

RESEARCH ARTICLE

UPHOLE REFRACTION SURVEY OF THE VELOCITY REGIMES IN SOUTH-EASTERN PART OF NIGER DELTA NIGERIA

Amonieah, J., Amakiri, A.R.C., Chukwu, C.B*

Department of Physics, Faculty of Science, Rivers State University, Port Harcourt, Nigeria.

*Corresponding author's email: benedict.chidi@yahoo.com

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ARTICLE DETAILS

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ABSTRACT

Uphole refraction survey of the velocity regimes in South-Eastern part of Niger Delta, Nigeria was carried out using a 12-channel seismograph: Mc SEIS 160M Model 1115. The study presents a regional weathering structure of the area, the velocities and depths of the weathered layers were calculated from the travel time of the seismic waves. The data were interpreted using the time – intercept method which revealed that the low velocity layer was fairly variable in thickness in the region, varying between 24.5m and 25.8m, with a regional average value of 25.12m. The weathered and consolidated layers have average Compressional wave velocities of 944.0m/s and 1907.69m/s respectively. The knowledge from the result of this study can be applied in oil and ground water exploration plans.

KEYWORDS

Weathering Layer; Uphole refraction survey; Low Velocity Layer; Consolidated layer; Seismogram

1. INTRODUCTION

Uphole method of seismic refraction survey is a field seismic technique which uses receivers on the ground surface and an underground source to derive information about the subsurface structure. There are many techniques for determining the weathering structure, some of these methods include the low velocity layer refraction survey, smoothing of reflections and refraction breaks (Alaminiokuma and Amonieah, 2012). The choice of the uphole survey technique is that it is one of the best and direct methods of investigating low velocity layer characteristics, with very high accuracy and resolution as compared to the other techniques mentioned above (Faust, 1953; Taford et al., 1976).

Weathered or weathering layer is the topmost layer of the earth's surface, where sediments are usually aerated, loosed and unconsolidated with air in the pore spaces which in most cases is covered by water. For weathered or low velocity layer, seismic velocities which are lower than the velocity in the underlying consolidated layer imply that gas (air or methane result from the composition of vegetation) fills at least some of the pore space (Wyllie et al., 1958). This layer is usually made up of loose unconsolidated sedimentary materials although igneous, metamorphic and consolidated sedimentary outcrops can have a weathered layer due to exfoliation and dilatation (Alaminiokuma et al., 2010).

Moreover, this layer, which is usually 4 to 50m thick, is characterized by low seismic velocities which are not only low (250 and 1000m/s) but at times highly variable (Amonieah et al., 2007). Velocities within the weathered layer vary both vertically and laterally (Nigerian Oil and Gas Industry Annual Report, 2018). This layer may not be detected by refraction shooting, this is because the rays entering a bed from above are always deflected in a downward direction (Faust, 1953).

2. GEOLOGY OF THE STUDY AREA

The study area is located in the South-Eastern part of Niger Delta, Nigeria with coordinates of latitude 4°38'4" N and longitude 7°3'31" E. The field is situated in swamps approximately 18km southeast of Port Harcourt as shown in figure 1. It lies on the mangrove swamp environment running parallel to the Nigerian coastline in the Niger Delta area. The area is sandwiched between the outer barrier island complex and the older sands of the Benin Formation, in a belt which reaches widths of between 30 and 40 km at the delta flanks and across the delta. This mangrove swamp zone crisscrossed by a network of dynamic rivers and creeks and has evolved primarily through the process of repeated bifurcation of the River Niger and its distributaries (Amonieah et al., 2007).

3. MATERIALS AND METHOD

3.1 Materials

Materials used in this study include hydrophone, seismogram MC SEIS 160M Model 1115, electric blasting caps, blaster, machete, cutlass and measuring tape.

3.2 Methodology

Holes were drilled at stations or layout as shown in figure 2. At each station two holes were drilled one to a depth of 66m and the other 2m at an offset of 7m. A hydrophone was suspended at a number of depths in the well by a means of a cable. The first depth logged was 60m the next 50, 40, 30, 25 – 0m. Each of these depths was designated to a particular channel. The explosive was then detonated in the shallow hole, with the aid of a blaster connected to the seismograph.

For each station, the same operations were carried out for the 12 channels using different explosives at various depths as shown in figure 3.

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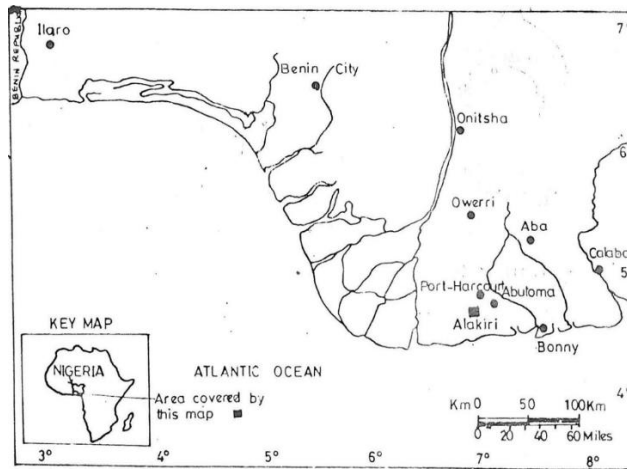


Figure 1: Area of Study

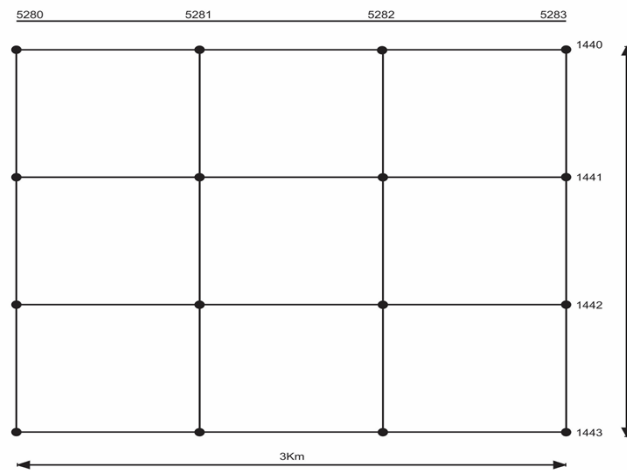


Figure 2: Seismic lines indicating Borehole locations

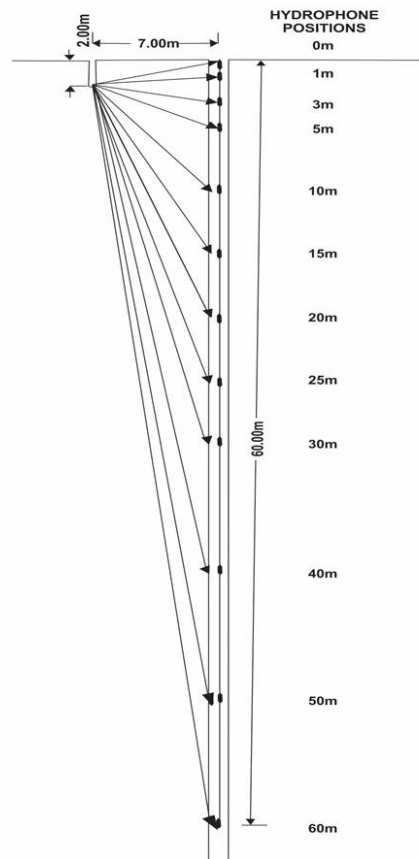


Figure 3: Showing Shot-points, Well Geometry and Energy paths

4. RESULTS AND DISCUSSION

4.1 Results

The result of the regional average weathering structure of the study area is presented in table 1 while table 2 shows the travel times data obtained

for the sixteen stations. The weathering structure includes the average velocities V_0 (air blast), weathered layer, V_1 and consolidated layer, V_2 . These seismograms were digitized to obtain the surface corrected time or the (T_s) travel time at all sixteen stations. Time versus depth (T-X) graphs were plotted to evaluate the velocities of the low velocity layers (LVL) and the consolidated layers as shown in figures 4 – 9.

Table 1: Regional Average Weathering Structure

Position	Zw(m)	Vw(m/s)	V0(m/s)	V1(m/s)	V2(m/s)
5280 1440	24.5	1450	400	947	1902
5281 1440	25	1450	400	930	1912
5282 1440	25	1450	385	936	1856
5283 1440	25	1450	385	955	1613
5280 1441	25	1450	385	919	1807
5281 1441	25.5	1450	400	945	2508
5282 1441	25.5	1450	400	940	1978
5283 1441	25	1450	385	932	1974
5280 1442	25.2	1450	417	920	2015
5281 1442	24.5	1450	400	947	1902
5282 1442	25.8	1450	400	930	1912
5283 1442	25.2	1450	455	959	1998
5280 1443	25.2	1450	455	957	1772
5281 1443	24.9	1450	455	964	1759
5282 1443	25	1450	385	961	1613
5283 1443	25.6	1450	455	962	2002
Average	25.12	1450	410.13	944	1907.69

Table 2: Travel Time Data

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Station No.	5280 1440	5281 1440	5282 1440	5283 1440	5280 1441	5281 1441	5282 1441	5283 1441	5280 1442	5281 1442	5282 1442	5283 1442	5280 1443	5281 1443	5282 1443	5283 1443
Depth (m)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)	T_s (sec)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	2.5	2.5	2.6	2.6	2.6	2.5	2.5	2.6	2.4	2.5	2.5	2.2	2.2	2.2	2.6	2.2
3.0	4.4	4.2	4.0	4.0	4.4	4.9	3.6	4.0	4.0	4.4	4.2	4.0	5.0	5.0	4.0	4.0
5.0	6.1	6.5	6.0	6.2	6.5	6.5	6.0	5.7	5.5	6.1	6.5	5.9	8.0	7.0	6.2	6.0
10.0	10.9	11.4	11.4	12.0	12.0	11.5	10.5	11.2	10.5	10.9	11.4	11.2	13.0	12.2	12.0	11.1
15.0	15.5	17.0	16.7	17.0	17.5	15.5	16.0	16.7	15.5	15.5	17.0	16.1	17.8	15.5	17.2	16.1
20.0	22.2	22.3	22.0	23.0	23.0	22.0	21.0	21.0	21.2	22.2	22.3	21.3	24.0	22.8	23.0	21.2
25.0	27.5	28.0	27.5	26.5	28.2	28.5	27.5	28.0	28.0	27.5	28.0	27.1	28.0	28.0	26.5	27.1
30.0	30.3	30.9	30.3	30.0	30.8	30.5	30.0	30.5	30.7	30.3	30.9	29.7	31.0	30.9	30.0	29.6
40.0	36.0	35.7	35.4	34.3	30.5	35.0	35.0	35.2	35.5	36.0	35.7	34.8	36.0	36.0	34.3	34.8
50.0	42.2	41.0	41.0	44.0	41.8	39.5	40.5	41.5	40.4	42.2	41.0	39.8	42.8	42.0	44.0	39.8
60.0	45.3	46.5	46.4	47.4	47.5	42.0	45.0	45.3	45.5	45.3	46.5	44.6	47.5	48.0	47.4	44.5

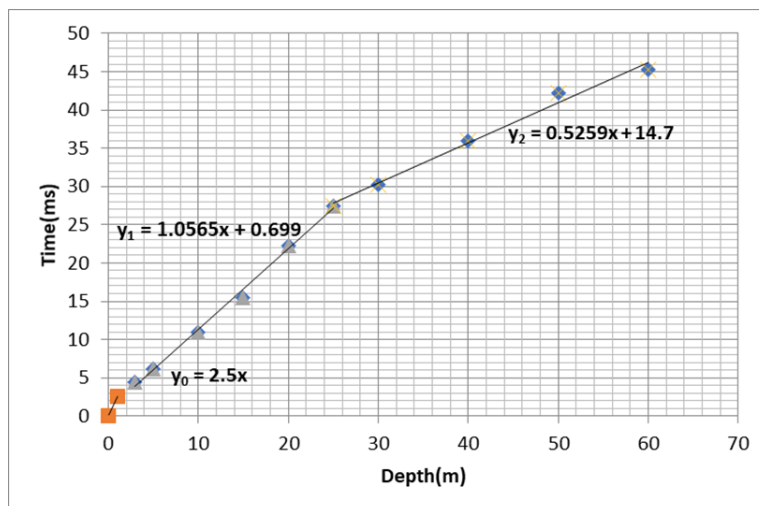


Figure 4: T-X Graph of Uphole Recording Log Position 5280 1440

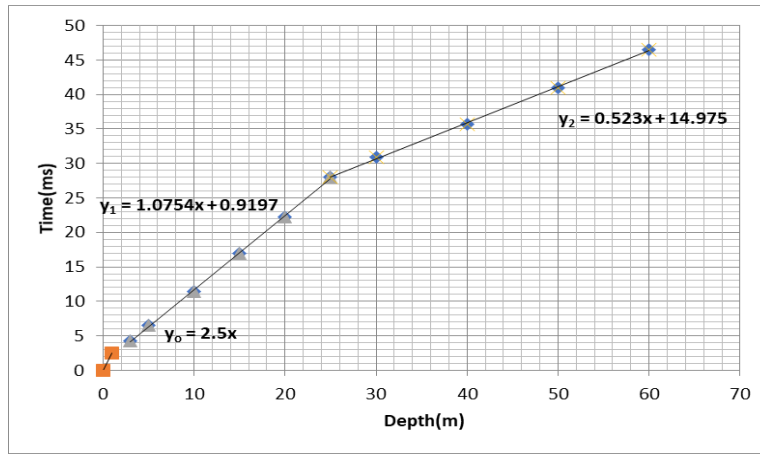


Figure 5: T-X Graph of Uphole Recording Log Position 5281 1440

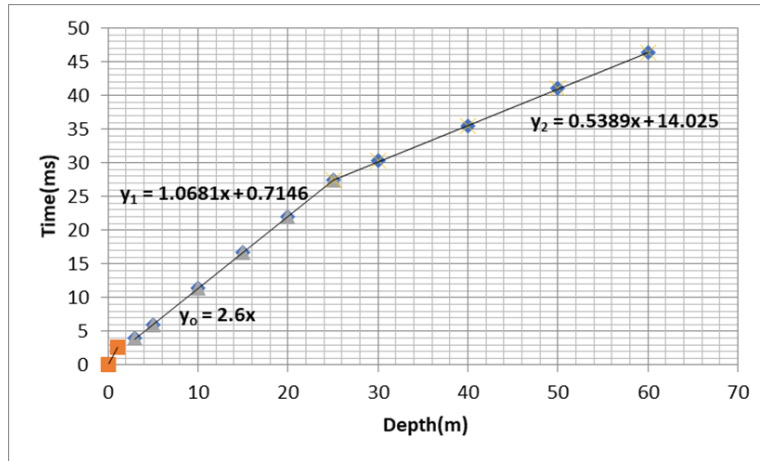


Figure 6: T-X Graph of Uphole Recording Log Position 5282 1440

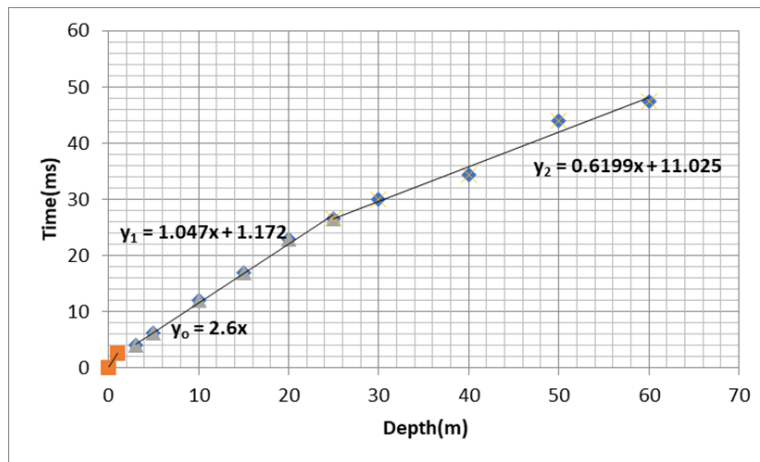


Figure 7: T-X Graph of Uphole Recording Log Position 5283 1440

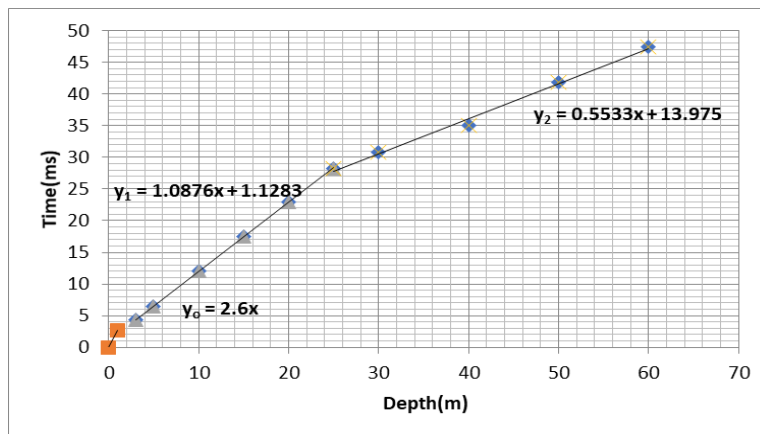


Figure 8: T-X Graph of Uphole Recording Log Position 5280 1441

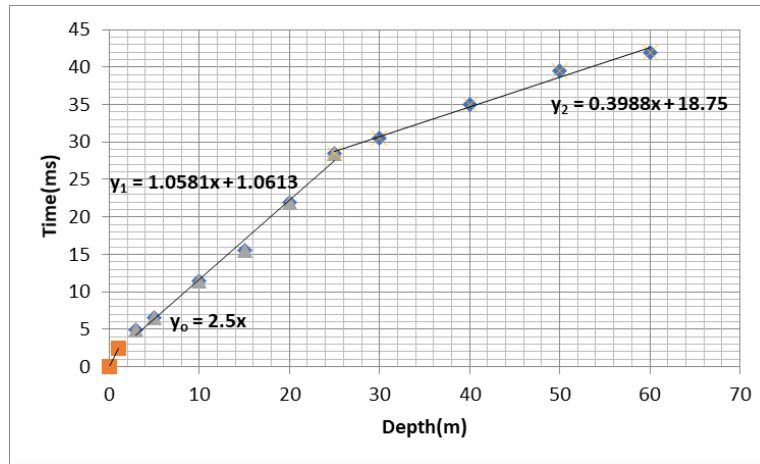


Figure 9: T-X Graph of Uphole Recording Log Position 5281 1441

5. DISCUSSION

Table 1 is the summary of the weathering thickness values and elevation velocities along each well. The velocities V_0 , V_1 and V_2 indicate the seismic velocities within the soft mud (layer close to earth's surface), weathered layer and consolidated layer respectively. A critical look at these results when compared to the weathering thickness reveals that the weathering velocities (V_1) increases with weathering depth. Similarly, the velocities (V_2) of the consolidated layer shows a trend of increase in velocities with depth of burial.

6. CONCLUSION

From the results of the analysis of data obtained from this study, the following conclusions were reached:

- i. Average air blast velocity of 410.13m/s.
- ii. The average weathering velocity is 944m/s.
- iii. The average velocity of the consolidated layer is 1907.69m/s;
- iv. The average weathering depth of the region is 25.12m.
- v. A velocity gradient of 34.6/s within the weathering zone;

The above information can be applied in the explorations for minerals, water and in road, dam and building construction.

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