PS From Conceptual Model to Static Model: A Novel Approach Integrating Seismic and Well Data Replicating Geological Concept into the Modelling Realm in a Basin Floor Fan System, Block 9, Offshore South Africa*

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Abstract

Replicating a geological concept from the mind of a geoscientist has been a fundamental objective in our industry since its birth. Understanding lithological and sedimentological processes and piecing together the sparse bits of available information to create a story, a valid story at that, has led to the continuous discovery of oil and gas. Data quality together with technological advancements has improved our ability to predict more accurately, but the original objective remains: to reconstruct a geological concept into a representative model. This paper elucidates a workflow carried out where well marker data is integrated with seismic amplitude data to generate the basis of (the container) of a 3D static model that accurately replicates the geological conceptual model. The depositional system is described as a fan complex, with an initial erosional phase forming an incised subaqueous channel, subsequently filled with backstepping and progradational mass flow episodes. A distinct seismic anomaly is visible over the channel area, and although it is adequate to delineate the edges of the system, the internal architecture (separation of each fan event) is beneath seismic resolution. An approach to integrate both seismic and well data was adopted; using a seismic attribute (Minimum Amplitude) map to outline the extent of the channel system with individual fans being defined in the wells using well markers based on biostratigraphy data. The result is a series of fan zones that matches the data and is commensurate with the idea of the geoscientist and the conceptual model.

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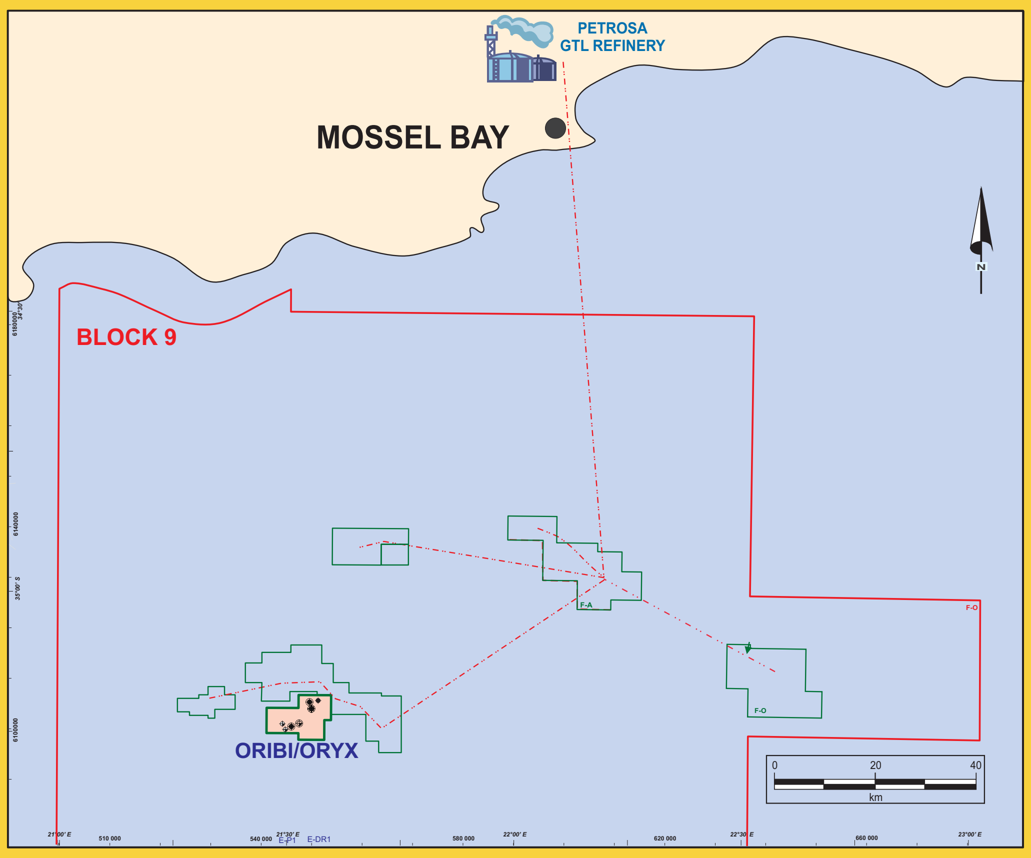
INTRODUCTION

The ability to represent a geological concept formed in the mind of a geoscientist in a succinct and clear manner, to other geoscientists and engineers is and always will be a key fundamental skill to be mastered by interpreters. Until recently, this communication was successfully done through perspective drawings and sketches such as the one on the bottom right of this page. The increased reliance on numerical and computer based exploration and uncertainty quantification, today requires the modern day geoscientist to "translate" the 3D conceptual environment into a numerical model with attributes coded to present geological features. This paper documents a typical workflow where actual observations (well derived data) are populated into a 3D numerical model honouring the geological concept observed by the interpreter, guided by seismic data.



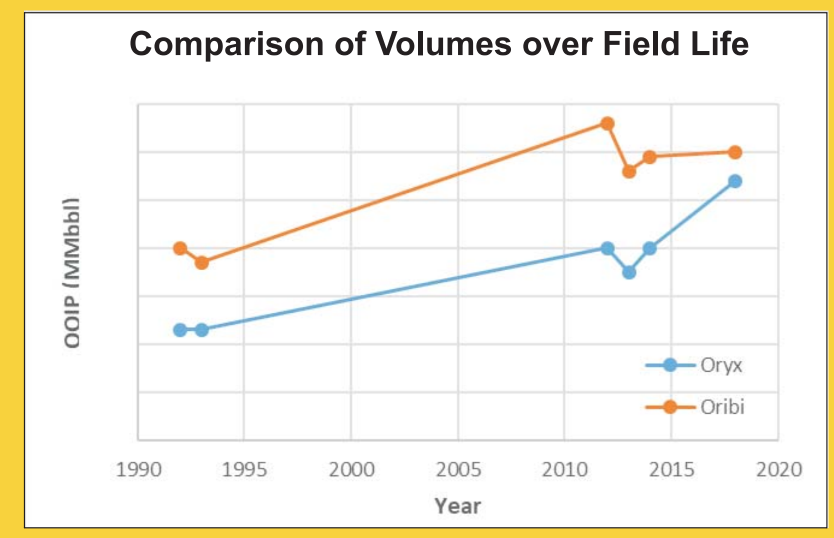
Location Map of Oribi and Oryx Oil Fields

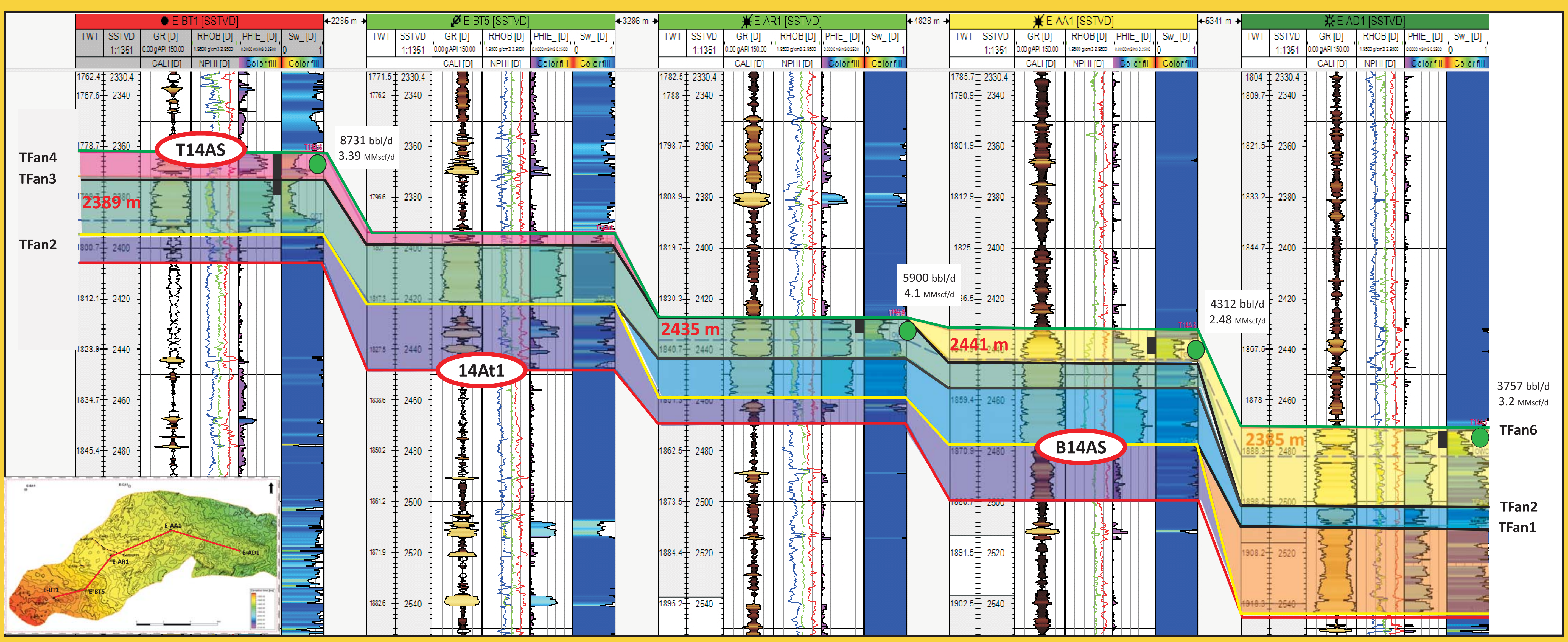
LOCATION & HISTORY

The Oribi and Oryx fields are situated approximately 120 km south south-west, offshore from Mossel Bay, South Africa. The Oryx field was discovered in 1988 and Oribi field in 1990. The fields started production in 1997 (Oryx) and 2000 (Oribi), produced via a floating production facility. Two production wells have been drilled in each field, both being supported by a water injection well. The fields have been shut in since March 2013 mainly because of an unfavourable economic climate at the time. An evaluation to assess the viability of re-establishing production is being done to evaluate the potential of an in-fill production well/s to access the un-swept areas of the fields.

PRODUCTION SUMMARY

To date, 27 MMbbl have been produced from Oribi and 18 MMbbl from Oryx. The combined remaining potential is estimated to be between 15-24 MMbbl. The graph (right) shows how the hydrocarbon-in-place estimates changed over time through the life of production. This is a good example illustrating the inherent uncertainty associated with the subsurface, and the effect that additional data has on the understanding of a field.

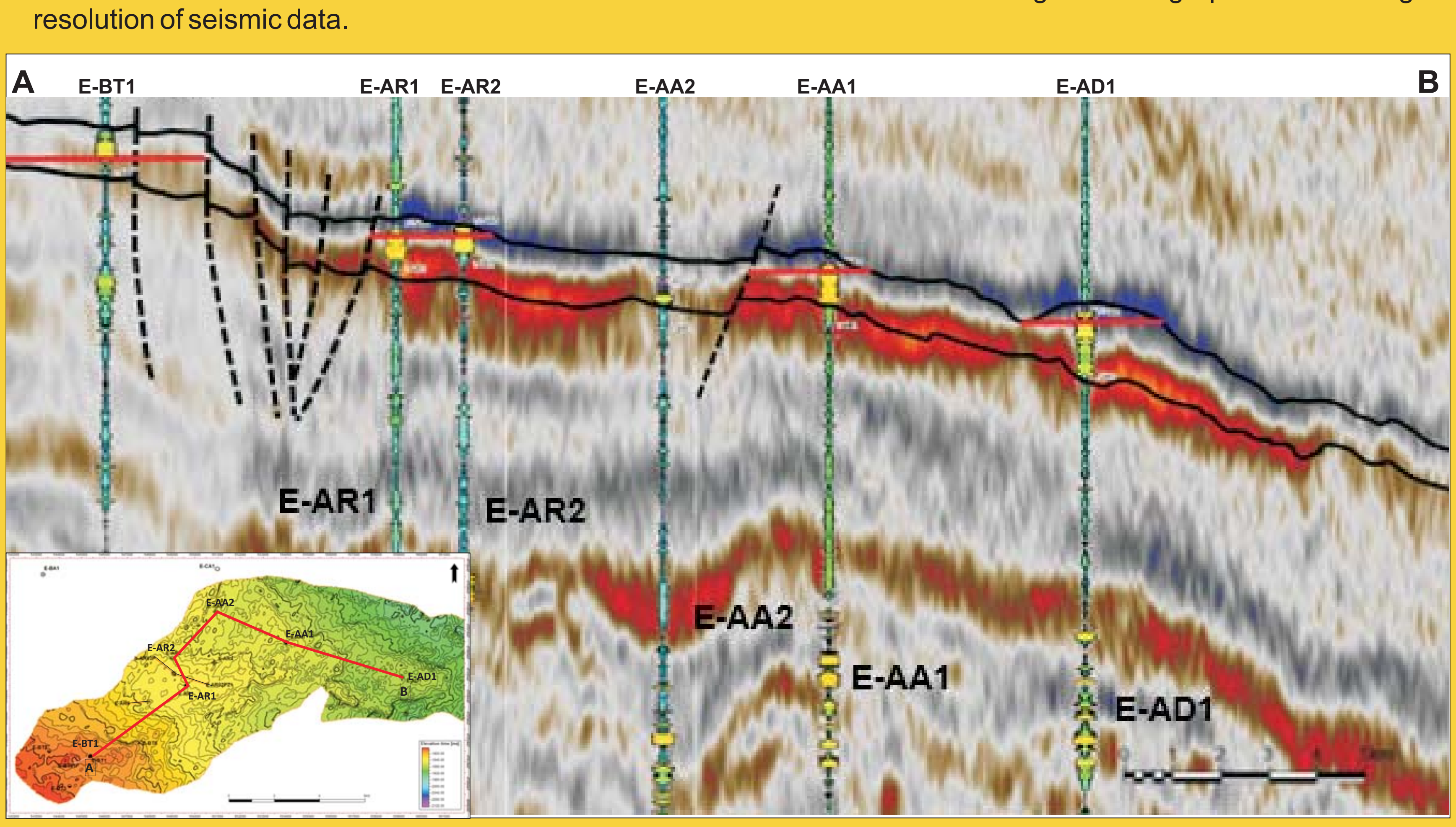




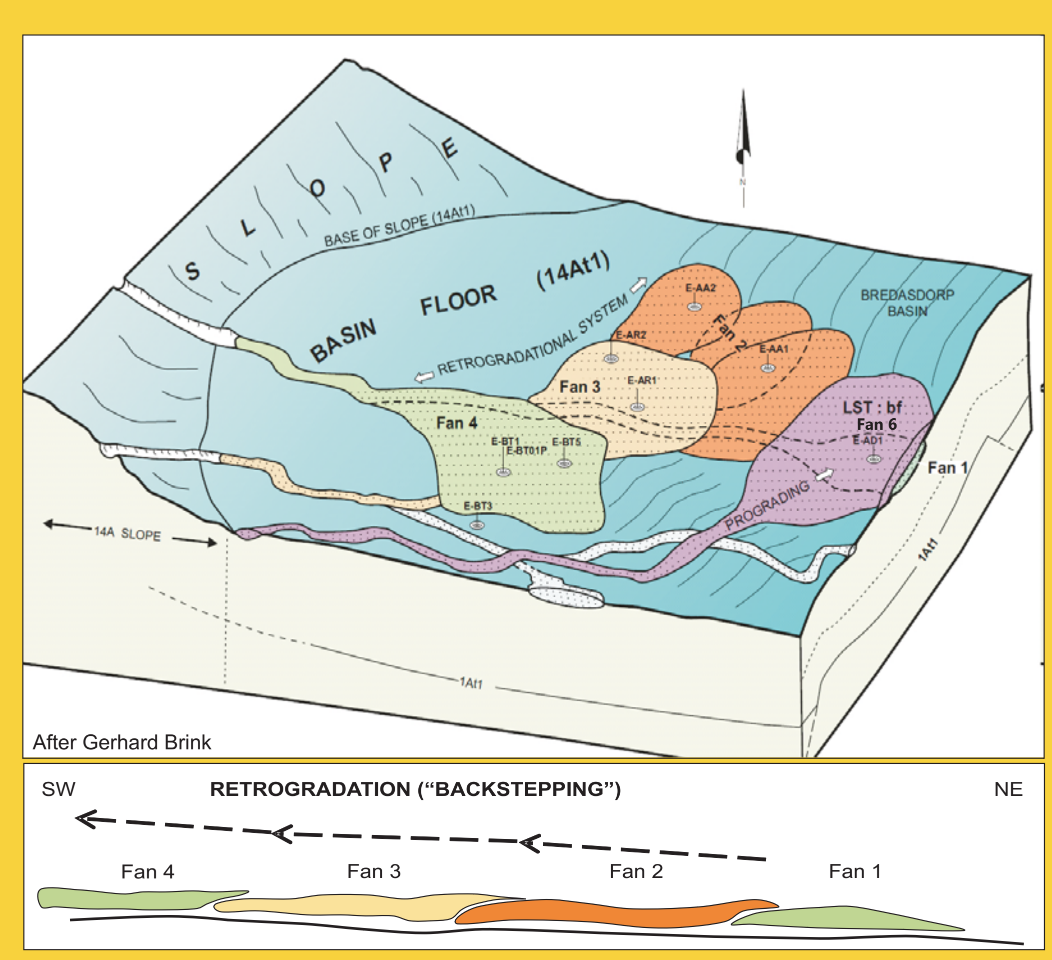
Well Sections showing the interpreted biostratigraphy markers for each individual fan in the main wells of the study

DEPOSITIONAL MODEL & WELL CORRELATION – INCORPORATING WELL DATA

The depositional system of the 14A sequence has been described as a fan complex, with an initial cut/erosional phase forming an incised subaqueous channel which was subsequently filled with sediment (fan deposits) from the west/south-west. Individual fans have been defined in the wells using well markers based on biostratigraphy data thereby confirming the timing of each fan event leading to a confident correlation between wells. Deposition of the sediment began with the first fan over the E-AD area (Fan 1). Three more episodes of fan deposition occurred, backstepping from E-AD towards E-AR and E-BT (Fan 2, Fan 3 and Fan 4). A final progradational event was responsible for Fan 6 being deposited over E-AD and E-AA (distal part of fan). The well section shows the definition of each fan in some of the main wells in the area. This definition through biostratigraphic data is integral for understanding the inter-reservoir unit relationships which are outside the resolution of seismic data.



Seismic section (Far-stack) parallel to the fan body deposition, through the main wells in the area



An Initial conceptual model illustrating the retrogradational deposition of the fan bodies.

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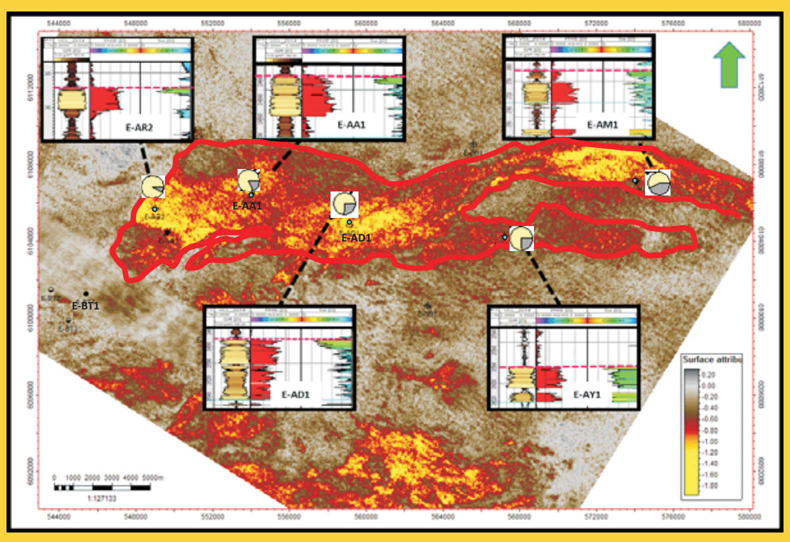
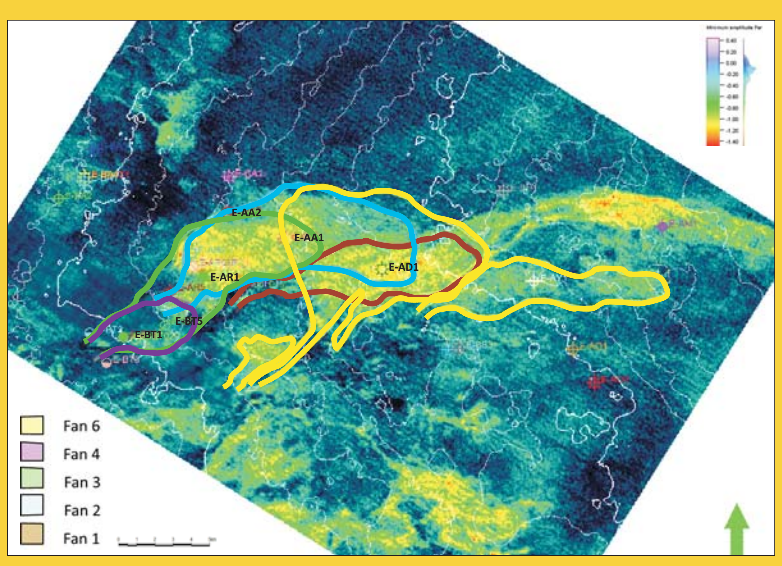
SEISMIC AMPLITUDE & ISOPACH MAPS – INTEGRATION OF WELL & SEISMIC DATA

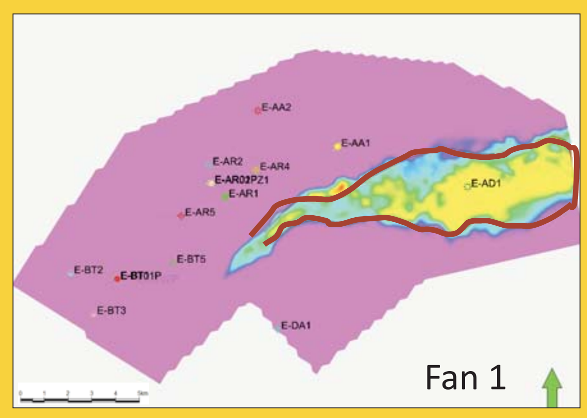
The 14A anomaly is clearly visible on seismic. It signifies the package of depositional events over the area and guides the extent of the channel system as a whole. All individual fan bodies were contained within the defined area of the anomaly. The interpreted zero-line from each fan defined the extent of the fan bodies which were in turn controlled by the generation of isopach maps using the biostratigraphy marker data shown in the well section.

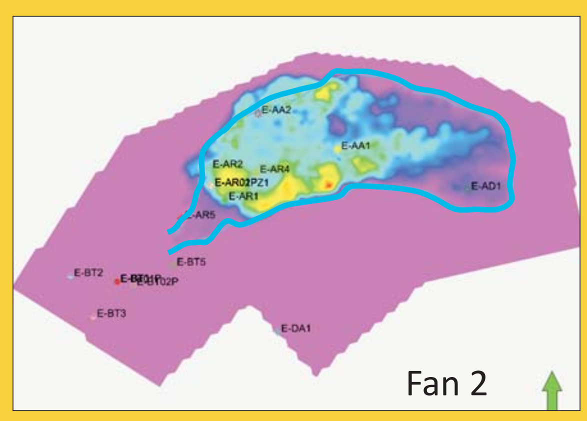


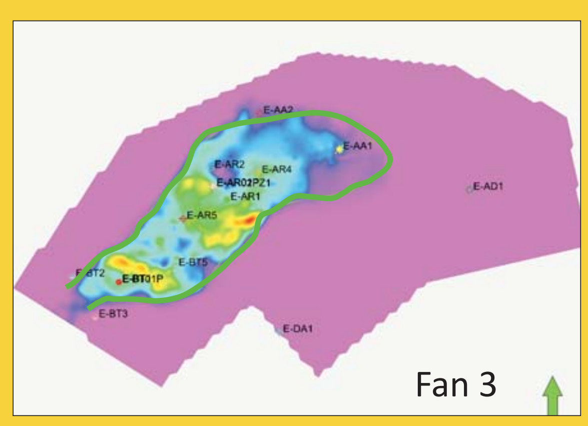
A Minimum Amplitude seismic attribute map (far-stack) was used to define the boundaries of the depositional system (red polygon), essentially delineating the container of the channel system. The pie graphs illustrate the content of sand in each well within the anomaly area.



The zero line for each individual fan superimposed on the Minimum Amplitude seismic attribute map (far-stack).



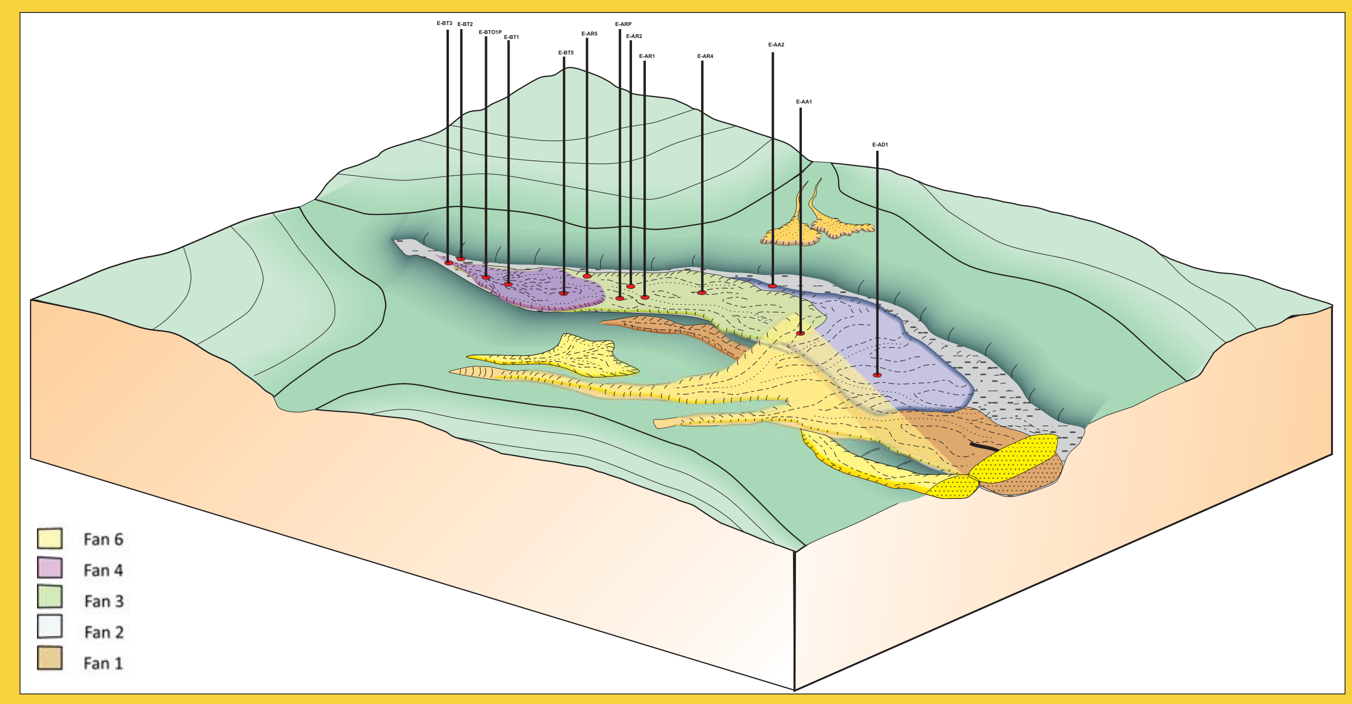


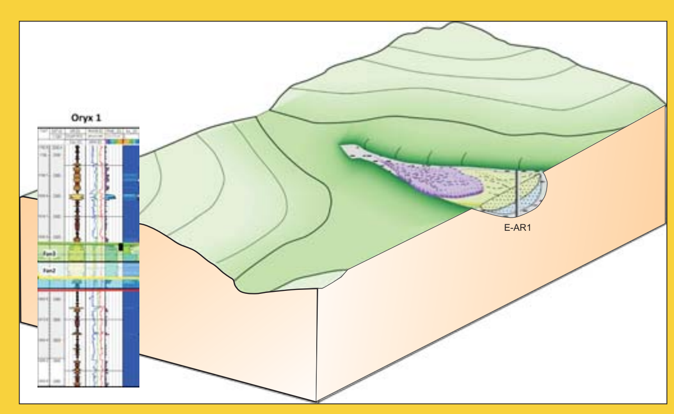


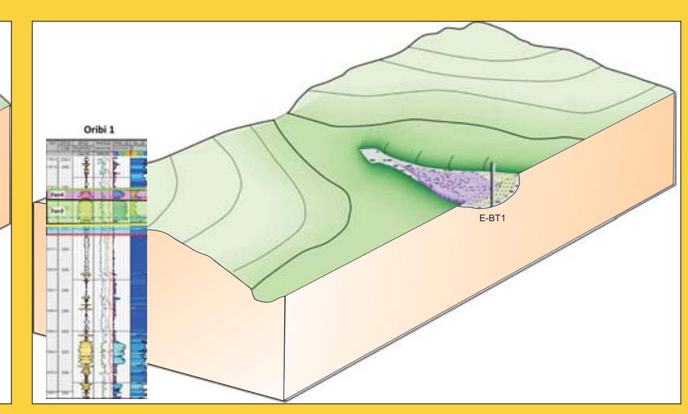
Isopach maps for three of the five fans, constrained by the outer extent of the seismic anomaly and internally controlled by the well data.

APPLICATION INTO THE CONCEPTUAL MODEL

A conceptual model has been created integrating the well and seismic data. Amalgamating this data together with the depositional trend, which indicates sediment input from the west/south-west, the conceptual model built, forms an idea of the fan deposition in the area.



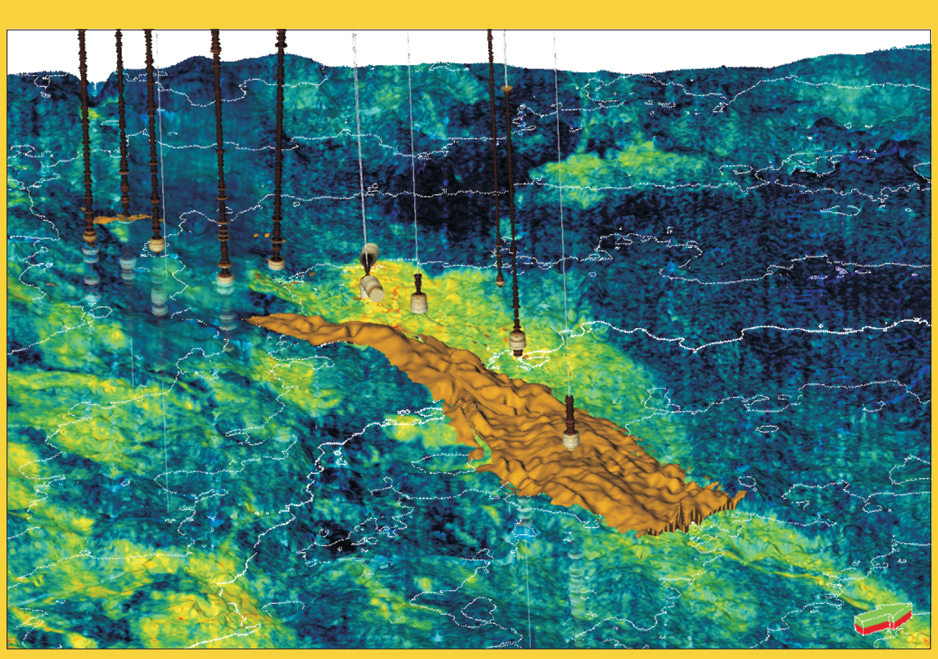


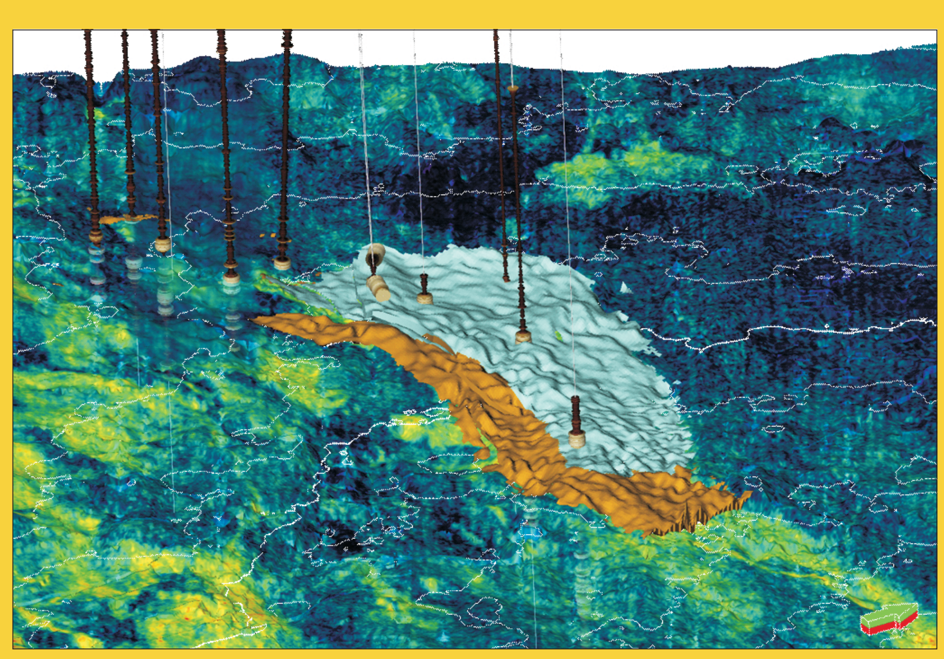


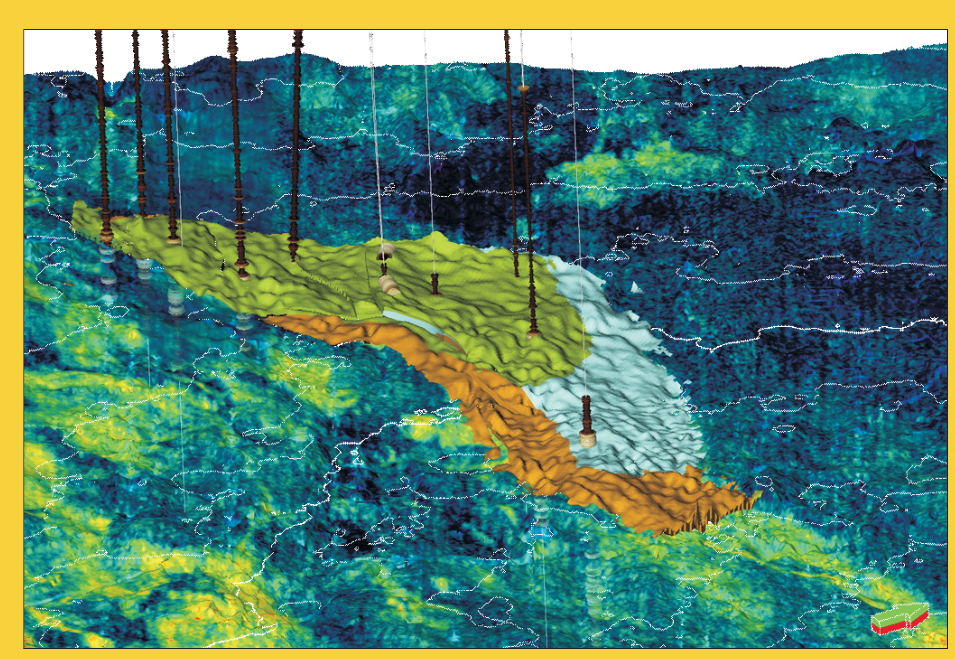
The above figures show sections through the conceptual model at the key wells, E-AR1 and E-BT1.

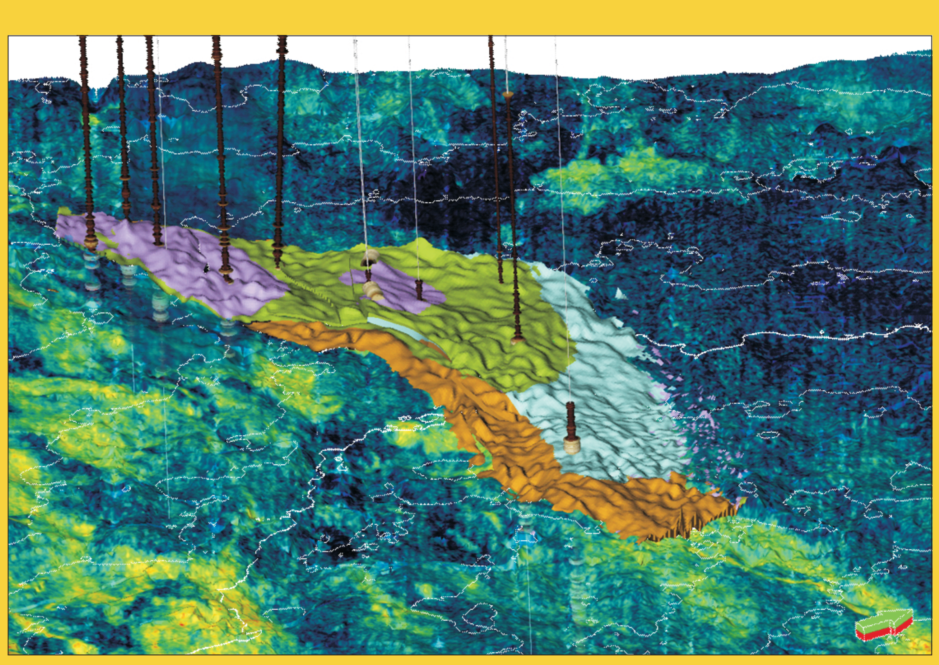
TRANSFORMING THE CONCEPTUAL MODEL INTO THE STATIC MODEL

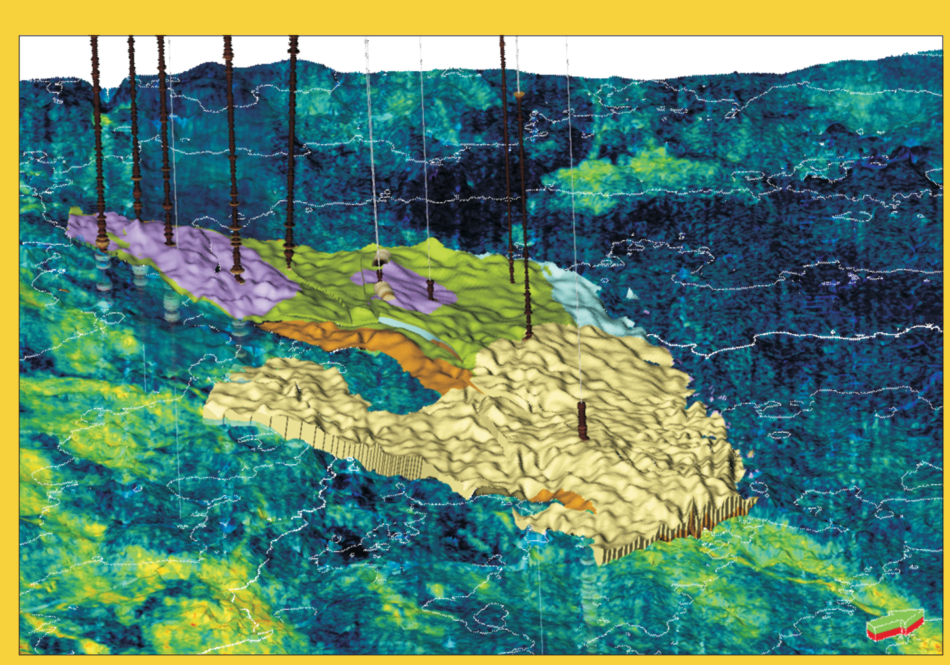
The culmination of the work is the translation of the conceptual model to the static model. The figures below (3D view) illustrate how each fan from the conceptual model is replicated in the static model with simplistic yet eye-catching accuracy. The first figure shows fan 1, and each subsequent figure adds the next fan in order of deposition. The last of the images depicting the fan development shown below represents the conceptual depositional model (above right) conceived by the interpreter.











SIMPLICITY IS THE ULTIMATE SOPHISTICATION *(Leonardo da Vinci)*

Although simple in nature, the workflow presented is a renewed reminder that complexity should not necessarily be the first step in our approach. Whilst the algorithms behind the process outlined in this presentation may be complex and by no means ‘simple’, as geoscientists we should always strive to keep our analogs and representations as simple as possible. We should harbour no illusions that we are ever able to uniquely quantify, at a geo-cellular level, exactly what Mother Nature has placed in the sub-surface. However, practical solutions yielding numerical models that are ‘easy enough’ to update with the introduction of new data, should always be our goal. The above approach illustrates how accurately the idea or concept in the mind of the geoscientist can be brought to life by applying a simple yet pragmatic methodology.