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# PETROLEUM EXPLORATION PROSPECT OF THE ABU WELL, X- FIELD ,OFFSHORE, COTE D' IVOIRE, WEST AFRICA.

**CHIGOZIE ABRAHAM OKAFOR[1]. AZUBUIKE-IJOMAH, KELECHI [2]. ADIELA,U.P[3]**
[1,] Department of Geology and Petroleum Geology, University of Aberdeen, Scotland
[2]Department of Geology, University of Port Harcourt, Port Harcourt,
[3] Department of Petroleum Engineering,, Nigerian Agip Oil Company, Port Harcourt

## ABSTRACT
The X-Field field was discovered in 1981 through the test of the X-Field structure within Abu Well. Integration of detailed 3D seismic interpretation, composite log and other well information has been carried out in this study to unravel the potential complexities relating to time-depth conversion, size of the hydrocarbon pool and fluid types associated with the Albian reservoir.

## INTRODUCTION
**PROJECT AREA**: The ABU Well, is located in X-field, offshore Cote d'Ivoire, West Africa it is about 8km north east , offshore of cote d'Ivoire basin.

The X-Field structure which comprises a three-way dip closed structure with a fault bound southern margin was tested in 1981. The well encountered a Late Albian sandstone that had good oil stain in core but tested 10MMscf/d of gas on test. Analysis suggest a gross gas column of 1.00ft at the crest of the structure (CNR database)

## AIMS AND OBJECTIVE
The principal aim of this study is to integrate well data, composite logs and detailed seismic interpretation and mapping to depth convert the X-Field structure. Top Reservoir structure, calculate the reservoir volume (STOIIP/GIIP) and ascertain the fluid types associated with the reservoir.

## REGIONAL GEOLOGY OF THE CÔTE D'IVOIRE BASIN
### TECTONIC SETTING
The X-Field structure which is the subject of this project is located in the footwall of a normal fault that defines the Espoir terrace in the Côte d'ivoire basin, Gulf of Guinea. The Côte d' Ivoire basin is a wrench-modified basin (Clifford, 1986).The basin is a narrow elongate trough measuring some 600km by 1500km with WSW-ESE orientation.

The basin is bounded by the St Paul Fracture zone to the north and Romanche Fracture zone to the south. These two strike-slip fracture zones controlled the evolution of the basin. Paleocontinents transform faulting was initiated between the African and South American continental plates in Early Cretaceous time. The thick continental crust of the African and South American platform started to break up, forming divergent basins or pull-apart grabens separated by transform faults (Blarez and Mascle, 1988). (De Matos 2000; McGregor et al, 2003) have used pre-transform (Neocomian-Barremian), syn-tranform (Aptian —Latest Albian) and posttransform (Cenomanian-Holocene) to classify the three structural and tectonic regimes in the Cote d, Ivoire basin.

The initial phase (Pre-transform) of the post-Hercynian opening of the North Atlantic and the splitting of North America from Eurasia and Africa began during Late Permian—Early Triassic time (Ziegler, 1988; Uchupi et al, 1976). The transform faulting (Syn-transform) that was initiated between the African and South American continental plates in Early Cretaceous time was active until middle to late Albian time, when the first oceanic crust was formed and the last connection between the two continents was breached. This phase created series of Albian highs such as the tilted fault blocks of Espoir (Blarez and Mascle, 1988; Morrison et al, 2000, Brownfield and Charpentier, 2006). A major Albian—Lower Cenomanian unconformity was a direct consequence of the final separation of the continental margins (Chierici, 1996; MacGregor et al, 2003). The dominant regional fault orientation that resulted from this phase was NW- SE faulting and conjugate SW- NE faulting and folding.

The end of syn-transform tectonism and sedimentation initiated the post-transform phase, which brought change in structural style involving deep-sea erosive canyons with N-S orientation due to sea floor spreading, and this structural style has continued to the present day. By Santonian time , continued crustal extension resulted in the formation of major oceanic crust, and the marginal basins and offshore platform of the basin were subjected to an increase in clastic deposition and thermal subsidence (typical passive margin downwarping) that was probably related to sea level fall, resulting in development of several Late Cretaceous and Tertiary unconformities especially in the western Ivorian basin. Miocene and Senonian unconformities are pronounced events of the post-transform

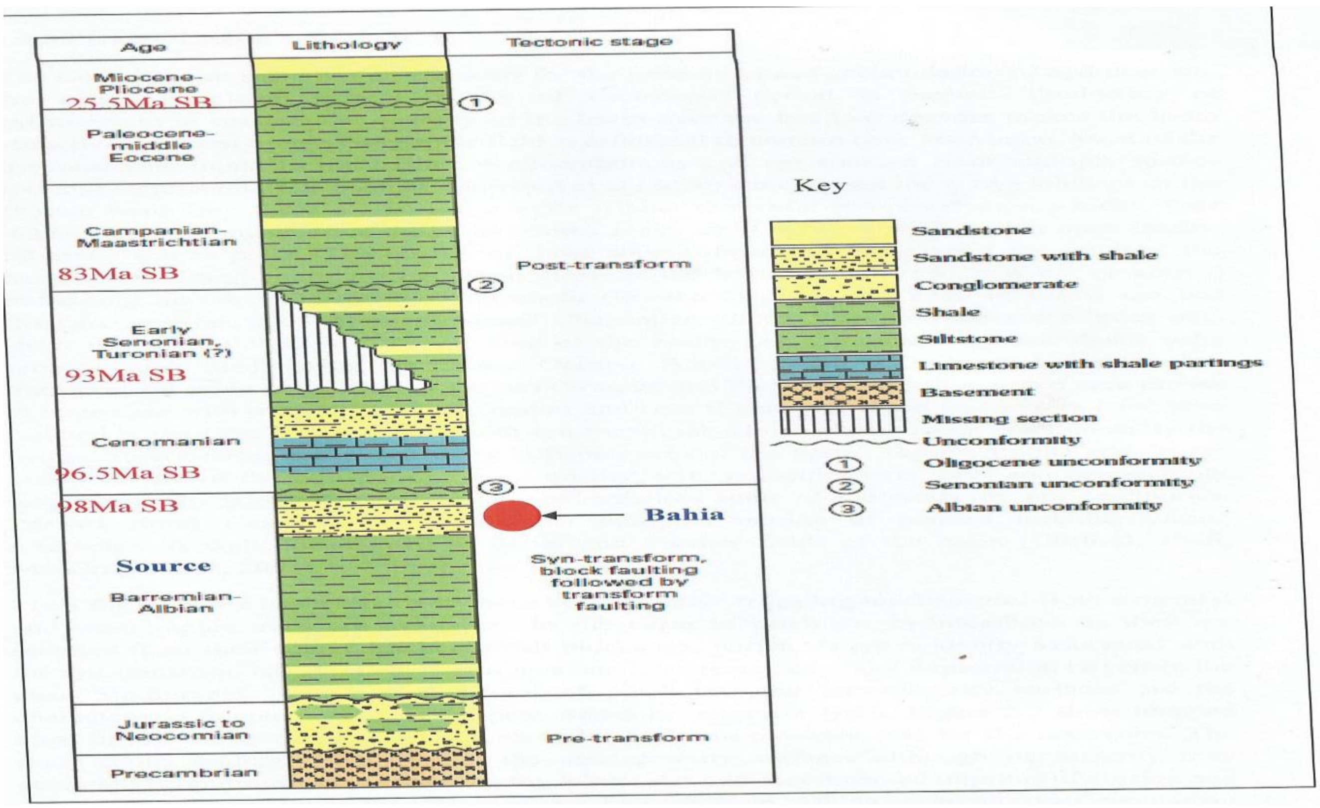


**Figure 1; Generalized stratigraphy of the central and western parts of the Cote d'ivore Basin**

## DATA

The data consist of 3-0 Seismic- a near and mid-cubes (GXT_near_time_8float_Mar02 and GXT mid_time 8float_Mar02) and the ci_26_Ensign-pstm-8bit that covers the northern part of the area.
The data are of zero phase and SEG normal polarity and maximum black peak was used as positive reflection and marked an increase in acoustic impedance. The seismic volumes were sampled at the rate of 4 milliseconds with a bin size of 12.5x12.5. The seismic volumes used in the project work was acquired in 2000 and has undergone vintage of seismic reprocessing displays corrected seismic gathers on Line 1820 of the GXT near cube before and after reprocessing with the Top Albian horizon marked in green. The gathers are clearly not flat in some places, The seismic data in the Bahia Albian reservoir structure show moderate

quality in some areas but variable and poorer quality portions suggesting the amplitude attenuation effects of gas (that probably leaks from the structure).Amplitude map shows the data quality.

## WELL LOG DATASET AND COMPOSITE LOG

Data from many wells in the area are available but only one well is located in the X- field. A. Well log data of Abu Well is available for the Petrophysical analysis and construction of synthetic seismogram. DST and RFT data from the well were also available.

## METHODS AND INTERPRETATION OF DATA

## CREATING OF SYNTHETIC SEISMOGRAM OF WELL C1-3X

The synthetic seismogram was created using the SynTool module of the Landmark Open Works software. Log measurements from this well provided data for the construction of the synthetic seismogram. The first operation is to edit the well logs prior to the synthetic preparation. The edited sonic log combined with bulk density logs (RHOB) serves as input for the preparation of the synthetic seismogram while the check shot survey was used for calibration of the time- depth curve in the well.

The SynTool module uses the sonic and the density log measurements to calculate the acoustic impedance (Al) and the reflection coefficient (RC) in the well. Equation (1) supports the principle behind the construction of synthetic seismogram.

AI=pV ……………………………………(la)

RC = (p2V2 —p1Vl)/(p2V2 + piVi)……………… equation (ib)

Where, Al = Acoustic impedance

p = density of a layer

V = velocity of a layer

RC = Reflection coefficient

plvl = density and velocity of layer above p2v2 = density and velocity of layer below.

The main purpose of a synthetic seismogram is to link well geology to seismic reflectors and this is achieved by converting rock properties from well logs to synthetic trace.

When there is change in rock property (velocity or density), it causes reflection. Once the acoustic impedance is calculated the reflection coefficient (RC) which is defined as the change in acoustic impedance between two seismically resolvable lithologic layers is also derived. Synthetic make 'rocks look like wiggles' using the convolution model (T = RC* W), which states that traces (T) are the result of the convolving (*) the reflection coefficient series (RC) with the wavelet (W) (Henry, 2000).

The first synthetic in this project was generated by convolving the RC with a trapezoidal (8 -14 -40 -60) zero phase filter (wavelet) but this could not tie correctly with the seismic. The alternative approach was to generate a synthetic by convolving the RC with an extracted statistical wavelet from the 3D seismic trace at line 1804 and trace 2401.

## SEISMIC MARKERS

The top Albian horizon is a regional unconformity surface in the entire Cote d' Ivoire basin. Biostratigraphic studies show the surface to be 96.5Ma.

It produces a very strong positive black peak. Other seismic makers in the basin are the Senonian unconformity surface (83Ma) and the Miocene unconformity surface 25.5 Ma . These correlative surfaces (sequence boundary) are important surfaces for velocity analysis in the basin.

## FAULT INTERPRETATION

The fault interpretation was carried out with SeisWork module in Open Works. Various approaches were adopted in the fault interpretation. A coherency volume was created in Post Stack Pal of Open Works to improve fault interpretation but due to poor data quality, the fault could not be identified very well on coherency time slices. Time slices were also useful in some point to identify fault trends during the fault interpretation. The majority of the fault interpretation was done using the dip sections, (figure 2). Most of the faults trends NW- SE

Two oppositely dipping normal faults were mapped that bound the reservoir area north and south. The south dipping fault has larger throw compared to the northerly dipping fault and both show en echelon array. These tilted faults formed the Sw-transform high of the Late Albian age in the X-Field Area.
Further to the northeastern part of the area are smaller faults. Some of these faults show evidence of transgression or pop-up which supports transform tectonics associated with the basin. These flower—like structures do not penetrate deep in the sections. Other smaller faults could not be confidently mapped due to poor data quality in the areas.

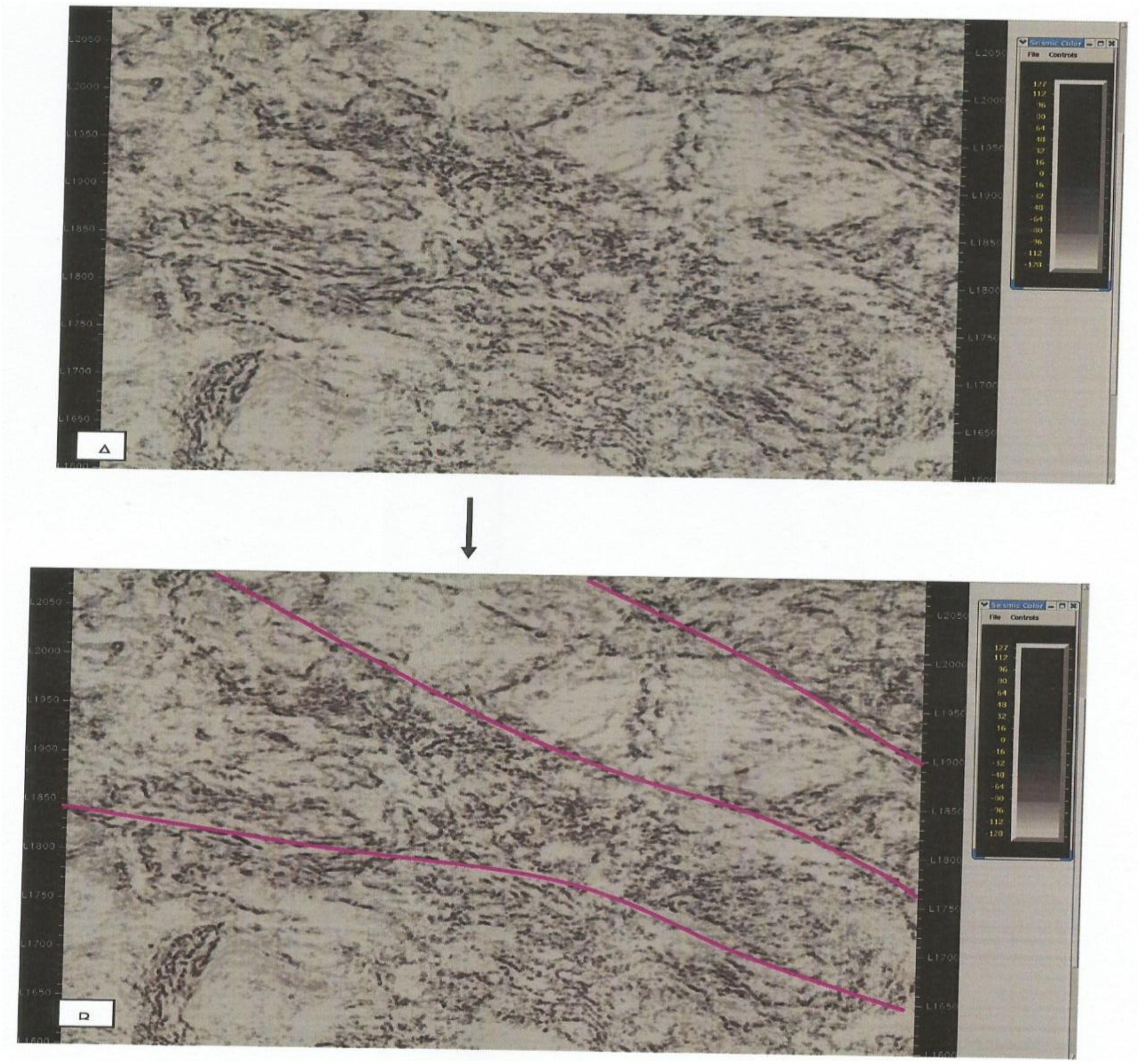

**Figure 2; Coherency slice at 2320ms TWT main faults trend do not appear on the slice**

## CREATING TIME STRUCTURE MAPS

The interpreted TWT data of the top reservoir were imported to Z-map for creating the top reservoir structure maps for the low case, base case and high case respectively. The maps are displayed the time structure maps show closures at 21 75ms.

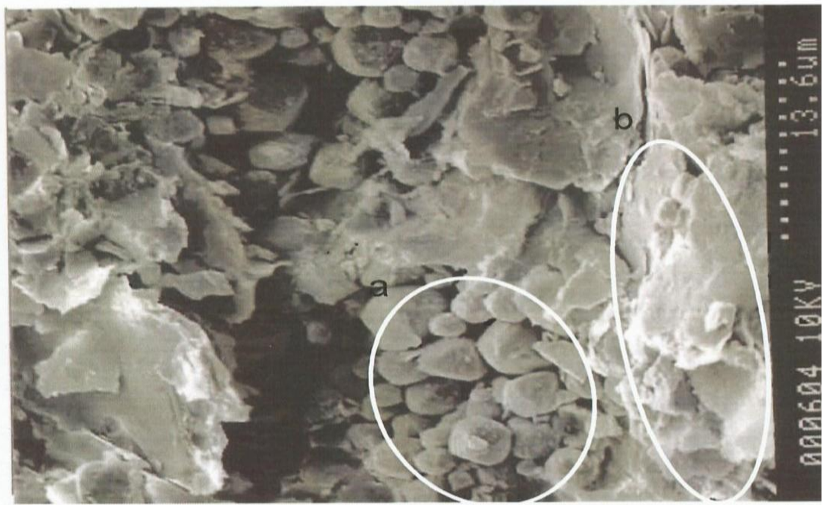


**Figure 3; SEM of sample from core depth 6826.5' (a) microcrystalline, autigenic siderite (b) mica grains partly replaced by clays**

## ATTRIBUTE EXTRACTIONS

Dip ,azimuth and edge detection attribute extractions were carried out but no significant result was achieved except on the azimuth attribute that show some fault orientation on the eastern part of the structure (figure 4). If such trend is continuous to the western part, reservoir compartmentalization is not unlikely RMS amplitude extraction using the StraAmp module to see if the sand can be clearly distinguished on seismic could not yield convincing result.

The amplitude map could not image the geology nor discriminate between the sand and other lithofacies clearly, this event could be attributed to the gas dimming that actually attenuates the true amplitude of the sand package in the reservoir . The amplitude map show clear distinction between areas of good data quality and poor data quality.

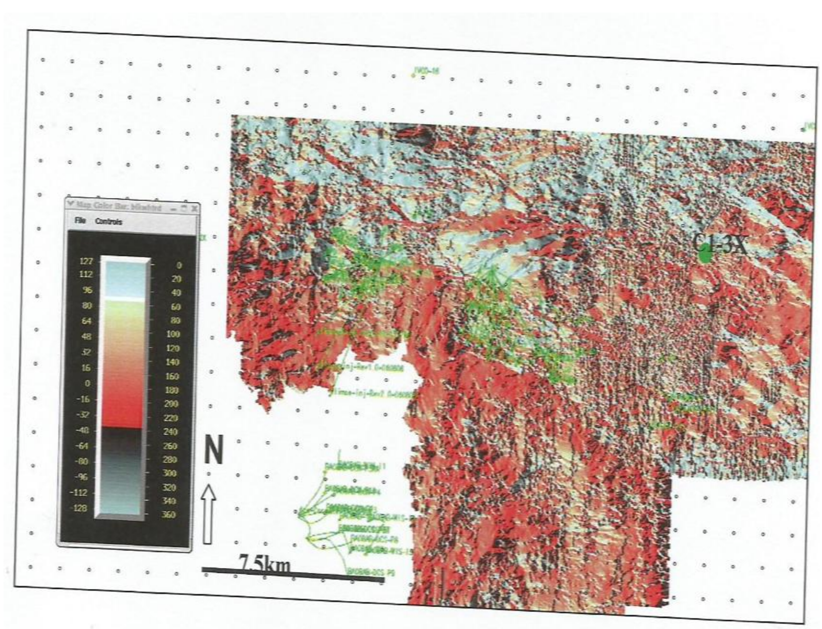


**Figure 4**; Azimuth map of the top Albian horizon


**Figure 5; Probability graphs of gas in place (GIIP)**

## VOLUMETRIC

## CALCULATION OF HYDROCARBON VOLUME

Calculation of the GIIP/STOIIP is carried out using the low case (minimum) base case (mode) and high case (maximum) GRV's calculated from seismic using Z-map..( Figure 5)

The base case well log input parameters were calculated from Abu well while the low case and high case well log input parameters were derived with probabilistic consideration from historical data from nearby fields in order to mitigate the uncertainty of poor well control on the field.

The input and results of the calculations are presented in tables 1 and 2 below;

**Table 1: INPUT DATA FOR GIIP CALCULATION**

| Variables | Unit | shape | mm | mid | max |
|---|---|---|---|---|---|
| GRV | Acre-Ft | triangle | 25920 | 28054 | 90843 |
| N/G | % | triangle | 35 | 43 | 70 |
| 0 | % | triangle | 18 | 21 | 22 |
| SW | % | triangle | 34 | 43 | 50 |
| FVF (l/Bg) | Scf/cf | triangle | 195 | 199 | 203 |

**Table 2: Result of GIIP**

| Ranges | GIIP (bcf) |
|---|---|
| P90 | 14.4 |
| P50 | 22.6 |
| P10 | 36.3 |
| Mean | 24.2 |

## DATA ANALYSIS

About four drill stem test (DST) were performed in the well. Only DST 2 flowed 10,000MSCFD of gas with specific gravity of 0.654 and about 580 BOPD with 37.3 API (light oil).

From the result, the Average GOR is about 181 l0.Other DST 's produced zero result. Cross - examination of the DST result show agreement with the well log signatures especially with the resistivity values of the formation. The DST points that produced oil and gas matched with the gas leg while the DST points that produced nothing correspond to the water bearing sands below OWC in well BLOCK JAGO-A..Core data reveals 16 feet of oil stains from 6785- 680l.6fl TVDss.

**Table 3 : Summary of DST result**

| DST NUMBERS | INTERVAL(FEET)TD | RESULT |
|---|---|---|
| 1 | 6954-6980 | No Production |
| IA | 6954-6980 | No Production |
| 2 | 6826-6858 | 10,000MSCFDGas |
| 580 BOPD | 3 | 6998-7028 AND 6954-6980 |

## RET DATA

The RET data plot was based on RET result summary. The pressure build up data was not available. The fluid gradients were calculated from PVT and DST data. The depth - pressure plot of well. plot indicate anomalous data points interpreted to have resulted from 'supercharged formation'. The scattered data points significantly raise the level of uncertainty on the data accuracy. No confident fluid contact can be established from the data and therefore could not give good correlation with the well log analysis result..

## RESERVOIR QUALITY

The Abu Well reservoir description is based on core information, biostratigraphy and well log data. The Late Albian reservoir consists of interbedded sandstone and shale with carbonate stringers in places that produces spikes in well logs. The carbonates are interpreted to have resulted from cementation process. Core descriptions are based on core reports from CNR database. A total of 82 feet of core was taken in the well with only 55 feet recovered. The coarse—medium grained sandstone units are micaceous with metamorphic fragments. These sandstone beds contain organic shale rip-up clasts and are commonly structureless with evidence of dewatering. Observation from well log data indicates that the sandstone are mostly cemented below the OWC.

CNR petrographic and diagenesis analysis reveals that the cored sandstones are dominantly arkose (immature) with high feldspar contents. Porosity development in the sandstone is related to dissolution of detrital grains during diagenesis. Late diagenesis in the sands created room for calcite cement dissolution thereby creating porosity variability between the cemented and the less cemented sand units. The authigenic (clay minerals) Kaolinite and illite line oversized pore throats in the scanning electron micrograph (SEM) and this could potentially reduce permeability leading to negative effect on reservoir quality. The core geometric mean permeability is 3.lmD although a log permeability result seems to be higher.

## CONCLUSION

The key findings of this research are as follows:

Multi-layer depth conversion approach over the structure reveal that the discovery well was not drilled on the crest of the structure

The base case crest of the structure is at -6700 TVDss which suggests a low relief structure with only 12111 TVT

Attribute analysis reveals potential reservoir compartmentalization features in areas with moderate data quality.

The GOC is -6813 ft TVDss and OWC at 6821 ft TVDss giving rise to a small oil column of 811 in well.

Well log analysis estimate an average porosity of 21%, 0.43 N/G and 43% water saturation. The reservoir component below the OWC display large deflection on density and sonic, which suggests carbonate cementation.

Range estimates for oil in place are 2.44 mmstb (low case) 3.47 mmstb (base case) and 4.67 mmstb (high case) with over 14.4 bcf GIP (low case) ,22.6 bcf (base case) and 36.3 bcf (high case). Core data indicate a medium to coarse-grained sandstone interbedded with siltstone and shale. The sandstone is arkosic with high feldspar content and core geometric mean permeability of 3.1 mD.

The depth- pressure plots reveals anomalous data points, therefore could not reliably correlate with the well log result in order to establish fluid contact.

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