

## N232: Salt Tectonics: Global Styles, Spanish Outcrops (Basque-Cantabrian Pyrenees, Spain)

Instructor(s): Mark Rowan and Josep Anton Muñoz/Eduard Roca

### Format and Duration

Field - 5 Days

Low Physical Demand

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## Summary

**Business Impact:** Participants will develop an understanding of global salt tectonics and its **practical application** to **petroleum exploration, production, and storage**.

In the Basque-Cantabrian Pyrenees, both field exposures and seismic data illustrate thick- and thin-skinned salt structures, extensional and contractional diapirs, halokinetic deformation involving turbidites, and allochthonous salt, in a passive-margin setting subsequently subjected to convergent-margin tectonics. This course covers the fundamentals of salt-related deformation and salt tectonic styles around the world, and includes global seismic interpretation exercises.

## Learning Outcomes

Participants will learn to:

1. Characterise the depositional and tectonic settings of layered evaporite sequences.
2. Understand the influence of different modes of salt tectonics on intrasalt deformation.
3. Assess the role of salt in different tectonic environments including rift basins, passive margins and convergent margins.
4. Evaluate salt structures developed or reactivated during extension, contraction and strike-slip deformation.
5. Appraise and interpret the stratal geometries associated with salt evacuation and passive diapirism.
6. Predict near-diapir stratal geometries and their impact on reservoir distribution.
7. Characterise allochthonous salt geometries on seismic data and evaluate the nature of subsalt deformation.
8. Evaluate the interaction between salt-related deformation and sedimentation in different depositional environments, from fluvial to deepwater.
9. Appraise the likely influence of salt bodies and salt welds on hydrocarbon generation and migration and top seal for hydrocarbons and hydrogen.

## Training Method

This is a combined field and classroom course, in a 60:40 ratio. Classroom sessions will comprise lectures, global case studies, and seismic interpretation exercises.

## Physical Demand

The physical demands for this course are LOW according to the RPS field course grading system; the course requires basic fitness levels. There will be several hikes each day up to a maximum of 3 km (1.9 mi) on tracks, paths, or beaches. Some locations are at elevations of around 1000 m (3280 ft). The field day at Bakio requires some scrambling over tidal foreshores with large, slippery boulders and ledges. Weather conditions can vary widely from hot and dry to cool and wet. Transport will be by coach on paved roads.

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## Who Should Attend

Geoscientists and reservoir engineers conducting petroleum exploration/production or investigating resource/waste storage in areas affected by salt tectonics.

## Prerequisites and Linking Courses

Previous experience of working salt basins is an advantage, but not necessary. A working knowledge of sedimentology, seismic interpretation, and structural geology is assumed.

## Course Content

Classroom modules will address the theory of salt-related deformation, compare to field analogues from elsewhere in the world, and review subsurface data and interpretation from major petroleum basins. Examples include the North Sea, Precaspian Basin, Persian Gulf and Zagros Mountains, eastern Mediterranean, offshore West Africa, offshore Brazil, and the Gulf of Mexico.

Lectures will cover: the tectonic setting of salt basins and the nature of layered evaporite sequences; the mechanics of salt movement; intrasalt deformation; extensional and contractional salt tectonics; salt evacuation and diapirism; near-diapir deformation; the emplacement and evolution of allochthonous salt; salt-sediment interaction; the impact of salt on hydrocarbon maturation, migration and seal.

Field modules will focus on those Cantabrian examples where there is the widest variety of salt styles and sediments. Depositional environments include sub-aerial, shelf clastics and carbonates, and deepwater turbidites. Diapirs were triggered during extension, grew passively, and show different degrees of reactivation during the Pyrenean contractional event. Field examples will be supplemented by seismic and well data over mildly reactivated diapirs offshore in the adjoining Bay of Biscay and over onshore Cantabrian salt structures where they are the focus of research programs for gas storage, carbon sequestration, and hydrogen storage. Cantabria is one of the few areas in Spain in which oil exploration is still active and storage opportunities are being pursued.

## Itinerary

### Day 0:

Arrive in Bilbao.

Group introductions, safety briefing, and introductory lectures.

### Day 1:

Full day lectures interspersed with global seismic exercises. Topics include: evaporite basins; fundamentals of salt tectonics (mechanics, drives, definitions); intrasalt deformation; dissolution of salt; thin- and thick-skinned extensional salt tectonics; translational salt tectonics.

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#### Day 2:

Full day field excursion to Poza de la Sal diapir – Triassic evaporites, contact with overlying strata, initiation mechanism and deformation in surrounding shallow water siliciclastics and carbonates. Includes discussion of local studies on intrasalt storage of carbon or hydrogen.

#### Day 3:

Morning lectures interspersed with seismic exercises. Topics include: thin-and thick-skinned contractional salt tectonics; strike-slip salt tectonics; vertical salt tectonics (salt evacuation and diapirism); passive diapirism.

Afternoon field excursion to Villasana de Mena diapir - near diapir deformation and stratal geometries.

#### Day 4:

Full day field excursion to examine halokinetic deformation surrounding the Bakio diapir: Diapir interior and margins, flanking deformation of adjacent deepwater turbidites and outer-shelf marlstones, major failure of the diapir-roof carbonate platform (debrites and olistoliths), unconformities and onlap. Includes mid-day lecture on halokinetic sequences.

#### Day 5:

Morning lectures: Allochthonous salt, restoration of salt structures; salt and the petroleum system (trap, reservoir, hydrocarbon maturation and migration, seal), wrap-up.

Afternoon field excursion to Sopela beach and summary of Basque-Cantabrian Pyrenees structure and salt tectonics.

#### Day 6:

Depart from Bilbao.