Structural Interpretation of the E2.0x Reservoir in the KC Field using 3D Seismic and Well Logs: A Case Study from the Eastern Niger Delta

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Abstract
The 3D seismic data interpretation was done on the shallow horizon E2.0X to provide structural and stratigraphic interpretation at this level. The KC field is located in OML-28 in the central swamp depobelt of the eastern Niger Delta. The structural interpretation showed positive indices for hydrocarbon prospect. The seismic and well data were used in the interpretation study. The seismic interpretation suggests that structural closure exists in the horizon mapped. It is characterized by a faulted rollover anticlinal structure, which is one of the major structural traps in the Niger Delta. The growth faults are conspicuously observed in the structural maps and the seismic sections run in this field.
Keywords: Structural, Interpretation, Rollover, Anticlinal, Trap.

INTRODUCTION

The 3D seismic data interpretation was done to determine the structural and stratigraphic analysis of the KC-E2.0X reservoir in the Niger Delta petroleum province. The KC field is in the seasonally flooded land area of the Eastern Division in OML-28, about 75km west of Port Harcourt (Fig.1). The field was discovered in May, 1971 by well-1, it lies within the central swamp (Onyejekwe, 2005). The field has 39 wells drilled to date. The log curves present in the seismic to well match are sonic, Density, Gamma ray and Caliper logs. The log data covers the interpreted E2.0X level. The interpreted horizon (E2.0X) shows a sand thickness of about 232.1 feet. The log data were used to produce a synthetic trace. The KC field is covered by 3D seismic data acquired in 1997 (Fig.2). A processing technique was applied including KF-filtering and 3D residual statistics. The data was migrated to zero-phase reflectivity seismic while Post-Stack-Image processing was also applied to the data in 1998 (Onyejekwe, 2005).

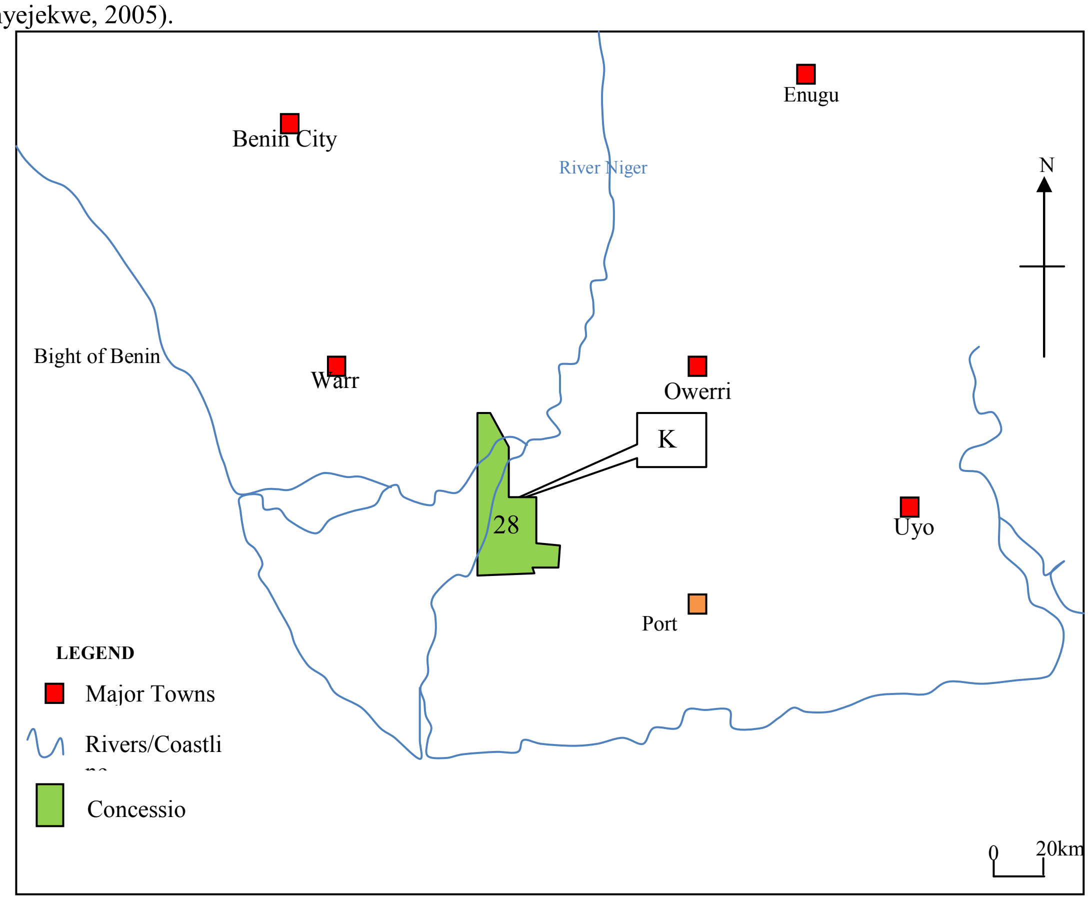


Fig.1 Location map showing the KC field

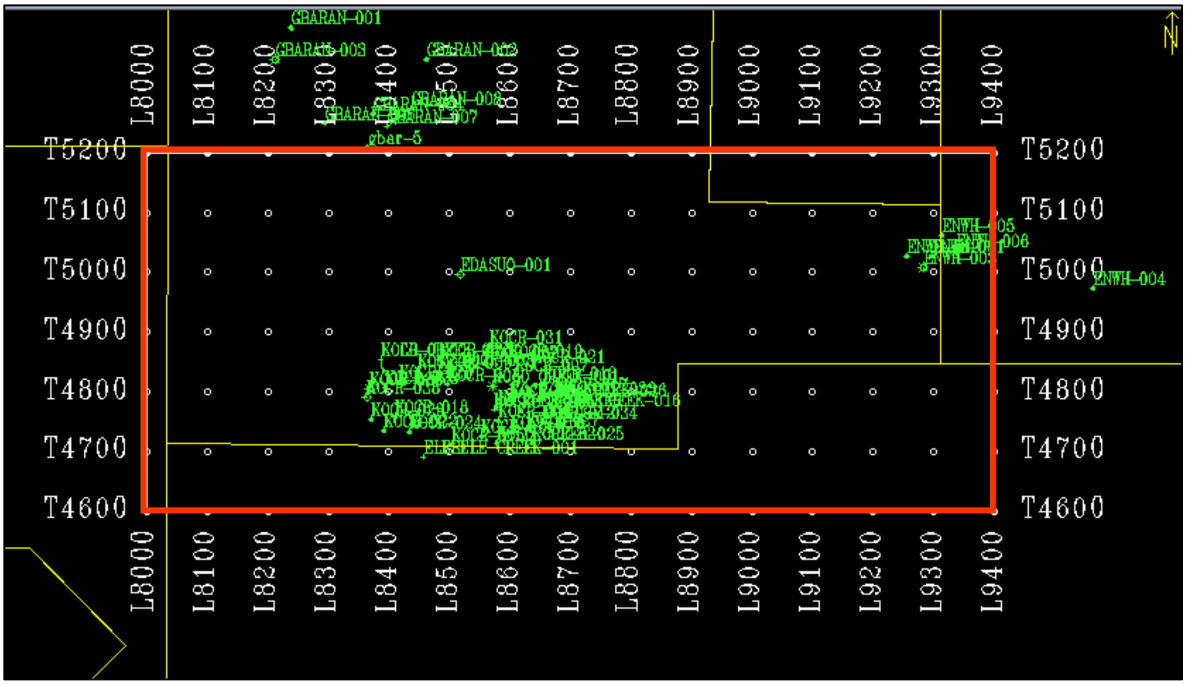


Fig.2: Basemap of KC area showing the 3D seismic survey outline (Onyejekwe, 2005).

The main structural features of the KC E2.0X reservoir show that the structure is a NW-SE trending rollover collapsed-crest anticline constrained to the North by the KC boundary fault. The crest of the structure has low relief with the flanks becoming steeper. Crestal faulting is intense with the general fault pattern being along the structural strike thereby presenting an essentially open fault system. Flank faulting is also significant but occurs at a lower frequency than at the crest. Hydrocarbons are mainly dip trapped with the northern boundary fault providing the major fault-assisted trapping to the north-east of the structure (Egele, 2003).

METHODOLOGY

The well and 3D seismic data were loaded into the openworks and 123DI databases. A quality check was performed on the data to ascertain the data quality. The seismic to well match was done on the KC-39 to identify the E2.0X level on seismic (Fig.3). The acquired sonic log (IDTC) and the density log (RHOB) are used to generate acoustic impedance log. The acoustic impedance log was convolved with a particular wavelet, which has a Butterworth corner frequency of T8-14-40-60 Hz to generate the synthetic. The synthetic was then displayed on the seismic. The software used for the synthetic seismogram is the SynTool, a Landmark Halliburton software tool. The seismic interpretation involves both the fault and the horizon interpretations after the seismic loop had been identified in the seismic to well tie. The faults were interpreted and assigned on every16th inline, except in ambiguous areas where closer grids of 8, and sometimes 4 were interpreted. Fault identification and correlation was carried out with the aid of semblance time slices, and fault contouring in Seisworks. Figs.4a-c show time slices of the semblance volume at 2000ms, 2500ms and 3000ms two-way time (TWT) respectively (Onyejekwe, 2005). Moreover, the horizon interpretation was done in Seisworks on the Median –filtered version of the 3D seismic data. The horizon was interpreted on 16 x 16 seed grid (maximum loop) with denser grid and arbitrary line interpretation done depending on the data quality. Interpretations are correlated from line to line, and the reflection times of picked events are compared directly at profile intersections (Fig.5). Mapping reflection times around a close loop of survey lines reveal any error in the identification or correlation of a reflection event across the area of a seismic survey (Telford et al., 1976, Dobrin, 1985; Kearey and Brooks, 2002; Egbunike, 2007).

In generating a depth map, the time map from the seismic interpretation and the checkshot (TZ) from a nearby well, KC well-001 (Table1) were used for this purpose. Excel software was used to plot Time – Depth (TZ) and generate polynomial function with the coefficient of 0.9988 (Fig.6). This is a plot of depth (ft) against time (ms) which has an equation of $Y = 0.0004x^2+2.9663x-151.16$. Export time horizon from 123DI software as ASCII file. Then, incorporate the polynomial function into a macro file that convert time map to depth map. Apply this macro file to the time grid to generate depth grid. This macro operation is executed in Linux operating environment using Linux command. A new depth grid file is generated and re-imported to 123DI for display as depth map.

RESULTS AND DISCUSSIONS

The seismic to well tie show a good synthetic to seismic match at a time shift of -30ms (Fig.3). The quality of the log data is good up to a depth of about 12250ft just below the base of the E2.0 sand. The data quality becomes poor from the depth of 12250-15000ft as shown in the calliper log in seismic to well tie. The poor data quality observed in the calliper log was as a result of borehole washouts at the depth of 12250-15000ft (Rider, 2002). Semblance time slices show that at shallow/intermediate depths the faults are easily identifiable and mappable. However, the semblance resolution deteriorates below 3 seconds (Fig.4a-c). This might be attributable to the fact that most of the crestal faults in the field die out with depths (>3secs.) (Onyejekwe, 2005).The time map was obtained from the seismic data interpretation. The amplitude extracted from the time of an event is then contoured. The E2.0X time map for KC showed that it is a faulted rollover anticlinal structure, which is one of the major structural traps in the Niger Delta (Weber and Daukoru, 1975; Doust and Omatsola, 1990; Stacher, 1995; Tuttle et al., 1999). The seismic data is usually in time domain. The time is expressed in milliseconds or seconds. Therefore, in time map the contour lines are expressed in time. The contour lines terminate at the major faults or discontinuities. The contours are closing around the fault at a much lower time (depth) Fig.7. This is an indication of a rollover (Hamed and Kurt, 2008). The time map derived from the seismic interpretation and the checkshot (TZ) from a nearby well, KC well-001 (Table1) were used to generate depth map (Fig.8).

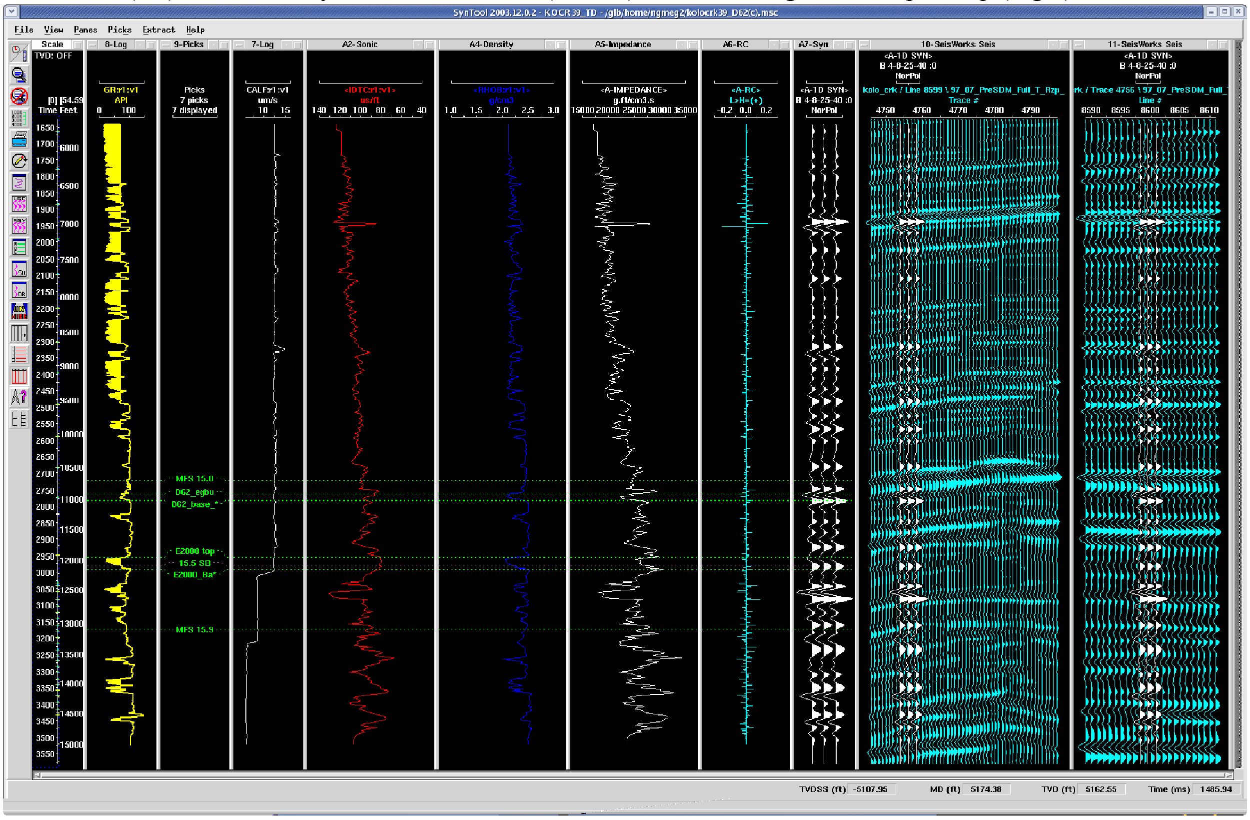
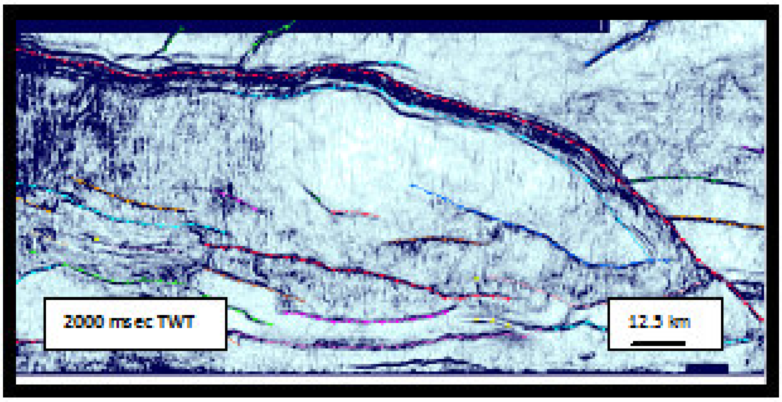
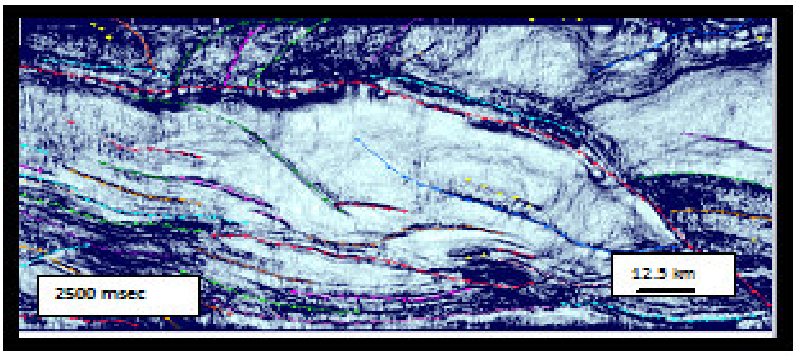


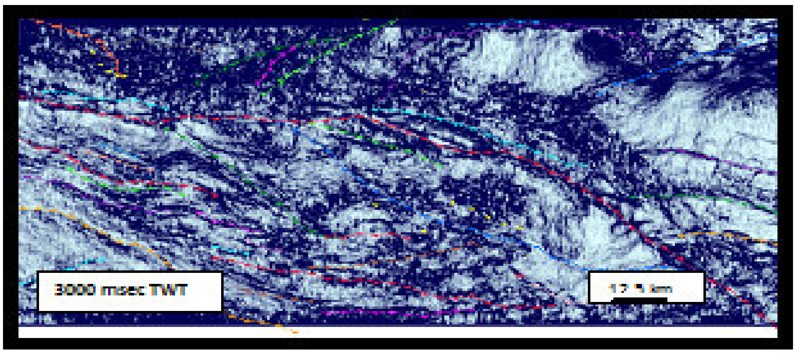
Fig. 3: KC-39 seismic-to-well match at a time shift of -30ms. The D6.2 and E2.0 reservoirs were identified on seismic data and the logs are good for qualitative interpretation study.



a: Time slice @ 2000 msec TWT.



b: Time slice @ 2500 msecs TWT.



c: Time slice @ 3000 msecs TWT.

4a-c Time slices through the KC semblance volume. At shallow/intermediate depths the faults are easily identified and mappable and deteriorates below 3000msecs (Onyejekwe, 2005).

Table 7: Checkshot (TZ) from a nearby well, KC well-001.

Wellbore name	Depth (ft)	One way time (ms)	Two way time (ms)
KC-001	3999.9	585	1170
KC-001	5999.9	844	1688
KC-001	7999.9	1073	2146
KC-001	9799.9	1255	2510
KC-001	9999.9	1280	2560
KC-001	10399.9	1329	2658
KC-001	10999.9	1383	2766
KC-001	11799.9	1464	2928
KC-001	3999.9	624	1248
KC-001	5999.9	868.5	1737
KC-001	7999.9	1088	2176
KC-001	9799.9	1264	2528
KC-001	9999.9	1286.5	2573
KC-001	10399.9	1334.5	2669
KC-001	10999.9	1387	2774
KC-001	11799.9	1477	2954

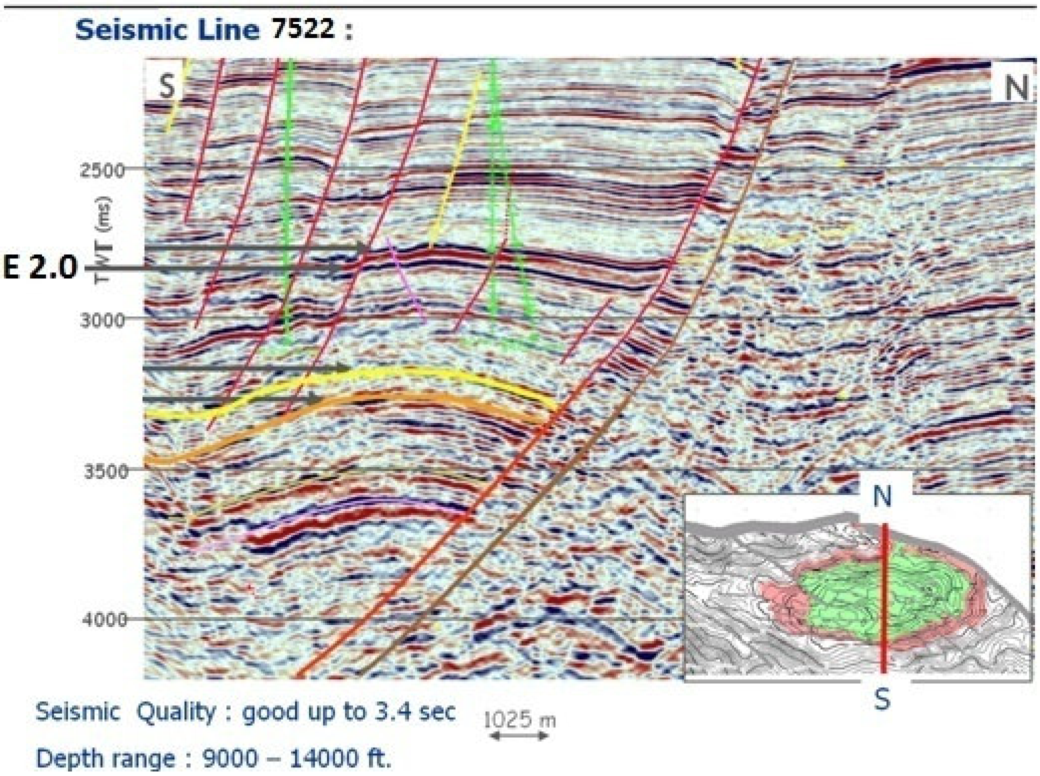


Fig.5 KC seismic section showing the mapped horizons.

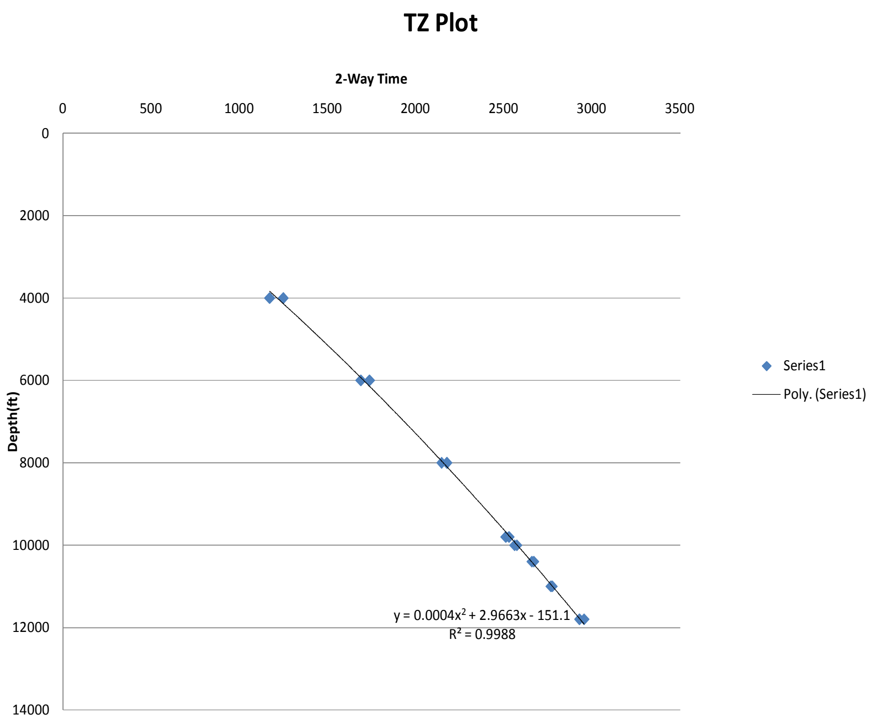


Fig.6 TZ Plot with polynomial function

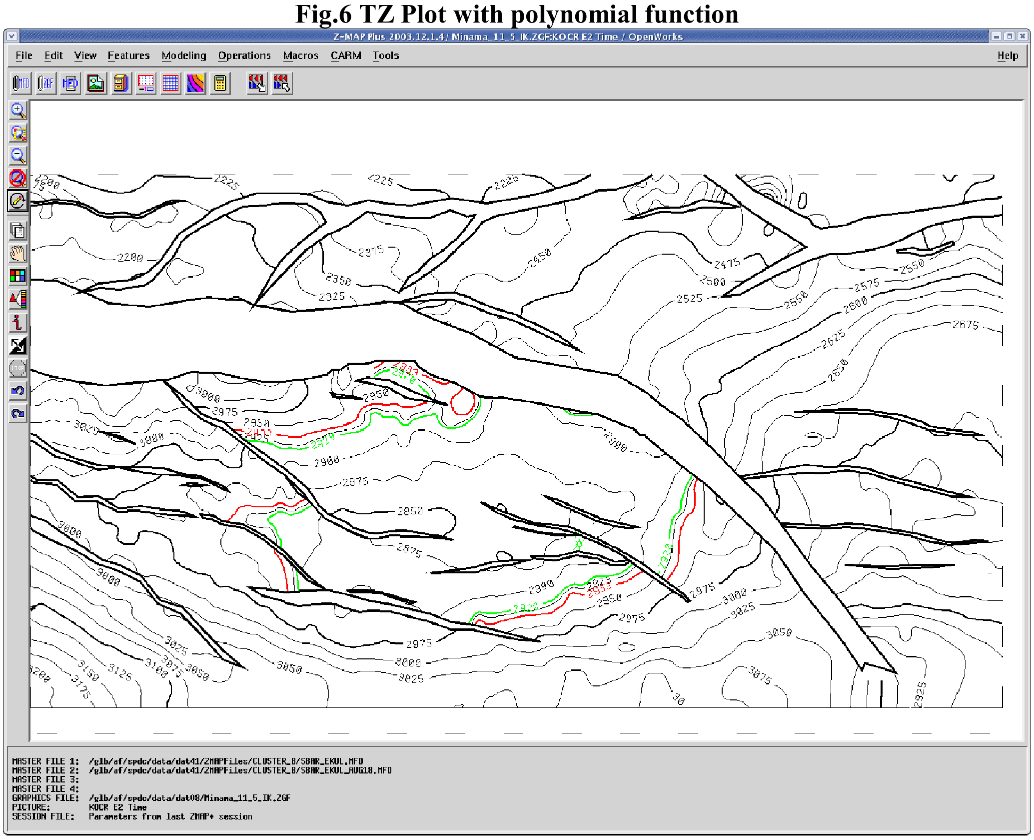


Fig.7 E2.0 Time map for KC depicting a faulted rollover anticline. The contours are displayed in milliseconds.

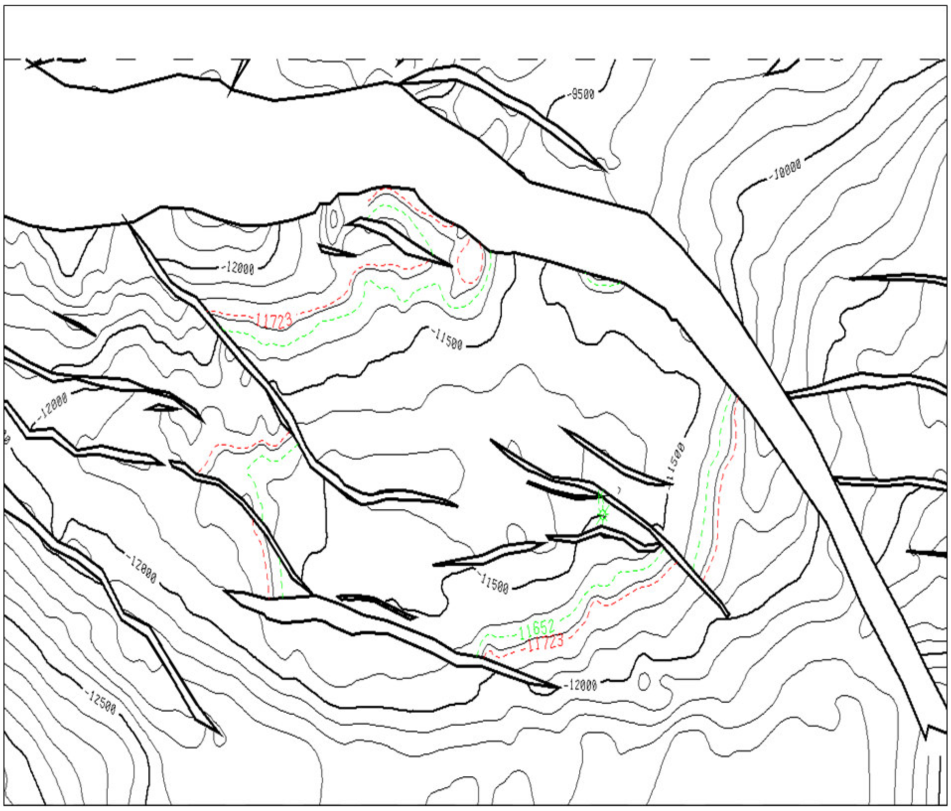


Fig.8 E2.0 Depth map showing the contours in feet (ft).

CONCLUSION

At shallow/intermediate depths, the semblance time slices show that faults are easily identifiable and mappable. The semblance resolution deteriorates below 3seconds. Seismic sections were interpreted for structures and found to contain structural closure. The interpreted horizon is characterised by a faulted rollover anticline. The growth faults are well exposed in the structural map and the seismic line.

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