Geomechanical Performance of Hydrate-Bearing Sediments in Offshore Environments

Schlumberger Plans
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Objectives

Develop the capability of building 4D Geomechanical models of the near-seafloor deep-marine hydrate-bearing sediments.

- Interface Petrel framework model with FLAC3D

Develop 4D geomechanics models of the near-wellbore region of hydrate-bearing deep-marine sediments
Scope of work 2006

H1 2006
- Review the geological structures on the U.S. continental margins characteristic of the gas hydrate stability zone (GHSZ).
- Determine whether Petrel's framework modeling tools can reproduce realistic fault and sedimentary structures of the (GHSZ)

H2 2006
- Evaluate the capability to interface Petrel with FLAC3D
- Recommend improvements to Petrel developers
- Contract ITASKA to interface Petrel to 3DShop and FLAC3D
- Selected Keathley Canyon as a field test site
- Build a small Petrel model
- Exported Petrel surfaces and geological properties to ITASKA software
Geological environment

- Hydrate Stability Zone

Complex structure due to salt diapirism
Figure 1. Map showing location of planned JIP coring/logging sites relative to gas hydrate sites and petroleum occurrences in the Gulf of Mexico (modified from Milkov and Sassen, 2001). Water depth contours shown in meters.
Modelling challenges seen in seismic section at Keathley Canyon

Unconformities & Pinchouts

- Waterbottom: 4260 feet BMSL
- Clays, coarser grained lenses, slope fans.
- Sand-shales, channel levee systems, Unconformity
- Sand-shale laminates, slope fan deposits.
- HST shales and sand layer laminates.
- LST slope fans, channeling, slope failures, chaotic events.

Possible Hydrate mound

Faults

Salt bodies

Discordant contacts-e.g. BSR

Keathley Canyon Inline 5591
Geomechanical Property Modelling Workflow

1. Geophysical Logs
2. Petrel Property Modeling
3. Interactive, Seismic volume extraction
4. 3D seismic volumes
   (time domain)
5. 3D geo-property volumes
   (depth domain)
6. FLAC3D Geomechanics Simulator
7. Digitize faults in, 3D Seismic volume
8. Model complex geobodies

- Vp
- Bulk Density
- Pp
- Framework model
- Bulk density
- Lithology
- Porosity
- Elastic parameters
- Strength parameters
- Pp
Keathley Canyon Horizons in Petrel
Keathley Canyon - preliminary bulk density volume

Gardner’s relationship:
\[ \text{RhoB} = a(V_p)^b \]

Coefficients for mudstone: \(a=1.75, b=0.265\)

Coefficients for sandstone: \(a=1.66, b=0.261\)
Faults are not explicitly modeled in ITASKA’s initial surfaces data set
ITASKA’s Modelling Workflow

- **Zmap Translator**: Translates Zmap files into triangular patches in 3DShop.
- **Base 3DShop**: Uses a Octree method to refine a coarse mesh in areas of interest.
- **Local Octree Refinement**: Reads volume properties from the grid file and assigns them to individual FLAC3D zones.
- **PETREL**: Translates Zmap files into triangular patches in 3DShop.
- **Volume Property Translator**: Reads volume properties from the grid file and assigns them to individual FLAC3D zones.
- **FLAC3D**: Result
Geologic Horizons in ITASKA’s 3DShop
Proposed Next Steps 2007

**ITASKA**
- Read Petrel property volume
- Design the software interface
- Perform a sample geomechanical calculation in FLAC3D

**Schlumberger**
- Refine the input velocity model
- Introduce well log data and perform log-guided seismic inversion
- Construct geomechanical property volumes
- Perform a sample geomechanical calculation in FLAC3D
Questions/Discussion