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Using geo-electromagnetic methods
in a responsible way
to support Humanity & minimize carbon footprint

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FOR SELF STUDY ONLY

>20 years of excellence in electromagnetic R&D

Using geo-electromagnetic methods in a responsible way to support Humanity and minimize carbon footprint

K.M. Strack

China 2019

KMS Technologies, Houston, Texas

www.KMSTechnologies.com

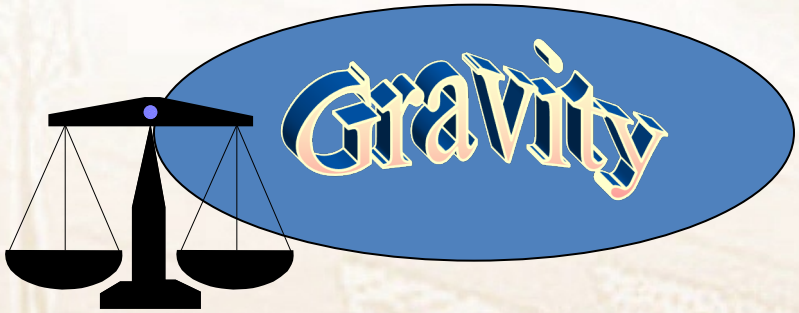
What is Geophysics & Humanitarian applications?

- Geophysics is a subject of natural science concerned with the physical processes and physical properties of the Earth and its surrounding space environment, and the use of quantitative methods for their analysis (Wikipedia)
- Geophysics = Astrophysics of the Earth

- Humanitarian – adds value to human life
- Responsible
  - Using less raw materials → less Carbon footprint
  - Renewable energy
  - Cost reduction = using less material

- Environmental geophysics: road building, reliability of tunnels, high rises, land slides etc.
- Earthquake geophysics (mostly seismology): Observing and predicting Earthquake, volcano eruptions
- Exploration of natural resources: oil & gas, minerals, hydrocarbons
- Production:
  - Improve recovery factor
  - Measure environmental compliance (avoid damage of reservoir)

Quantitative methods – our tool kit



Source: seg.org

Gravity: the fly on the back of an elephant

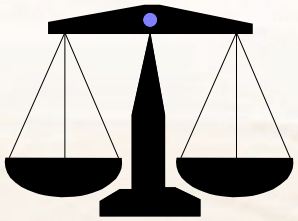


Figure courtesy of Lacoste-Romberg

In gravity prospecting, we measure very small variations in the force of gravity from rocks within the earth. Different types of rocks have different densities, and the dense rocks have the greater gravitational attraction.

To the left is a "gravimeter" which measures the force of gravity in the earth.

Source: seg.org

A Fun Experiment You Can Do!

With a small kitchen scale, measure the weight of different rocks you find in your area. The heavier rocks have a greater gravitational pull than lightweight rocks.

Pyrite is a heavy rock

Sandstone is a lighter rock

Did you know … In oil exploration, we measure changes in gravity that may be only one-millionth or even one-ten millionth of the earth's total gravity field.

Source: seg.org

Magnetic rocks I

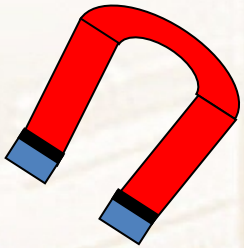


Figure courtesy of Scintrex, Ltd.

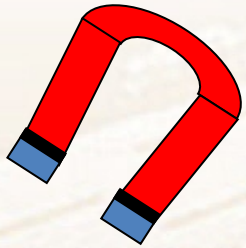
In Magnetic prospecting we look for variations in the magnetic field of the Earth. The magnetic field of sedimentary rocks is usually much smaller than igneous or metamorphic rocks. This let's us measure the thickness of the sedimentary section of the Earth's crust.

The instrument to the left is a "magnetometer" which let's us measure the magnetic field of the earth.

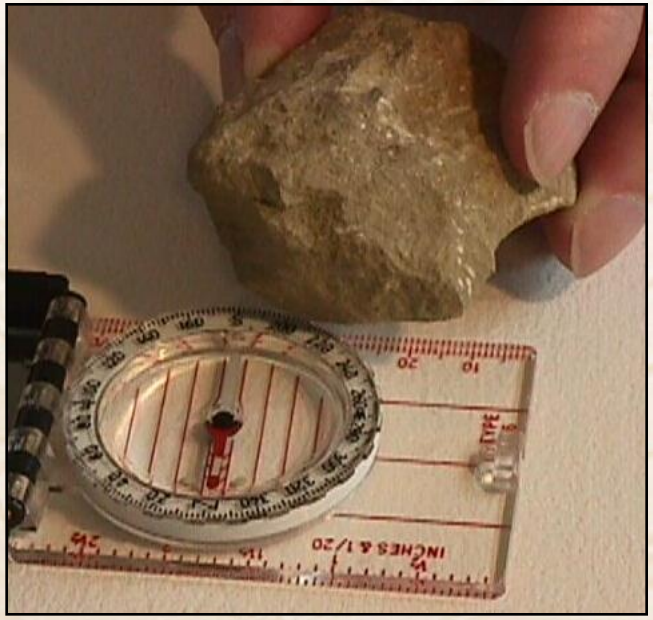
Source: seg.org

Magnetic rocks II

Many rocks such as magnetite are naturally magnetic. Compare a piece of magnetite with a piece of sandstone by holding a compass near each rock. Does the compass behave the same?



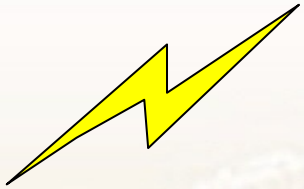
Magnetite



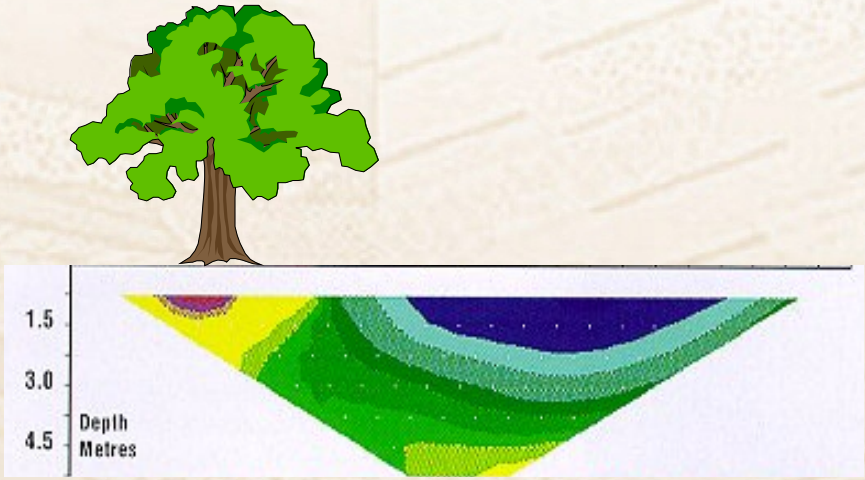
Sandstone

Source: seg.org

Electricity I



All rocks conduct electricity to varying degrees.
The resistance to electrical current flow is called "resistivity".
Resistance is measured using electrodes that are implanted in the earth. Resistivity surveys are commonly used for groundwater studies.



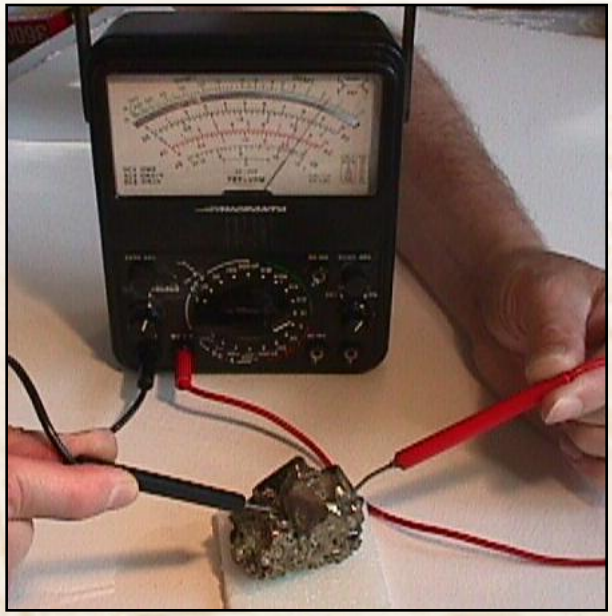
Figures courtesy of Scintrex, Ltd.

Fresh water is resistive,
brackish water is conductive.

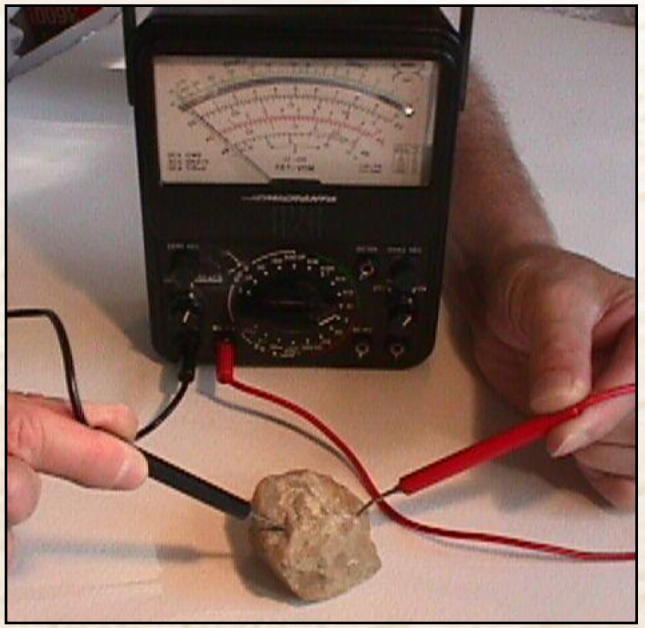
Source: seg.org

Electricity II

With an Ohmmeter, check the resistance of different rocks in your area. Do you find that some rocks are more "resistive" than others?



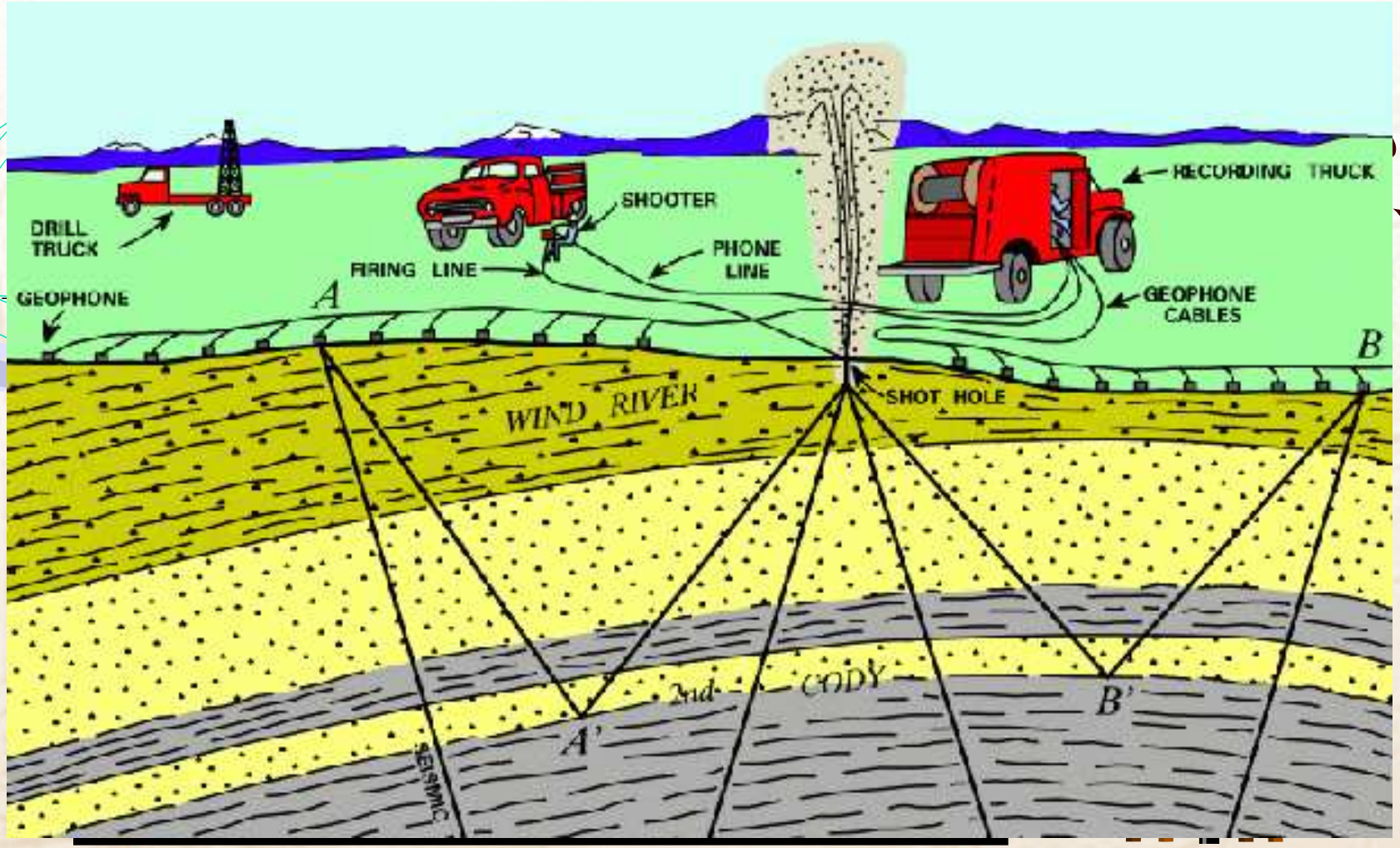
Pyrite has little resistance. It conducts electricity easily.



Sandstone is very resistive. It does not conduct electricity very easily.

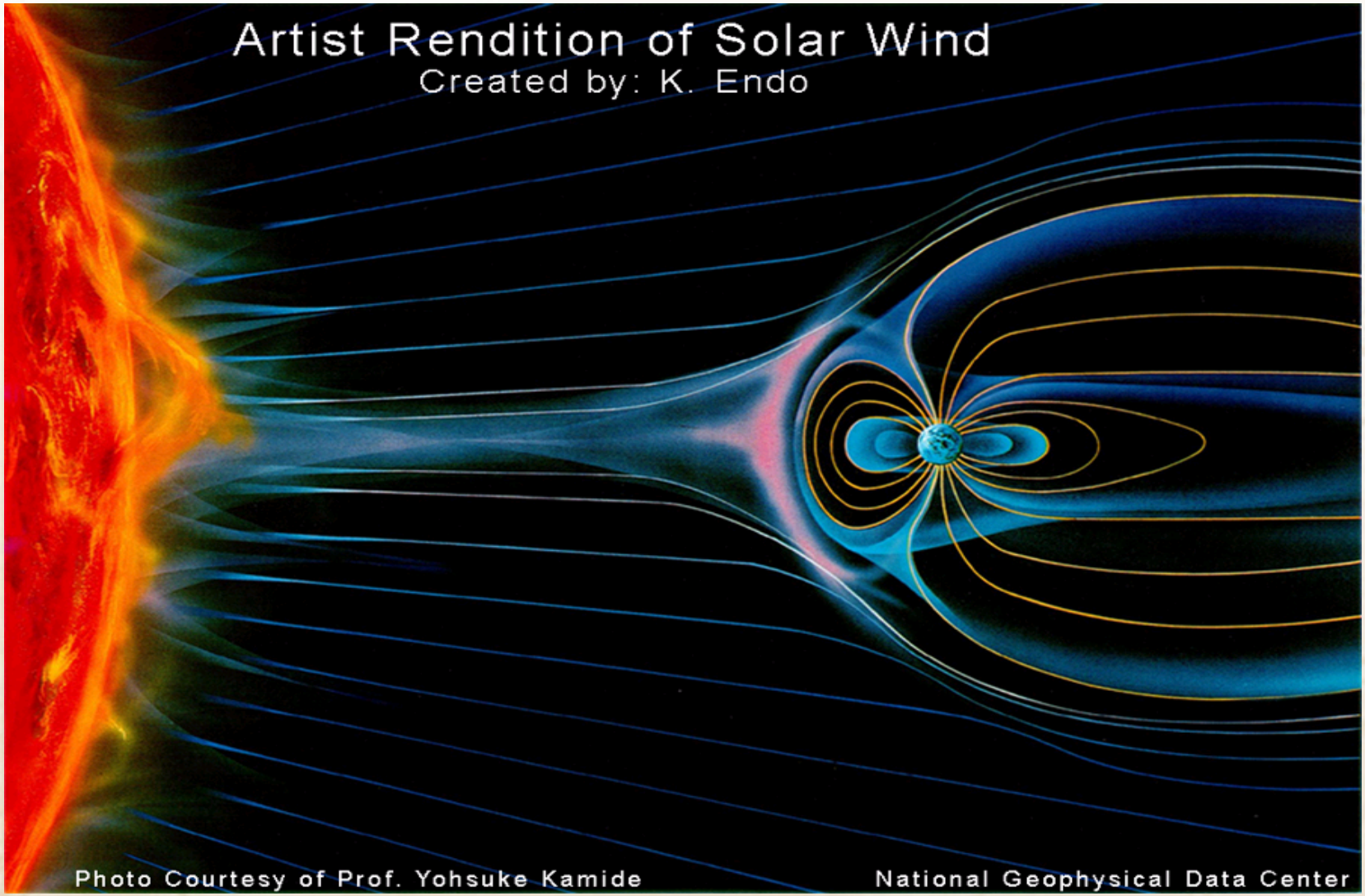
Source: seg.org

Sound waves – seismic : finding oil

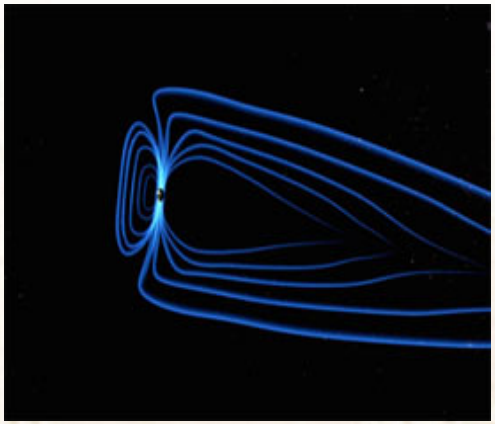


Source: seg.org

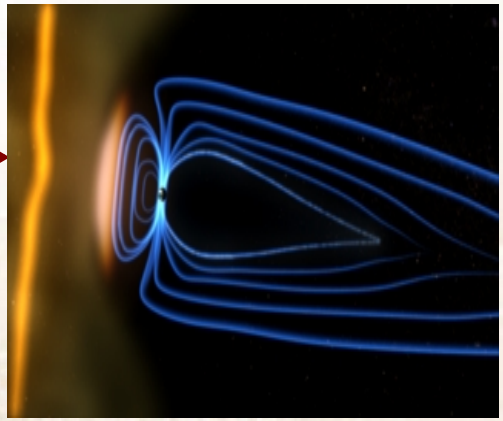
Solar wind influences Earth's magnetic field



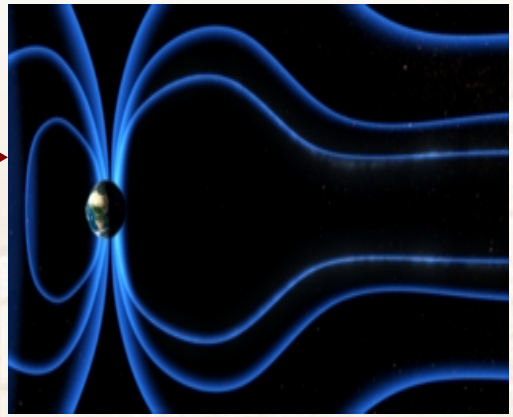
Ionosphere sources in time steps



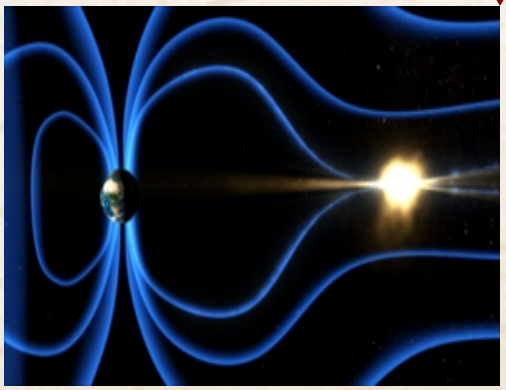
Earth's Magnetic Field



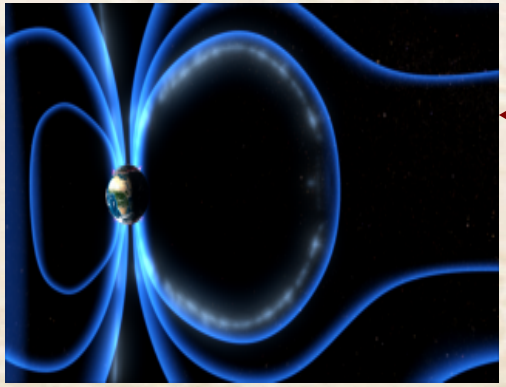
Massive solar outburst travels on the solar wind



The solar wind distorting earth's magnetic field



Two magnetic field lines are reconnecting

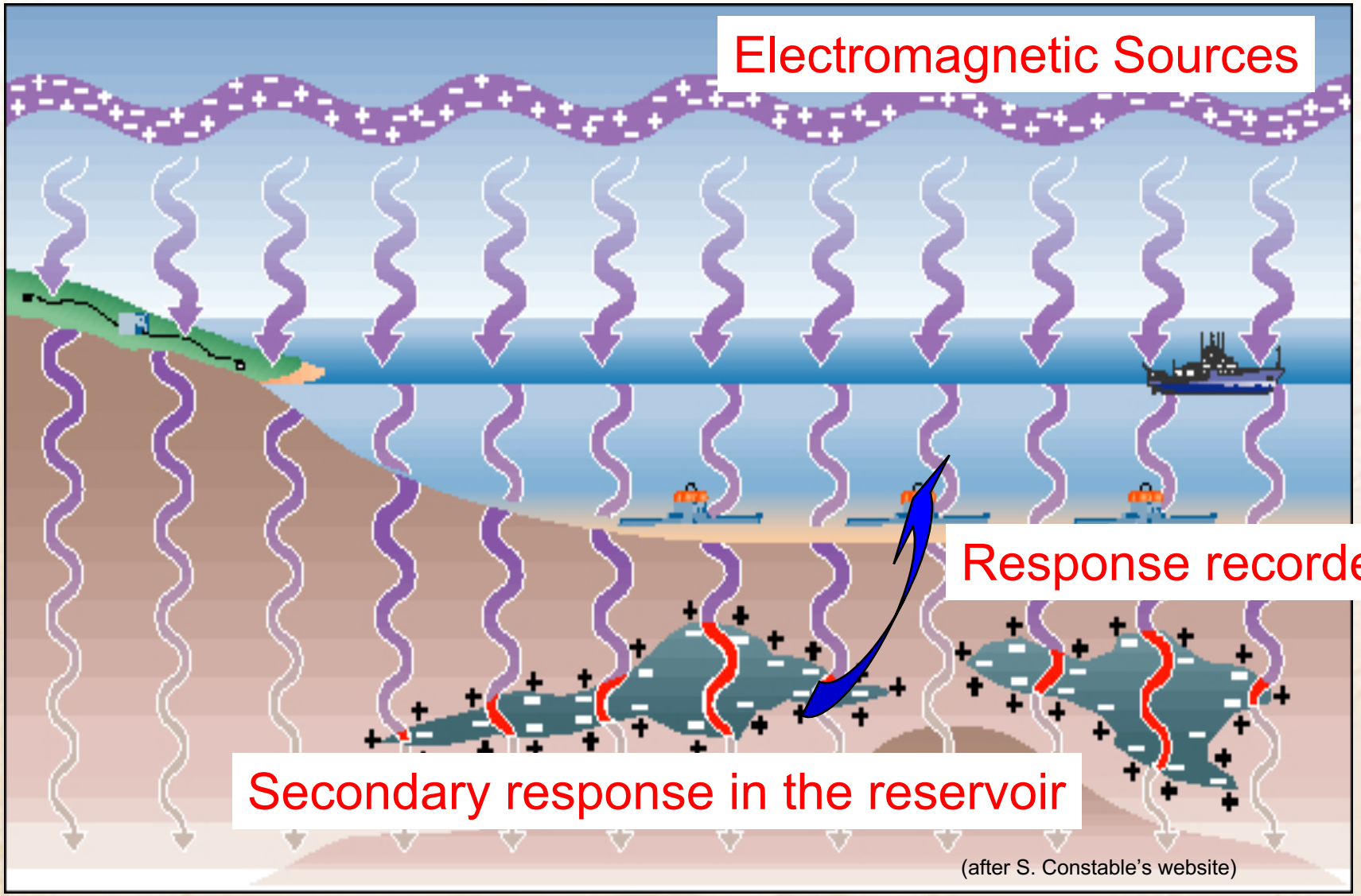


This fired particles towards the earth

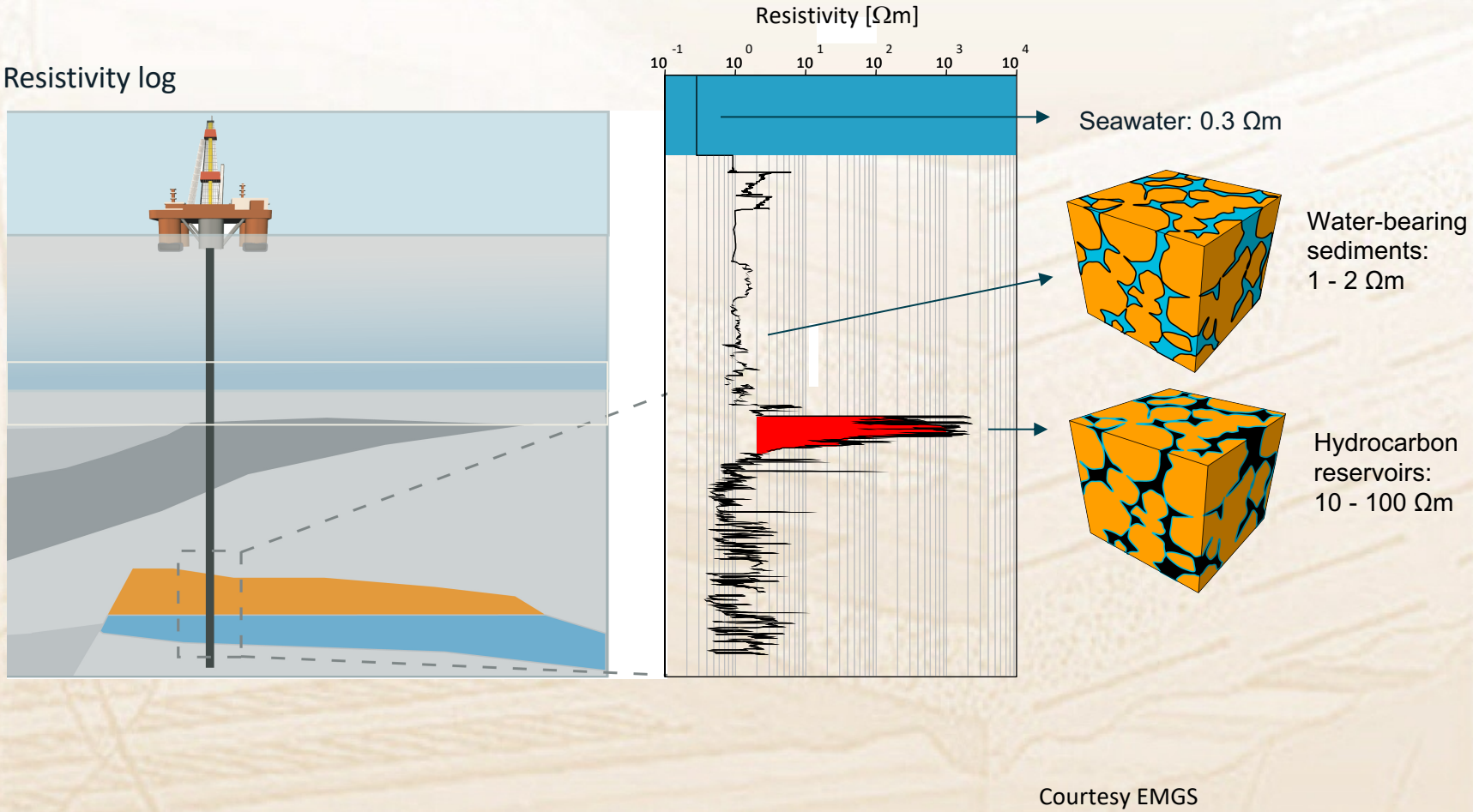
Induces electric field in Ionosphere & in extreme produces Auroras.

after http://svs.gsfc.nasa.gov/

Principle of Marine MT (Magnetotellurics)

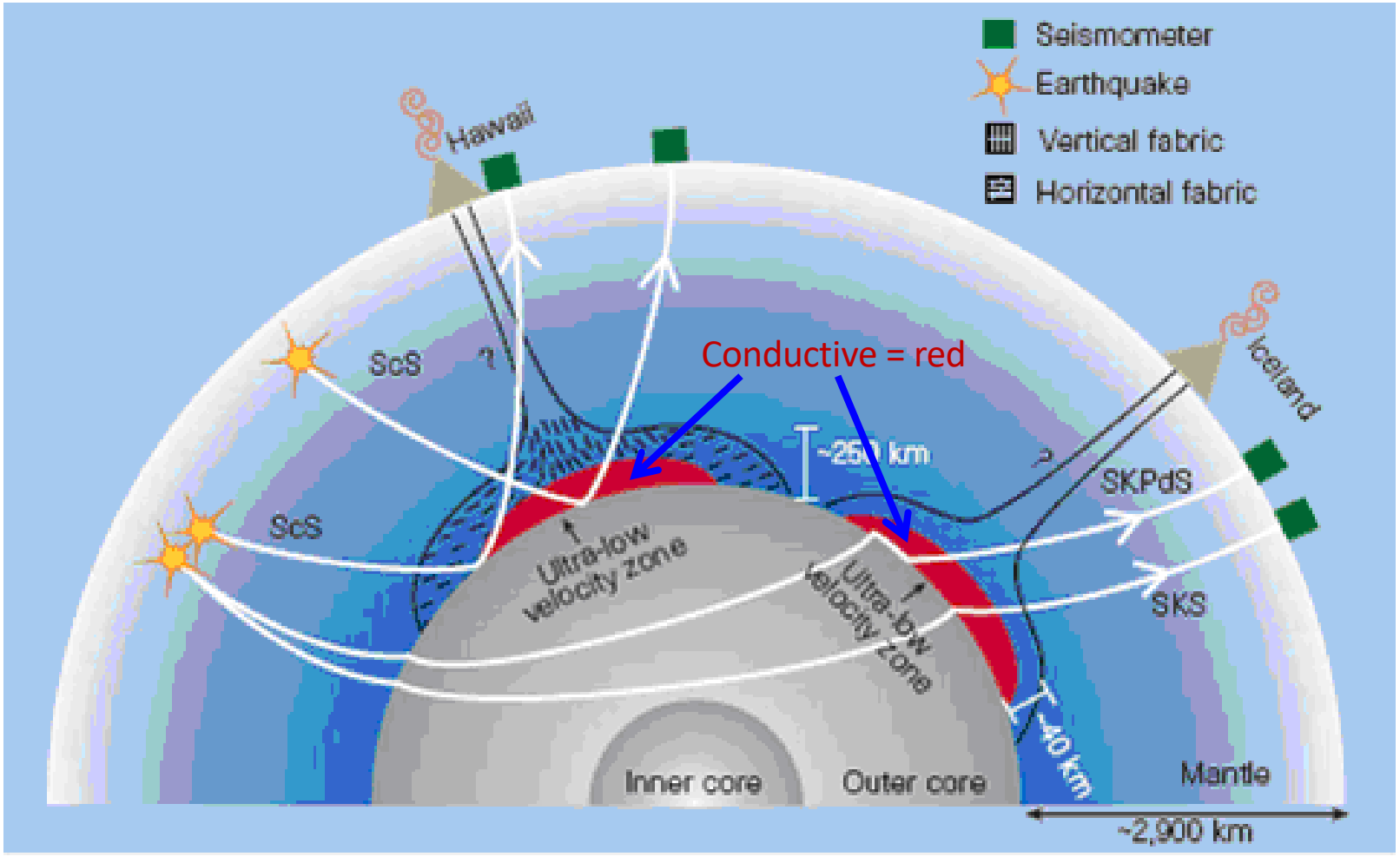


Hydrocarbon are resistive

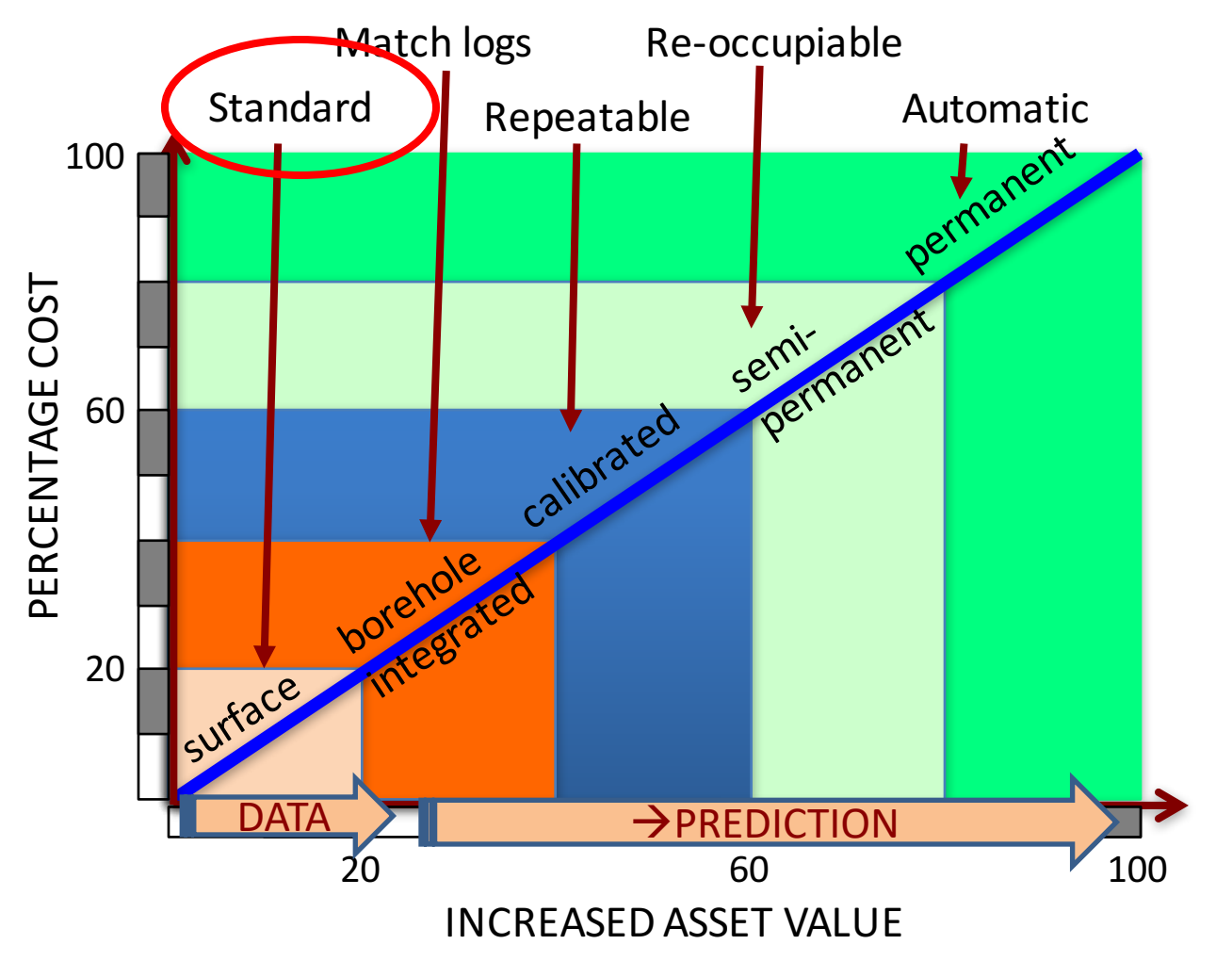


Courtesy EMGS

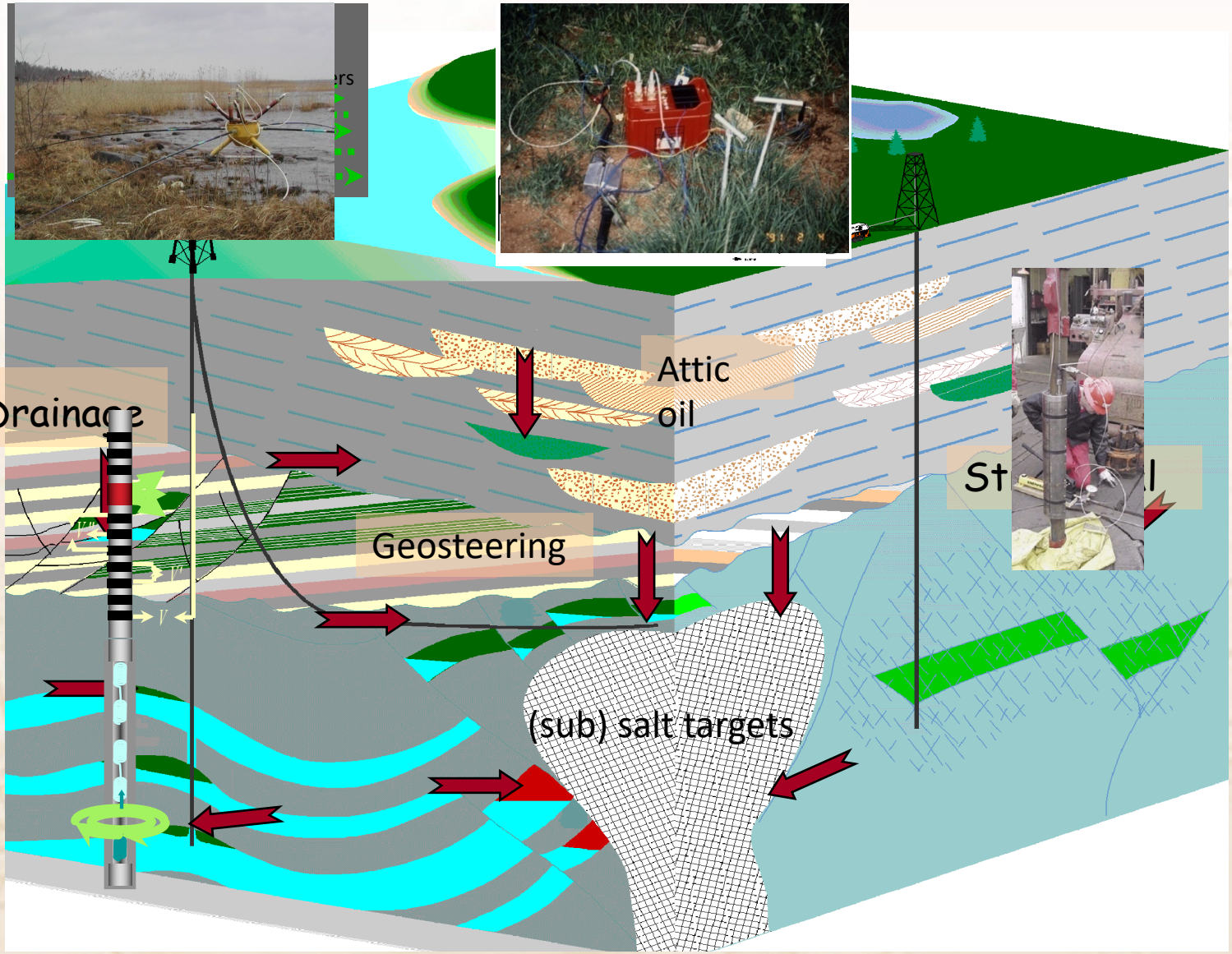
Geothermal targets



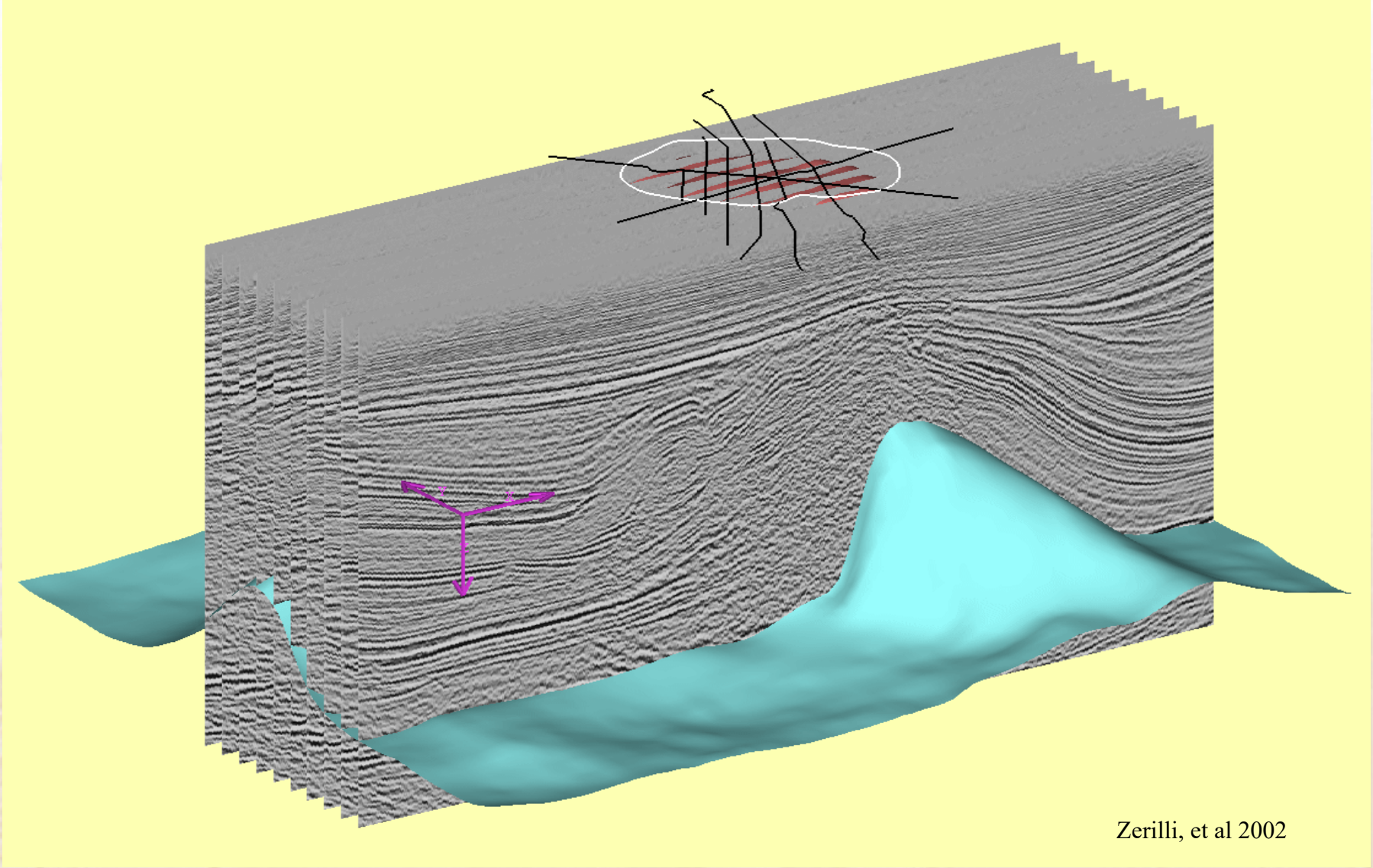
Geophysics in the oil technology life cycle



Technology components: Land, borehole & marine



Fully integrated Hi-res MT, gravity and seismic



Zerilli, et al 2002

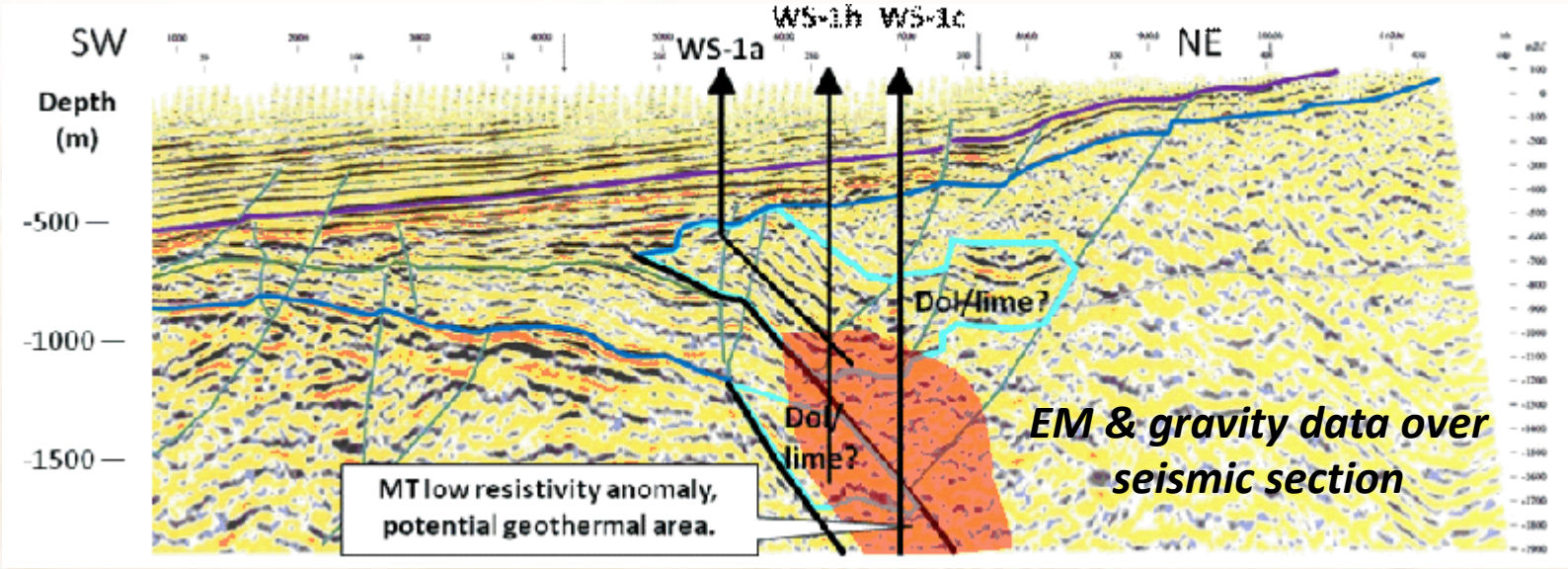
Benefits of geophysics in Oil industry

- Finding reserves …≈ 10% of reserve value
- Finding missed oil …≈ 10-20% of total reserves
- More geophysics in borehole data interpretation/design …≈ 20-40%
- 3D geophysics in geosteering … 3-5 times efficiency
- Efficient reservoir drainage …≈ 10-20% of total reserves
- Enhanced oil recovery …≈ 20-30 % of total reserves

Geothermal

Iceland: Geothermal energy !

Hungary: Drilling gives 3 MW, drill location from geophysics

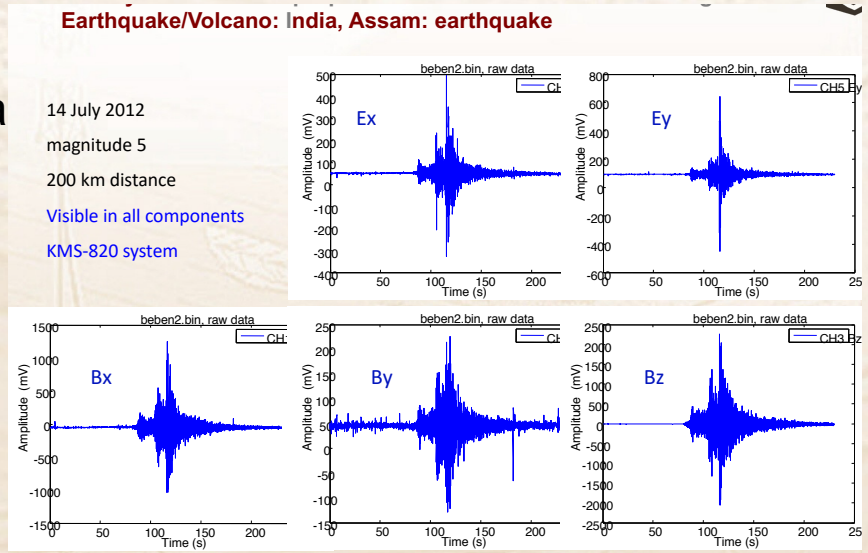


Benefits of geophysics in geothermal industry

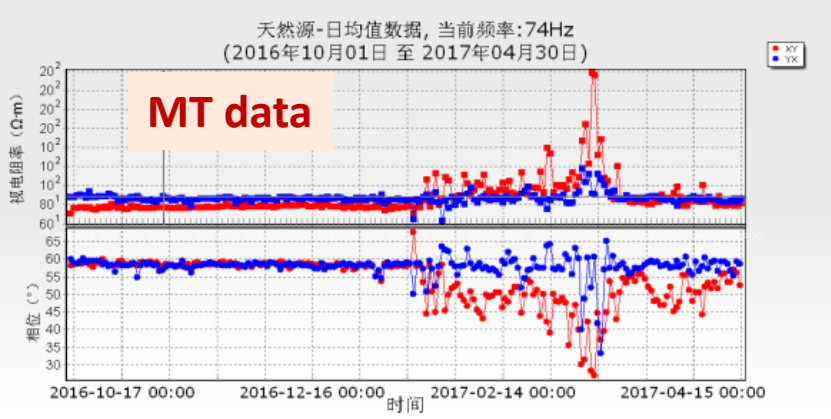
- Finding zone with more/hot fluid …→ locate drill site
- Monitoring induced seismicity...→ predict reservoir damage
- Monitor temperature change via resistivity.

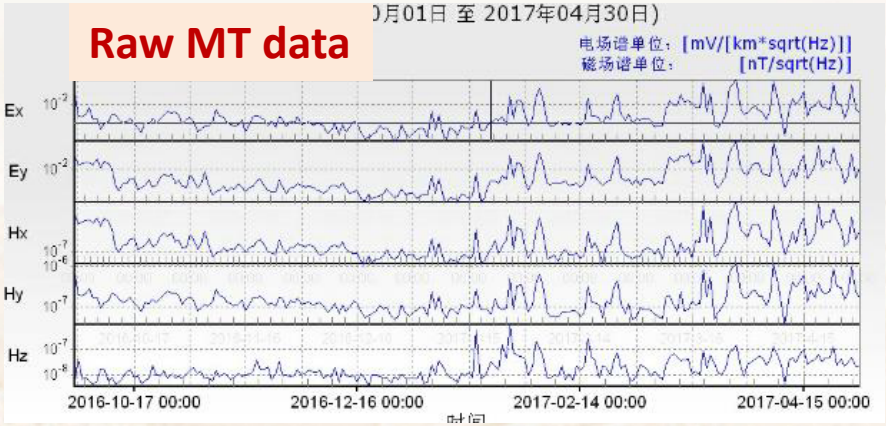
Extending reservoir experience to Earthquake prediction

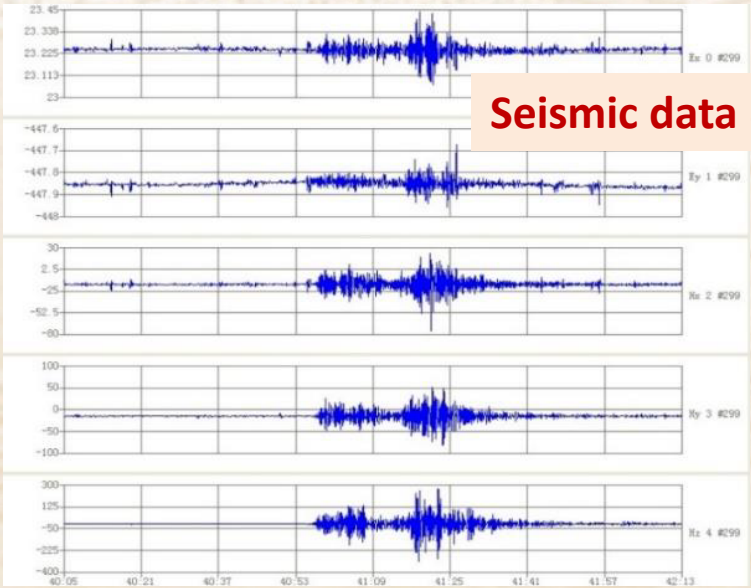
- Historic work don win China and still more advance
  - DEATH: 38% weather related; 60% Earthquakes
  - 60% of Earthquake related death in China
- Geologic analogue are Volcano applications
  - Example from Japan & German teams
- Prediction
  - Option 1: Focus on large area
  - Option 2: Small target



Chinese program: Yangbi earthquake data

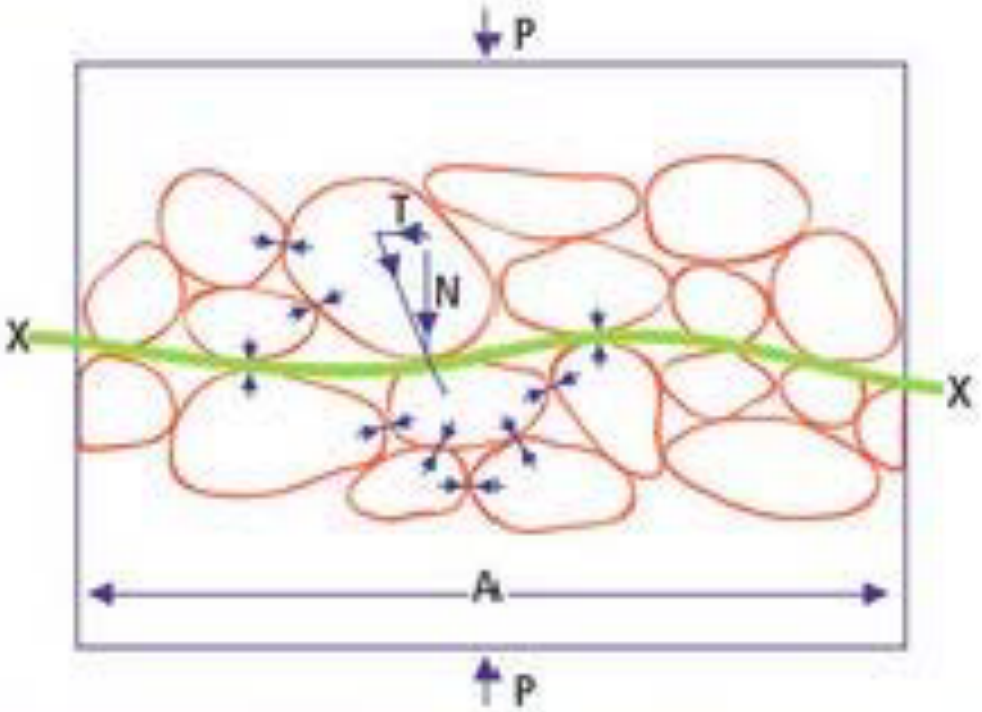






Zhang et al., 2017

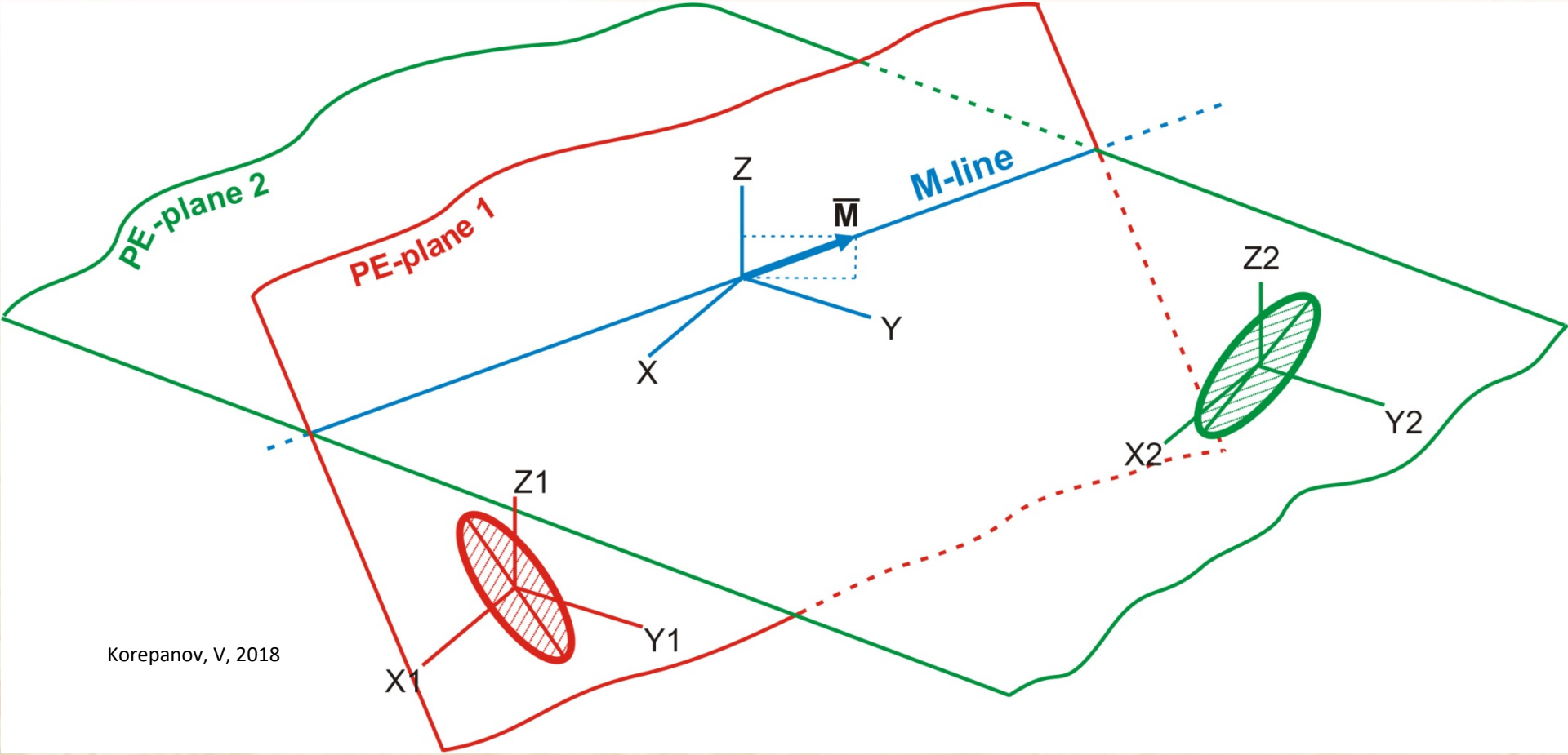
ALTERNATIVE: Reservoirs seal: EM & microseismic - effective stress



- Microseismic signature from fracturing
- EM responds to fluid/electron movements →
- EM signature from brittle & fracturing

After Carlson, 2013

Prediction: target KNOWN area



M-line contains the magnetic dipole moment **M**, which is aligned along it and its position can be calculated from PE parameters

- Earthquake prediction is possible with EM
- BUT how do you know you are right?
- Also the volume of the quake is not known beforehand → we do not know mechanism
- China leads the research – more required
- **If it works it can save many lives!**

- For engineering applications EM geophysics is standard
- For deep oil/geothermal application it use is slowly emerging
- Biggest value is in production saving cost & environment

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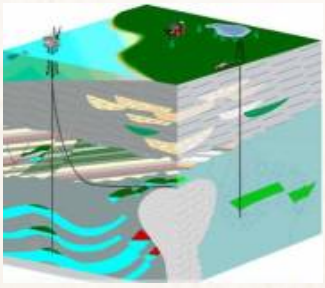

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