Distributed Sensing in Offshore Fields: Seismic and Flow Monitoring for Reservoir Characterization

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Outline

- Introduction
- DAS Seismic Measurements and 4D
- Seismic Acquisition during Production monitoring
- Conclusions
Why Use Distributed Acoustic Sensing Offshore?

- More Fiber Optic is being deployed in complex wells i.e. smart well monitoring, deep water
- FO is deployed to lower the number of interventions in wells
- FO being deployed as part of life of well monitoring
- DAS measurements can either be used by reservoir/petroleum engineers or geoscientists
- Geoscience applications are seen as an add-on while monitoring wells → Lower intervention costs compared to conventional tools
Distributed Sensing 101

- How DAS Data Is Converted Into Waterfall Visualizations

![Diagram of Distributed Sensing](image)
Advances in Interrogator Technology are yielding higher SNR
Repeatability in DAS and CO2 Plume Tracking with TimeLapse VSP

Repeatable DAS Surveys capture subtle amplitude anomalies from CO2

- MultiWAW source geometry is low cost and suitable for aerial tracking of plumes

Oropeza-Bacci et al. CSEG 2017
Field QC - Gauge length impact on SNR

Change Interrogator Settings in Real Time to ensure best quality Signals

- 7m Gauge
- 16m Gauge
Gauge Length Modeling i.e. Deep Targets

i.e. estimate the longest Lg without introducing a notch in the spectra

Lg=16m

Notch in spectra

Lg=32m

RTM @40Hz
Smaller Boat – Lower Costs → Same Quality Image

32m Gauge Length

Decreasing Airgun Size →

Wang et al. 2017
Reduced Source Size and Coverage for Low-Cost Reservoir Monitoring

Targeted source footprints and smaller boat size

Multi-Well Acquisition on producing and shut-in wells provide complementing views of the reservoir

Tatanova et al. 2017
GOM: 4D Reservoir hardening and softening

Multiwell 4DVSP: Water Injector, Gaslift producer(s) and Inactive
NRMS 7%
Smaller Faster Surveys: 36000 shots ~ 6000 shots; 5110in³ - 500in³

Zwartjes et al. 2017
Blow Gas Cloud - Offshore SE Asia

55000 Shots; Three Highly Deviated and Producing Wells

Reflections are images below gas cloud with DAS receiver sensors

AbdulRahim et al, 2017
Below Gas Cloud - Offshore SE Asia

Multiwell 3DVSP acquired during dual production string activity

Signal analysis enables us to extract seismic data from variable production noise

AbdulRahim et al, 2017
A single DAS measurement can convey different information in different frequencies:

- **Low** frequencies:
  - Liquid transport
  - Fluid interfaces
  - Thermal disturbances

- **Medium** frequencies:
  - Flow through ICVs
  - Flow past obstacles

- **High** frequencies:
  - Flow through GLVs
Assess Entire Reservoir Production Over Time

PLTs are single snapshot measurements – Fiber shows the dynamic variations.

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Conclusions

- DAS IU can measure seismic waves from active or passive sources and fluid signals from the well engineering
- Changing optical settings in the IU can enhance the responses that are of interest → Not all signals are created equal and should be interrogated with certain considerations
- DAS data is repeatable and suitable for low-cost 4D seismic surveys
- Dual DAS measurements can enhance signal processing across multiple disciplines → Geophysicist’s Noise can be Petroleum Engineer’s Signal!
- Opportunities for fiber sensing may include subsea
Questions

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