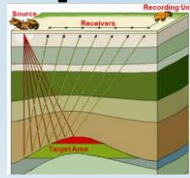


## Seismic Attribute Processing to Find Deep Aquifers



John Jansen, P. Ge., Leggette, Brashears and Graham

LEGGETTE, BRASHEARS & GRAHAM  
Member of WSP

## As we develop deep aquifers we face special challenges

- Competition for water is driving interest in deeper brackish resources
- Drilling deep is very expensive
  - Existing data is sparse
  - Cost of failure is high
- Most shallow geophysical methods lose resolution below 500 to 1,500 feet
- Brackish aquifers look like clay-rich confining units to electrical methods
- Petroleum industry developed the seismic reflection method to provide high resolution subsurface images to great depths

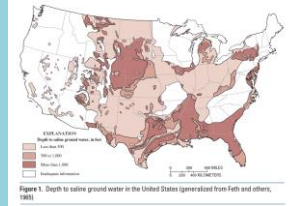
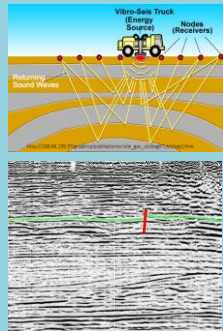


Figure 1. Depth to saline ground water in the United States (generalized from Feth and others, 1981).

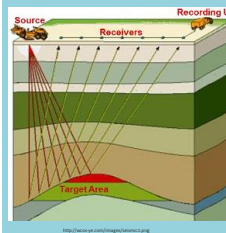
## Seismic Reflection

- 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.



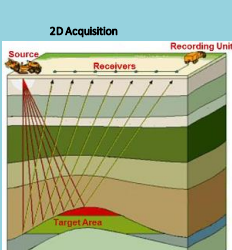
## Seismic Reflection Data Acquisition

(Mostly Bay Geophysical)

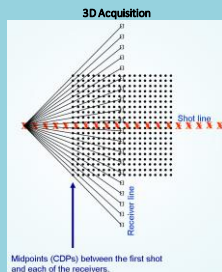


- Specialized equipment and crews
- Acquisition costs typically \$10,000 per mile plus mobilization

## 2 D Vs. 3D Seismic Acquisition



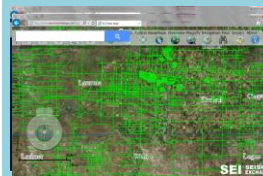
http://www.ge.com/images/inline/2.png



Midpoints (CDPs) between the first shot and each of the receivers.

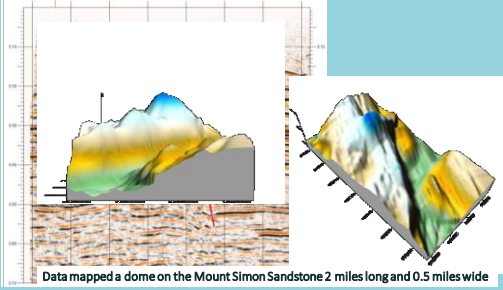
http://www.ge.com/images/inline/3d.png

## Purchasing Existing Oil and Gas Data Far Less Expensive

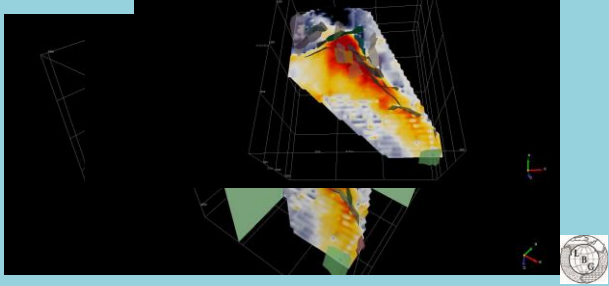


- Most oil and gas regions have extensive libraries of existing seismic surveys
- Lines are of differing vintage and quality
- Modern 3D surveys becoming more common
- Lines or portions of lines can be purchased for 10 to 20% of acquisition costs
- Older vintage lines (1970s or 1980s) can be reprocessed to improve quality

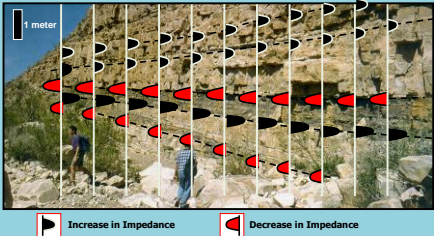
### Typical Seismic Reflection Section



### 3D Seismic Reflection to Map Structures



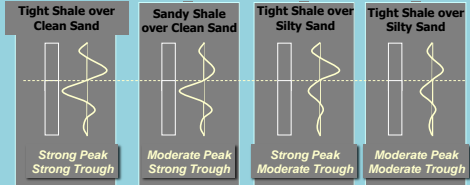
### Reflection Provides Good Vertical and Lateral Resolution



**Able to resolve boundaries of beds a few feet thick**

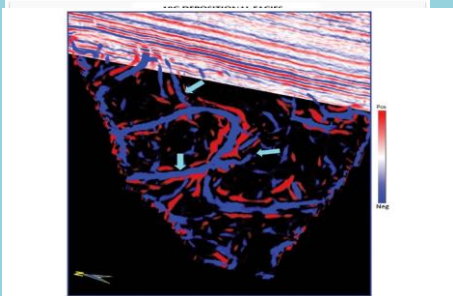
[http://archives.aapg.org/slide\\_resources/schroeder/13/index.dfm](http://archives.aapg.org/slide_resources/schroeder/13/index.dfm)

### Seismic Wavelet Changes With Rock Properties



[http://archives.aapg.org/slide\\_resources/schroeder/13/index.dfm](http://archives.aapg.org/slide_resources/schroeder/13/index.dfm)

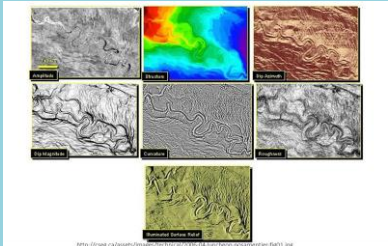
### Mapping Channel Sand Based On Amplitude



<http://imgarcade.com/zoom/images/width/200/height/100/seismic-attributes-fig01.jpg>

### Seismic Attributes:

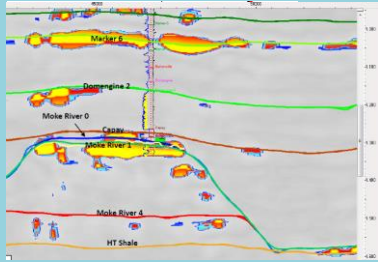
- Any measurement derived from seismic data
- Usually derived from the shape, amplitude, position or changes relative to adjacent traces
- Can identify rock type, porosity, fluid properties, fractures, thin beds, etc.
- Seismic attributes reveal features, relationships or patterns that would not otherwise be apparent



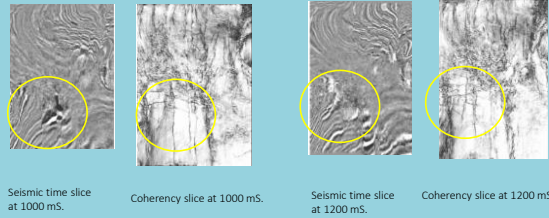
<http://img.ca/water/online/images/width/200/height/100/seismic-attributes-fig01.jpg>

### Attribute Processing of Seismic data to Map Sand Vs. Shale

- Mapping channel cuts and sand units at depths of over 5,000 feet.
- Produces map of sand zones on top of structure map of formation

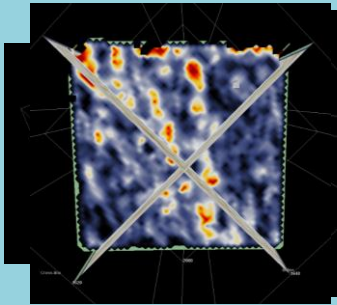


### Using Coherency Attribute to Highlight Faults



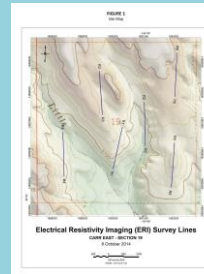
Gersztenkorn, et al, 1999

### Recent Project Mapping Channel Sands



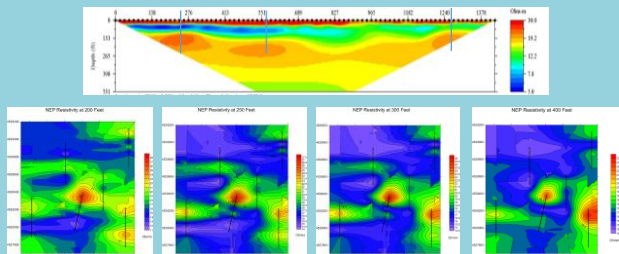
- Purchased 3D seismic data set
- Picked major sand units
- Processed attributes on horizons
- Amplitude Attribute shows some potential channels
- Similarity attribute sharpens sand units

### Shallow Reflection Data Quality Poor

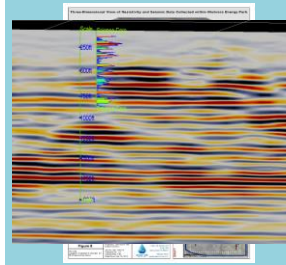


- Oil and Gas surveys typically designed to maximize data quality in the range of about 5,000 to 15,000
- Data quality degrades in the upper few thousand feet due to the acquisition geometry and processing
- Shallow data can be improved by reprocessing and trimming out long offset data, but there is a limit
- For this data set we were able to get good data below about 500 feet
- We wanted to look at potential aquifers from about 200 to 2,000 feet.
- Reflection data would not give us coverage in the upper part of the zone
- Added a shallow electrical resistivity survey to map sands in the upper 500 feet
- 2 miles of data collected in 6 lines run in three field days

### Typical Resistivity Line and Interpolated Depth Slices



### 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 sand intervals from 200 to 700 feet
- Initial estimated well capacity (120 gpm) is twice initial objective
- Established a non-tributary water right of 400 af

Hope you picked something up...

