

N325: Advanced Structural Interpretation for Petroleum Exploration and Development in Fold and Thrust belts (Pyrenees, Spain)

Instructor(s): Josep Anton Munoz and Ken McClay

Format and Duration

Field - 6 Days
Moderate Physical
Demand

Summary

There is renewed focus on hydrocarbon exploration in fold and thrust belts, both offshore in deepwater fold belts in passive and active margins, and also in sub-aerial belts such as the Sub-Andean fold and thrust belts of South America and particularly in the northern Zagros in Kurdistan, Iraq. This course aims to provide the participants with the modern concepts and tools to carry out effective exploration and development in these structurally complex terranes.

Learning Outcomes

Participants will learn to:

1. Examine thrusts and related structural styles in the field including different fault-related folds and thrust sequences.
2. Identify the structural features typical of regions where multiple deformation events have occurred, in particular the reactivation of faults and structural inversion.
3. Recognise growth strata and decipher the kinematics of structures from their analysis.
4. Compare and contrast the structures produced in extensional, and contractional tectonic regimes and discuss the influence of salt on structural styles.
5. Integrate surface data with subsurface data (seismic and well data) and apply this knowledge in the construction of cross sections and 3D structural models.
6. Apply the knowledge gained to improve structural interpretations or to validate interpretations.

Training Method

A six-day field course. The course will be held in the Ainsa and Tremp regions of the southern Pyrenees fold and thrust belt. The general format will be classroom lectures and practicals in the mornings followed by field exercises in the afternoons.

Physical Demand

The physical demands for this class are MODERATE according to the Nautilus field course grading system. The field area is at a moderate altitude in the Pyrenees, with a high point of approximately 1500 m (5000 ft) and some participants may experience unexpected fatigue or shortness of breath. The longest walk is approximately 5 km (3 miles) on trails that are occasionally steep and uneven underfoot. There are walks of up to 2 km (1.2 miles) most days and participants can expect both hot and cold conditions and should be prepared for wet weather. Please note that days are typically long and the class may not finish until 7 or 8 pm, with the evening meal as late as 9 pm.

Who Should Attend

Geologists, geophysicists and seismic interpreters working in fold and thrust belts in both exploration and development phases of operations. Reservoir engineers will also gain an improved understanding of the effects of contractional stresses on the geometries and internal deformation of carbonate and clastic

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reservoirs. The course is aimed at those who wish to improve their knowledge and understanding of contractional systems to enhance their predictive capability in the subsurface.

Course Content

The Pyrenees is a unique natural laboratory for fold and thrust terranes and shows a great variety of structural styles involving sedimentary successions in different depositional settings. A deepwater fold and thrust belt is exposed in the Ainsa area where structures related to the thrust system, such as fault-related folds and extensional collapse features, are very well expressed. These are good analogues for deepwater fold and thrust systems such as the Atlantic margins and areas in SE Asia. Pyrenean structures also involve a thick succession of Mesozoic and Paleogene carbonates, some of which are detached on Triassic salts giving rise to classic salt tectonic geometries. Fracture systems developed in these carbonates also have a unique potential as analogues for the Zagros fold and thrust belt and other belts involving fractured carbonates. The last stages of the Pyrenean evolution are characterized by emergent thrust systems into a continental foreland basin which display the interaction between thrust-related structures and continental syn-orogenic sediments. Reactivation of Mesozoic extensional faults has resulted in spectacular inversion structures which will also be examined on this course.

Itinerary

Day 0:

- Arrive in Barcelona

Day 1:

- Travel to Ainsa

Afternoon

Classroom session 1

- Introduction to the course – aims, objectives and methodologies
- Geodynamics of fold and thrust belts – deepwater fold belts – sub-aerial fold belts
- Hydrocarbon systems in fold and thrust belts

Day 2:

Classroom session 2

- Introduction to the tectonics and evolution of the Spanish Pyrenees
- Fundamental thrust systems – geometries fault-related folds

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Field Session 1

- Anatomy of a foreland fold and thrust belt – Ainsa transect – Part 1
- A transect from the basement-involved thrust sheets of the axial zone to the central part of the fold and thrust belt – examples of emergent basement involved thrusts, deformed platformal carbonates and allocthonous thrust sheets above foreland basin sediments.

Day 3:

Classroom session 3

- Mechanics of fold and thrust belts
 - Deepwater fold belts
 - Sub-aerial fold belts
 - Dynamic Coulomb wedge systems – analogue and numerical models
- These principal topics will be illustrated with field, seismic examples together with analogue and numerical model examples.

Field Session 2

- Anatomy of a foreland fold and thrust belt – Ainsa transect – Part 2
- Deepwater fold and thrust belts. Geometry and kinematic evolution. Extensional structures associated with fault-related folds.

Day 4:

Classroom session 4

- Thrust fault-related fold systems
 - Fault bend folds
 - Fault-propagation folds
 - Detachment folds
 - Hybrid folds
- These principal topics will be illustrated with field, seismic and numerical model examples. Syntectonic growth strata will also be analysed in these systems

Field Session 3

- Detachment and fault-propagation folds – Ainsa basin
- Detailed analyses of fault-related folds and syntectonic growth strata
- Travel to Tremp at the end of Day 4.

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Day 5:

Classroom session 5

- Fracture systems in fold and thrust belts
- Principles
- Fracture systems in folded carbonates
- These principal topics will be illustrated with field, seismic and numerical model examples. Syntectonic growth strata will also be analysed in these systems

Field Session 4

- A transect from the central part of the fold and thrust belt to the foreland basin– examples of stacked thrust systems, detachment folds and growth strata in foreland basin sediments. Thrust sequences.

Day 6:

Classroom session 6

- Inversion structures in fold and thrust belts
 - Principals of inversion
 - Modelling of inversion
 - Effects of pre-existing basement features in fold and thrust belts
 - Fracture systems in inversion structures
- These principal topics will be illustrated with field, seismic and numerical model examples. Syntectonic growth strata will also be analysed in these systems

Field Session 5

- Fracture systems in detachment and fault-propagation folds
- Detailed analyses of fracture systems, characterization and analyses
- Inversion structures – Tremp basin
- Boixols and San Cornelli anticlines – inversion folds in carbonate platformal sequences, growth strata and fracture systems in carbonates

Day 7:

- Return to Barcelona
- End of Course