Small is beautiful: AGL physical modeling and salt measurements

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Introduction & motivation

• Why physical modeling?
• AGL physical modeling system
• Scaled models of resource interest
  – laser-etched glass
  – 3D printed materials
  – Inclusions and injection
• Fracture results
• Ultrasonic measurements on salt & sediments
Schematic diagram of ultrasonic system

100 kHz to 5 MHz sources and receivers
Use 10,000 factor to compare to seismic:
100 kHz = 10 Hz, 5 MHz = 500 Hz
AGL Ultrasonic Research Systems

Marine system

Land System

Ultrasonic measurement system
Example of CMP profiles in ultrasonic experiment in laser fractured glass (processed by Bode Omoboya)
3D printed models

Prism A

HTI

Prism B

VTI

51 mm

51 mm

51 mm

51 mm
Hydraulic fracture model with horizontal well

Model PM 4 (real)

Image patch of fracture in PM 3 (microscope)

Model PM 4 (drawing)
Future of Modeling with 3D printed material

Vertical fractures

Tilted fractures

Horizontal fracture

Combination of fracture systems

3D printed Material
Halite Core from a salt dome.

Core as it was delivered to AGL

This part of core was cut for ultrasonic measurements
Velocity of Compressional wave (Vp) and Shear wave (Vs) along of axis of Salt core. Density.

Table 1. Results of three tests: Velocity Vp and Vs, and Vp/Vs ratio

<table>
<thead>
<tr>
<th>Test N</th>
<th>Vp, Km/s</th>
<th>Vs, km/s</th>
<th>Vp/Vs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.512</td>
<td>2.611</td>
<td>1.728</td>
</tr>
<tr>
<td>2</td>
<td>4.532</td>
<td>2.624</td>
<td>1.728</td>
</tr>
<tr>
<td>3</td>
<td>4.521</td>
<td>2.609</td>
<td>1.733</td>
</tr>
<tr>
<td>Average</td>
<td>4.522</td>
<td>2.615</td>
<td>1.729</td>
</tr>
</tbody>
</table>

Ultrasonic transducers for P- and S-wave Velocity measurements with central frequency 500 kHz

Density:
Core 1 – 2.124 g/ cm³
Core 2 – 2.054 g/ cm³

Ro of salt core – 2.09±0.04 g/ cm³
Salt core in device for anisotropy measurement.

Ultrasonic transducers, used shear wave transducers – 0.5 MHz central frequency
Azimuthal velocity of Compressional (Vp1) and Shear (Vs1) waves for section 1 of salt core-2
Azimuth was taken confidential.

Vp

Vs
Pressure dependent velocity (Vp and Vs) measurement within sample of core 2 (De-hua-Han Rock Physics Lab, UH, AGL)

Halite cylindrical sample (D=36.84mm, L=50.36mm)

Vp and Vs of Salt core 2 under Confining pressure

Vp/Vs versus confining pressure
Conclusions:

- AGL physical modeling Laboratory has 3 Ultrasonic research systems: a) Marine, b) Land, c) Ultrasonic measurement system.
- They are used for modeling seismic survey, microseismic monitoring tests, time-lapse seismic, and characterization of rocks and material elastic properties.
- Seismic physical modeling solve the geophysical problems in more economical and fast way.
- Study properties of rocks support in interpreting field data
- 3D printing material gives new opportunity for physical modeling of reservoir or rocks containing tectonic or hydraulic fractures in anisotropic medium.
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