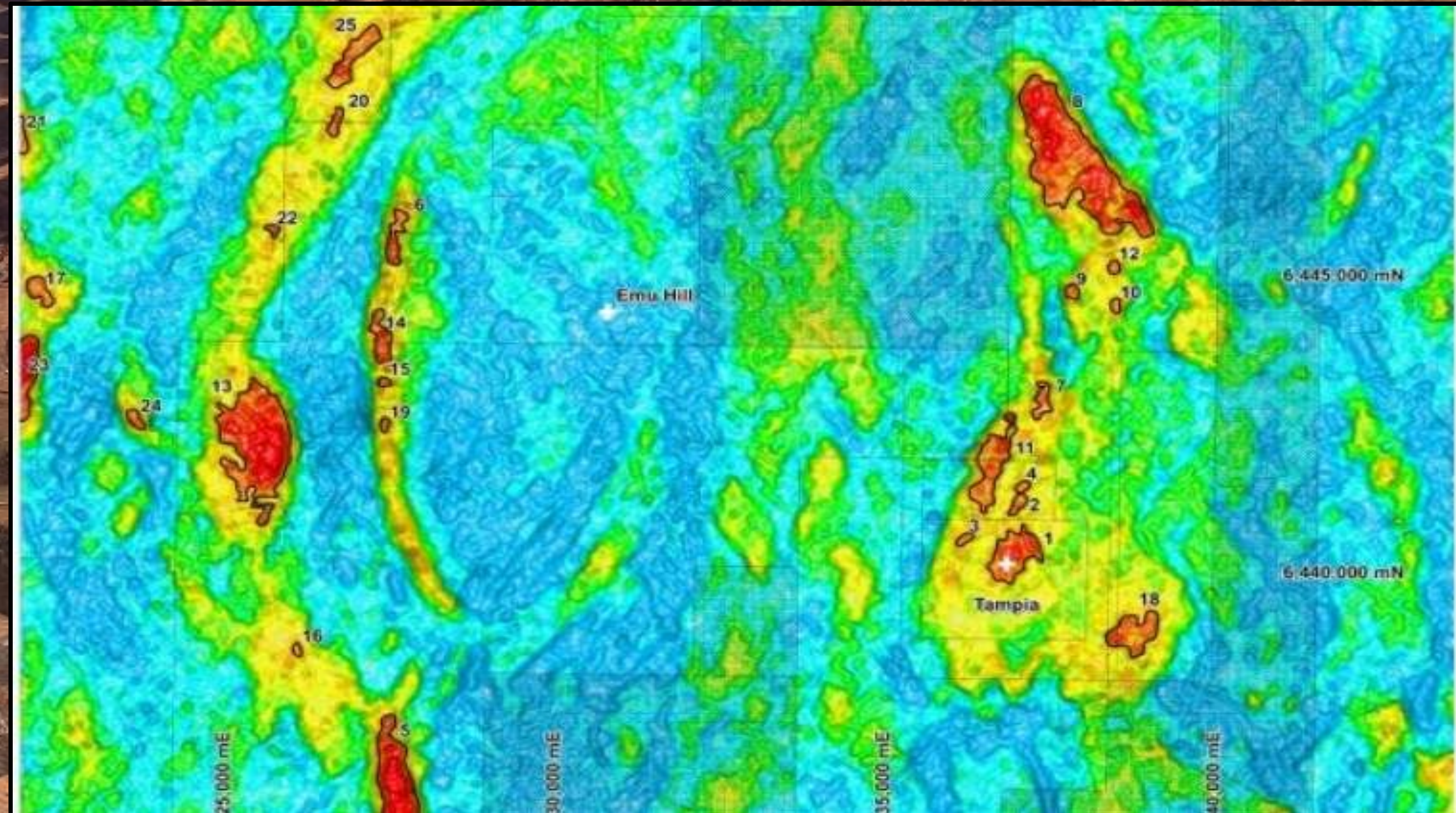
Mid-Atlantic Ridge magnetic anomalies



# Geophysics: Gravity method

## Mining: Ore Exploration

Bouguer gravity map  
(Western Australia)

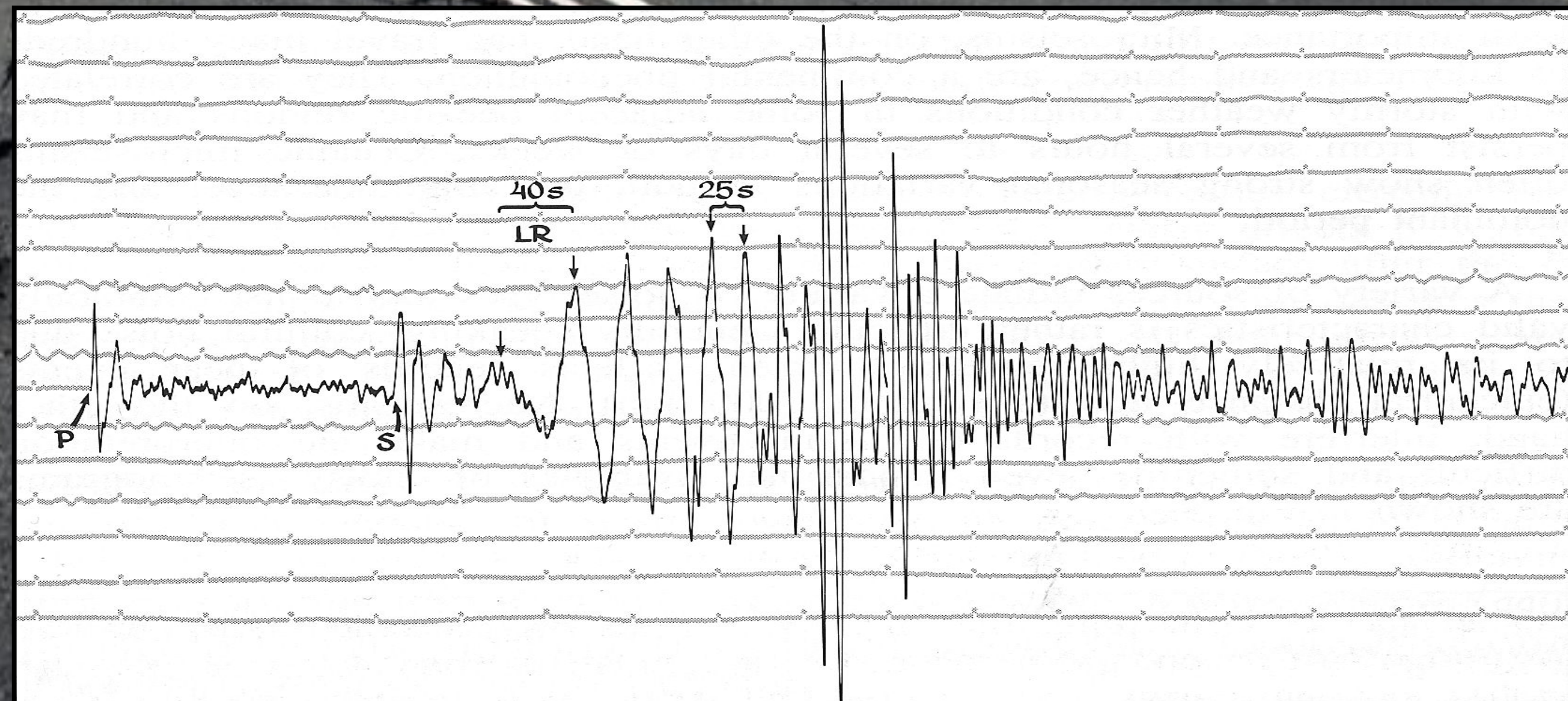




# Geophysics: Seismic method

## Earthquake Seismology

Epicenter: Greece Station: Sweden,  
Magnitudo 5.7, Focal depth 9 km.

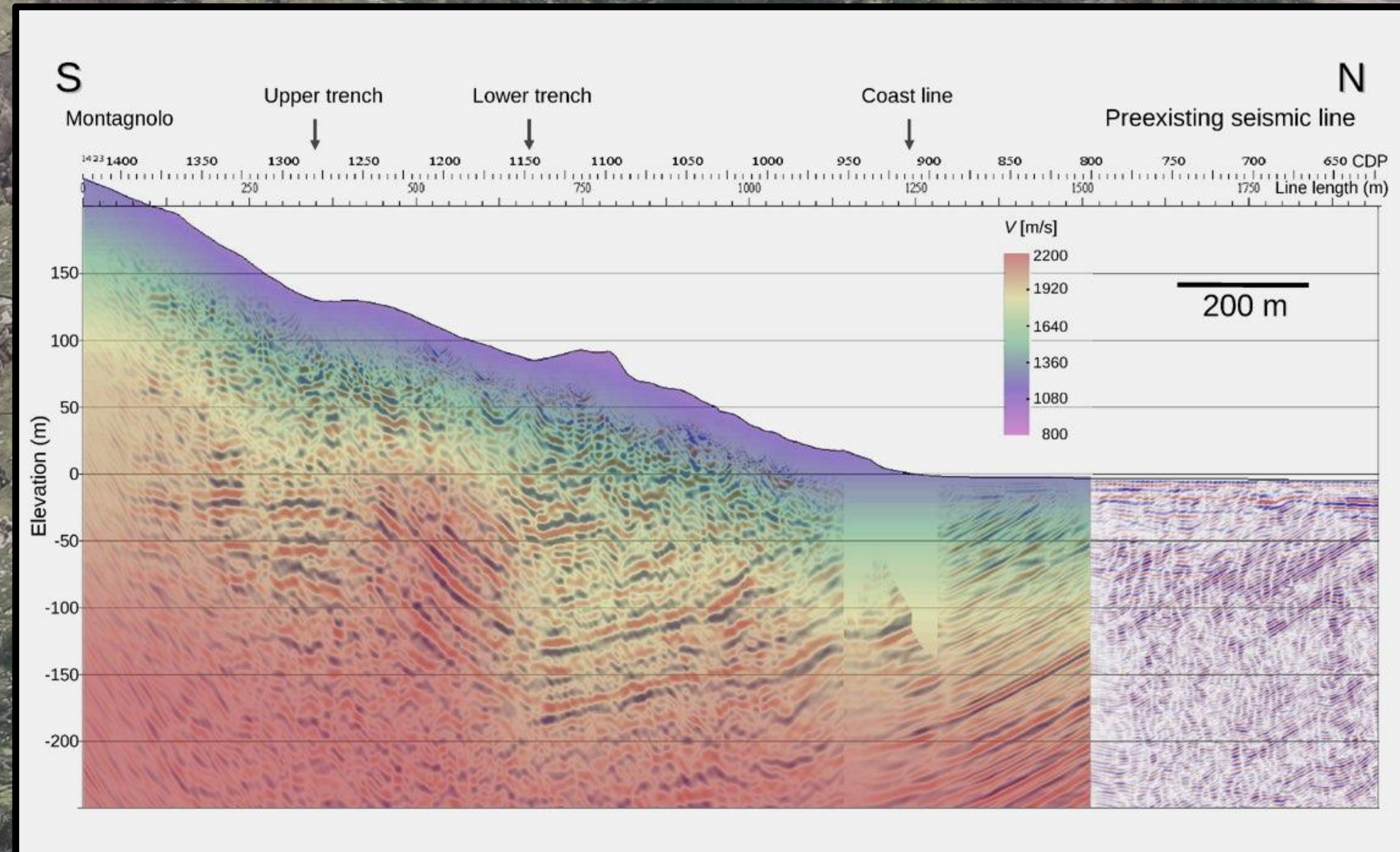




# Geophysics: Seismic method

## Landslides characterization and monitoring

The Ancona (Italy),  
Landslides  
revealed by a 2D  
seismic reflection profile

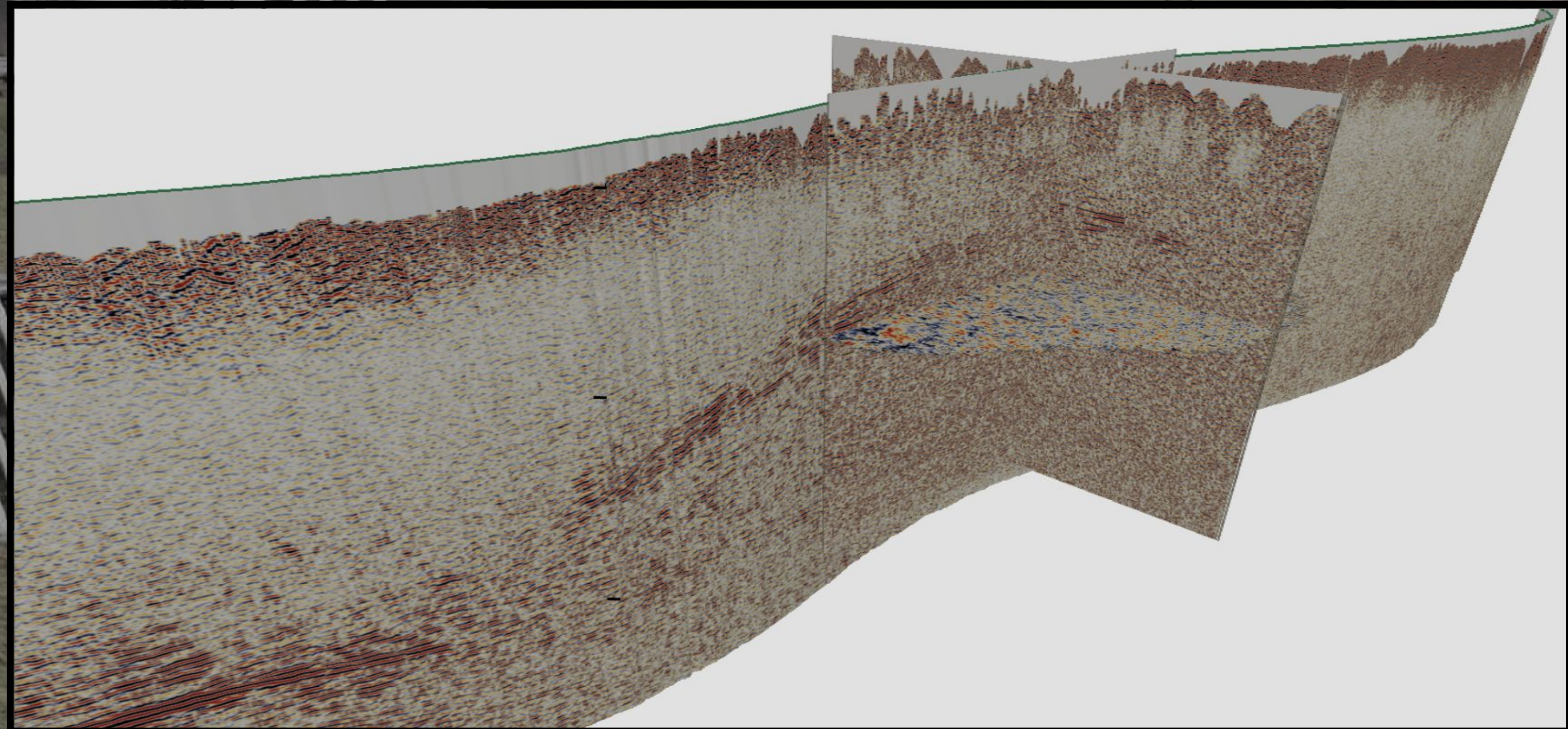




# Geophysics: Seismic method

limiting climate change: CO<sub>2</sub> sequestration

Seismic reflection  
profile





# Elements of Geophysics: course content ... *squeezed* !

**Basics of Geology:** The Earth at various scales; Rock types and Minerals.

**Continuum mechanics:** Elastic properties. Stress & Strain tensors; Stress-Strain and energy; Generalized Hooke's Law for a fully anisotropic (triclinic) elastic medium; Common symmetries: orthorhombic, exagonal, isotropic, at various scales; Elastic constants for isotropic solids; Hooke's Law for isotropic media.

**Waves:** scalar and vector wave equation; D'Alembert & Harmonic solutions; Polarization; The Green function; From waves to Rays: the Eikonal equation;

**Solving the forward problem with rays:** From the earth model to the observations. Seismograms given the subsurface velocity.

**Solving inverse problems at various scales:** Seismograms from **earthquakes**; Estimation of the wave velocities of the spherical Earth with an analytical approach: the Wiechert-Herglotz equation; Seismograms for **exploration seismology**; Estimating the velocities: an example for cross-hole tomography. Estimating the velocities and densities at an interface from the reflection coefficients: numerical inversion of the Zoeppritz equations.  
Non-uniqueness, ambiguity and ill-posedness (just the basics).

**Examples and additional topics**

**ORAL EXAM**