

Setting Boundaries: Using Geophysics to Build Better Site Models



<http://www.commercialriskeurope.com/uploads/images/news/latest-news/Napa-Valley-Quake-01.jpg>

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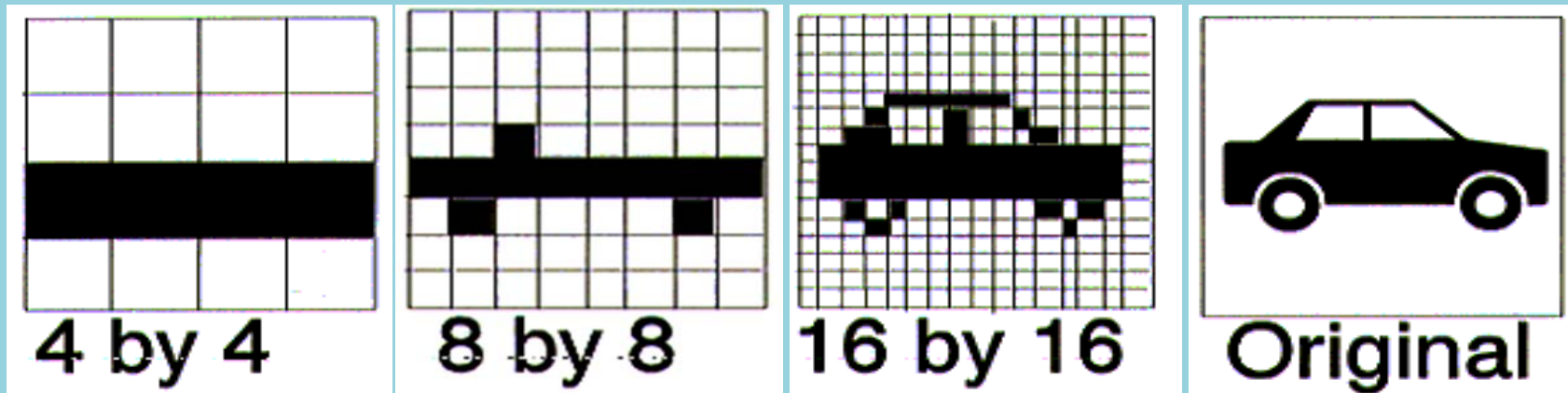
A Tradition of Excellence Since 1944

A model should be as simple as possible, but no simpler

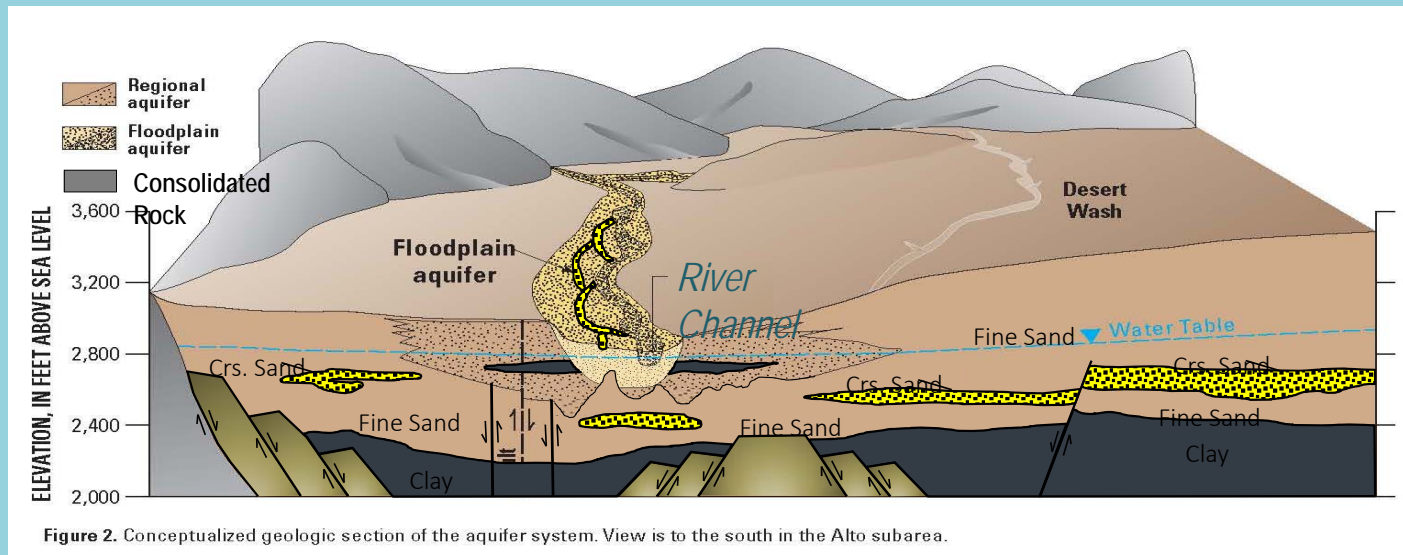
(Albert Einstein)

How do we decide the level of complexity of our models?

- a) We have more than enough data to define the site geology and we simply choose a mesh that fully represents the complexity
- b) We have some pre-existing borings, a few regional reports, if we are lucky we have a pumping test or two, a limited budget, and we do our best and worry about the rest.

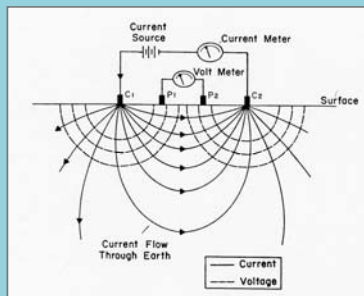


Some Sites Are Suitable for Interpolation, Some are Not

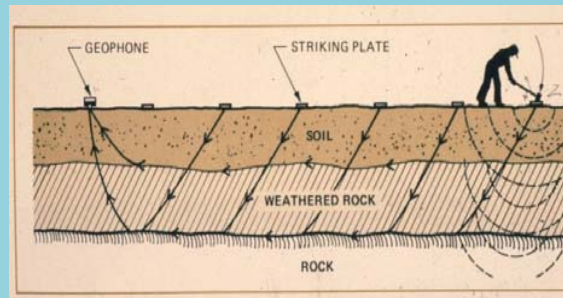


- Sites that have simple structure and uniform aquifers can be characterized by a few holes
- Sites that require more complete data:
 - Stratigraphic changes like facies changes along a geologic unit
 - Flow barriers like pinch outs or faults
 - Preferential flow paths like fractures, channel sands, and some faults
 - Breaches in confining units or cross connections between units
 - Density flow, like salt water zones

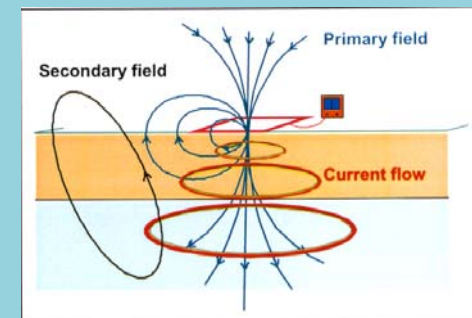
Common Geophysical Methods



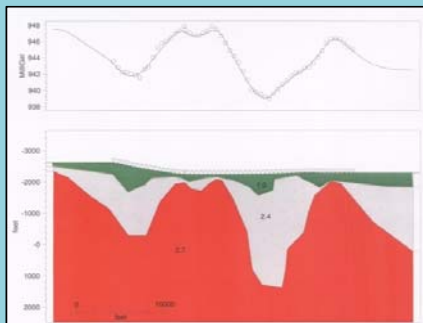
Electrical resistivity



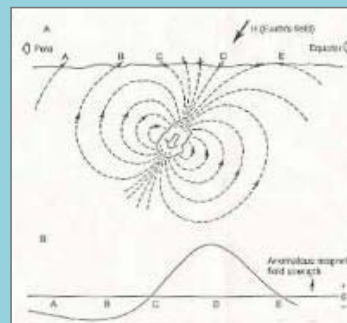
Seismic



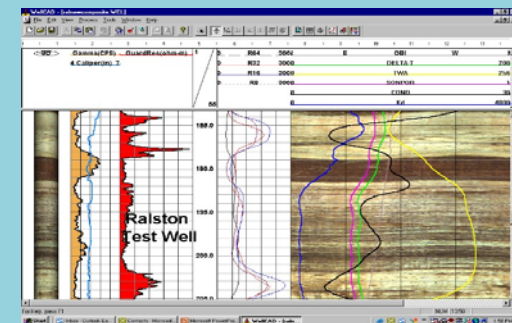
Electromagnetics



Gravity surveys

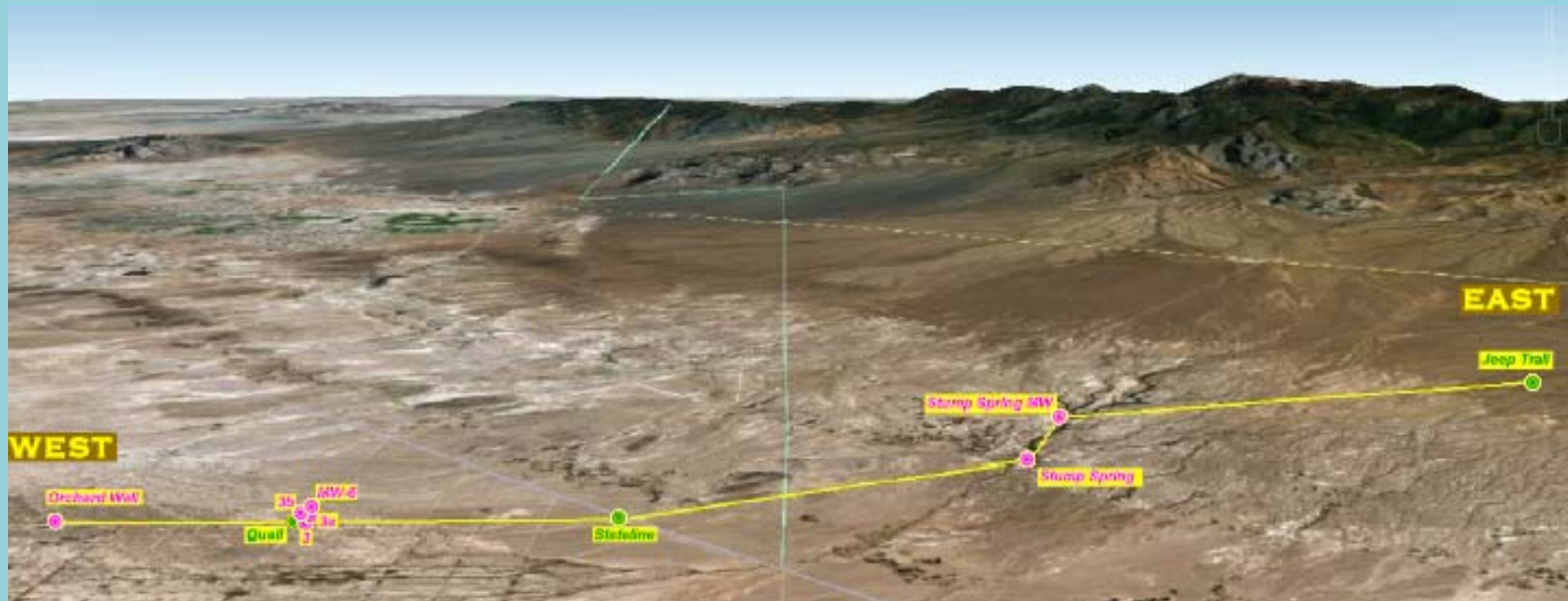


Magnetometry

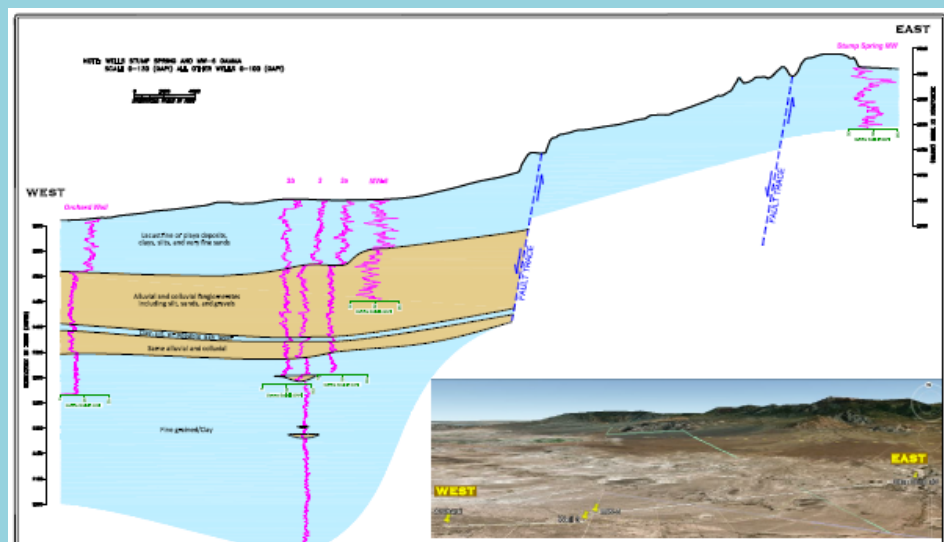


Borehole Logging

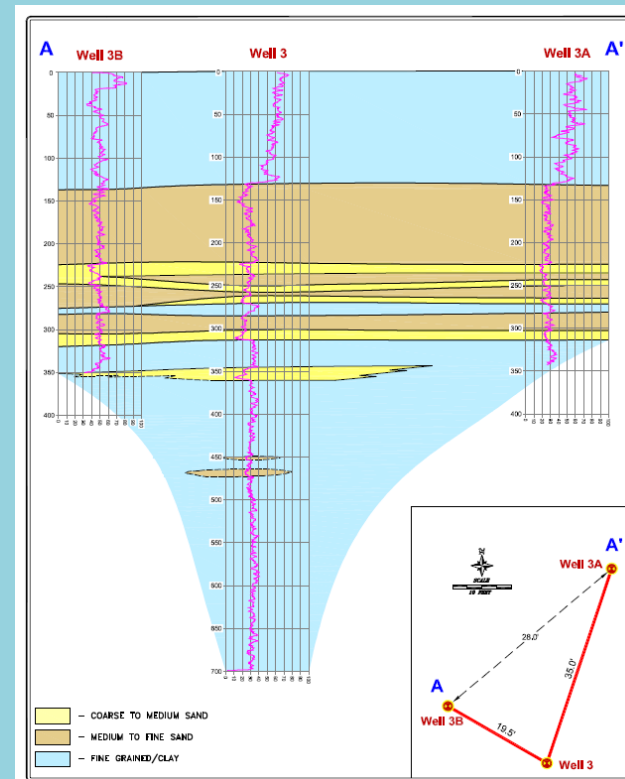
Recovering Stratigraphic Information from Old Cased Wells



Gamma Logs Can See Through Casing in Old Wells

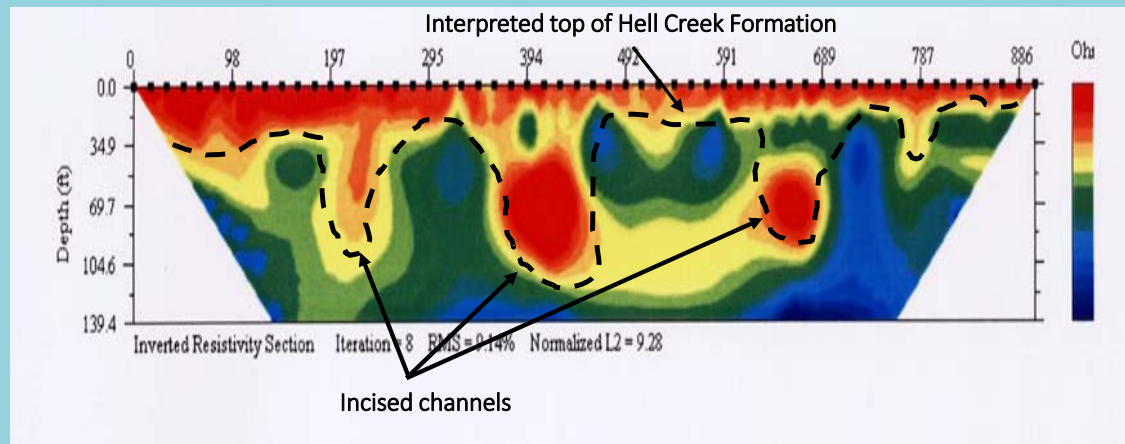
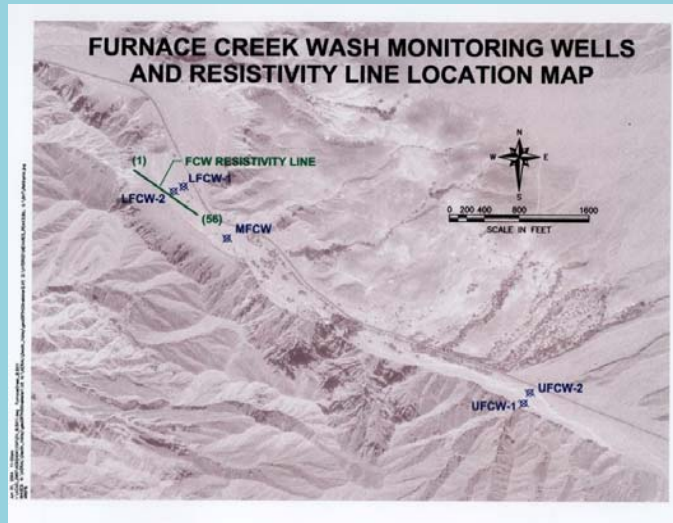


- Can give you a formation log in old wells
- Can identify sands and clays
- Can map aquifers on a regional basis



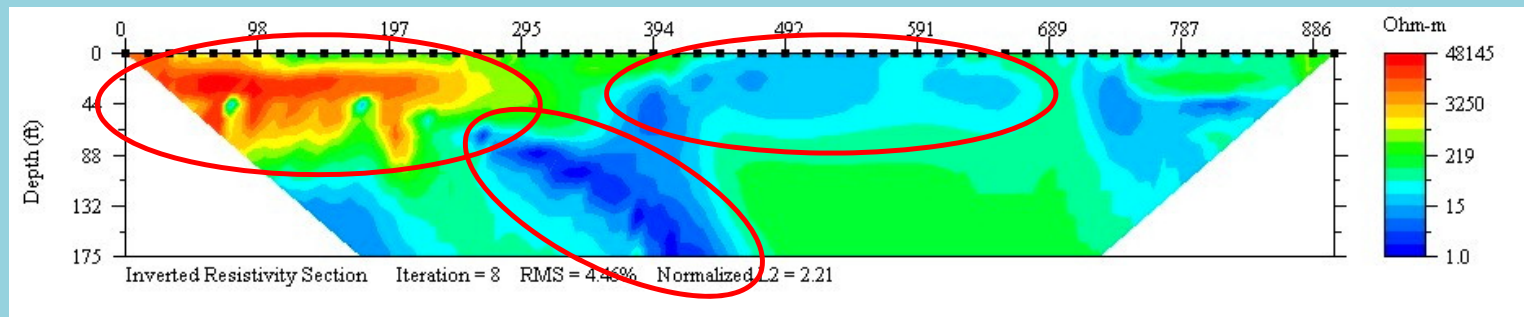
Furnace Creek Wash Resistivity Survey

Mapping channel sands for production well

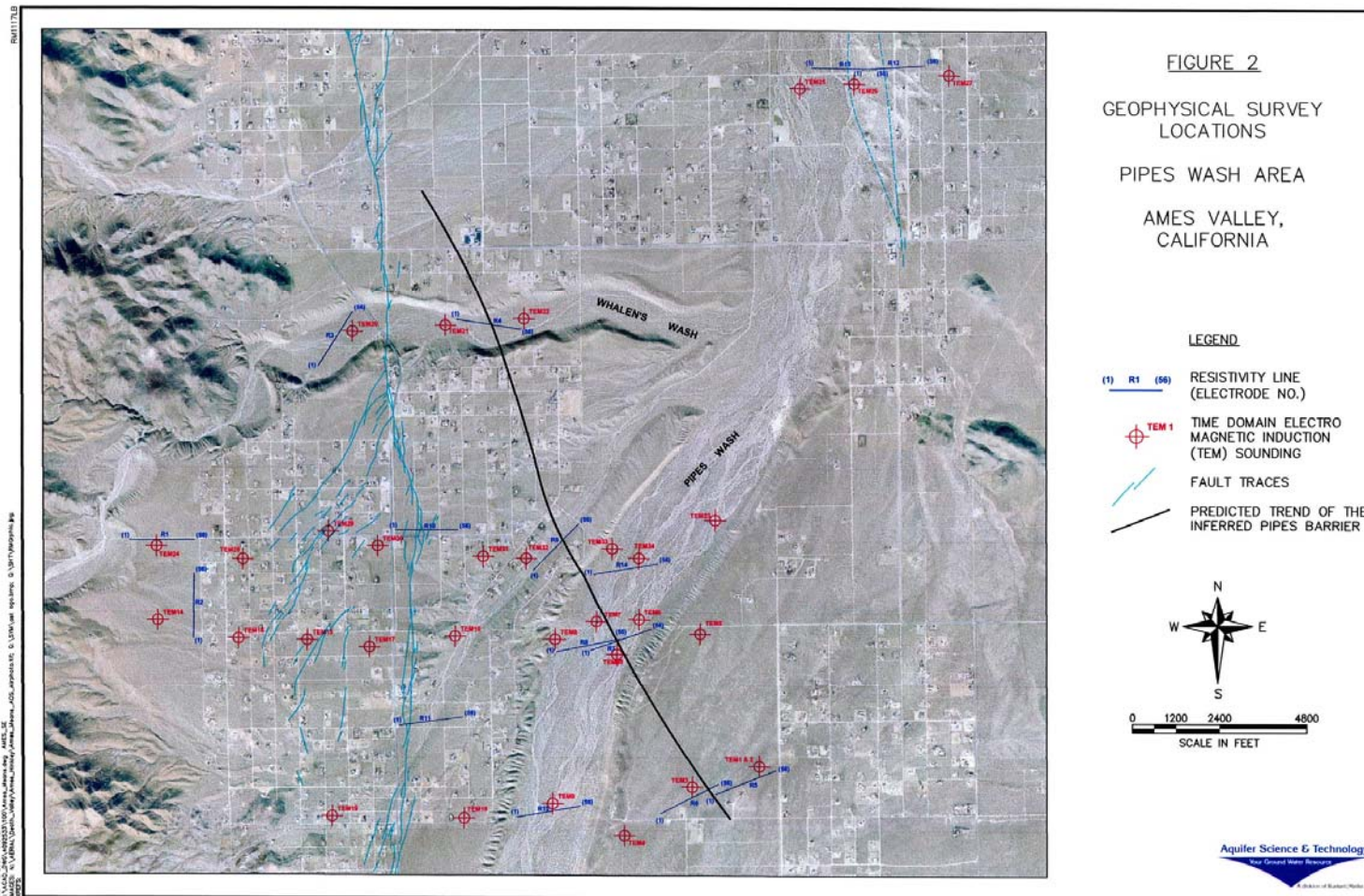


Mapping Feeder Fracture For the Nevares Spring Mound, Death Valley National Park

- Goal was to replace shallow collection gallery with drilled well for water supply
- Mapped conductive feature related to spring mound
- Borehole hit hot water in two fault planes at 180 to 185 feet
- Water flowed 6 feet above ground level
- Developed as safer water supply for Park employees

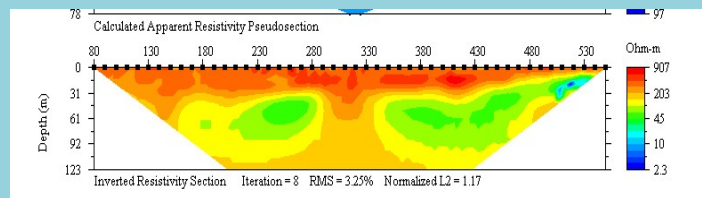
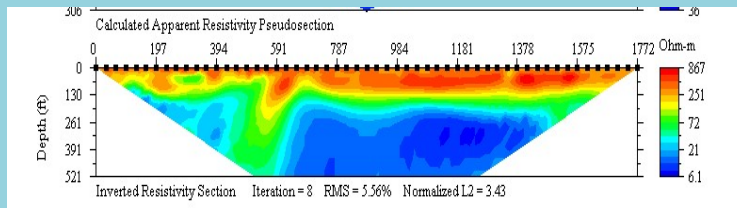
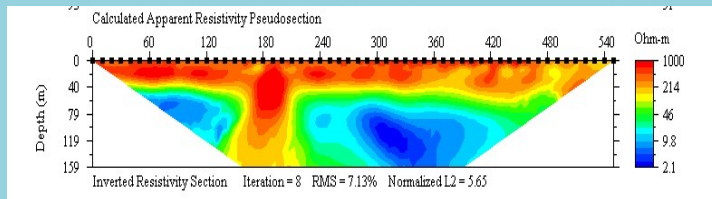


Mapping Buried Faults Inferred from Water Table Offsets

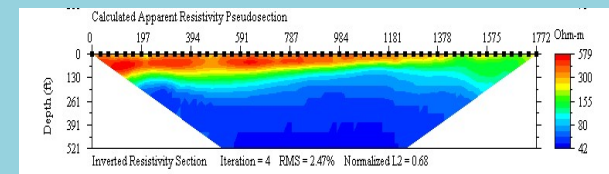
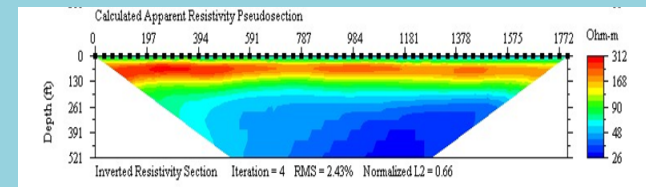


Mapping Faults, Depth to Water, and Grain Size

Faulted Lines

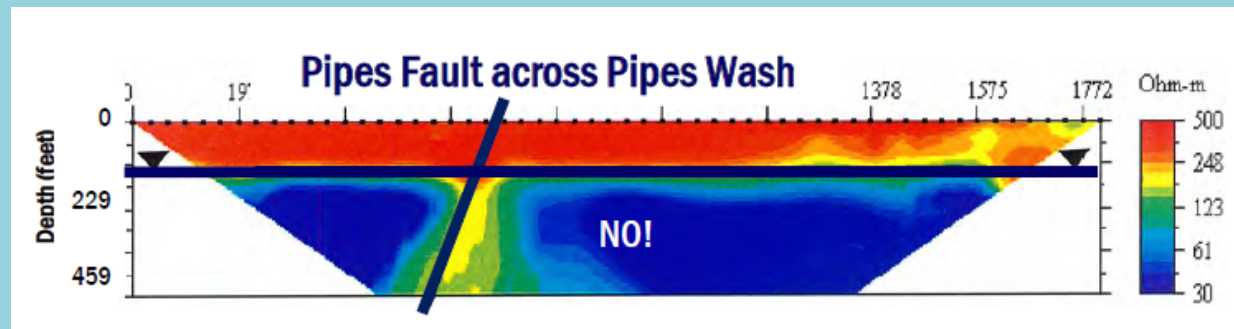


Non-faulted Lines



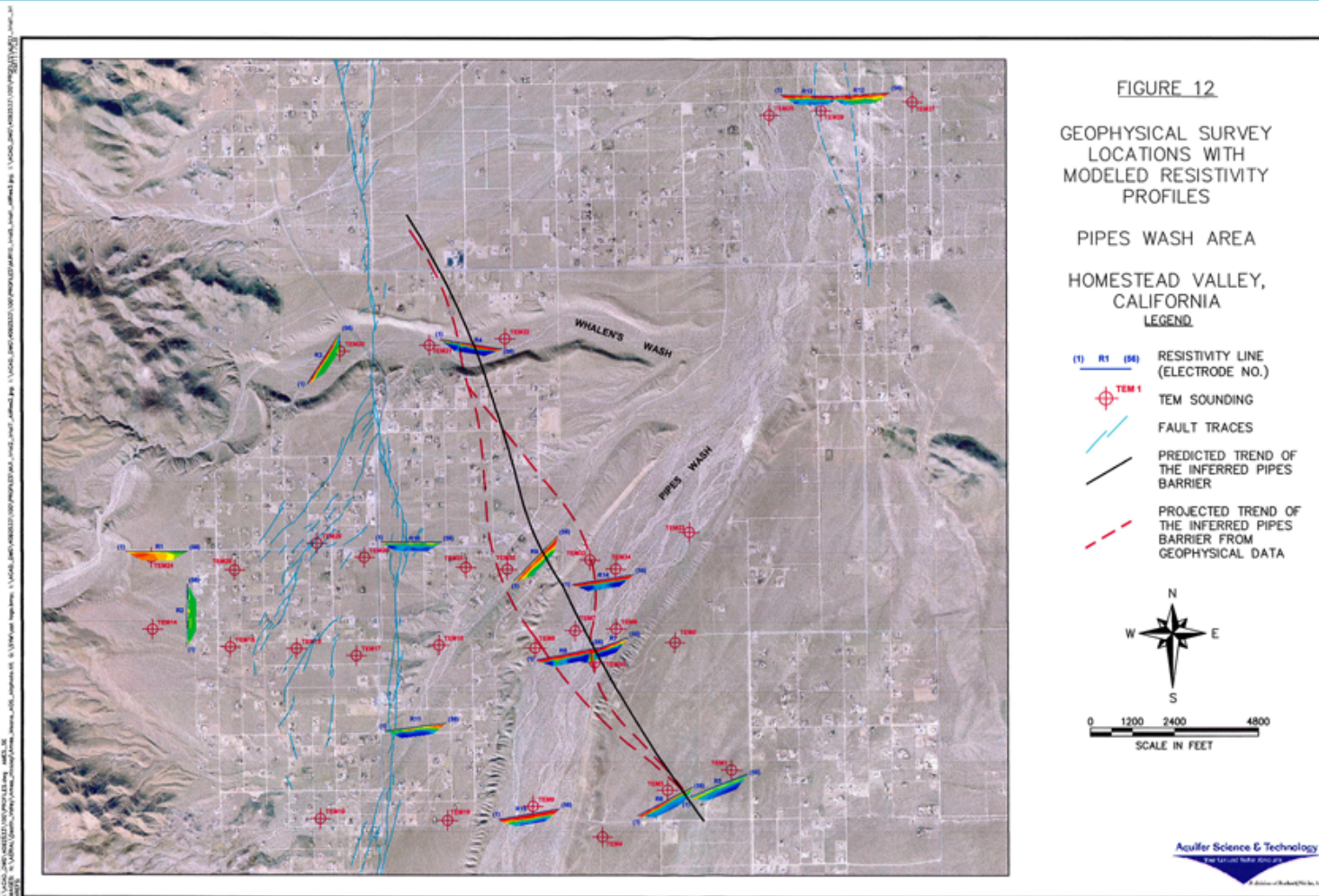
Mojave Water Agency, Ames/Means Valley, Yucca Valley, CA

Some faults are hydraulic barriers, some not



From Todd Engineers

Inferred Pipes Barrier Mapped as Fault with at Least One Splay



Coal Beach Naval Base

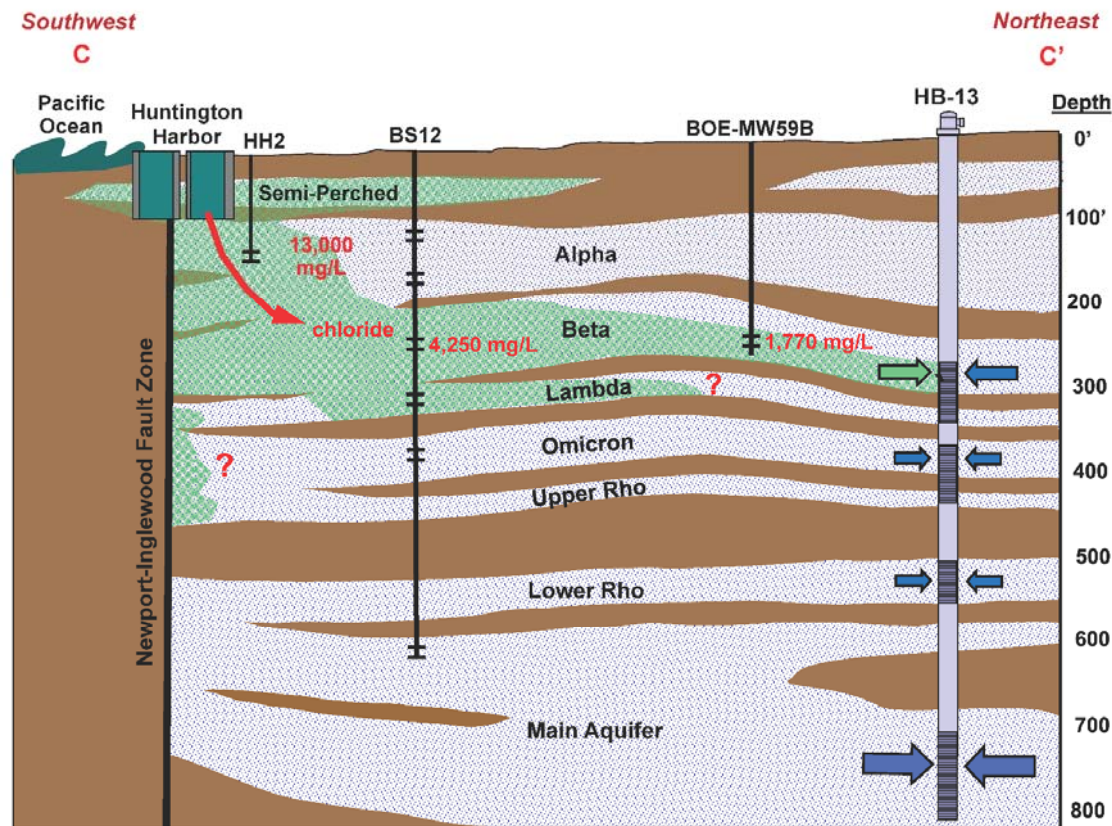


Figure 12-28. Schematic Geologic Cross-Section from Huntington Harbor through Sunset Gap

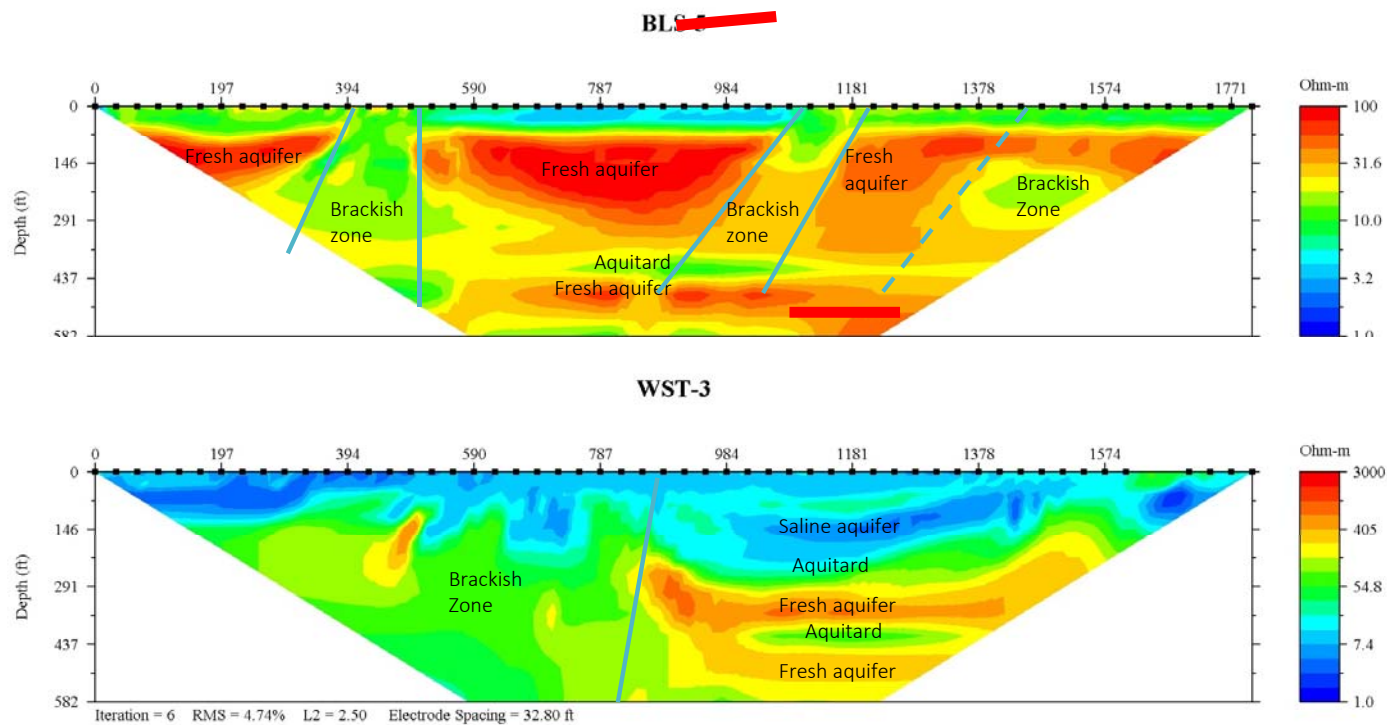
- Naval Base
- No Barrier
- Suspected
- 20 resistivity soundings along 4 profile lines

fer system

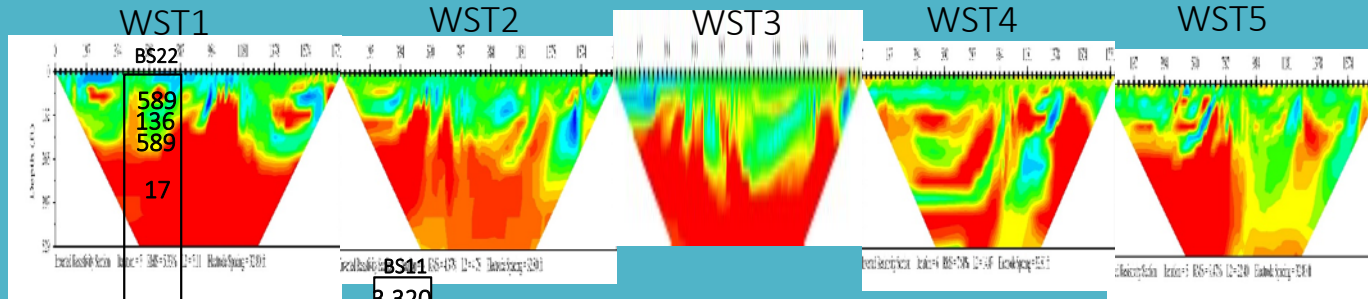


Typical Resistivity Lines from Seal Beach Site

Showing Layered Aquifer System with Faults and Salt Water Intrusion Areas



BS21
189
355
580
1,280
14



BS17
37
37
73

BLSA1

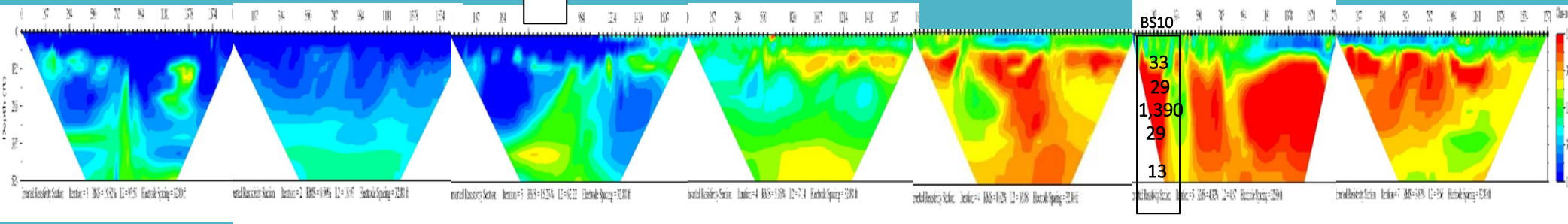
BSA3

BLSA4

BLSA5

BLSA6

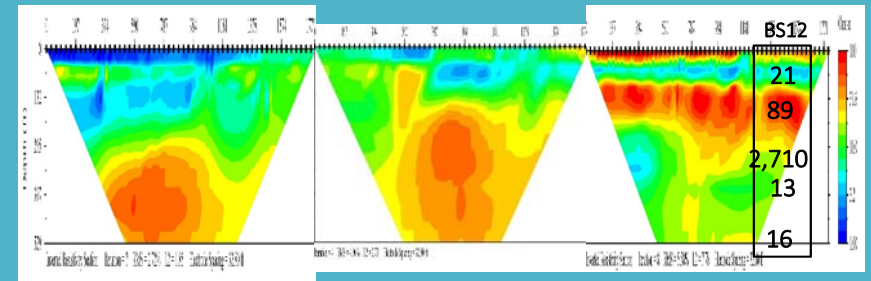
BLSA7



RR1

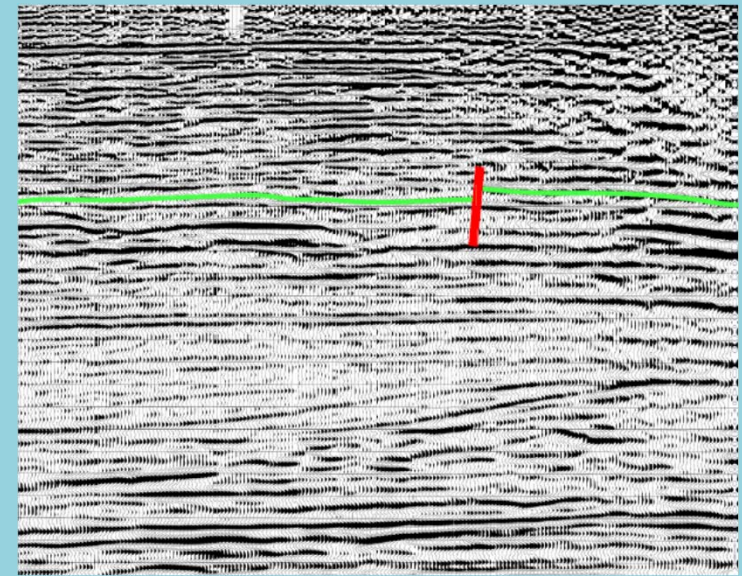
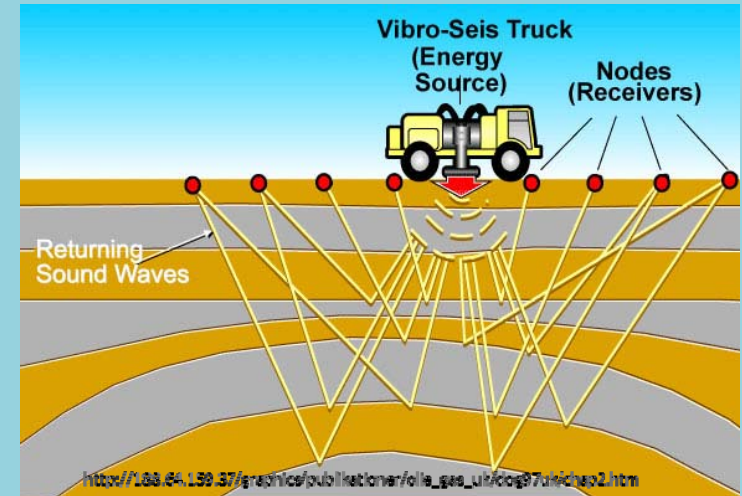
RR2

RR3

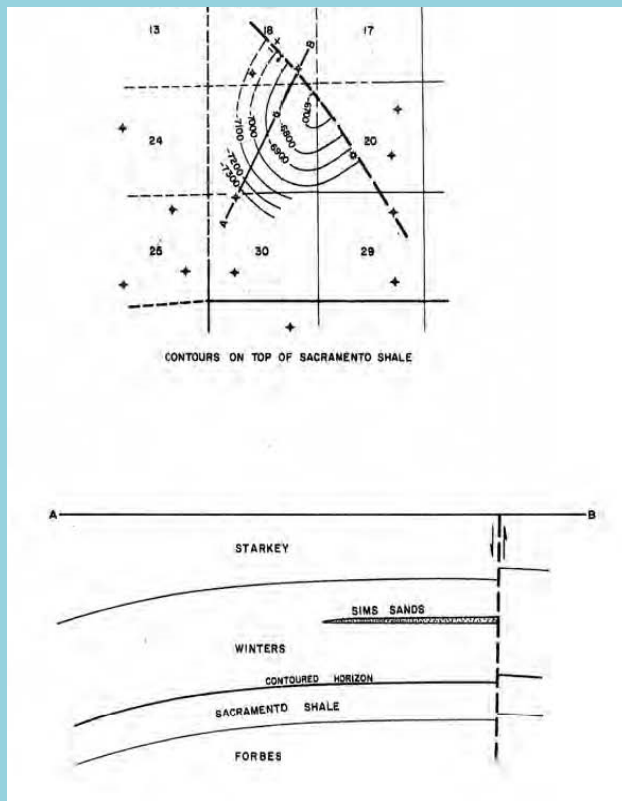


Seismic Reflection

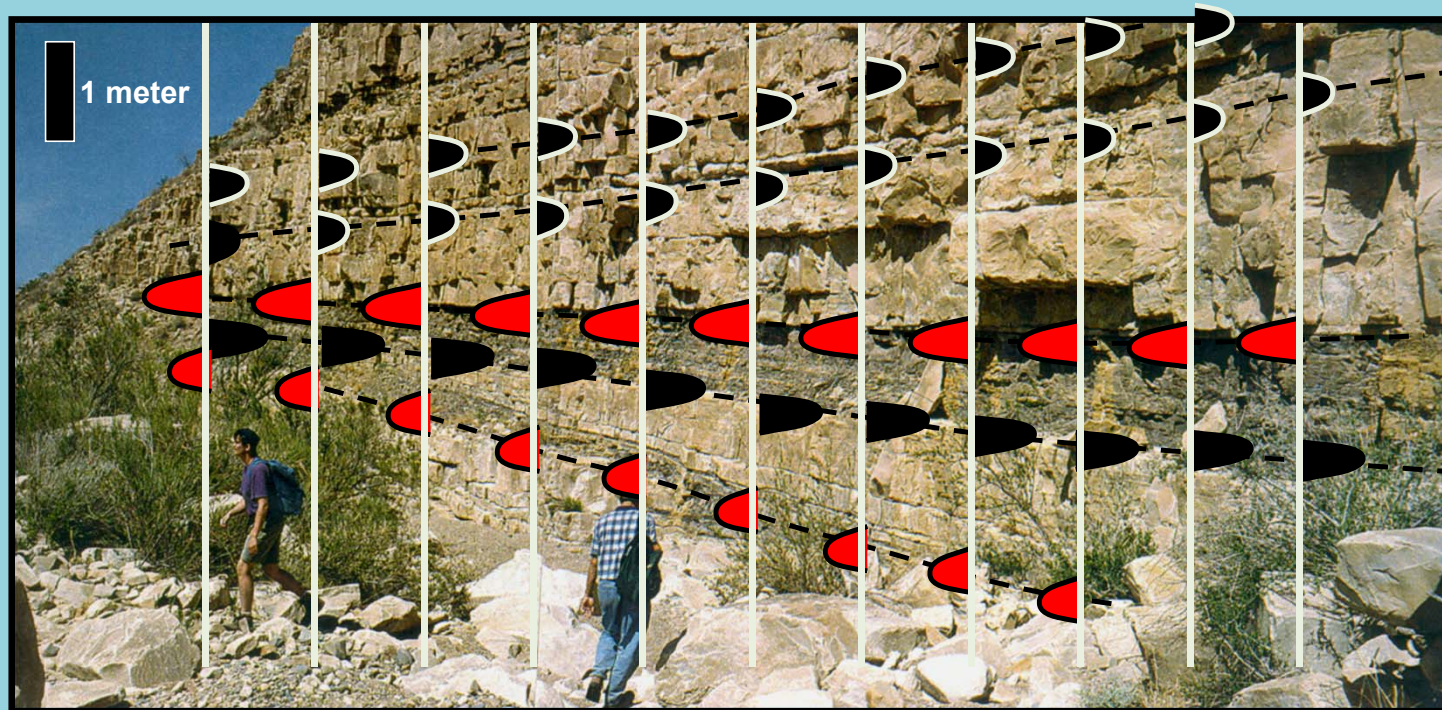
- Not a common method in ground water studies....so far
- Produces a continuous image of the subsurface
- Can map complex structure, stratigraphy, fracture density, and fluid type.
- Requires more sophisticated field equipment, processing, field procedures, and well control.
- Difficult to apply to shallow exploration targets (i.e., above approximately 50 to 100 feet).
- Exploration depth over 30,000 feet.



Using Seismic Data to Resolve Structural Ambiguity



Reflection Provides Good Vertical and Lateral Resolution



Increase in Impedance

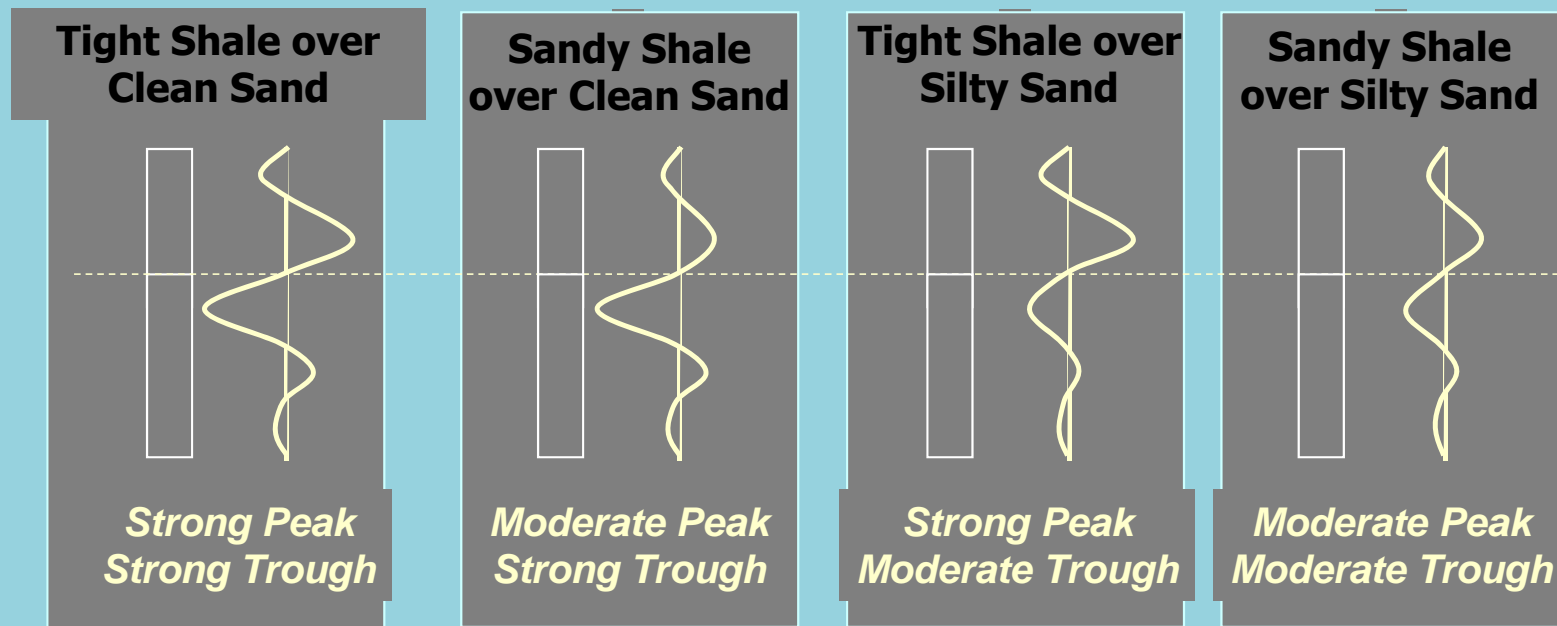


Decrease in Impedance

Able to resolve boundaries of beds a few meters thick

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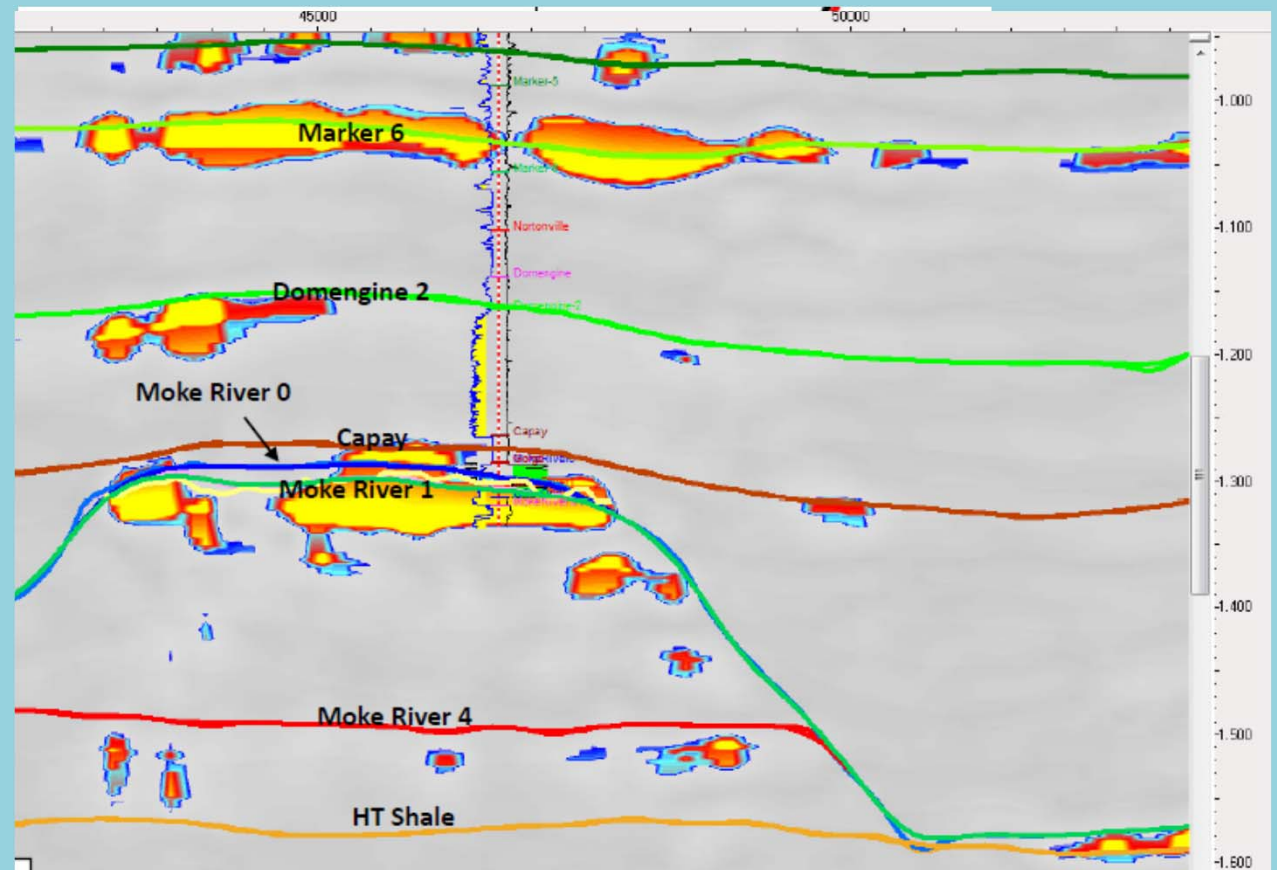
Seismic Wavelet Changes With Rock Properties



http://archives.aapg.org/slide_resources/schroeder/13/index.cfm

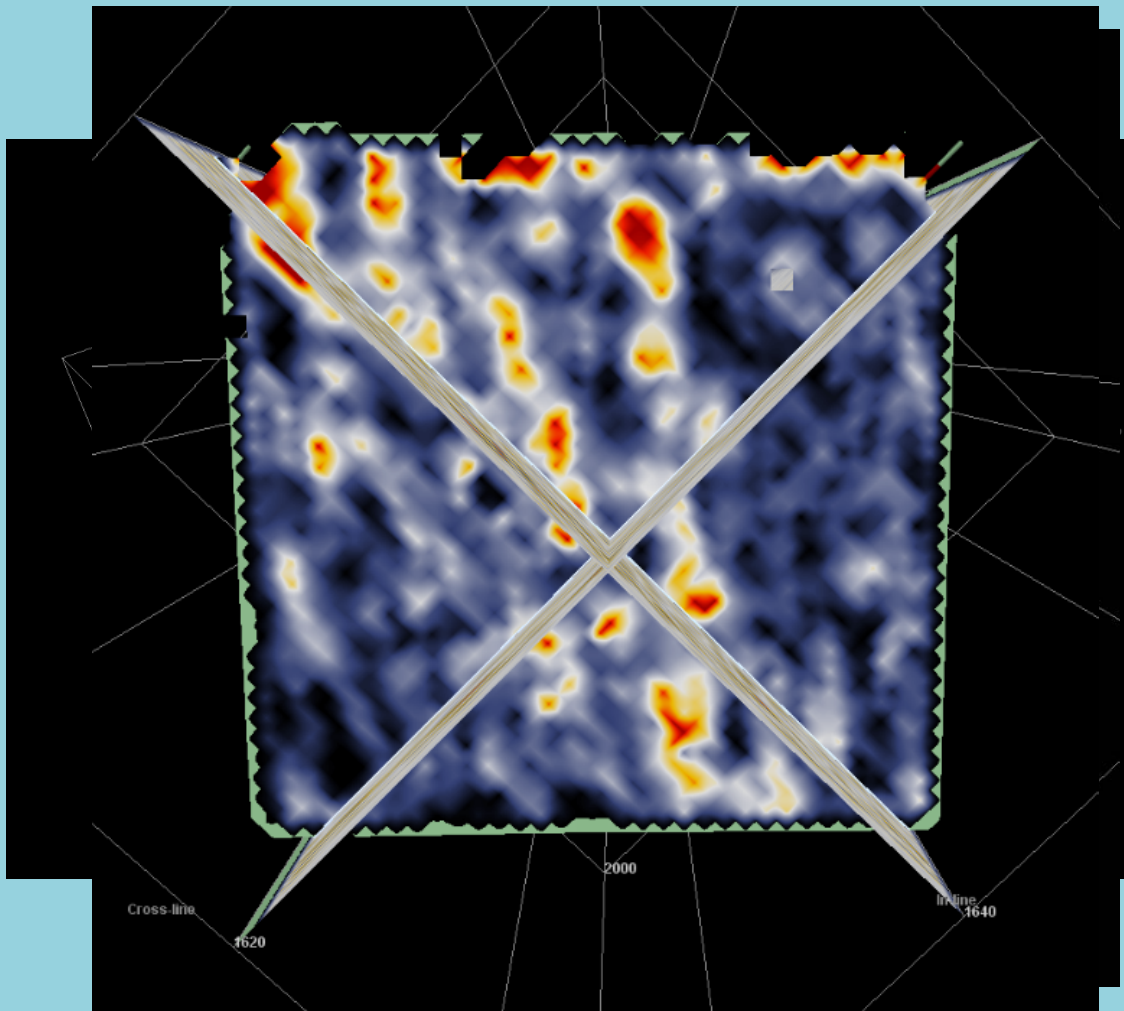
Attribute Processing of Seismic data to Map Sand Vs. Shale

- Mapping channel cuts and sand units in Central Valley of California.
- Produces map of sand zones on top of structure map of formation



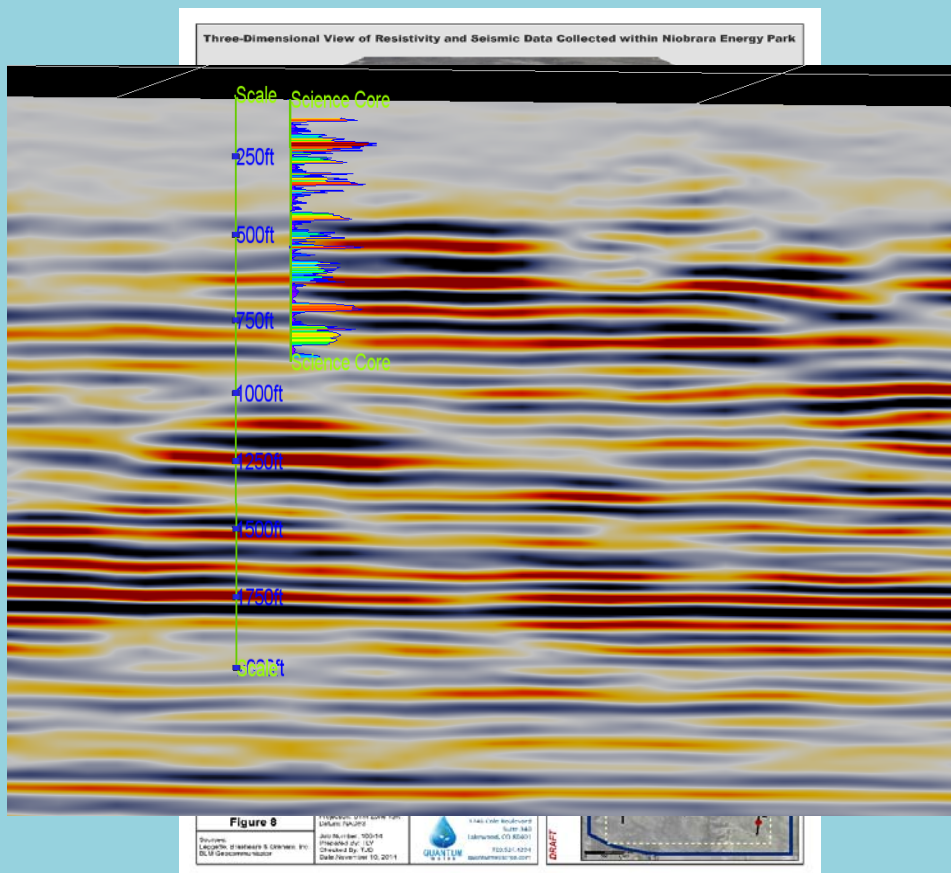
Attribute processing to show sand packets

Recent Project Mapping Channel Sands



- Purchased 3D seismic data set
- Picked major sand units
- Processed attributes on horizons
- Amplitude Attribute shows some potential channels
- Similarity attribute sharpens sand units

Combined Surface Resistivity Survey for Shallow Zone to Seismic Attribute on Deeper Horizons



- Goal was to find water supply from channel sands in shale-rich stratigraphic sequence
- Mapped channels with resistivity survey to about 400 feet
- Drilled 2 shallow wells at 90 gpm each
- Used seismic amplitude and similarity to map sands to about 1,000 feet
- Drilled to 800 feet
- Several silty sand intervals from 200 to 700 feet
- Initial estimated well capacity (120 gpm) is twice initial objective

Purchasing Existing Oil and Gas Data Far Less Expensive



Companies have extensive
seismic surveys
of vintage and quality
becoming more

lines can be
20% of acquisition

(1970s or 1980s) can
improve quality

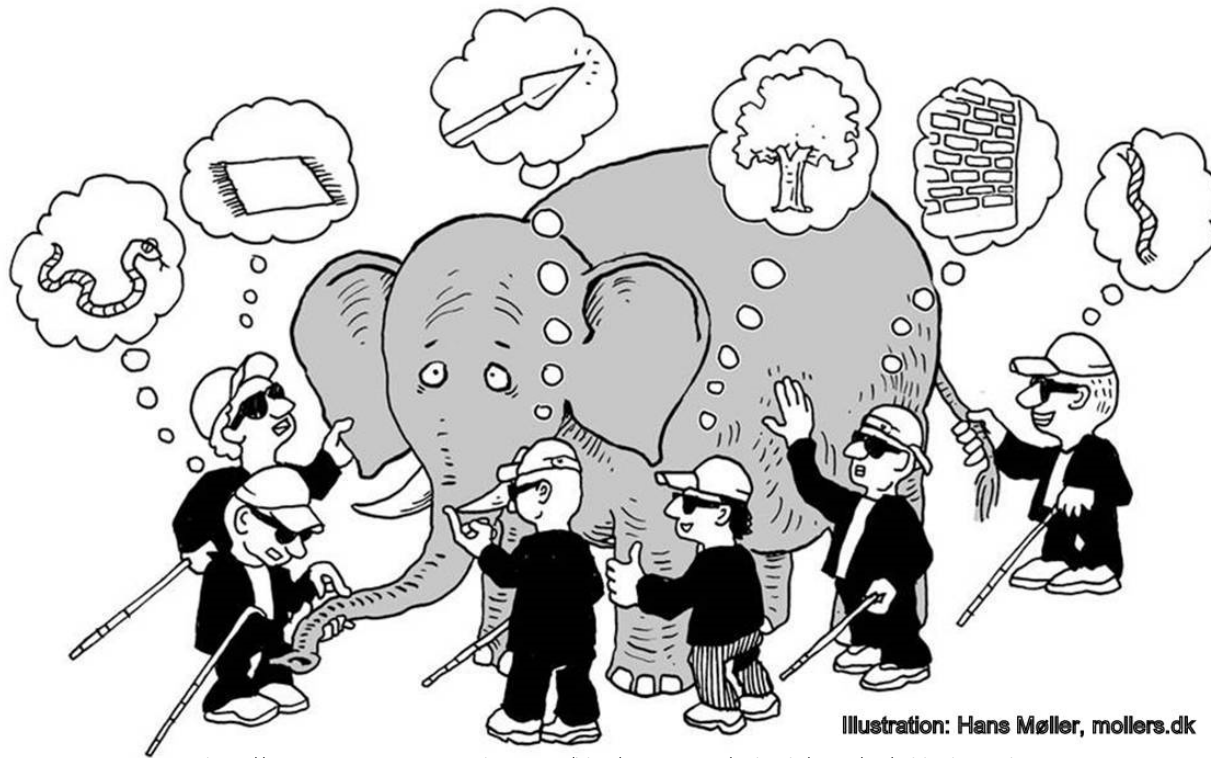


Illustration: Hans Møller, mollers.dk

<http://www.engagementaustralia.org.au/blog/wp-content/uploads/2015/03/6-blind-men-hans.jpg>