RESERVOIR MODEL AND APPLICATION OF SEISMIC ATTRIBUTES TO PREDICT LOWER MIOCENE B10 SANDSTONE RESERVOIR DISTRIBUTION IN SU TU DEN OIL FIELD, BLOCK 15-1, CUU LONG BASIN

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Summary

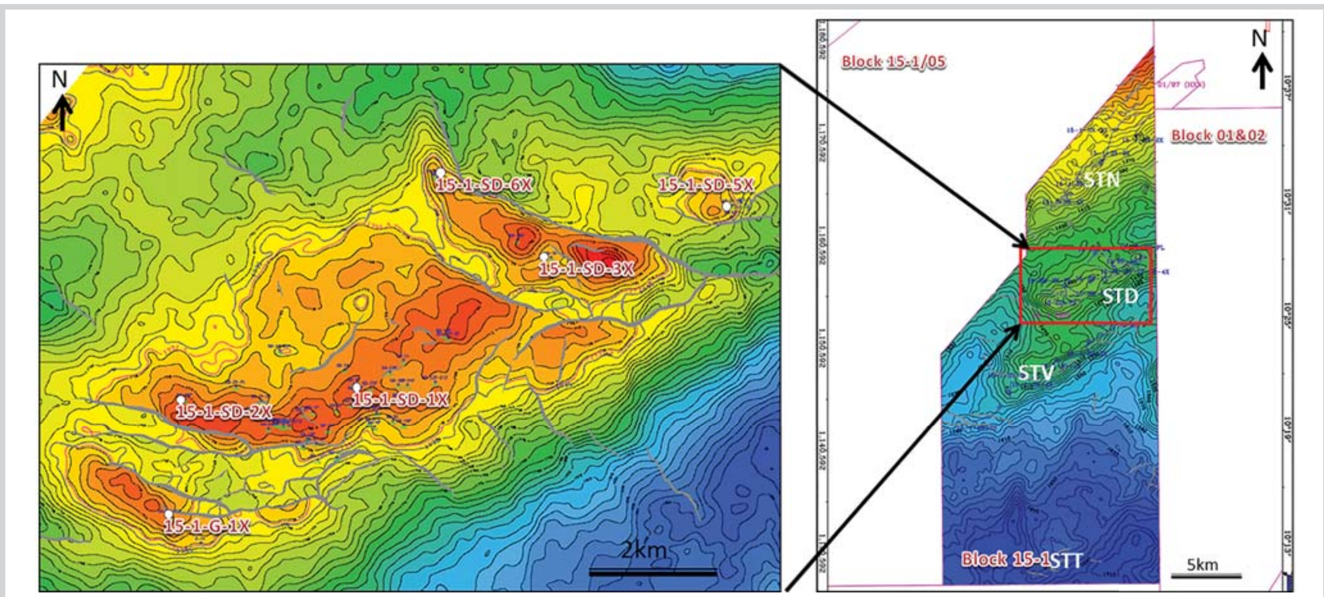
A clear understanding of the geological model and distribution of a reservoir is very critical for better production approaches. Precisely determining the geological concept is an initial step to orientate reservoir study. The combination of geological model with the results of seismic attribute analysis is the key to determine reservoir distribution. This paper addresses a detailed analysis of regressive delta fan facies of Lower Miocene B10 reservoir which have been investigated by integrating core description, biostratigraphy, well log patterns, seismic characteristic, and seismic attributes.

Key words: *Facies, depositional environment, mouth bar, distributary channel, seismic attributes, seismic inversion.*

1. Introduction

B10 sandstone reservoir in Su Tu Den oil field is one of the most prolific Lower Miocene reservoirs with excellent properties. Located in Block 15-1, Cuu Long basin, offshore southern Vietnam, Su Tu Den oil field is about 120miles (180km) to the south-east of Ho Chi Minh City. To date, hydrocarbons have been discovered in several reservoirs of Su Tu Den oil field. In this field, the main produced commercial reservoir is fractured basement. Additional commercial hydrocarbon also has been produced from the Lower Miocene and Oligocene "C". Some minor hydrocarbon presences were found in the Oligocene "D" and "E" sequences at Su Tu Den oil field, but not yet in sufficient quantities to merit development.

The oil bearing arkose B10 sandstone reservoir is the main clastic reservoir that has been producing since 2003. This reservoir varies from 10 - 12m in thickness with a depth range from 1,700m to 1,740m TVDSS (true vertical depth subsea). Closing contour covers the area of around 14km^2. The cumulative production (in 2015) is 73MMstb with a total of 14 active production wells. Characterised by high porosity (28% on average),



(a) (b)

Figure 1. *Time structure map of B10 highlighted by exploration wells (a) and the location of Su Tu Den field in Block 15-1 (b)*

permeability (> 2,200mD), and low residual fluid (36%), the B10 sandstone reservoir is considered one of the best quality clastic reservoir in Cuu Long basin. Understanding the geological model and its distribution is a key for increasing production efficiency. This paper will address an integration of seismic characteristics, seismic attributes with a geological model to predict the sand-body distribution of the B10 reservoir in Su Tu Den field, Block 15-1, Cuu Long basin.

2. Database and methodology

The seismic data used is PSDM Kirchhoff re-processed in 2002 covering an area of 337km^2 and 6 exploration wells with sufficient data, including biostratigraphy results (analysed by VPI labs) for study (Figure 1).

Cores have been taken from two wells with detailed description of the lithofacies and depositional environment (described by ConocoPhillips) for calibration with well-log pattern analysis. High resolution biostratigraphic analysis provides calibration of both depositional systems and specific depositional environment based on foraminiferal analysis and palynological-palynofacies analysis. The consistent combination of that information would lead to a reasonable depositional model. The workflow for the work is presented in Figure 2.

3. Geological model

The initial geological model was constructed based on integrated core description and high resolution biostratigraphy data. The interpretation results of

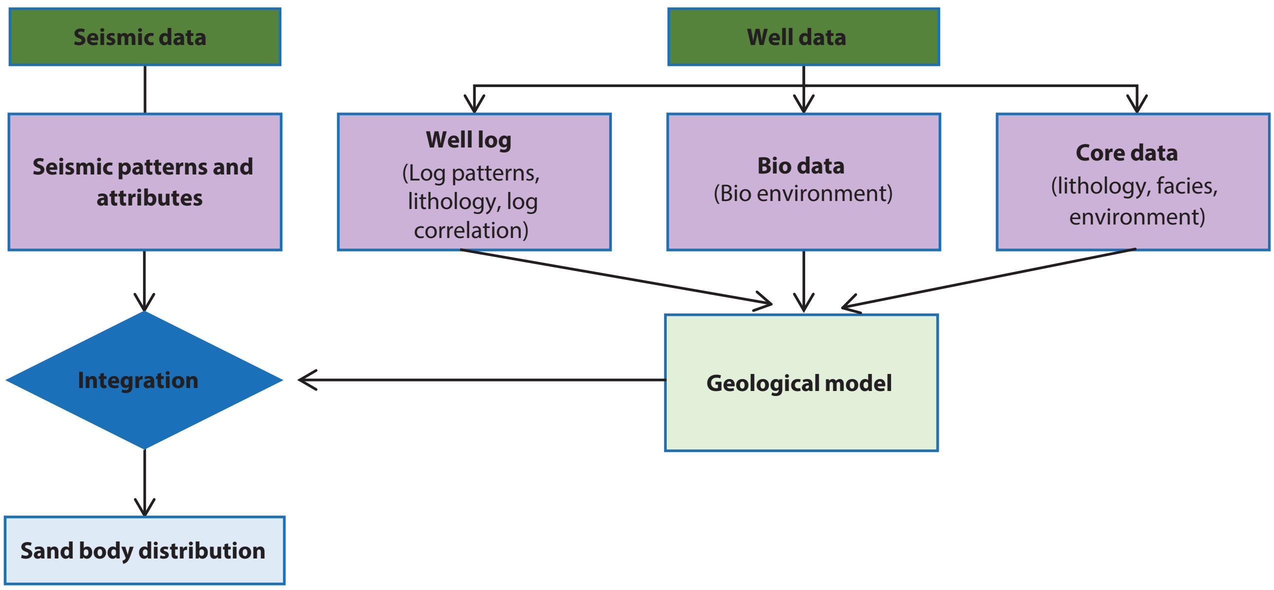


Figure 2. *Workflow chart for the study*

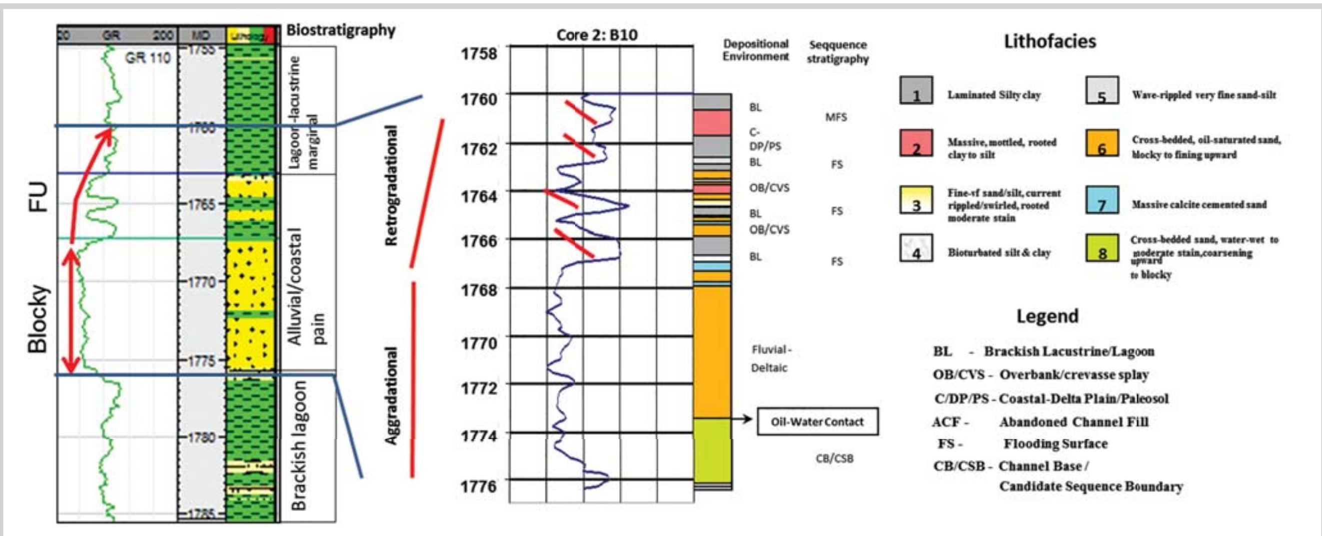


Figure 3. *Calibration of core to log patterns showing the facies of mouth bar at the base and distributary channel toward the top*

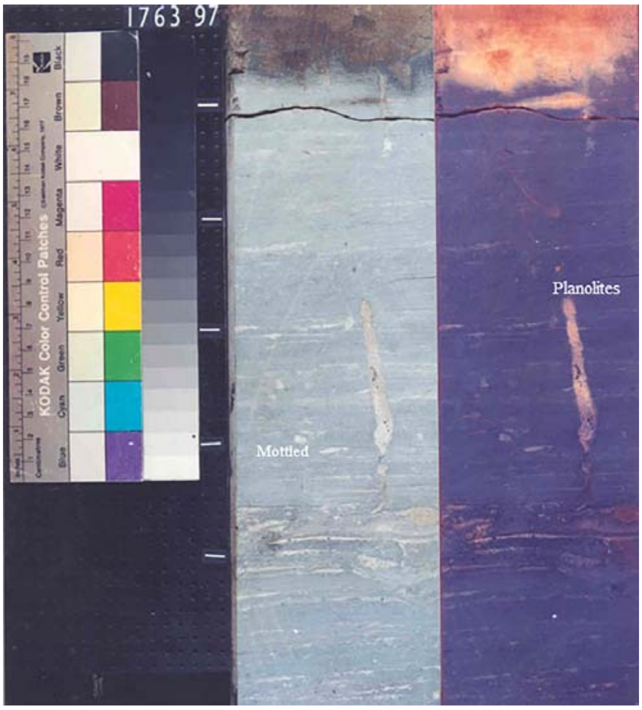


Figure 4. *Lithofacies 1, laminated silty clay, mottled interpreted as lacustrine to brackish-marine deposits. Bioturbation in this facies is sparse to absent and typically consists of Planolites sp. Forms. Most sedimentary structures comprise streaky to lenticular low angle silt laminae, indicating an overall low energy setting. The vertical scale is 1 foot (0.33m).*

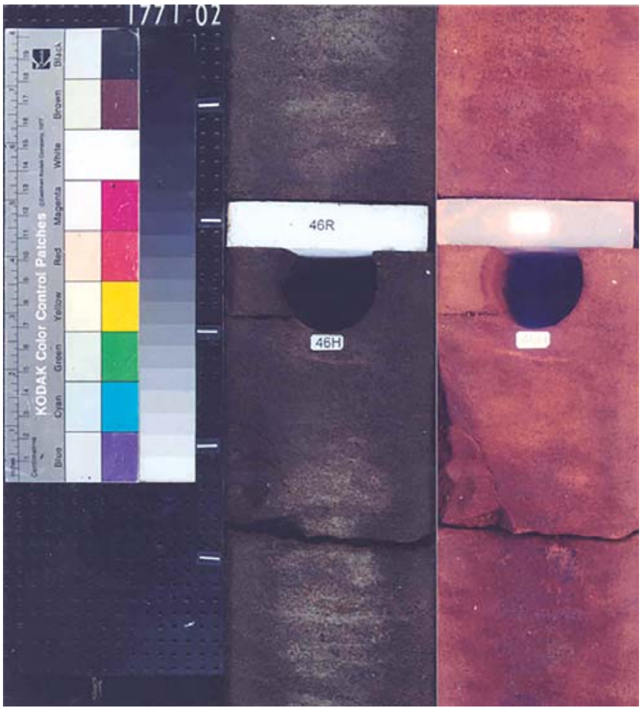
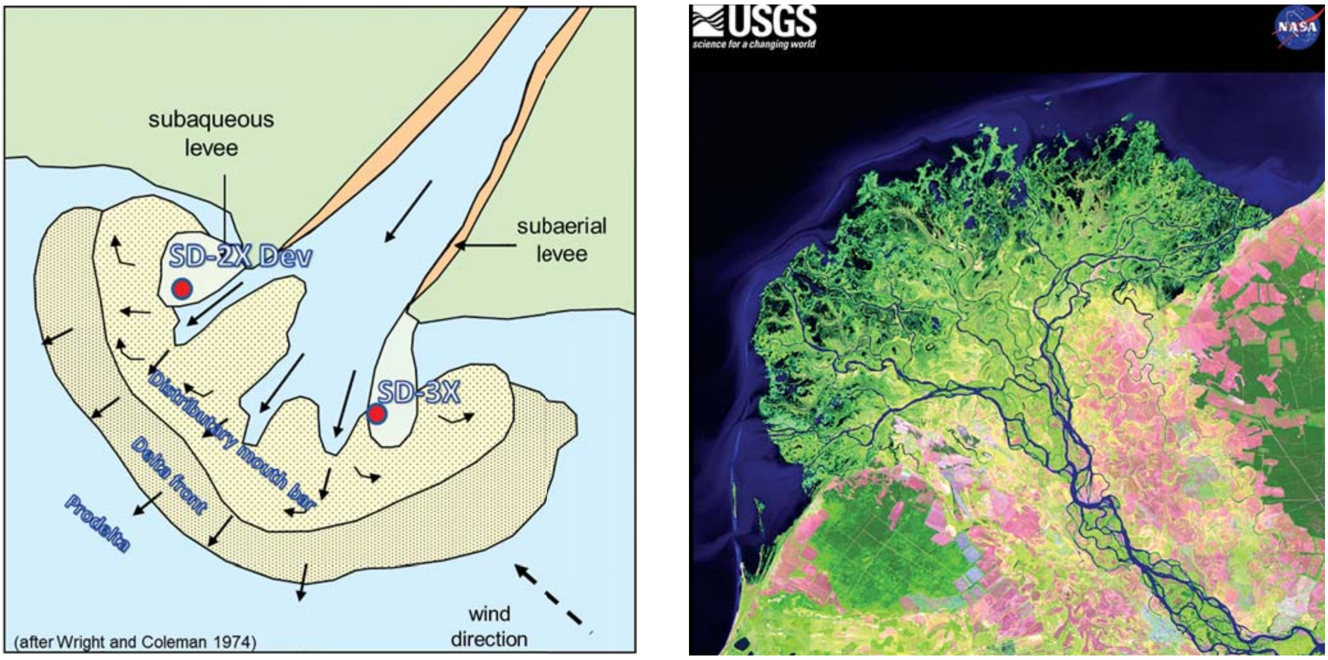


Figure 5. *Lithofacies 6, oil stained, massive to low angle laminated and cross-bedded sand. Grain size ranges from lower coarse to lower fine. Part of a blocky aggradational to fining upward succession. Interpreted as deposits of distributary mouth bar, distributary and fluvial channels. The vertical scale is 1 foot (0.33m).*



(a) (b)

Figure 6. *Schematic of B10 depositional setting with relative location of two taken cores (a) and a partial satellite paleogeographic analog of modern Selenge River delta-North Mongolia (b)*

depositional environments and sequence stratigraphy from core data were based on observed lithology, grain size, sedimentary structures, laminae geometries, and bioturbation styles. B10 reservoir succession was described as an aggradational stack of cross-bedded and low angle laminated sands deposited in fluvial dominated delta in the lower part and distributary channel in the upper part [1, 2] (Figure 3).

Analysis of foraminifera and palynological assemblages from wells of B10 zone in Su Tu Den field reflects a slow transgression progress from bottom to top. This slow transition occurred from alluvial plain/

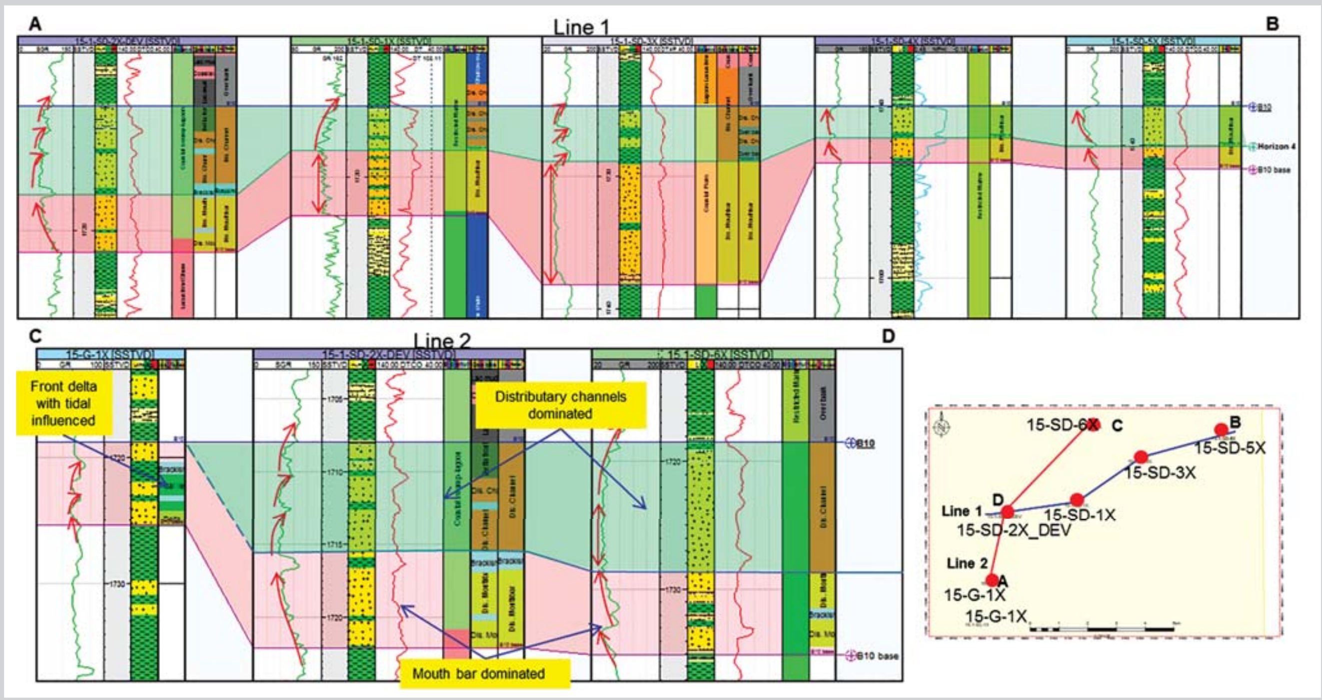


***Figure 7.** Well log correlations in the main pool of Su Tu Den area showing the two different section of B10 sand with dominant mouth bar in the lower part and the distributary channels in the upper part*

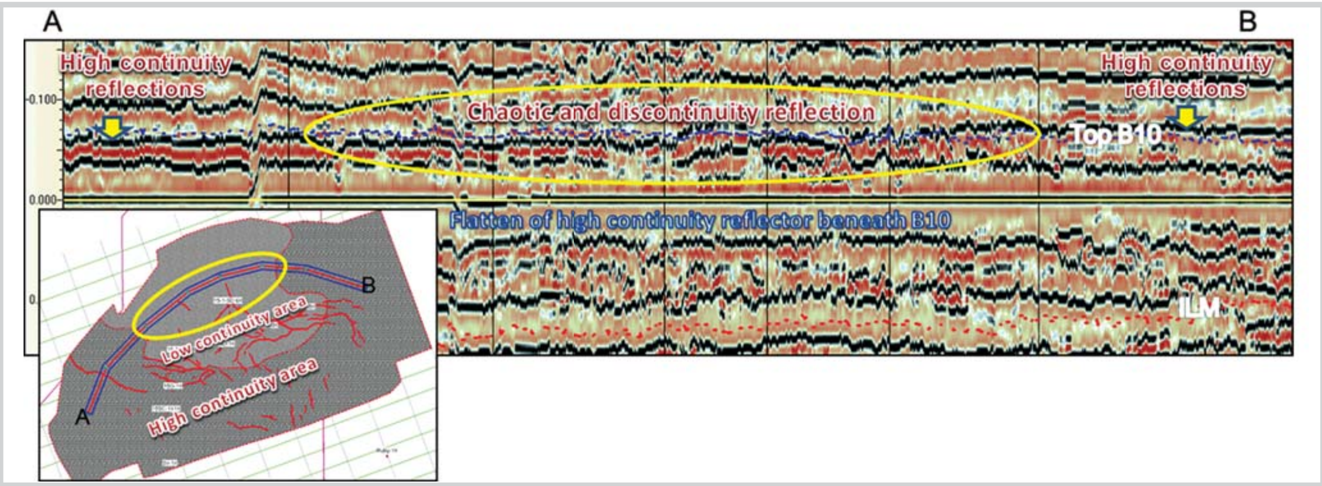


***Figure 8.** Flattened paraphrase seismic showing low and high continuity implies a different depositional environment of B10. The index map showed a spatial distribution of continuity reflection zones*

channels to freshwater lagoon/lacustrine with brackish influence [3 - 6]. The depositional environment derived from biostratigraphy data totally agrees with the core description (Figures 4 and 5) [2] that helps interpreter determine the geological model concept (Figure 6).

Calibration of the core, biodata to the well-log patterns is the next step for facies and environment interpretation for the entire wells. Core to log pattern calibration in Figure 3 of SD-3X shows the mouth bar facies featured by a blocky profile with slightly coarsening upward trend; while fining upward succession (bell shape) reflects distributary channels. Generally, a regression environment of B10 distinctively could be divided into 2 parts: 1) more dominance of mouth bar facies in the lower section and 2) series of stacked distributary channels in the upper section (Figure 7).

4. Analysis of seismic characteristics and seismic attributes

Seismic data takes an important role in defining spatial distribution. Seismic facies analysis is based on seismic reflection to separate the areas of different seismic responses that possibly could imply different depositional

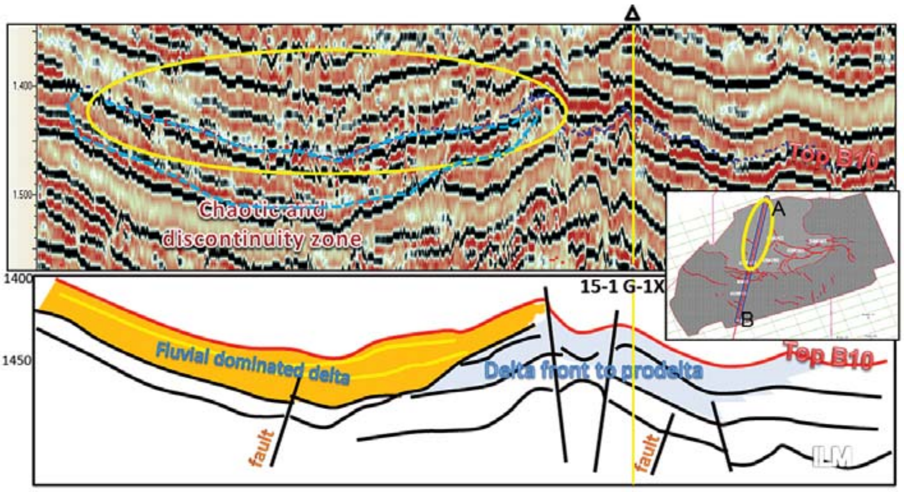


Figure 9. Paraphrase seismic showing depositional environment of B10 (upper) and a cartoon representing related environment (lower)

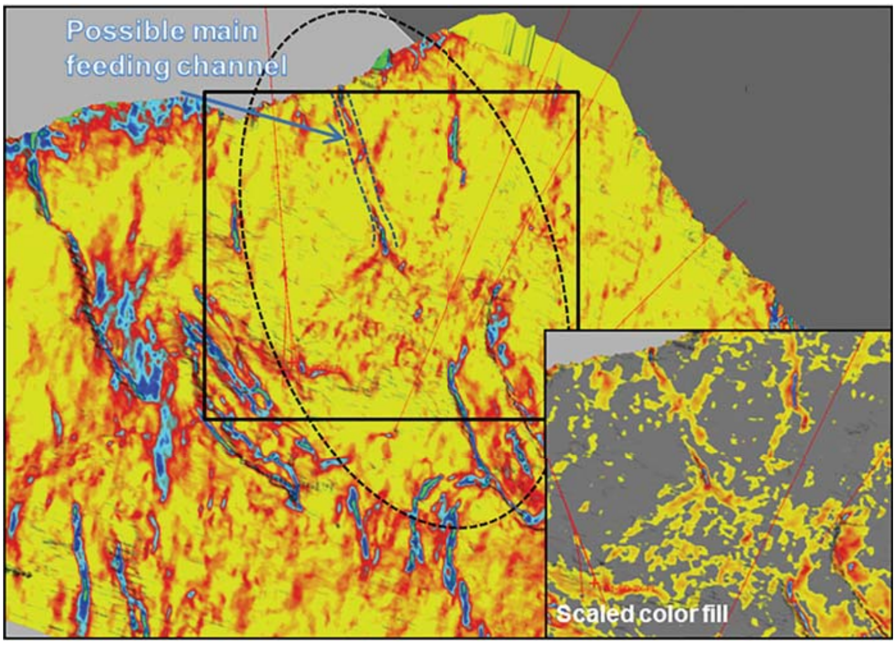


Figure 10. Extracted map from discontinuity cube with a window (B10 0/+30ms) showing a fan shape delta

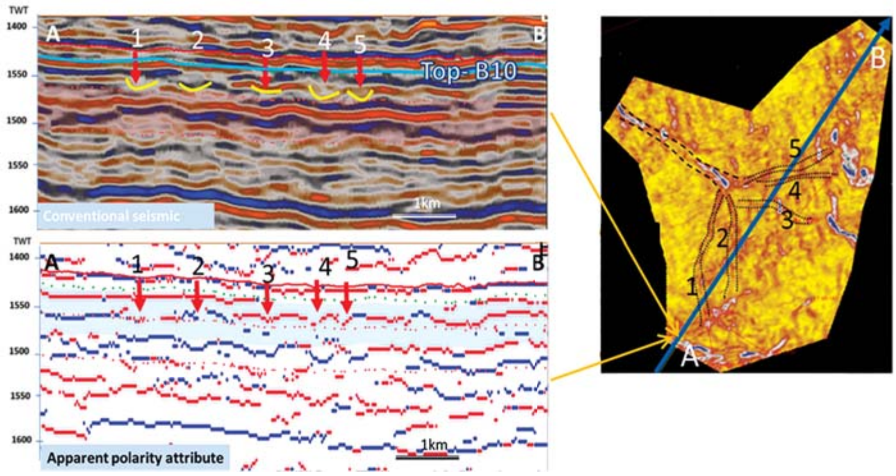
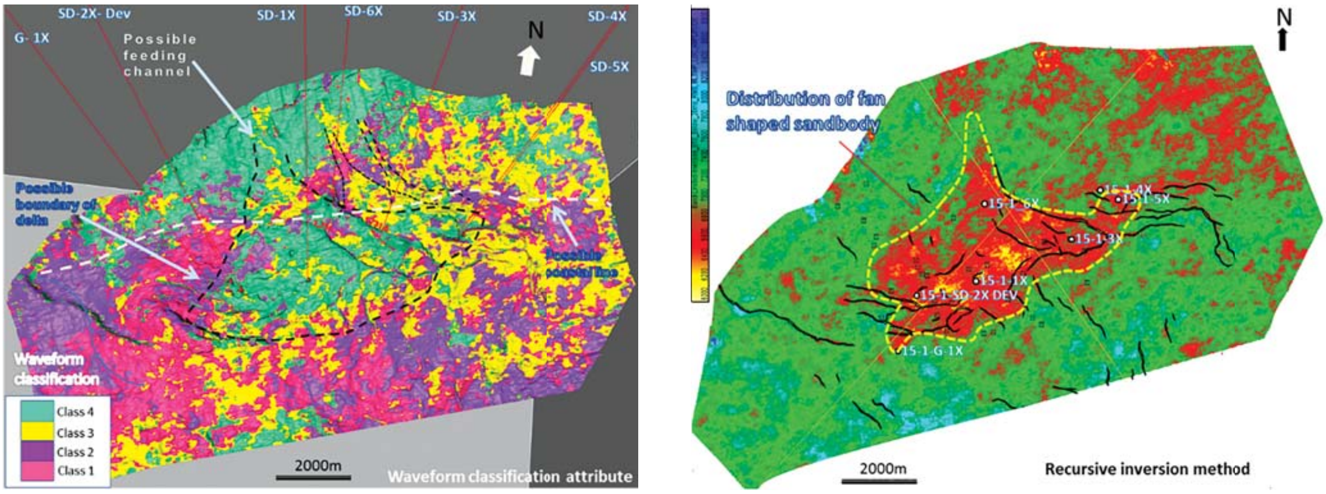


Figure 11. Possible distributary channels in apparent polarity attribute (lower section) and their position in fan delta (top right) compared with modern analogy (bottom right)

environments. Using paraphrase attribute - instantaneous phase with the background component removed, the seismic section with chaotic and discontinuity features probably indicates the domination of fluvial environment meanwhile conformable and continuous reflection could be considered as an indicator for marine influenced areas (Figure 8). Figure 9, North-South seismic line, crossing well 15-1-G-1X, shows the separation between the chaotic and discontinuity area (the yellow eclipse) and the area of conformable and more continuous reflection, implying differently influenced environment as discussed previously.

A seismic attribute is a quantitative measure of a seismic characteristic. Analysis of attributes has been integral to reflection seismic interpretation since the 1930s. There are now more than fifty distinct seismic attributes calculated from seismic data and applied to the interpretation of geological structure, stratigraphy and rock/pore fluid properties [7]. The study and interpretation of attributes provide us with some qualitative information of the geometry and physical parameters of the subsurface [8]. In this paper, we present some of the valuable seismic attributes as inputs for reservoir distribution prediction. An amplitude extraction technique has been applied to cover the whole interval of the reservoir to seek for any geological event. As a result, a possible delta fan can be observed in horizon based attribute extraction map from discontinuity cube of B10 reservoir covering the window of 0/+30ms



(a) *(b)*

Figure 12. *Waveform attribute of B10 (a) and the horizon based (window: 0/+25ms) stochastic inversion extraction (b) showing possible fan delta shape*

(Figure 10). A number of possible feeding channels from North-northwest and the distributary channels are visually observed on re-scaled colour fill. On section view, these distributary channels possibly can also be seen on conventional seismic and apparent polarity attribute section (Figure 11). The waveform classification method [9] (Figure 12) - modern techniques that make it possible to define and map subtle changes in seismic response also provide very clearly the similar fan delta shape which is difficult to observe on conventional seismic. Integration of depositional facies derived from the well log with seismic attributes will lead to the prediction of B10 sand-body spatially. A useful additional extraction with a window of 0/+25ms from seismic inversion [10] clearly illustrates the area extent of fan delta/sand-body.

5. Conclusions

Understanding geological model and its reservoir distribution is the main goal of any geologist when characterising the reservoir. Using different seismic attributes with agreeable calibration to the geological model constructed from direct data provides excellent information to determine the spatial distribution of a reservoir since it is not easy to observe on conventional seismic. In this study, we have integrated different disciplines to determine the facies of B10 reservoir that was deposited as a regressive delta fan and its possible distribution. This result may provide very useful information for 3D geological modelling for better producing approach.

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