Geosciences 2020, 10(1): 1-9
DOI: 10.5923/j.geo.20201001.01

Comparative Analyses of Uphole and Seismic Refraction Techniques in Near-Surface Attributes Delineation: A Case Study of North-Central Niger Delta

G. I. Alaminiokuma

Department of Earth Sciences, Federal University of Petroleum Resources Effurun, Effurun, Nigeria

Abstract Uphole and seismic refraction techniques used for the delineation of near-surface attributes in the North-Central Niger Delta were comparatively analyzed in order to provide proper guide on the viable technique(s) to meet exploration objectives. Different field parameters and data were considered and statistically compared. Results reveal that the uphole technique is cost-intensive, requires many crew men, time-intensive, limited in areal coverage, delivers small quantity of data in a long period and provides information for mapping hidden and thin layers while the seismic refraction technique is cost-effective, requires few crew men, time-efficient, extensive in areal coverage, delivers large quantity of data within a short period and effectively resolves dipping layers. Statistical computations reveal that the uphole technique has low Coefficient of Variations (CVs) for thicknesses: Z_1 (33.70%) and Z_2 (57.07%) while seismic refraction technique has high CVs: Z_1 (37.96%) and Z_2 (84.66%). The low CVs for Z_1 and Z_2 implies low dispersion and precise estimation of the thicknesses. Conversely, seismic refraction technique has low CVs for velocities: V_0 (14.5%), V_1 (12.44%) and V_c (1.93%) while the uphole technique has high CVs: V_0 (49.25%), V_1 (61.71%) and V_c (12.27%). The low CVs for velocities imply low dispersion and good estimation by seismic refraction technique while the high CVs by the uphole technique imply high dispersion and high estimation of velocities. These results suggest that uphole technique provides the most direct measure of the thickness of near-surface layer while seismic refraction technique resolves velocity better around the mean value. Therefore, where resources are favourable, both techniques should be deployed in the same prospect to accurately delineate the near-surface attributes.

Keywords Uphole, Seismic Refraction, First-Breaks, Velocity, Thickness, Coefficient of Variation, Near-surface, Niger Delta

1. Introduction

The exploration for hydrocarbon, solid minerals and the delineation of bedrock for geotechnical engineering significantly depend on the proper description of the near-surface and its attributes such as thickness, velocity, acoustic impedance, absorption coefficient and nature of lithology. This description can be conducted mainly by downhole detectors spread (uphole survey) or surface detectors spread (seismic refraction survey).

The particular technique to be chosen by the seismologist may depend on several factors among which are: volume of information required, areal coverage, quality of data acquired, cost and duration of acquisition among others. A technique may be capital intensive yet delivers good quality data while another may be capital effective yet delivers poor quality data and vice versa. Therefore, the choice of a technique based mainly on one of the above-mentioned factors may not suffice.

Several studies have been conducted using the uphole/downhole and seismic refraction methods to determine the near-surface/weathered low velocity layer (LVL) characteristics in different parts of the Niger Delta Basin. A summary of some of these previous studies are given in Table 1. A Comparative analysis to reveal the advantages and disadvantages of employing these two main techniques for the delineation of near-surface attributes is very necessary considering their importance on seismic and structural information in 3D/4D reflection survey for oil and gas exploration.

Consequently, this research is an attempt at investigating the near-surface layer in the North-Central Niger Delta to establish the most appropriate technique to deploy. In accomplishing this, various uphole and seismic refraction surveys field parameters and data acquired in the same

* Corresponding author:
alaminiokuma.godswill@fupre.edu.ng (G. I. Alaminiokuma)
Published online at http://journal.sapub.org/geo

prospect have been analyzed and interpreted to produce the thickness(es) and velocities of the weathered layer(s). This has the advantage of effectively and accurately providing the near-surface information essential in choosing the suitable technique by the seismologist.

2. Location of the Study Area

The area of study is the Niger Delta sedimentary Basin (Figure 1). It is situated on the Continental margin of the Gulf of Guinea in Equatorial West Africa between Latitudes 3° N and 6° N and Longitude 5° E and 8° E. The study area is located in the North-Central part of the Niger Delta Basin (Figure 1) and it covers about 468.5 and 313.16 km^2 of surface and subsurface areas respectively. It is delimited by Latitude 05° 00" 0' and 05° 30" 0’ and longitude 06° 10" 0' and 07° 10" 0' [13].

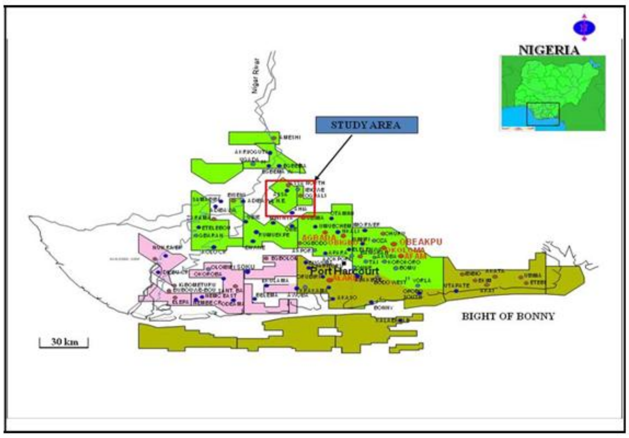

Figure 1. Map showing the Study Area

3. Methodology

The uphole and seismic refraction surveys were conducted within the same 4D seismic prospect in the North-Central onshore Niger Delta on a grid of 4 x 4.km^2 (Figure 2). Data for 30 upholes were acquired in order to cover the entire prospect while data for 6 forward and reverse seismic refraction shooting schemes (lines) were acquired at intervals that allowed for a complete coverage of the prospect since they are laterally extensive. The various field acquisition parameters considered in this work are shown in Table 2.

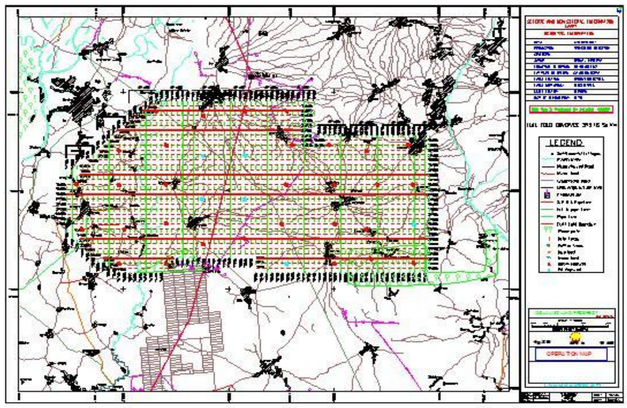

Figure 2. Uphole and Seismic Refraction Surveys Location Map

Table 1. Previous Studies of the Near-surface/Weathered Layer in the Niger Delta

Researchers	Technique Used	Results, Observations
[1]	12 Uphole locations	Results reveal a weathered layer that is thickest in the NW, E and SE with an average of 4.2 m and thinnest in the North-Central with a value of 3.8 m; a sub-weathered layer that is thickest in the NW and SW with an average of 32.1 m and thinnest in the SE with a value of 19.0 m and an underlying consolidated layer with great thickness.
[2]	21 Uphole locations	The weathered layer thicknesses and the velocities were found to range between 4.8m to 25.3m and 413ms^{-1} to 614ms-1 respectively. Several contour and analytical maps were generated for the weathered and consolidated area.
[3]	20 Uphole locations	Results of the study revealed that the velocity of the low velocity layer ranged between 144 and 996m/s with a regional average of 407m/s. The thickness of the low velocity layer varied between 3.0 and 9.6m with a mean value of 5.0m. Similarly, the velocity of the consolidated layer ranged between 1449 and 1812m/s with a mean value of 1738m/s. Results of the static correction carried out on the seismic reflection data revealed a substantial improvement in the resolution of the data after static correction.
[4]	16 surface-laid-geophones and 14 downhole-laid-hydrophones	Results showed a substantial variation of the weathered layer thickness and elevation in the two study areas. In the Upper Flood Plain, LVL thickness varies between 2.8 m and 40 m with an average of 21.46 m. In the Mangrove Swamp, the thickness varies between 2.0 m and 5.5 m with an average of 3.40 m. The weathered layer thickness in the Mangrove Swamp is fairly uniform having an average of 3.4 m. This highly variable LVL thickness indicates the necessity of correcting for this layer during seismic reflection processing. A close study of the results reveals a thickening of the weathered layer northwards accompanying the increase in elevation. Elevations in Upper Flood Plain vary between 3.4 m and 156 m with average of 69.90 m; the elevations in Mangrove Swamp vary between-0.10 m (sub-sea) and 0.4 m with an average -0.0043 m implying that the topography of the Mangrove Swampy area is highly variable and undulated. The weathered layer velocity in the Upper flood Plain varies between 313.67 ms^{-1} and 984 ms^{-1} with average of 438.80 ms^{-1}. In the Mangrove Swamp, weathered layer velocity varies between 294.5 ms^{-1} and 863 ms^{-1} with average of 524.10 ms^{-1}. The average velocities of the underlying consolidate layer in the Upper Flood

Researchers	Technique Used	Results, Observations
		and Mangrove Swamp are 1753.28 ms^{-1} and 1603.51 ms^{-1} respectively depicting a general increase in the velocity with amount of consolidation of the bedrock in the two area
[5]	21 uphole locations	The average thickness of the weathered layer to the top of the consolidated layer is 4.8m with an average velocity of 466m/s. The weathering thickness ranges from 2.9-8.9m and the velocity ranging from362m/s to 689m/s. The consolidated layer velocities ranges from 1642m/s to 1884m/s with an average of 1746m/s sufficient enough to support engineering structures.
[6]	14 downhole locations	Results show that the thickness of the weathered layer varies from 2.6 to 5.8m with an average of 4.3m. The weathered layer velocity ranges from 383 to 985 ms^{-1} with an average value of 546 ms^{-1}. The consolidated layer has a velocity ranging between 1646 and 1893 ms^{-1} with an average value of 1763 ms^{-1}
[7]	50 Seismic refraction survey locations	The thickness of the low velocity layer in the area varies from 3.6 to 46.2 m with a regional average of about 24.0 m. The weathered layer and the refractor beneath it were found to have average P-wave velocities of about 600.0 and 1842.0ms^{-1} respectively
[8]	29 LVL refraction lines and 1 uphole shot point	Results reveal an average regional thickness of 4.4m. The average weathered layer compressional wave velocity was about 525ms^{-1}. The underlying consolidated layer has an average velocity of about 1800 ms^{-1}
[9]	10 Uphole locations	Results reveal that the low velocity layer was fairly variable in thickness in the region between 24,0m and 29.0m with a regional average of 25.62m. The weathered and consolidated layers have average compressional wave velocities of 937.9ms^{-1} and 1862ms^{-1} respectively
[10]	61 LVL Refraction Survey locations	Results show that the weathered layer velocity ranges between 210 and 994 ms^{-1} with an average of 552 ms^{-1}, the sub-weathered layer velocity varies from 1358 and 2464 ms^{-1} with an average value of 1734 ms^{-1}. The thickness of the weathered layer varies from 2.8 to 52.8m with an average value of 19.3m
[11]	14 Uphole locations	Results show a variation in thickness of the LVL from 2.0 to 5.7 m with an average of 3.4 m. The velocity of the LVL ranges between 295 and 727 ms^{-1} with an average of 562.7 ms^{-1} while the velocity of the sub-weathered layer ranges between 1502 and 1918 ms^{-1} with an average of 1716 ms^{-1}
[12]	168 LVL Refraction Survey Data	Results show that the LVL thickness in this region is highly variable ranging between 2.9 and 45.5 m with a regional average of about 20.0 m. The weathered layer and the refractor beneath it have average compressional wave velocities of about 500 and 1732.0 ms^{-1} respectively

Table 2. Field Acquisition Parameters for Uphole and Seismic Refraction Surveys

FIELD ACQUISITION PARAMETERS	UPHOLE SURVEY	SEISMIC REFRACTION SURVEY
Number of Acquisition Points	Thirty (30) deep holes drilled to cover the entire prospect	Six (6) seismic lines laid out at specific intervals to cover the prospect
Field Layout/Geometry	63.0m Deep holes drilled at planned grid positions (intersections between source and receiver lines), cased with PVC and logged to maximum depth of 60.0m.	Surface detector spread with a total spread length of 70.0m comprising 6 shots: 3 forward shots and 3 reverse shots. Shots were recorded at 75.0m and 5.0m off each end of the spread with 2 additional shots both 210.0m off each end of the spread for deeper data
Acquisition Terrain	Conducted at locations where surface water existed and accessible by water truck for deep hole drilling	Conducted on dry land areas where water delivery by truck was impossible
Energy Type/size	0.2 kg of dynamite per shothole	5 to 10 energy caps per shothole
Source Depth	1.0m deep shothole drilled 2.0m away from the recording hole	1.0m deep shotholes drilled by thumping to bury charges
Receiver Type	Downhole cable with 11 hydrophones positioned at different intervals (Figure 3).	12 SM4, 10 Hz geophones laid on the surface but centered about the intersection (Figure 4)
Duration of Acquisition	It takes an average of 4 to 5 hours from setup to drilling one hole by the semi-manual, engine powered rotary method and another 1 to 2 hours from casing with PVC to logging the drilled hole. It took about 3 months to complete drilling and logging of the 30 upholes.	It takes an average of 1 hour from layout of the geophones and instruments to recording of signals. It took about 1 week to complete the acquisition of the 6 seismic refraction survey lines
Recording Instrument	Multichannel-channel seismograph OYO GEOSPACE MCSeis-160MxV5.42	Multichannel-channel seismograph OYO GEOSPACE MCSeis-160MxV5.42
No. of Personnel	1 seismologist, 6 uphole crew and 10 drillers	1 seismologist and 6 layout and pickup crew and 1 driller
Data Processing	By picking first-breaks with OYO Geospace Corporation Uphole data analysis software version 1.0b from the recorded traces	By picking first-breaks with OYO Geospace Corporation data analysis software version 1.0b from the recorded traces
Data Plotting	Time-Depth curves (Figure 5) were plotted with OYO Geospace Corporation Uphole data analysis software version 1.0b.	Time-Distance curves (Figure 6) were potted using a package that applies advance features of Microsoft Excel
Data Analyses	The various measured field data were analyzed and interpreted using the standard equations in Table 3	

Table 3. Equations for Uphole and Seismic Refraction Surveys Data Analyses

DATA ANALYSES PARAMETERS	UPHOLE SURVEY	SEISMIC REFRACTION SURVEY
	EQUATIONS	
Time-Depth/Offset Plots	[14] $T = \left(\frac{1}{V_i}\right) Z + T_c$ Equation (1) Where: i = 0, 1, 2…; Z = Depth(m); T_c = Intercept on the Vertical Axis (*ms*)	[15] $T = \frac{X}{V_1} + \frac{2Z\sqrt{V_1{}^2 - V_0{}^2}}{V_1 V_0}$ Equation (2) Where: T= Time(*ms*); X= Distance (m); V_0 = First Layer Velocity(ms^{-1}); V_1 = Second Layer Velocity(ms^{-1})
Computation of Velocities	$Velocity, V_i = \frac{\Delta Z}{\Delta T}$ Equation (3)	$Velocity, V_i = \frac{\Delta X}{\Delta T}$ Equation (4)
Determination of Layer Thicknesses	The thicknesses of the layers were simply determined by extrapolating from the point of intersection (knee) of the curves to the depth axis	[16] $Z = \frac{T_i}{2} \frac{V_0 V_1}{\sqrt{\left(V_1^2 - V_0^2\right)}} + \frac{D_s}{2}$ Equation (5) $Z_1 = \left[\frac{t_2 {}^{-2Z}{}_0 \sqrt{(V_c^2 - V_0^2)}}{V_c V_0}\right]\left[\frac{V_c V_1}{2\sqrt{(V_c^2 - V_1^2)}}\right]$ Equation (6) Where: D_s = Shot Depth(m); Z_0 = First Layer Depth(m); Z_1 = Second Layer Depth(m); V_c = Consolidated Layer Velocity((ms^{-1})
Assumptions	Some assumptions were made by both techniques in the application of equations (1) to (6): Horizontally flat layers Homogeneous and isotropic medium Straight ray and wave paths Velocity increases with depth	

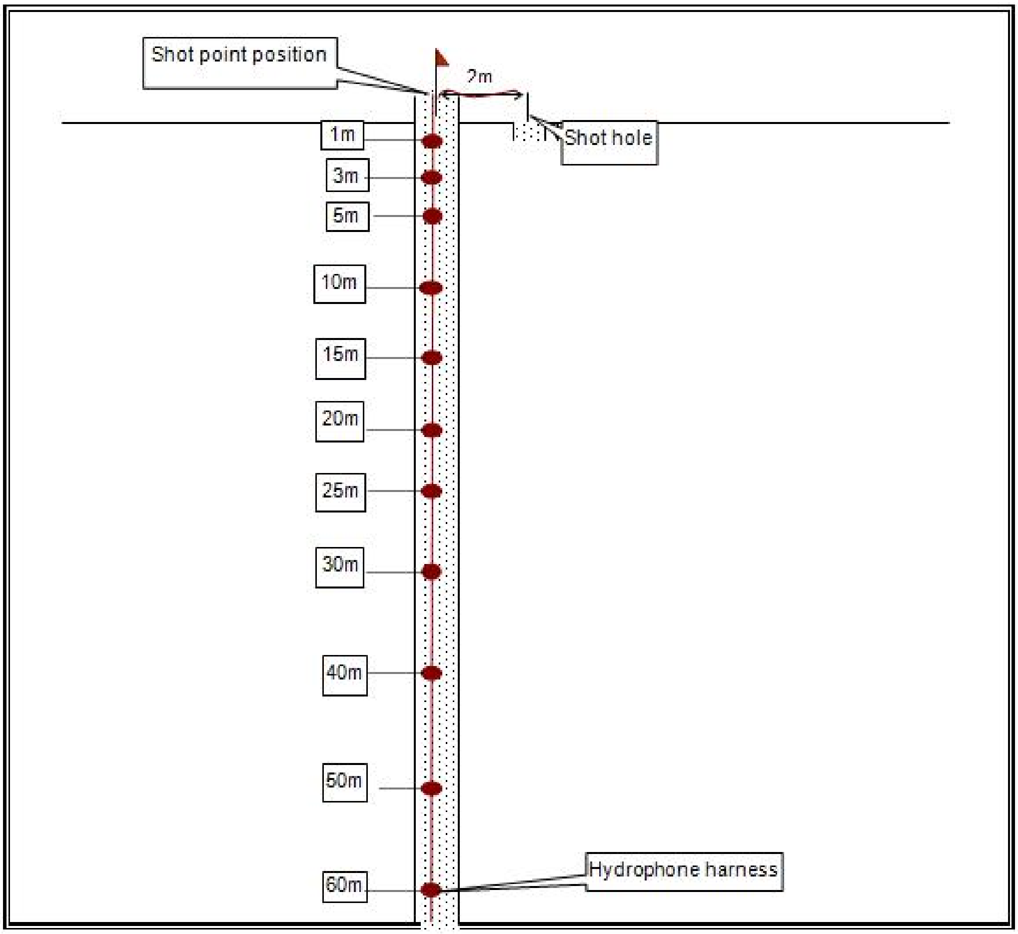

Figure 3. Uphole Survey Hydrophone/Source

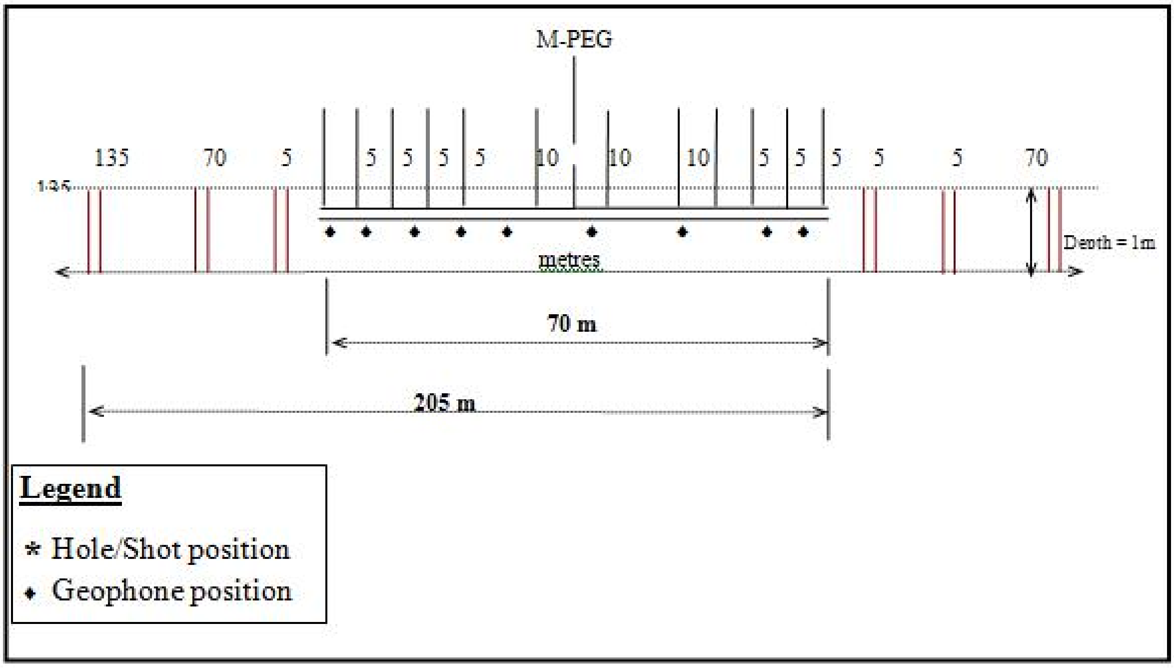

Figure 4. Seismic Refraction Survey Geophone/Source array

Table 4. Summary of Uphole (UPH) and Seismic Refraction Survey (SRS) Results

S/N	SHOT POINT	EASTINGS	NORTHINGS	ELEV. (m)	Z0 (m)	Z1 (m)	V0 (m/s)	V1 (m/s)	VC (m/s)	REMARKS
1	35085 / 74905	465603.34	140644.11	14.69	1.4	30.7	219	1364	2005	UPH
2	34185 / 75005	466103.91	136143.26	13.32	1.5	22.0	240	1298	1786	UPH
3	33485 / 75705	469603.50	132643.26	11.32	1.6	35.7	447	1541	1817	UPH
4	35085 / 75705	469602.73	140644.63	11.24	2.7	35.3	678	1665	2140	UPH
5	34185 / 75805	470103.72	136144.20	11.48	1.5	-	466	-	1835	UPH
6	35785 / 75705	469604.12	144144.42	13.80	2.0	26.3	358	1475	1916	UPH
7	36585 / 76405	472803.12	148147.33	12.02	1.7	-	639	-	1828	UPH
8	35085 / 76505	473602.77	140639.76	12.26	3.5	-	941	-	1800	UPH
9	35885 / 76605	474104.41	144646.86	14.12	3.0	-	537	-	1772	UPH
10	33485 / 76605	474103.21	132643.54	31.79	3.0	19.30	276	621	1747	UPH
11	34285 / 76605	474102.01	136643.23	12.10	2.9	-	778	-	1815	UPH
12	33885 / 77305	477603.68	134644.28	30.87	4.7	11.4	218	817	2208	UPH
13	35685 / 77305	477604.05	143645.66	36.74	1.7	16.4	200	503	1750	SRS
14	36485 / 77305	477603.78	147643.06	36.55	1.3	19.4	199	722	1760	UPH
15	34785 / 77305	477603.94	139143.04	33.10	1.7	13.9	264	475	1667	SRS
16	33985 / 78105	481605.39	135143.55	36.52	2.6	17.4	265	673	1712	UPH
17	35685 / 78105	481603.51	143643.56	40.20	1.3	15.3	225	425	1735	SRS
18	34785 / 78105	481603.57	139143.80	38.60	1.3	14.9	205	450	1680	SRS
19	36585 / 78105	481603.59	148143.43	42.77	2.2	19.0	265	658	1783	UPH
20	36585 / 78905	485604.13	148143.94	44.45	2.2	18.1	256	635	1807	UPH
21	35885 / 79005	486103.30	144637.50	44.50	1.5	19.5	290.0	634.0	1767.0	UPH
22	34285 / 78805	485104.00	136642.90	37.90	3.8	16.4	324	681	1770	UPH
23	34285 / 79805	490104.16	136643.96	39.93	2.1	15.2	252	630	1610	UPH
24	33485 / 79805	490102.97	132643.74	37.60	2.6	12.8	233	659	1721	UPH
25	35085 / 78905	485604.20	140643.00	40.50	2.2	17.6	290	649	1756	UPH
26	33485 / 78905	485603.00	132643.60	36.10	3.4	14.0	300	603	1670	SRS

S/N	SHOT POINT	EASTINGS	NORTHINGS	ELEV. (m)	Z0 (m)	Z1 (m)	V0 (m/s)	V1 (m/s)	VC (m/s)	REMARKS
27	35885 / 79705	489604.53	144643.44	44.39	2.2	19.9	291	704	1742	UPH
28	35085 / 79805	490103.55	140643.81	40.84	4.3	17.7	302	816	1784	UPH
29	35785 / 80405	493103.63	144143.14	44.07	2.5	13.9	286	646	1670	UPH
30	35085 / 81305	497604.23	140643.99	43.60	2.1	13.9	224	616	1759	UPH
31	35885 / 81205	497103.61	144643.87	47.44	2.8	17.6	313	630	1803	UPH
32	33585 / 80505	493603.60	133143.60	37.50	3.1	21.9	322	939	1998	UPH
33	33485 / 81305	497603.95	132643.40	39.50	2.1	18.1	374	710	1721	UPH
34	34285 / 81305	497603.89	136641.49	42.40	2.5	14.7	255	565	1680	SRS
35	35085 / 80605	494103.42	140643.65	41.09	2.0	13.5	248	660	1764	UPH
36	34185 / 80405	493102.50	136142.56	39.26	2.3	13.4	301	607	1712	UPH

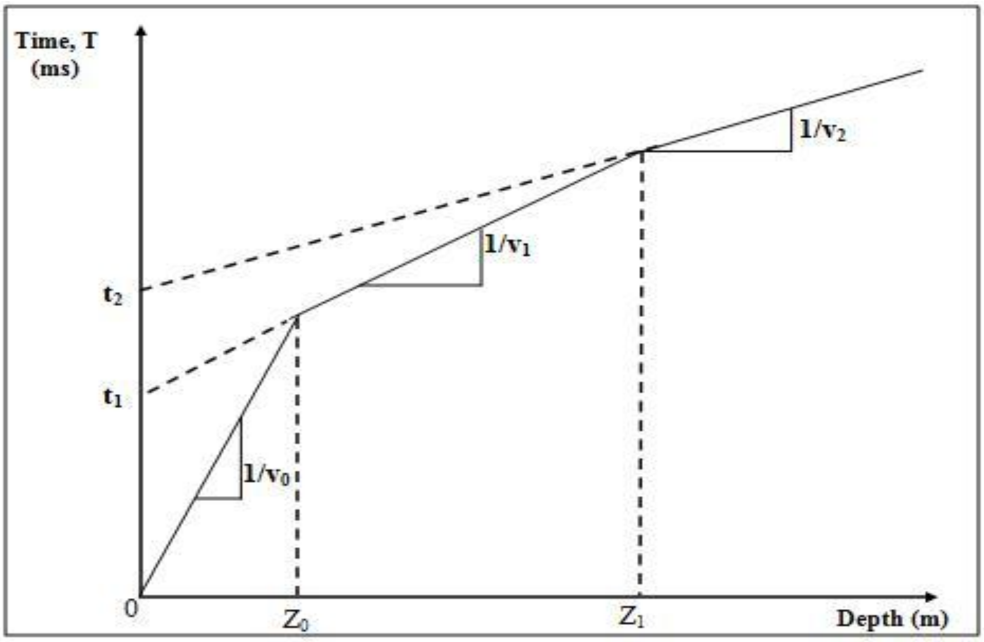

Figure 5. Typical Time-Depth Plot for Uphole Survey

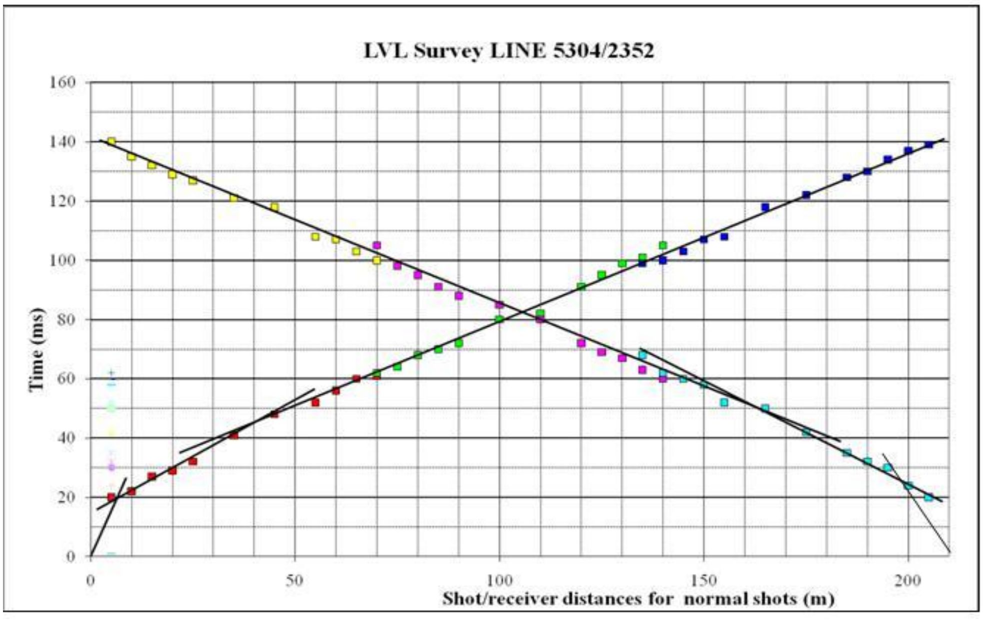

Figure 6. Typical Forward and Reverse Time-Offset Plot for Seismic Refraction Survey

4. Results

Table 4.0 shows the measured and computed field results while Figures 5 and 6 show typical Time-Depth/Distance plots for the uphole and seismic refraction techniques respectively.

4.1. Statistical Comparison of Results

For good comparative analyses of results, standard deviation, σ of the various results were computed as shown in Table 5. Their respective coefficients of variations (CVs) which give direct statistical comparison of the measure of dispersion between the results obtained by both techniques are computed and shown in Table 6 and Figure 7.

5. Discussion

A visual examination of the data in Table 2 shows the range of values of the different near-surface attributes obtained by the uphole and seismic refraction techniques. It can be observed that the thickness(es) of all the existing layers were not completely resolved by the uphole technique. The technique only recorded complete data for the first layer thickness, Z_1 and null data for some of the second layer thickness, Z_2 at five shot points: 34185/75805, 36585/76405, 35085/76505, 35885/76605 and 34285/76605 while the seismic refraction technique recorded complete data for the thickness and velocities of both layers. The uphole technique showed greater values for the thicknesses and velocities of the layers. This can probably be attributed to the fact that the hydrophones are located in situ the recording hole as the near-surface is vertically traversed.

Table 5. Computation of Standard Deviation (SD)

Method of Analysis	V_0	V_1	V_c	Z_1	Z_2
	$\sigma = \sqrt{\frac{\sum(V_{0i}-\bar{V}_0)^2}{N}}$	$\sigma = \sqrt{\frac{\sum(V_{1i}-\bar{V}_1)^2}{N}}$	$\sigma = \sqrt{\frac{\sum(V_{ci}-\bar{V}_c)^2}{N}}$	$\sigma = \sqrt{\frac{\sum(Z_{1i}-\bar{Z}_1)^2}{N}}$	$\rho = \sqrt{\frac{\sum(Z_{2i}-\bar{Z}_2)^2}{N}}$
Uphole Survey	177.8109	432.9893	218.0625	0.824621	9.244999
Seismic Refraction Survey	35.2077	62.6092	32.8126	0.75277	0.84656

Table 6. Computation of Coefficient of Variation (CV)

Method of Analysis	V_0	V_1	V_c	Z_1	Z_2
	$CV = \frac{\sigma}{\bar{V}_0}(100)\%$	$CV = \frac{\sigma}{\bar{V}_1}(100)\%$	$CV = \frac{\sigma}{\bar{V}_c}(100)\%$	$CV = \frac{\sigma}{\bar{Z}_1}(100)\%$	$CV = \frac{\sigma}{\bar{Z}_2}(100)\%$
Uphole Survey	49.25	61.71	12.27	33.70	57.07
Seismic Refraction Survey	14.58	12.44	1.93	37.96	84.66

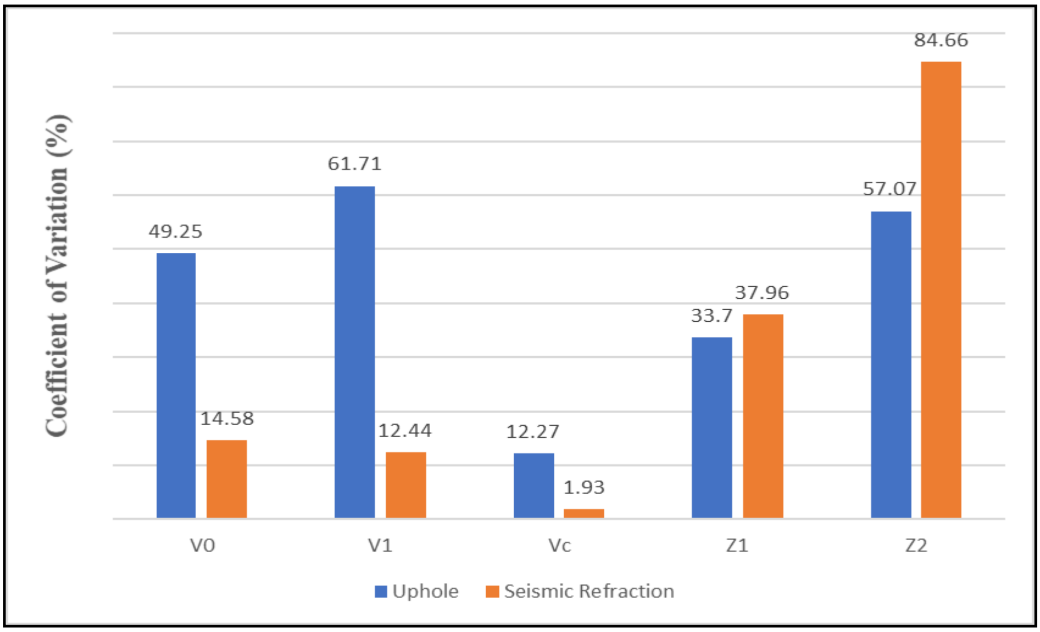

Figure 7. Chart showing the Coefficient of Variations (CV) of the different Near- Surface Parameters for the Uphole and Seismic Refraction Techniques

More so, the coefficients of variations in Figure 7 show the measure of dispersion among the near-surface seismic attributes. The results reveal that the uphole technique has low Coefficient of Variations (CVs) for thicknesses: Z_1 (33.70%) and Z_2 (57.07%) while seismic refraction technique has high CVs: Z_1 (37.96%) and Z_2 (84.66%). The low CVs for Z_1 and Z_2 implies low dispersion and precise estimation of the thicknesses. Conversely, seismic refraction technique has low CVs for velocities: V_0 (14.5%), V_1 (12.44%) and V_c (1.93%) while the uphole technique has high CVs: V_0 (49.25%), V_1 (61.71%) and V_c (12.27%). The low CVs for velocities imply low dispersion and good estimation by seismic refraction technique while the high CVs by the uphole technique imply high dispersion and high estimation of velocities. The high CVs may be due to high attenuation of seismic energy resulting to time delays as signals traverse low velocity materials through the mud cake and PVC casing to the hydrophones in the recording hole.

6. Conclusions

From this study, the following general comparative conclusions shown in Table 7 can be adduced:

Table 7. Comparative Conclusions

ITEMS	UPHOLE SURVEY	SEISMIC REFRACTION SURVEY
Operating Cost	Capital intensive. The equipment and logistics involved make it very expensive to deploy as many deep holes up to 66m are drilled and logged.	Cost efficient. The geophones are simply laid out on the ground surface along predetermined seismic lines and connected to the recording equipment
Areal Coverage	Vertically extensive thus it is limited in areal coverage	Laterally extensive thus, covers large area during a survey
Acquisition Duration	Time-intensive for data acquisition. It takes about 4 to 5 hours from drilling to logging	It is time-efficient. It takes just about 1 hour from layout to pick-up for the acquisition of large volume of data
Data Analyses	Requires few formulas for computations and analyses	Requires extra formulas and assumptions for computations and analyses
Depth Resolution	Images deep and provides the most direct measure of the LVL with less signal attenuations since the hydrophones are just located inside the drilled holes as the near-surface is vertically traversed	Images shallow depths and uses indirect methods to compute and determine LVL parameters. It is prone to ground rolls
Detection of Structures	Provides additional information for recognizing thin and hidden layers [17]	The forward and reverse shooting schemes provide information for the delineation of dipping layers
Personnel	Requires about 17 crew men in the acquisition process, that is more crew men	Requires about 8 crew men in the acquisition process, that is few crew men
Terrain	Usually conducted in areas where surface water is available and easily accessible to water trucks. So, bulldozers have to be used to excavate rough roads to create access roads to the uphole location	Can be conducted on dry lands and areas where water delivery by truck is impossible. Seismic lines are just marked cut through
Acquisition Challenges	Formations in some locations were rather too difficult to drill. The holes in areas with extended sand columns, often collapse and this led to repetition of drilling operation at some of the locations	Some dry and marshy locations make it difficult to establish good ground coupling of geophones.

7. Recommendations

For the delineation of the near-surface seismic attributes: LVL thicknesses and velocities, no one technique can be conclusively endorsed as it depends significantly on the available resources, areal coverage, duration of acquisition, quantity and quality of data required. Of these, the quality of data required is of paramount importance to the seismologists in the multinational oil and gas companies. Whereas, the uphole technique deploys many crew men to suitably provide the most direct measure of the LVL in a long period, the seismic refraction technique deploys few crew men to acquire more quantity of data in a short period and resolves the dipping layer within the near-surface. So, where the resources are favourable, it is recommended that both techniques be deployed together to accurately delineate the near-surface seismic attributes considering the importance/effects of this zone in 3D/4D seismic reflection exploration for hydrocarbon.

ACKNOWLEDGEMENTS

The authors wish to thank Shell Petroleum Development Company Nigeria for making available the data used in this research and to the Department of Petroleum Resources for the permission to use the data.

REFERENCES

[1] Alaminiokuma, G. I., Omigie, J. I., 2019, Anisotropic Properties of the Near-surface in South-Western Niger Delta:

Implications on Geotechnical Constructions. Journal of Geology and Mining Research, 12(1), 1-12.

[2] Adikwu, O. S., Okereke, C., Anene, F. C. and Selemo, A. O., 2018, The Effect of Elevation and Weathered Layer on Seismic Data Quality: Case Study of Olo Field, Niger Delta. International Journal of Geophysics and Geochemistry. 5(1), 9-18.

[3] Opara, A. I., Agoha, C. C. and Okereke, C. N., 2017, Low velocity layer characterization in the Niger Delta: Implications for seismic reflection data quality. J. Geol. Soc. India. 90, 187–195.

[4] Uko, E. D., Emudianughe, J. E and Eze, C. L., 2016, Comparison of the Characteristics of Low Velocity Layer (LVL) in the Mangrove Swamp and in the Upper Flood Plain Environments in the Niger Delta, using Seismic Refraction Methods. J. Geol. Geophys. 5: 248.

[5] Adeoti, L., Ishola, K.S., Adesanya, O., Olodu, U. and Bello, M.A., 2013, Application of Uphole Seismic Refraction Survey for Subsurface Investigation: A Case Study of Liso Field, Niger Delta, Nigeria. World Applied Sciences Journal, 26 (5), 573-582.

[6] Alaminiokuma, G. I., Amonieah, J. and Amakiri, A. R. C., 2011, Static Correction Parameters in the Lower Flood Plains of the Central Niger Delta, Nigeria. Global Journal of Environmental Sciences, 17(1), 123 – 129.

[7] Osagie, L. O., 2009, Weathering Structure of South-Western Niger Delta, Nigeria. Pacific Journal of Science and Technology. 10(2), 672-679.

[8] Enikanselu, P. A., 2008, Geophysical Seismic Refraction and Uphole Survey Analysis of Weathered Layer Characteristics in the “Mono” Field, South-Western Niger Delta, Nigeria. Pacific Journal of Science and Technology. 9 (2), 537-546.

[9] Amonieah, J., Alaminiokuma, G. I., Abdulrahaman, A., Suleiman, M. N., 2007, An Uphole Seismic Survey of the Weathering Structure of Alakiri (OML-18) in the Niger Delta Basin of Nigeria. International Journal of Environmental Issues 5, 7-15.

[10] Akpabio, I. O. and Onwusiri, H.N., 2004, The Computation Of Lvl Correction Parameters In Parts Of Western Niger Delta (OML 62), Global Journal of Geological Sciences. 2(1), 45-50.

[11] Eze, C. L., Okwueze, E. E. and Uko, E. D.. 2003, The velocity-thickness characteristics of the mangrove swamp low velocity layer (LVL) South central Niger Delta, Nigeria. Global Journal of pure and applied sciences 9: 369-374.

[12] Uko, E. D., Ekine, A. S, Ebeniro, J. O. and Ofoegbu, C. O., 1992, Weathering Structure of the East Central Niger Delta, Nigeria. Geophysics 57: 1228-1233.

[13] Alaminiokuma, G. I., Amonieah, J., 2012, Near-Surface Structural Model for Enhanced Data Acquisition and Processing in the North-Central Niger Delta. American Journal of Industrial and Scientific Research 3, 252-262.

[14] W. M. Telford, L. P. Geldart, P. E. Sheriff and D. A. Keys, Applied Geophysics. Cambridge University Press, London, Pp. 271 – 274; 281 – 284, 1976.

[15] Knox, W. A., 1967, Multi-layer near surface reflection Computation in Musgrave, A.W. Ed; Seismic reflection prospecting: Soc. of Expl. Geophysics 197 – 216.

[16] M. B. Dobrin, 1976, Introduction to Geophysical Prospecting, 3rd Edition, McGraw-Hill Book Co., Inc. New York.

[17] Marsden, D., 1993, Static correction. A review, The Leading Edge.