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2-Dimensional Seismic Interpretation Of X-Field In The Niger Delta

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Abstract: *Geological information obtained from well log is one dimensional data. 2-D seismic data provides an alternative to the well log as data can be correlated between wells. The two dimensions of the seismic are the distances (shot/receivers) on ground-horizontal axis and time-vertical axis. Interpretation was done manually by picking reflections and faults on the seismic lines. Three reflection patterns were identified as Zones 1, 2 and 3 marked by boundaries 1 and 2. The colouration of red and black of the lines is as a result of polarity used for the Niger Delta during data processing. Sands correspond to red colour while shales correspond to black.*
Keywords: *3-Seismic, Reflection, bounadries, Interpretation*.

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I. Introduction

Geological data are obtained in the borehole through ditch cuttings and core samples. These data are very difficult to get and are very costly. Geophysical seismic data are alternative to the geological data because data can be interpreted between wells.

2-D seismic data are obtained by positioning sources (shots) and receivers (geophones) along a straight line on the surface. It is assumed to be a repeat of 1-D seismic measurements achieved by positioning sources and receivers at the same point. The structure of the subsurface formation is mapped by measuring the times required for a seismic-wave, generated by a near-surface vibration, to return to the surface after reflection from interfaces between formations having different properties (Dobrin and Savit 1988). The processing results are graphs of the signal of amplitude against travel-time (millisecond), conventionally displayed with the time axis pointing vertically downwards in milliseconds. The geophone positions are the horizontal distances (feet/metres).

The Niger Delta (Figure 1) is an oil producing basin containing structural and stratigraphic traps (Bouvier et al. 1989). The seismic data obtained from the basin consist of information that could be extracted and compared with the geological data.

II. Geology of the Niger Delta

Structure

The Niger Delta is underlay by granitic and basaltic rocks (Ablewhite et al. 1985) (Figure 2). The Niger Delta is divided into five zones: The zone of intense clay diapirism on the outer continental shelf and slope, the zone of collapse crust structure and back to back growth faults, the zone of regular rollover structures, the zone of updip limits of growth faults and rollovers and the zone of Cretaceous Anambra basin delta complex.

Stratigraphy

The delta can be divided into three broad lithofacies units. The upper part consists of massive continental sandstones (Benin Formation), which overlie an alternation of paralic sandstones, shales, and clays (Agbada Formation). These, in turn, grade downward into predominantly undercompacted, overpressured marine shales, clays, andsiltstones with some turbidite sandstones (Akata Formation) (Bouvier et al. 1989).

Diapers

Several marine geophysical profiles off the southern part of the Niger Delta reveal the presence of diapiric structures beneath the continental slope and rise (Mascle et al. 1973).

III. Data And Method Of Interpretation

The field is 55 km to Onitsha and it is very close to Nun River field. A basemap (Figure 3), three seismic lines (Inline and crossline) were provided (Figures 4, 5 and 6) together with interpreted logs of A-2 and A-1 wells (Figure 7) and checkshot (Figure 8) data were provided.

IV. Methodology

Geology

The Gamma ray (GR) log was used to interprete the Formation boundaries (Short and Stauble 1967).

Akata, Agbada and Benin Formations had been described in the type localities, Akata-001, Agbada-002 and Alele-001 respectively. The Akata Formation is at a depth of 7,180ft below the derrick floor.The Agbada Formation is located at 5,750ft. The Benin Formation is at the top of Agbada Formation. On seismic sections patterns of reflections were used to identify the Formations. The Akata Formation corresponds to the overpressure zones (shadow zone) which correlates with areas of poor imaging, no reflection is present, (shadow zone) (Aikuola et al.2010).

The Agbada Formation's reflection is continuous and is affected by the presence of faulting (Ablewhite et al. 1985, Bouvier et al 1989). The Benin Formation is horizontal and is not affected by faulting.

Fault Analysis

A fault is interpreted as a break in continuity (Telford *et al.* 2004). Growth faults are initiated around local depocentres and grow during sedimentation. The greater amount of sediment accumulates close to the fault in the downthrown block compared with the upthrown block.

Two methods were used to identify the presence of faults.The first is analysis of Fault cut using GR and resistivity logs (Olisa and Okafor 2014, Olisa and Oke 2014).

The second method is the identification of growth faults on the seismic sections. Growth faults on the seismic section show a marked flattening with depth (listric).

Reflectors

A reflector is marked by the continuity of reflection on the data either the peak or the trough. It is marked by change in patterns.

Polarity

Traditionally, deflection of seismic signal produces the peak and trough. On seismic section, the display is shaded in white or black colouration. The data were trasformed to zero phase. The final data could be SEG normal or reversed. The convention is refer to as Society of Exploration Geophysics (SEG) format. The SEG normal corresponds to an increase in impedance being represented by a peak (Herron ,2013).

Well-Seismic tie

A geological boundary was first identified using well log (Formation top). The formation tops are in feet/metres. This was converted to time to identify the reflector on the seismic (Bouvier et al. 1989).

V. Interpretations

Basemap

The basemap shows the positions of 365 and 425 inlines as well as 425 crossline (x-lines) (Figure 3). Point O is the position where the lines crossed. The area of the basemap is 200km X 300km (600,000 km^2).

Seismic data

The data is of good quality with events and faults clearly marked although the quality does deteriorate considerably over the structural crest where the wells are located (Bouvier et al. 1989). The seismic data are acoustic impedance seismic. Seismic horizons (shales) were interpreted and mapped because of their seismic continuity and adequate seismic-to-well correlation. Thick sandstones were orange to red (positive amplitude). Thick shales were green to black (negative amplitude). The vertical axis is the two-way-time (TWT) in milliseconds while the horizontal axis is the shotpoints/receivers positions. The X-line 425 horizontal axis increases from 120 to 540 from right to left (Figure 4B) while lines 365 and 425 horizontal axis increase from 210 to 540 from left to right (Figures 5B and 6B). The wells were located at the collapse crestal area where structures are disrupted. The distance between adjacent shot-point is 25m which is the seismic trace distance.

Well-to seismic tie

An adequate seismic-to-well match was achieved by correlating time converted spontaneous potential (SP) and GR logs (Figure 7) with the acoustic impedance seismic (Figures 4, 5 and 6) using checkshot data (Figure 8). The tops and bottoms of sandstones on SP logs correspond with zero crossings on acoustic impedance seismic, marking the transition between negative acoustic impedance contrasts (hard shale to soft sandstone) and positive acoustic impedance contrasts (soft sandstone to hard shale).

X-Line 425

Figure 3 shows the position of X-line 425 on the basemap. Figure 4 shows the seismic crossline 425 with 120 to 540 shot-points or receivers from right to left. The orientation of the X-line is north-south direction. The shot-points or receivers point are 40 laid on the ground horizontally. Figure 4A is the uninterpreted seismic section while Figure 4B is the interpreted section. Figure 4C shows the identity of crossline 425 (zoomed Figure 4A). Two geological boundaries were marked, boundary 1 and boundary 2 at times 1.60ms and 2.2ms respectively. These two boundaries separate three zones (differentiated by reflection patterns), Zone 1, 2 and 3. F1 was marked.

Wells A-2 and A-1 are located on the section at shotpoint/receiver 320 and 310 respectively based on their positions on the basemap (Figure 3) and crestal structure on the seismic as guides. Horizon 3 was marked on the A-2 and A-1 and then tied to X-line 425 with the checkshot.

The top of this sand (sand 5150) in these wells were 5030ft (1533m) in A-2 and 5015ft (1529m) in A-1 (Olisa and Oke 2014). Using Time-depth curve, Figure 7, the depth was converted to time on the seismic at the well location. The converted times in A-2 and A-1 are 1.895ms and 1.889 respectively. The continuous red reflections are marked on the seismic at 1.89ms.

Line 365

Figure 3 shows the position of line 365 together with A-2 and A-1 wells on the basemap. Figure 5 shows the seismic line 365 with 120 to 540 shot-points or receivers positions from left to right. The orientation of the line is West-East direction.

Figure 5A is the uninterpreted seismic section while Figure 5B is the interpreted section. Two geological boundaries were marked, boundary 1 and boundary 2 at times 1.60ms and 2.2ms respectively. These two boundaries divided the seismic line into three zones: Zone1, zone 2 and zone 3 (differentiated by reflection patterns) (Figure 5B). A-2 and A-1 are located on the poorly imaged zone, (shadow zone/Fault zone) (Aikuola *et al.* 2010).

Line 425

Figure 3 shows the position of line 425 from west to east. A fault block 1 was marked at TWT 1.2ms/shot-point 300 and TWT 1.2ms/shot-point 520 based on the disruption of seismic events 1 (Figure 6). At TWT 2.0ms, fault block 2 was identified. The reflection pattern in fault block 1 is horizontal and could be traced for a long distance. Reflection pattern of fault block 2 is curved and short.

An overpressure zone at TWT 2.4ms/shot-point 400 was identified based on different reflection pattern from other zones.

VI. Conclusion

2-Dimensional seismic data is very valuable for delineating the subsurface as it gives two dimensional interpretations. The reflections were picked based on continuity of events. Sands and shales correspond to red and black.

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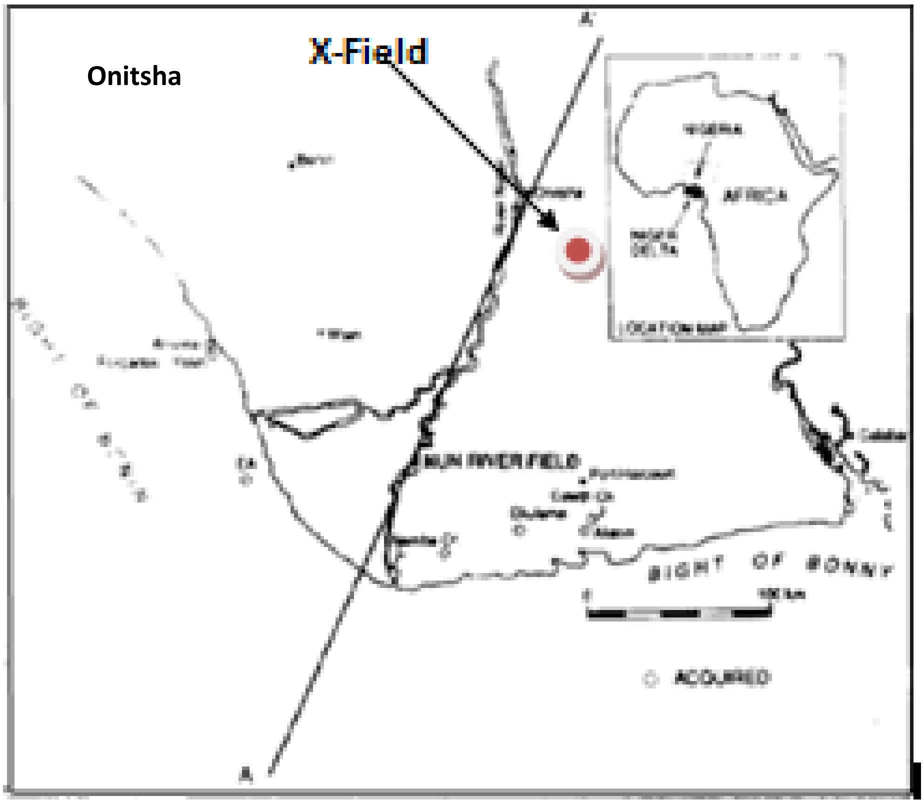

Figure 1: The Niger Delta and the X-Field (Bouvier et al. 1989)

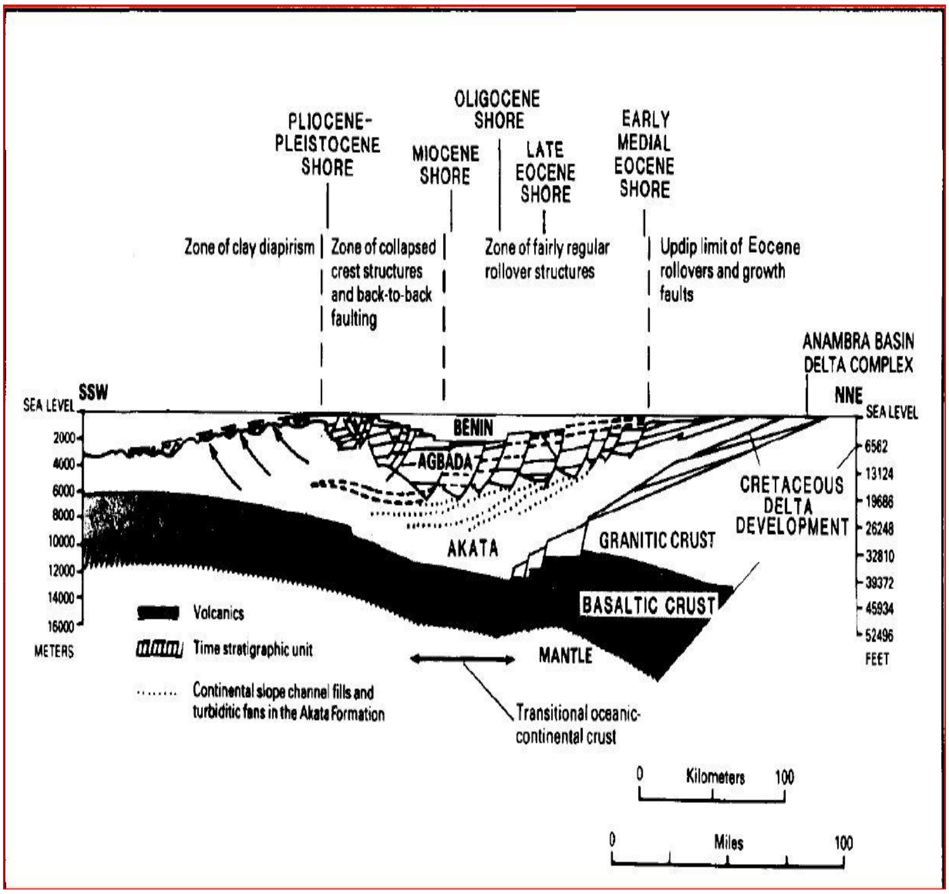

Figure 2: A section of the Niger Delta (Ablewhite et al.1985)

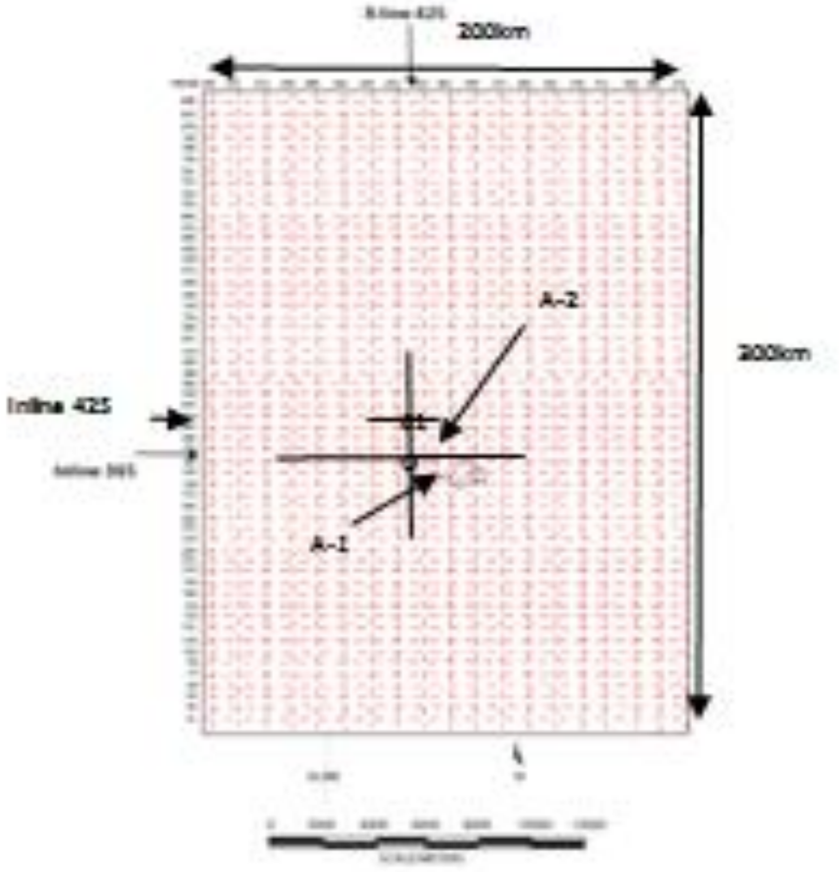

Figure 3: Basemap of the Study Area.

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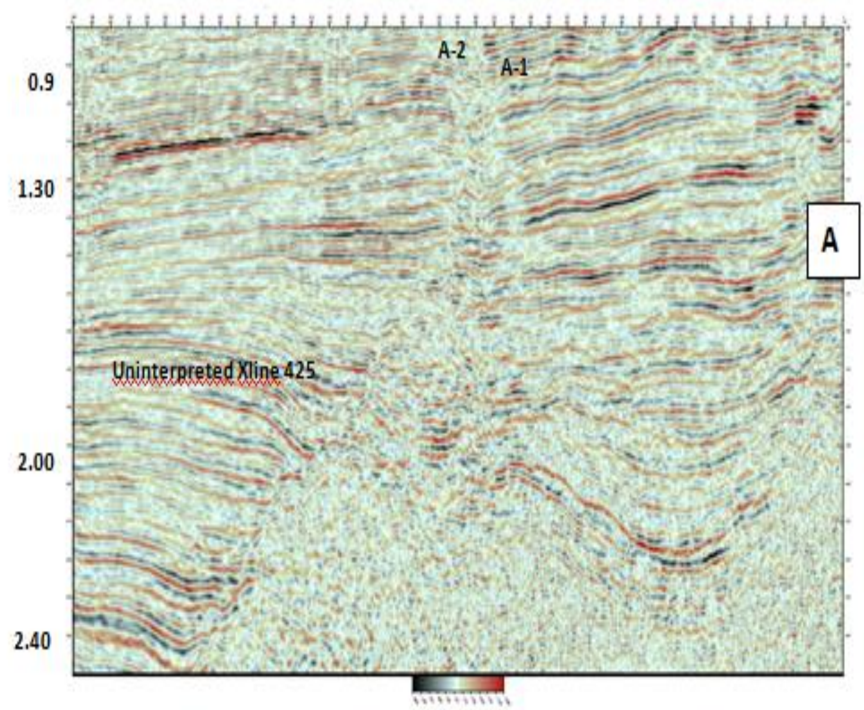

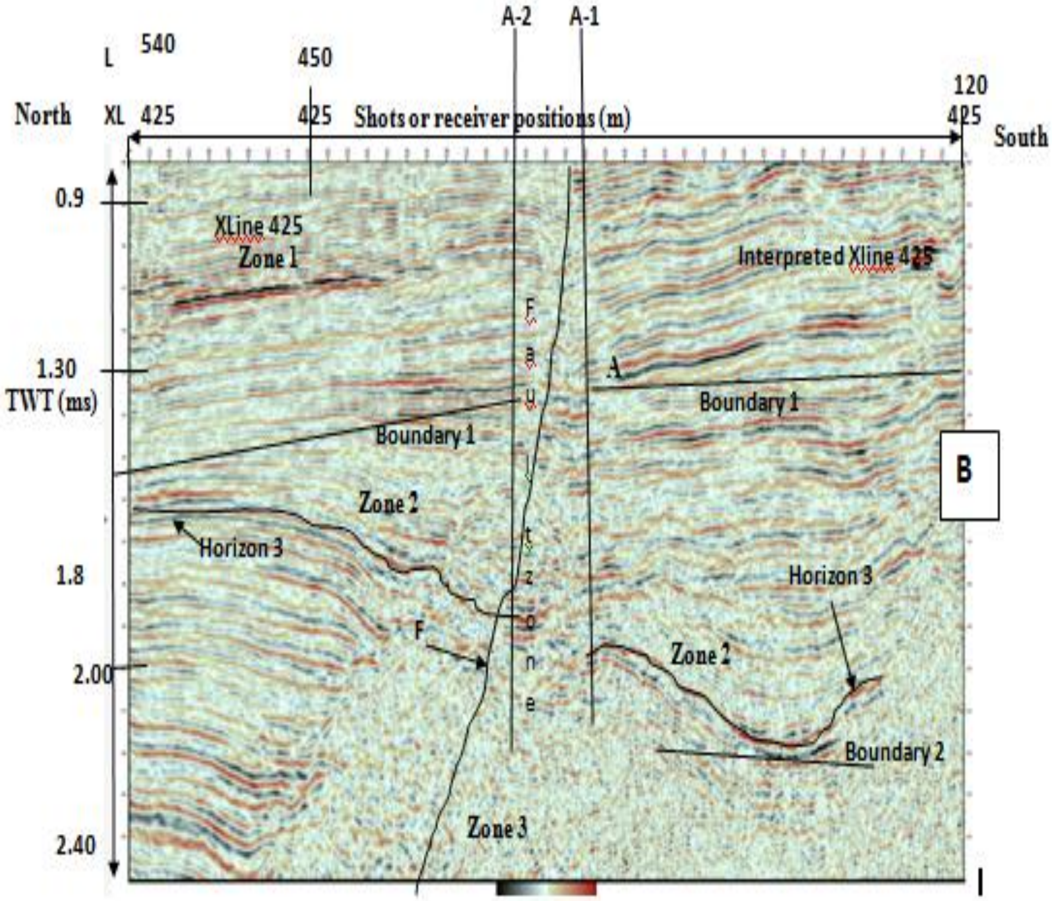

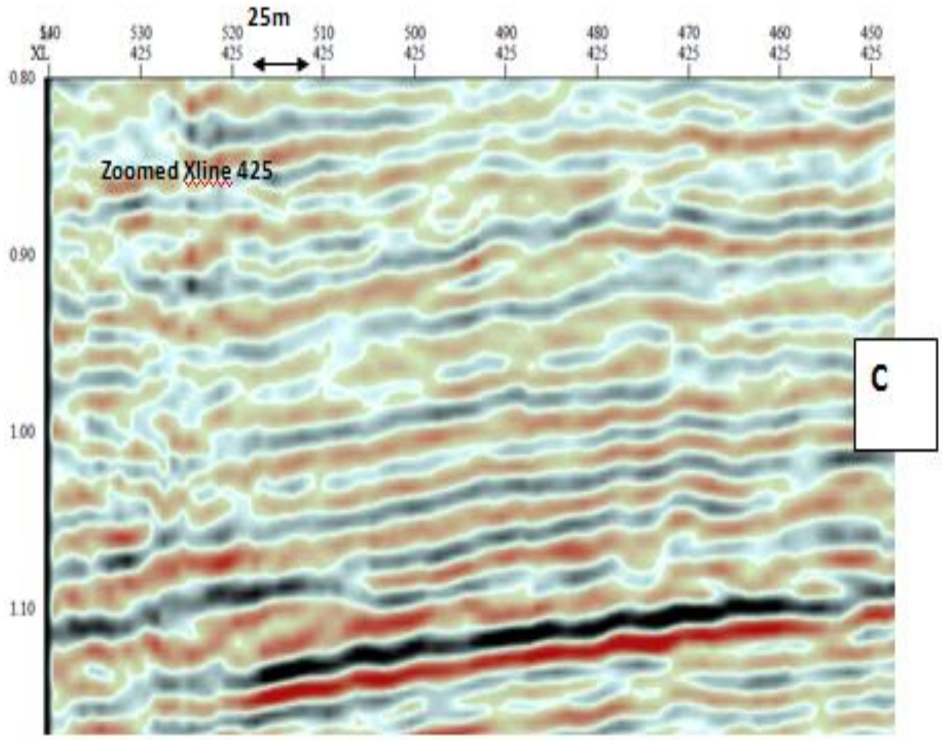

Figure 4: Xline 425(A) Uninterpreted. (B) Interpreted. (C) Zoomed.

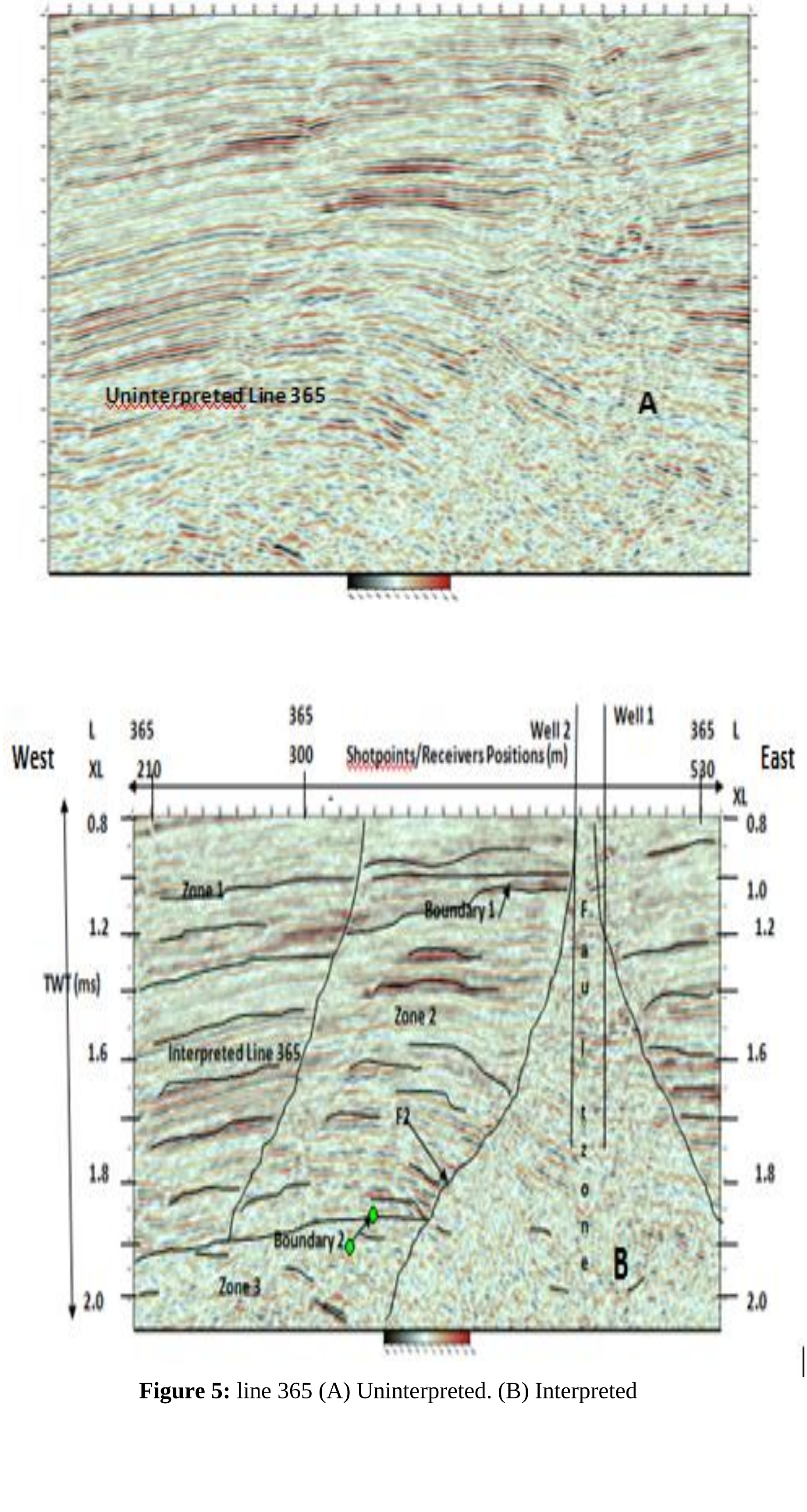

Figure 5: line 365 (A) Uninterpreted. (B) Interpreted

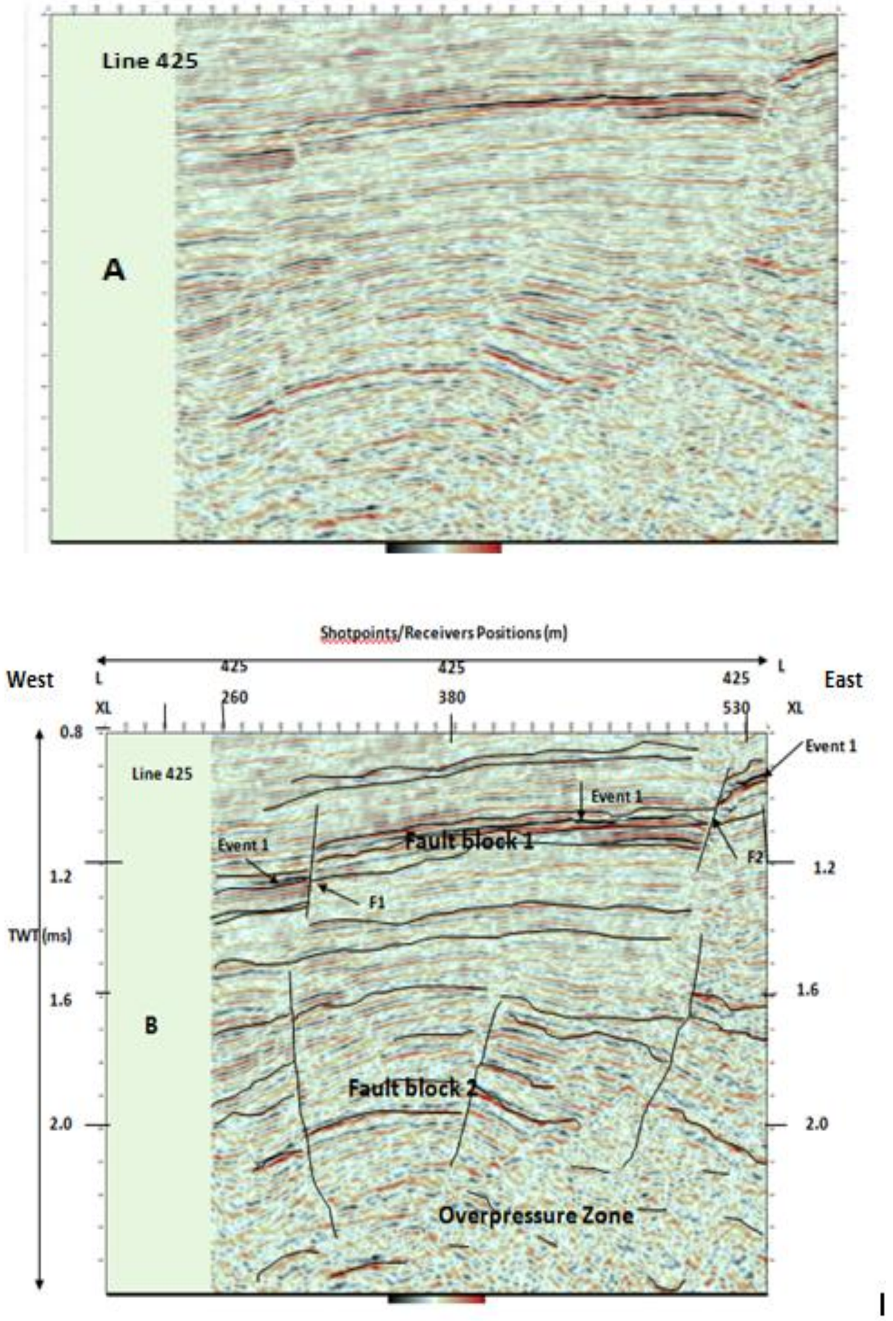

Figure 6: line 425 (A) Uninterpreted line 425. (B) Interpreted

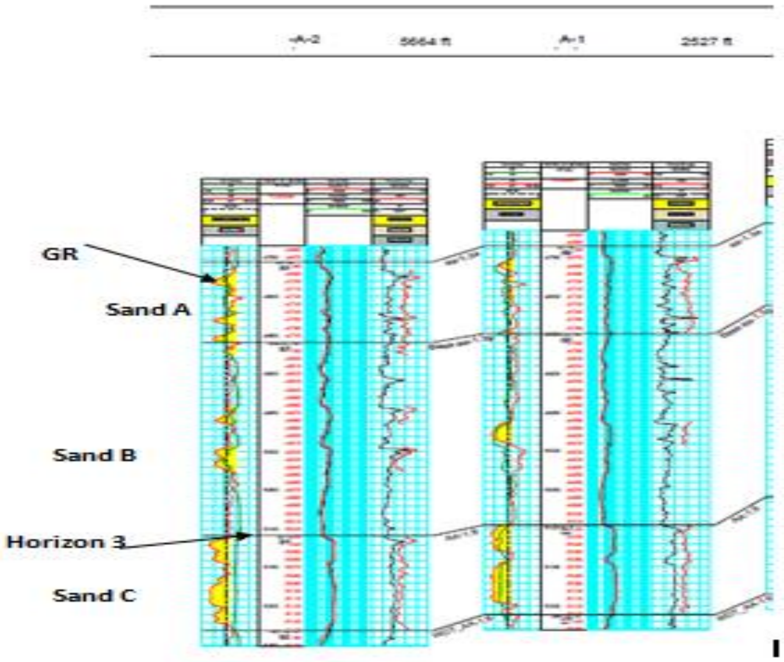

Figure 7: Well A-2 and A-1

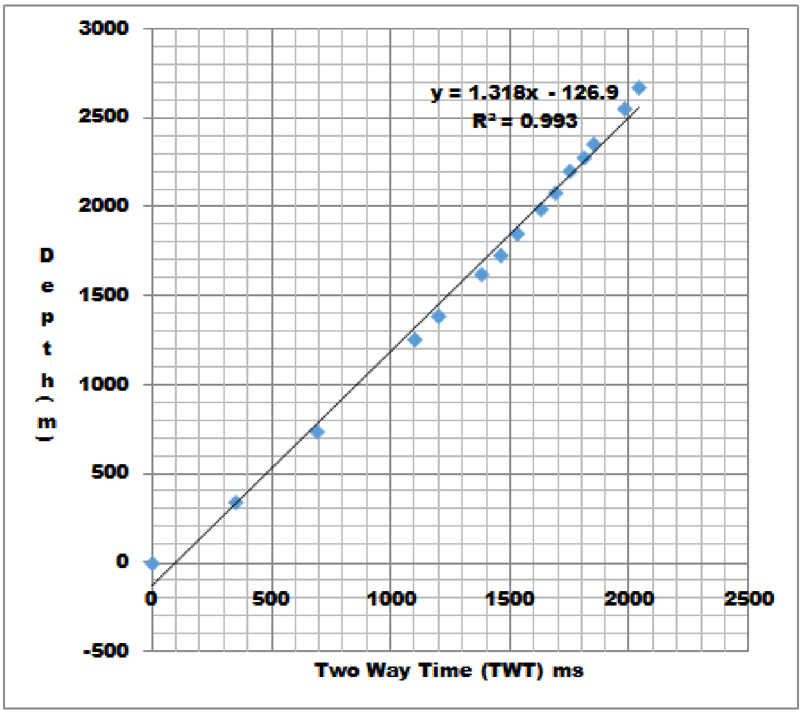

Figure 8: Checkshot data

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