

N142: Structure and Fault Systems in Hydrocarbon Exploration and Production (*Southern Pyrenees, Spain*)

Instructor(s): Josep Anton Muñoz and Eduard Roca

Format and Duration

Field - 6 Days
Moderate Physical Demand

Summary

This field and classroom course examines the structural interpretation of fault systems in contractional and extensional tectonic regimes from outcrop to regional scale. The Spanish Pyrenees are a magnificent natural laboratory in which to study thrust structures, as well as inverted extensional basins. These basins exhibit facies and geometries of syn-rift sediments, enabling analysis of extensional fault geometries and subsequent inversion.

Learning Outcomes

Participants will learn to:

1. Characterise thrusts and related structural styles in the field including different fault-related folds and thrust sequences.
2. Evaluate extensional fault systems at crustal and outcrop scales and analyse extensional fault geometries and related structures in 2D and 3D.
3. Determine the structural features typical of regions where multiple deformation events have occurred – in particular the reactivation of faults and structural inversion.
4. Interpret growth strata and decipher the kinematics of structures from their analysis.
5. Analyse the influence of salt on extensional and contractional structural styles.
6. Integrate surface data with subsurface data (seismic and well data), apply this knowledge in the construction of cross sections and 3D structural models.
7. Apply the knowledge gained to improve structural interpretations or to validate interpretations.
8. Analyse the influence of fracture systems and fault sealing on reservoir production/performance.

Training Method

A six-day field course with field observations and exercises supported by classroom lectures. The proportion of field time to classroom time is approximately 80:20. This course will also make use of Digital Outcrop Imagery (DOI).

Physical Demand

The physical demands of this class are graded MODERATE according to the Nautilus Training Alliance field grading system. The field area is at a moderate altitude in the Pyrenees, with a high point of approximately 1500 m and some participants may experience unexpected fatigue or shortness of breath.

The longest walk is approximately 3 km (1.8 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

The course is aimed at non-specialist explorationists, geologists and geophysicists wishing to improve

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their understanding of structural geology, particularly in regions of multiple deformation. The course is suitable for early to mid-career geoscientists or new hires with some background in structural seismic interpretation. Experienced workers may also benefit from the course as an update and refresher to modern structural geological thinking.

Course Content

This is a six-day combined field and classroom course which aims to review the fundamentals of structural interpretation of fault systems and related structures. The course will cover contractional and extensional structural regimes from outcrop to regional scale. It will be held in the southern Pyrenees of Spain to take advantage of the excellent exposures of this magnificent natural laboratory. Field case studies will be combined with seismic examples, numerical models and exploration case studies.

The course will be based in the Can Boix resort (www.canboix.com). This hotel is located at the South-Pyrenean thrust front and is a superb locality for thrust tectonics related topics. It is also close to an inverted extensional basin which beautifully demonstrates tectonic inversion geometries. Well-preserved facies and geometries of the syn-rift sediments will enable discussion of the extensional fault geometries of this inverted basin.

Structural models

- Construction of cross-sections and 3D structural models from surface and subsurface data.
Restoration and forward modelling
- Fault systems
Geometry and definition of the main geometrical features. Types of faults and fault classification.
Fault-related rocks
- Thrust systems
Introduction to orogenic systems and thrust and fold belts: mechanics and evolution
Geometry of thrust systems: a single surface. Thrust systems. Thrust sequences
Fault-related folds: fault-bend folds, fault-propagation folds and detachment folds
Other kinds of thrust-related folds. Growth geometries of syn-orogenic sediments
Tectonic styles of thrust systems: emergent thrust systems, deepwater thrust and fold belts and thrust fronts
- Extensional fault systems
Introduction to the geometry of extensional systems at crustal scale
Geometry of extensional fault systems and related structures: from a single fault at 2D to complex geometries at 3D. Fault-related folds in extensional regimes
- Inversion tectonics
Introduction: mechanics of fault reactivation. Kind of inversion tectonics
Inversion tectonic geometries and related structures
- Salt tectonics
Structural styles associated with salt tectonics

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Programme

Day 0

- Group assemblies in Barcelona.

Day 1

- Classroom sessions: Introductions. Introduction to the geology of the southern Pyrenees. Introduction to fault systems.
- Field excursion – depart Barcelona, examination of extensional fault systems en route to Can Boix.

Day 2

- Classroom sessions: Seismic exercises of Western Mediterranean and Atlantic extensional fault systems. Discussion of the Catalan Coastal Ranges extensional fault system basen on field and seismic data.
- Field trip to the frontal thrust system of the south-central Pyrenees. The topic of the trip will focus on the thrust geometry of an emergent thrust front and a thrust imbricate stack. Thrust sequences will be discussed on the basis of the geometrical and age relationships between synorogenic sediments and thrust structures.

Day 3

- Classroom sessions: Thrust-related folds. Tectonic styles of thrust systems. Mapping and seismic exercises will complement field observations.
- Field excursion to the Sant Corneli-Bóixols fault-propagation anticline. Geometry from field, seismic and well data. 3D geometry, kinematics and fracture distribution.

Day 4

- Classroom sessions: Inversion tectonics.
- Field trip to the Organyà Early Cretaceous inverted basin. Inversion tectonic geometries. Discussion on different inversion events: inversion in a strike-slip regime and inversion during the Pyrenean compressive event. Geometry of the extensional structures and their relationships with the facies and geometries of the syn-rift sediments.

Day 5

- Classroom sessions: Review of structural styles studied and case studies discussed, related to the different tectonic regimes.
- Field excursion to Boixols anticline to examine carbonate fracture systems and fault sealing capacity.

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Day 6

- Classroom sessions: Growth strata.
- Examination of growth strata in the field.
- Return to Barcelona late afternoon/early evening.