Seismic monitoring of hot and cold heavy oil production

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Seismic monitoring of steam fronts done in cooperation with Husky Energy.
Contributers of Slides to this Talk

- Katherine Brittle
- Jon Downton
- Brian Hoffe
- Larry Lines
- Brian Russell
- Rob Stewart
- Ian Watson
- Alberta Research Council
Alberta Government Funding

- AOSTRA Project Funding for “Hot Flow” Monitoring 1999-2000 was funded for $340,000.
- COURSE Project Approved for 2001-2004 for amount of $181,200.
Why are we interested?

- Canadian oil sand deposits = 1.7 trillion barrels of bitumen, an estimated 300 billion are recoverable.
Recent Study Area

Steam Drive Production
Pikes Peak Sample

- Core samples of Waseca sands were used in velocity measurements
Different Ways to Examine Time-Lapse Differences

- Difference of migrated time sections for repeated surveys
- Difference in impedance inversion estimates
- Differences in AVO responses
- Changes in VP/VS ratio
Reflectivity Difference Section
AI Difference Section
AVO Sections (from Jon Downton)

Full offset stack

Channel

Delta-Lambda section

Channel

Fluid stack

Channel
2000 P-P (vertical component)
2000 P-S (radial component)
Vp/Vs isochron ratio (Mnvl to L.Mnvl)
Importance of “Cold Flow” Monitoring

• Several oil fields in Alberta and Saskatchewan involve production of heavy oil sands without use of steam injection.
• There are zones of very high porosity created by production termed “wormholes”.
• Question: Can the effects of “wormholes” be detected by seismic monitoring?
Wormhole Schematic

- Wormhole schematic following cold production
- Miller, et al. (2001 CIM Petroleum Soc.)
- Laureshen (2001)
Building “Wormholes”

- Alberta Research Council has built “wormholes” in their reservoir simulation laboratories
- References: Tremblay et al. (1998 SPE/DOE symposium)
- Sawatzky (2001)
“Wormhole Models”

- Increased porosity and permeability occurs in “wormhole tubes”
- References: Tremblay et al. (EAGE Symp., 1999)
- Sawatzky (2001)
Wormhole Seismic Velocity Model

- Input “wormhole” seismic velocity model into finite-difference wave equation synthetic seismogram program
Synthetic Seismograms

- A seismic response from “wormholes” will require very high frequencies (khz range), mega size wormholes, or an effective medium (many wormholes)
Conclusions

• In “hot flow”, seismic monitoring tools include differencing of reflectivity, impedance, AVO, and VP/VS ratios.
• In “cold flow”, it is not clear whether we can detect the effects of “wormholes” by seismic methods.
Please stand by for future developments.