TETRA TECH RPS ENERGY | TRAINING

N074: Geological and Seismic Interpretation of Thrust Structures for Exploration and Reservoir Characterization *(Montana, USA)*

Instructor(s): Peter Hennings

Format and Duration

Field - 5 Days
Moderate Physical Demand

Summary

The class uses interwoven outcrop observations, seismic exercises, lectures, and a comprehensive class project to teach fundamental and advanced concepts in the geological and seismic interpretation of thrust structures and systems to improve skill and confidence in interpretation approach and ability the characterize structurally-complex reservoirs.

Business Impact: This course equips participants with essential skills for accurate geological and seismic interpretation, directly enhancing decision-making in exploration and development projects including CCS, ultimately leading to more efficient resource extraction and reduced operational risks.

Learning Outcomes

Participants will learn to:

1. Analyze thrust structure and system geometry and kinematic evolution by applying principles of critical wedge mechanics, demonstrating an understanding of how thrust systems evolve over time and space.
2. Interpret reflection seismic data to identify and evaluate structural features, ensuring geometric admissibility, kinematic compatibility, and mechanical consistency in interpretations.
3. Apply kinematic and mechanical concepts to develop and refine interpretations of complex geological structures, integrating surface and subsurface data to produce cohesive models.
4. Evaluate the role of mechanical stratigraphy in controlling the geometry and evolution of thrust structures, and use this understanding to inform structural interpretations.
5. Interpret thrust imbricates, wedges, and duplex systems within a larger compressional framework, demonstrating the ability to connect individual structures to system-scale processes in both 2D and 3D contexts.
6. Assess the manifestation of geological structures in reflection seismic data, applying structural interpretation techniques to improve accuracy and reliability in subsurface mapping.
7. Develop a systematic approach to structural interpretation and analysis, gaining experience in identifying key features and understanding their implications within a broader geological context.

Training Method

A five-day field course comprised of fieldwork, lectures, practical exercises, and an integrated interpretation project. Approximately 60% of the course time is dedicated to fieldwork, with the remaining 40% spent in the classroom. Discussions and presentations take place on two evenings.

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Physical Demand

The physical demands for this class are MODERATE according to the RPS field course grading system. Fieldwork is in central Montana, where conditions can range from cold and wet to warm and dry. Participants will be taking numerous short walks and three longer hikes that range in length between 4-4.8 km (2.5-3 miles) with elevation gains ranging between 180 and 275 m (600-900 ft). The field locations are at elevations up to about 1,900 m (6,200 ft), which may lead to unexpected fatigue or shortness of breath for some participants. Transport is by SUVs. Driving is on blacktop roads and mostly improved dirt roads to the field locations.

Who Should Attend

The class is suitable for exploration and development geologists and geophysicists concerned with seismic imaging, seismic interpretation, structural analysis, or geomodeling in petroleum systems or CCS projects with compressional structural elements.

Course Content

The class is based in the Rocky Mountain Front Ranges of western Montana. The main topics discussed are:

1. Seismic structural analysis of compressional systems
2. Overview of the architecture of compressional structural styles
3. Detailed 2D and 3D interpretation approaches and computer techniques
4. Cross-section construction and analysis

Elements considered include thrust belts and foreland basins, deep-water toe-thrust systems, and basement-involved structures. A critical consideration of the course is the integration of 2D and 3D interpretation methods required to properly construct 3D models that can be used for quantitative prediction.

Near the end of the course, participants integrate seismic data with complex velocity architecture with first-hand outcrop observations to develop a geometrically and kinematically viable thrust belt cross-section. During this exercise, computer-aided cross-section and analysis techniques are used to demonstrate appropriate methods for quantitative treatment.

The following itinerary may change due to weather or accessibility:

Day 0 - Travel to Great Falls, Montana

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1. Arrival in Great Falls, MT, and transfer to Choteau, MT.
2. Evening lecture – Introduction of the course, structural geology of the Northern Rockies, discussion of objectives, introduction of the week-long class interpretation project
3. Overnight in Choteau, MT

Day 1

- Field Module – Sun Canyon area (2D internal architecture of thrust belts)
  - Setting and regional geology of the Montana Disturbed Belt and Sawtooth Mountains
  - Overview hike of Sun Canyon geology
  - Role of mechanical stratigraphy in controlling deformation geometry
  - Thrust timing and sequence
  - Thrust fault to fold relationships
  - Mechanisms for formation of 2D thrust structure closure
  - First-hand data collection for the team interpretation project
- Overnight in Choteau, MT

Day 2

- Field Module – Sawtooth Mountain foothills structures along Canal Road
  - Mechanisms of displacement transfer of thrust displacement from strong to weak rocks
  - Manifestation of seismic response in tightly imbricated and folded structures
  - Mechanisms for formation of 3D thrust structure closure
  - Formation and geometry of wedge structures
  - Progress team project
- Lecture Module – Seismic interpretation of thrust structures and systems in 2D and 3D and progress team project
- Overnight in Choteau, MT

Day 3

- Field Module – Teton Canyon and Ear Mountain ONA
  - Hike in BLM Ear Mountain Outstanding Natural Area
  - Teton Anticline cross section interpretation project
  - Impact and utility of critical assumptions in thrust interpretation
  - Interpretation of thrust hanging wall and footwall relationships for 2D interpretation
- Lecture Module – Methods for achieving admissibility in thrust structure interpretation and progress team interpretation project
- Overnight in Choteau, MT

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Day 4

- Field Module – southern Sawtooth Mountain Range
  - McCarthy Peak hike
  - 3D geometry of thrust structures
  - Displacement transfer between large-scale thrust structure domains
  - Mechanisms of thrust imbrication
  - Mechanisms and deformation associated with rapid loss of thrusting along strike
- Lecture Module – progress team interpretation project
- Overnight in Choteau, MT

Day 5

- Final project work, team presentations, course wrap-up discussion
- Late AM - drive to Great Falls for afternoon flights home