Summary

The course aims to give attendees firstly a knowledge of the theory and practicality of microseismic monitoring and secondly an understanding of the problems to avoid and the methods that promote success. It will cover the essential geophysics and engineering aspects of this technology and provide information to promote best practice when contracting for a microseismic monitoring service/installation.

Learning Outcomes

Participants will learn to:

1. Investigate the basics of microseismic event location.
2. Assess what drives location precision, accuracy and error (learn about the semantic and operational ambiguity of uncertainty).
3. Judge the importance of the velocity model in terms of error, (in)appropriateness and calibration.
4. Discern the difference between inversion and imaging methods and the practicalities of surface and downhole methods.
5. Assess the history of this technology, its development and the direction it is now taking.
6. Evaluate a microseismic service report, gauge the quality of the raw data, the quality of the results and query the analytical strength of the conclusions.
7. Select best practices when contracting for microseismic services.

Duration and Training Method

A three-day classroom course. Discussions of case histories and exercises augment lectures. Each attendee will have access to a PC supplied with a VM containing visualization and processing software.

Who Should Attend

This course has been designed for both geophysicists and engineers who wish to develop a sound general understanding of this technology and fill in a few technical gaps.

Prerequisites and Linking Courses

There are no prerequisites for the course, but a familiarity with geophysical methods and/or stimulation techniques as well as some experience working with resource plays would be of benefit. High-school math will be enough to understand the mathematical section to this course.

Basic Application level exposure to seismic principles is offered in N085 (Introduction to Seismic Interpretation) and to completion techniques in N967 (Introduction to Reservoir Engineering).

Linked Skilled Application level courses include N206 (Seismic Tools for Unconventional Reservoirs), N250 (Evaluation Methods for Shale Reservoirs) and N944 (Shale Gas and Shale Oil Completions Using Multi-Staged Fracturing and Horizontal Wells).
Course Content

The recording and analysis of microseismic activity is a technique that allows us to observe stress changes taking place in a reservoir in both space and time and to use this information to relate the rheology of the sub-surface geology to fluid movement and pressure change. The course will cover the geophysical basis to event location, the importance of network design in understanding resolution, accuracy and artefact. A discussion on the impact of picking accuracy, velocity model accuracy will help to dispel some of the myths associated with hypocentral mis-location.

The content of this course should provide enough information to promote best practice when contracting for a microseismic monitoring service/installation and to guide any interested participant to find more advanced information on this topic.

Introduction and overview

1. Introduction

2. Historical context
   - Technology development and transfer of technology to oil and gas industry
   - Development within oil and gas industry

3. Why monitor microseismic activity?
   - Geomechanical change in sub-surface
   - Applications:
     i. HFM: Geometry, infill
     ii. Production: fault reactivation, compartmentalisation
     iii. Cap rock integrity

Some fundamentals of Seismology

4. Earthquake seismology and geomechanics
   - Type of Faults/Failure
   - Intro to Source mechanisms
     i. Focal mechanism, moment tensors
   - Source parameters
     i. Stress drop, fault radius, moment, magnitude
   - B-values
   - Mohr circle failure criterion

Microseismic Data Collection

5. Data
   - Source signal
i. Bandwidth, Size, Directionality
   - Transmission
     - Effect of rheology of sub-surface and well completion
   - Tool/system response
     - Resonance, noise, sensitivity, coupling
     - Surface recording techniques and borehole tools
     - Tool/system limitations: sample rate, resolution
   - External influences
     - Noise sources, tool movement,
   - Practical effects of these issues
     - Network design and geometry on location
     - Use of perf, sliding sleeve, jet pack, coil tubing, etc.
     - Recording distance, noise, well conditions
     - On pad vs off pad recording on noise conditions

Technology applications and discussions

6. Interpretation
   - Coping with inaccuracy and uncertainty
     - Recording geometry issues, known velocity, formation issues
   - Complicated wavefields

Case histories summaries and Workshop session

7. How to QC a Microseismic Monitoring job
   - Signal to Noise
   - Error Estimates
   - Common processing issues and how to identify them.

8. Case histories
   - Cap Rock
   - Tight Gas Sands, fluvial
   - Tight Gas Shale
   - Fault reactivation
   - EOR operations
   - “Other” Data integration examples
     - Surface/downhole and Imaging/Inversion
     - Tilt, microseismic

9. Workshop session: Exploration and clarification of common misunderstandings and answers to questions arising during the course
   - Why do tensile fracs generate shear events?
- Why straddle the perf?
- Does a larger pumped volume mean more events?
- How accurate is a good location?
- How uncertain is a bad location?
- What does aseismic mean?
- Why is tensile failure so quiet?

10. Summary

- New developments in microseismic
  i. Surface microseismic
  ii. Migration, semblance methods, etc.
- Looking forward with microseismic monitoring technology
- Technology gaps
- Synergy with other techniques
- Digital oilfield

11. Hands-on Microseismic Processing Session

The purpose of this part of the class is to familiarize the attendee with microseismic waveform data, microseismic image volumes and the effects of stacking/picking and velocity models on the locations.

Data Example

- Review project geometry
  i. Receiver geometry and horizontal orientation
- Analysis of Event Waveforms
  i. Source stack
  ii. Receiver stack
  iii. Filtering
  iv. Picking P and S waves
- Velocity model considerations
- Effects of picking
- Effects of velocity model