N108: Exploration and Geological Model Development in Fluvial Reservoirs (Ebro Basin, Spain)
Tutor(s): Gary Nichols, John Fisher and Stephanie Kape

Summary
This field based course integrates fluvial sedimentology predictive models with applied exploration and field development, using case studies from the Miocene of the Ebro Basin, Spain. Variations in fluvial architecture are considered in terms of proximal to distal setting within a depositional system and the impact of the architecture on field developments are considered, together with practical guidance on the choices made in building static and dynamic models of these complex systems.

Learning Outcomes
Participants will learn to:

1. Evaluate the sedimentology and basin fill architecture of a fluvial system.
2. Predict significant changes in sedimentology and stratigraphic architecture, both laterally and up or down dip in fluvial reservoir systems.
3. Integrate the interactions of the controls on fluvial architecture.
4. Assess the impact of fluvial architectures, flow zones and sedimentary heterogeneity on potential recovery in different hydrocarbon fluid and development scenarios.
5. Plan how both static and dynamic data can be incorporated to characterise fluvial architecture.
6. Evaluate and rate different modelling options for different architectures, fluids and development scenarios.
7. Manage the issues of up-scaling in heterogenous fluvial systems and select appropriate techniques to use in different scenarios.

Duration and Training Method
A five-day field course in the Ebro Basin, the foreland basin of the Southern Pyrenees. The course is a mixture of field presentations, fieldwork including sedimentological exercises, modelling exercises/discussions and short classroom sessions.

Physical Demand
The physical demands for this class are LOW according to the Nautilus Training Alliance field course grading system. Fieldwork is carried out in the agricultural lowlands of the Ebro Basin. Access to the outcrops is easy, with most localities being roadside stops. The longest walk on the field course is approximately 2 km (1.25 miles) along a relatively flat hillside path. Some short walks up to 0.25 km (0.15 miles) take in river side paths and scrub land.

Who Should Attend
The course is aimed at experienced exploration and development geoscientists, petrophysicists and reservoir engineers who are keen to better understand fluvial systems and the practical application of that knowledge in the generation of effective static and dynamic models of a complex geological setting.

Prerequisites and Linking Courses
N108 is an important component of both the Clastics and field-based Reservoir Development and Modelling
Course Content

Hydrocarbon reservoirs within fluvial depositional settings are challenging environments for geoscientists to interpret and develop. Significant changes in stratigraphic architecture occur over short distances, both laterally and up or down dip, and strongly impact production performance. An understanding of the issues involved in developing different fluvial architectures and the decisions required to model these complex heterogenous reservoirs are critical to predicting the long term production behaviour. Chronostratigraphic control is often poor and sandstone body correlation is difficult because of the multi-scale heterogeneity of fluvial deposits. Predictive models of fluvial systems are the subject of much academic discussion, with sea level controlled models only applicable in coastal regions. Many fluvial systems preserved in the rock record are generated in internally draining basins or far upstream of sea level influence and are subject to different control mechanisms. Observations from modern and ancient analogues suggest that fluvial facies have a wide range of architectures, supported in the subsurface by different production behaviours from similar facies.

The Ebro Basin in northern Spain formed as a foreland basin to the Pyrenean orogenic belt, which developed in the Cenozoic as a result of crustal shortening between the Eurasian plate and the Iberian sub-plate. The Luna and Huesca distributive fluvial systems were coeval, fluvial systems of Miocene age on the northern flank of the Ebro Basin. Both systems show a decrease in channel geometry and grain size distally and there is also a distal increase in the proportion of sheet sandstones interpreted as deposits of unconfined flow events. The distributive fluvial systems were built up by a series of avulsions which built up a fan-shaped body of sediment
with a radial palaeoflow pattern. Exposures allow fluvial channel and overbank facies to be considered at reservoir scale and correlation over tens of kilometres up and down flow can be made. During the course, the differences that might be expected in analogue fluvial systems under different conditions of tectonic setting, climate and sediment supply will be emphasised.

Exercises carried out at outcrops and in classroom sessions illustrate the influence of sedimentological architecture on modelling options for different development scenarios. Predictive facies models will be discussed and their application to understanding the controls on the architectures developed and preserved in the rock record, from both an exploration and development perspective. Understanding the controls on fluid flow behaviour within the reservoir is key to determining how to model it for different development scenarios. The course will explore how to use static and dynamic data to differentiate between fluvial architectures in the subsurface and examine production challenges posed by different sedimentary stacking and sedimentary depositional structures. Questions of scale, from core to log to outcrop to simulation model and then how to upscale in complex heterogeneous environments will be discussed in the field and classroom.

Day 0
Arrival in Barcelona and transfer to hotel
Evening course safety brief and introductory lecture, followed by group dinner in the hotel

Day 1
Drive from Barcelona to Ayerbe
Basin introduction
Fieldwork at Biel (proximal fluvial deposits)

Day 2
Fieldwork at Pertusa (medial system sandstone bodies)
Fieldwork at Monzon (modelling exercise)

Day 3
Fieldwork at Piraces / Vicien (channel belt modelling exercise)
Fieldwork at Albero Bajo (meandering channels)
Fieldwork at Bolea (distal fluvial deposits)

Day 4
Fieldwork on the Aguero Fan (syntectonic deposition)
Fieldwork on the Tormos sheet sandstones (fluvial-lacustrine facies)
Classroom exercise session

Day 5
Fieldwork at Sigena (distal fluvial-lacustrine architecture)
Lunch followed by transfer to Barcelona and departure