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Stratigraphic 3D Modelling of the Eocene Deepwater Systems in the Aínsa Basin (South-Central Pyrenees, Spain)

Modern 3D high resolution seismic surveys usually reveal more detailed reservoir architecture than it was possible in the past. These new data also provide higher lateral resolution of facies variability and stratigraphic architecture which are of primary importance when dealing with deep offshore turbidite reservoirs.

Classical facies models derived from outcrop studies are generally focused on depositional processes and generally don't link precisely the lateral variability of facies with the internal 3D architecture of sandy reservoirs. Facies are still commonly described independently from 3D seismic architecture in a stamp like collection approach.

The resulting reservoir models and the associated numerical models are thus based on oversimplified interpretations of facies relationships which cannot be only justified by data sets, grid size or computers limitations.

As a consequence and as part of a research program sponsored by Total, it was decided to go back to the rocks with the study of the Ainsa sub-basin outcrops with the aim of representing and understanding the 3D geometrical architecture of the infill of several channelised turbidite reservoirs in relation with lateral facies variability.

The 3D architectural model representing the channelised turbidite systems of the Ainsa sub-basin was built using the GOSED software. GOSED is a 3D sedimentary modelling module working within the GOCAD modeling environment. The toolbox provides intuitive and familiar tools for sedimentologists to work effectively within the reservoir modeling workflow by allowing the integration of sedimentological data and sedimentary concepts directly into the 3D modeling environment.

The results of GOSED approaches are 3D sedimentary models which capture the fine-scale heterogeneity at the wells or vertical outcrop cross section and distribute this information throughout the model.

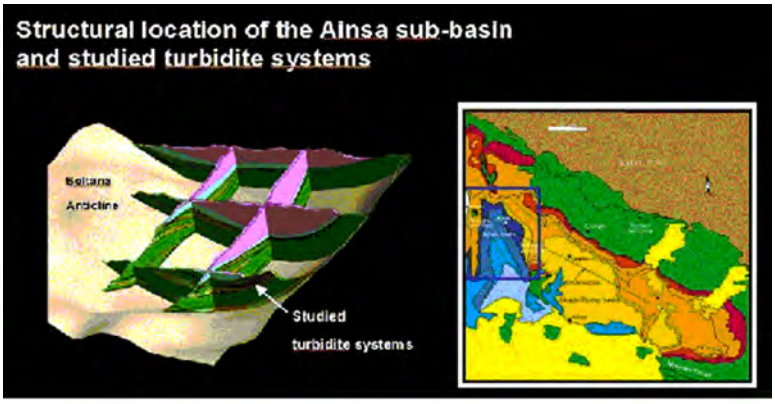

Fig. 1 : Geological setting of the studied turbidite systems and view of the GOSED model.

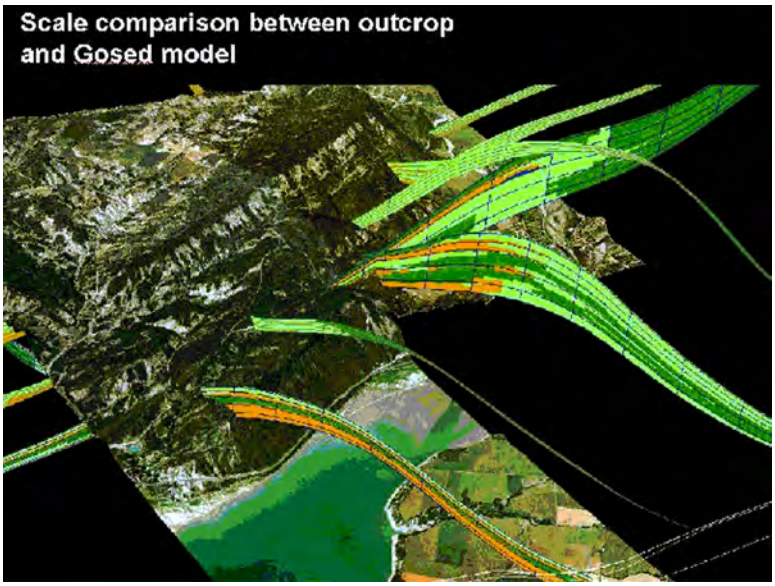

Fig. 2 : Outcrop view and intersection of the GOSED model.

The models have a realistic appearance and are well constrained by well data, cross-sections or by outcrop sedimentological observation and concepts such as with the studied example. This was done keeping in mind an optimum number of cells within the model.

The Gosed toolbox is used at TOTAL research center in Pau and has been successfully applied to subsurface reservoirs like Elgin, Al Khalij and Dalia. GOSED is the only tool specifically developed for conditioning reservoir models with sedimentological information, and comparable tools are not available commercially. Consequently, the tools and associated know-how potentially give Total a competitive advantage in the reservoir characterization stage of field development.

With the studied outcropping turbidite systems, the first step consisted in building a semi-regional conventional 3D structural model with Gocad using structural sections and formation isopachs as only few seismic lines are available here.

Mapping was thus mainly constrained by field work geology. The following regional geological surfaces were modelled in 3D (from base to top): base of Cretaceous, Alveolina Group top, Figols, Castissent and Santa Liestra Groups, and Sobrarbe deltaics.

This 3D structural model was helpful for a full 3D restoration of the main depositional surfaces leading to a quantitative analysis of tectono-sedimentary interactions.

Then a specific area (3D GOSED cube : 17 km x 12 km) was selected covering the entire Ainsa syncline to produce the GOSED model of the Ainsa basin turbidite systems and to display 3D facies distribution. The selected area for detailed 3D sedimentary modeling is shown on Figure 1 with a fence like representation of some selected cross-sections intersecting the present day outcrop topography.

The final product is a field scale continuous gridded model with various (Ex : 1x100x100m) size cells which can be compared with the real small scale geological observations made on the field. Figure 2 is showing how outcrop geology can be compared with the coarse grid numerical model using 3D aerial numerical orthophotos.

Facies and their spatial distribution are simulated using GOSED functionalities like proportion curves and algorithms allowing 3D facies and internal surfaces representation anchored on several drawn interpreted cross-sections

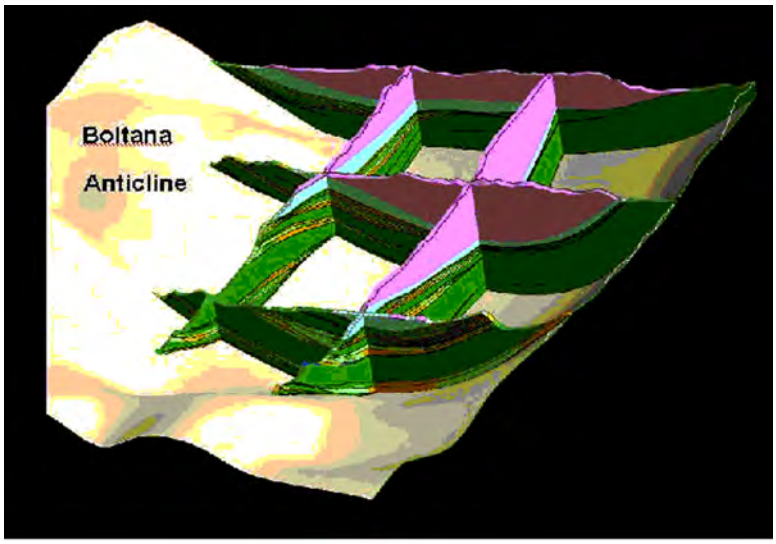

Fig.3 : 3D view of the reservoir scale modeled area intersected by topography

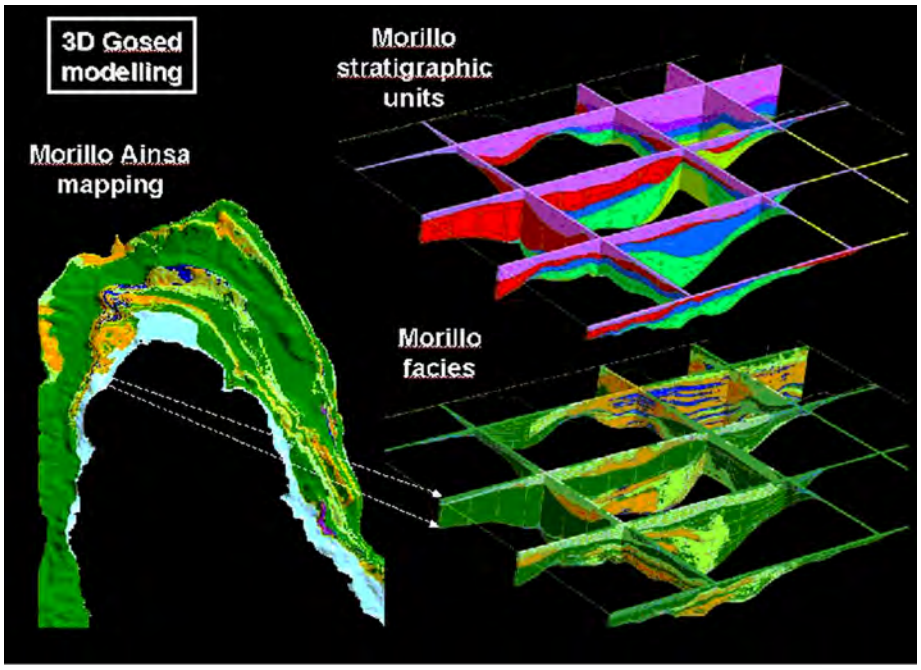

Fig.4 : Final geological outcrop map showing facies distribution and the resulting flattened stratigraphic fence diagram showing facies distribution.

measured cross-sections. More detailed selected fine gridded models (cube : 2km x 1km) were built around selected outcrops allowing fine scale representation of facies and strata relationships.

The integration of the large scale sedimentary geological 3D model with the structural model furnish new insights on how small and large scale turbidite stages and substages facies distribution architecture evolves in 3D in relation with structural deformation linking facies variability and stratal architecture evolution.

The sedimentary modelling of the Ainsa basin provides a unique 3D model allowing interactive field trips for sedimentologist, reservoir engineers and geophysicists.