N206: Seismic Tools for Unconventional Reservoirs

Instructor(s): Heloise Lynn

4 Days	Competence Level: Skilled
Classroom Course	

Summary

E & P professionals completing this course will understand the theory and the practical application of multi-azimuth PP 3D surface seismic and well-bore technologies including microseismic monitoring. Participants will acquire the skills required to actively participate in the planning of data acquisition and processing of azimuthally dependent 3D seismic surveys and VSPs and also the interpretation skills required to analyze data from azimuthally anisotropic unconventional reservoirs. A discussion of the use of multi-component 3D is offered, if participants have multi-component data back in their office.

Learning Outcomes

Participants will learn to:

1. Understand the fundamentals of seismic wave propagation in anisotropic media and the relevance of wide azimuth multi-component and PP seismic technologies in the evaluation of unconventional reservoirs.
2. Recognize the importance of symmetry in the subsurface and how it might impact seismic wave propagation and data interpretation.
3. Utilize data sources such as outcrop information, core analyses, cross dipole sonic logs, VSPs, passive (micro-seismic) monitoring, and other down-hole tools to calibrate seismic responses from fractured reservoirs.
4. Provide direction in the planning of 3D seismic and VSP surveys to achieve exploration objectives.
5. Supervise seismic data processing activities to preserve azimuthally- dependent parameters such as travel times, frequency, phase, and AVO.
6. Assess the relevance of various seismic attributes from azimuth sectored pre-stack time migrated 3D data.
7. Construct workflows using multi-attribute seismic data to characterize unconventional reservoirs.
8. Provide direction in the planning of drilling programs.

Duration and Training Method

This is a four-day classroom course with lectures augmented by case history discussions and daily exercises.

Who Should Attend

This course has been designed for geoscientists familiar with the basic principles involved in seismic reflection and VSP technologies and who have an interest in the exploration and/or development of unconventional reservoirs. Prospective students should also have a minimum of one-year's experience interpreting 3D seismic data before attending this class.

Prerequisites and Linking Courses

Geoscience personnel without significant exposure to seismic principles should consider taking N085, "Introduction to Seismic Interpretation", or N080 "Geophysics for subsurface professionals" before taking N206. For those desiring optional preparation material, please read the textbook "Multicomponent Seismic Technology", by Hardage, DeAngelo, Murray, and Sava, (SEG, 2011). This book will be provided for student review during the course.

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Course Content

Day 1:

- Overview: Why anisotropy is a useful tool for unconventional reservoirs
- Fundamentals of P and S wave propagation: Isotropy, layer and azimuthal anisotropy, homogeneity, heterogeneity, unequal horizontal stress, the Thomsen parameters
- Symmetries of sedimentary rocks: VTI (flat layers), HTI (unequal horizontal stresses and/or 1 set of vertical aligned fractures), ortho-rhombic (flat layers + vertical cracks and/or the tri-axial stress field having one stress truly vertical), monoclinic, triclinic
- Multi-component terminology, shear wave splitting
- Robust seismic measurements of anisotropic parameters
- Introduction to passive seismic (micro-seismic) monitoring
- Acquisition considerations: full azimuth/full offset 3D surveys; P-P, P-S, vertical component and 3C receivers
- Exercise

Day 2:

- 3D wide azimuth data processing: P-P goals, issues, techniques.
- Offset Vector Tile binning to optimize PSTM results
- Sectored azimuthal traveltime analysis vs. non-sectored approach
- Pre/post stack inversion: Azimuthal P and S impedance
- Support data: Multi-azimuth VSPs, crossed dipole sonic, FMI/FMS, borehole televiewer, World Stress Map, outcrops, oriented cores, local structure maps, production data, interference data, multi-well testing
- Case History: Micro-seismic monitoring (surface and down hole) combined with surface seismic measurements
- Exercise

Day 3:

- Rock physics
  - Lab measurements of VP and VS in non-fractured rock
  - Rock properties that affect VP/VS
  - Geomechanical properties that affect P and S wavefields
  - Lab measurements of S velocity behavior in fractured rock
  - Exercise
- Determining fast-S and slow-S azimuths with 3C data
- P-wave propagation in fractured rock
- Stress and fracture concepts
- Exercise

Day 4:

- Interpretation techniques (P-P): Azimuthal analyses of travel times and AVO

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- Hydro-fracture considerations, inherent reservoir strength (mineralogy, composition, porosity, cementation), in-situ horizontal stress field, paleo-strain features (existing faults and fractures).
- Exercise: Modeling of P-P and P-S amplitude responses
- Overview of mapping software for interpretation purposes
- Exercise
- Overview of microseismic monitoring
  -Fundamentals and data collection
  -Interpretation
  -Case histories