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STATIC CORRECTION PARAMETERS IN THE LOWER FLOOD PLAIN OF THE CENTRAL NIGER DELTA, NIGERIA

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ABSTRACT

Downhole seismic survey was conducted over the lower flood plain of the Central Niger Delta within the Kaiama prospect (OML 28) in an attempt to compute and determine the static correction parameters for the area. Analysis and interpretation of data from 14 downhole locations using NESURVELANA software shows that the thickness of the weathered (low velocity) layer is laterally variable from about 2.6m to 5.8 m with an average of 4.3 m. The weathering velocity ranges from 383 m/s to 985 m/s with an average value of 546 m/s. The consolidated layer below the weathered layer has a velocity ranging between 1646 and 1893 m/s with an average value of 1763 m/s. Knowledge of these computed parameters can be applied in oil and gas exploration and interpretation, also in civil engineering, where the determined LVL provides an estimate of the foundation depth for massive construction works, another area of application is in the exploration and exploitation of groundwater.

KEYWORDS: Weathering layer velocity, Weathering Layer thickness, Downhole, Lower flood plain, and, Kaiama-Niger Delta,

INTRODUCTION

Seismic reflection times are always affected by geometric irregularities of the sub-surface layers. The non-uniform weathering of the near-surface layer is the main cause of these irregularities and these in turn give rise to lateral variations in velocities. Datuming through an incorrect weathering layer can corrupt the stack, possibly introducing false structures into deep reflectors (Doherty, 1992). A good static correction is desirable for two reasons, namely, to obtain the correct structural interpretation and to obtain a high-resolution section which can be used for stratigraphic interpretation (Marsden, 1993).

atum static correction requires that the velocity and thickness of the weathering layer be known for the accurate mapping of the underlying structures for oil and gas exploration.

Analysis of the weathering layer properties can reveal how they vary vertically and or laterally. A commonly used method among others is the downhole technique which is known to providing the most direct measure of these parameters (Telford et al, 1976).

The importance of the weathering layer velocities and thicknesses in static correction and mapping of the deep structures have been highlighted by several researchers in the Niger Delta. Akpabio and Onwusiri (2004) have computed the low velocity layer (LVL) correction parameters using data from sixty-one different locations in the Western Niger Delta. The results show that the weathering velocity ranges from 210m/s to 994 m/s, with an average value of 552 m/s; the sub-weathering layer velocity varies from 1358m/s to 2464 m/s, with an average value of 1734 m/s. The thickness of the weathering layer varies from 2.8m to 52.8 m with an average value of 19.3m. Eze et al (2003) determined the thickness and velocity of the low velocity layer in the mangrove swamp of the Niger Delta of Nigeria. Results obtained showed a variation in the thickness of the weathering layer from 2.0m to 5.7m with an average of 3.4 m. The velocity of the LVL here ranges between 295m/s and 727 m/s with an average of 562.7 m/s while the velocity of the sub-weathering layer ranges between 1502m/s and 1918 m/s with an average of 1716 m/s. In the refraction experiment conducted by Uko et al (1992) over parts of the East-Central Niger Delta, the velocity of the weathering layer and the velocity of the refractor were calculated from critically refracted arrivals using flat-layer models. The results obtained show that the thickness of the weathered layer in the region is highly variable, ranging from 2.9m to 45.5m with an average of about 20.0m.The weathered layer and the refractor beneath it have average P-wave velocities of about 500.0m/s and 1732.0 m/s respectively.

In this paper, the seismic static correction parameters (weathering layer thickness and velocity information) of the lower flood plain of the Central Niger Delta have been computed using downhole refraction data acquired in the study area.

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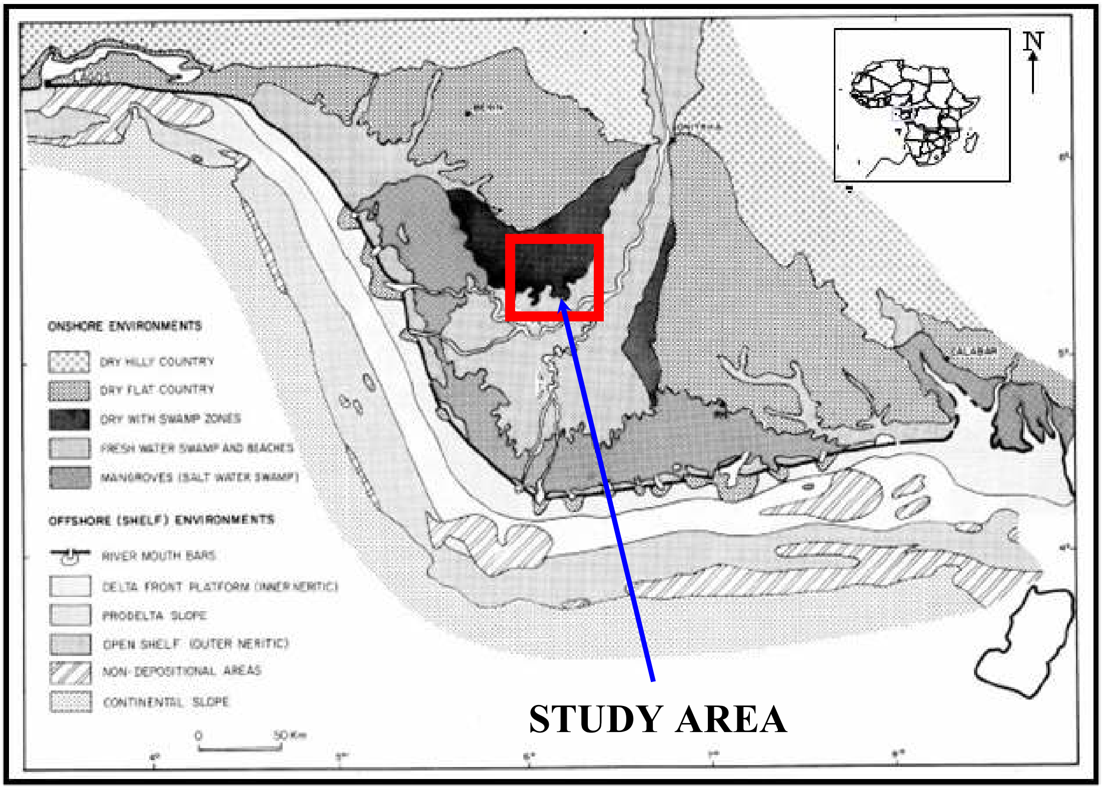

Figure 1: Present terrain and sedimentary environment of the Niger Delta. (Offshore shelf environments are from Allen, 1965)

GEOLOGICAL SETTING

The Niger Delta covers an area of about 140,000 km², within the Gulf of Guinea and has an average sediment thickness of about 12.0km (Figure 1). This siliciclastic system began to prograde across the preexisting continental slope into the deep sea during the late Eocene (Burke, 1972), and is still active today. The stratigraphy of the Niger Delta (Figure 2) can be divided into three major units (Short and Stauble, 1967), starting from the Eocene to the Holocene age: (1) The Akata formation with an average thickness of 4500m, consisting of marine clays with silty and sandy interbeds (Whiteman, 1982). (2) The Agbada formation, is characterized by Parallic to marine-coastal and fluvial-marine deposits, mainly composed of sandstones and shale, organized into coarsening upward offlap cycles, and (3) The Benin formation, which consists of continental and fluvial sands, gravel, and backswamp deposits (2500 m thick).

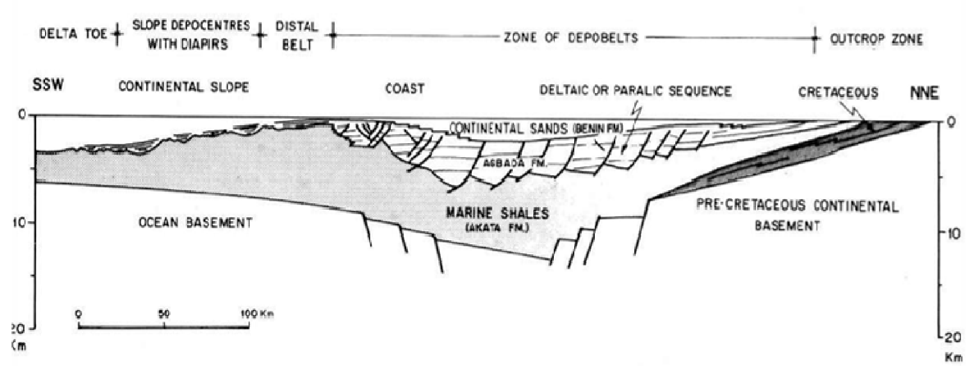

Figure 2: Schematic structural section through the axial portion of the Niger Delta showing relationships of the tripartite division of the Tertiary sequence to the basement.

LOCAL SETTING

The study was carried out in the lower flood plain, in the Central part of the Niger Delta; covering an area of about 2100 km² (Figure 1), bounded by 6º14´E and 6º36´E longitudes and 4º55´N and 5º24´N latitudes. According to Merki (1982), the lower flood plain environment extends from the Forcado-Nun bifurcation of the Niger to the levee indented margin of the brackish marine mangrove swamp environment. The top soil is mainly clay to a depth of about 5 m. Beyond this depth the lithology changes to medium coarse sand which is found to continue to a maximum depth of 60.0 m in this study. Distributaries are continually formed and the streams depth rarely exceeds 10.0 m.

METHODOLOGY

The data used in this study was acquired by the downhole seismic refraction method. In this case the logged hole was drilled to a depth of 66.0m. At an offset of 3.0m, another hole was drilled to a depth of 1.5m, in which a cap energy source was detonated with the aid of a 24-channel (Terralock. Mark - 3) seismograph. The arrival times of the generated sound waves were recorded down the hole at several intervals to a depth of 60.0m (Figure 4). However the first few intervals of the parameters were adequately computed. A total of fourteen holes were drilled and logged in the study area (fig 3). A typical monitor record for location K01 is shown in Figure 4. These times were corrected for slant travel and source paths (Table 1), using equation (1) below:

$$t_v = \frac{t_S(h-1.5)}{\left[\left(\frac{5h-7.5}{h}\right)^2 + (h-1.5)^2\right]^{1/2}} \quad (1)$$

Where t_v = vertical travel time; t_s = slant travel time; h = respective receiver depths

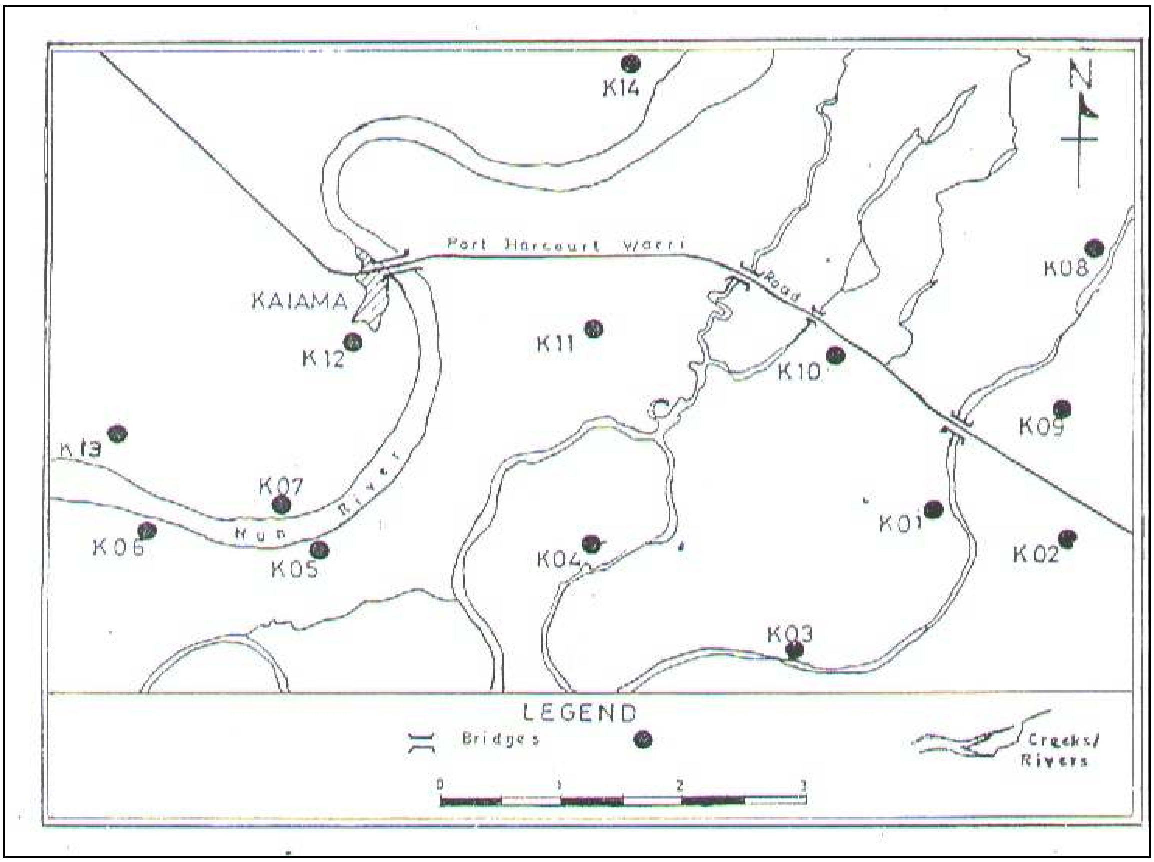

Figure 3: The downhole profile location map of the study area

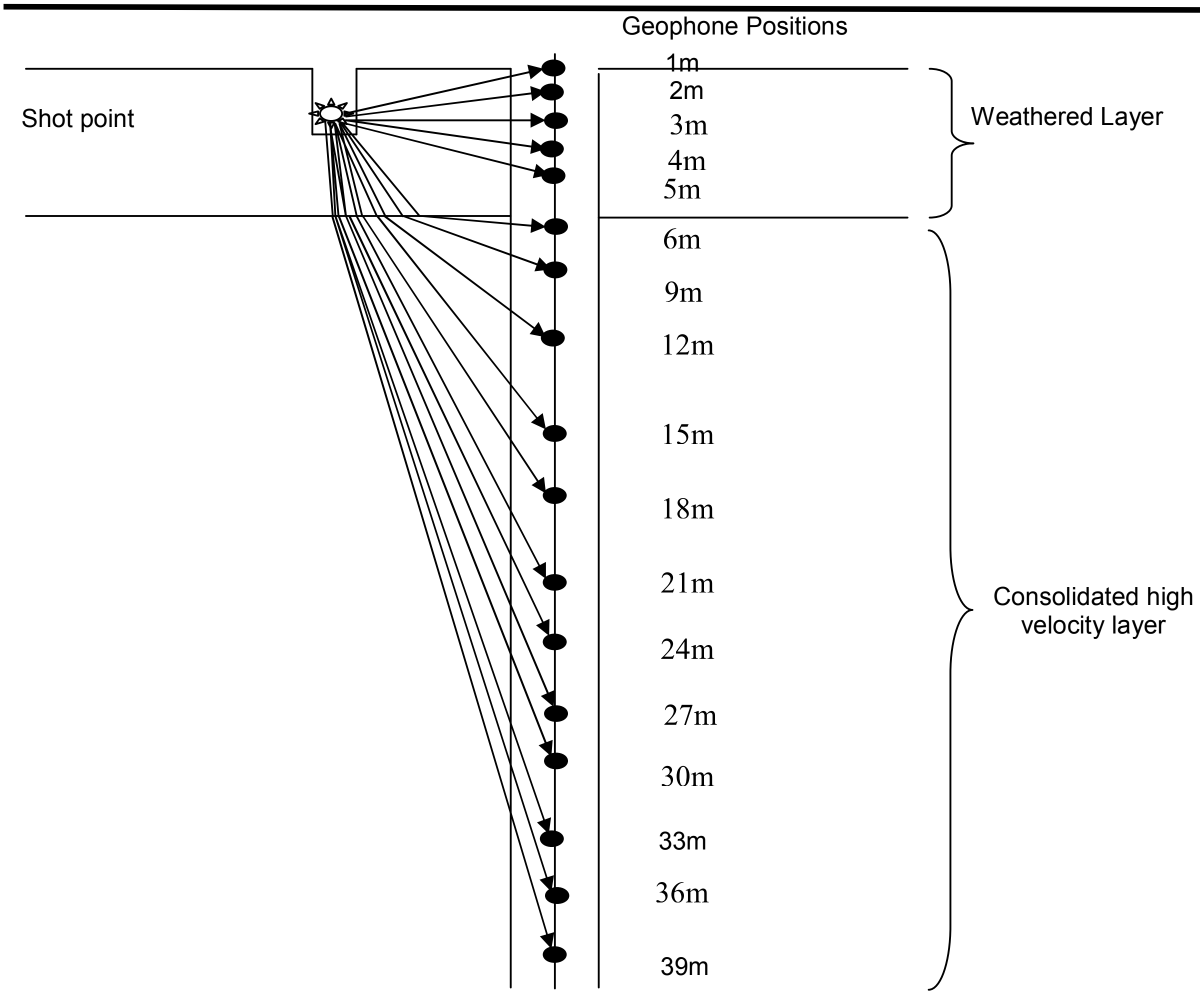

Figure 4: Theoretical ray path for Downhole method

PRESENTATION OF DATA AND ANALYSIS

The corrected travel times shown in Table 1 were plotted against the receiver offsets. Figure 5 shows a typical travel time curve obtained for the downhole for one of the locations, using NESURVELANA Software, developed by Alaminiokuma (2004) for analyzing near-surface velocity data. The velocities and the thickness of the layers were automatically computed by the Software.The computations of the thickness of the discrete layers with their respective velocities were obtained from the lines intersects and the inverse of the slopes of the linear segments determined by the Software. The time-depth profiles of all the fourteen downholes studied in this work have characteristic two principal line segments indicating a single-layer condition in the area.

RESULTS, DISCUSSION AND CONCLUSION

A summary of the computed thicknesses and velocities for the area of study is presented in table 2. The weathering layer showed significant variation in thickness and velocity, while the overburden thickness in the area varies between 2.6 m and 5.8 m and the velocities vary between 383 m/s and 985 m/s. The area has an average weathering thickness and velocity of 4.3 m and 546 m/s respectively. The velocity of the consolidated layer is between 1603m/s and 1893 m/s with an average value of 1763 m/s. This gives an indication of lateral variations in velocity and thickness of the weathering layer. Holes K01, K04, K05, K08, K12, and K13 were observed to have thicknesses of 5.0 m and above.

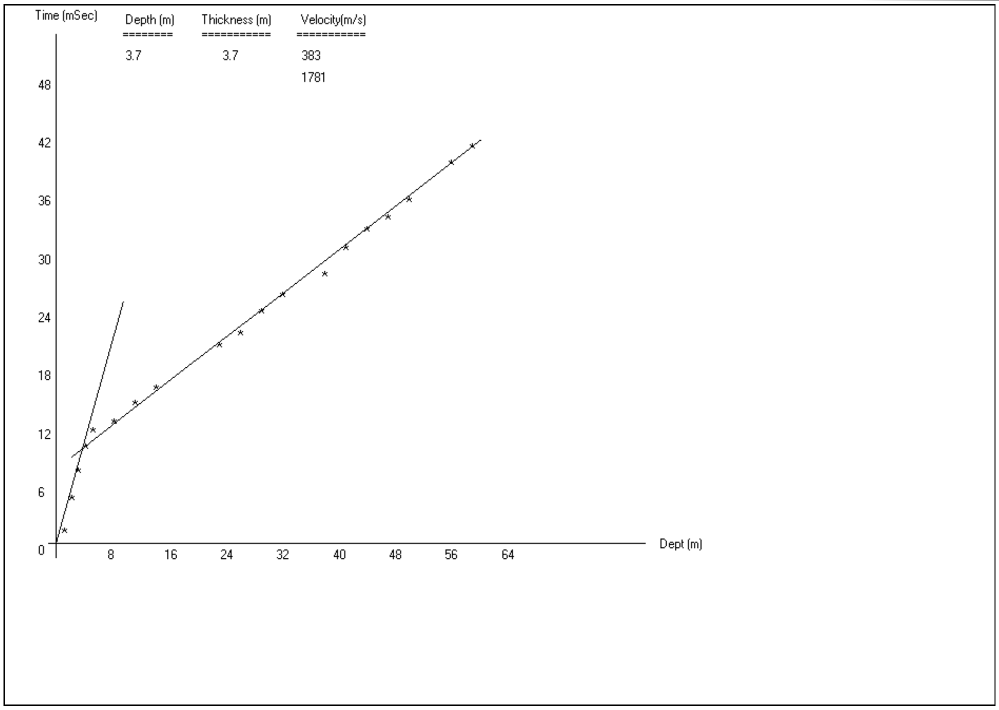

Figure 5: Typical plot of the corrected travel time versus depth curve by the NESURVELANA Software

Results from these wells which are variously scattered within the prospect showed no relationship with the elevation trend. On the other hand, holes K02, K06, K07, K09 and K14 have thicknesses below 4.0 m. The results here also did not suggest any regular change with the elevation trend. The sediment structure and the increasing thickness, may be due to various stream activities. The difference in the results obtained in this lower flood plain and those obtained by other researchers in the Mangrove swamp, Western and East-Central Niger Delta areas may be as a result of large scale and small scale cross bedded strata occurring in sand bodies in this area. This has given rise to the irregular weathering structure of this area. Although the weathered layer in this area may be only a few meters thick, its abnormally low velocity causes time delays to rays passing through it, thus having the effect of shifting reflection events on adjacent traces out of their true relationships.

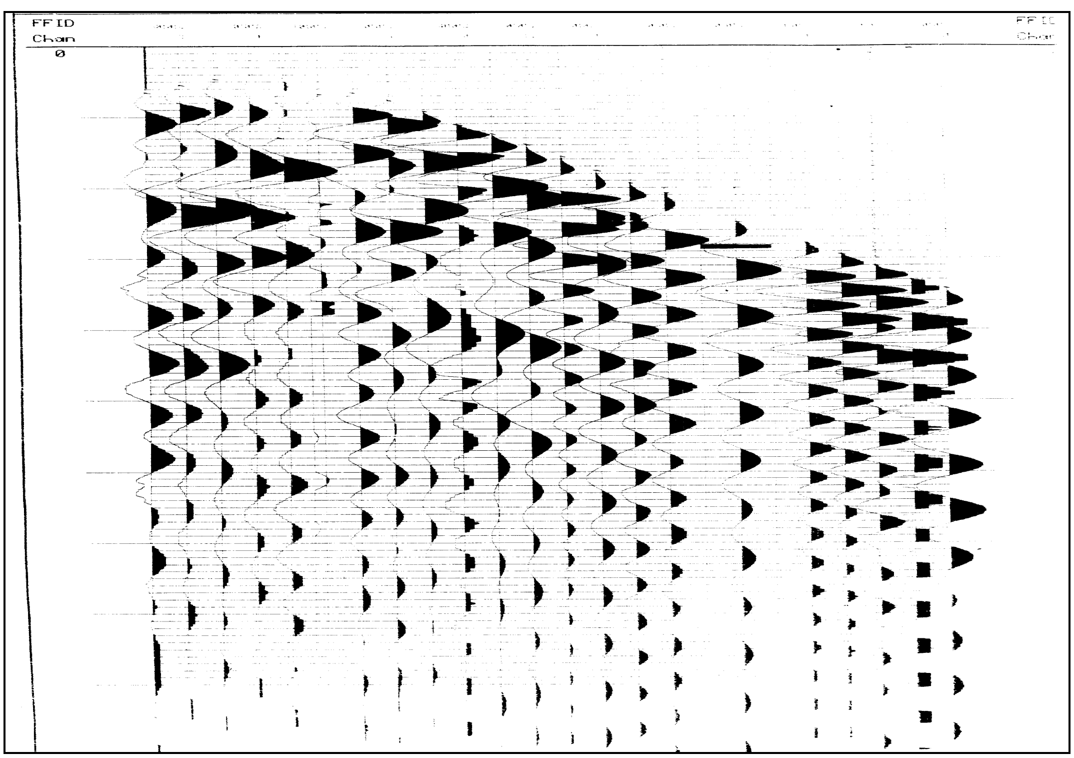

Figure 4: Typical Downhole monitor record for location k 01.

The method discussed herein and the interpretations of the data obtained have shown how the thickness and velocity of the weathered overburden and velocity of the consolidated shallow layer were determined. These parameters which changed rapidly but erratically in both horizontal and vertical directions suggest the need for consistent and accurate static correction of seismic reflection data acquired in this area and may, if not corrected for, lead to false indications of significant structural relief features.

Table 1: Typical corrected travel times for hole K01 in the Central Niger Delta

Trace No.	Phone Depth (m)	Source Offset (m)	Source Depth (m)	Raw pick time (ms)	Vertical Time (ms)	Source depth Correction (ms)	Final time (ms)
1	1.0	5.0	1.5	15.0	-1.5	3.1	1.6
2	2.0	5.0	1.5	11.0	1.1	3.1	4.2
3	3.0	5.0	1.5	10.0	2.9	3.1	6.0
4	4.0	5.0	1.5	9.0	4.0	3.1	7.1
5	5.0	5.0	1.5	10.0	5.3	3.1	8.8
6	6.0	5.0	1.5	-	-	-	-
7	9.0	5.0	1.5	11.6	9.7	3.1	12.8
8	12.0	5.0	1.5	9.1	8.2	3.1	11.3
9	15.0	5.0	1.5	10.8	10.1	3.1	13.2
10	18.0	5.0	1.5	12.0	11.5	3.1	14.6
11	21.0	5.0	1.5	14.0	13.6	3.1	16.7
12	24.0	5.0	1.5	15.0	14.6	3.1	17.7
13	27.0	5.0	1.5	17.5	17.2	3.1	20.3
14	30.0	5.0	1.5	19.0	18.7	3.1	21.8
15	33.0	5.0	1.5	21.0	20.7	3.1	23.8
16	26.0	5.0	1.5	21.5	21.3	3.1	24.4
17	39.0	5.0	1.5	23.6	23.4	3.1	26.5
18	42.0	5.0	1.5	25.6	25.4	3.1	28.5
19	45.0	5.0	1.5	27.0	26.8	3.1	29.9
20	48.0	5.0	1.5	29.0	28.8	3.1	31.9
21	51.0	5.0	1.5	31.5	30.3	3.1	33.4
22	54.0	5.0	1.5	32.0	31.9	3.1	35.0
23	57.0	5.0	1.5	34.0	33.9	3.1	37.0
24	60.0	5.0	1.5	35.0	34.9	3.1	38.1

Table 2: Summary of Downhole results in the Central Niger Delta

Downhole No.	Weathered layer thickness (m)	Weathered layer velocity (m/s)	Consolidated layer velocity (m/s)
K01	5.4	524	1746
K02	3.7	383	1781
K03	4.3	546	1743
K04	5.0	461	1716
K05	5.7	492	1756
K06	2.6	538	1818
K07	3.0	592	1603
K08	5.4	985	1801
K09	2.6	469	1799
K10	4.4	444	1795
K11	4.0	489	1782
K12	5.8	434	1800
K13	5.7	528	1646
K14	3.0	765	1893
Average	**4.3**	**546**	**1763**

REFERENCES

Allen, J. R. L., 1965. Late Quaternary Niger delta, and adjacent areas-sedimentary environments and lithofacies: American Association of Petroleum Geologists Bulletin, v. 49, p. 547-600.

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

Alaminiokuma, G. I., 2004. Computer program for the analysis of near-surface velocity data: M.Sc. Thesis (unpublished), Rivers State University of Science and Technology, Port Harcourt, Nigeria.

Burke, K. C., 1972. Longshore drift, submarine canyons and submarine fans in development of the Niger Delta: AAPG Bulletin, 56, 1975 – 1983.

Dobrin, M. B., 1976. Introduction to Geophysical Prospecting. McGraw-Hill Book Co., London.

Docherty, P., 1992. Solving for the thickness and velocity of the weathering layers using 2-D refraction tomography: Geophysics, 57, 10, 1307 – 1318.

Eze, C. L., E. E., Okwueze, and E. D. Uko., 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, (3): p. 369-374.

Marsden, D, 1993. Static Corrections – A Review Part I. The Leading Edge, I, 12, (1): p.43 – 49

Merki, P., 1972. Structural geology of the Cenozoic Niger Delta, in T. F. J. Dessauvagie and A. J. Whiteman, Eds., African geology: Ibadan, Nigeria, Ibadan University Press, 635 – 646.

Short, K. C., and Stauble, A. J., 1967. Outline of geology of Niger Delta: American Association of Petroleum Geologists Bulletin, 51, 761-799.

Telford, W. M., L. P. Geldart, P. E. Sheriff, and D. A. Keys, 1976. Applied Geophysics. Cambridge University Press, London.

Uko, E. D., A. S. Ekine, J. O. Ebeniro, and Ofoegbu, C. O., 1992. Weathering Structure of the East Central Niger Delta, Nigeria, Geophysics, 57 (9): 1228-1233.

Whiteman, A., 1982. Nigeria – Its Petroleum, Geology Resources and Potential: London, Graham and Trotman, 394.