Global Journal of Human-Social Science: B
Geography, Geo-Sciences, Environmental Science & Disaster Management
Volume 18 Issue 4 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-460X & Print ISSN: 0975-587X

Prospect Maturition using Seismic and Offset Well Data: The Osemu-Niger Delta Case Study

By Isaac Aigbedion, Innocent Okogbue & Ataman J.O
Ambrose Alli University

Abstract- The AVO Fluid Inversion (AFI) technique to predict the probability of oil and gas occurrence in OML-X and quantify the uncertainties associated with the fluid prediction using Seismic sections and some well picks from nearby Ose Field. The seismic data interpretation of the Osemu prospect was based mainly on the picking of seven horizon layers (including the sea bottom). Four deeper horizons (C, D, E & F) were analysed for prospect generation and volumetric estimation. Results showed a major NW-SE trending growth fault controlled sedimentation and structural deformation in the study area. The seismic interpretation has identified two main prospects in the Osemu area. These are named Osemu-Main and Osemu-Upper. From the study two wells are recommended to be drilled on the structure. The two are expected to pierce all the four reservoirs considered in the volumetrics mid way between the crest and the flank.

GJHSS-B Classification: *FOR Code: 059999p*

PROSPECTMATURITIONUSINGSEISMICANDOFFSETWELLDATATHEOSEMUNIGERDELTACASESTUDY

Strictly as per the compliance and regulations of:

Prospect Maturition using Seismic and Offset Well Data: The Osemu-Niger Delta Case Study

Isaac Aigbedion [α], Innocent Okogbue [σ] & Ataman J.O [ρ]

Abstract- The AVO Fluid Inversion (AFI) technique to predict the probability of oil and gas occurrence in OML-X and quantify the uncertainties associated with the fluid prediction using Seismic sections and some well picks from nearby Ose Field. The seismic data interpretation of the Osemu prospect was based mainly on the picking of seven horizon layers (including the sea bottom). Four deeper horizons (C, D, E & F) were analysed for prospect generation and volumetric estimation. Results showed a major NW-SE trending growth fault controlled sedimentation and structural deformation in the study area. The seismic interpretation has identified two main prospects in the Osemu area. These are named Osemu-Main and Osemu-Upper. From the study two wells are recommended to be drilled on the structure. The two are expected to pierce all the four reservoirs considered in the volumetrics mid way between the crest and the flank.

I. Introduction

The Osemu anomaly is one of the three major structures identified in OML-X (approx. 725 Sq.km) in water depth ranging between 60 and 160 meters in the Niger Delta- Nigeria. The other prospects are the Osno and Ose in the north and east respectively. The latter have been drilled and are currently producing and providing the referenced logs and well information used for the Osemu prospect study.

A recent acquisition of approximately 360 km^2 3D seismic data over the Osemu prospect and the subsequent delivery of the processed seismic data prompted the interpretation of the data.

The seismic data interpretation of the Osemu prospect was based mainly on the picking of seven horizon layers (including the sea bottom). Four deeper horizons (C, D, E & F) were analysed for prospect generation and volumetric estimation. All the four horizons are considered to lie within the prolific Agbada formation of the Niger Delta basin Integration of 3D seismic model with petrophysical data has been a beneficial endeavor in use in the petroleum industry for some years now (Adeoye and Enikauselu, 2009; Aigbedion and Iyayi, 2007; Emujakporu and Faluyi, 2015) in petroleum provinces where exploration and production strategies merge, detailed understanding of petrophysical properties is highly desired. Landmark's software and computer hardware located in-house were used in the interpretation of the seismic sections. The Geophysical data consisted of approximately 360 Km^2 of conventional 3D seismic and a depth model for the entire volume. The closest well with a check shot (Ose-5) is about 17km away from the prospect. The overall aim of this study is to use the AVO Fluid Inversion (AFI) technique to predict the probability of oil and gas occurrence in OML-X and quantify the uncertainties associated with the fluid prediction.

II. Objectives of the Study

The overall aim of this study is to determine whether drillable anomalies exist in the Osemu prospect. The specific objectives of the study are as follows:

i. Identify and interpret the potential hydrocarbon bearing anomalies of interest in the study area
ii. Mature the prospect anomalies into drillable targets
iii. Compute the hydrocarbon in place.

III. Location of Study

The Osemu prospect is located in the southern part of the Niger Delta within OML-X (Oil Mining Lease) approximately 80 kilometers from the coastline (Figure 1). It is within the shallow offshore Niger delta.

Author α σ ρ: Ambrose Alli University, Ekpoma.
e-mail: isaacaigbedion@yahoo.com

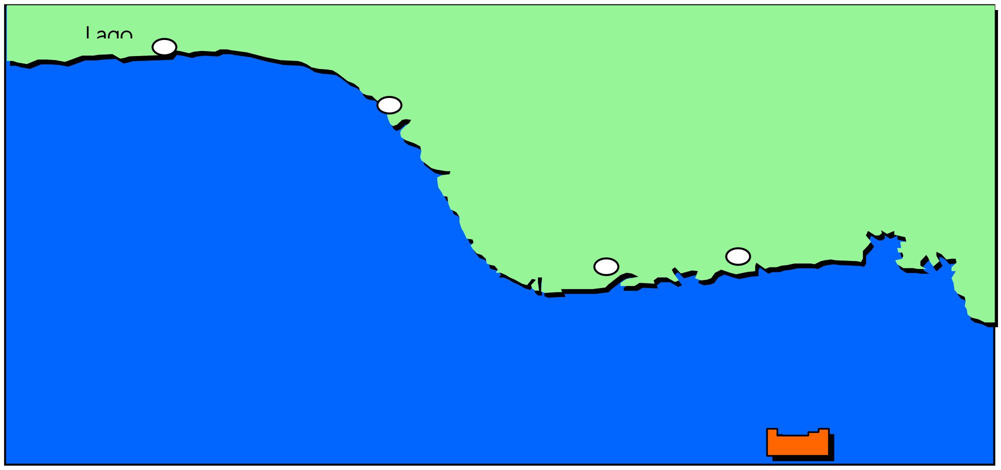

Fig.3.1: Location Map of Osemu Field

IV. Geology of the Study Area

The Niger Delta is situated in the Gulf of Guinea (fig. 1) and extends throughout the Niger Delta Province as defined by Klett et al (1997). From the Eocene to the present, the delta has prograded southwestward, forming depobelts that represent the most active portion of the Delta at each stage of its development (Doust and Omatsola, 1990). These depobelts formone of the largest regressive deltas in the world with an area of some 300,000 km2 (Kulke, 1995), a sediment volume of 500,000 km3 (Hospers, 1965), and sediment thickness of over 10 km in the basin depocenter (Kaplan et al. 1994).

Three geological formations are considered as part of the petroleum system in the Niger Delta. The basal one composed of marine shales, called the Akata Formation. This unit ranges in thickness from 600 m to more than 6000 m (Weber and Daukoru, 1975; Aigbedion and Hafiz,2017). The overlaying formation is named Agbada. This formation consists of interbedded sands and shales and is known as the hydrocarbon bearing zone. The cap unit is the Benin Formation and comprises continental fluvial sands. This unit is a non-hydrocarbon bearing formation.

.

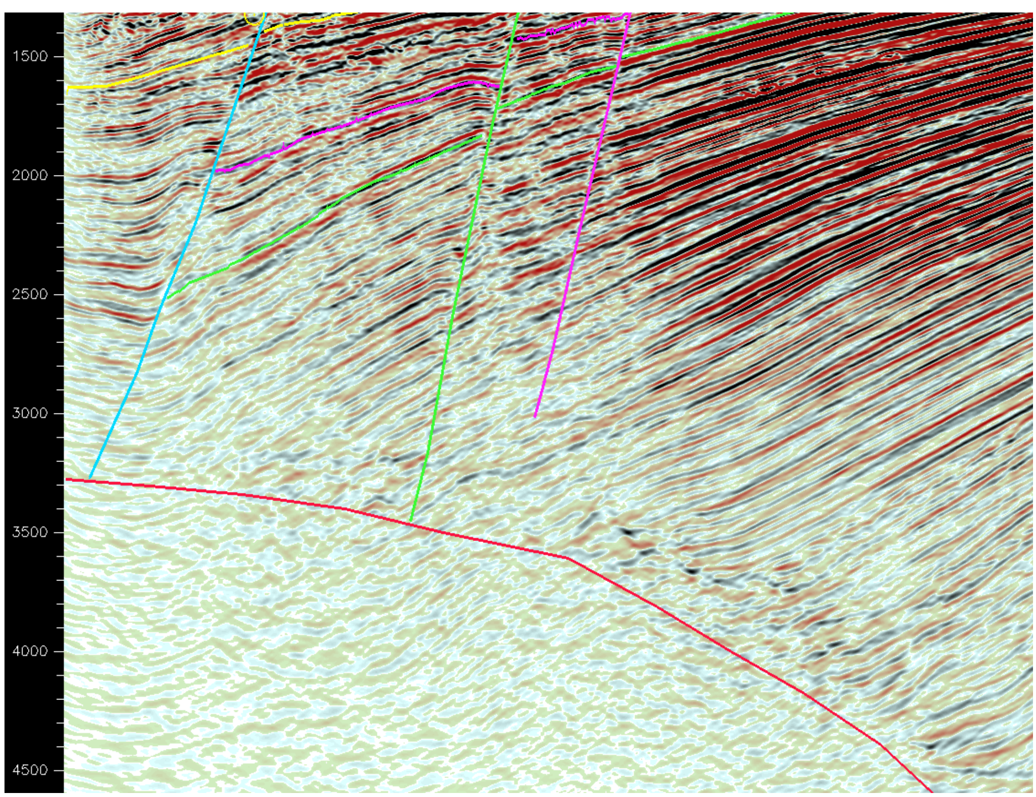

Fig.4.0: Akata Shale mapped from 3300ms

a) Structures

Two structural patterns can be observed in the Osemu area from the fault orientations, and shape of the mapped levels

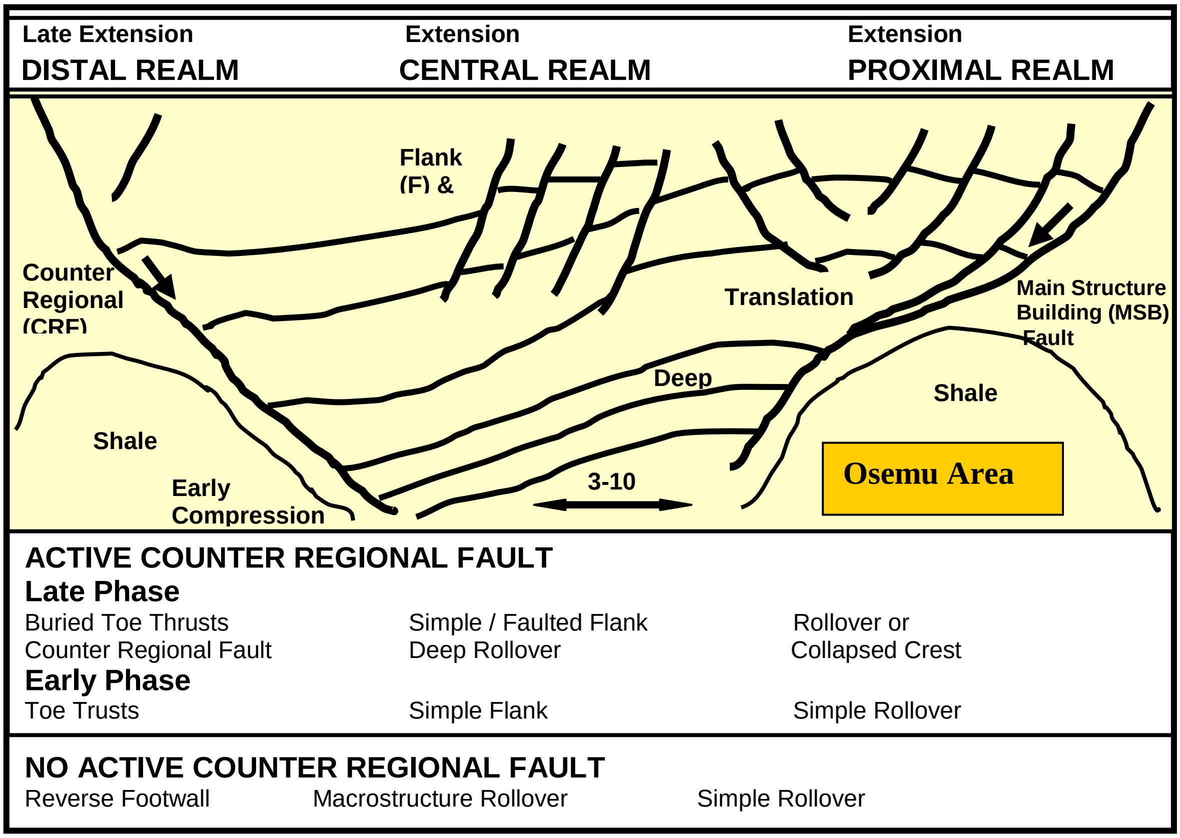

Fig.4.1: The Main Structural Framework of the Osemu Area.

The main structural controls are the arcuate NW-SE trending, synthetic growth faults. The Osemu area faults are subvertical with expressions at the sea-bed. This could be attributed to fault rejuvenation caused by tectonics of the underlying under-compacted massive Akata shales. Deformation takes place by gravitational gliding of rigid block along a decollment horizon above underlying shale as result of sedimentary loading (Figure 5).

Another remarkable feature in the Osemu geology is the pattern of termination of the NW-SE crystal faults which also corresponds to the point of bifurcation of the major fault into a bigger down dip component and a splinter at the up thrown. This arrangement suggests that the crystal collapse also initiated the extension of the major fault SE in a stress release mechanism. Subsequent sediment loading led to the SW rotation of the major fault to form an arcuate limb that supports the high zone of the Osemu closure (figure 15)

Lithostratigraphy: The Tertiary section of the Niger Delta is divided into three formations, representing prograding depositional facies that are distinguished mostly by the lithofacies mix. It is possible to summarise the stratigraphic column of the Niger Basin in three main diachronous lithologic formations; Benin, Agbada, and Akata (Figure 6).

Benin is the youngest formation and is comprised of continental, fluvio-alluvial and upper coastal plain sediments with good porosity, but generally low permeability, this fact limits to oil production from the Benin Formation in the Basin. The sequence passes laterally into the paralitic / deltaic sandstone of the Agbada Formation.

The majority of hydrocarbons produced in the basin come from the alternating sandstone and siltstone that make up the *Agbada* Formation. A shelf to the deltaic/lagoonal environment characterized the sequence deposits. The observed small and large-scale sedimentary cyclicity is probably mainly related to climatic change effects. Growth faults control/influence the sedimentation patterns. The paralic sandstone of Agbada Formation passes offshore into the distal prodelta\deep marine shale of the Akata Formation.

The *Akata* Formation at the base of the delta is of marine origin and is composed of thick shale sequences (potential source rock), turbidite sand (potential reservoirs in deep water), and minor amounts of clay and silt. Beginning in the Palaeocene and through the Recent, the Akata Formation formed during low stands when terrestrial organic matter and clays

Global Journal of Human-Social Science (B) Volume XVIII Issue IV Version I Year 2018

were transported to deep-water areas characterized by low energy conditions and oxygen. Turbidity currents likely deposited deep-sea fan sands within the upper Akata Formation during the development of the Delta. The Akata Formation (Eocene - Early Miocene) is dark grey marine shale throughout the basin and is typically considered to be the source rock for most of the hydrocarbon production in the area.

Deposition of the three formations occurred in each of the five of flapping siliciclastic sedimentation cycles that make up the Niger Delta. These cycles (depobelts) are 30-60 kilometers wide, prograde south-westward 250 kilometers over oceanic crust into the Gulf of Guinea, and are defined by syn-sedimentary faulting that occurred in response to variable rates of subsidence and sediment supply. The interplay of subsidence and supply rates resulted in the deposition of discrete depobelts. When further crustal subsidence of the basin could no longer be accommodated, the focus of sediment deposition shifted seaward, forming a new depobelt. Each depobelt is a separate unit that corresponds to a break in the regional dip of the delta and is bounded landward by growth faults and seaward by large counter-regional faults or the growth fault of the next seaward belt.

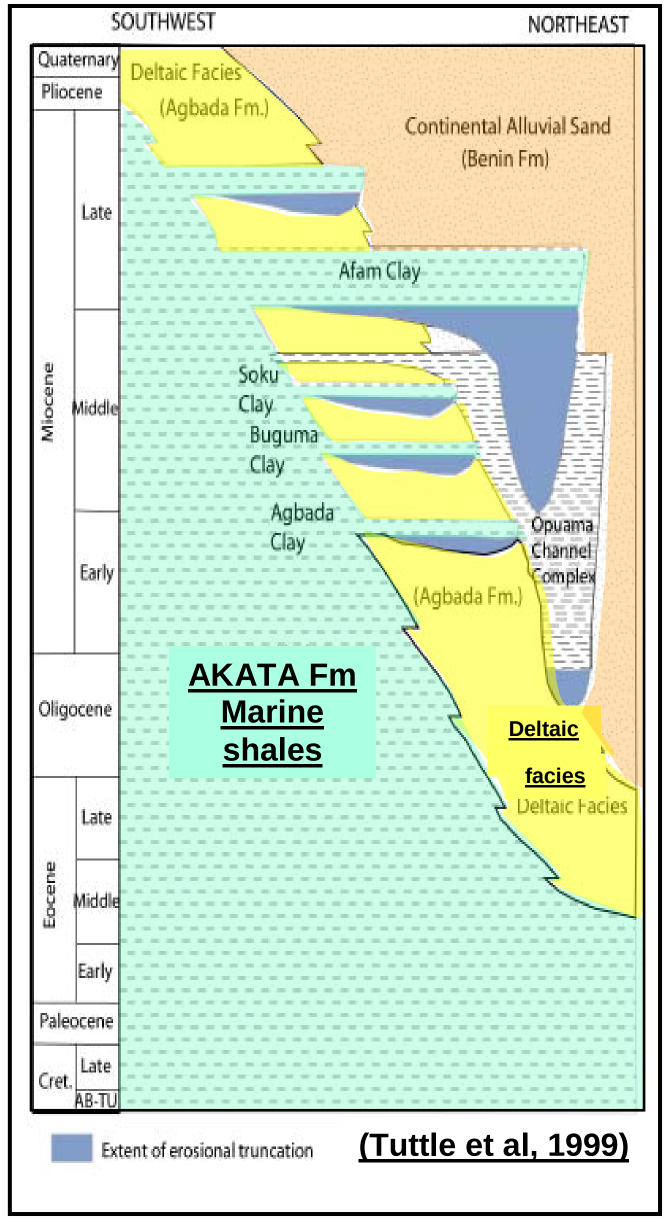

Fig.4.2: The Stratigraphic Profile of the Niger Delta

V. Materials and Methods

a) Materials

The Geophysical data consisted of approximately 360 Km^2 of conventional 3D seismic and a depth model for the entire volume. The closest well with a check shot (Ose-5) is about 17km away from the prospect. Since realistic check shot data was not available, it was necessary to use the RMS velocities provided by the processing company for conversion of the time generated maps to depth. The second order polynomial equation $y=0.0001x^2 + 0.9453x - 97.214$ was used for the conversion.

The geological data and the petro physical information referenced here were some well picks from nearby Ose field.

The following sets of data were used in the interpretation:

Seismic: Full Stack
Angle stacks (0-15 and 25-40)
Control Well: Ose 5 well data
Velocities: Stacking velocities from seismic

VI. Methodology

The simplified workflow is as outlined below:

- An overview of the entire seismic volume was taken before deciding which reflectors should be mapped. Reference was also made to the depth at which hydrocarbon was found at nearby Ose and Osno fields.
- Horizons and faults were then mapped on crosslines and inlines.
- The mapped horizons were then exported along with their respective fault polygons to the mapping software.
- The time maps were then converted to depth by the RMS-Velocity equation for the seismic volume ($y=0.0001x^2+0.9453x-97.214$).

a) Fault Picking

The major NW-SE (Osemu F1) controlling fault was mapped across the area. The throw of fault decreases gradually towards the SE until it is truncated by a major arcuate, south dipping fault.

b) Horizon Mapping

A total of seven horizons were mapped. They represent the top of seismic sequences identified within a time zone of 1200 ms-2600ms. This is considered as the zone of interest by reference to the prospect levels in the adjacent Ose-Osno fields.

Seven Horizons were mapped including the sea bed. Four Horizons are considered prolific (C, D, E & F) due to their situation within the Agbada depth ranges. All Horizons were interpreted in time, then gridded and converted to depth. Figures (8, 10, 12, 14, 16, 18, & 20) shows Sea Bed, Horizons A, B, C, D, E & F in time. Figure (9, 11, 13, 15, 17, 19 & 21) shows the respective horizons map in depth.

The velocity model for the depth conversion was built into the respective time horizons to produce a depth equivalent using the RMS velocities (figure 2).

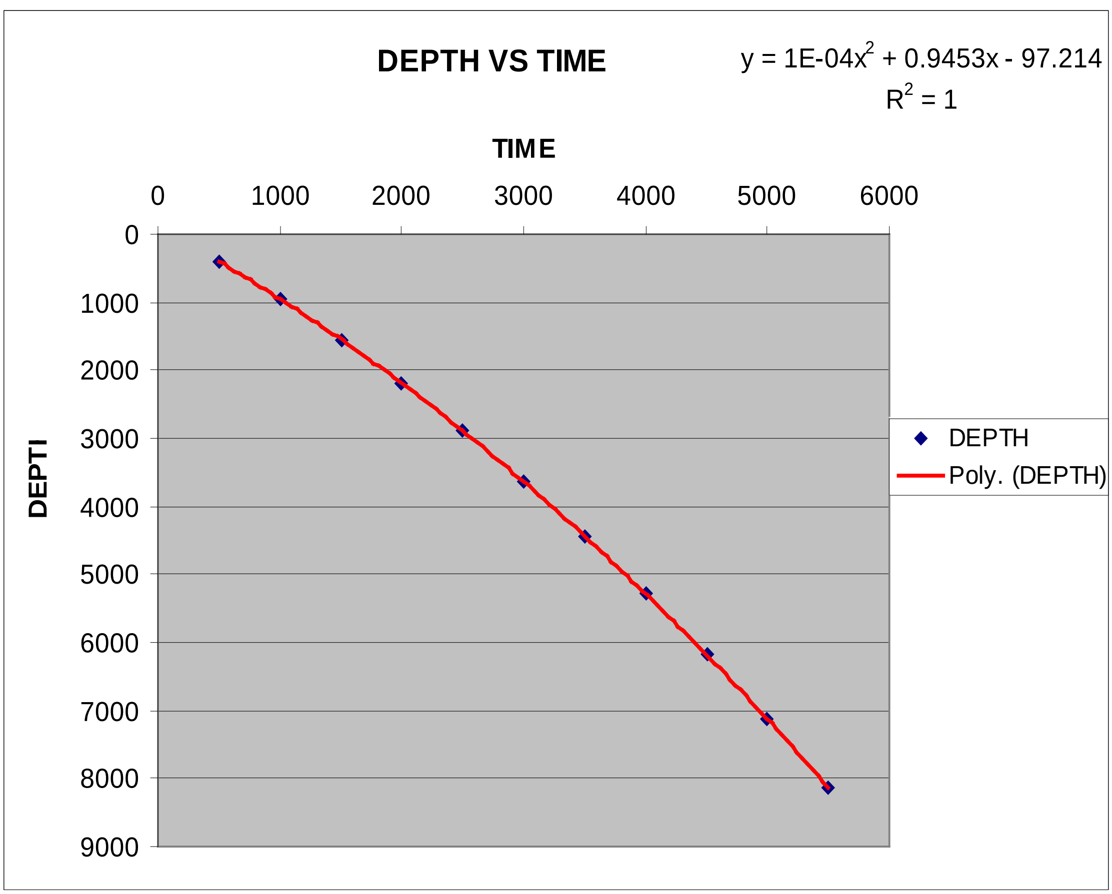

Fig 5.0: Graph Shows plotted Time-Depth value for RMS velocities

c) *Amplitude Extraction*

Amplitude extraction was done on all the mapped time horizons. Maximum Negative Amplitude maps were produced (figure 3a & 3b). The amplitudes did not show any hydrocarbon related anomalies as observed by their non-conformance to structure.

The angle stacks were also examined for possible AVO effects. There was slight amplitude boost with offset.

VII. Discussion of Results

a) *Prospects Identification*

o The seismic interpretation has identified two main prospects in the Osemu area. These are named Osemu-Main and Osemu-Upper. (Figure 6.1)

- The Osemu-Main prospect is a tongue-like NW-SE trending formed at the downthrown block of the structure building fault. The structure is fault assisted at shallower levels (A-C) and faults dependent at depth. The areal extent of Osemu prospect is enhanced by the termination of the controlling fault against a south-dipping synthetic fault. The sealing capacity of the termination point impacts significantly on the prospectivity of the Osemu-Main.
- The Osemu-upper prospect is formed as a wedge between the bigger branch of the major fault and the northern splinter fault.

b) *Estimation of Hydrocarbon-In-Place*

The deterministic estimation of oil in place for the Osemu Field was completed using 3-D geological modeling in the Zmapp software package. This procedure involves bringing structural surfaces in from the geophysical package (Landmark), building a detailed fault model, and then modeling both facies distributions and the distribution of petrophysical parameters within the facies model (Deutsch and Hallstrom ,2000).

Probable areas measured from depth maps for the prospective horizons ranges from 726 acres in Horizon E.0 to 3975 acres for Horizon C.0 (Table 1). Three cases were considered in determining the possible closure area. These are minimum, most likely and maximum contour closures representing varying sizes.

Table 1: Contour Values, Depth Values [,And Areas] For Each Top

TOPS	CONTOUR LINE	CASE	TVDSS (m)	AREA (acres)
Horizon C	1800	Minimum	1,780	1322
	1900	Most Likely		2622
	2000	Maximum		3975
Horizon D	2200	Minimum	2,125	1655
	2250	Most Likely		2366
	2300	Maximum		3480
Horizon E	2500	Minimum	2,525	726
	2550	Most Likely		1072
	2650	Maximum		2583
Horizon F	3030	Minimum	2,930	2022
	3040	Most Likely		2082
	3050	Maximum		2135

The four (4) Horizons considered for volume estimation (C, D, E & F) have a total of 410.58mmbls as P50, 309.32mmbls P10 and 445.21mmb is as P90.

Global Journal of Human-Social Science (B) Volume XVIII Issue IV Version I Year 2018

Detail of the volumetrics is shown in the table below.

SAND	VALUE	CONTOUR CLOSURE	AREA ACRE	AVERAGE NET THICHNESS	NET RK VOL. ACRE-FT	NET RK VOL. MMBLS	AVG-Ø (%)	AVG-Sw (%)	OHIP MMBLS	FVF	STOIP MMBLS	REC FACTOR	U-RESV OIL-MMB	COM-PROD MMBLS	RR MMBLS
C.0	MINIMUM	-1780	1,322	45.00	59,490.00	461.52	0.26	0.25	90.00	1.260	71.43	0.30	21.43	0	21.43
	MOST LIKI	-1900	2,622	45.00	117,990.00	915.37	0.28	0.35	166.60	1.260	132.22	0.30	39.67	0	39.67
	MAXIMUM	-2000	3,975	45.00	178,875.00	1387.71	0.24	0.45	183.18	1.260	145.38	0.30	43.61	0	43.61
D.0	MINIMUM	-2200	1,655	45.00	74,475.00	577.78	0.26	0.25	112.67	1.260	89.42	0.30	26.83	0	26.83
	MOST LIKI	-2250	2,366	45.00	106,470.00	825.99	0.28	0.35	150.33	1.260	119.31	0.30	35.79	0	35.79
	MAXIMUM	-2300	3,480	45.00	156,600.00	1214.90	0.24	0.45	160.37	1.260	127.28	0.30	38.18	0	38.18
E.0	MINIMUM	-2500	726	45.00	32,670.00	253.45	0.26	0.25	49.42	1.260	39.23	0.30	11.77	0	11.77
	MOST LIKI	-2550	1,072	45.00	48,240.00	374.25	0.28	0.35	68.11	1.260	54.06	0.30	16.22	0	16.22
	MAXIMUM	-2650	2,583	45.00	116,235.00	901.75	0.24	0.45	119.03	1.260	94.47	0.30	28.34	0	28.34
F.0	MINIMUM	-3030	2,022	45.00	90,990.00	705.90	0.26	0.25	137.65	1.260	109.25	0.30	32.77	0	32.77
	MOST LIKI	-3040	2,082	45.00	93,690.00	726.85	0.28	0.35	132.29	1.260	104.99	0.30	31.50	0	31.50
	MAXIMUM	-3050	2,135	45.00	96,075.00	745.35	0.24	0.45	98.39	1.260	78.08	0.30	23.43	0	23.43
TOTAL		MINIMUM (P10)									309.32		92.79		92.79
		MOST LIKELY (P50)									410.58		123.17		123.17
		MAXIMUM (P90)									445.21		133.56		133.56

Table Showing detailed volume calculations for the four Horizons considered in the volumetrics.

c) *Risk and Uncertainties*

The following Table summarizes the risk of finding flowable Hydrocarbons for both Osemu-Main and Osemu-Upper prospects.

S/N	Parameter	Indication	Probability of Success	
			Osemu-Main	Osemu-Upper
1	Trap	Fault assisted. Major fault up to surface	0.5	0.5
2	Seal	Top and lateral seal confirmed in Osno/Ose	0.5	0.5
3	Timing	Migration after syn-depositional, faulting	0.7	0.7
4	Closure	200-1000m structural relief.	1	0.5
5	Reservoir	High quality sands (adjoining blocks of OPL 90, Osno&Ose prolific.	0.8	0.6
6	Porosity	Nearby field in the range of 19-35%	1	0.8
7	Permeability	As in Osno-Ose production profile	1	1
8	Source	Thick Akata shales. Same for nearby discoveries	1	1
9	Maturation	Thick overburden. Targets Deeper than nearby Discoveries	1	1
10	Migration	Migration path through fault systems	1	1
11	Preservation	Unlikelihood of biodegradation due to fault Extension to the surface.	0.6	0.6
12	Hc Quality	Oil and solution gas as in Osno/Ose.	0.9	0.9
13	Recovery	Natural drive as in Osno/Ose	1	1
		Overall Probability of Success	**0.85**	**0.78**

VIII. Conclusion and Recommendations

1. A major NW-SE trending growth fault controlled sedimentation and structural deformation in the area.
2. Two wells are proposed to be drilled on the structure. The two are expected to pierce all the four sands considered in the volumetrics mid way between the crest and the flank.
3. Fault analysis is to be carried on the main structure building fault to ascertain its sealing ability.
4. The Osemu upper prospect should be explored if the Osemu main is successful.
5. A time-depth model to be created from check shot data on one of the exploratory wells and compare with the RMS velocity and update it accordingly.
6. All essential log suite must be run during the exploratory drilling stage to acquire accurate and precise petrophysical details.

References Références Referencias

1. Adeoye TO, Enikanselu P (2009). Reservoir Mapping and Volumetric analysis using Seismic and Well Data. Ocean J. App. Sci. 2(4):66 – 67.
2. Aigbedion Isaac and Hafiz Abdullai (2017). Evaluation of Hydrocarbon Prospect of Fareed

Field, Western Niger Delta, Nigeria Journal of Geography, Environment and Earth Science International, ISSN: 2454-7352, Vol.: 7, Issue. 4

3. Aigbedion I, and Iyayi SE (2007) Formation Evaluation of Oshioka Field, using geophysical well logs Middle-east J. of Scientific Res.2 (3 –4):107 – 110
4. Emujakporue GO, Faluyi TO (2015). Evaluation of hydrocarbon volume in'TRH' Field, onshore Niger Delta, Nigeria. Int. J. Geophy and Geochem.2 (5):113 -123.
5. Evamy, B.D., Haremboure, J., Kamerling, P., Knaap, W.A., Molloy, F.A., and Rowlands, P.H., (1978), Hydrocarbon habitat of Tertiary Niger Delta: American Association of Petroleum Geologists Bulletin, v. 62, p. 1-39.
6. Doust, H., and Omatsola, E., (1990), Niger Delta, in, Edwards, J. D., and Santogrossi, P.A., eds., Divergent/passive Margin Basins, AAPG Memoir 48: Tulsa, American Association of Petroleum Geologists, p. 239-248.
7. Kaplan, A., Lusser, C.U., Norton, I.O., (1994), Tectonic map of the world, panel 10: Tulsa, American Association of Petroleum Geologists, scale 1:10,000,000.
8. Klett, T.R., Ahlbrandt, T.S., Schmoker, J.W., and Dolton, J.L., (1997), Ranking of the world's oil and gas provinces by known petroleum volumes: U.S. Geological Survey Open-file Report-97-463, CD-ROM.
9. Kulke, H., (1995), Nigeria, in, Kulke, H., ed., Regional Petroleum Geology of the World. Part II: Africa, America, Australia and Antarctica: Berlin, GebrüderBorntraeger, p. 143-172
10. Weber, K.J. and Daukoru, E. (1975) Petroleum Geology of the Niger Delta. Jour. Min. Geol., 12, 9-12.

Appendixes

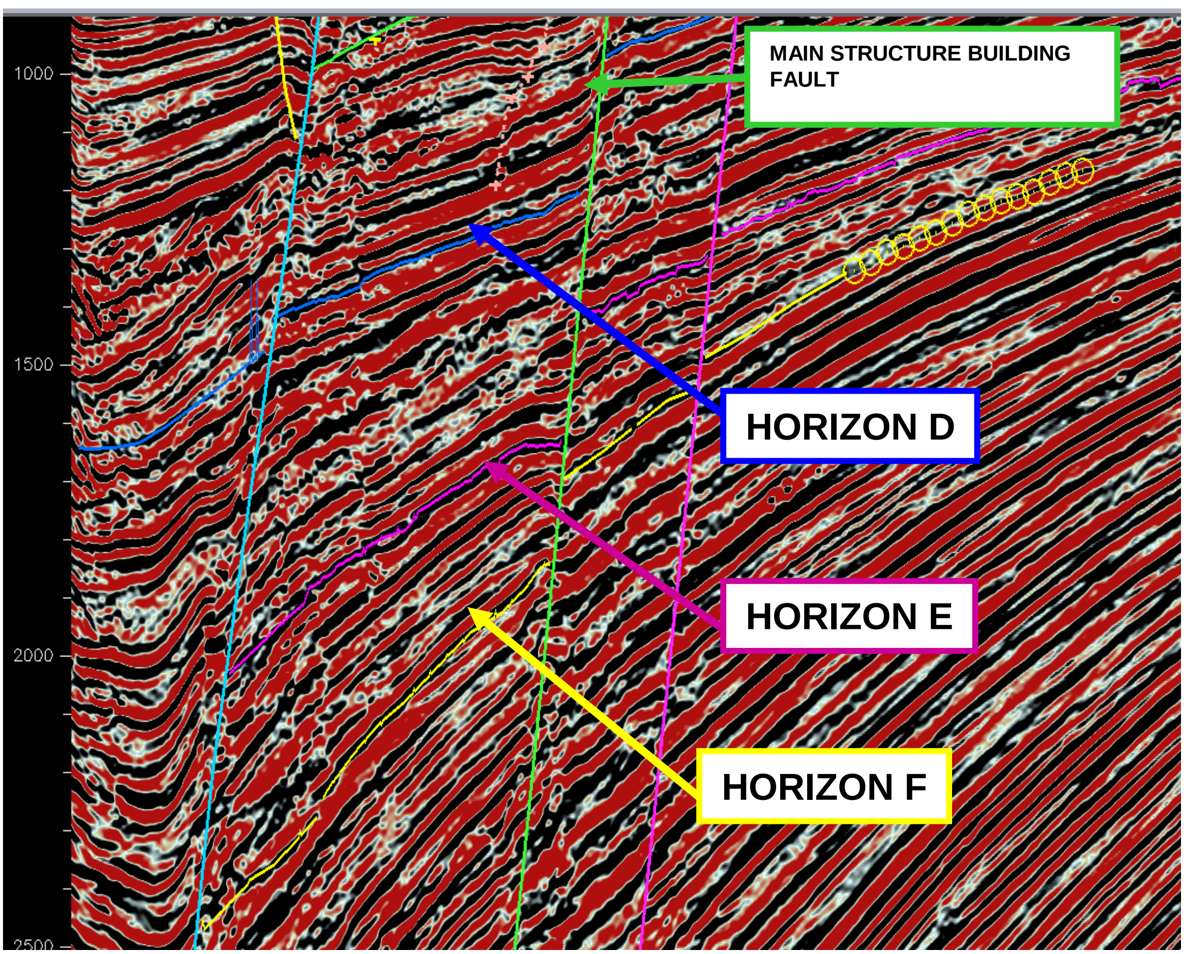

Fig. 7: Seismic in-line showing Main Structure building fault and mapped horizons

Global Journal of Human-Social Science (B) Volume XVIII Issue IV Version I Year 2018

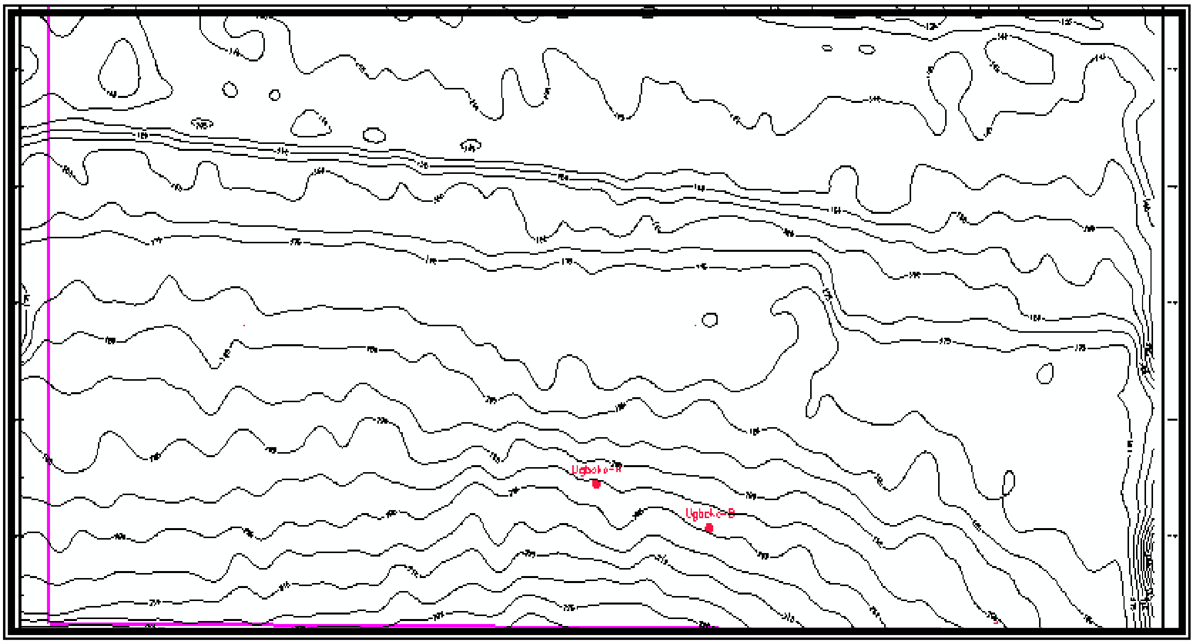

Fig.8: TWT of The Sea Bed

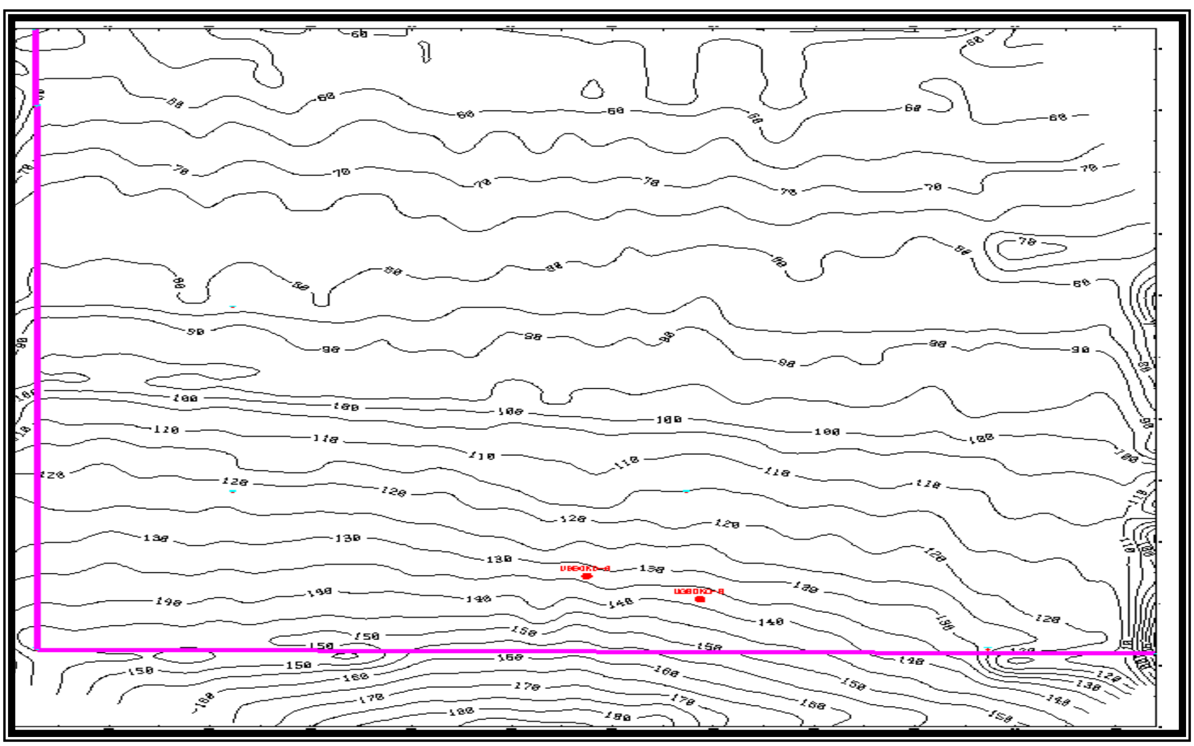

Fig.9: Depth Map of the Sea Bed

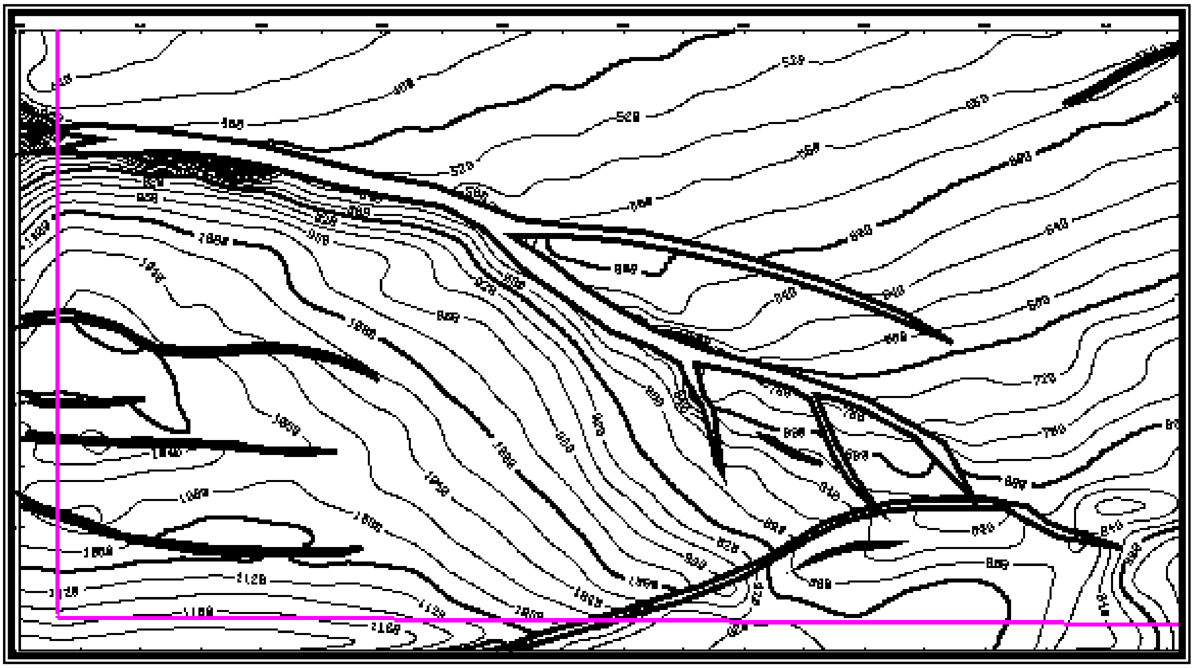

Fig.10: TWT Structure Map Of Horizon A

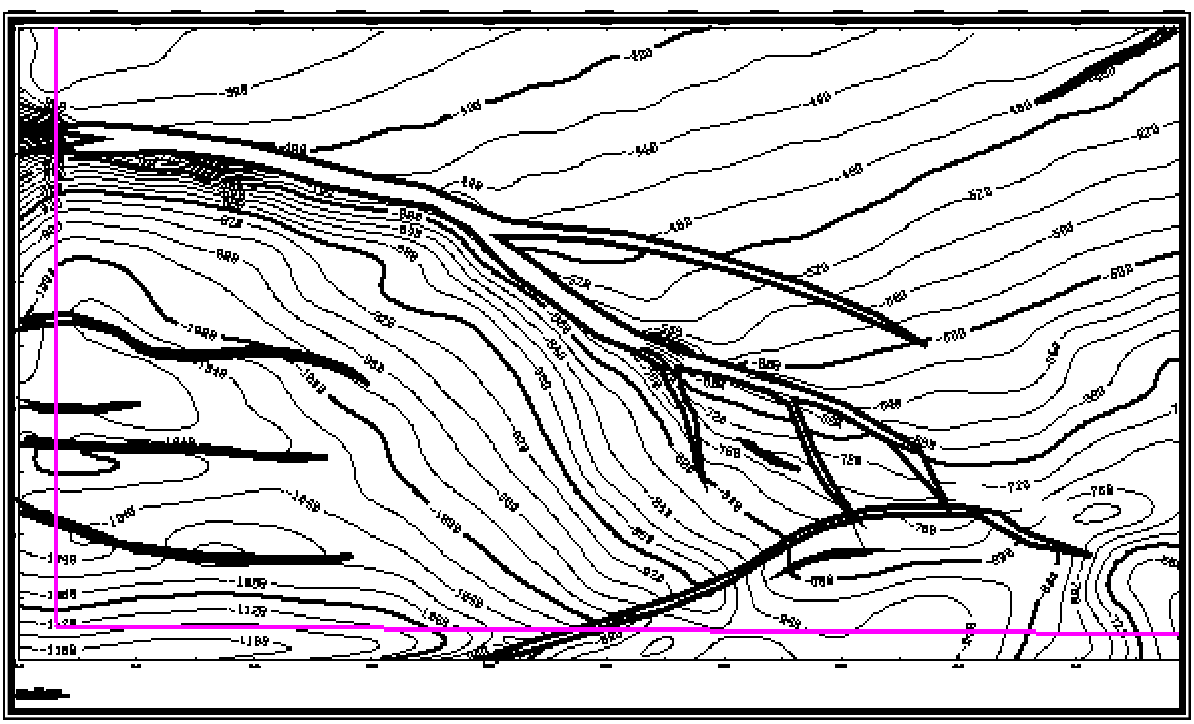

Fig.11: Structural Depth Map of Top A Horizon

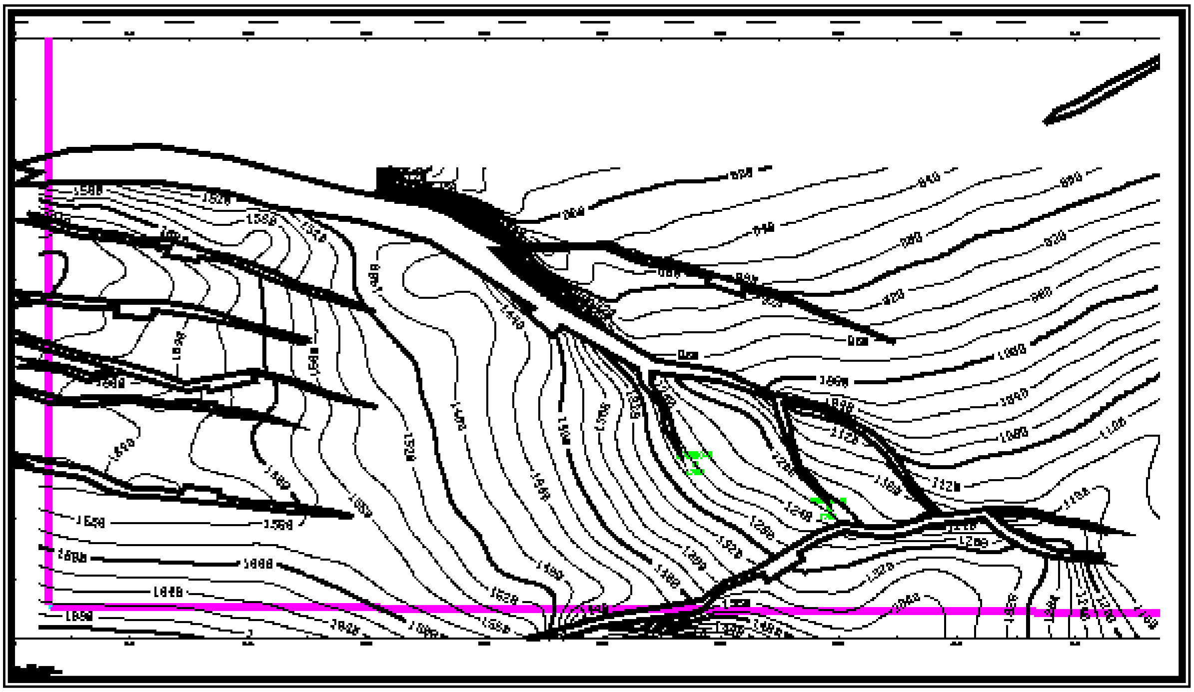

Fig.12: TWT Structure Map of Horizon B

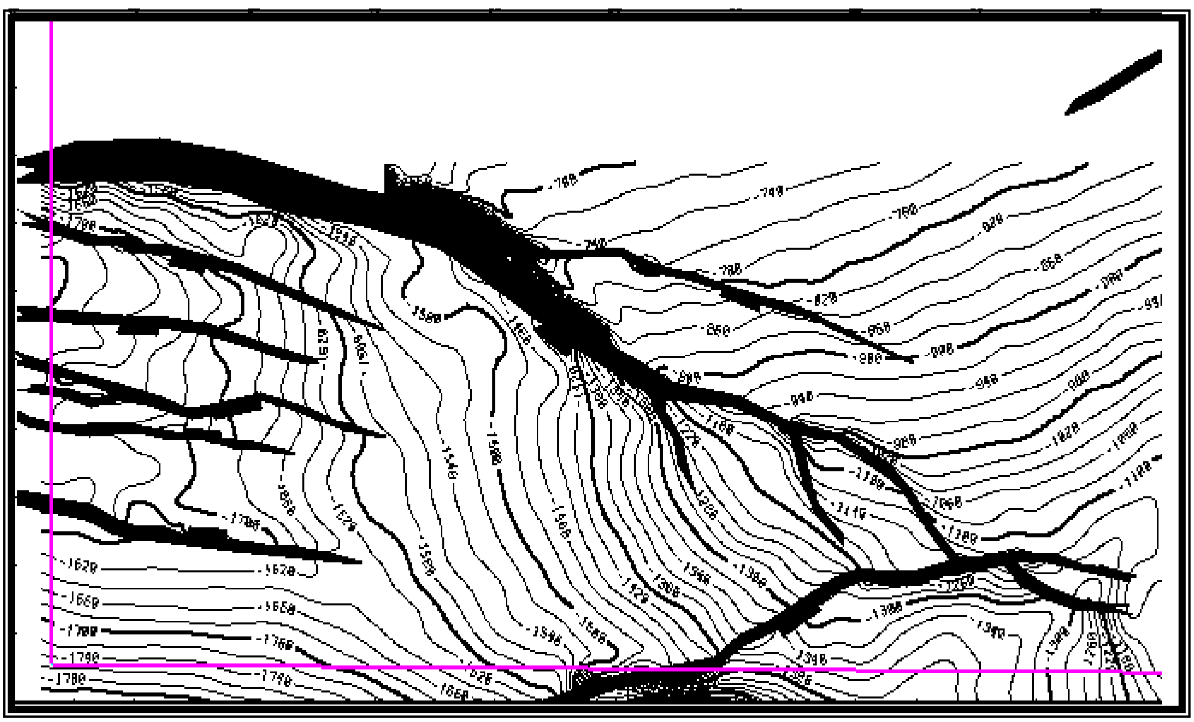

Fig.13: Structural Depth Map of Top B Horizon

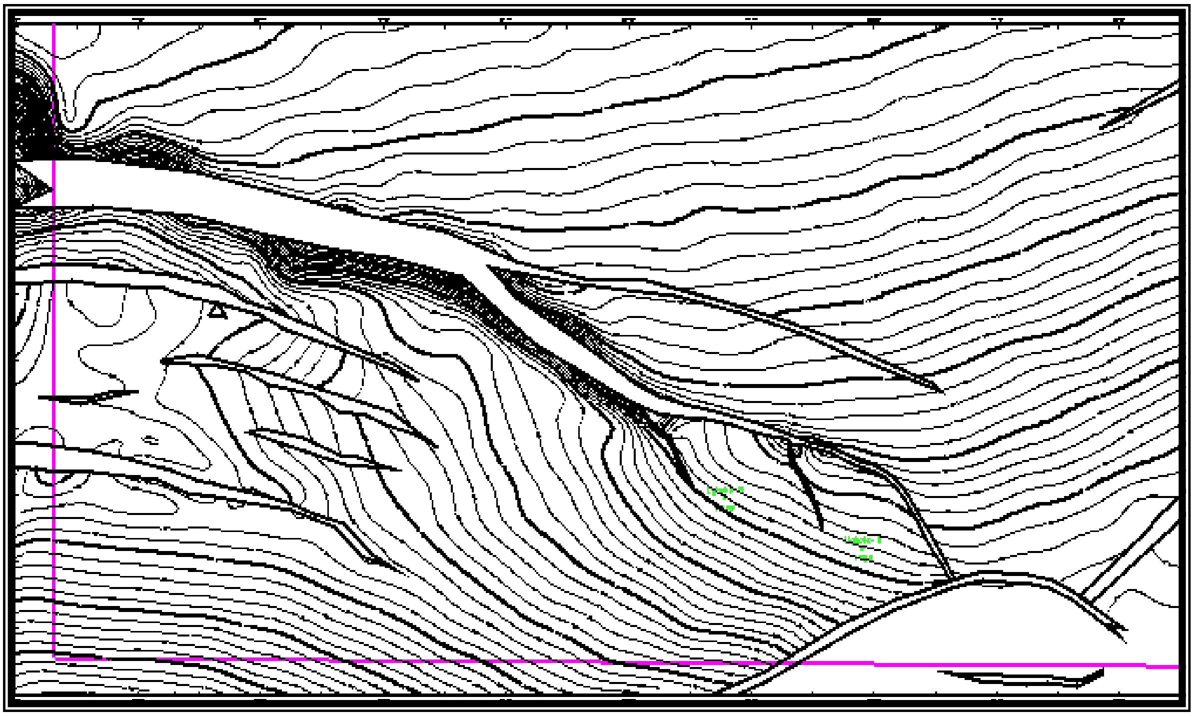

Fig.14: TWT Structure Map Of Horizon C

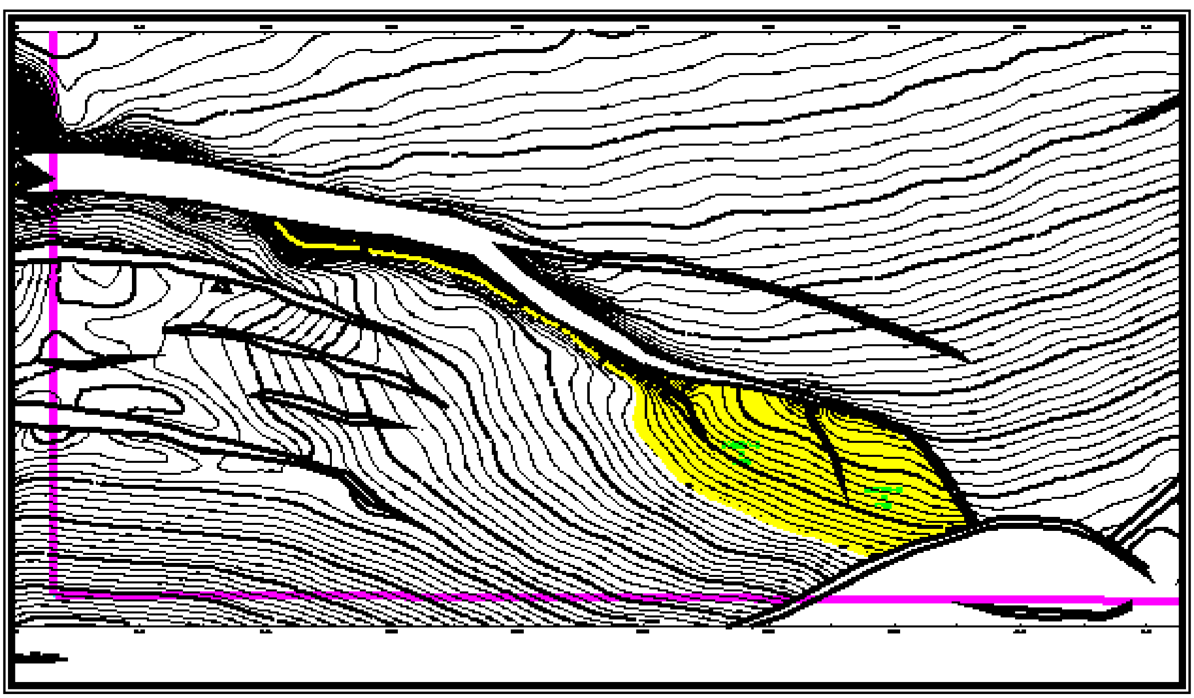

Fig.15: Structural Depth Map of Top C Horizon

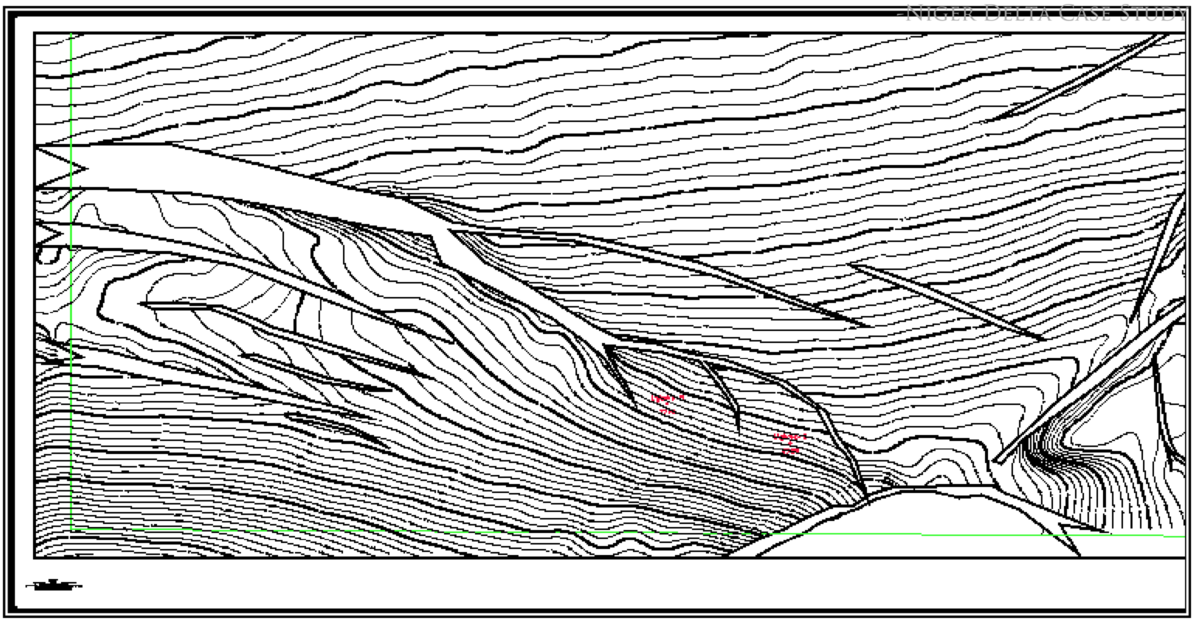

Fig.16: TWT Structure Map of Horizon D

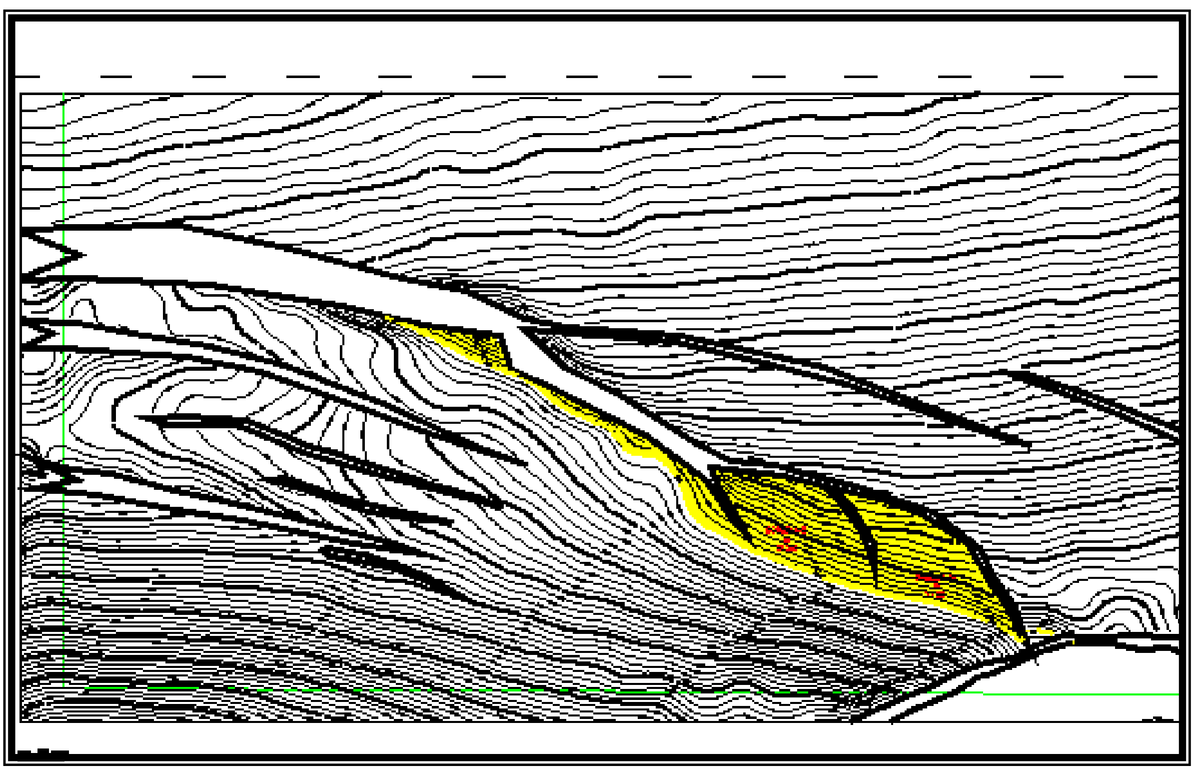

Fig.17: Structural Depth Map of Top D Horizon

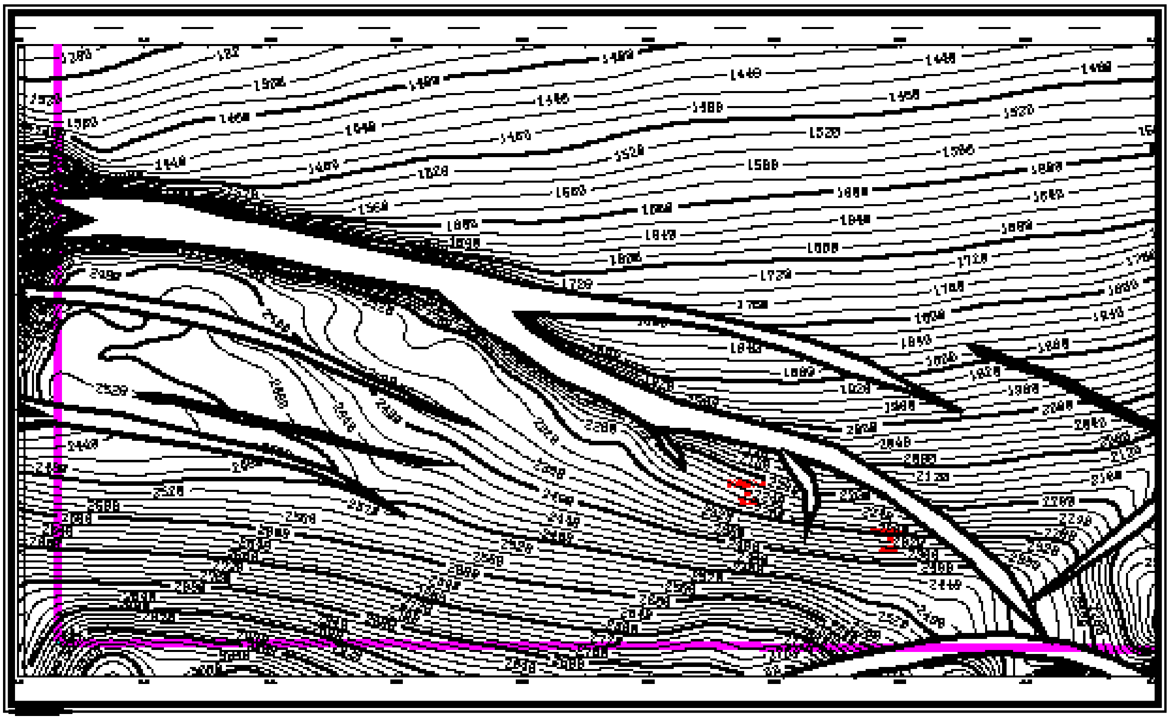

Fig.18: TWT Structure Map Of Horizon E

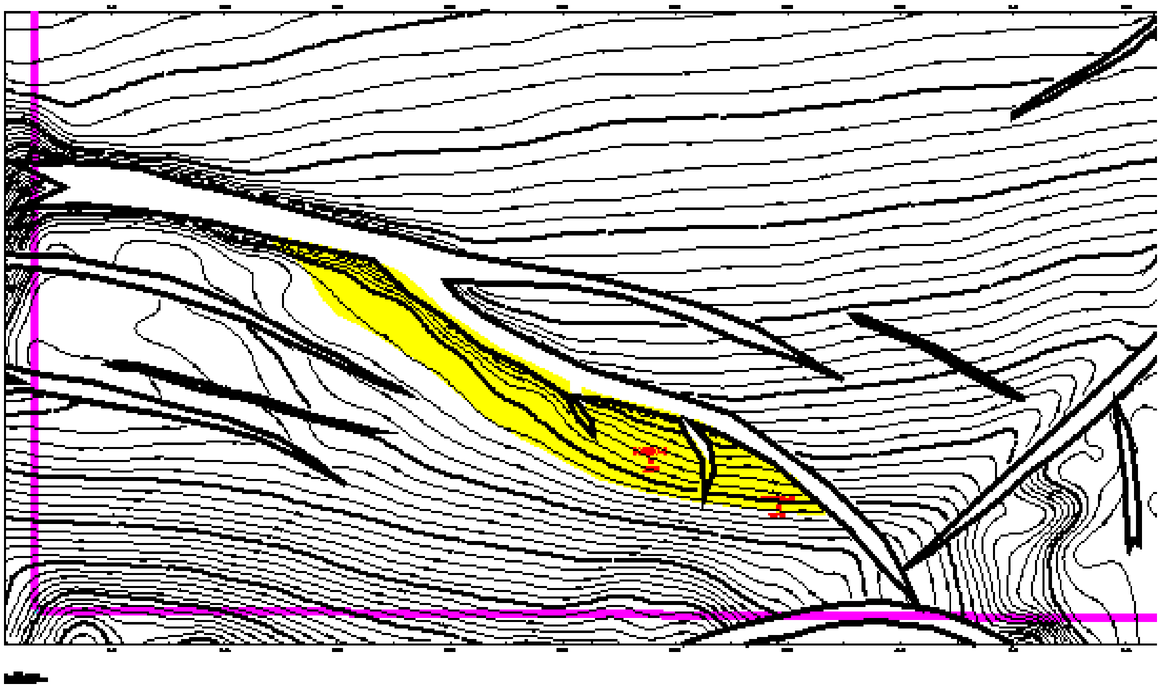

Fig.19: Structural Depth Map of Top E Horizon

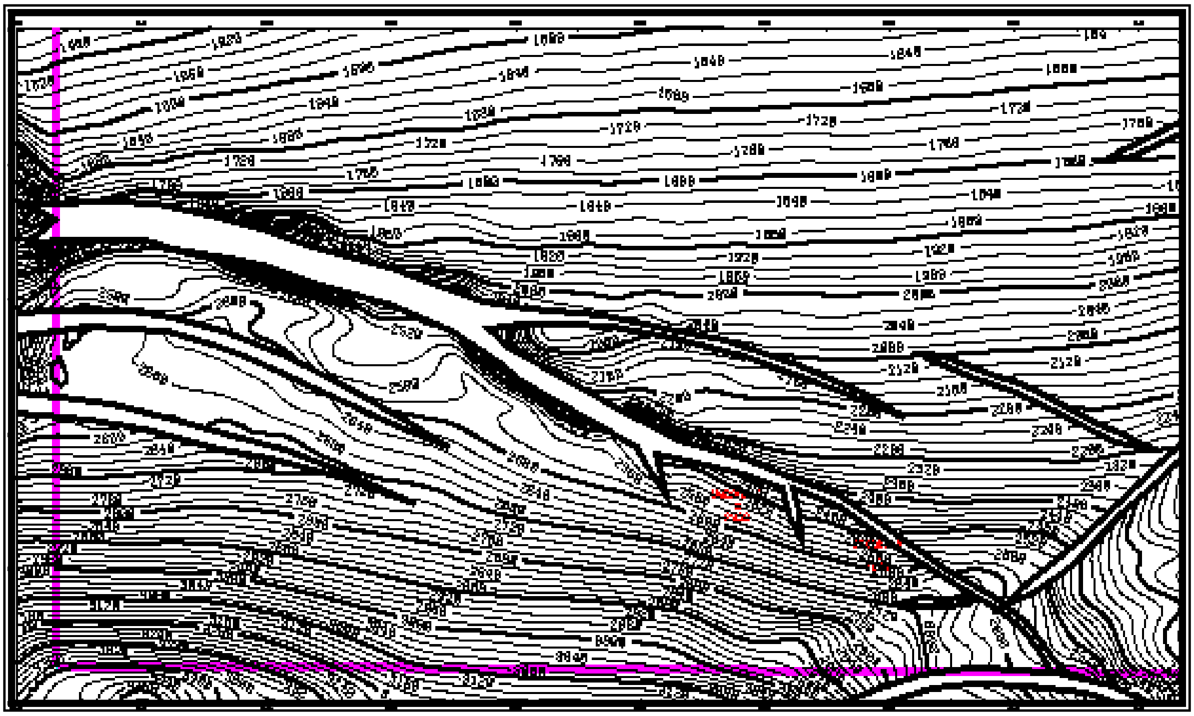

Fig.20: TWT Structure Map Of Horizon F

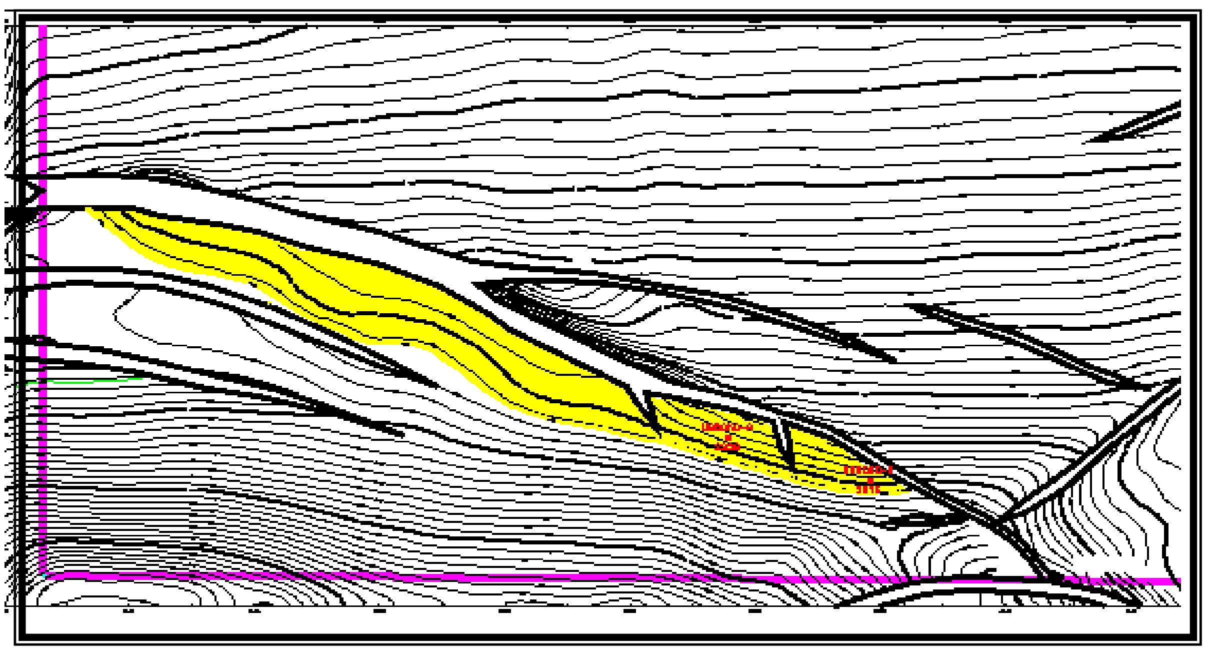

Fig.21: Structural Depth Map of Top F Horizon

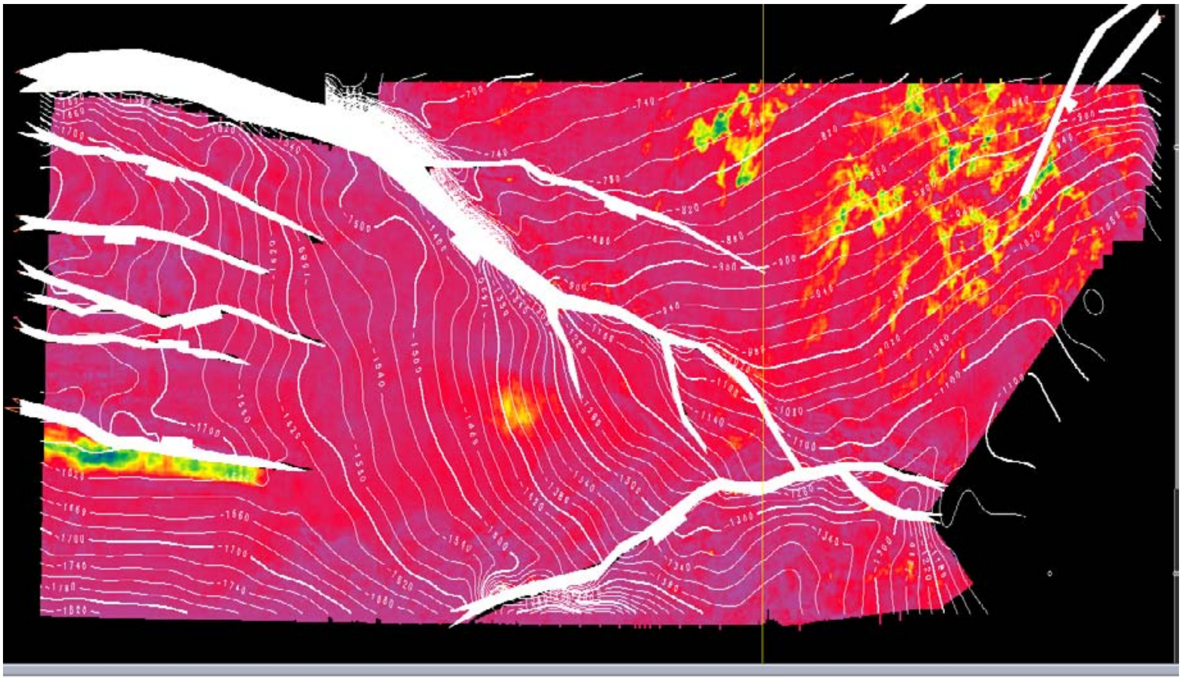

Fig.22: Maximum Negative Amplitude +/-20ms for B.0 Horizon.

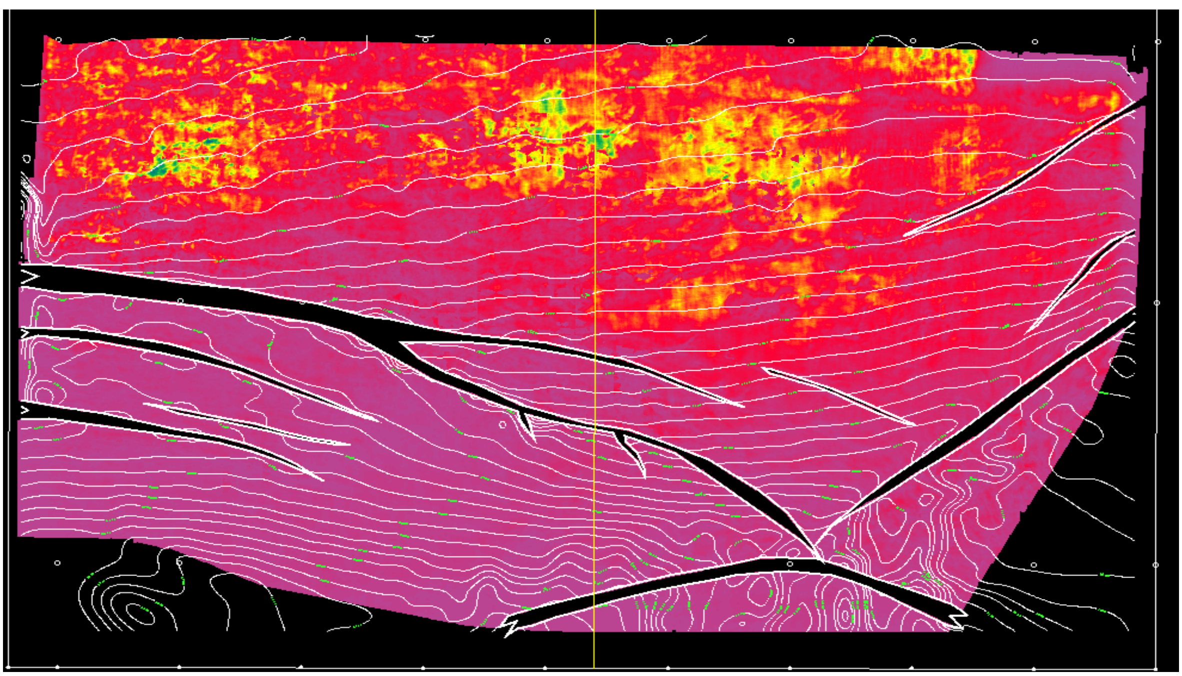

Fig.23: Maximum Negative Amplitude -20+50ms for E.0 Horizon.