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THE USE OF SPECTRAL DECOMPOSITION AS A HYDROCARBON INDICATOR IN THE NIGER DELTA OILFIELD

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Abstract

The use of frequency analysis had been known in the petroleum industry for decades. The present study was born out of the need to demonstrate the applicability of spectral analysis in the search for hydrocarbon in the Niger Delta Basin. The objectives of the study were to show the presence of hydrocarbon and demonstrate the use of frequency analysis in the determination of the fluid contact. The spectral analysis of the D6.2 reservoir in KC field was performed using ndi software. The Short Time Fourier Transform (STFT) method is used with the specified frequency range of 5 - 50 Hz. The analysis was done over a time interval of 1500 – 4000ms. The window length and the taper used is 256ms and 20% respectively. The location of the calibration well-39 on the gas leg is at track 8600 and the bin is at 4784. The location of well-32 on the brine leg is at track 8426 while the bin is at 4854. Moreover, the seismic / frequency / amplitude generated is extracted from both the gas leg and the brine leg respectively. The result of the spectral decomposition shows the presence of hydrocarbon in the D6.2 reservoir and establishes a possible hydrocarbon contact. The hydrocarbon contact at 2690ms shown by the frequency maps agreed with the contact established in the amplitude versus time cross plot.

Keywords: *Hydrocarbon; Spectral; Analysis; Contact; Amplitude*.

1. Introduction

The spectral decomposition was done in the D6.2 reservoir in KC field in the Niger Delta Basin. This method utilizes wavelet transforms to obtain frequency spectral with high temporal resolution without the windowing problem associated with traditional Fourier analysis. Spectral decomposition transforms the seismic data (time domain) into the frequency domain. Spectral analysis produces a continuous time-frequency analysis of a seismic trace [1]. Thus, a frequency spectrum is output for each time sample of the seismic trace. Spectral decomposition has been used for a variety of applications including layer thickness determination [2-5] and stratigraphic visualisation [5]. The purpose of this study is to show that spectral decomposition has the capacity to uncover the effects of hydrocarbon accumulation on seismic data acquired from the Niger Delta Basin. The analysis revealed the presence of hydrocarbon and used to determine the hydrocarbon contact in the D6.2 reservoir. This result ordinarily could not have been resolved using the conventional Fourier-based spectral decomposition methods [7-9]. Knowledge of the exact location of the hydrocarbon contact in a reservoir is very necessary for hydrocarbon column determination which is an important parameter in calculating the volume of petroleum in the field.

The objectives of the study were to (i) show the presence of hydrocarbon (ii) demonstrate the use of frequency analysis in the determination of the fluid contact.

2. Location, historical background and geology of the field

The KC field is in the seasonally flooded land area of the Eastern Division in OML-28, about 75 km west of Port Harcourt (Fig.1). The field was discovered in May, 1971 by well 1, it lies within the central swamp. The field has shallow gas bearing reservoirs with the E2.000x being the only oil-bearing reservoir with a total of twenty-five drainage points [10]. The 2D geological model of the field is a fault rollover structure bounded to the north by a major growth fault to the south by a system of faults, with dip-closed eastern and western boundaries. The D sand consists of six reservoirs and is gas bearing from 9,200 – 11,570 ft.ss. At the E2.000x level, a major E-W trending synthetic crestal fault separates the field into a main upthrown and downthrown block. The sand is hydrocarbon bearing within 11,300 – 11,900ft.ss with an oil rim of 200ft overlain by a large gas cap. The E2.000x reservoir consists of deltaic package of barrier sheets and channel sands deposited in five cycles. The sand quality improves towards the north with the channel sands. Poor sand development and system of faults limit aquifer into the reservoir. The field has 39 wells drilled to date. Thirty-five of these penetrated the E2.000x reservoir. The field came on stream in 1973 and in June 1974 peaked at a production rate of 43,000 barrels of oil per day.

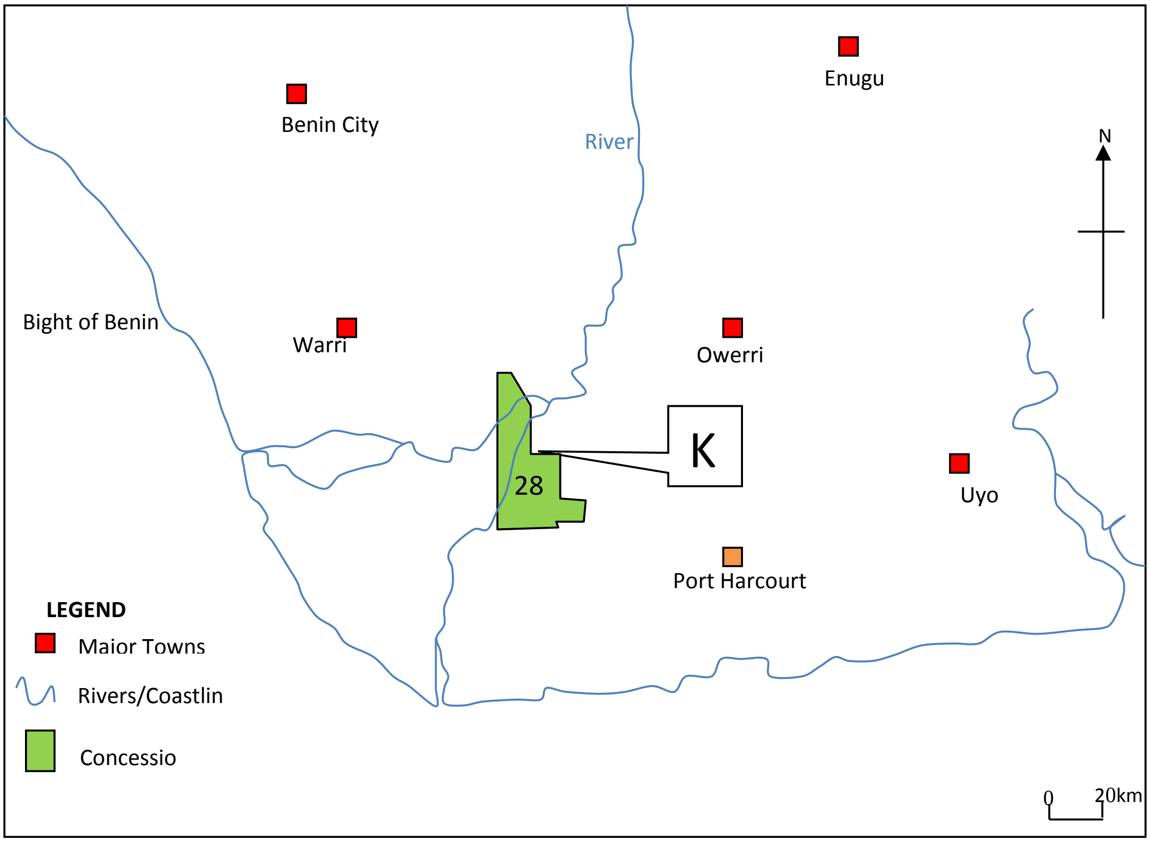


Fig.1. Location map showing the KC field

The main structural features of the KC E2000x and D6200 reservoirs show that the structure is 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 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 [11].

3. Methodology

The spectral decomposition of the D6.2 reservoir in KC field was carried out using ndi software. The ndi software is Shell Petroleum Development Company (SPDC) software. The method used is the Short Time Fourier Transform (STFT) and the specified frequency range is 5-50 Hz. The analysis was performed over a time interval of 1500 – 4000ms. The window length is 256ms and the taper is 20%.

The location of the calibration well-39 on the gas leg is at track 8600 and the bin is at 4784. The location of well – 32 on the brine leg is at track 8426 while the bin is at 4854. In the gas leg, the seismic trace/frequency/amplitude is extracted (Figs. 2 and 3) while from the brine leg, the seismic trace/frequency/amplitude is extracted as shown in Fig.4. The top and base of the reservoir at the gas leg is determined at 2644ms and 3025ms respectively from the well data or seismic interpretation. The top of the reservoir at the brine leg is at 2716ms.

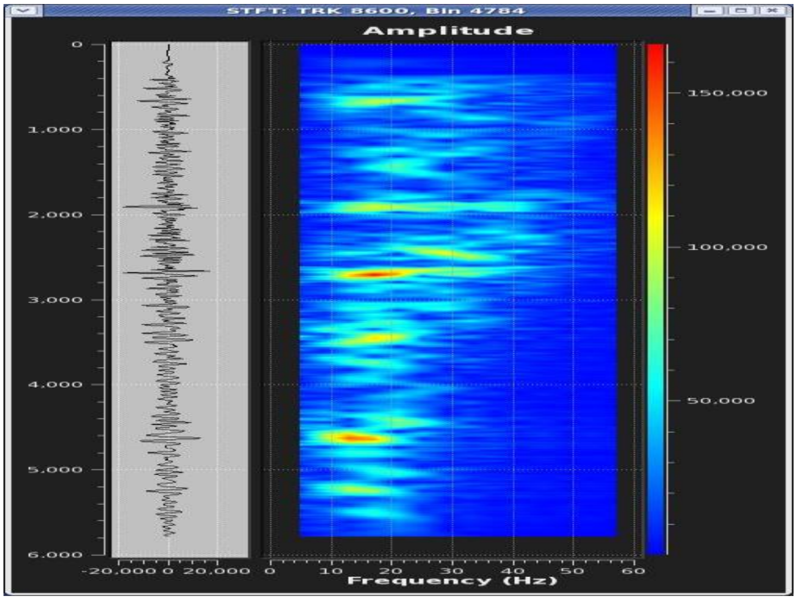


Fig.2. Extracted seismic trace/frequency/amplitude at the gas leg. The diagram shows very high amplitude occurring at low frequency range of 8 – 22.9Hz

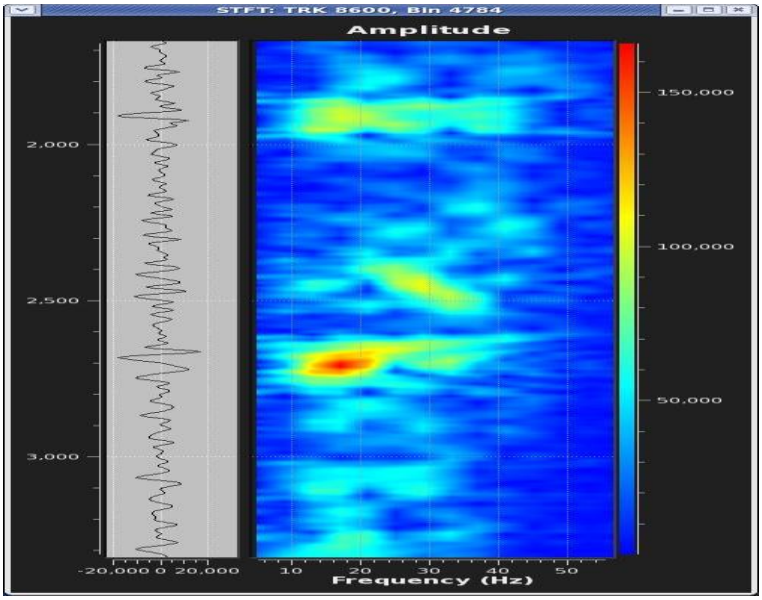


Fig.3. Zoomed extracted seismic trace/frequency/amplitude at the gas leg. The diagram shows very high amplitude at a low frequency range of 8 – 22.9Hz

4. Results and discussions

The result of the spectral decomposition or frequency analysis shows the presence of hydrocarbon in the D6.2 reservoir and establishes a possible hydrocarbon contact. The dominant frequency range for gas leg is 8 – 22.9 Hz (Figs. 2 and 3) while the dominant frequency range for brine leg is at 24 – 36 Hz (Fig.4).

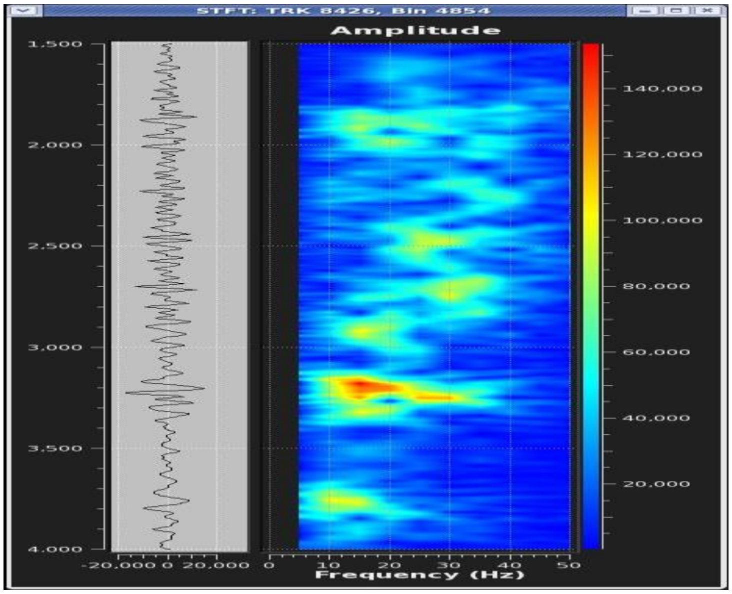
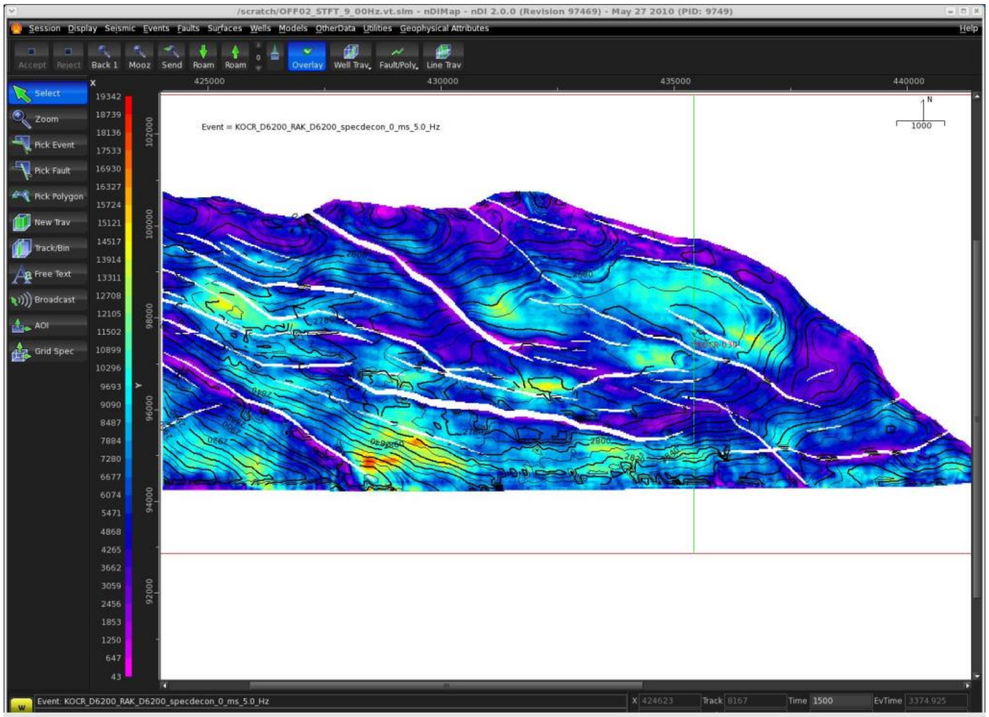


Fig.4. Extracted seismic trace/frequency/amplitude at the brine leg. This shows low amplitude response occurring at very high frequency range of 24 – 36Hz

The dominant frequency range for both gas leg and brine leg conforms to the results obtained from the frequency maps (Fig.5, Fig.6, Fig.7, Fig.8 and Fig.9).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Event: KOCR_D6200_RAK_D6200_specdecon_0_ms_5.0_Hz

X 424623 Track 8167 Time 1500 EvTime 3374.925

Fig.5. Frequency map generated at 5Hz. The 5Hz frequency could not separate the brine from the gas

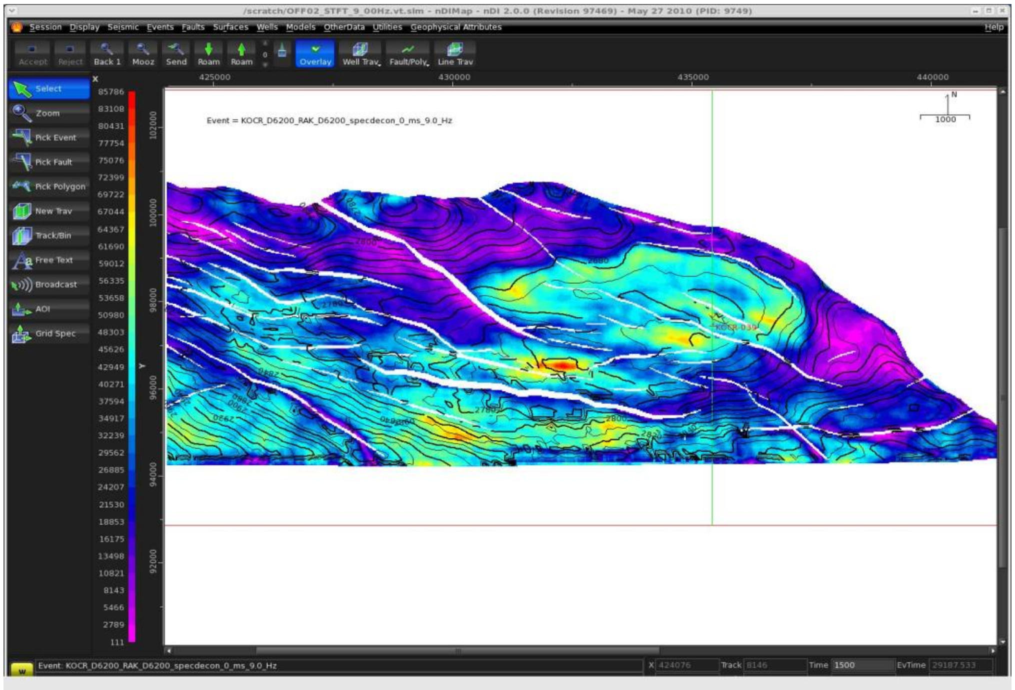
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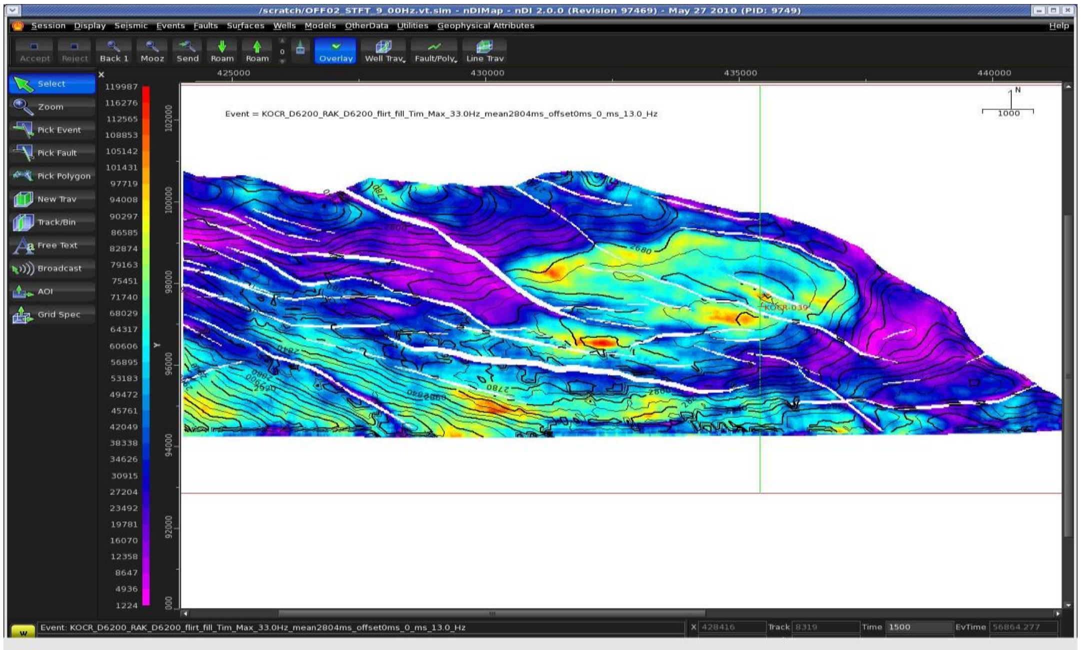
Fig.6. Frequency map generated at 9Hz. The 9Hz frequency gives the best separation of the brine from the gas and the best conformable amplitude to structure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X 428416 Track 8319 Time 1500 EvTime 56864.277

Fig. 7. Frequency map generated at 13Hz. The 13Hz frequency shows the separation of the brine from the gas

It has been observed that using the dominant frequency ranges between 9 – 15 Hz gives the best isolation of the gas from the brine. The 9Hz frequency gives the best conformable amplitude to structure and calibrated contact as measured in the KC field. The extracted seismic trace/frequency/amplitude at the gas leg in well-39 shows very high amplitude at a low frequency range of 8-22.9Hz. The high amplitude response (amplitude boom) occurring at low frequency range was due to the effect of hydrocarbon (gas) in the reservoir. However, the extracted seismic trace/frequency/amplitude at the brine leg in well-32 depicts much lower amplitude occurring at higher frequency ranges of 24-36Hz. The low amplitude response occurring very high frequency range is interpreted as a result of the presence of brine-water in the reservoir.

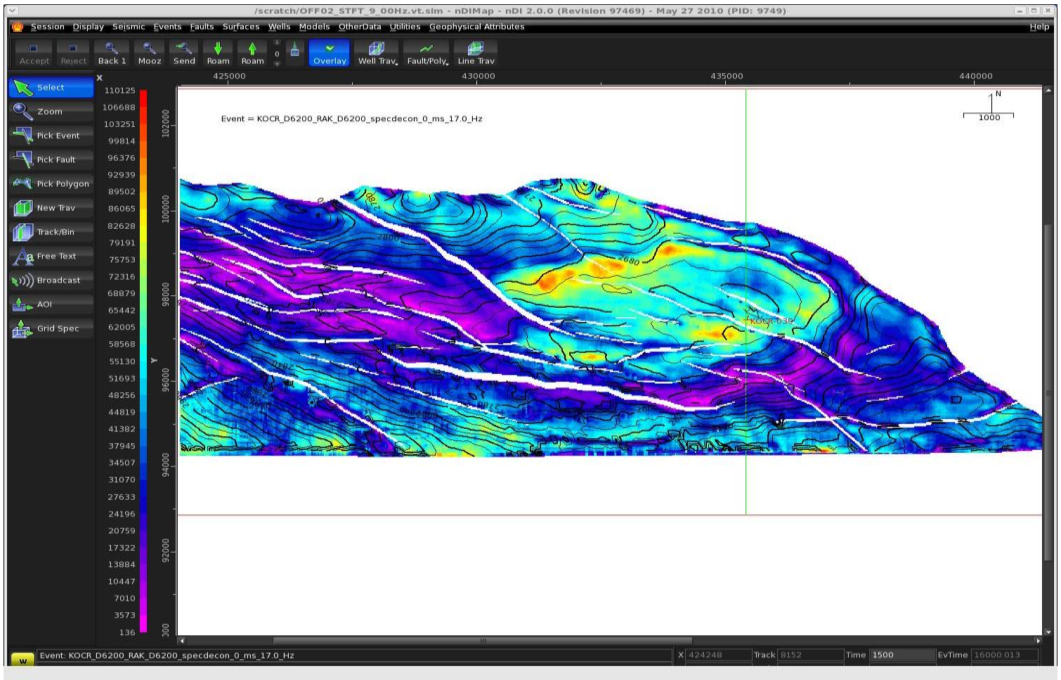

Fig. 8. Frequency map generated at 17Hz. High frequency of 17Hz becomes difficult to show contact or the separation between the brine and the gas

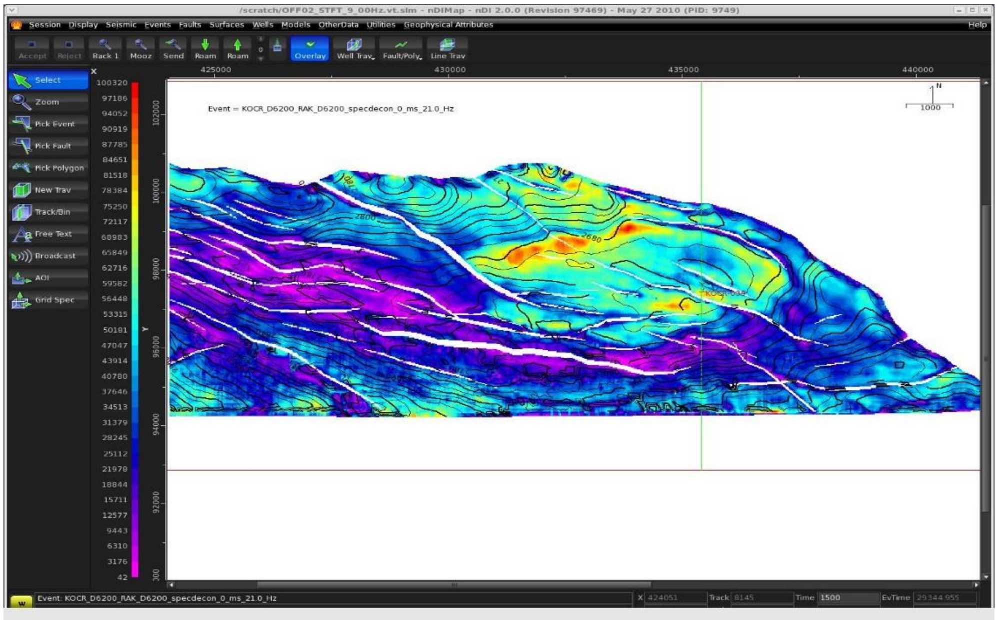

Fig. 9. Frequency map generated at 21Hz. At high frequency of 21Hz showed that it was difficult to separate the brine from the gas or define the contact

The contact shown by the frequency maps (Figs.6 and 7) also agrees with the contact established in the amplitude versus time cross plot (Fig.10).

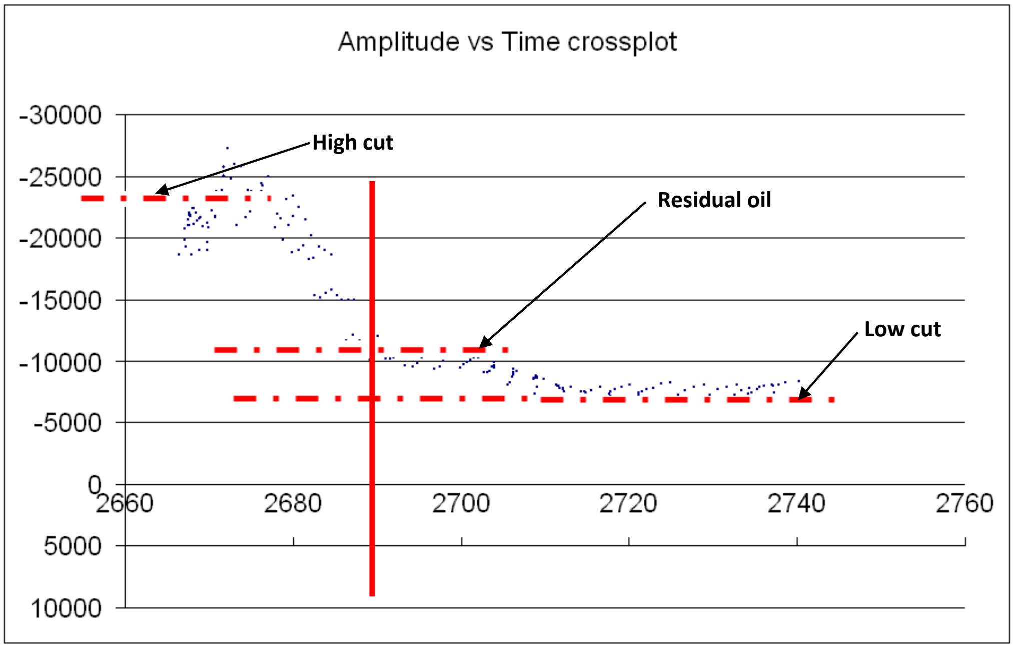

Fig. 10. Amplitude versus time (milliseconds) cross plot. The graph clearly defines the separation of high amplitude from the low amplitude values at 2690ms. The dots represent different values of amplitude at different time values

The separation of amplitudes between the brine and gas is clearly demonstrated in the frequency maps generated at 9Hz and 13Hz frequencies which define the hydrocarbon contact at 2690ms. This result agrees with the hydrocarbon contact established in the amplitude versus time cross plot (Fig.10). At higher frequency of 17Hz and above it could no longer separate the brine from the gas fluid. Therefore, at higher frequency the hydrocarbon contact could not be visible again or becomes difficult to define the contact.

5. Conclusion

The spectral analysis showed the presence of hydrocarbon in the D6.2 reservoir. This is shown by the dominant frequency range for gas leg at 8-22.9 Hz while 24-36 Hz is the dominant frequency range for brine leg. The hydrocarbon contact was established at 2690ms and found to be gas-water contact. The dominant frequency between the ranges of 9-15 Hz gives the best isolation of the gas leg amplitude from the brine leg amplitude. The 9Hz frequency gives the best conformable amplitude to structure and calibrated contact in the KC field.

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