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Spectral Analysis of Dynamite Shots of Different Charge Sizes at Varying Shot-Depths in Mid-West Niger Delta, Nigeria

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Abstract: ***Spectral analysis of dynamite shots in study area of Niger Delta showed strong signal strength with a frequency range up to 0 - 67Hz at detonation, except for defective shot depths or shallow patterns sources. At stipulated shot depths, recorded frequencies were in the range of 5Hz to 100 Hertz. Reflection events on the monitor record were fair-to-good in strength and amplitude. The Signal strength was strong for those shots acquired at the stipulated charge depth of 4m. Thus, optimal signal strength, associated with optimum frequency content can be obtainable at specification depth. Experimental shots with quality controlled drilling, loading and tamping at 4 metres depth for the 2kg explosives charge size had good energy returns with optimal signal strength ranging from 0 to 67Hz. It was however strongest when the charge size was increased (or duplicated) from 2kg to 4kg. The 4kg explosive charge size had very good energy return but was not cost-effective in the production setting.***

Keywords: Spectral analysis, shot depths, frequency content, frequency bandwidth

1. Introduction

Dynamite shots (explosive energy source) at some portion of the Niger Delta were showing a mixture of weak reflections and strong reflections. Even when the shot depths and charge sizes were planned to be uniform, in order to produce close signal strengths, but disparities existed. Spectral analysis was then conducted to identify the range of signal frequencies contained in the seismic data at the various locations (Sheriff and Geldart, 2006) of contributing dynamite shots of varying charge-sizes, at varying shot depths. Good and bad states of the dynamite explosives were to be verified to distinguish between shots because of quality of the explosive charge and the occurrence of low-frequency data amidst high integrity signals coming from shot records of similar charge-size and depths of the area.

The location of the study area lies in the southern part of Nigeria lies between 4deg 30' N and 5degrees 50' N, 6 degrees 30'E and 7degrees 45minutes E.

Logistics and equipment challenges inadvertently introduced discrepancies to the seismic data and affected the realisation of optimum signal frequency bandwidth. This problem can be isolated and controlled by the provisions of spectral analysis (Hatton, et al. 1986). Operationally, drilling crews in the field might venture to cut corners during loose supervision and erroneously make claims of achieved shot depth records comparable to the stipulated or program issued target. This in turn introduced errors when exported to the headers and used for data processing (Telford, et al. 1976). Apparent weak shots resulting from defective shot depths were characterized by low frequency range as though shots in weathered layer. Unless a spectral analysis of data from experimental shots was conducted misplacement of shallow shot depth sources for weathered shots of different depths will be inevitable.

Where the spectral analysis has identified the range of signal frequencies of shots of 4m depths, the low frequencies and amplitudes of comparative shots of 2.5m shallow depths became significantly conspicuous, and sorted out. When the mistake is of wrong headers supply, the consequence is usually a mis-match, which decreases the Signal/Noise ratio. The outcome of entry of wrong shot depth records often resulted in smearing of the signal quality.

With a drilling design of nominal 5 holes pattern at 4m depth, and additional (deeper) 6m holes pattern planned for flushing in wet areas; the spectral analysis of pattern shots of common depths of 4m will showcase a contrast in seismic signatures based on change in frequency attributes.

In the production setting, the seismology section continued with planning of drilling programs complying with safety distances and verified omissions report from survey section. The seismology section had generated the pre-plots for the swath, to show the optimal sub-surface coverage satisfying the minimum specification of 48 folds or multiplicity 4800% contributed by shots from Near-offsets, Mid-offsets, and the Far-offsets. The data processing and Quality Control tools inclusive of the Linear Move-Out (LMO) displays were used for evaluating the accuracy of geometry (Yilmaz, 1987), between the sources and receivers in the field acquisition layout. This played the useful role of validating the quality of data. The depth checkers were utilized to quality controlling drill depths.

2. Geologic Setting

The Niger Delta sedimentary basin is made up of the geologic Tertiary Niger Delta. Chrono-stratigraphically, the Niger Delta sedimentary basin is a result of three depositional cycles namely: firstly the marine incursion in the Cretaceous that deposited some shales and was terminated by mild folding in the Santonian (Reijers et al., 1997). The second was the development of the pro Niger

Delta that ended in the Paleocene marine transgression. The third cycle marked the continuous development of the main Niger Delta from Eocene to Recent. Three litho-stratigraphic subdivision exists in the subsurface of Niger Delta. This is made up of the upper sandy Benin formation, a middle layer of alternating sandstone and shale known as Agbada Formation and the underlying shale deposit known as Akata Formation. Afam clay is a separate member of Benin formation known as an ancient valley fill. Akata, Agbada and Benin Formation range in age from Tertiary to Recent, Paleocene to Eocene. Three main formations have been recognised in the subsurface of the Niger Delta complex (Short and Stauble 1967; Orife and Avbovbo 1982). These are the Benin, Agbada and Akata Formations. The three formations were laid down under continental, transitional and marine environments respectively (Short and Stauble, 1967). The Benin Formation was deposited in a continental-fluviatile environment and mainly consists of sands, gravels and back swamp deposits which vary in thickness from 0 to 7000ft. The Agbada Formation was laid down in paralic, brackish to marine fluviatile, coastal and fluvio-marine environments and consists of interbedded sands and shales. Many subenvironments have been recognised within these major units. The Agbada Formation becomes much shalier with depth and varies in thickness from 0 to 1000 to 15000 ft. The Akata Formation consists of marine silts, clays and shales with occasional turbidite sands and silts forming sinuous lenses. The Akata Formation varies in thickness from 0 to 20000 ft and like the other two formations, age varies from Paleocene to Recent. Deposits belonging to these three formations are being laid down today and so thickness estimates should be viewed as arbitrary and are dependent on location.

The Benin Formation and its equivalent form extensive outcrops inland from the Agbada Formation and south of the outcrops of the Ameki Formation and Imo Shale. The Akata Formation outcrops subsea on the delta slope and open continental shelf and is not exposed onshore unless we view the deeper water facies of the Imo shale as Akata Formation laid down in the front of the Paleocene Anambra Delta complex (Whiteman, 1980).

The present day late Pleistocene deposits sit on top of a great pile of mainly deltaic sediments which have accumulated since late Cretaceous time within the structural constraints defined basically by a complex triple junction system.

3. Objective

The aim of the project is to utilize Spectral analysis to identify the range of signal frequencies contained in the seismic data of different shots of explosive energy source with varying charge-sizes, and shot depths at various locations of this part of eastern mid-west of Niger Delta.

4. Methodology

Spectral analysis was conducted on experimental dynamite shots employing two different ways on each of the shots. The first approach was done using a 3second window on a receiver line for all the shots. It was also conducted using the same selected windows having the same group of traces and time ranges. For good comparison, selected windows were limited to regions of high S/N ratio, avoiding ground rolls, first breaks and noisy traces.

5. Analysis of Results and Discussion

Sample spectral analysis showed the signal strength amplitude dimensions, and the frequency range of 0 to 50Hz which lies within the limits of acceptable good seismic frequency, as in figures 1 and 2. At duplication of charge size, as in figure 3, there was improvement of quality even when the same depth was maintained. On the spectral analysis, the signal strength starts at -72db and peaks at -51db, with a frequency range of 0 - 48Hz at detonation. Typical recorded seismic frequencies are in the range of 5 to 100 hertz. Reflection events on the monitor record were the best of all the samples in strength and amplitude. The signal strength was the strongest.

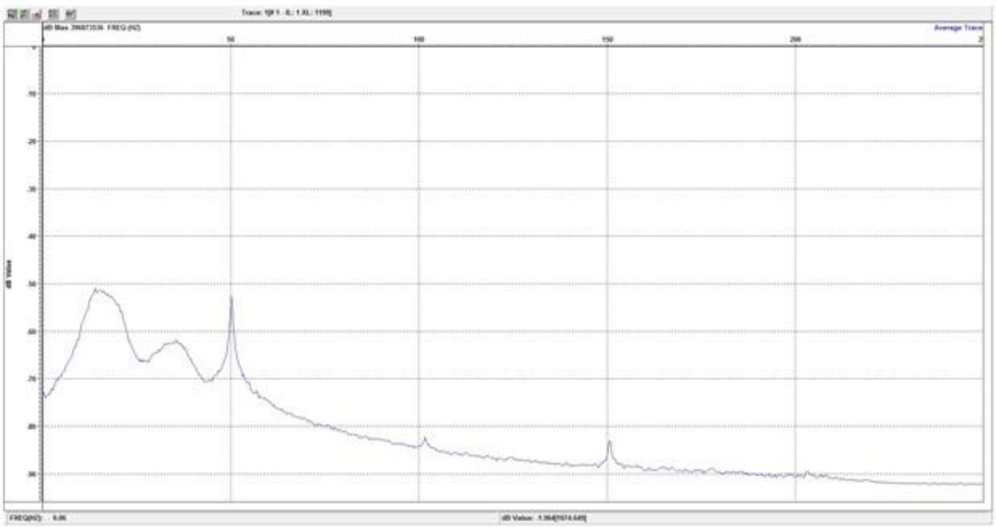

Figure 1: Showing trend at compliance to shot depth Specification 4m, 5 holes pattern all at 4m depth, frequency bandwidth as the width of peak frequency, and tapers to minimum frequency, with gentle slope table surface.
Sample Record Analysis of FFID 1720, Shot Point 1560/5562
("Sample" Pattern: 5 X 4m Dynamite Charge: 5 x 400g = 2kg

Spectral Analysis of SP 1560/5562 on RL 5564 (0 – 3 SECS)
Charge Size: 2KG, Old Type Dynamite
Depth: 4M Average, 5 Holes Pattern.

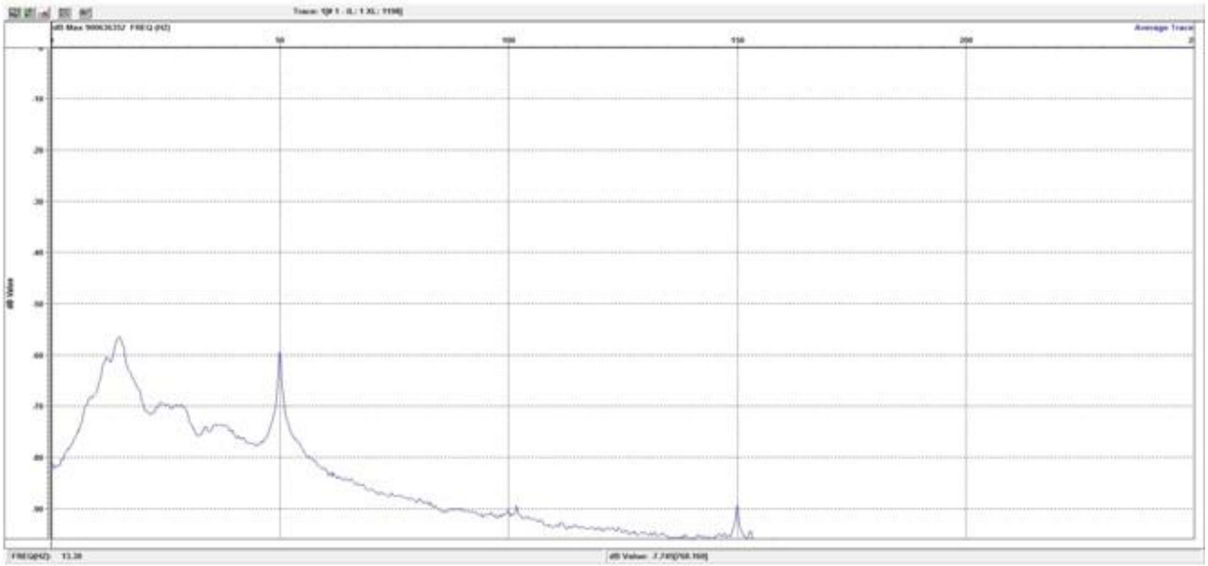

Figure 2: Showing deviation from Spec. Depth 4m pattern at 2.2m, frequency bandwidth reduced to lesser width of peak , and tapers to zero frequency.

Sample Record Analysis of FFID 1717, Shot Point 1560/5565.
Pattern: 5 X 4m Dynamite Charge: 5 x 400g = 2kg
Spectral Analysis OF SP 1560/5562 on RL 5564 (0 – 3 SECS)
Charge Size: 2KG, New Type Dynamite
Depth: 2.2M Average, 5 Holes Pattern.

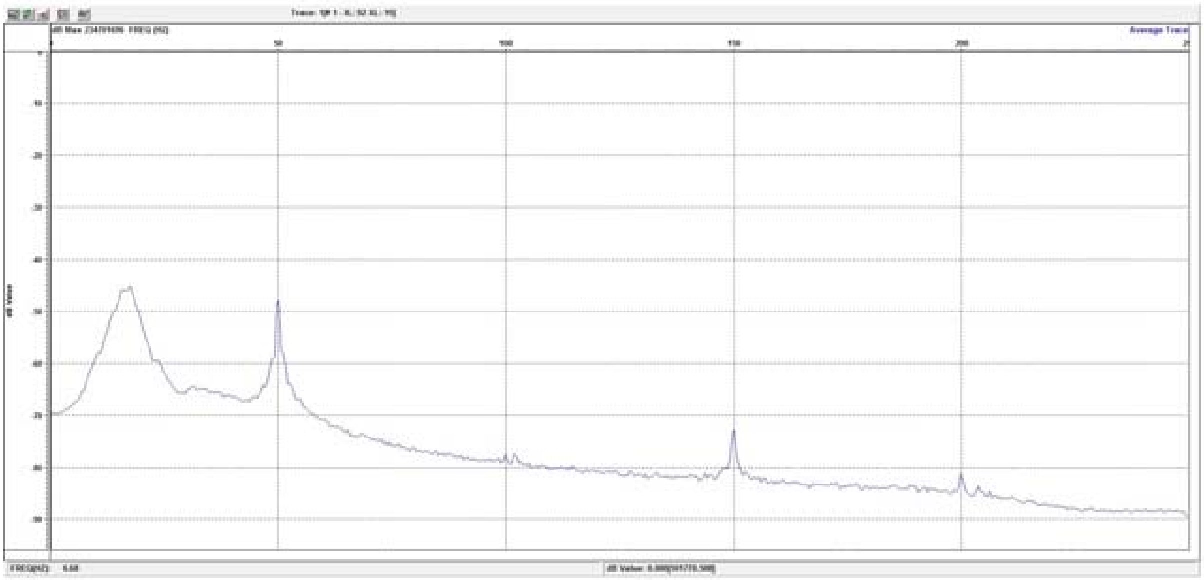

Figure 3: Showing deviation from Stipulated depth 4m for 5holes pattern at 2.9m, frequency bandwidth reduced to lesser width of peak , and tapers to zero frequency.

Sample Record Analysis of FFID 1714, Shot Point 1560/5566
Pattern: 5 X 4m Dynamite Charge: 5 x 800g = 4kg
Spectral Analysis OF SP 1560/5562 ON RL 5564 (0 – 3 SECS)
Charge Size: 4KG, Depth: 2.9M Average, 5 Holes Pattern

Up to figure 4, the Spectral Analysis display showed the signal strength starts at -73db and peaks at -51db with a frequency range of 0- 47Hz at detonation. Typical recorded seismic frequencies are in the range of 5 to 100 Hertz. Reflection events on the monitor record were very good in strength and amplitude. However, figures 5 to 7 showed truncation of signal frequency bandwidth due to weakness of shots associated with defective shot depth and bad quality of dynamite source.

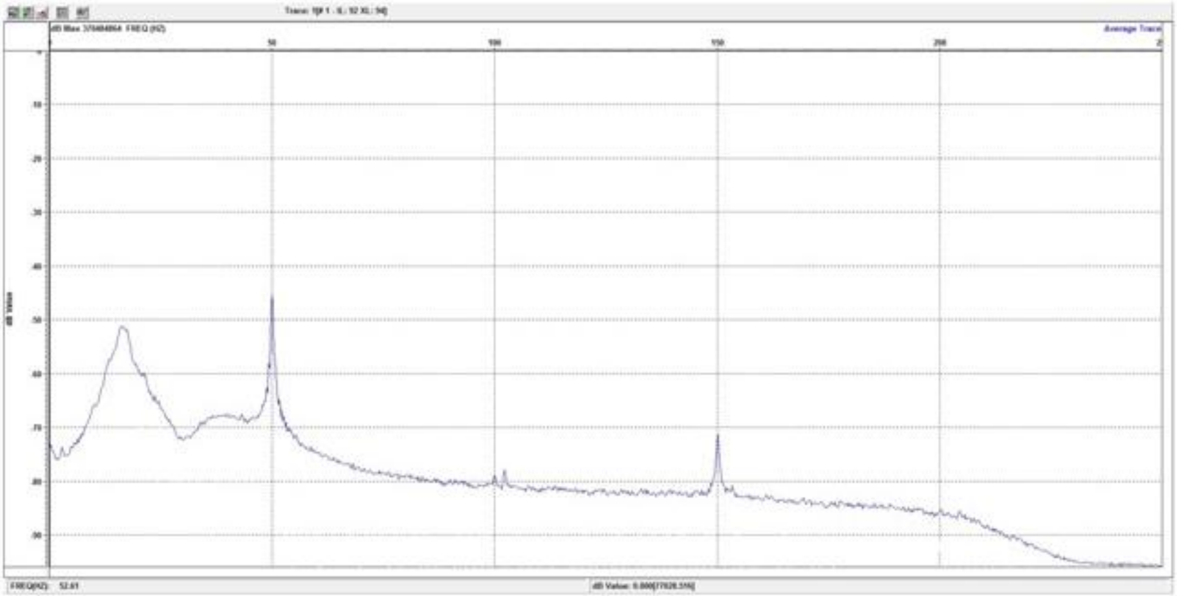

Figure 4: Signal frequency content trended good and bandwidth of peak frequency at Specification depth 4m, 5 holes pattern (all at 4m depth), showing good quality frequency bandwidth 0 to 48Hz peak upon detonation, and tapers to gentle slope table surface.
Sample Record Analysis of FFID, Shot Point 1470/5526.
Pattern: 5 X 4m, Dynamite Charge: 5 x 400g = 2kg
Spectral Analysis OF SP 1470/5526 ON RL 5564 (0 – 3 SECS)
Charge Size: 4KG, Dynamite
Depth: 4.0M Average, 5 Holes Pattern. Production Shot 2

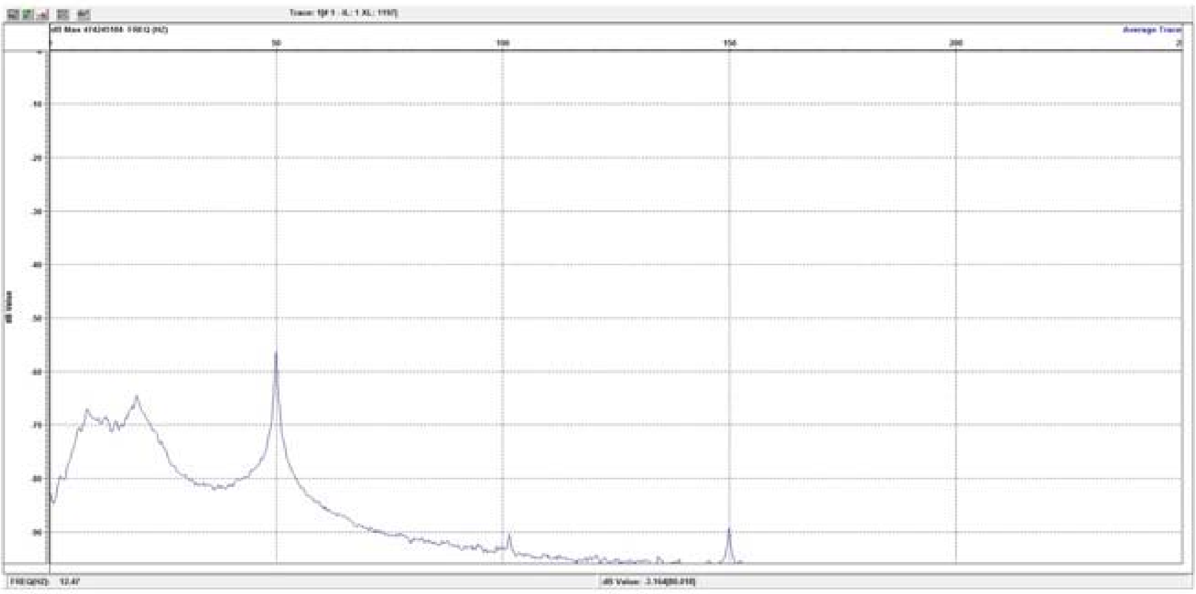

Figure 5: Truncated bandwidth of signal frequency due to weakness of shot. Status: Rejected.
Sample Record Analysis of FFID, Shot Point 1560/5574.
Weak cancelled shot.
Pattern: Unknown, Dynamite Charge: 5 x 400g = 2kg
Spectral Analysis of SP 1560/5526 ON RL 5564 (0 – 3 SECS)
Charge Size: 4KG, New Type Dynamite
Depth: 4M Average, 5 Holes Pattern. Cancelled As Weak

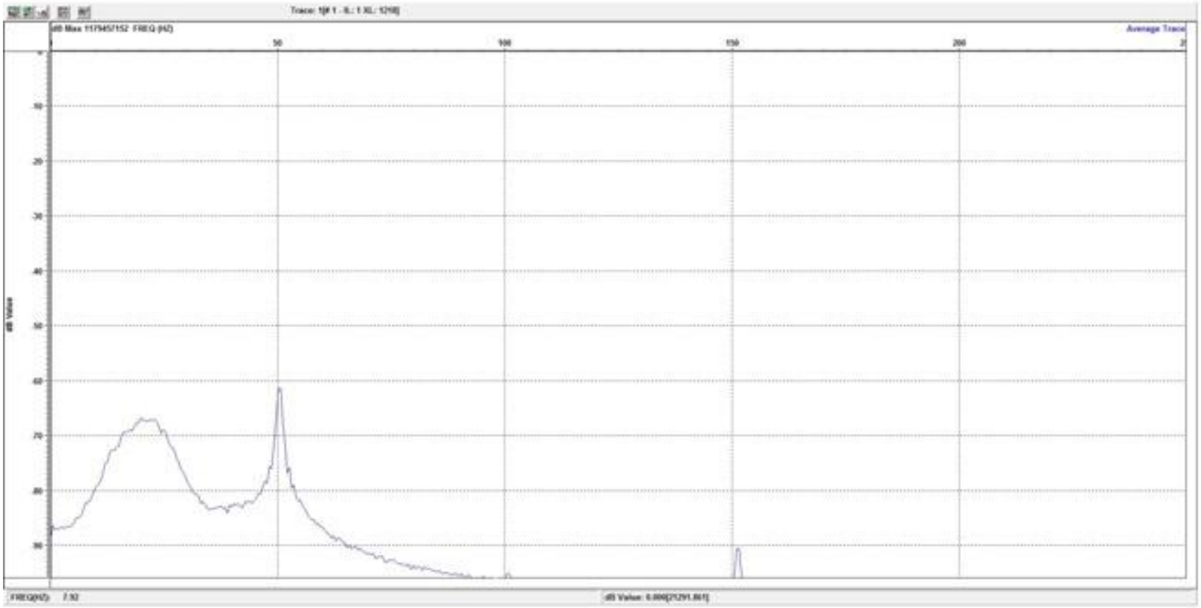

Figure 6: Truncated signal frequency bandwidth due to weakness of shot. Status: Rejected.
Sample Record Analysis OF FFID, Shot Point 1515/5497.
Cancelled weak shot, attributed to deviation from Specified shot depth
Pattern: Unknown, Dynamite Charge:5 x 400g = 2kg
Spectral Analysis OF SP 1515/5497 ON RL 5564 (0 – 3 SECS)
Charge Size: 2KG, Dynamite
Depth: 4.0M Average, 5 Holes Pattern.Cancelled Weak Shot 1

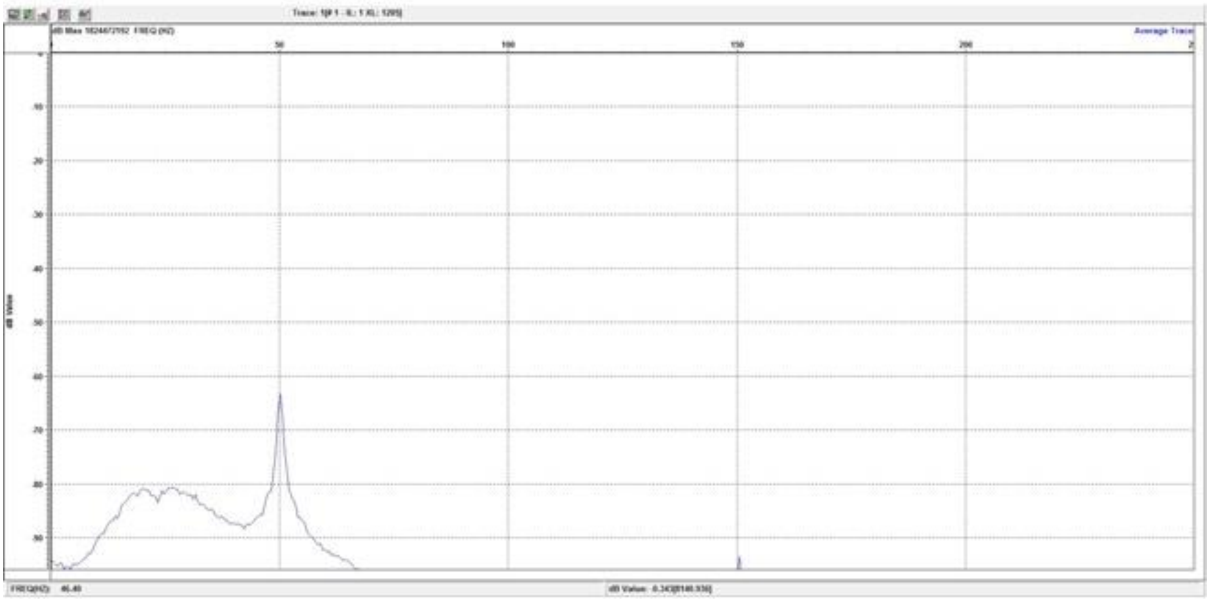

Figure 7: Truncated signal frequency bandwidth due to weakness of shot. Status: Rejected.
Sample Record Analysis OF FFID, Shot Point 1515/5520.
Pattern: 5 X 4m, Dynamite Charge: 5 x 400g = 2kg
Spectral Analysis OF SP 1515/5520 ON RL 5564 (0 – 3 SECS)
Charge Size: 2KG, Dynamite
Depth: 4.0m Average, 5 Holes Pattern. Cancelled Weak Shot 2

Non-uniform shot depths due to differential holes collapse (1 or 2 out of 5), yielded averagely good quality: When the modal class of shot holes were of optimal specification depths, the effect of the collapsed holes translated to minimal negatively impact on the signal frequency bandwidth, as evident on figure 8. A brute stack which was generated from shots of optimal depths or specified depths without erroneous contribution of defective shots showed strong reflections, as evident on figure 9.

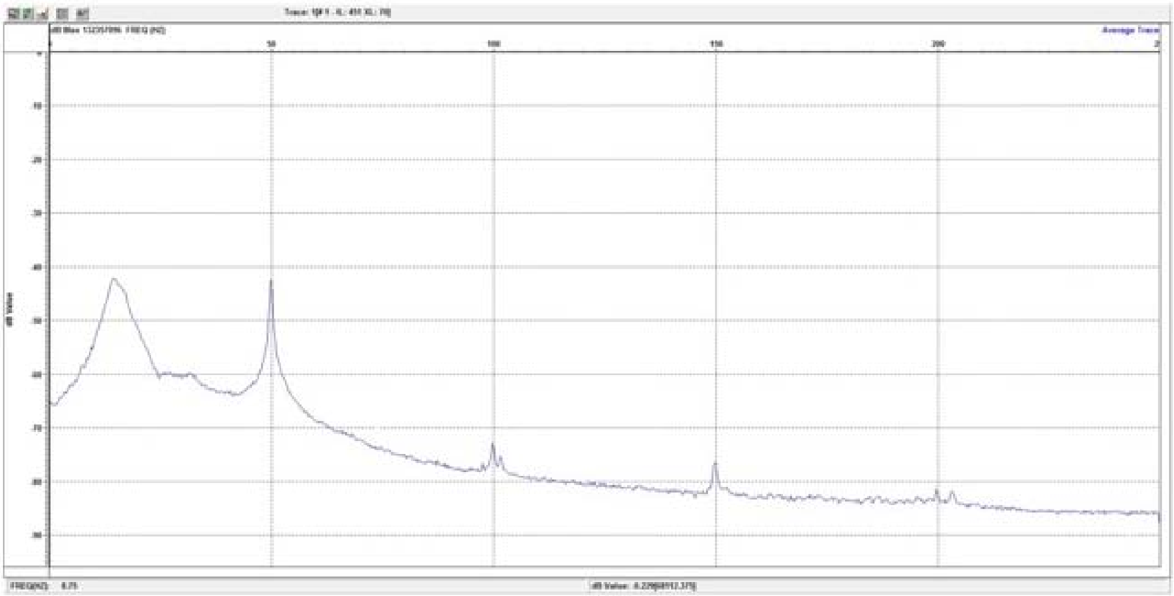

Figure 8: Showing trend at Specification Depth 4m, 5 holes pattern all at 4m depth, frequency bandwidth width of peak, and tapers to good frequency, of gentle table surface.
Sample Record Analysis of FFID, Shot point 1545/5552.
Pattern: 5 X 2.6m, Dynamite Charge: 5 x 400g = 2kg
Spectral Analysis OF SP 1515/5520 ON RL 5564 (0 – 3 SECS)
Charge Size: 2KG, OLD TYPE DYNAMITE
Depth: 2.6M Average, 5 Holes Pattern. 1 Collapsing Hole

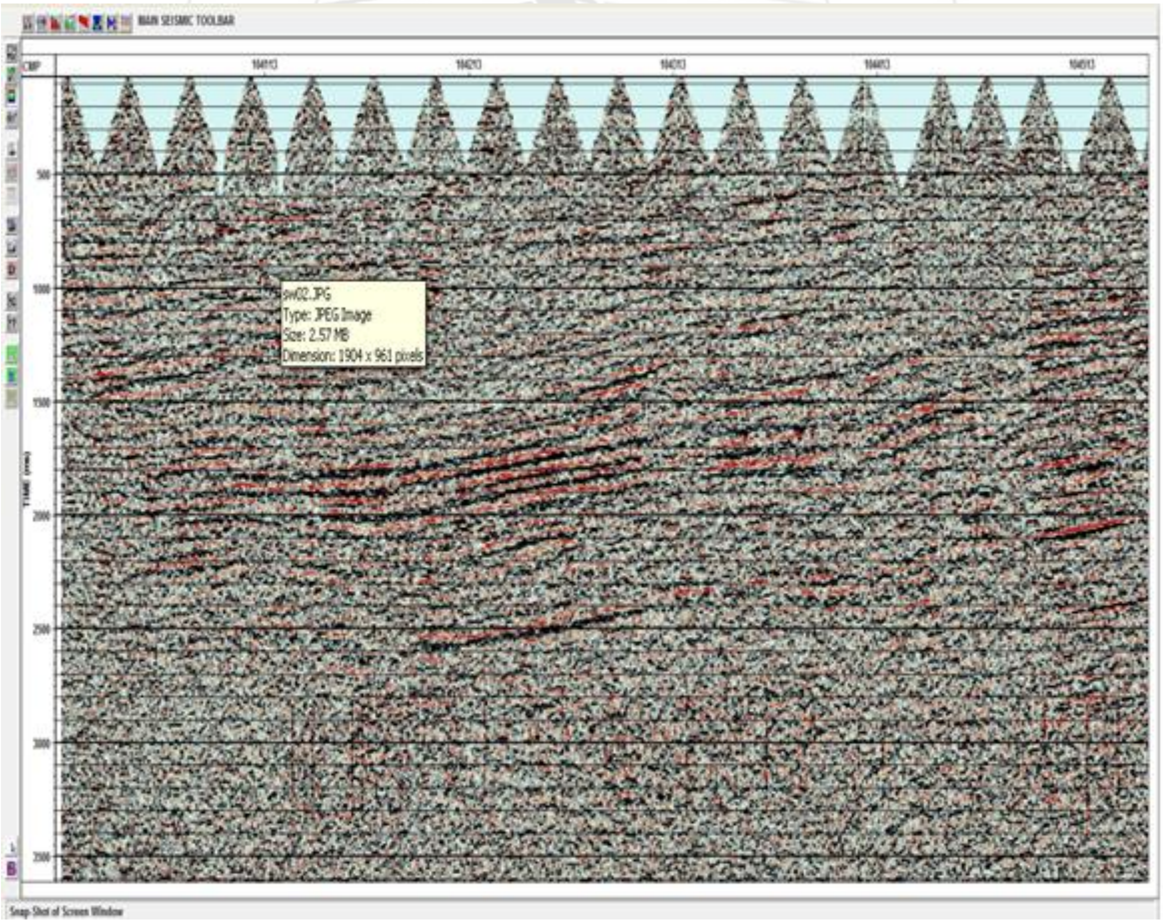

Figure 9: Brute stack from dynamite shot records, Shot depth 4m, 5 holes pattern compliant depth, Spectral Analysis, showing strong structural signatures of reflectors. (Courtesy of United Geophysical Company).

6. Conclusion

Spectral analysis of dynamite shots in the area showed strong signal strength with a frequency range up to 0 - 67Hz at detonation, except for defective shot depths or shallow patterns sources. At stipulated shot depths, recorded frequencies were in the range of 5Hz to 100 Hertz. Reflection events on the monitor record were fair-to-good in strength and amplitude. The Signal strength was strong for those shots acquired at the stipulated charge depth of 4m. Thus, optimal signal strength, associated with optimum frequency content can be obtainable at specification depth.

Experimental shots with quality controlled drilling, loading and tamping at 4 metres depth for the 2kg explosives charge size had good energy returns with optimal signal strength ranging from 0 to 67Hz. It was however strongest when the charge size was increased (or duplicated) from 2kg to 4kg. The 4kg explosive charge size had very good energy return but was not cost-effective in the production setting.

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