

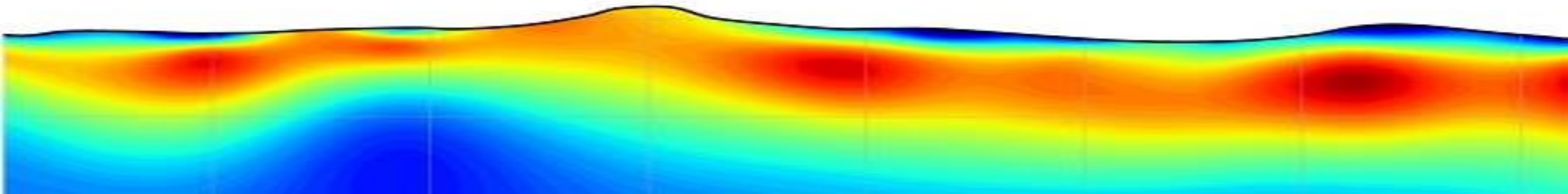
# ESS302 Applied Geophysics II

Gravity, Magnetic, Electrical, Electromagnetic and Well Logging

## Framework and Physical Properties

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Feb – May, 2019



# Geotechnical: Water gushing hazard



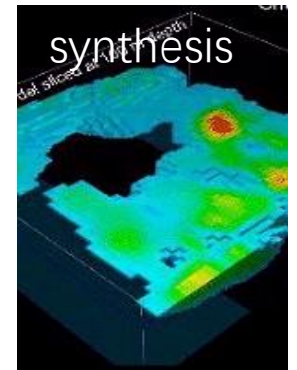
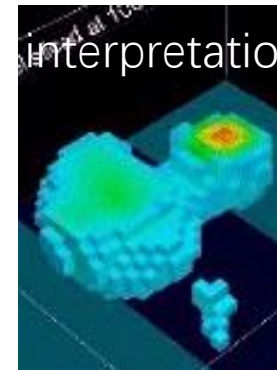
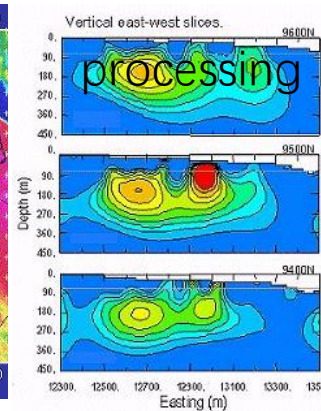
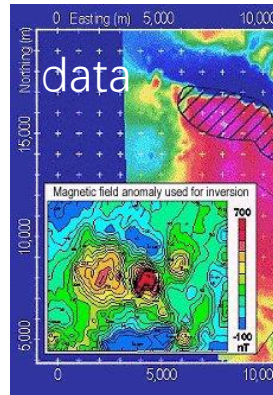
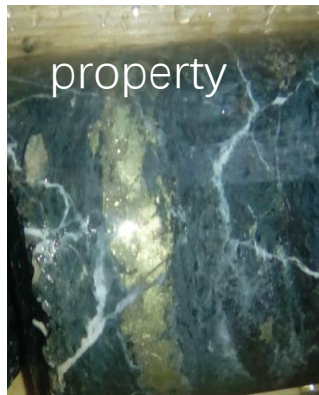
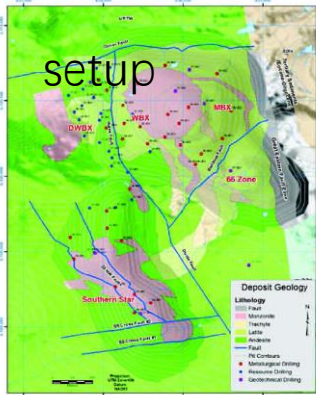


# A water detection project

- What information do you have before doing any geophysical work?
- How do you choose the geophysical methods?
- What do you expect from the survey?
- Criteria of success?
- What else?

# The seven-step framework

1. Setup: What is the question to be answered?
2. What are the diagnostic physical properties?
3. Choose survey and design data acquisition.
4. Data collection
5. Processing of field data
6. Interpretation
7. Synthesis



# 1. Setup

- Ask questions...
- Gather information...
- Establish expectation...

Bad question: "Where is the water?"

Good question: "Where is the best location for drilling?"

Showing of small water gushing/wet ceiling/leakage

Fresh or salt water

Interference from mining activities

Budget and feasibility

An cross section image or a 3D volume?

Use the results for drilling?

Scale of resolution centimeter, meter or tens of meter?

Be realistic!



## 2. Property

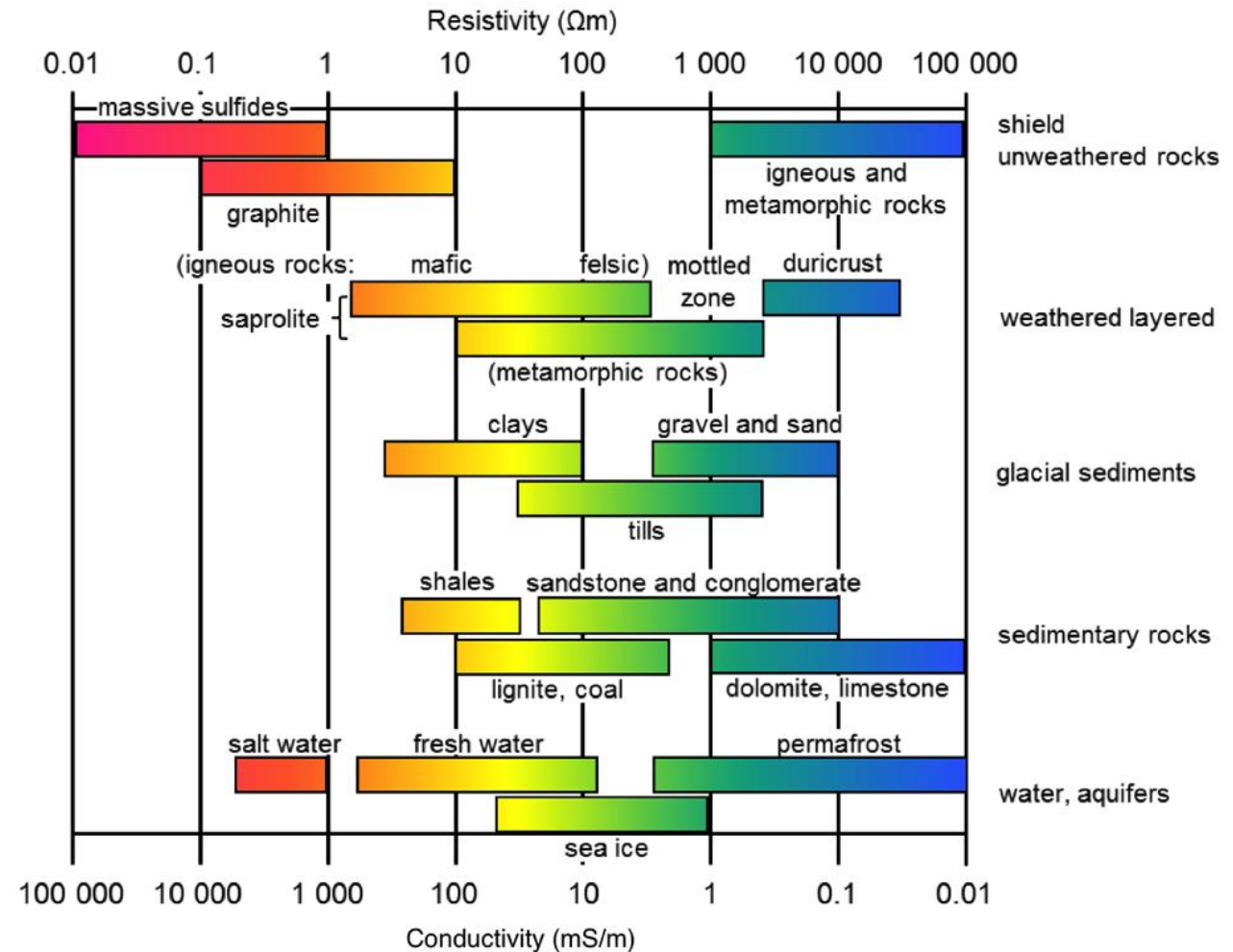
Background: sandstone

Target: water

What physical property?

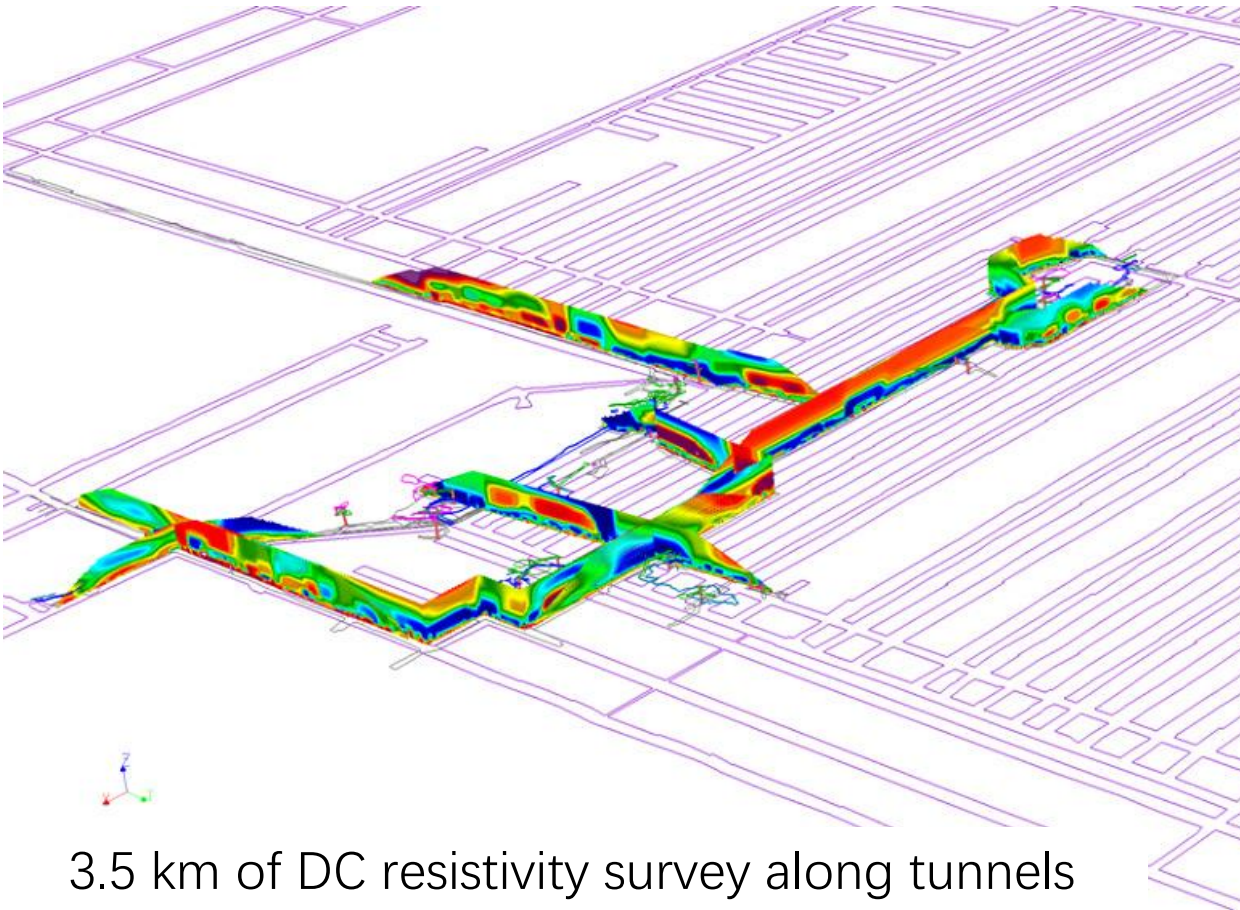
Contrast large enough?

What survey can exploit the physical property contrast?





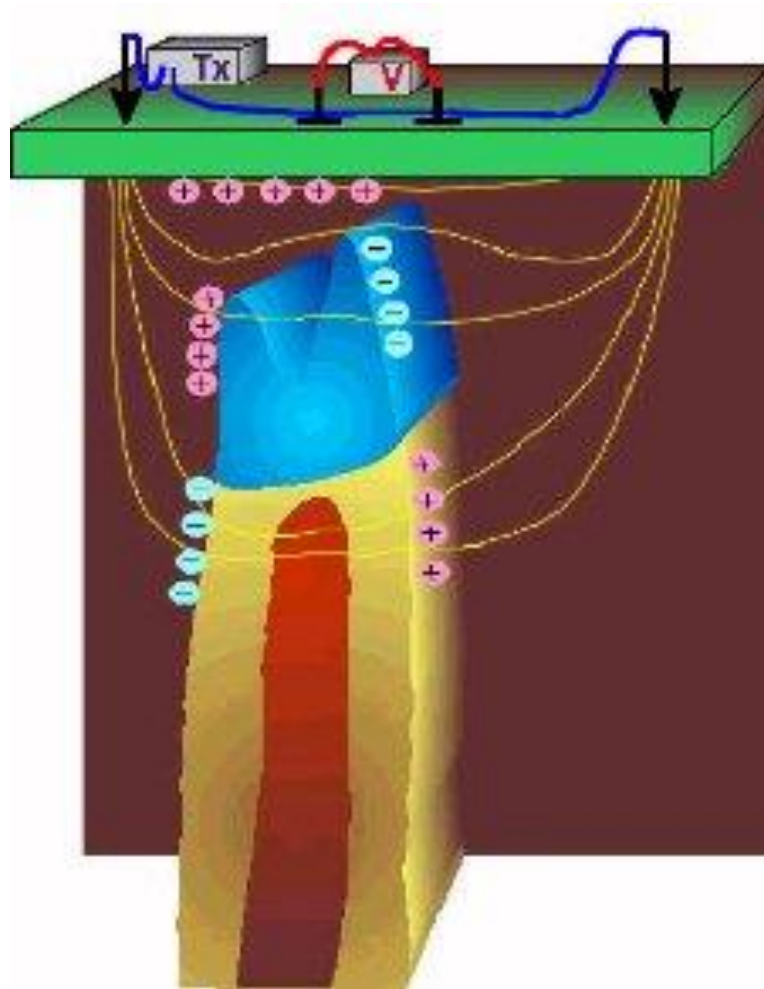
### 3. Survey



3.5 km of DC resistivity survey along tunnels

- Active or passive
- Platform
- Station/line spacing
- Cost-effectiveness
- Feasibility study
- Noise source
- Instrumentation

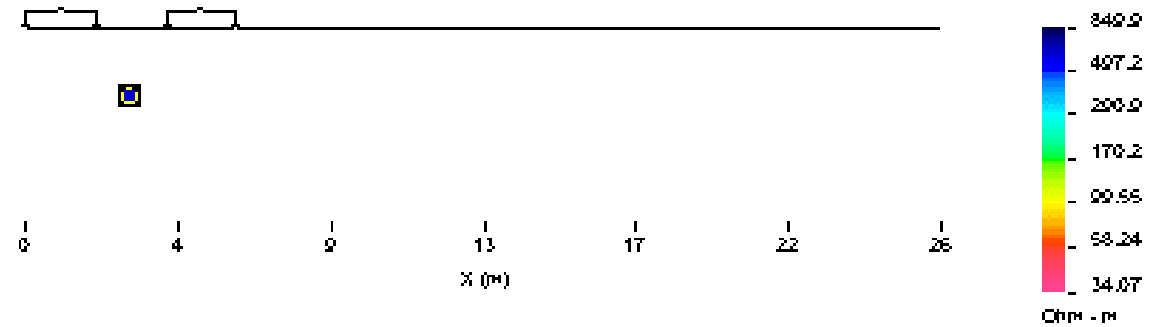
## 4. Data



### Apparent resistivity pseudo-section

Geop Astron SE front lawn. : dipole-dipole : 38 data

Observed Apparent Resistivity



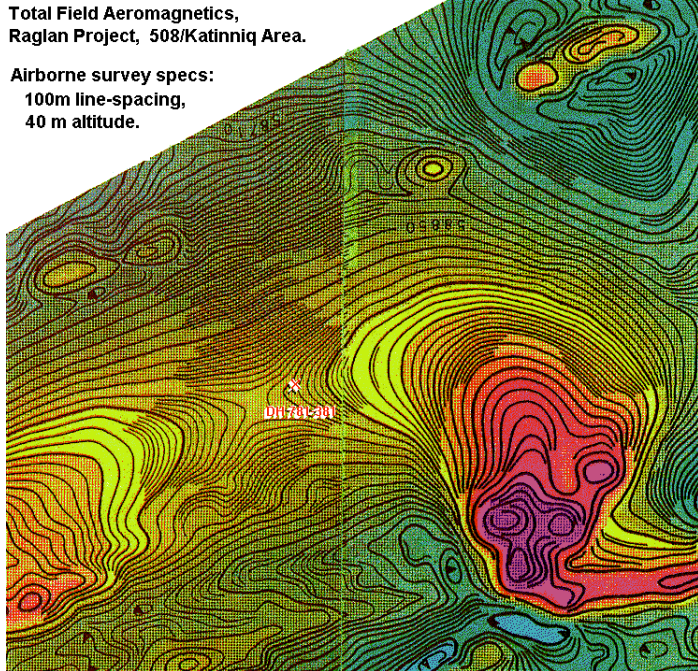
- Data quality control & visualization
- Bad data removal
- Stacking, de-noising, filtering
- Preliminary processing/interpretation



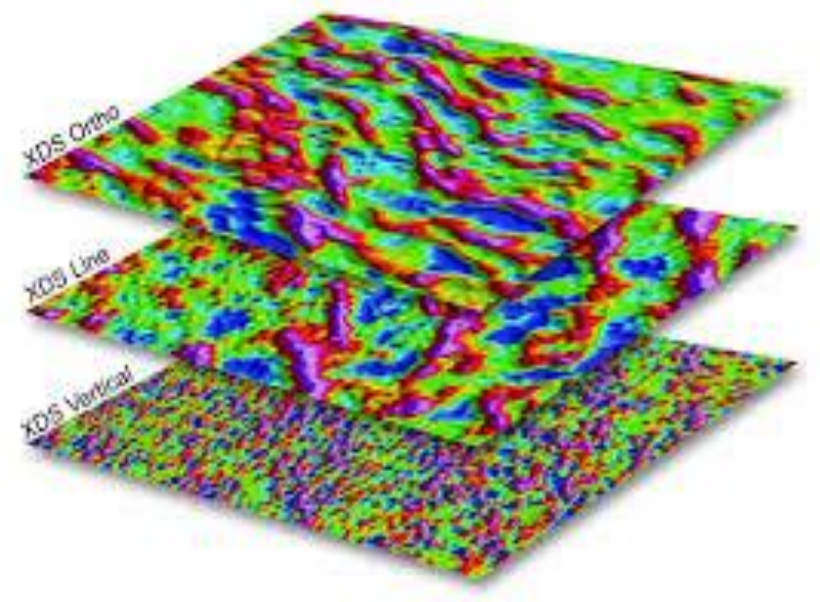
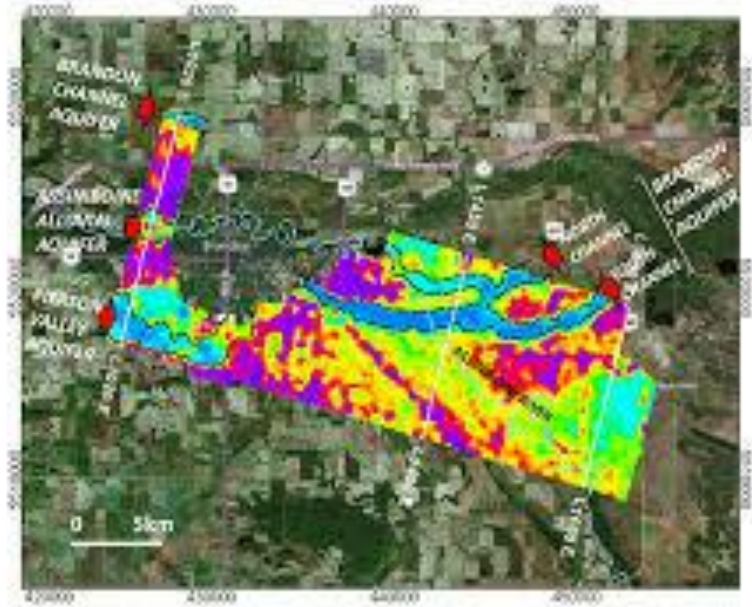
# 4. Data

Total Field Aeromagnetics,  
Raglan Project, 508/Katinniq Area.

Airborne survey specs:  
100m line-spacing,  
40 m altitude.



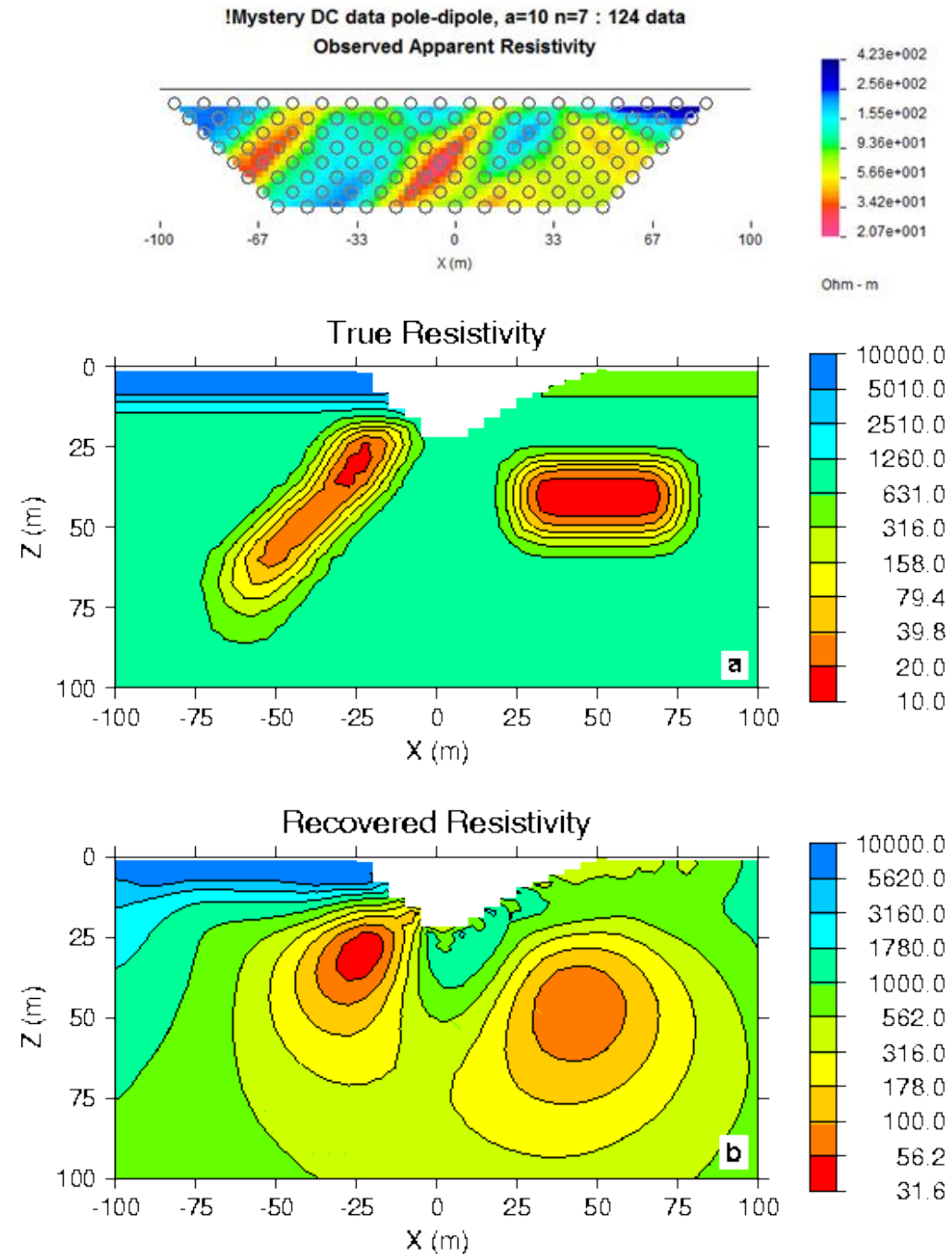
VTEM dBz/dt – Middle-Time (0.13-0.88ms) TAU



Data collected over a large area

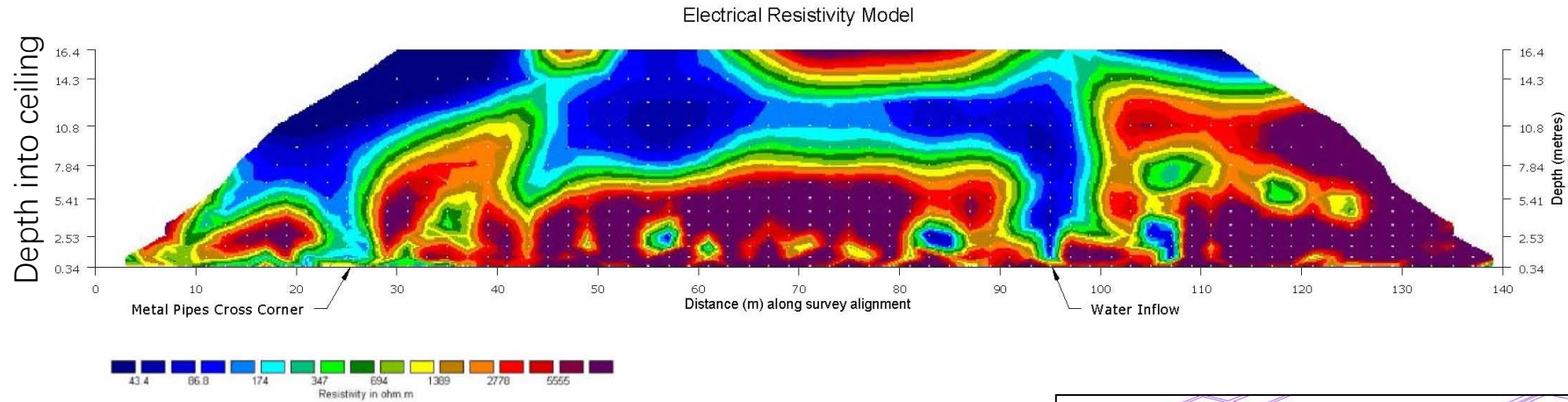
# 5. Processing

- A pseudo-section (plot of data) may not be a good representation of subsurface
- Use a technique called **inversion** to convert data to a physical property model through physical modeling

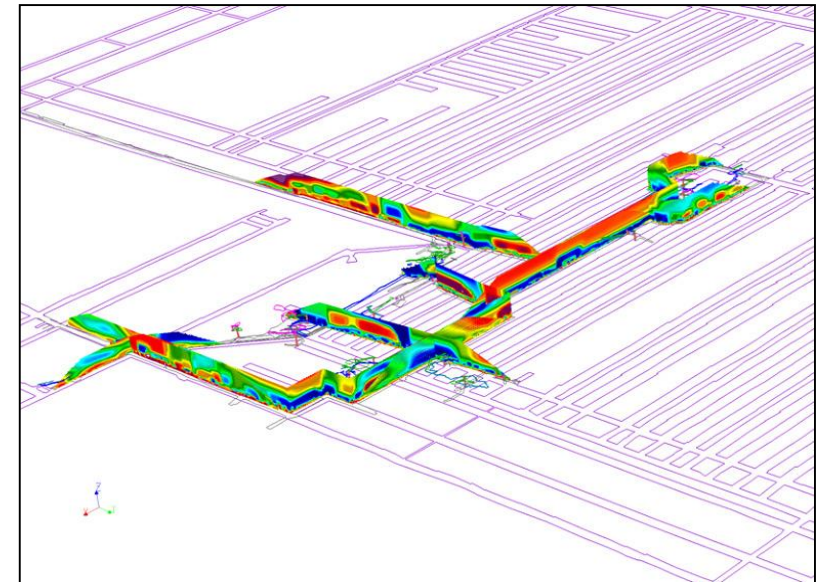




## 6. Interpretation

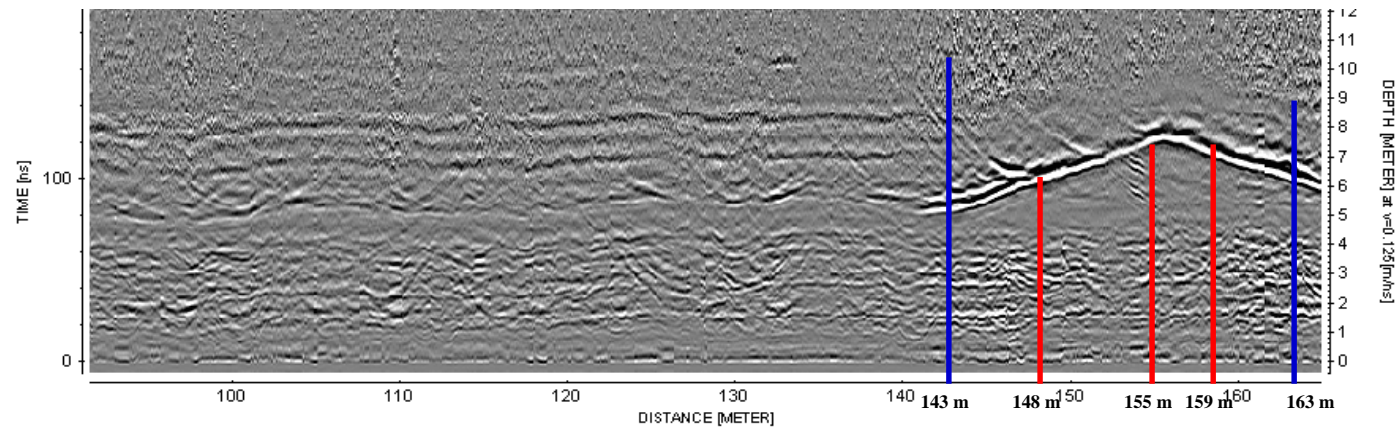
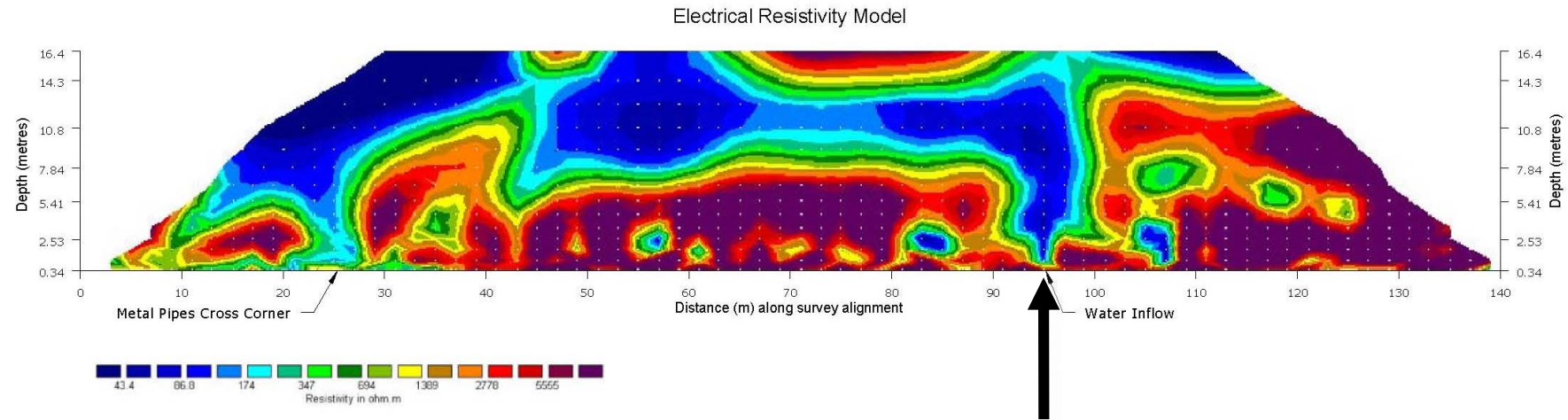


- Large area of “blue” (low resistivity)
- Two “out-cropping”
- One is metal pipe; the other is water inflow





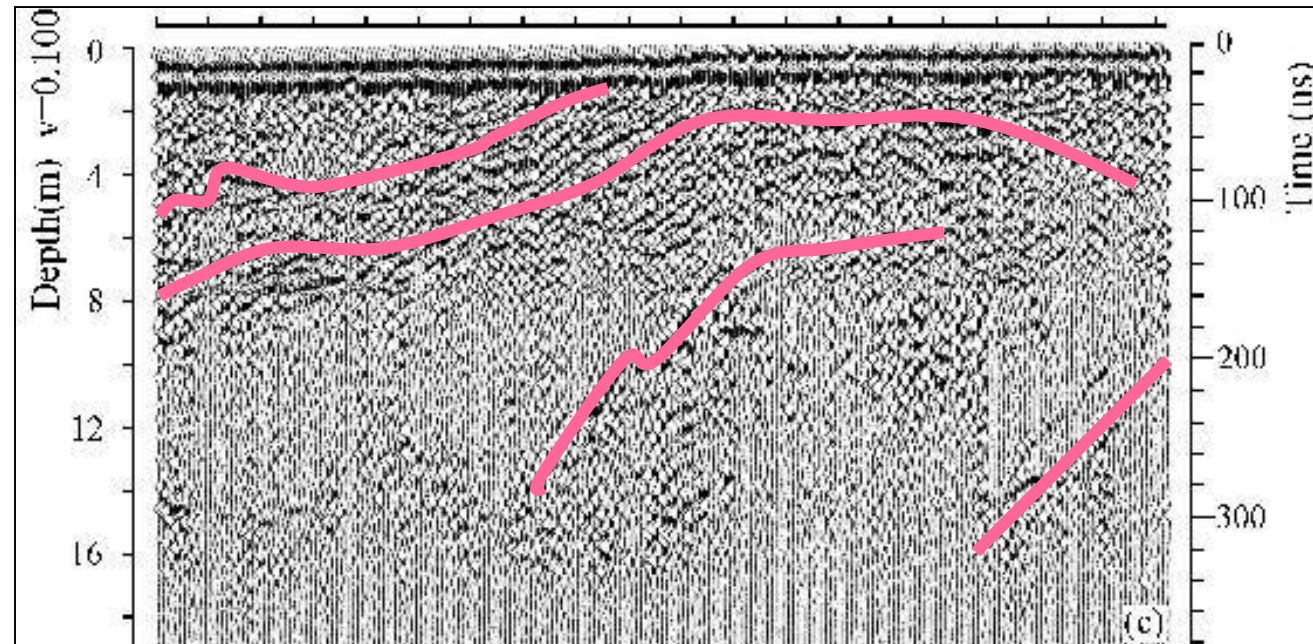
# 7. Synthesis



**Ground Penetrating Radar** Drill-holes with no water —

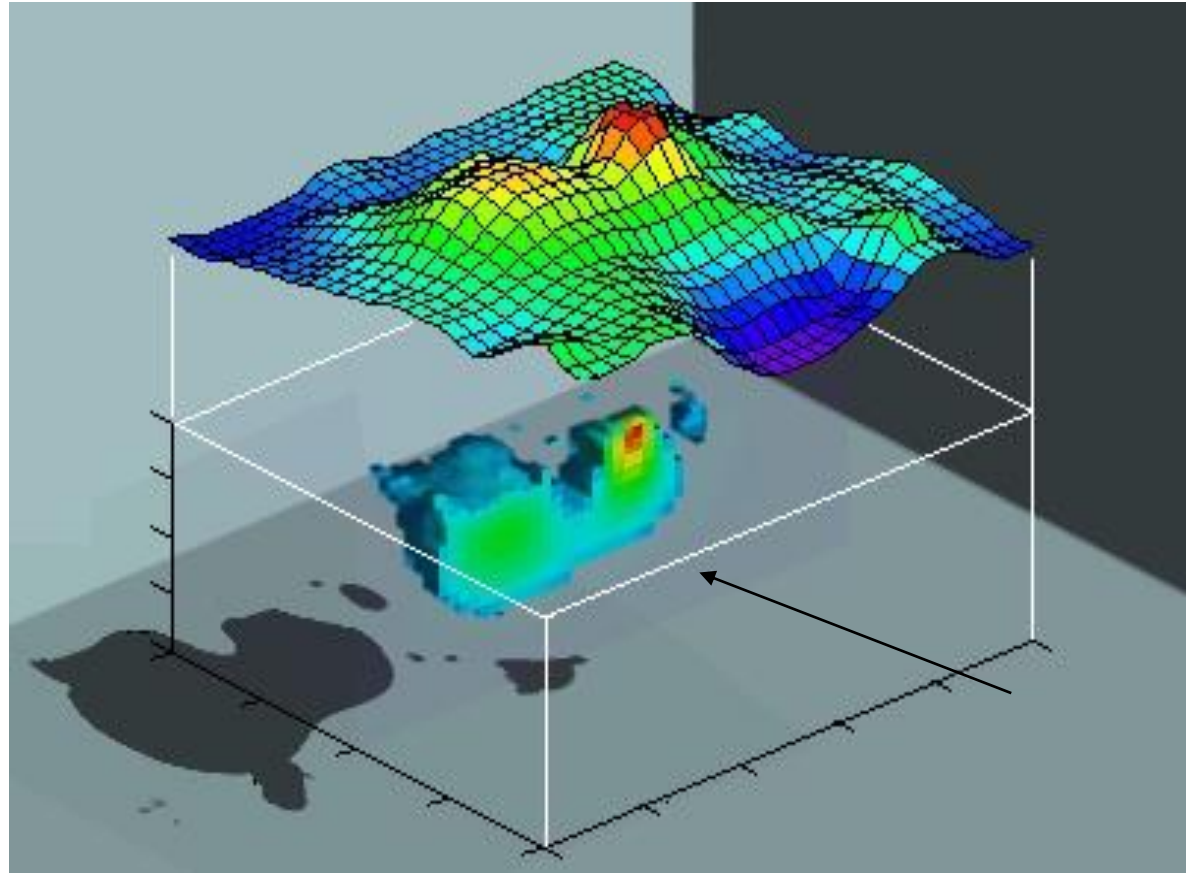
Water found —

# Geophysics = Information



Seismic wave bounced back when hitting “boundaries”.

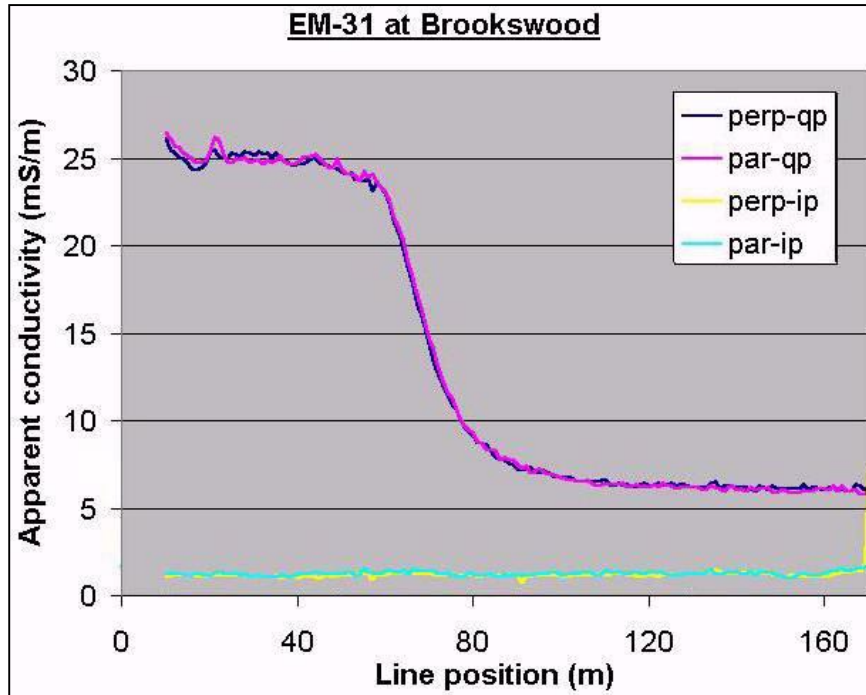
# Geophysics = Information



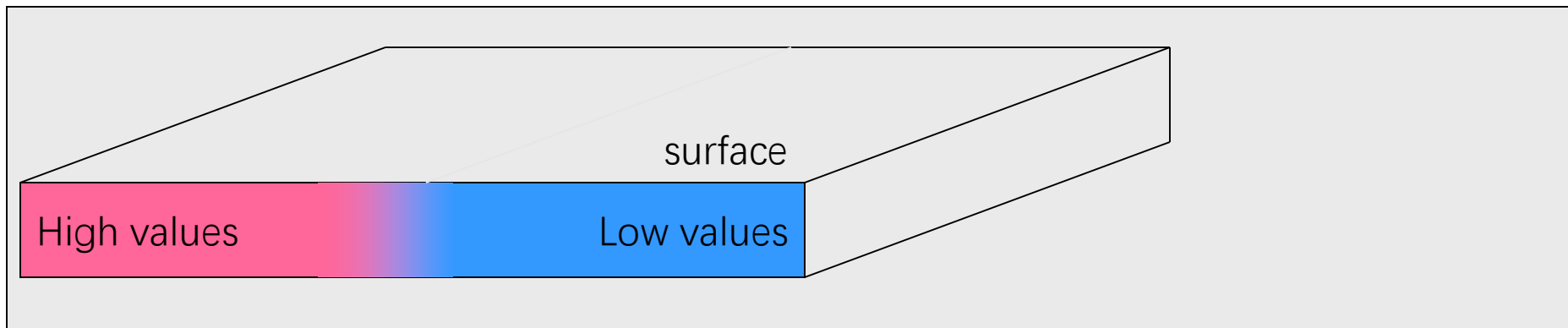
Ore bodies “disturb” geo-magnetic field.



# Geophysics = Information



Saltwater aquifers  
“generate” more electric  
current.



# How do we distinguish different objects?

- Characterize materials by physical properties:

- **Density**
- **Magnetic susceptibility**
- **Electrical conductivity**
- **Chargeability**
- **Electrical permittivity**
- **Elastic moduli**

Wood

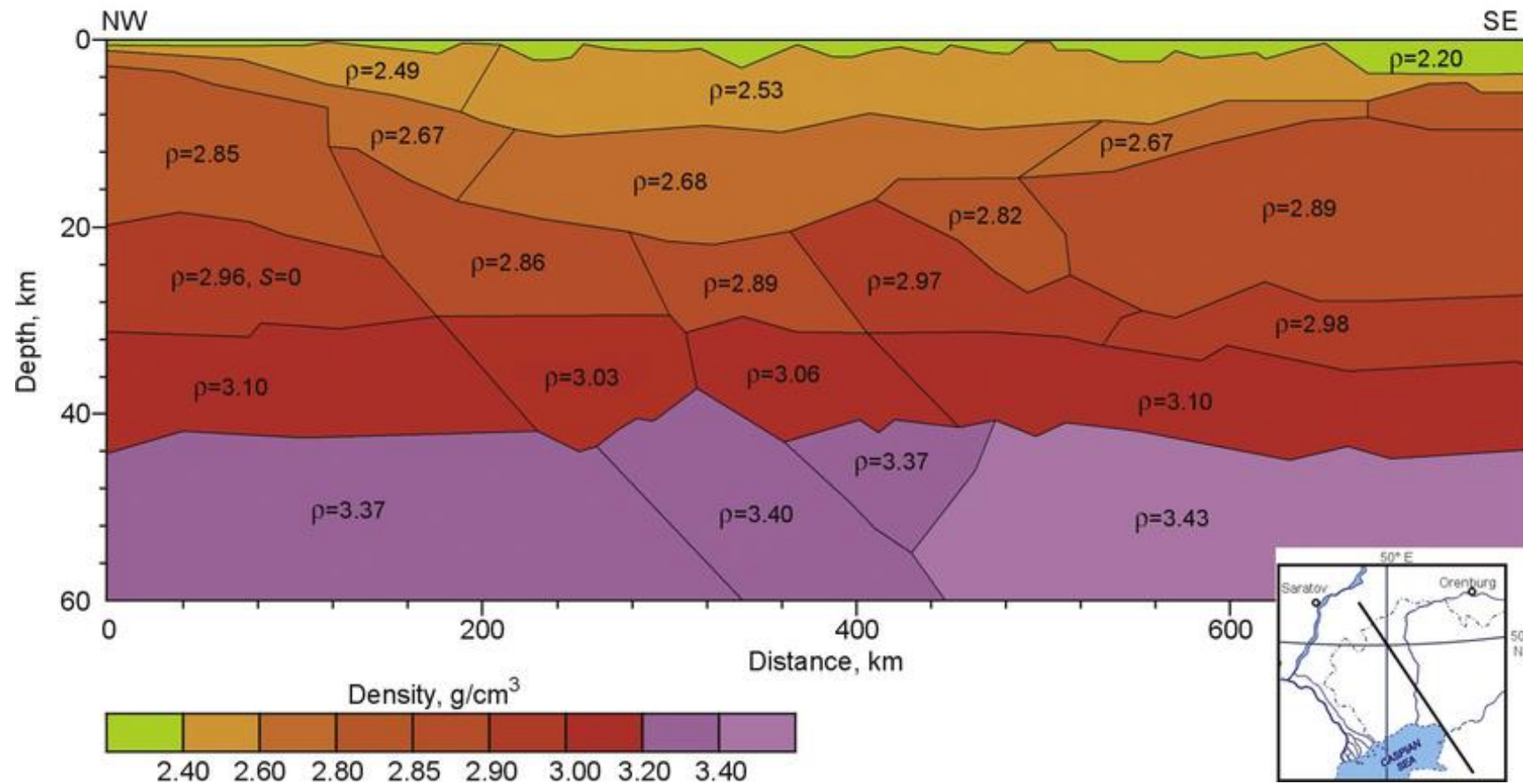


Steel



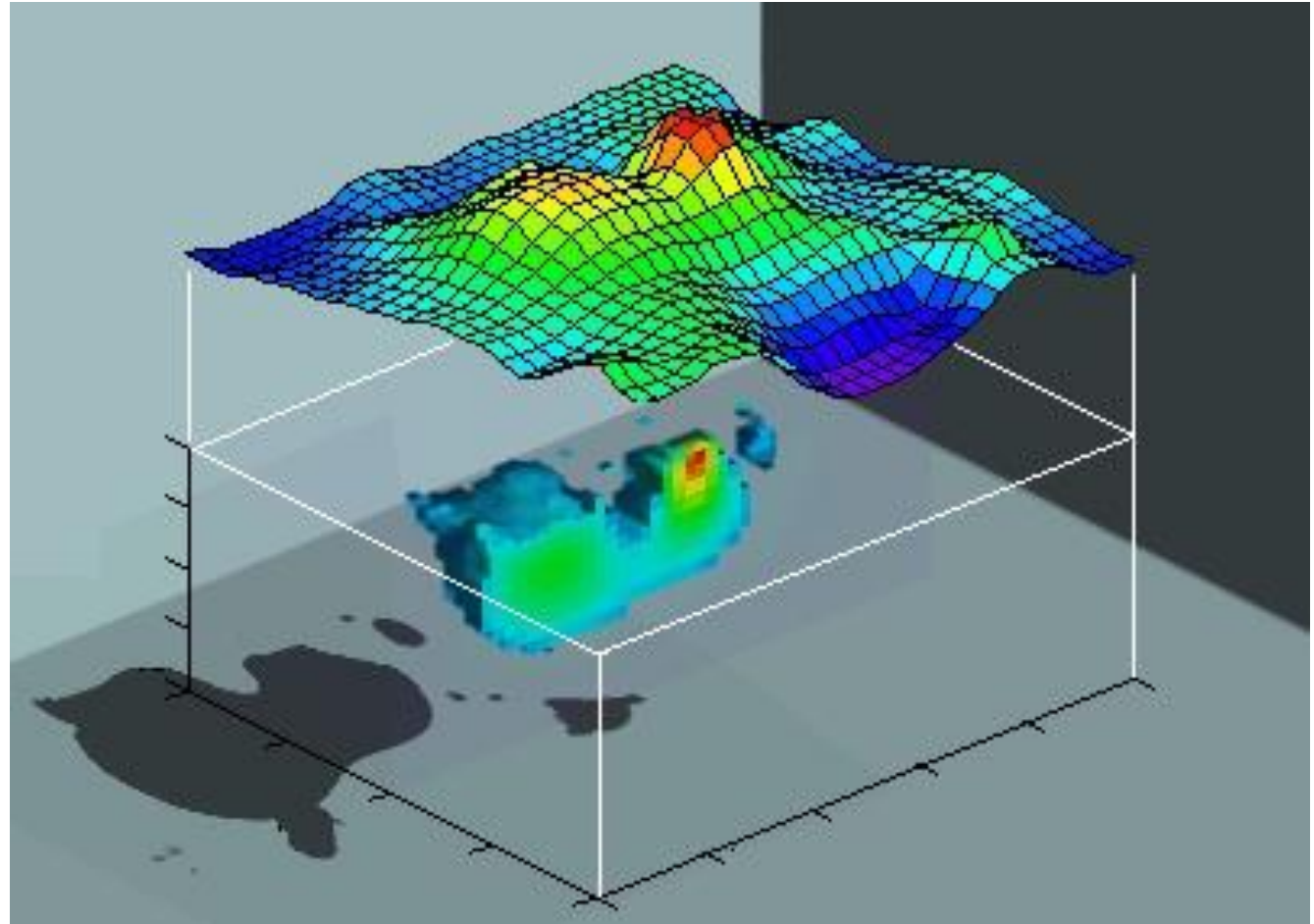
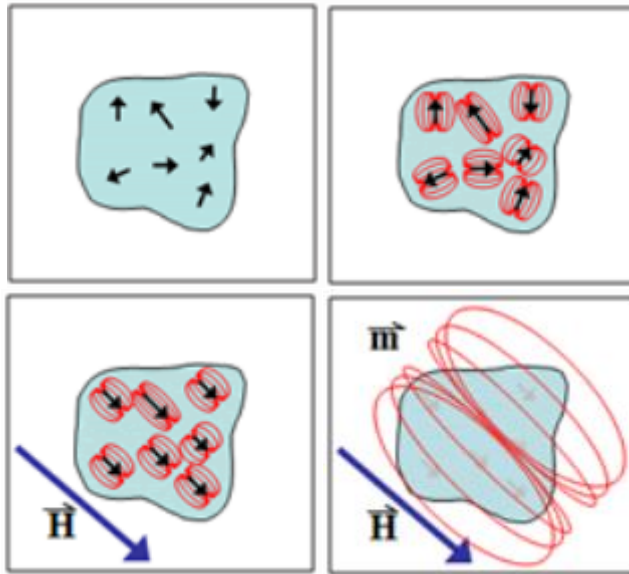
- Think about talking about one object in your daily life in terms of its physical properties, instead of its chemical properties...

# Structure of a sedimentary basin (density)

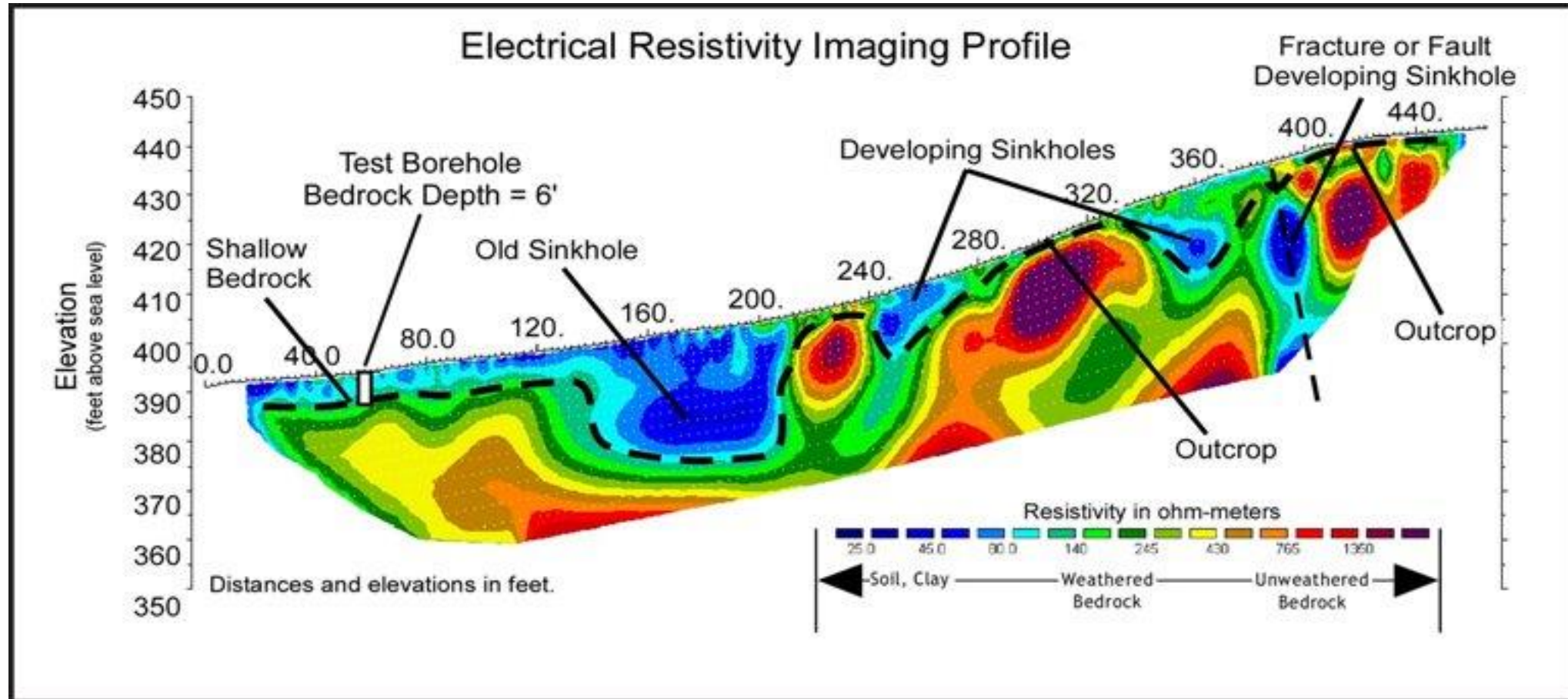




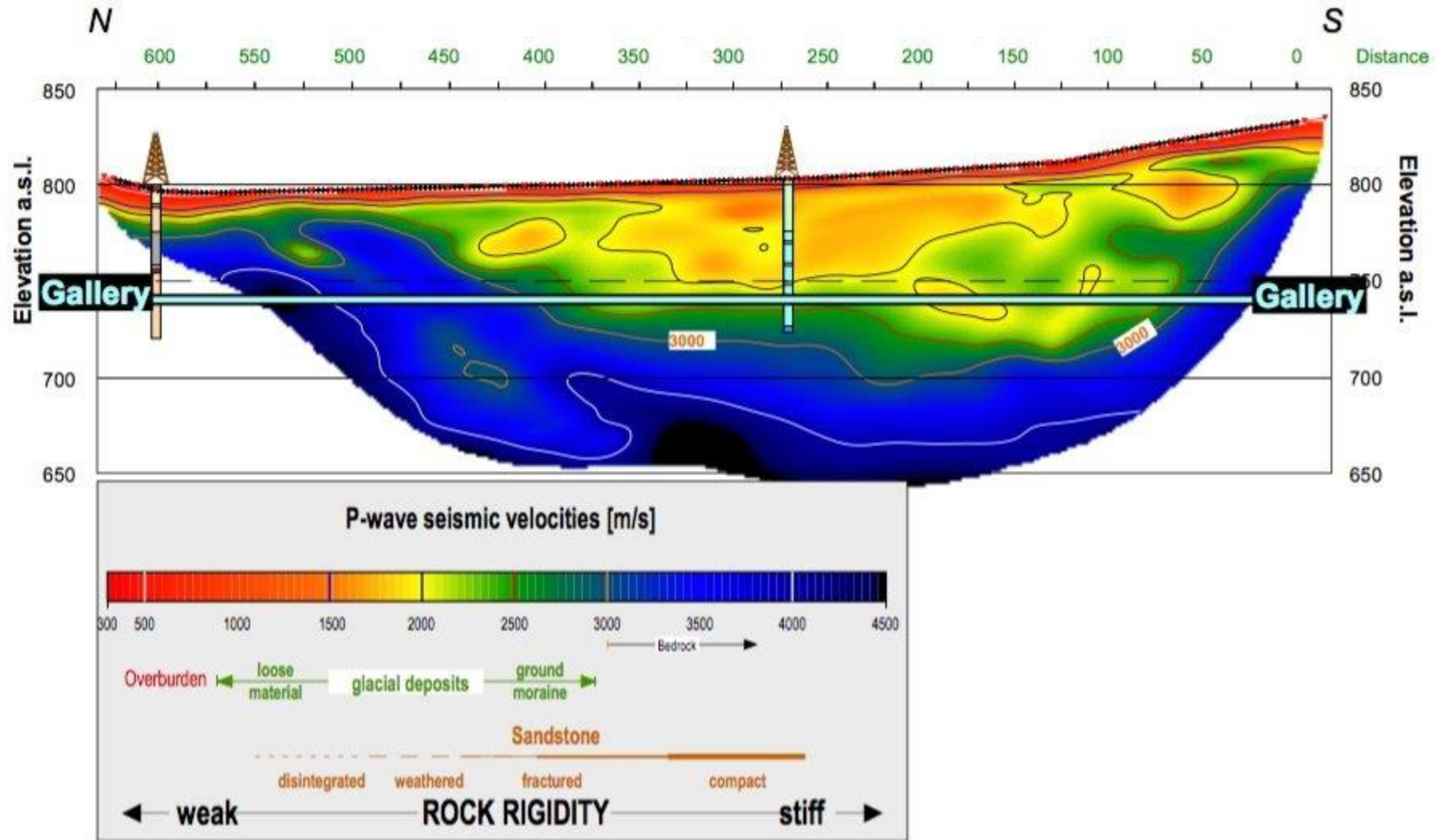
# Mineral deposit (magnetic susceptibility)



# Sinkholes (electrical conductivity)



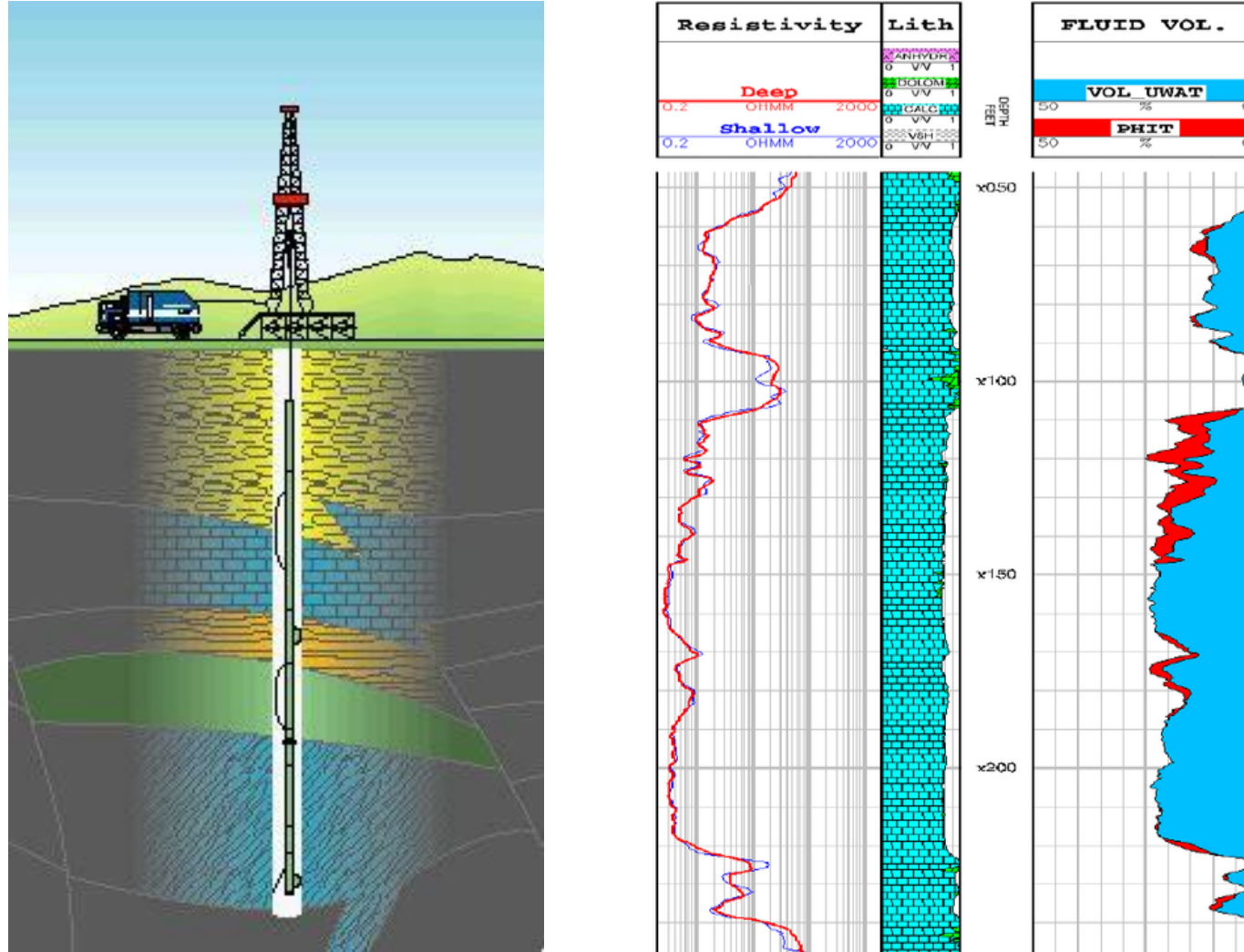
# Structure of a sedimentary basin (velocity)





# Oil/gas reservoir (electrical resistivity)

Well logging



well logging  
(everything in borehole)

# Maxwell Equations

$$\nabla \cdot \mathbf{D} = \rho$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

zero frequency

low frequency

high frequency

steady state

quasi-static state

EM wave

mechanical wave

magnetic

electrical

electromagnetic (induction)

electromagnetic (geo-radar)

seismic

gravity

potential field

electrical conductivity/resistivity

wave phenomena



