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DETERMINATION OF WEATHERING DEPTH BY UPHOLE SHOOTING TECHNIQUE IN SOME PARTS OF OWERRI, SOUTH EASTERN NIGERIA

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ABSTRACT

Certain irregularities associated with seismic operation are due to the extent and depth of weathering in the vicinity of the seismic operation. The extend and depth of weathering as characterized by low seismic velocity is very important in static correction, especially where shots are taken in the weathering layer.

Result from 21 uphole positions recorded during a seismic prospecting programme for petroleum exploration in the study area revealed three seismic layers as follows:

(a) A top intermediate silty sand (Highly weathered)
(b) An intern mediate sand layer(subweathered layer)
(c) A third weathering layer consisting of sand and Gravel beds.

The result indicates a varying depth of weathering between 1.8 to 5.0m with an average value of 3.53m and an average velocity 36m/sec. The intermediate layer with of 9.2m to 20.9m has an average velocity of 733m/sec. The weathering and subweathered layers have a total average depth of 21.76m and an average velocity of 547.3m/sec.The result which is consistent with velocity values of unconsolidated sediments is utilized for weathering correction during processing of seismic data. The area around Ihiagwa marked by close contours are likely inversion zones, indicating possible subsurface complexity.

Keywords: Weathering layer, Uphole Shooting Static Correction, Average Velocity and Unconsolidated Sediments.

INTRODUCTION

The study area lies between $5^0 24^1$ to $5^0 37^1$ N and $6^0 49^1$ to $7^0 5^1$E in the west of Owerri Municipal , North Eastern part of Niger-Delta Basin (fig1) it covers an area of about 450km^2, drained mainly by River Otamiri and its tributaries. The area is within the Rain Forest belt of Nigeria, with annual rainfall in excess of 2200cm, spread over the year . The peaks are in the months of June – July and September and the lows are between the months of November and February.

Weathering depths and layers can be investigated by a number of applied geophysical techniques such as Electrical Resistivety, Seismic Refraction and Uphole Seismic Reflection. Recent improvement in uphole seismic technique gives an edge over other methods. Uphole shooting is a reliable and acceptable method of determining weathering depth and layers during petroleum exploration..

Apart from petroleum exploration, results of upholes surveys have been widely applied in exact determination of overburden thickness and depth to consolidated layers during mineral exploration and foundation studies respectively.

Robert and Mcbeath, (1979) stated that sediment Velocities usually show small variation, in velocity except where the type of sediment changes quickly, such as with reefs, salts domes and faults. Variations in thickness and velocity of layers are most pronounced near the surface because of the process of weathering which produces a layer of non-homogenous and unconsolidated material at the earth's surface. This layer is called the weathering (or weathered) layer as product of both mechanical and chemical processes. In many areas, weathering depth will represent the groundwater table Dohr, (1976). In addition to the travel time anomalies caused by the variable thickness and velocity of weathering layer, other seismic effects also appear in this layer. A higher rate of energy absorption occurs in the weathered layer than in consolidated sediments.

Seismic shooting in the weathering layer results in low energy penetration of the subsurface for a given source-energy level thus exciting a greater proportion of boundary waves (Parasnis, 1978).

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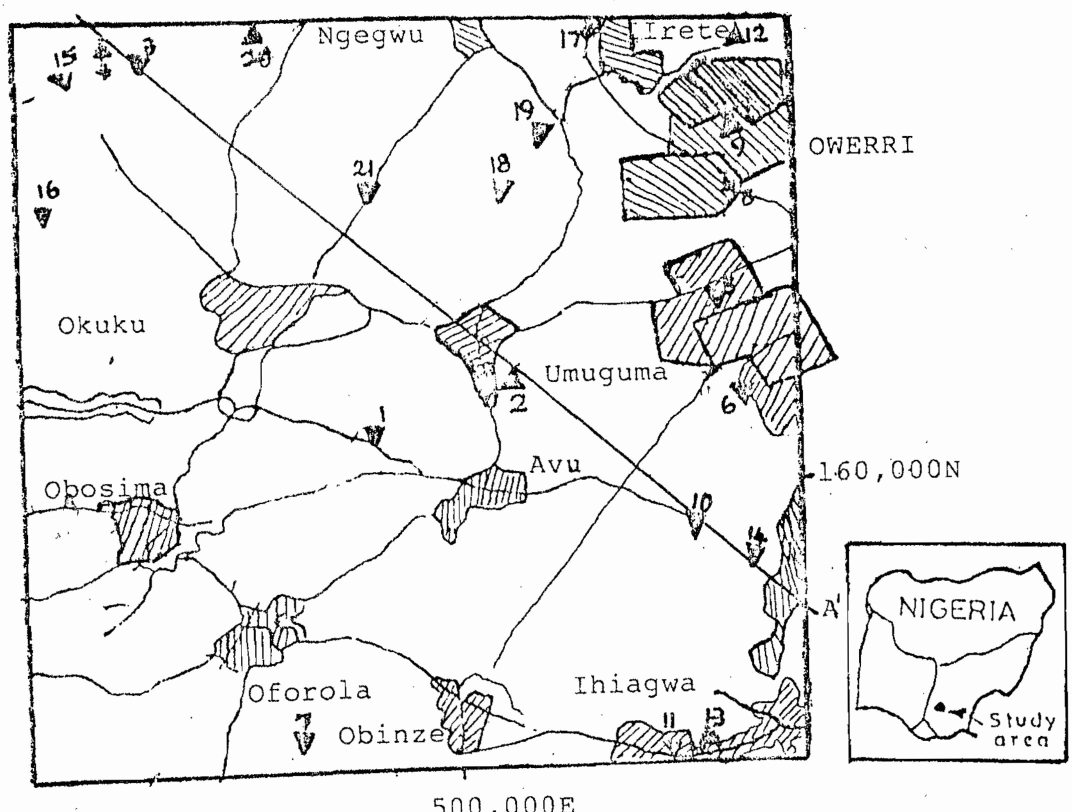


Fig.1, Study area, showing uphole locations (▲)

The total effect reduces Signal-Noise ratio of the records. Because of the above factors, it is most desirable to determine the depth of weathering so that all seismic shooting, for petroleum exploration can be carried out beneath the weathering layer as much as possible (Robert and Mchbeath, 1979. As a rule, the resultant effect of the weathering layer, must be corrected in all seismic data during processing.

According to Dohr, (1976), if 'uphole time' is deducted from the registered time, all extraneous influences that may lie in the layers between detonation point and the earth's surface are removed.

OUTLINE OF GEOLOGY

The study area is underlain by Tertiary sediments, predominatly coastal plain sands known as the Benin Formation (Miocene to Recent). A geologic section across the area from Northwest to the Southeast reveals that the upper 300m of the formation consists of thick Sandy units which grade into clayey sand with gentle dip seawards (Short and Stauble, 1967).

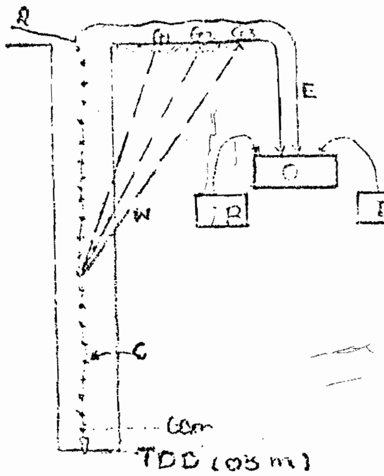
They further described the sand units as mostly coarse grained, poorly sorted and with lenses of fine-grained sands. Reyment (1965) referred to the mode and environment of deposition as mixed continental. From evidence of paleonlological studies, the sediments were transported from hinterland rock weathering process and deposited in shallow water environment during Oligocene and plio-pleistocene time (Onyeagocha, 1980).

DATA ACQUISITION

The Uphole Time field technique was adopted to determine the weathering layer. This is because considerable time can be saved if the correction is made directly from Uphole-Times rather than First-Arrival_Time on the individual reflection traces (Dobrin, 1978).

Data acquisition was preceeded by proper desk study, adequate survey plan and design. A total of 21 uphole stations were used for this study. Each station is located on trace line intercept with the source in a seismic reflection survey. Each uphole is to a total drill depth of 63m using the flush method.

Explosive loading is with the aid of marine rope up to 60m. Three geophones were used on offsets of 1m, 2.5m and 5m from centre of the hole respectively and aligned in a straight line. This allows for recording of three different arrival times, with the extreme offset as control. Both explosives and the detonator caps numbering 24



∅10cm

Fig. 2: Showing uphole shooting field arrangment
R = Maring Rope
C = Detonator Cap
W= Returning Wave
G = Geophone
O = Oyo Recording System
D = Decoder
B = Battery

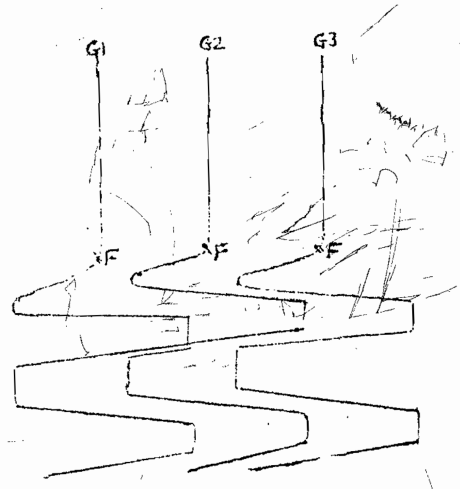


Fig. 3: Showing configuration of recorded waves and First breaks (F).

per hole are lowered to predetermined depths of detonation.

Topographic data which serve as point control are received from both the conventional and Global Positioning System (GPS) with accuracy of 2 in horizontal elevation and 1 in vertical elevation. A zero datum plane is generally considered (Lowrie, 1997). Lithologic samples from well cuttings obtained at 3m depth interval were analyzed to correlate interpretation of uphole data. This technique generated improved seismic signals with adequate bandwidth and strength giving minimal distortion.

The 10cm diameter upholes were drilled by thumping method and finally flushed for at least 20min, to depth of 60m.

DATA PROCESSING

The uphole data was recorded on field worksheets, on diskettes and on papers to safeguard against loss. First breaks were picked from the playback records (Fig. 3) and processed on an Excel spreadsheet.

Time Correction: The 2.5m offset distance and the depth of shotholes were considered, in order to produce the corrected first arrival times. Below is the time correction equation.

Corrected Time (ms^{-1}) = (UHT*0.001)*(SHD/SHD*SHD+OD*OD)^(0.5)*(1000)

where UHT = Uphole Time Measured
SHD = Shot Point Depth
OD = Offset Distance from Centre of hole.

DATA ANALYSIS

Corrected time for all first arrivals is plotted against depth of shot to have a total of 21 Time-Depth graph with lithologic description on one side.

A sample of the Time-Depth graph is as shown (Fig. 4) for uphole #01.

The following points should be noted

1. The points that correspond to the intercepts on the Y-axis defined as D_1, D_2 and D_3 respectively represent the depths.
4. The thickness of the first layer (T_1) is the difference between D_1 and the Datum plane. (Thus 1.8-0=1.8m)
3 Thickness of second layer (T_2) is difference between D_2 and D_1 (Thickness 17.7-1.8=15.90cm)
4. The third layer is not terminated therefore its actual thickness is not known.
5. Average Velocity (V) m/sec

$$\frac{\text{Thickness of Layer}}{\text{Time } (T_2) \text{ of layer-initial Time } (T_1) \times 0.001}$$

6. 1860.0 m/sec was considered as replacement velocity.

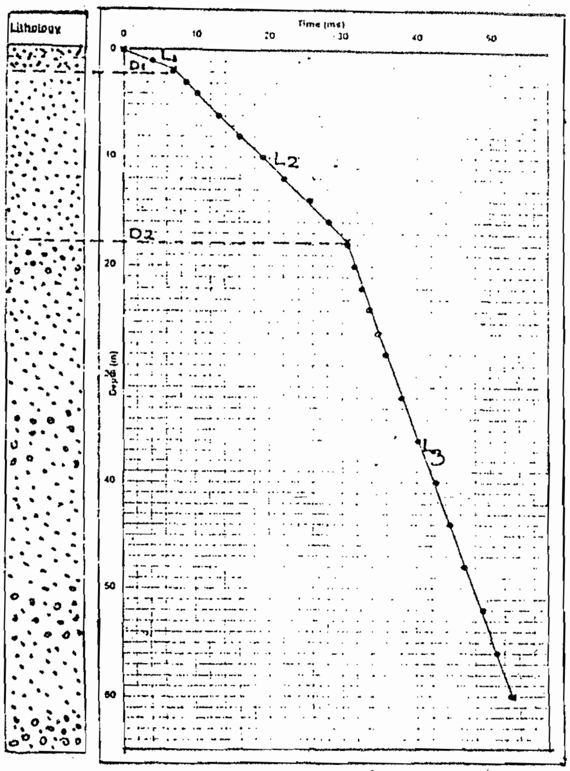


Fig. 4: *Time-Depth Graph and litho Section. L1' = Ferruginized Silty sand, L2 = Sand, L3 = Sand/Gravelbed.*

SUMMARY AND CONCLUSION

The subsurface lithology of the study area is not complex. It consists of a sequence of three sandy units which can be described as follows:

1. A top soil consisting of highly ferruginized sand which is unconsolidated.
2. Unconsolidated and fairly ferruginized sand
3. A medium to coarse grained fairly unconsolidated sand with gravel bed. This has been illustrated in Fig. 4 and Fig. 5 representing cross-sections A-A[1] as in Fig. 1. An isopach contour map representing depth of weathering across the area is produced Fig. 6. From here, further information on subsurface topography of the weathering depth across the area has been translated on the same line of previous sections as X-X_1 Fig.7.

In uphole number 11, only two layers are identified, due to low elevation being near stream valley. The study area has low topography with isolated ridges that have gentle slopes.

The average values for the weathered layer and the weathering layers are 361.60m/sec. 732.99m/sec and 1788.48m/sec respectively,

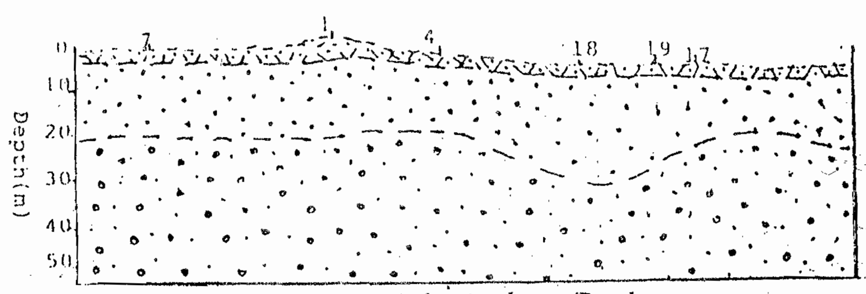


Fig 5: Cross-section A-A showing layers/Depths.

Ferruginised silty sand Sand Sand with Gravel

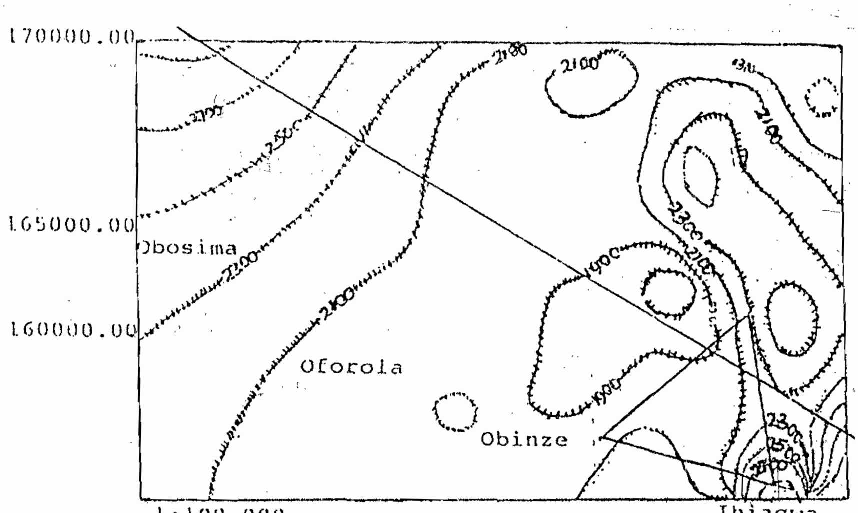


Fig 6: Isopach map, base of weathering

Uphole No	D_1	D_2(m)	D_3(m)	T_1	T_2	T_3	Z_1	Z_2	Z_3	V_1	V_2	V_3	SE
1	1.8	17.7	60.0	1.8	15.9	42.3	54.1	38.2	-4.1	260.87	670.89	1838.8	55.9
2	3.2	15.3	60.0	3.2	12.1	44.7	54.4	42.3	-2.4	347.3	657.6	1856.4	57.57
3	2.1	19.1	60.0	2.1	17.0	40.9	56.0	39.0	-1.9	318.2	658.9	1956.9	58.11
4	4.1	17.9	60.0	4.1	13.8	42.1	55.7	41.9	-0.2	402.0	654.0	1739.7	59.8
5	2.3	22.0	60.0	2.3	19.7	38.0	66.5	46.8	8.8	328.6	654.5	1948.7	68.79
6	2.8	23.7	60.0	2.8	20.9	36.3	63.4	42.5	6.2	335.4	705.1	1928.7	66.19
7	4.0	20.7	60.0	4.0	16.7	39.3	53.3	36.5	-2.7	449.4	670.7	1945.5	57.29
8	5.0	20.1	60.0	5.0	15.1	39.9	64.4	49.3	9.4	500.0	705.5	1789.2	69.40
9	3.8	16.0	60.0	3.8	12.2	44	62.3	50.1	6.1	469.1	674.0	1833.3	66.12
10	4.8	24.2	60.0	4.8	19.4	35.8	58.9	39.5	3.7	484.9	673.6	1945.6	63.72
11	3.3	60	-	3.3	56.7	-	35.4	-21.3	-	370.8	1817.3	-	38.71
12	2.0	18.1	60.0	2.0	16.1	41.9	69.4	53.4	11.4	253.2	710.6	1923.8	71.43
13	2.7	11.9	52.1	2.7	9.2	40.2	44.0	34.8	-5.4	351.9	708.5	1950.0	46.74
14	3.2	16.0	60.0	3.2	12.8	44.0	51.6	38.8	-6.2	363.6	646.5	1921.4	54.79
15	3.3	22.1	60.0	3.3	18.8	37.9	67.6	48.8	10.9	379.3	688.6	1839.8	70.88
16	5.0	10.0	15.0	5.0	5.0	5.0	65.4	45.0	7.87	290.0	650.8	193.8	67.87
17	4.7	17.9	60.0	4.7	13.2	42.1	81.2	48.0	5.9	479.6	663.3	1871.4	65.94
18	4.8	26.6	60.0	4.8	21.8	33.4	64.6	42.8	9.4	393.4	719.5	1964.7	69.41
19	4.6	23.6	60.0	4.6	19.0	36.4	63.4	44.4	8.0	442.3	701.1	1784.3	67.95
20	5.0	10.0	15.0	5.0	5.0	5.0	55.4	38.48	0.08	0.00	0.00	0.00	60.08
21	4.5	19.8	60.0	4.5	15.3	40.2	57.0	41.7	1.5	416.67	653.9	1810.8	61.46

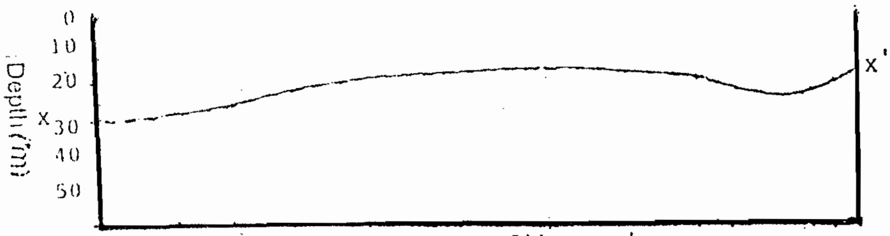


Fig.7; Weathering depth profile X-X'

confirming the effects of weathering and depth on seismic velocity.

The thickness of weathered layer on the North-East of Niger Delta of which the study area is part, varies from location to location but with an average of 3.5m and 361.60m/sec as average velocity. The sub-weathered layer with average thickness of 21.77m has average velocity of 732.99m/sec. The average velocity of the layer representing the base of weathered layer is 1788.48m/sec approximately.

The area around Ihiagwa marked by close contours requires further investigation. This may be multiple reflection, due to sub-surface complexity associated with structural or stratigraphic disposition, which Lang (1981) referred to as inversion zone. The sudden increase in weathering depth across this zone(Fig.7) suggests relatively high porosity and permeability. Based on this finding, it is advisable to disallow disposal of refuse within the vicinity to avoid groundwater pollution. This is important since the characteristic shallow water table of this zone provides for the use of shallow hand-pump water boreholes.

Such zones will require deeper cement grouting at the near surface horizon during construction of any water borehole.

The understanding of weathering depth across a given area is very helpful in road construction.

Zones with relatively deep weathered depth along profile of a road under construction therefore requires specific foundation treatment. Persistent road failures within Owerri area and other parts, North-East of the Niger Delta can be said to occur at such zones. A more detail research is already proposed on the implications of weathering depth to Groundwater development, Highway and Environmental Engineering.

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REFERENCES

Dobrin, M.B. and Savit, C.H., 1988. Introduction to Geophysical Prospecting (4th ed), McGraw-Hill NY.

Dohr, G., 1976. Geology of Petroleum, Applied Geophysics in Introduction to Geophysical Prospecting Pitman pyb. Vol. 1

Lang, D.P., 1981. Seismic Field Technology And Quality 1 :15-23.

Lowrie, W., 1997. Fundamentals of Geophysics Cambridge University Press.

Onyeagocha, A.C. 1980, Petrography and Depositional Environmental of the Benin Formation. Nigeria Journal of Mining and Geology. 17(2):142 –151

Parasnis, D.S., 1978. Principles of Applied Geophysics 3rd Edition Science Paperbacks.

Reyment, R.A., 1965. Aspect of the Geology of Nigeria. Robert, G. McBeath 1979; Static Correction; The near surface Introduction to Seismic Data processing part II.

Short, K.C. and Stauble, A.I., 1968. Geol. Mag. Vol. 105.