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Investigation Of The Influence Of Shear Wave Velocity Structure On The Generation Of Surface Wave Using Seismic Method.

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Abstract
Although the surface wave can serve a very useful purpose if adequately utilized to infer near surface information making use of the Multichannel Analysis of Surface Wave (MASW), it can also constitute serious menace to the entire body wave seismic data during acquisition and processing, if there is no deliberate plan to remove it during data acquisition. This research was carried out with the objective to examinehow shear wave velocity structure of rocks can influence the generation of surface wave. This will throw more light and facilitate the design of an effective means of getting rid of the menace of surfacewave at the level of data acquisition, when it is not needed forMASW analysis, which is the method used to generate shear wave velocity models for this research. The result has shown that the amplitude of the generated surface wave decreases as the shear wave velocity increases.The 3D surface has shown that the zones with lowest velocity structure generate the largestamount of surface wave, and vice versa. The result also revealed the amplitude of the surface wave increases as the shot offset decreases. It was therefore recommended that large amount of offset distance be used during seismic data acquisition in region with low shear wave velocity structure to reduce the menace of ground roll on seismic data.

***Keywords**: Shear wave, Surface wave, Velocity Structure, Amplitude, Seismic Method, MASW.*

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I. Introduction

In most surface seismic surveys when a compressional wave source is used, more than two-thirds of total seismic energy generated is imparted into Rayleigh waves (Richart et al., 1970). Although the surface wave can serve a very useful purpose if adequately utilized to infer near surface information making use of the Multichannel Analysis of Surface Wave (MASW), it can also constitute serious menace to the entire body waveseismic data during acquisition and processing, if there is no deliberate plan to remove it during data acquisition.

Robert 1994, describes a method used to characterize the regional azimuthalvariance of ground-roll for the vertical component of the Cold Lake 3-D seismic data set.

Carolyn, 2010 state that coherent noise such as ground roll can be measured at a specific velocity or suite of velocities. The noise can then be removed from the data based on velocity.

By virtue of the strong kinematic differences between reflections and ground roll, it is possible to estimate partial data reconstructions that model the ground roll component (Ken and Sacchi, 2011).This research was carried out with the aim of investigating, how shear wave velocity structure of rocks can influence the generation of surface wave. This will Elucidate and facilitate the design of an effective means of getting rid of the hazard of surface wave at the level of data acquisition, when it is not required for MASW analysis, which was used to generate the shear wavevelocity models of this research.

Location of the study area
The study area is Zaria, located within the basement complex of northern Nigeria. The study area (Fig. 1) is bounded by latitude 11° 13′ 52.37″N, longitude 7° 41′ 49.26″E and latitude 11° 06′ 16.72″N, longitude 7° 42′ 11.56″E, with average elevation of 650 m.

Geology of the area
The older granite outcrops in the vicinity of Zaria are exposures of a syntectonics to late-tectonic granite batholiths which intruded a crystalline gneissic basement during the Pan-African Orogeny. This batholith is a north-south oriented body, about 90 x 22 km, extending from Zaria southward to the vicinity of Kaduna.The Zaria granite batholith belong to a suite of syn and late tectonic granites and granodiorites that

marked the intrusive phase of the late Precambrian to early Palaeozoic Pan-African Orogeny in Nigeria (McCurry, 1973).

Fig 1: Location Map of the study area, image map adapted from Google earth

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[1] McCurry, P., 1973, *Geology of Degree Sheet 21, Zaria, Nigeria*. Overseas geol. Min. Res. 45.

Data Acquisition

Five seismic profiles were acquired for this research work using the principle of common Mid point (CMP) method. During the data acquisition the receivers where set at 1 m interval, with an offset ranging from 1 to 10 m. After each stack of 5 shots at a given shot position, the receiver closer to the shot was taken ahead of the other receivers and placed 1 m after the last receiver. The connections to the various receivers were swapped in the direction of increasing profile, and the shot was advanced 1 m forward. When all the connections were completed the shots were repeated and the generated seismogram was saved for onward processing. The process was repeated until the end of profile was reached. The recording parameter that was used for the survey is shown in Table 1.

Recording Parameter	
Source	Sledge Hammer
Receiver Type	Planted Vertical Geophone
Receiver Interval	1 m
Source Interval	1 m
Source Offset	1 to 10 m
Receiver spread length	23 m
Record Length	1 s
Sample Interval	0.25 ms

Table 1: Data Acquisition Parameters

Data Processing

The seismograms generated in the field were downloaded from the seismograph into the workstation where the data processing was carried out. The raw seismic data was imported into the processing software, where it was displayed in the amplitude traces after the initial Geometrical assignment to the dataset to give each trace a unique number. This was saved in the specified header fields of the dataset in the project database.The amplitude valuesof the sixth trace in each of profile, and the amplitude tracesof the first five shot gather were extracted from each of the five profiles for the purpose of analysis and comparison. The dispersion image (Fig 2), which is a plot of phase velocity versus frequency, was calculated for respective shot gather in the current dataset. The dispersion image was calculated using a velocity range of 0 to 500 m/s and a frequency range of 0 to 70 Hz. The fundamental mode was selected in the neighborhood of the higher mode and body wave. The dispersion curve was generated by selecting the maximum and minimum point of the fundamental mode.The $V_s$profiles were calculated using an iterative inversion process that involved initial input of poison's ratio and density. At the end of the inversion process 2D V_s velocity model was generated displayed in station number distance along the surface and depth within the subsurface.The velocities values were extracted from each profile, at the beginning, midpoint and at the end of each profile as shown in table 2. The extracted velocity values were contoured into a 3D surface, using the profiles Global Positioning System (GPS) co-ordinates, for ease of visualization of velocities distribution in the survey area.

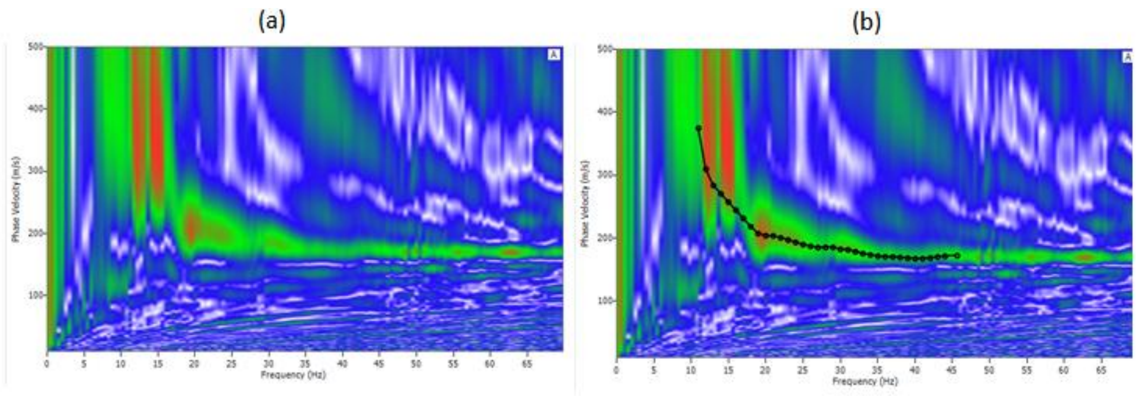

Figure 2: (a)The generated dispersion image of a shot point (b) Extracted Dispersion

II. Results And Discussion

Qualitative examination of the wiggle amplitude traces shown in figure 3 to 7, showed that, the amplitude of the traces decreased from profile 1 to profile 5. The largest amplitude was recorded in profile 1, while the least amplitude was recorded in profile 5. Figure 8 to 12 shows the Vs model of the five profiles. The Vs model represents the distribution of shear wave velocity within the subsurface. The velocity values from the model can be obtained by making reference to the coloured scale bar attached by the side of the models. The Vsmodels show a general increase of velocity with depth. The models shear wave velocities ranges from a minimum of 200 m/s in profile 1 to a maximum of 4000 m/s in profile 5.

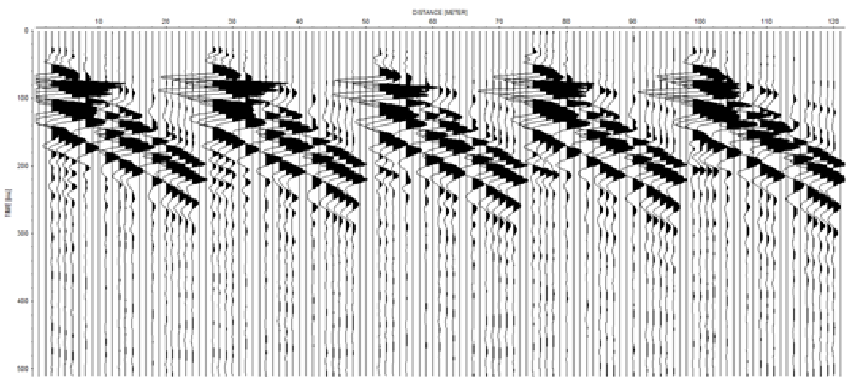

Figure 3: Amplitude traces of the first five shot gather for profile 1

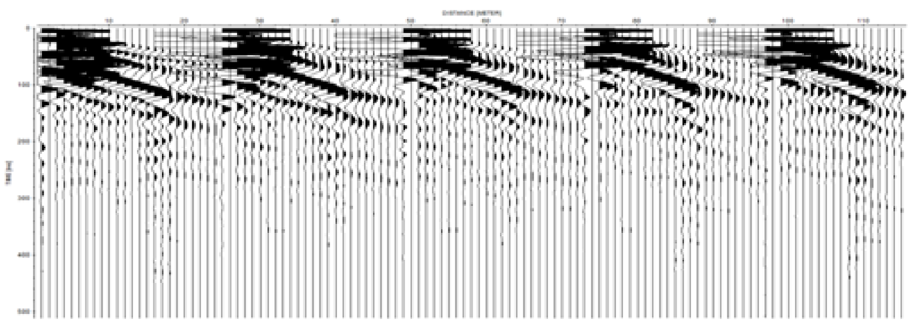

Figure 4: Amplitude traces of the first five shot gather for profile 2

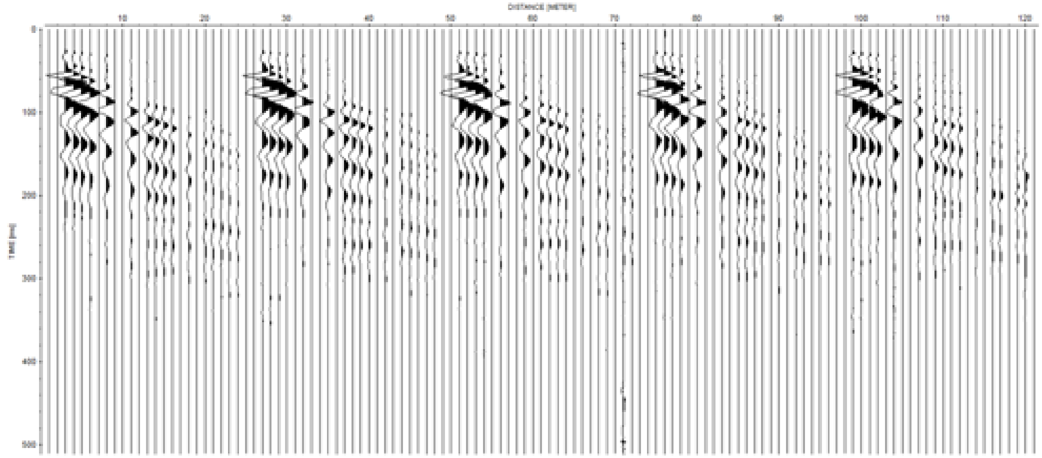

Figure 5: Amplitude traces of the first five shot gather for profile 3

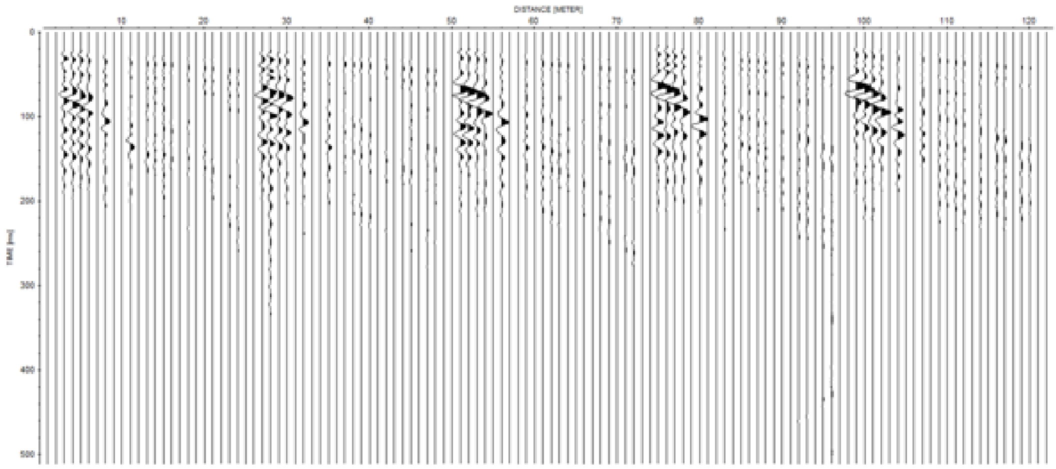

Figure 6: Amplitude traces of the first five shot gather for profile 4

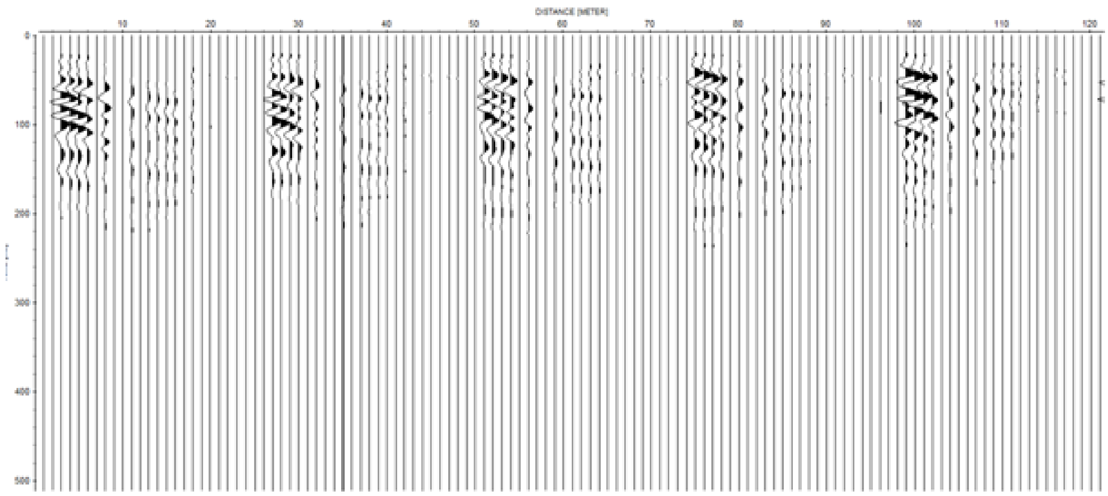

Figure 7: Amplitude traces of the first five shot gather for profile 5

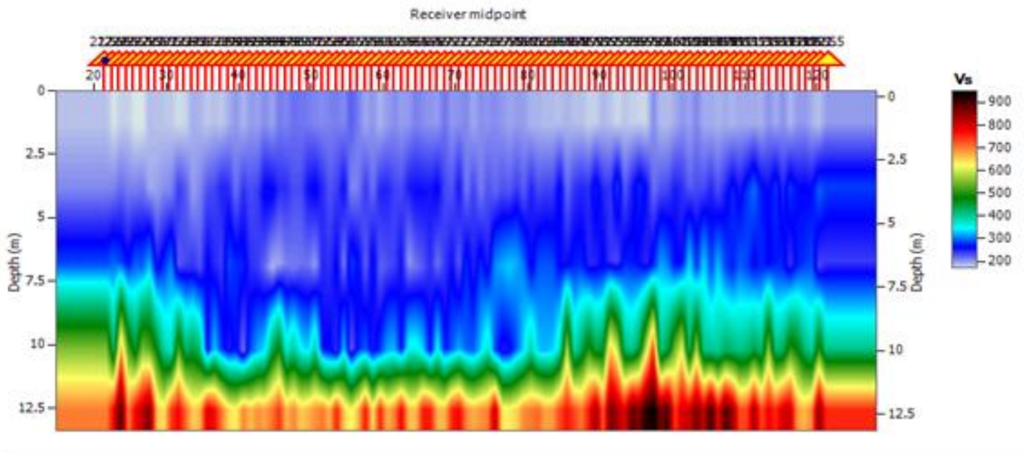

Figure 8: Vs model of profile 1, showing the distribution of shear wave velocity

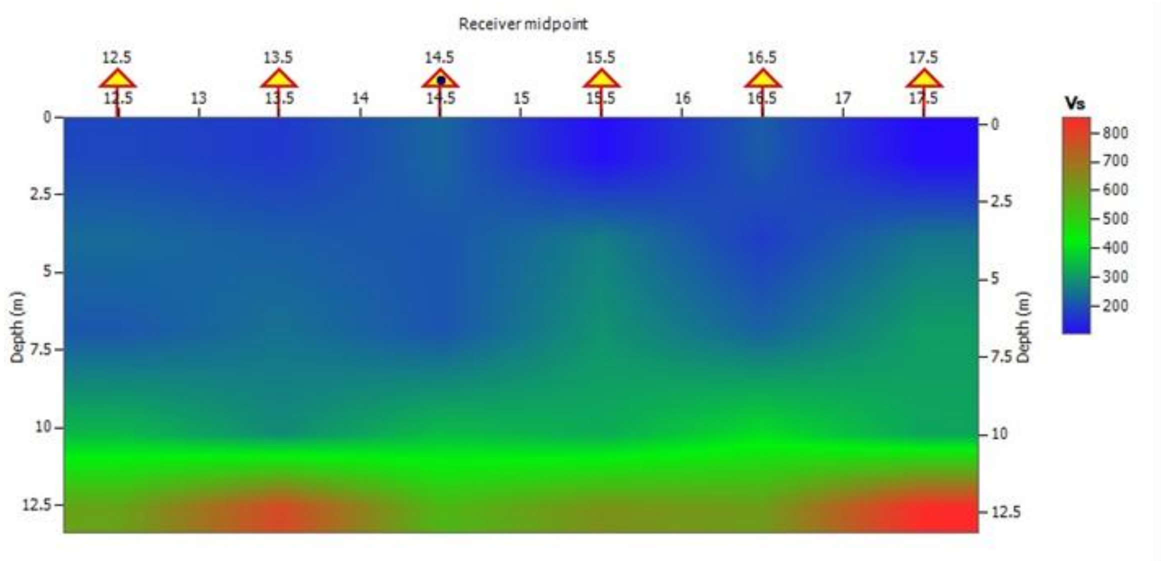

Figure 9: Vs model of profile 2, showing the distribution of shear wave velocity

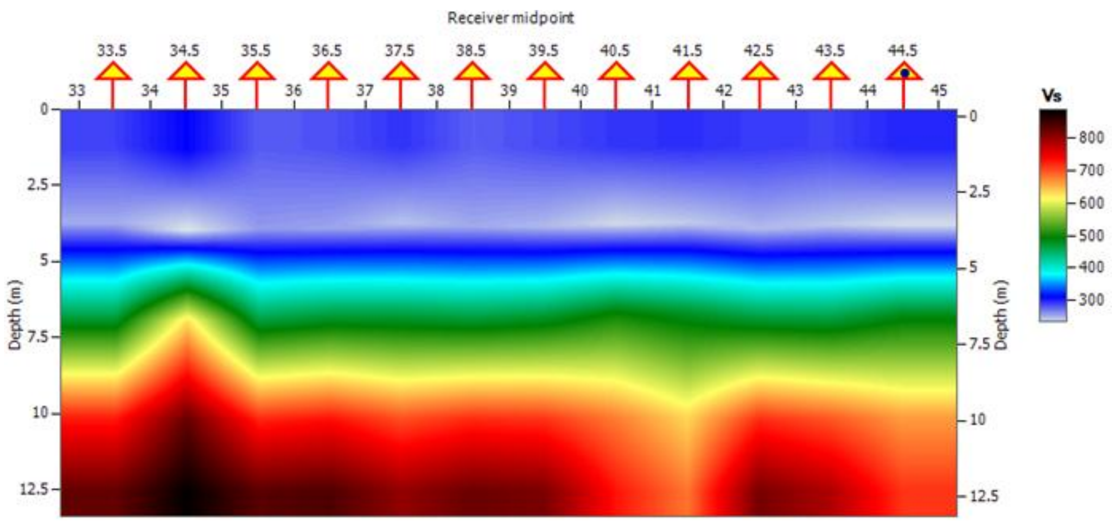

Figure 10: Vs model of profile 3, showing the distribution of shear wave velocity

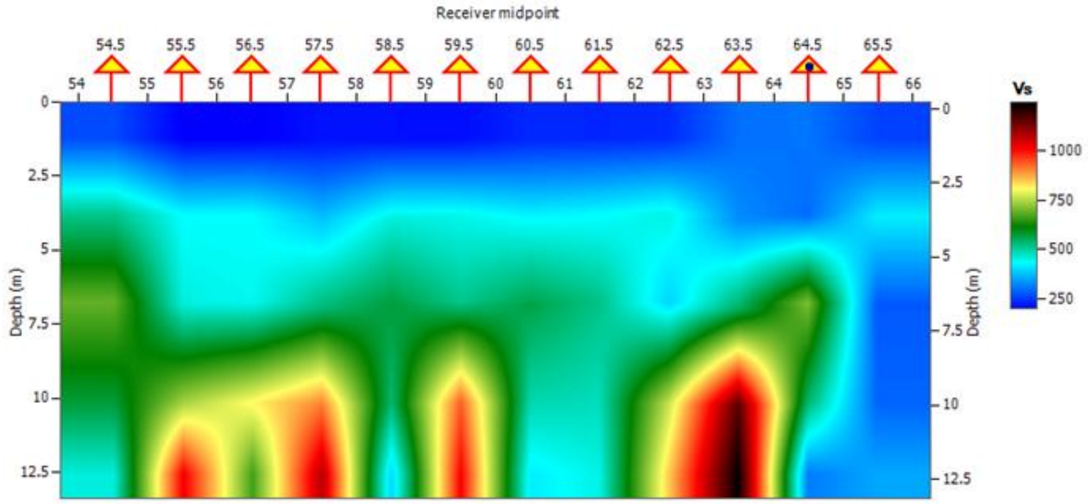

Figure 11: Vs model of profile 4, showing the distribution of shear wave velocity

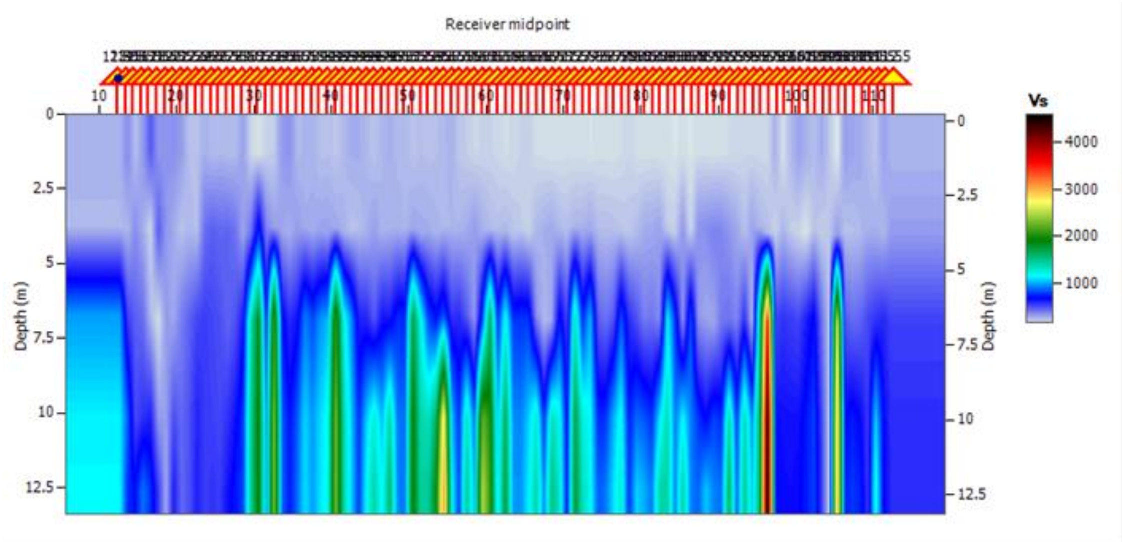

Figure 12: Vs model of profile 5, showing the distribution of shear wave velocity

The average Shear wave velocity value extracted from each Molded Vsprofile, as shown in table 2, revealed that, the average shear wave velocityincreased from profile 1 to profile 5. And this stand as the first clueto the fact that amplitude of the traces reduces with increase in average shear wave velocity. To confirm this, the amplitudes of the sixth trace in each of the profiles were extracted, Table 3. The sixth trace was chosen because, it is relatively far from the shot, and therefore will not be affected so much by the shot impact. A plot of the amplitude value of the traces against the average shear wave velocity (Fig. 13) revealed that, the amplitude of the surface wave traces decreases as the shear wave velocity increases, and vice versa. The 3D surfaces (Fig. 14) generated from the extracted average shear wave and their GPS coordinates depict the distribution of shear wave velocity within the survey area. It confirm that, based on the velocity distribution, the profiles that generated the largest amplitude surface wave (Example Profile 1 and 2) were located in low velocity zone, while the profiles that generated the surface wave with the least amplitude e. g profile 5, were located in zone of high shear wave velocity.

Table 2: Extracted Vs values with their GPS coordinates

Profile	Longitude (Degrees)	Latitude (Degrees)	Station Positions where velocity was extracted (m)			Vs(m/s) Values at Station Positions			Average Vs (m/s) values
			Beginning	Mid Point	End	Beginning	Mid Point	End	
Profile 1	7.657517	11.13402	20	70	120	350	150	330	277
Profile 2	7.660417	11.15310	12.5	15	17.5	280	350	392	341
Profile 3	7.646033	10.97565	34	39	44	602	551	510	554
Profile 4	7.675083	11.17390	55	60	65	550	610	570	577
Profile 5	7.652367	11.08430	10	60	110	1000	1200	850	1017

Table 3: Extracted average Vs values and trace amplitude Values

Profile	Average Vs (m/s) values	Amplitude Values
Profile 1	277	23.19
Profile 2	341	19.05
Profile 3	554	6.42
Profile 4	577	2.5
Profile 5	1017	2.16

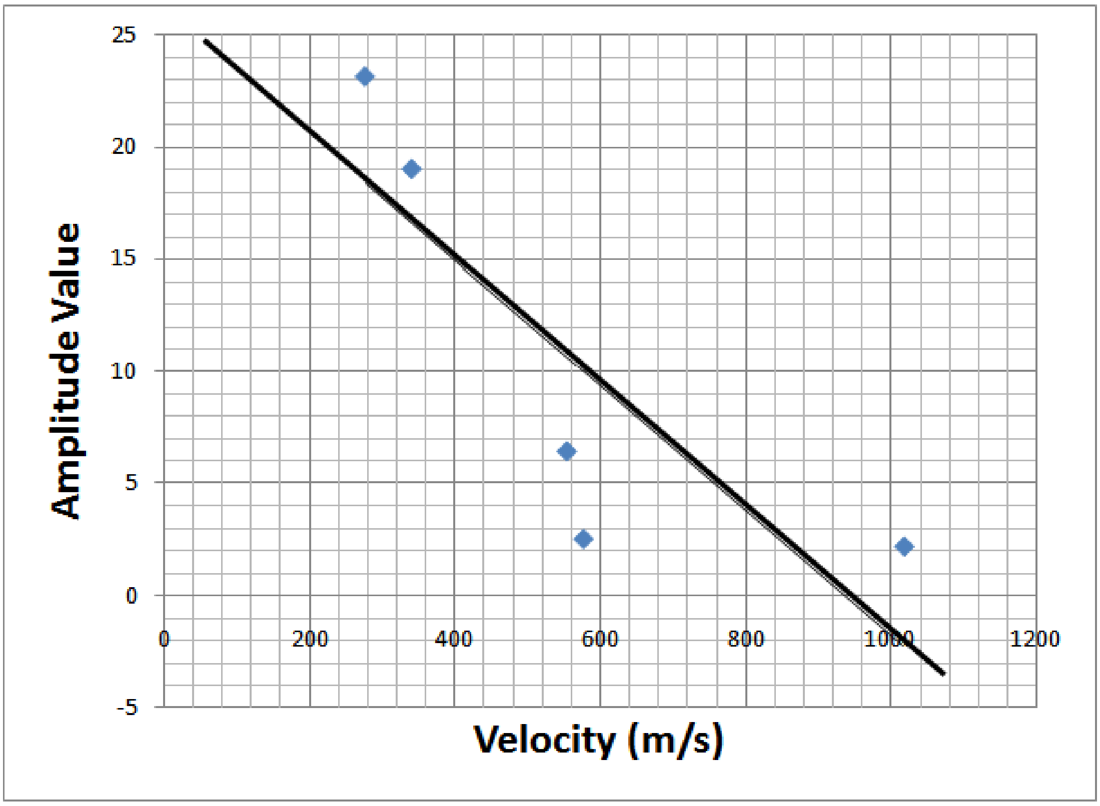

Figure 13: Plot of extracted average Vs values and trace amplitude Values

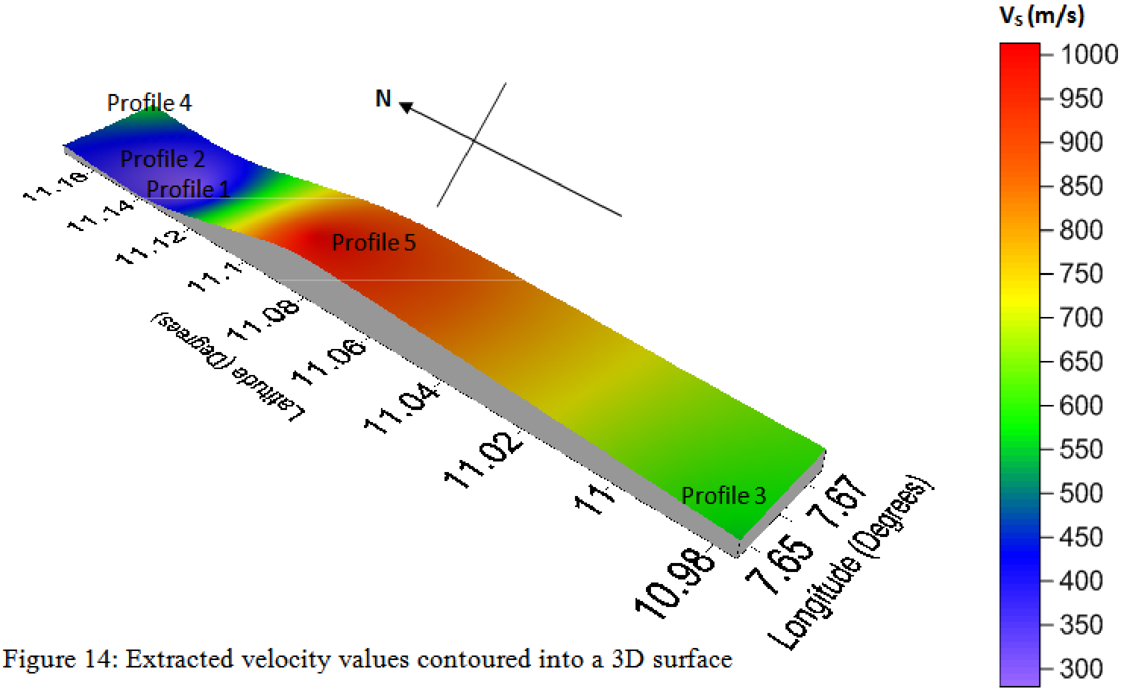

Figure 14: Extracted velocity values contoured into a 3D surface

To investigate how the amplitude varies with offset for a particular shot gather (single shot), the amplitude values of a particular shot gather with 24 traces (Fig. 15) were extracted, as shown in table 4. The amplitude values were plotted against the offset as shown in figure 16. The result revealed that there was a rapid drop in amplitude within the first six traces, and the amplitude of the remaining traces dropped exponentially afterward. This categorically implied that amplitude of the traces reduces with increase shot offset distance.

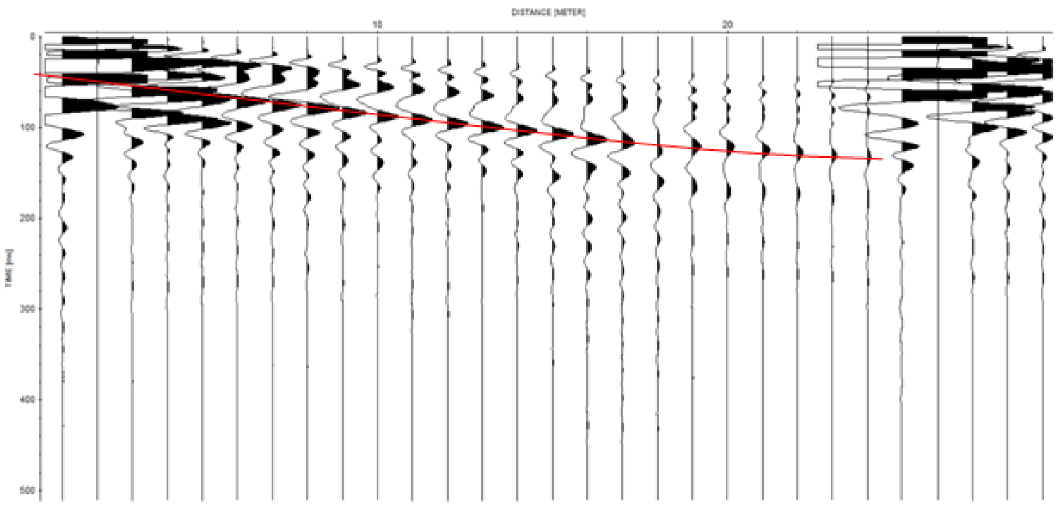

Figure15 : Shot gather of 24 amplitude Traces

Table 4: Extracted trace amplitude, with offset

Offset (m)	Amplitude Values
1	137.49
2	80.00
3	58.47
4	44.315
5	16.6
6	18.81
7	16.62
8	18.82
9	14.08
10	12.37
11	11.84
12	11.96
13	12.46
14	11.41
15	12.04
16	11.76
17	7.03
18	2.73
19	4.94
20	4.32
21	4.43
22	3.28
23	2.57
24	1.8

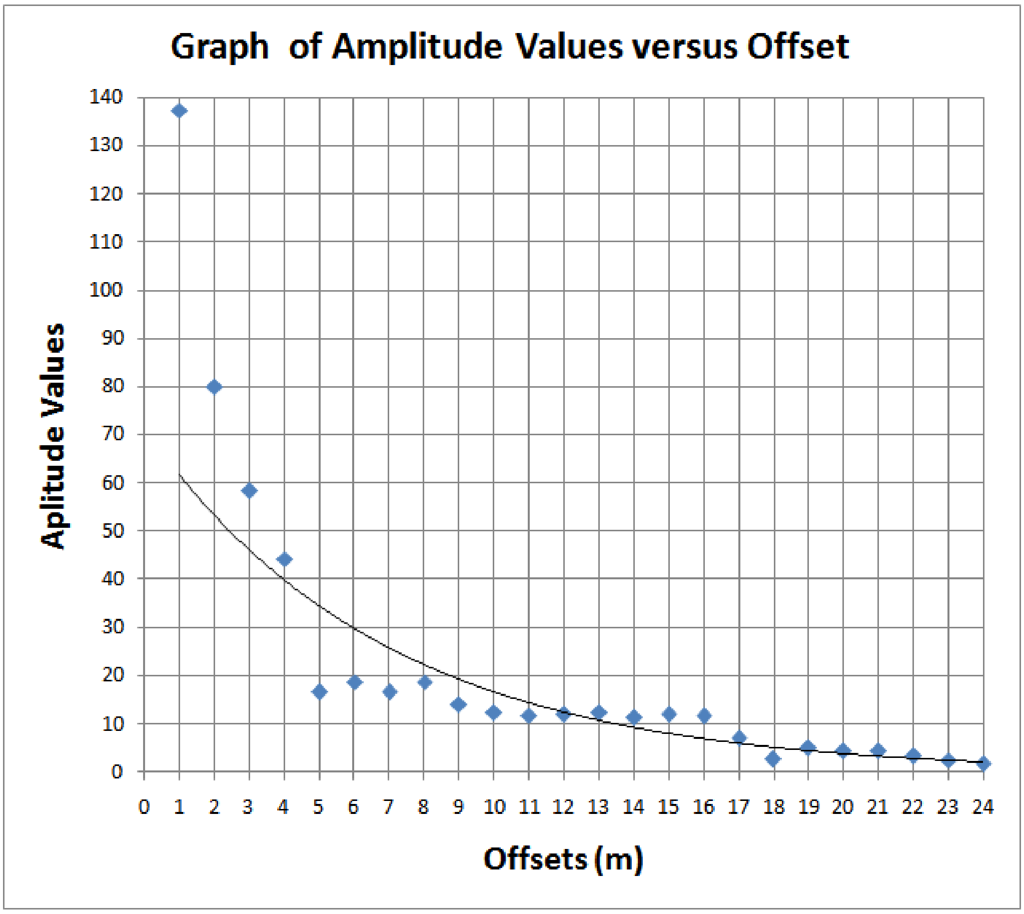

Figure 16: Plot of the trace amplitude within a shot against the offset

III. Conclusion

So far this research has brought out the fact that qualitative examination of the recorded amplitude in the various profiles, has shown that it decrease from the first profile down to the fifth profile. The shear wave velocities models,showed a general increase of velocity with depth. A plot of the traces amplitude against the shear wave velocity has confirmed that the amplitude of the surface wave traces decreases as shear wave velocity increases. The 3D surface has show that the zone with the lowest velocity structure, generate the largest amplitude surface wave, and vice versa. It has also revealed the fact thatthat amplitude of the traces reduces with increase shot offset distance.

Based on these research findings, there is the likely-hood that areas with very low shear wave velocity will generate large amount of surface wave with high amplitude that could mask the vital information in recorded seismic data. Therefore, it is recommended that large amount of offset distance should be employed during data acquisition in regions where the shear wave velocity is low, to get rid of the menace of the surface which could otherwise mar the entire seismic data. This will therefore require initial reconnaissance test to ascertain the shear wave velocity structure in a given zone, before the main field work is embarked upon.

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