3D Seismic Evaluation and Opportunity Identification in Some Parts of the Niger Delta.

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ABSTRACT

Eve Block is located in the eastern shallow offshore Niger Delta, on the present-day shelf in water depth ranging from approximately 10-60 meters. The Eve Block area is partly covered by short cable 3D seismic data of different vintages. Multiple interpretations through integration of these 3D seismic data sets and well data have shown presence of many traps.

Four horizons were mapped regionally over the Eve Blocks to capture opportunities at shallow, intermediate and deep levels. In the Eve Block three additional deeper horizons were mapped. Most structures consist of tilted fault blocks both in a foot wall and hanging wall setting, some of them in collapsed crests. Very few four way dip closures were identified and those that do exist show limited areal extent. Well results on oil and gas distribution indicate hydrocarbon fill to be increasingly more gas prone with increasing depth of the accumulations.

(Keywords: petroleum reserves, petroleum traps, Niger Delta, seismic data)

INTRODUCTION

Eve Block is an irregularly bounded acreage block shaped roughly like an eastward facing duck's head with open beak. The northern boundary of the block is generally aligned with the Upper Miocene expanding growth fault. The northern most eastward extension of the block (the upper beak) covers the downthrown rollover closures of this fault. The southern boundary of the block is aligned in part with a second growth fault, namely the Pliocene expander. The block is located in the east central shallow offshore Niger Delta, on the present-day shelf in water depth ranging from 10-60 meters. The acreage area is 1150 sqkm. 78% of the block is covered by 1990's vintage short cable 3D seismic data.

Exploration activities started in the Eve Block in the mid1960s. To date 40 wells have been drilled on the block including 15 new field wildcats. These wells discovered two economic oil fields and four partially appraised or marginal oil discoveries four partially appraised - predominantly gas discoveries. Exploration efforts to date in the entire shallow offshore focused on the shallow and intermediate levels at depths less than 10,000 ftss.

This study is meant to identify hydrocarbon potential in this offshore block and provide a consistent evaluation of the block for further work.

GEOLOGICAL FRAMEWORK

The K block, is rectangular acreage block on the present-day shelf. Its northern boundary parallels a late Miocene expanding down to the basin growth fault. The SE margin of the block runs along or just downthrown and parallel to the Pliocene expander. Gravity and magnetic modeling shows that the Shallow Offshore depobelt is located on transitional crust (25km thick) bounded to the north by a major down to the basin growth fault system, and to the south by a counter regional fault system. The dominant structural style is collapsed crest structure, K type faults, simple and deep rollovers and back to back structures.

The shallow offshore consists of deltaic sequence that is overall regressive in nature and is divided into three diachronous units; the Benin, Agbada & Akata formations. The Benin formation consists of continental/fluviatile and backswamp deposits, the Agbada is paralic, brackish to marine, coastal fluvio-marine organized into coarsening upwards “offlap” cycles and the Akata formation comprises of marine pro-delta shales. Shales of the Akata formation are thought to be over-pressured in response to delta progradation and believed to be the main source rock in the Niger Delta. The map of the study area is as shown in Figure 1.

DEPOSITIONAL ENVIRONMENT

Biofacies as obtained from the SPDC Petrotrek-FINDER database indicate essentially inner neritic to bathyal settings with local stringers of fluviomarine influence for the main objective section in study area. This indicate that shelf during these periods were largely submerged.

This NW-SE stratigraphic correlation panel (Figures 2 and 3) is an attempt at correlation of sequence boundaries 0-7 and MFS 5.0. The NW-SE correlation of sequence boundaries (rSB) 0-7 flattened on the main MFS 5.0 (Bolivina-46) is based on biofacies, biostratigraphy, log patterns and seismic interpretation.

A regional structural rise to the south-east can be discerned from the correlation. Properties such as net to gross, reservoir-seal pairs and stratigraphic subdivision into thermal/biogenic gas and oil were deduced from the panel. The MFS 5.0 is regionally mappable in the entire acreage indicating its reliability as marker horizon and seal. This flooding event represents an approximate subdivision into shallow and intermediate and the deep facies, for subsurface tank subdivision.

SEISMIC INTERPRETATION

Van Gogh applied improved the data considerably. Imaging below 3 seconds which is the domain of most of the possible material leads may require a major reprocessing activity for maturing the prospects. The interpretation was done using Openworks and 123DI, initially in individual survey projects and later with a multi survey project.

Fault Interpretation: A FaultHigh volume was generated and time slices at various Two-Way-Time (TWT) values helped visualize the fault pattern over the entire area. FaultHigh is a similar volume as Semblance but generally of better quality. Fault planes are well defined on the FaultHigh data down to approximately 1.5 seconds twt but this does vary areally. The main reason for the loss of fault resolution on the FaultHigh volume seems to be the progressive loss of high frequency events with increasing depth. Figure 3 show timeslice through the FaultHigh volume at 1500ms twt values. Both the major and minor faults are clearly visible down to the 1500 ms slice.

Four horizons were mapped regionally to capture opportunities at shallow, intermediate and deep levels. These events were selected at or near flooding surfaces of approximately 5.2, 5.6, 5.8, and 6.0 Ma years. Limited use was made of well tops due to the difficulty of correlating these markers regionally. Substantial growth on many faults has resulted in large uncertainty on across fault correlations although in some area correlation could be made around fault tips or across area with significantly reduced throw.

The FaultHigh data was used extensively to pick fault polygons, especially for the shallower 5.2 and 5.6 events. Quality of the maps at 5.8 and 6.0 levels is reduced due to the significant decrease in signal to noise with depth. Overall structural geometry for the deeper leads is however still reasonable well defined, but these leads will need improved data quality to be matured or will remain of higher risk compared to the shallower leads.

Depth Conversion: The time grids were generated in Petrosys and exported back to 123DI where they were depth converted using the Eve-003 well velocity. Below the TD of this well (app. 3000ms or 4000 mss), a constant velocity was used of 4200 m/s.

Mapping: Four horizons were mapped regionally to capture opportunities at shallow, intermediate and deep levels. Time structure and depth structure maps were generated for the different levels. The maps are as shown in Figure 7 through Figure 10. Prospective levels are the conventional delta play consisting of leads at the 5.2, 5.6, and 5.8 levels.

Structural Analysis: Structurally, the study area is characterized by a distinctively fault-closed dominated structural play. Very limited 4-way dip closed structures are present.

The major structural control of deposition are depobelt boundary faults, active and prominent on the 3D data in the east of the block (Figures 4 – 6).

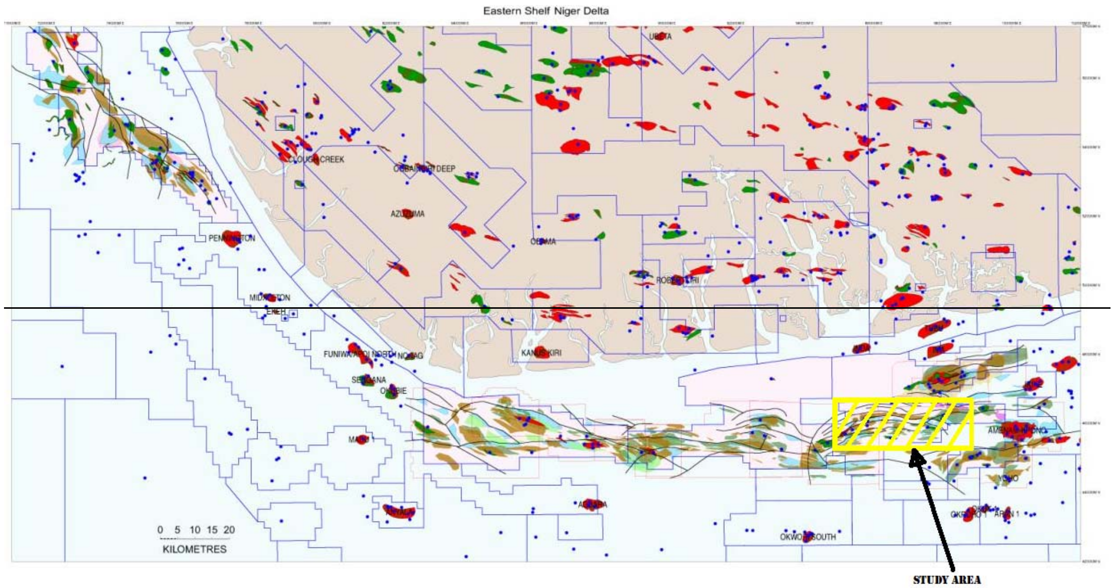

Figure 1: Map of Niger Delta Showing the Location of the Study Area.

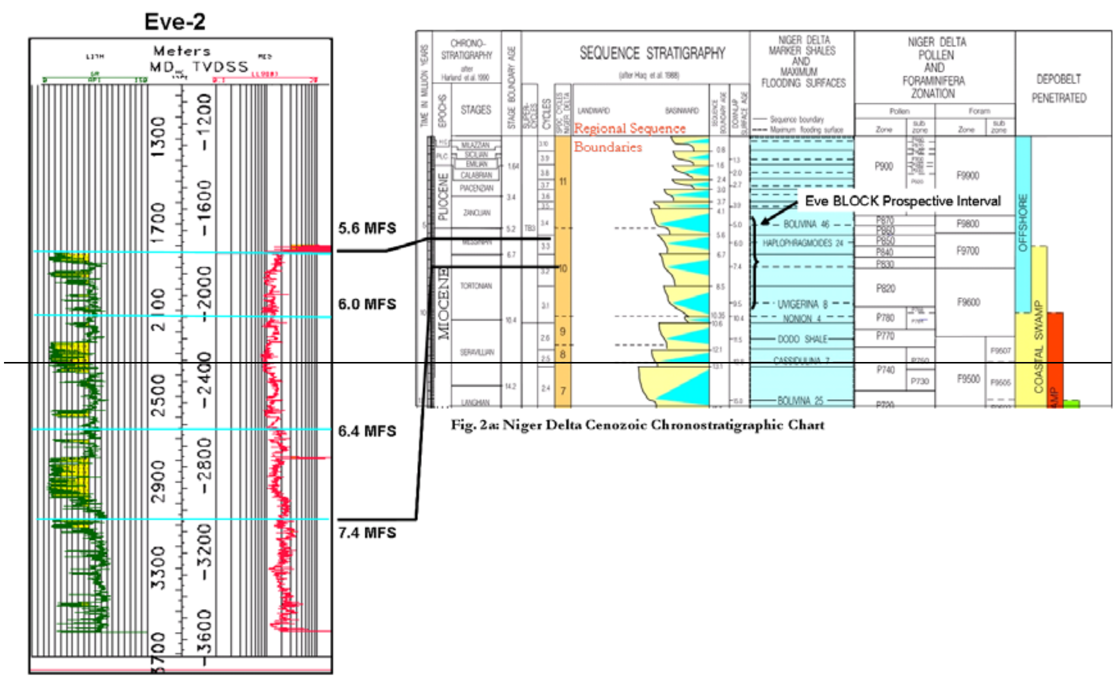

Fig. 2b: Eve-2 with a TD of 12,100 ft represents the analogue for the deep objectives in the Block.

Figure 2a and 2b.

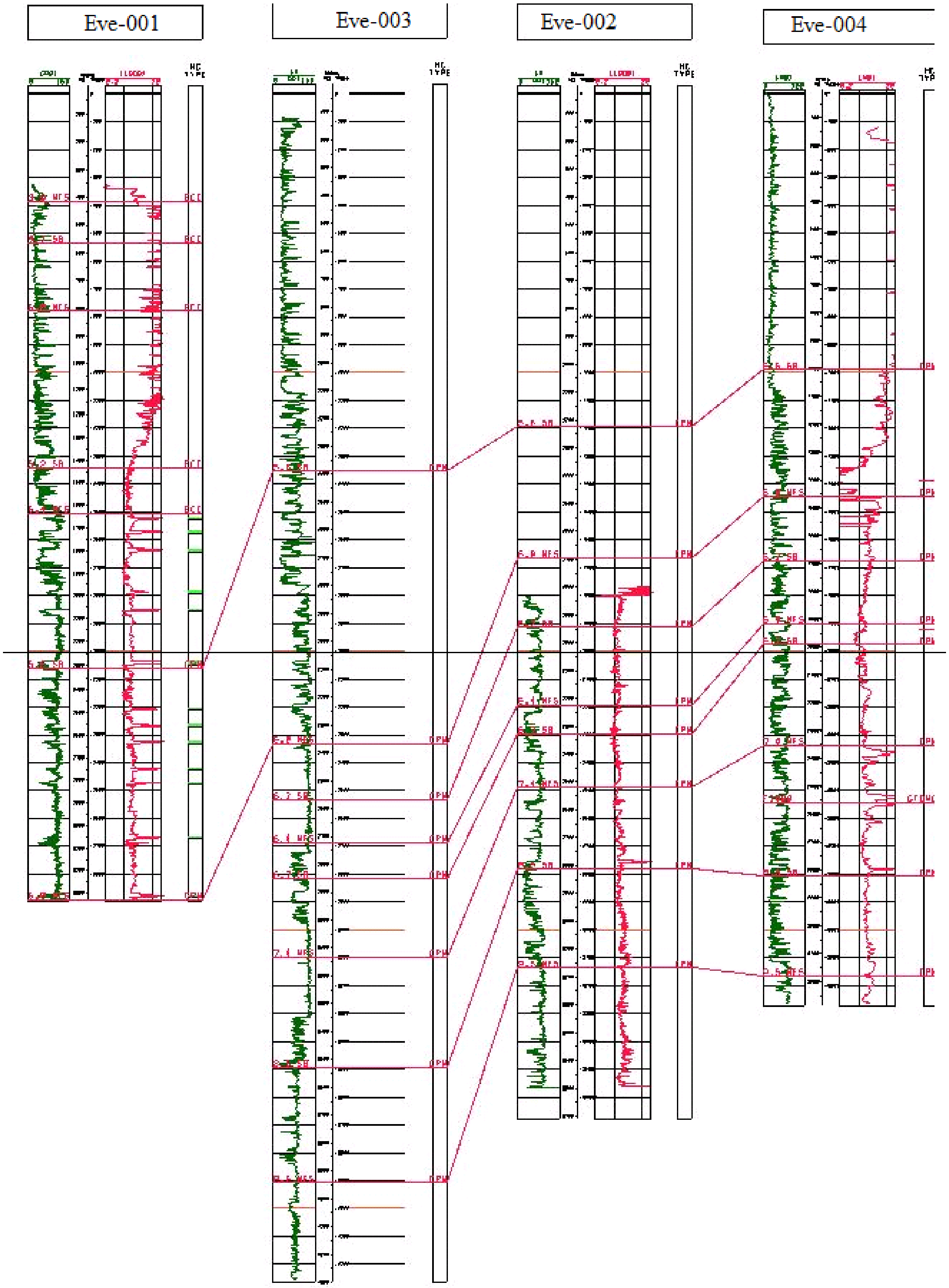

Figure 3: NW-SE Stratigraphic Correlation Panel (Horizon Intrepretation).

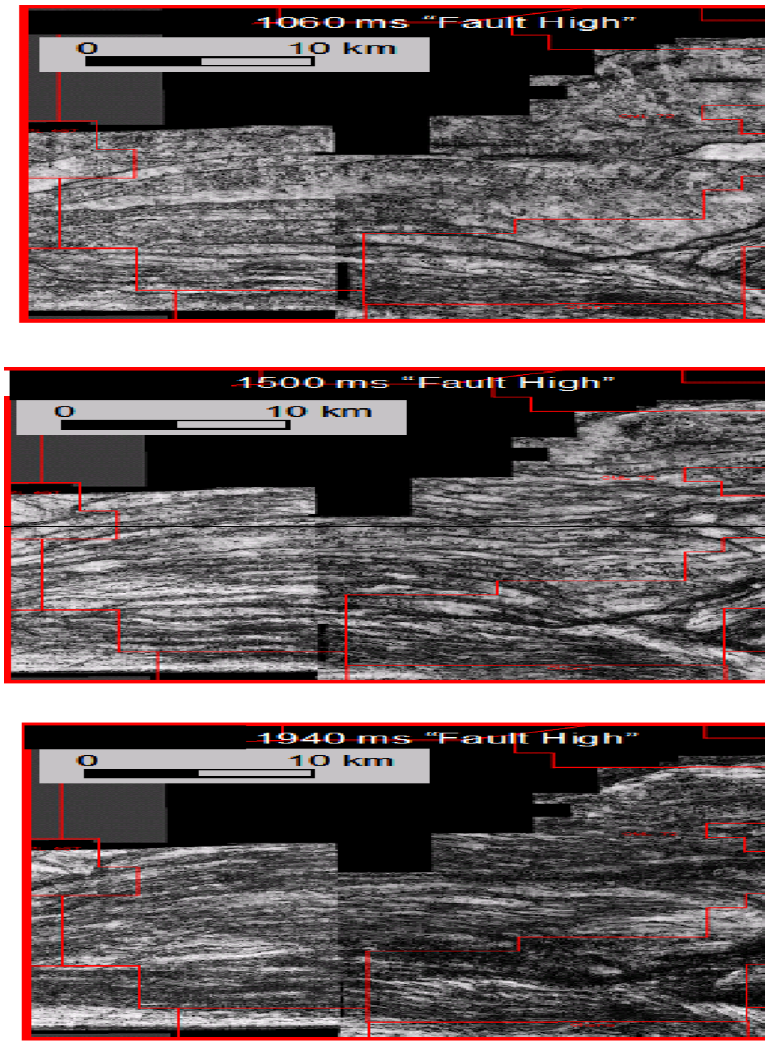

Figure 4: Time Semblance Across the Eve Field

The northern boundary fault is most likely located to the north of the 3D data volume and 2D data coverage in the western part of the block or absent and most extension is taken up by the southern, counter-regional boundary fault. The major southern boundary fault is itself faulted by a more recent, major, south verging fault in the western part of the block. Intradepobelt synthetics and antithetics are initiated relative to both the DBF defining the northern initiation of the depobelt and the counter-regional fault near the southern limit of acreage.

The large boundary faults show increasing throws with depth with significant growth of the older packages. Such configuration produce deep hanging wall fault bound closures that form deep objectives at the 6.0 level. At shallow and intermediate levels, structurally simple rollovers and collapsed crests result from the overall extension.

Figure 4 shows time slices through a Fault-High data volume. Fault-High is similar to Semblance but generally shows higher fault resolution. At the intermediate level of 1500 ms shown in Figure 4, the fault planes are well defined on the Fault-High time slices and both the major and minor faults are easily discernible. From approximately 1.5 seconds downward the resolution of the Fault-High data volume deteriorates and this type of data is of limited use for fault interpretation.

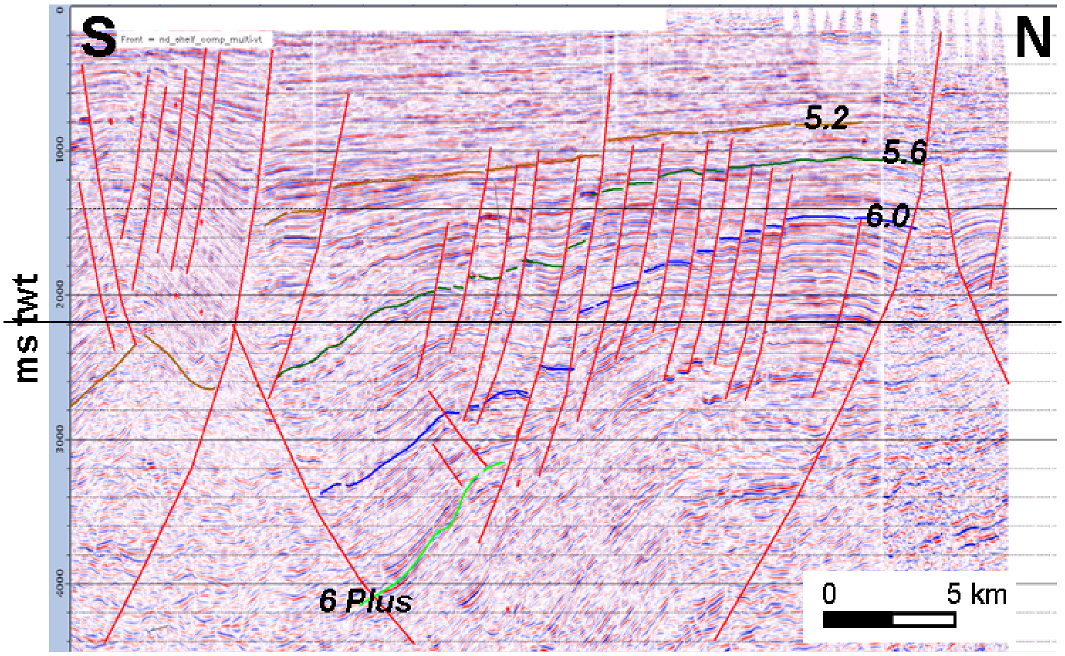

Figure 5: Structural (Dip) Cross Section 1.

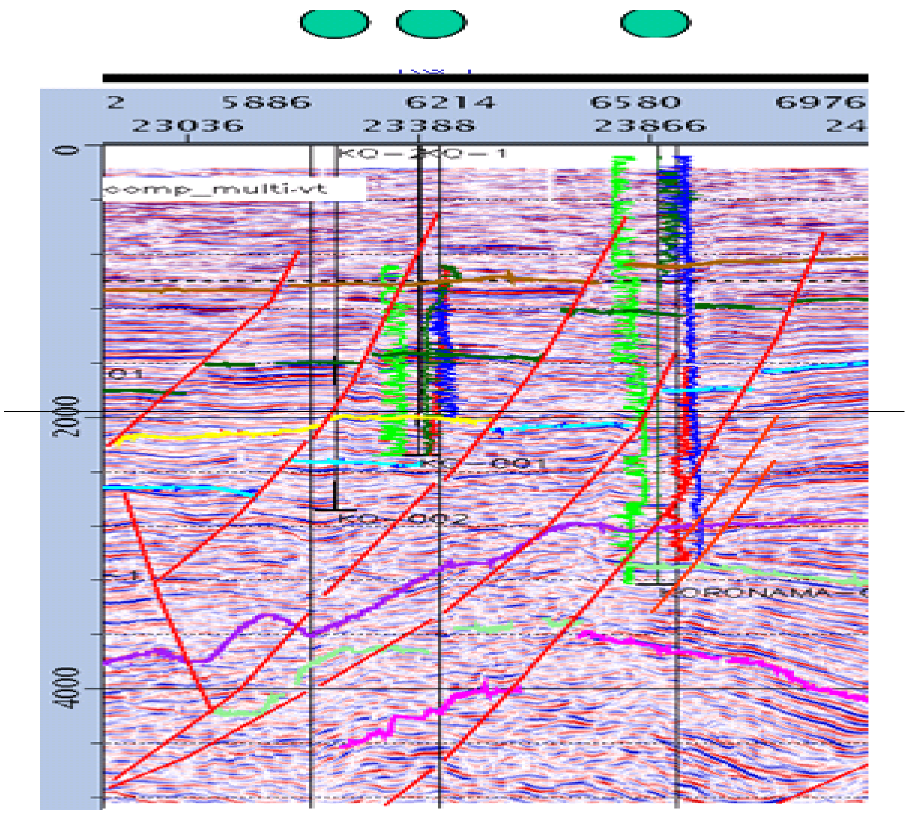

Figure 6: Structural (Dip) Cross Section 2.

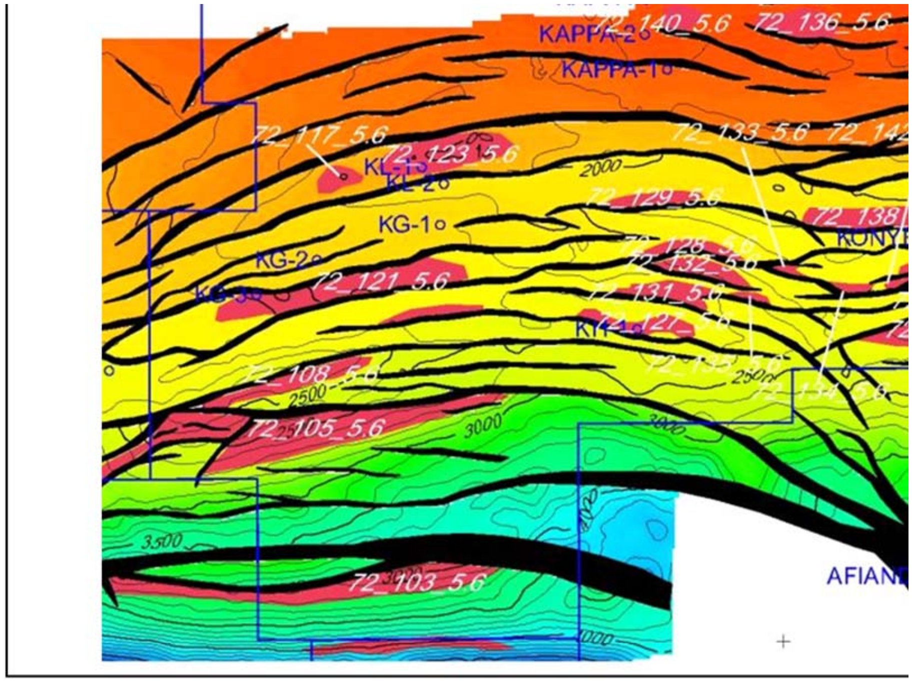

Figure 7: 5.2 Time Structure Map.

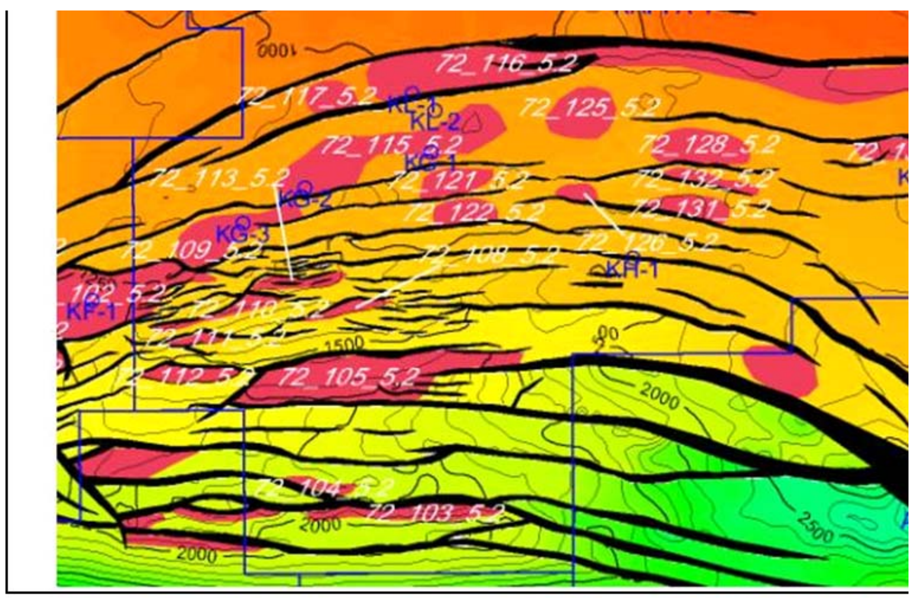

Figure 8: 5.2 Depth Structure Map.

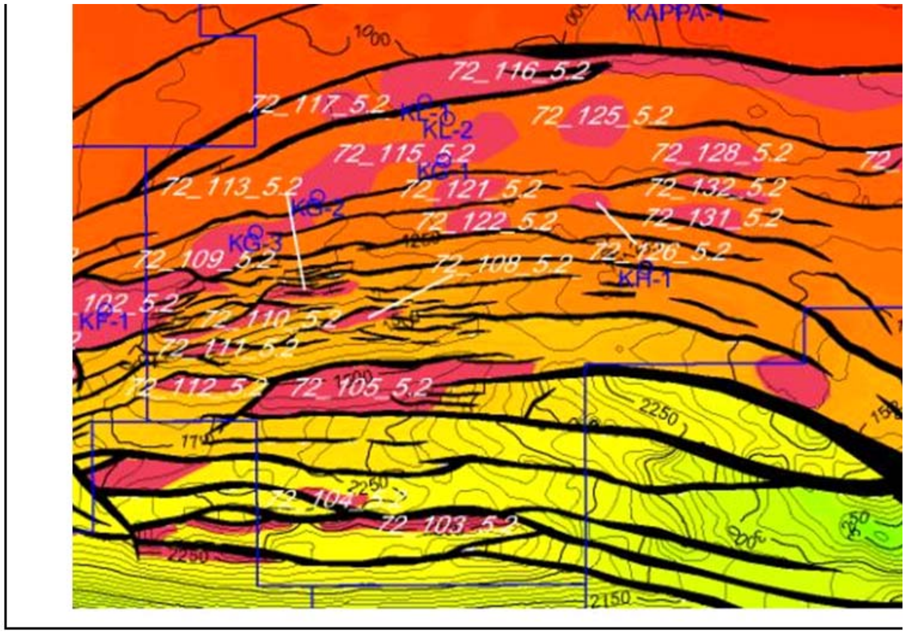

Figure 9: 5.6 Time Structure Map.

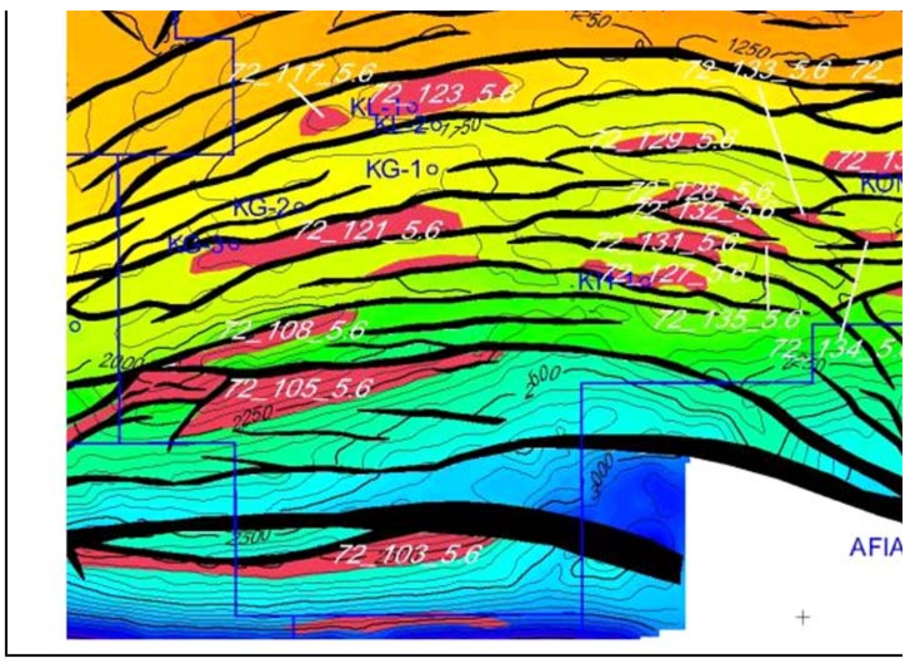

Figure 10: 5.6 Depth Structure Map.

Structurally, prospectivity is hampered with depth since fault blocks generally show increased dip and significant hydrocarbon columns are needed to build up sizeable volume.

RESULTS AND DISCUSSION

Structural evaluation and prospect identification in Eve Field has been carried out at shallow and intermediate levels. Events mapped are 5.2, 5.6, and 5.8 Ma flooding surfaces. Shallow and intermediate plays are conventional deltaic deposits in mainly fault bounded structures. Undrilled structures at these levels are in general small and this, combined with fairly small expected column heights (50 meters average) for this play, results in fairly small volumes. Leads at the deeper level are often at significant depths and expected to be mildly over-pressured.

Average column heights for these leads is expected to be significantly higher at 200 meters but the structures are often steep, resulting in moderate volume expectations. Those column heights are limited by cross fault spillage in the sandy deltaic section over the crest of the roll and average columns are shorter. Deeper structures have less faulting. Continuing down section the large rollover has a large fourway closure. This megastructure has been penetrated by 7 wells that just tag or penetrate slightly below the flooding surface shale package.

Three of the wells encounter no sand reaching TD within the main flooding surface shale. Three encountered gas in thin sands and the seventh well saw a mixture of gas bearing and wet thin sand stringers. The possibility that this large megastructure may have a deeper sand in the main body of the 6_0 section that is charged over the whole closure is the rationale for prospect 72_105_5.2 and represents the largest volume in the yet to find reserves.

A new trend of leads was identified in this study. The leads are all fault closures on the upthrown side. These closures are near the edge of the 3D and migration pull up at the edge of the survey interferes with their mapping and may be limiting the amount of closure on these structures.

The two isopach maps of the events (Figures 11 and 12) demonstrate continuous progradation and distinct sediment depocenters especially where growth faults were more active. Progradation is accompanied by gravitational redeposition of sediments along the upper slope or against counter regional faults.

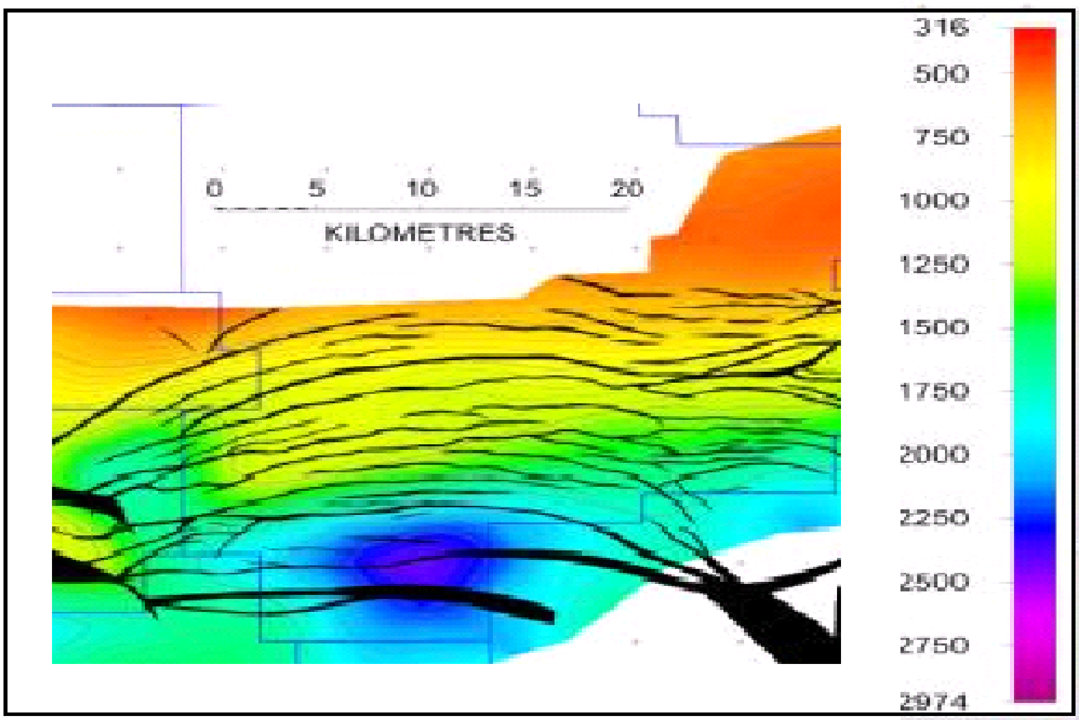

Figure 11: 5.6-6.0 Isopach Map [m] (Upper Miocene).

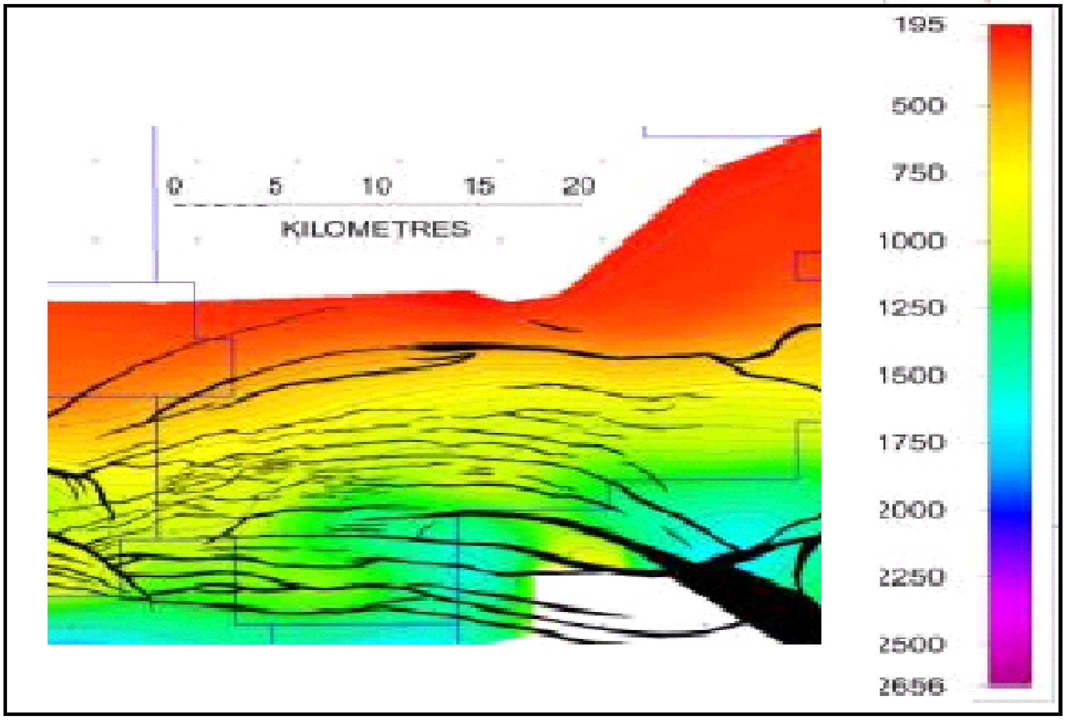

Figure 12: 5.2-5.6 Isopach Map [m] (Upper Miocene).

CONCLUSIONS

Shallow and intermediate plays are conventional deltaic deposits in mainly fault bounded structures with Downthrown Roll Simple Closure. Deeper structures are Downthrown Simple Closure with Upthrown Fault Trap.

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