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(RESEARCH ARTICLE)

Benchmarking short-time Fourier transform against discrete Fourier transform for stratigraphic feature mapping: insights from the TMB field, Niger delta

Richmond Uwanemesor Ideozu [1], Fortune Ijeoma Chiazor [1, *], Kolawole Awolola [1] and Michael Nelson Mba-Otike [2]

[1] *Department of Geology, Faculty of Science, University of Port Harcourt, Choba, Rivers State, Nigeria.*
[2] *Department of Geology, Dennis Osadebay University, Asaba, Nigeria.*

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Abstract

This study benchmarks Short-Time Fourier Transform (STFT) against Discrete Fourier Transform (DFT) for mapping stratigraphic features in the TMB Field, Niger Delta, a prolific petroleum province where high-resolution reservoir characterization directly impacts field development decisions. Interpretations of wireline logs (Gamma Ray, Sonic, Resistivity) of Well 06 and 3D post-stack seismic logs (SEG-Y format) resulted in establishing a sand reservoir interval (6300-6384 ft) converted to two-way time (2.440-2.468 s) through checkshot calibration. Spectral decomposition was implemented in MATLAB with systematic optimization of the STFT window parameters (4 ms, 8 ms and 16 ms Gaussian windows) and the final choice was made based on quantitative resolution metrics. Amplitudes across 10 time slices (4 ms sampling) through the reservoir interval showed changes in the amplitude which highlighted the formation fluid changes and sequence boundary. Direct comparison shows that STFT having optimized 8 ms window gives high-quality localization of stratigraphic features than DFT especially in identifying subtle channel geometries (meandering channel found at 4-6 Hz bandwidth) which are then smothered in DFT by spectral averaging. Frequency attributes are used to discriminate lithologies: sand bodies exhibit dominating frequencies between 20-30 Hz and those of shales 40-50 Hz, as would be expected between acoustic impedances of unconsolidated Tertiary sediments. The study sets quantitative performance standards for classical spectral decomposition in the TMB Field, and it offers a reproducible standard against which to compare subsurface stratigraphic delineation and backgrounds enhancing an advanced time-frequency approach (synchro squeezing transforms, machine learning strategies). The open-source implementation and workflow documentation of MATLAB makes it transparent and allows its extension to comparative studies. Findings indicate that optimized STFT is adequate to perform operational stratigraphic mapping in resource-limited contexts, providing operational implications to delimit the reserves and determine the placement of wells in the Niger Delta and other similar mature basins.

Keywords: Short-Time Fourier Transform; Discrete Fourier Transform; Spectral decomposition; Stratigraphic mapping; TMB Field; Niger Delta; Reservoir characterization

1. Introduction

Spectral decomposition is pivotal in seismic stratigraphic interpretation, yet the systematic validation of classical techniques across certain basins is necessary before the deployment of advance techniques. Transformation of seismic signals improves the visibility of the subsurface by transforming data of traditional amplitude measurements (seismic domain) to other transform domains (Neidell & Charuk, 2018), through mathematically sound and seismically compatible transforms, e.g. Fourier and Hilbert transforms (Van Spaendonck *et al.*, 2002). Such a method isolates geologic signal versus processing artefacts and allows the correct recovery of rock-fluid information of seismic data

* Corresponding author: Chiazor F. I

(Ofuyah *et al.*, 2014). Fourier analysis breaks down signals in terms of sinusoidal components on the assumption that the content of the frequency is time-invariant (Robertson and Nogami, 1984). The Fourier transform gives smooth spectral property measured across long trace lengths but is unable to detect local temporal changes in spectral content (Taner *et al.*, 1979). The reason behind this limitation is that when a geologic sequence is convolutionally filtered with the source wavelet using broad time windows, amplitude spectra will be created dominating the wavelet signature, as opposed to the subsurface properties. STFT addresses this limitation by applying narrow, moving windows that capture wavelet overprints reflecting local acoustic impedance and layer thickness variations. The aim of seismic interpretation is better resolution and visualization of structural and stratigraphic features, prediction of the thin-bed reservoir thickness, noise rejection, and direct hydrocarbon marking (Ofuyah *et al.*, 2014). The orthodox interpretation processes utilize fault and horizon mapping, sequence stratigraphy, basic spectral analysis and seismic modelling in order to produce structural, stratigraphic and reservoir maps in order to delineate and exploit hydrocarbons. Nevertheless, such methods often become ambiguous in interpretation because of poor seismic resolution, display bias, artefacts, and poor well-seismic calibration, which invalidates effective well location (Ofuyah *et al.*, 2014). The resolution of seismic traces and its clarity relies on the high frequencies and proper bandwidth (Dobrin, 1988). The traditional seismic data are band-limited and they may not resolve fine geologic qualities. To achieve resolution enhancement, seismic source parameters, such as wavelet properties and bandwidth frequencies, are to be attended closely since this is the basic element governing detection and imaging properties (Okaya, 1995). Although geologic features can have wavelength bandwidths of 0-1000 Hz or greater, the common bandwidth of seismic is 15-65 Hz, vertically. Field acquisition and processing may record moderate high frequencies, but low frequencies that would provide critical stratigraphic information (below 10 Hz) or high frequencies that are found only in well data (above 100 Hz) are not visible on standard seismic traces. It is worth noting that gas sands and oil reservoirs amongst other hydrocarbon-bearing formations often have abnormal-low frequency responses under productive intervals (Sheriff, 1973). The spectral decomposition methods are frequency-resolution methods based on the principle that thin-bed reflections have the characteristic frequency-domain expression that is suggestive of bed thickness in time (Partyka *et al.*, 1999). The time-domain calibration restores the information that has been lost in the common seismic responses and the time-frequency transformation (spectral decomposition) achieved through Fast Fourier Transform (FFT) convolution extracts the stratigraphic information that is hidden and the subtle horizon anomalies. The stratigraphic exploration theory focuses on deep-seated aspects concerning low-frequency responses. Irrespective of the significance of high-resolution spectral techniques, the use of high-resolution spectral techniques in the analysis of seismic signals in the Niger Delta is not well developed and documented in the literature (Ofuyah *et al.*, 2015). The present-day commercial interpretation tools and software systems offer a reliable solution to the problem when the geologic environment is favorable and can be improved to be reliable in the recognition of reservoirs and characterization in challenging environments. This capability gap implies that better methods are needed to enhance the number of success ratios in field appraisal and determine potential exploration targets. Innovative and high-resolution methods of quick, precise, and optimal 3-D interpretation of seismic data are therefore a necessity.

This study benchmarks spectral decomposition performance using STFT and DFT for seismic data analysis in the TMB Field, Niger Delta. This work provides a reproducible framework of subsurface stratigraphic definition and a validation standard against which advanced time frequency techniques can be assessed as higher levels of computational resources and expertise will be available in the basin by setting quantitative performance standards of these foundational methods. Although recent time frequency methods, such as synchro squeezing transforms, variational mode decomposition, and deep learning-assisted spectral decomposition, are theoretically superior in estimating the instantons frequencies, the requirement of advanced computational resources and expert knowledge have limited their application to the Niger Delta. Moreover, these sophisticated techniques need to be tested by the accepted standards of certain basins prior to use. This study aims at the optimization and use of classical STFT and DFT methodology in the TMB Field, which sets performance basis on which any advanced method studies can be in the future. The rationale behind the selection of these underlying methods is that they do not need any special computational hardware, can be fully reproducible by an open-source implementation, and are based on the algorithms of the commercial interpretation software that is extensively used in the petroleum industry of the Niger Delta. The TMB field is situated in the Coastal Depobelt of Niger Delta, Nigeria. Chevron's basemap (Figure 1) shows the well layout and our primary interest is the Well 06. The Niger Delta Basin is located between latitudes 3 ° and 6 ° N and longitudes 5 ° and 8 ° E in Equatorial West Africa. It is classified as one of the most prolific oil- producing Tertiary Deltas in the world (Ideozu *et al*., 2020; Odesa *et al.*, 2024; Ideozu *et al.*, 2025a, b; Eyankware *et al.*, 2025; Mba-Otike *et al.*, 2025), comparable to the North Slope of Alaska, the Mississippi, the Orinoco and the Mahakam (Reijiers *et al.*, 1997).

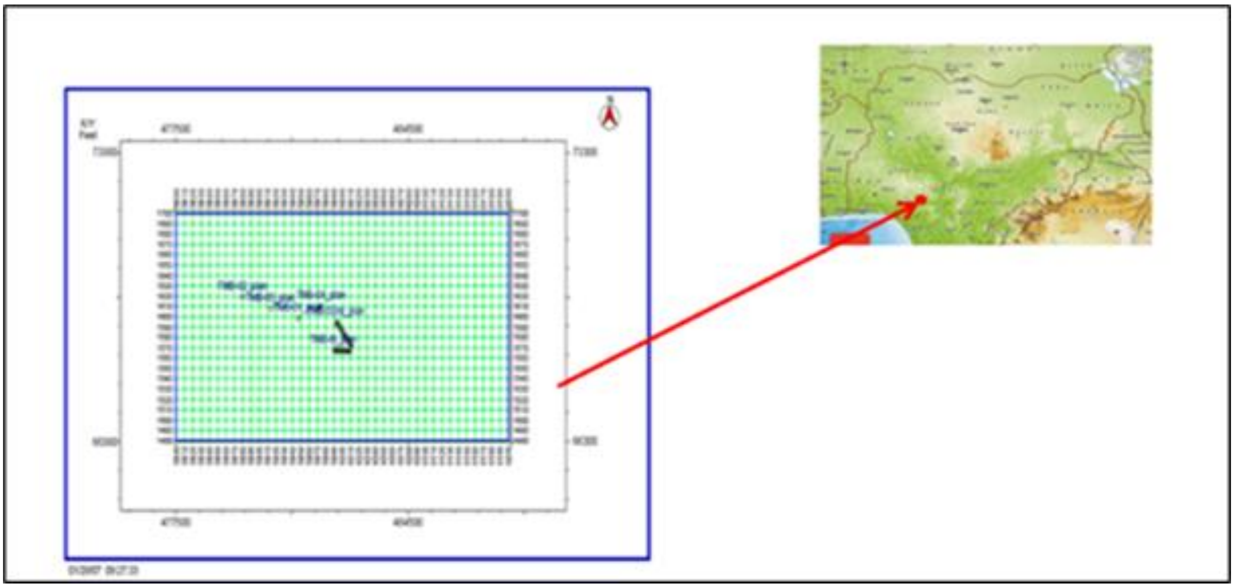


Figure 1 Study area base map showing all wells with well 06 as TMB 6 plan (Courtesy: Chevron; modified)

It was formed at the same time as the opening of the Gulf of Guinea and the Equatorial Atlantic in the Aptian- Albian period, when the Equatorial part of Africa and South America began to diverge. Coal- bearing Mamu sediments and the tidally led Ajali formations built up when the Nkporo cycle tended towards a general regression with related progradation during this Epoch (Reijiers *et al,* 1997). The Niger Delta Basin sedimentary fills comprise a sequence of offlap cycles of fluviomarine systems which has successfully extended out over the continental edge into the oceanic basement in a step like manner, mirroring a basinward net progradation to the south. Oomkens (1974) showed that the upper 30 m of the deltaic complex are dominated by tidal channel sands; fluviatile sands predominate under 30 m. The advancement of the delta began in the Cenozoic and has extended to the present day. The Niger Delta Tertiary Section comprises three Formations known as the Akata, Agbada and Benin Formation which represents the prograding depositional environments and this tripartite regressive sequence has been deposited in the Niger Delta (Short and Stauble, 1967, Avbovbo, 1978, Evamy *et al,* 1978, Doust and Omatsola, 1990). The Formation named Akata is the Delta sequence base composed of shales, silts and clay. Akata Formation is mainly believed to house the source rocks and also some turbidite sands. The Akata has a thickness between 2000 m to 7000 m and about 5000 m in the Deep water (Doust and Omatsola, 1990). The paralic clastic sequence present in the entire depobelts called Agbada Formation is major oil-producing unit in the Niger Delta, age Eocene to Pleistocene. The Agbada Formation has thickness more than 3500 m and it is an accumulated deltaic sequence in the fluviodeltaic, delta-front and delta-topset environments (Doust and Omatsola, 1990). The main reservoirs are the basin floor fan and channel deposits within Agbada Formation. The recent unit is the Benin Formation and is made up of Continental Deposits, age Late Eocene to Holocene. These include coastal and alluvial sands that are approximately 2000 m in thickness (Avbovbo, 1978). Agbada Formation is covered by Benin Formation in some onshore coastal regions (Kulke, 1995), while the Benin Formation's offshore continental sands are thinner and disappear near the shelf edge (Cohen and McClay, 1996). The Basin of the Niger Delta is part of the pre-oceanic section of the Abakaliki-Benue Fracture Zone of the Southern Nigerian Basin. In the west, the Okitipupa Basement High separates it from the Benin or Dahomey Basin and in the east, the Volcanic Line of Cameroon bounds it. Its northern margin transverses some older tectonic elements; Abakaliki Uplift, Calabar Flank, Afikpo Syncline and Anambra Basin (Reijiers *et al*, 1997). The tectonism of the Pre and synsedimentary, as explained by Ejedawe *et al,* (1984) and Stacher (1995), controlled the advancement of the delta (Evamy *et al*, (1978). The Fracture Zones of the Cretaceous shown as ridges and trenches in the deep Atlantic controlled the continental margin tectonic framework along Equatorial Africa West Coast (Knox and Omatsola, 1987). The fracture zone ridges divide the margin into different basins and form the border faults of the Cretaceous Benue-Abakaliki Trough in Nigeria, which cuts deep into the Shield of West African. The trough is a failed arm of a triple rift connected to the South Atlantic opening. In this region, rifts began in the Late Jurassic period and continued in the Middle Cretaceous region of the Niger Delta and in the Late Cretaceous region decreased altogether (Lehner and Ruiter, 1977).

2. Materials and Methods

2.1. Materials

The materials used for this research was provided by the Chevron through the Department of Petroleum Resources (DPR) and include: Seismic Amplitude Data, Well Log Suites, Base Map of Field, Check Shot Data. Workstation and MATLAB (for algorithm development) and Surfer-8 (for map generation) software were provided by the Federal University of Petroleum Resources, Effurun, Nigeria.

2.2. Methods

The selection of Discrete Fourier Transform (DFT) and Short-Time Fourier Transform (STFT) for this study was based upon considerations of computational accessibility, reproducibility, and baseline establishment for the TMB Field. These foundational methods require only standard computational resources and enable full algorithmic transparency. Furthermore, they provide necessary performance benchmarks against which advanced time-frequency techniques may be validated as computational resources and specialized expertise become available for the Niger Delta basin. The methods adopted in this research are;

Discrete Fourier Transform (DFT): The DFT technique is the digital correspondent of the continuous Fourier transform and is expressed as;

$$F(\omega)=\int_{-\infty}^{\infty} f(t)e^{-i\omega t}dt \quad \ldots\ldots 1$$

Where, ω is the Dual Fourier of the variable 't'. If 't' signifies time, then ' ω' represents the angular frequency which is akin to the temporal frequency 'f' (Yilmaz, 2001).

Also, f(ω) comprises both real ($f_r(\omega)$) and imaginary ($f_i(\omega)$) components.

Hence,

$$f(\omega) = f_r(\omega) + if_i(\omega) \quad \ldots\ldots 2$$

$$A(\omega) = [f_r^2(\omega) + f_i^2(\omega)]^{1/2} \quad \ldots\ldots 3$$

$$\emptyset(\omega)= \tan^{-1}[f_i(\omega)/ f_r(\omega)] \quad \ldots\ldots 4$$

Where $A(\omega)$ and $\emptyset(\omega)$ are the phase and amplitude spectra respectively (Yilmaz, 2001). The disadvantage of the DFT i.e. spectral blurring can be enhanced with short time former transform (STFT) application.

Short Time Fourier Transform (STFT): The STFT or Windowed Fourier transform is an analysis with fixed resolution. It maps to 2-D frequency-time plane from a seismogram. It is driven by the need for a spectral representation which integrates the time- varying characteristics of a non- stationary signal (Chakraborty and Okaya, 1995). Assuming that the signal f(t) i.e. time-domain seismogram is stationary when viewed via a limited extent g(t) window, centred at the time(T), the STFT can be expressed as follows:

$$STFT(t,f) = \sum f(t)g^*[t-F]\, e^{-i2ft} \quad \ldots\ldots 5$$

Where g(t) is the function for window, and e^{-iwt} represents Fourier kernel. A 2-D function in a time-frequency plane (t, f) is obtained when the signal is mapped by the transform. The choice of window g(t) is the critical factor for STFT analysis (Chakraborty and Okaya, 1995). The major disadvantage or shortfall of Discrete Fourier Transform is that it gives an average representation and scalar attributes of the frequency behaviour in an entire seismogram with no local concentrations of energy information. This can be enhanced by STFT application.

The STFT Limitations are:

- Limitation in time-frequency resolution.
- The resolving capability of STFT is reduced as a result of finite length time domain moving windows over which the 1-D Fourier transforms.

In practice, the movement of the windows along the seismogram with an increase in time significantly smaller than the window width. This creates a more resolute F- T transform by more fine sampling along the time axis. (Chakraborty and Okaya, 1995).

This involves the adoption of convolution methods of Fast Fourier Transform, while the outcome of the seismic analysis will be displayed as seismic facies maps and cross- sections.

3. Results

The results for this research are displayed in Figure 2 to Figure 14. The data of well log (Gamma Ray, Sonic and Resistivity Logs) of Well 06 of the TMB Oil Field were plotted using Gnuplot (Figure 2). In sedimentary formations, high Gamma Ray log anomaly is indication of formation shale content. This is due to high radioactive elements content in shales and clay. Formations with a very low radioactivity level are called Clean Formation, unless it is contaminated with radioactive such as Granite wash or volcanic ash or there is dissolved radioactive salts in the formation fluid. Gamma Ray reading is good for identification of non-shaly and shales beds.

The depth-time conversion was validated through synthetic seismogram correlation with the nearest seismic trace at the reservoir level, yielding a correlation coefficient of 0.78. The established sand interval (6300–6384 ft) ties to two-way time of 2.440–2.468 s, with the reservoir top showing positive impedance contrast (peak) and the base showing negative contrast (trough). This tie quality supports subsequent spectral decomposition analysis.

The sedimentary formations radioactivity mainly ranges between a few API units in salt or Anhydride to over 200 API in shale formation (Schlumberger, 1989). A Gamma Ray of high rate of count implies a shaly sand radioactive sand or shale formation while a Gamma-Ray of low rate of count signifies a Sandy formation (Table 1).

Table 1 Summary table of responses by GR and Resistivity logs (Ashish, 1999)

Log Type	Sand	Shaly Sand	Sandy Shale	Shale	Comments
Gamma	Low	Medium	Medium	High	<40 Sand, 40 – 75 Shaly Sand, 75 -100 Sandy Shale and >100 Shale.
Resistivity	High	Medium	Medium	Low	Dependents on the type of fluid and measure of the fluid resistivity.

Based on Table 1, a sand interval was identified from depth 6300 ft to 6384 ft highlighted with a red rectangle across the well logs (Figure 2) and then zoomed in to be examined in detail (Figure 3). The established sand depth interval 6300 ft – 6384 ft from well log was converted to time (ms) using check shot that tied in with 2.440 s to 2.468 s. STFT analysis was done with Gaussian windows of three lengths of 4 ms, 8 ms and 16 ms. The 4 ms window offered better temporal resolution (6 ms) and poor frequency differentiation (±25 Hz) which resulted in lithologic ambiguity. The 16 ms window improved frequency precision (±6 Hz) but blurred temporal boundaries, obscuring the channel feature. The 8 ms window achieved optimal balance: temporal resolution of 12 ms adequate to resolve the 24 ms two-way travel time of the 84 ft sand interval, and frequency resolution of ±12 Hz sufficient to distinguish sand (20–30 Hz) from shale (40–50 Hz) responses. The rationale of choice is recorded in Figure 6, which focuses on comparing amplitude spectra and channel detection clarity between window parameters. Based on the depth to time conversion, seismic data over the established sand interval (reservoir window) was extracted in time and the seismic amplitude was sliced at a data sampling interval of 4ms. A total of ten (10) time slices were obtained, a time slice before the top of sand interval (2.440 s) and below the base of the sand interval (2.468 s). The time slices are 2.436 s, 2.440 s, 2.444 s, 2.448 s, 2.452 s, 2.456 s, 2.460 s, 2.464 s, 2.468 s and 2.472 s. The horizontal sections of the time slices are displayed to show the sand interval changing with depth (Figure 4). The original seismic magnitude and phase were plotted graphically for the sand top (2.440 s) (Figure 5) and then transformed using Discrete Fourier Transform and Short Time Fourier Transform within MATLAB software in order to determine the dominant frequency (Figure 6). The decomposed data are presented in Figure 7 and Figure 8 to Figure 14 for both DFT and STFT respectively and will be discussed based on the three (3) seismic attributes used in this research include magnitude, phase and frequency. The magnitude shows sequence boundary over the window, phase shows discontinuity/continuity while frequency indicates lithology with low frequency indicating sand and high frequency indicating shale.

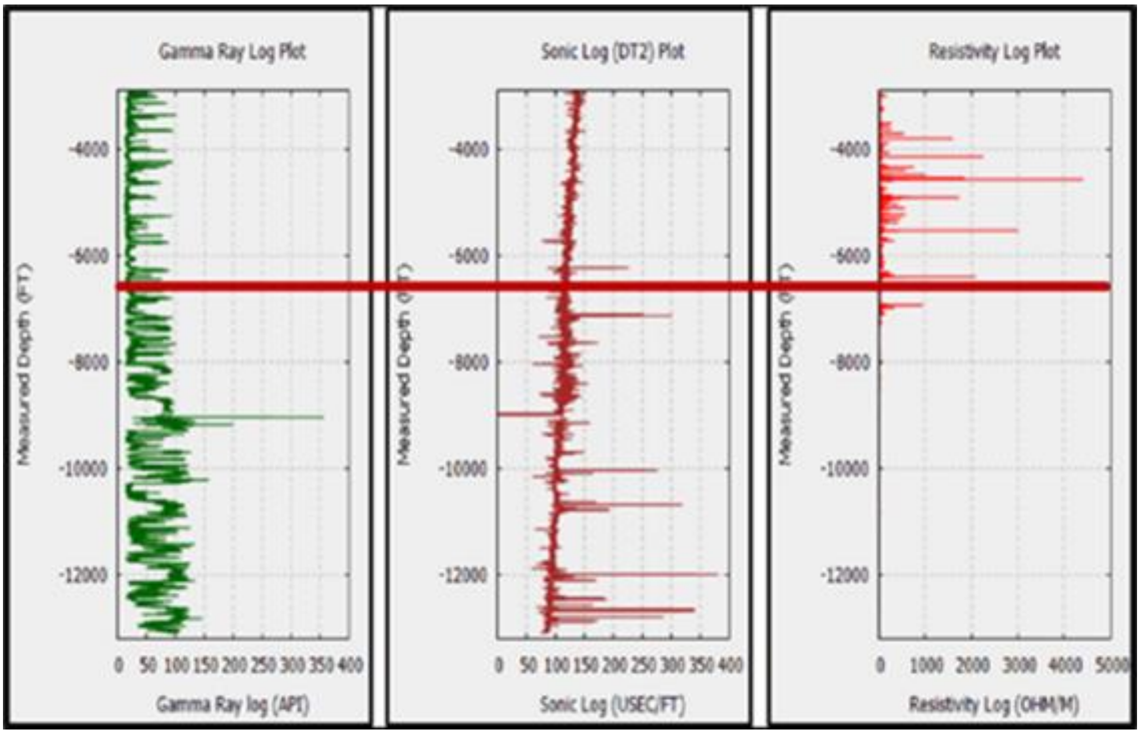


Figure 2 Plot of whole Gamma Ray, Sonic, and Resistivity data respectively for Well 06 with red rectangle across showing the sand interval established

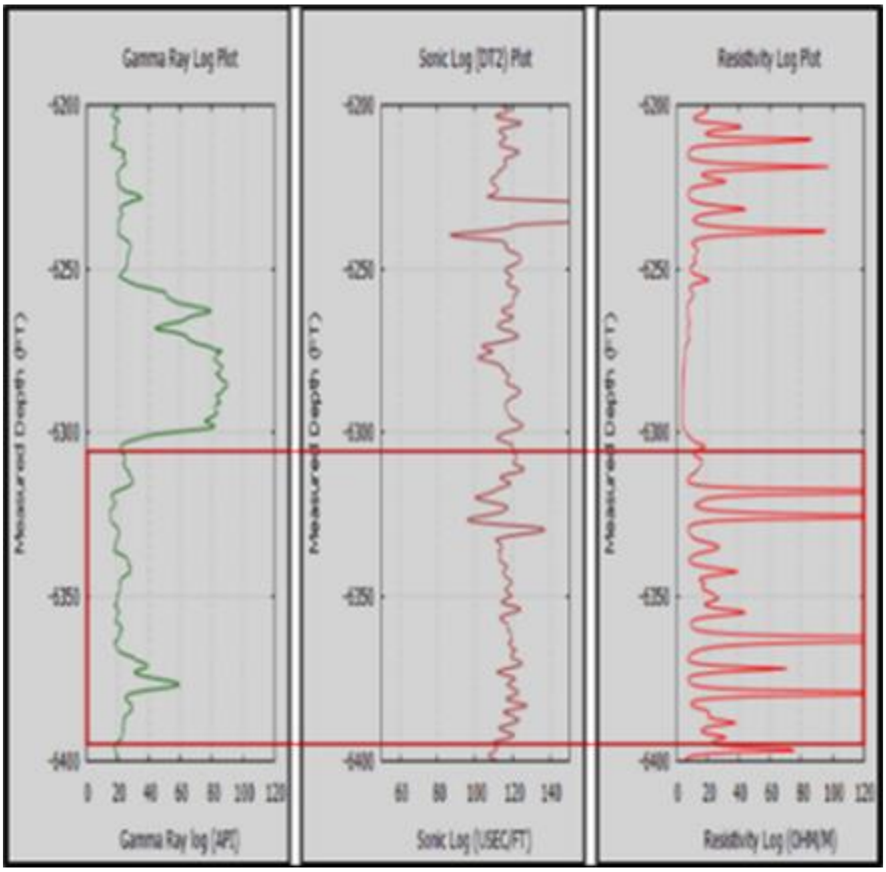
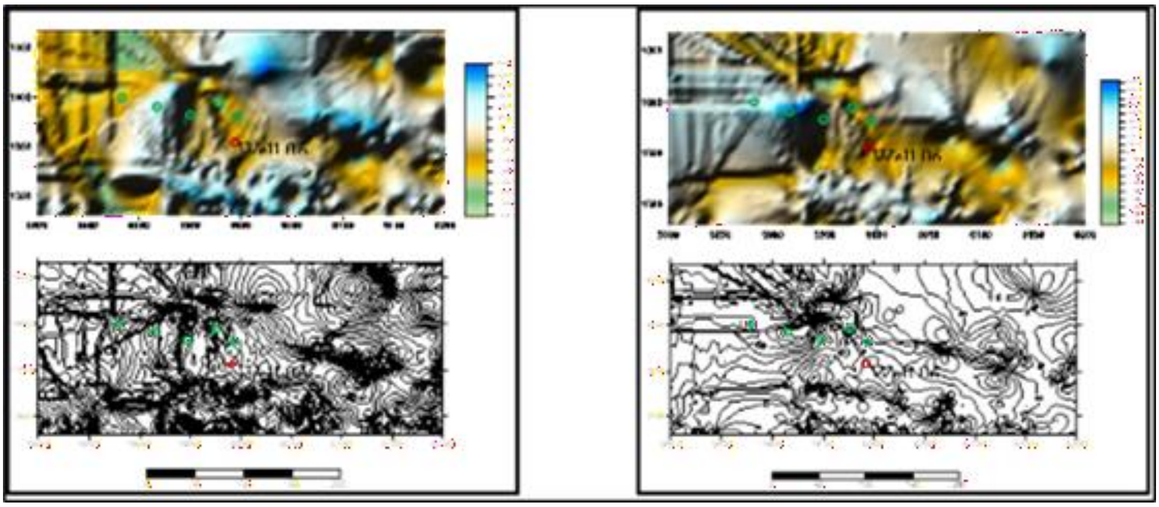
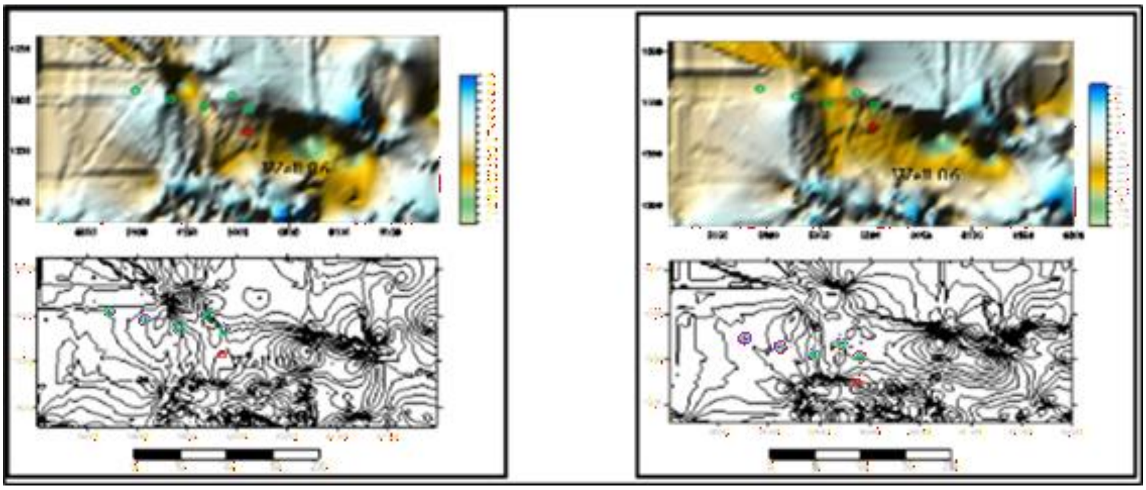


Figure 3 Plot of Gamma Ray, Sonic and Resistivity data respectively plotted for some parts of the dataset for Well 06 with the red rectangle across showing the sand with depth interval 6300 – 6384ft.



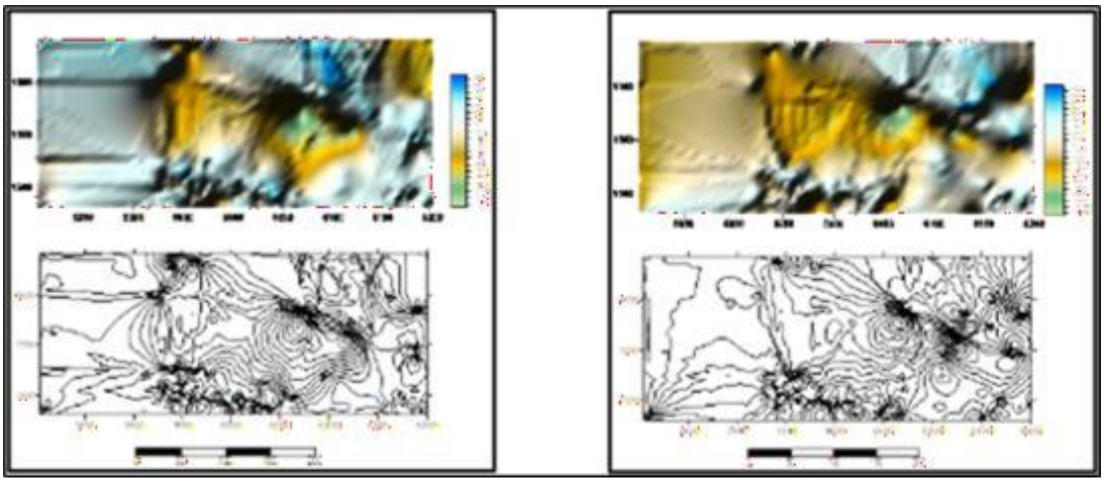
a) Time Slice (Amplitude) at 2.436sec.

b) Time Slice (Amplitude) at 2.440sec.



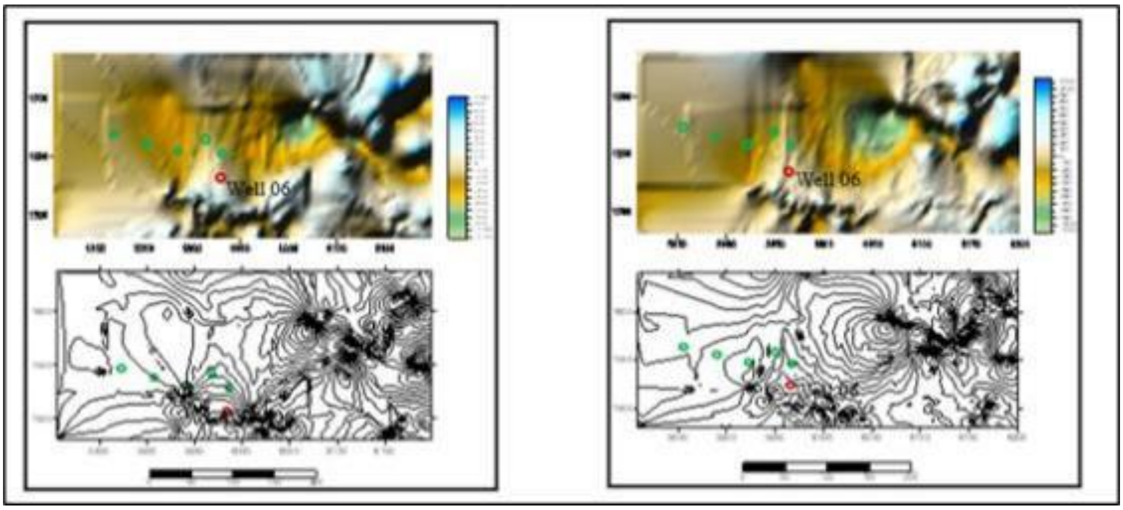
c) Time Slice (Amplitude) at 2.444sec.

d) Time Slice (Amplitude) at 2.448sec.

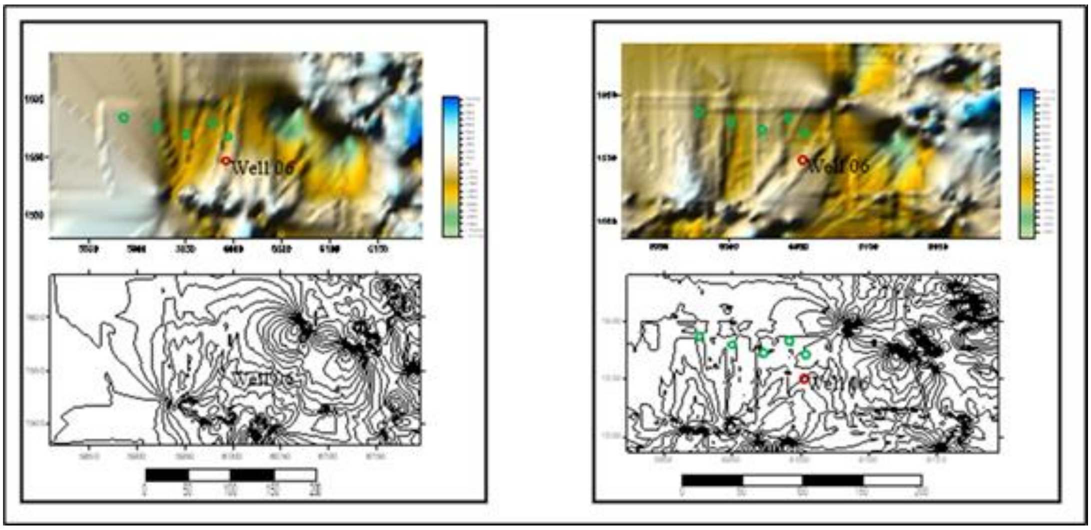


e) Time Slice (Amplitude) at 2.452sec.

f) Time Slice (Amplitude) at 2.456sec.



g) Time Slice (Amplitude) at 2.460sec. h) Time Slice (Amplitude) at 2.464sec.



i) Time Slice (Amplitude) at 2.468sec. j) Time Slice (Amplitude) at 2.472sec.

Figure 4 Time slices at 4ms sample interval across the selected sand interval showing variation of reservoir character with TWT and red ring signifying well in use

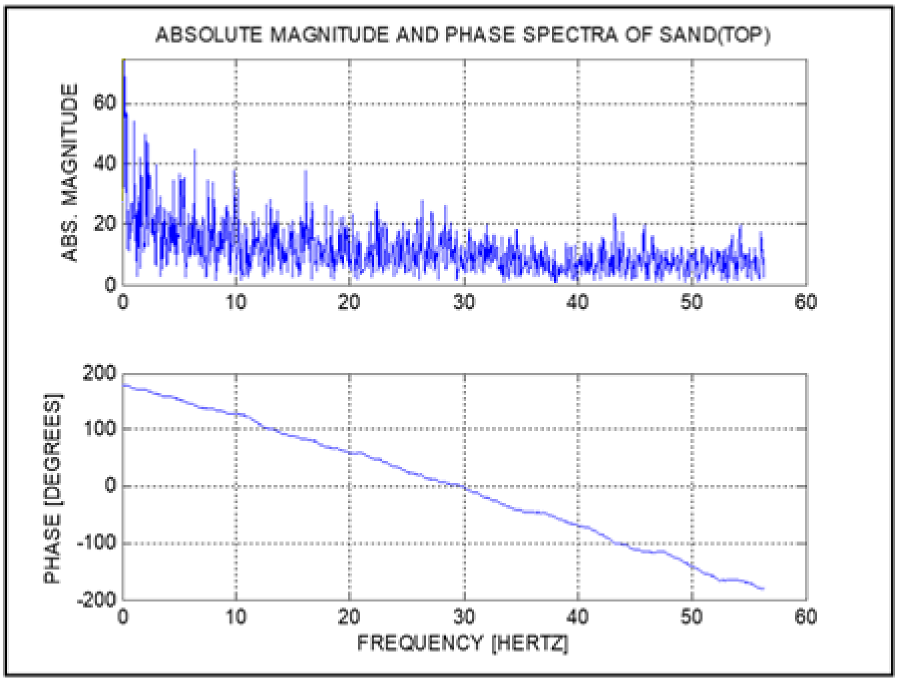
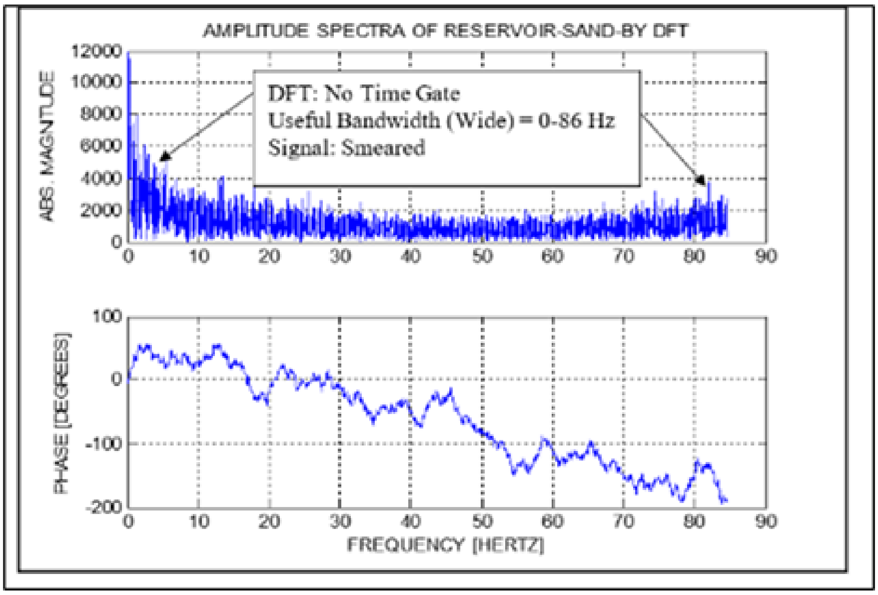
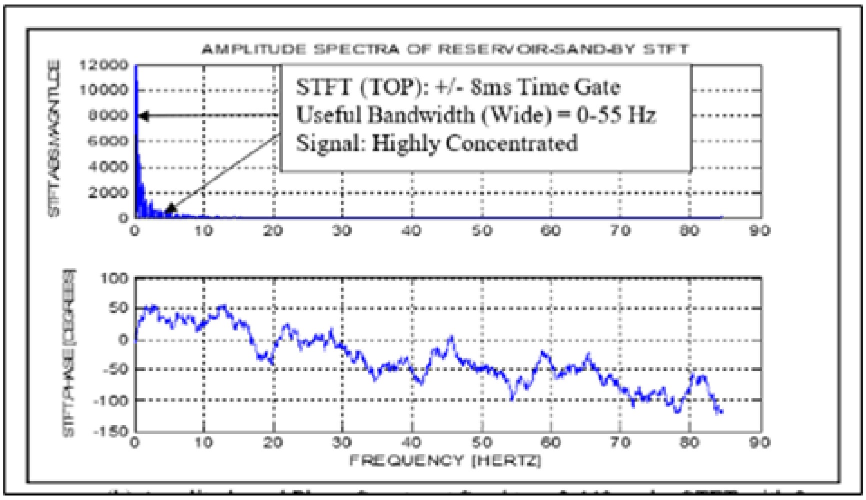


Figure 5 Absolute magnitude and phase spectra of Sand Top (2.440sec)

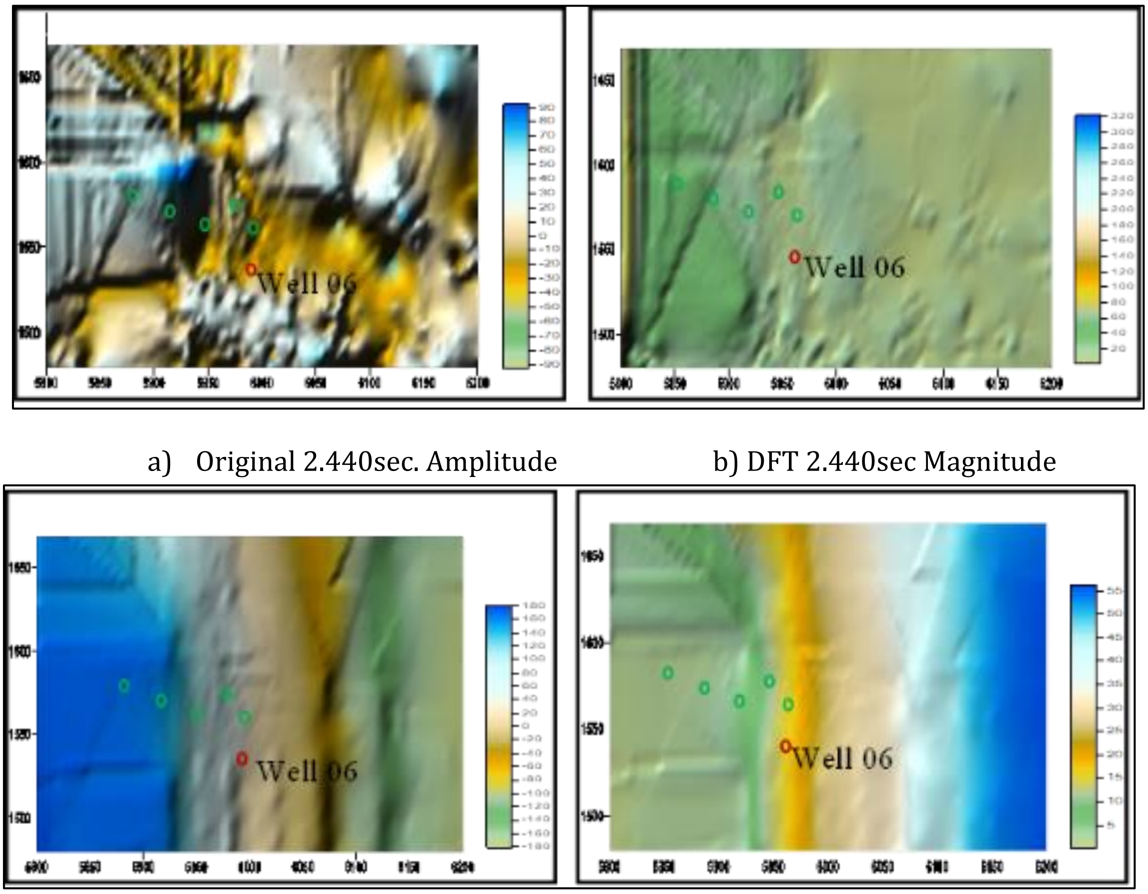


(a) Amplitude and Phase Spectra at Sand top, 2.440sec by DFT



(b) Amplitude and Phase Spectra at Sand top, 2.440sec by STFT with 8ms window, and Gaussian function.

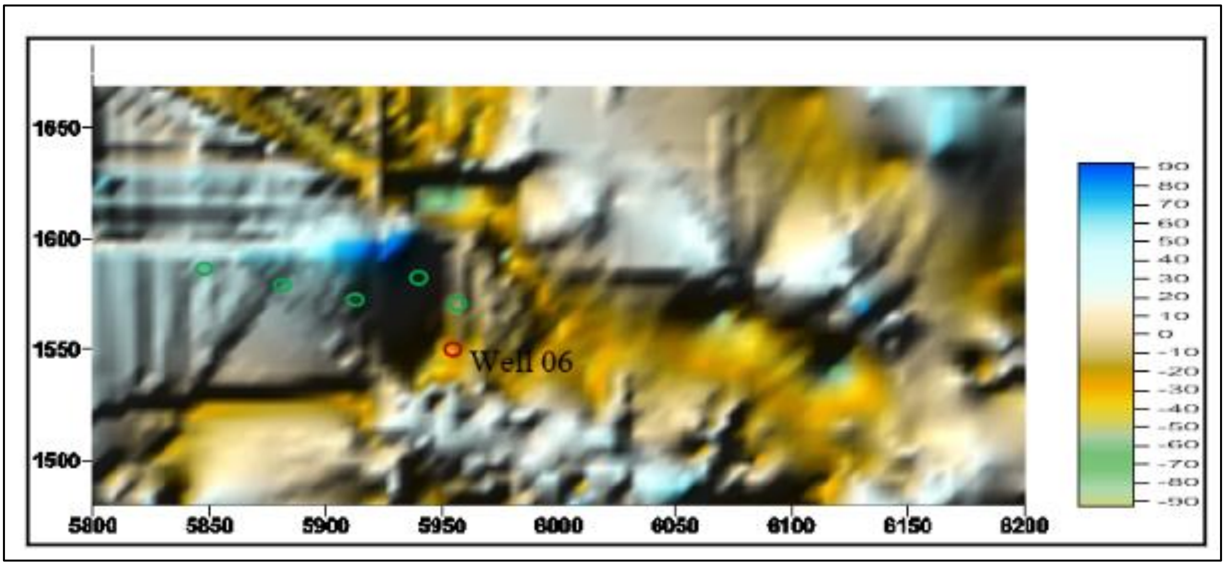
Figure 6 Amplitude and phase spectra of reservoir top by DFT and window by STFT with Dominant Frequency of about 43Hz



a) Original 2.440sec. Amplitude b) DFT 2.440sec Magnitude

c) DFT 2.440sec Phase d) DFT 2.440sec Frequency

Figure 7 Discrete Fourier Transform of the established Sand Top (2.440sec)



(a)Original Amplitude

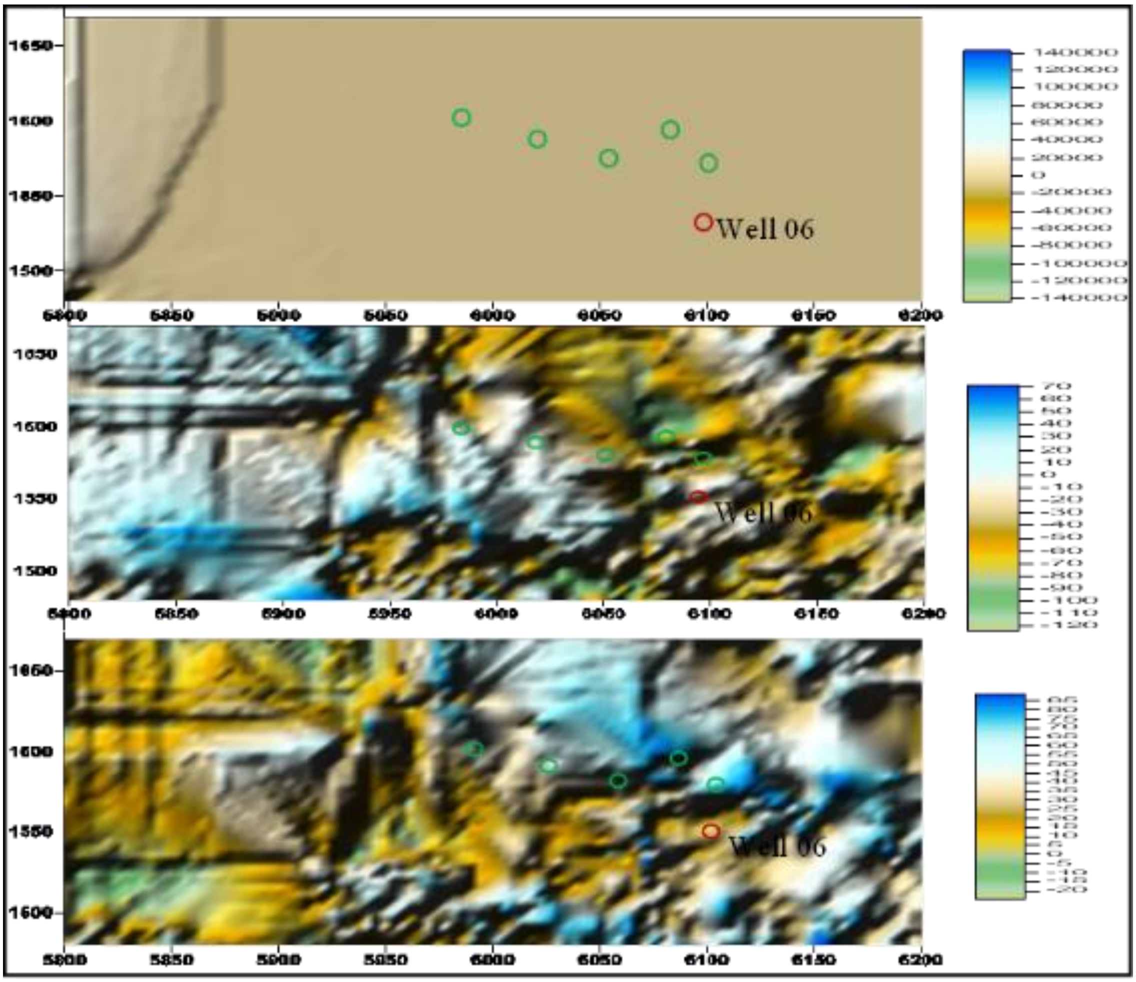


Figure 8 Original and full bandwidth STFT attributes; from top (a) Original amplitude (b) Magnitude (c) Phase and (d) Frequency

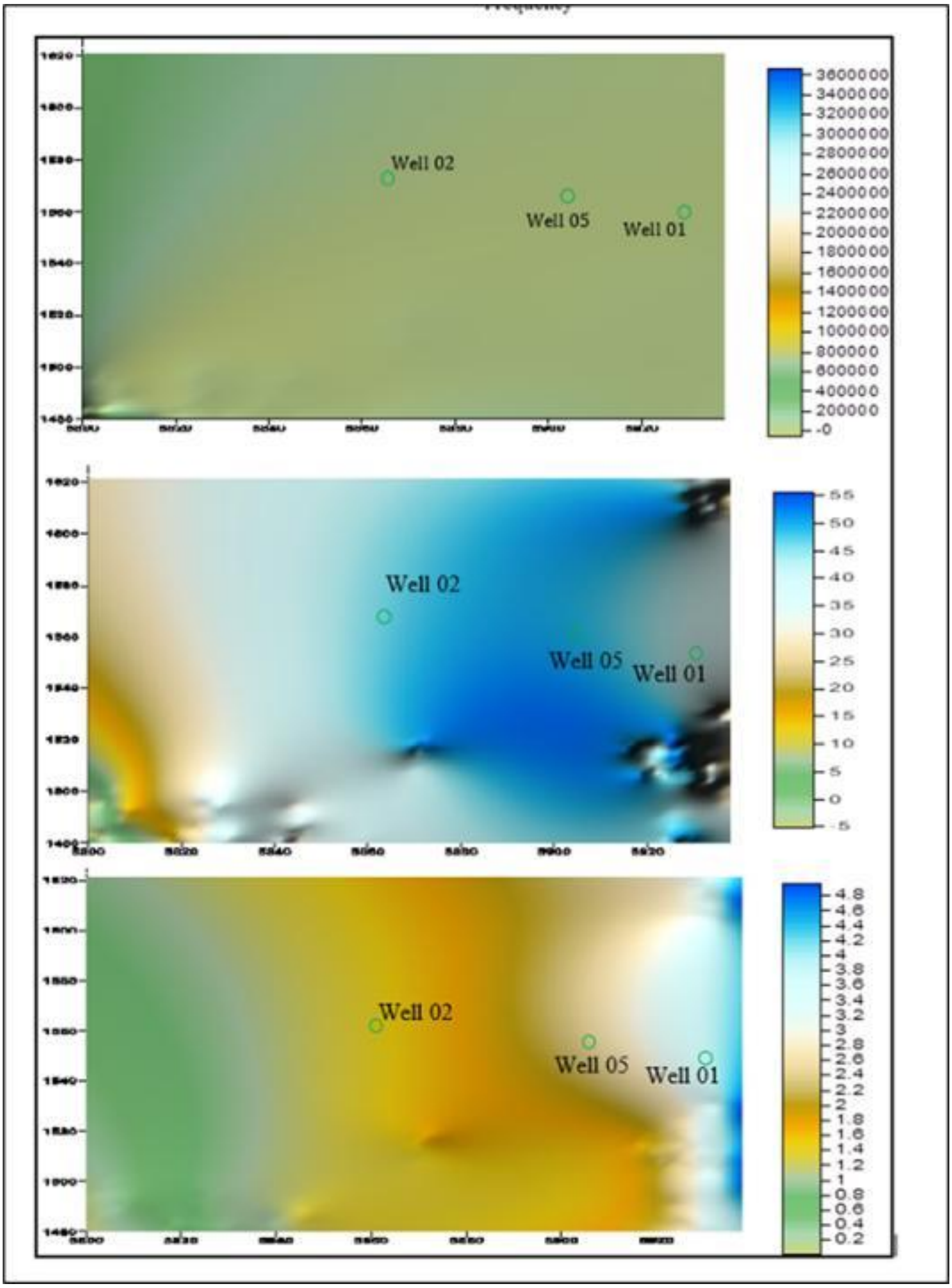


Figure 9 Frequency maps; bandwidth STFT (0-5Hz): (a) Magnitude (b) Phase and (c) Frequency

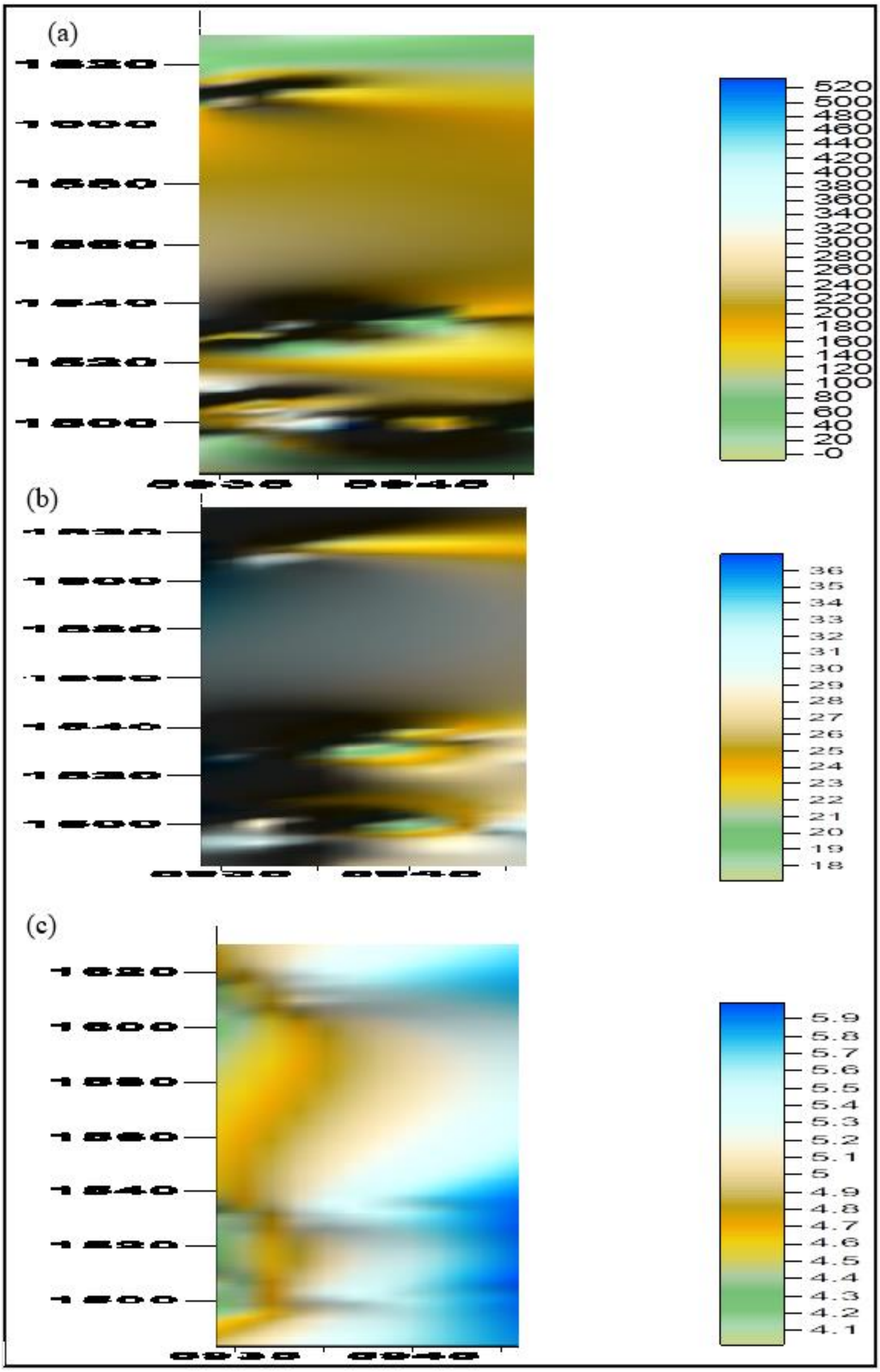


Figure 10 Frequency maps; bandwidth STFT (4-6Hz/mean 5Hz) (a) Magnitude (b) Phase and (c) Frequency

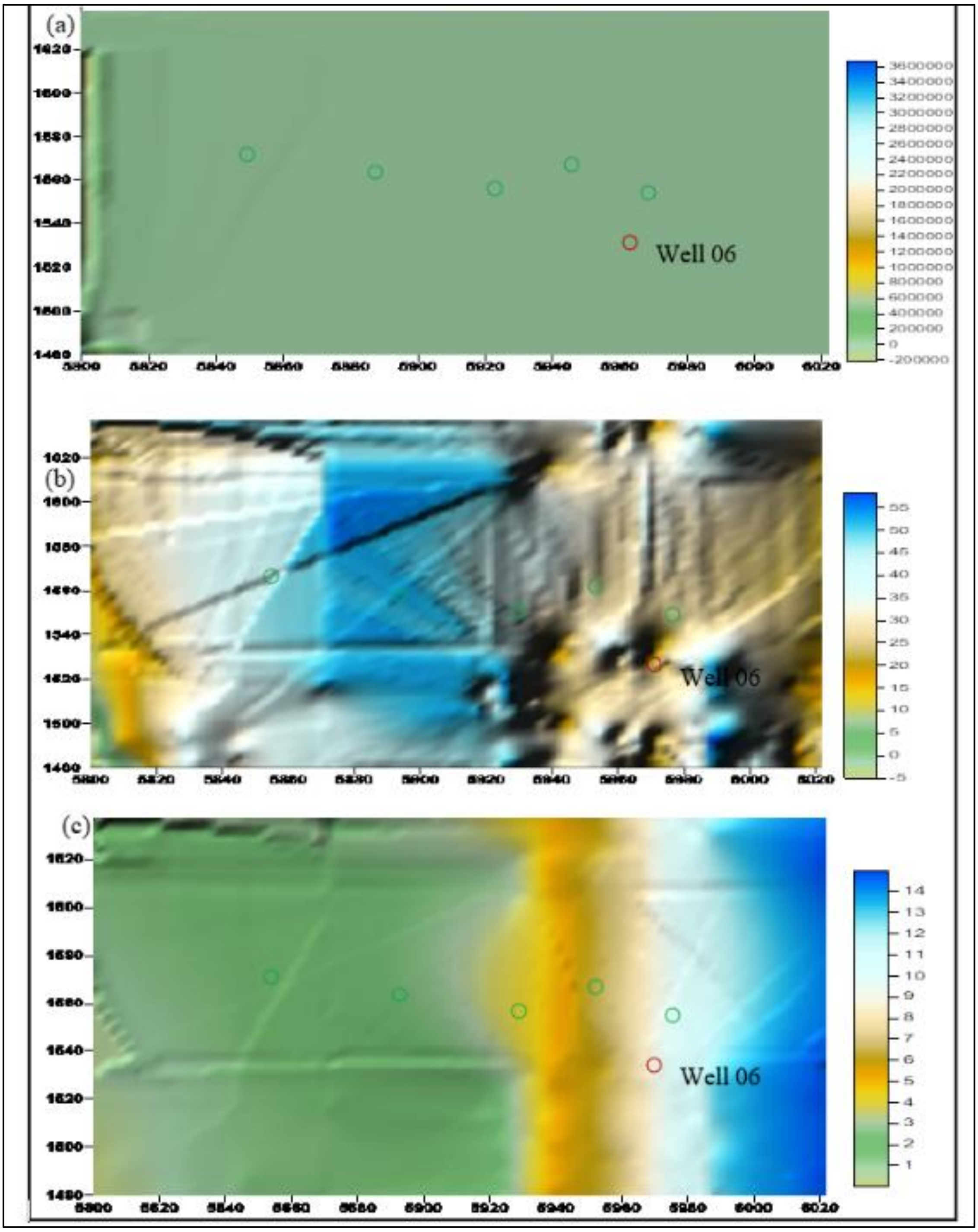


Figure 11 Frequency maps; bandwidth STFT (0-15Hz) (a) Magnitude (b) Phase and (c) Frequency

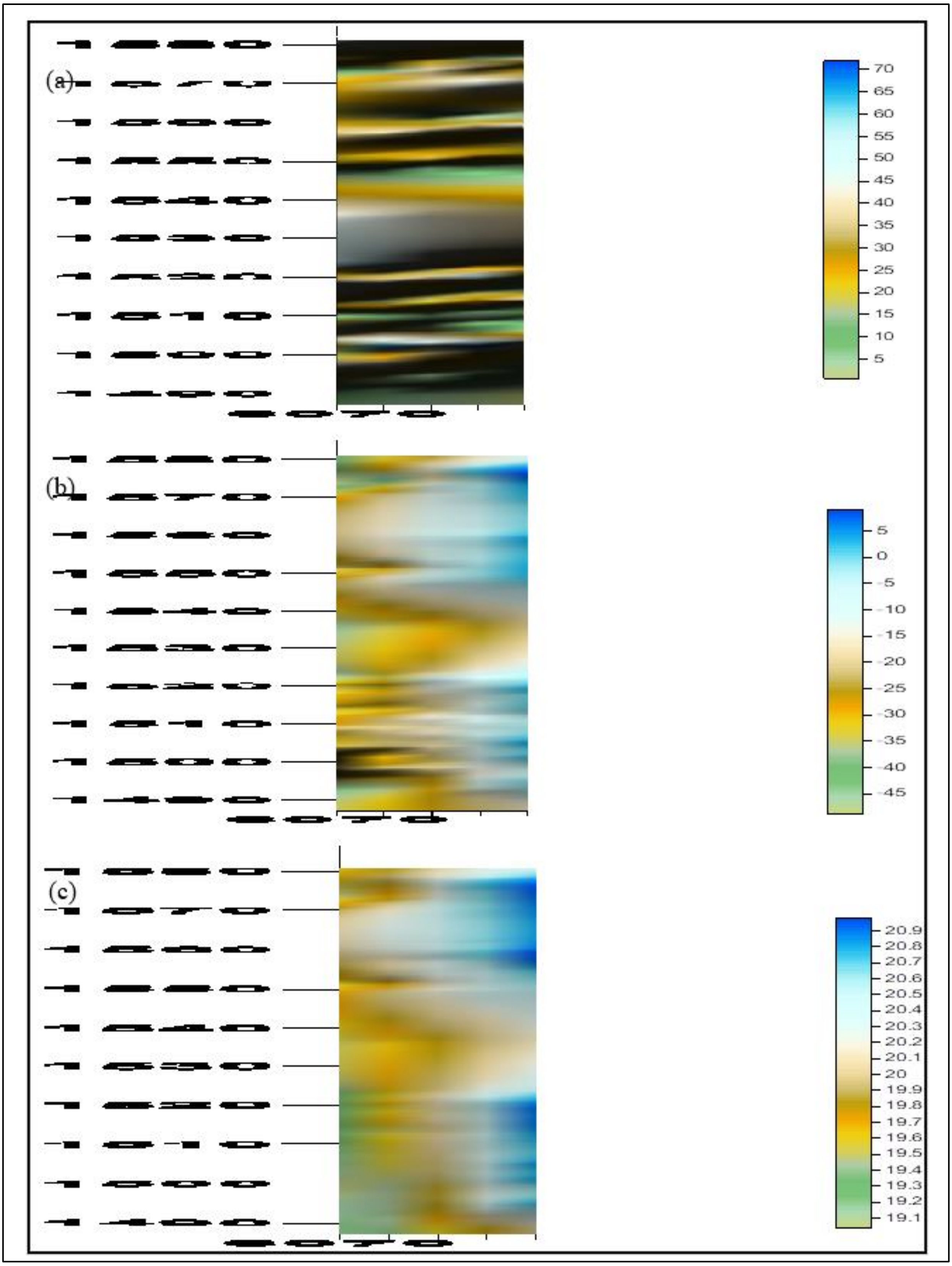


Figure 12 Frequency maps; mono-frequency STFT (20Hz) (a) Magnitude (b) Phase and (c) Frequency

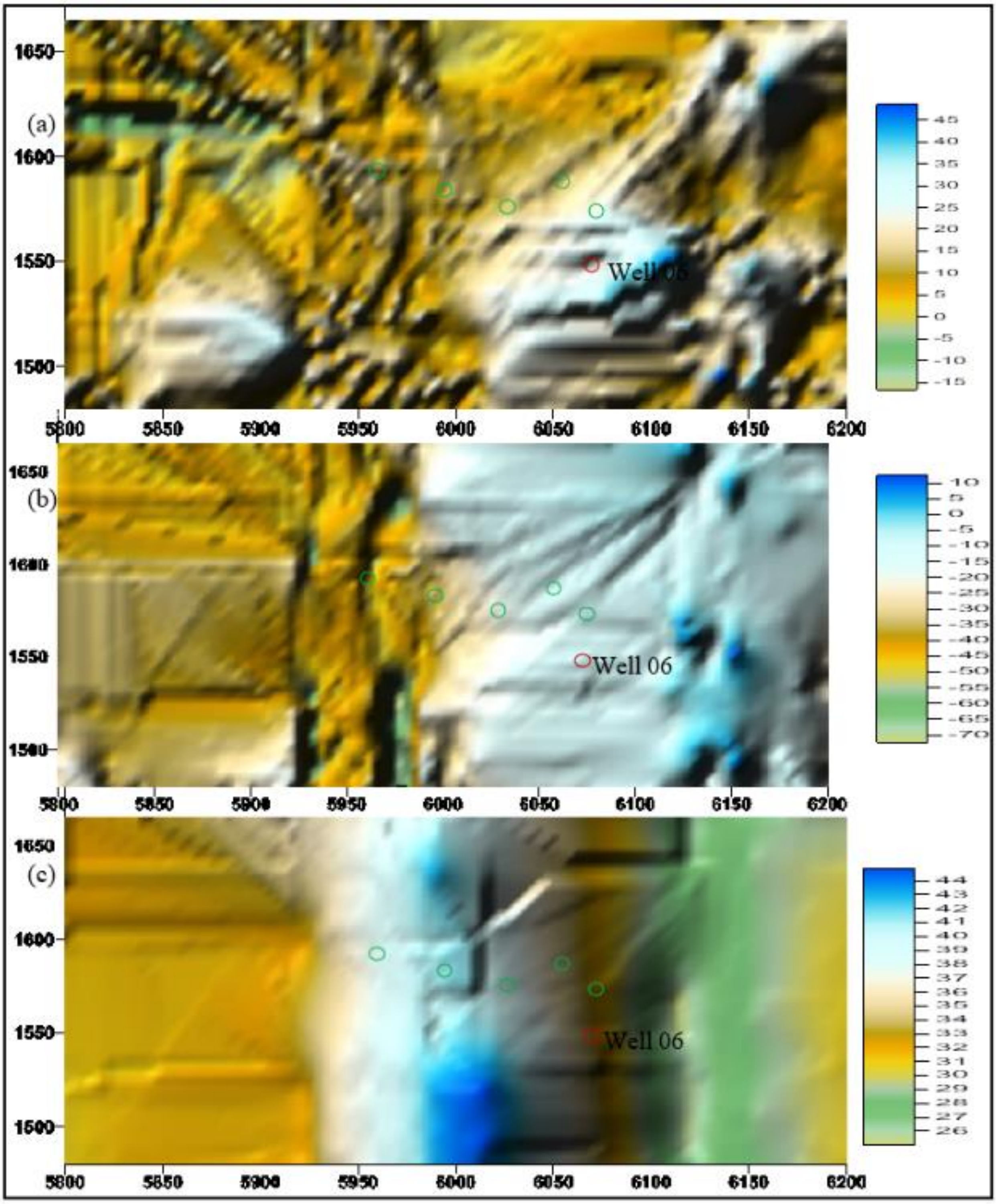


Figure 13 Frequency maps; bandwidth STFT (25-45Hz) (a) Magnitude (b) Phase and (c) Frequency

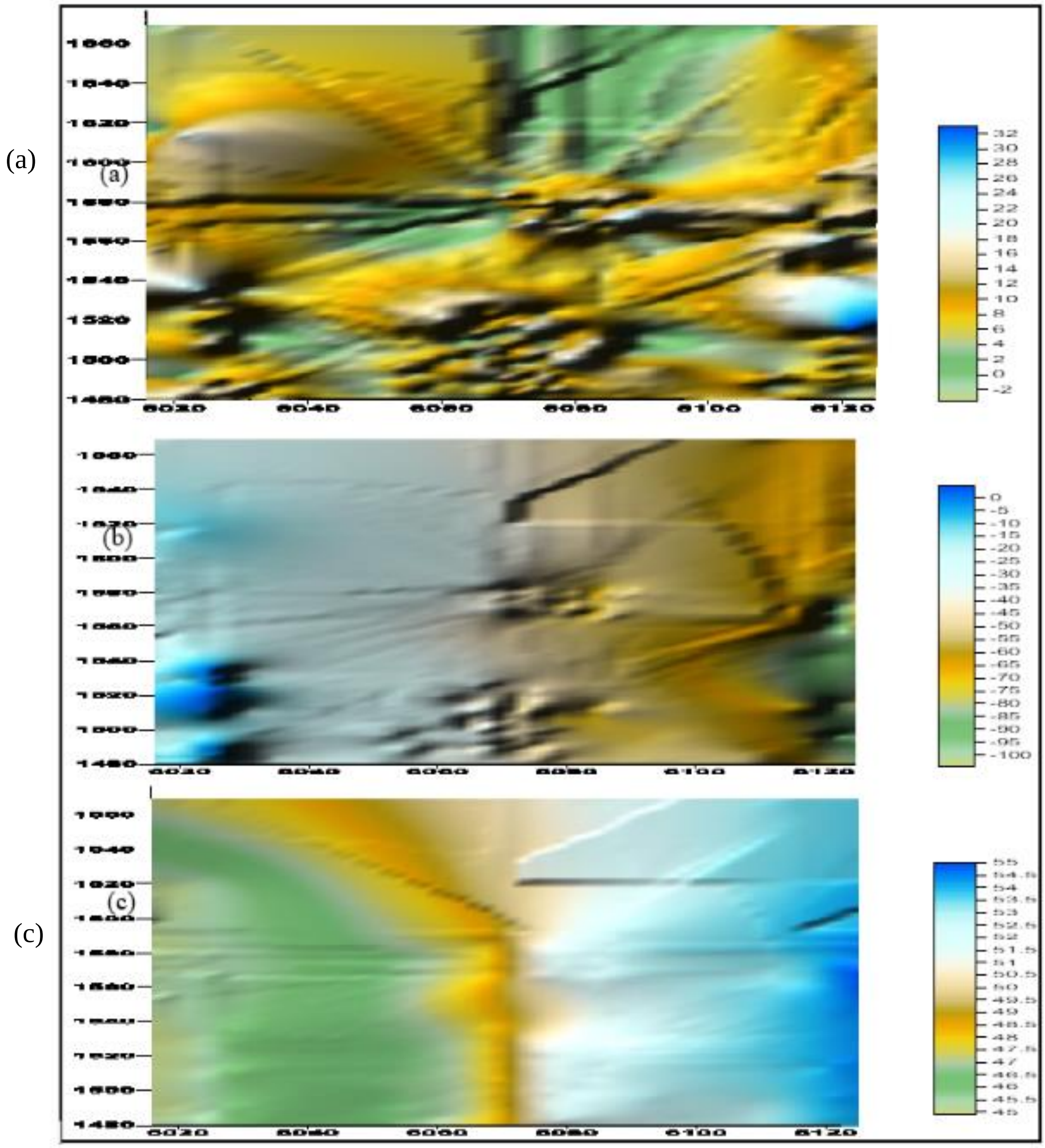


Figure 14 Frequency maps; bandwidth STFT (45-55Hz) (a) Magnitude (b) Phase and (c) Frequency

4. Discussions

The DFT phase map of 2.440 sec shows that there is continuity from well 06, 04 to 03 with slightly similar value but well 02 and 05 showing a discontinuity from other 3 wells. The DFT frequency map of 2.440 sec indicates that well 06 has similar lithology with well 03 and 04 i.e. shale and well 02 and 05 indicates a sandy formation (Figure 7). Figure 8 is the map of the full bandwidth short time Fourier transform of top of the 2.440sec with no distinct stratigraphic features due to combination of all the frequency. The 0-5Hz frequency map of the sand top (2.440sec) slice presented in Figure 9 suggests that the magnitude values are similar in Well 01, Well 02 and Well 05 that is same sequence boundary while the phase shows discontinuity as you move from left to right and the frequency indicates that Well 02 has a lower frequency (Sand) than Well 05 and Well 01 (Sandy shale). The variation could be due to difference in fluid content or lithology. A 4-6Hz (mean 5Hz) frequency map for the sand top (2.440sec) slice as shown in Figure 10 shows what could be a meandering channel. The meandering channel is not clearly visible on the 0-15Hz frequency map due to turning effect (Figure 11) but shows similar lithology as 0-5 Hz with Well 03, 04 and 6 having higher frequency (shale) and the wells have same sequence boundary. A mono-frequency map of the sand top (2.440sec) presented in Figure 12 also indicates subtle stratigraphic feature (Channel) similar to Figure 10. The bandwidth of 25-45 Hz and 45-55 Hz shows the same lithology type in the various wells as bandwidth 0-5Hz and 0-15 Hz. but no visible channel (Figure 13 and 14). In this study, the classical spectral decomposition techniques were deliberately chosen in order to set the quantitative standards of the TMB Field. Although synchrosqueezing transform (SST) and multi-synchrosqueezing (MSST) provide better time-frequency concentration of non-stationary signals, their application in the Niger Delta needs: (1) efficient computing assets to perform iterative reassignment processes; (2) expert knowledge of parameter selection (wavelet type, thresholding); (3) validation of the basin-specific parameters. The comparison of STFT and DFT offered here gives us the familiar background of such future advanced method researches. The MATLAB codes and workflow reported along with this paper aims at supporting these comparative extensions as computational resources are made available.

5. Conclusion

This study establishes that Short-Time Fourier Transform provides superior resolution of stratigraphic features compared to Discrete Fourier Transform in the TMB Field, Niger Delta, while DFT offers improvement over original time-domain data. The study establishes the existence of channel stratigraphic characteristics of the Niger Delta reservoirs and the dynamic frequency domain of STFT allows localization in the channel to be better than frequency response averaged in DFT. The findings show a better knowledge of the lithofacies change with depth in the reservoirs because the frequency-domain data is able to capture geological features that are obscured by time-domain amplitude data. This increased knowledge aids in the confidence of drilling operations and gives pay zone targeting information. The study also offers the first methodical reference point of classical spectral decomposition in the TMB Field, and quantitative measures of performance can be established against which new time-frequency methods (synchrosqueezing, machine learning) may be verified as they become feasible in the Niger Delta. Its open-source implementation guarantees reproducibility and means that further development of the method can be performed in resource-constrained research conditions.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study

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