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Seismic Refraction Investigation Of Western Part Of The Federal University Of Technology, Gidan Kwano Campus, Minna, Niger State.

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Abstract

A seismic refraction investigation of western part of the Federal University of Technology, Gidan Kwano Campus, Minna, Niger State was carried out. This survey was carried out along six major profiles covering a total area of about 125,000m² using a portable three – channel seismic signal enhancement seismograph. Careful interpretation of the seismic data obtained shows two geologic sections within the survey area. The first layer or top soil has a velocity that varies between 716.33ms^{-1} and 2024.29 ms^{-1} with an average value of 1237.86 ms^{-1}. This corresponds to dry sand, clay and gravel. The second layer is the refractor layer whose velocity ranges, between 1935.36 ms^{-1} and 7485.03 ms^{-1} with an average value of 4581.67 ms^{-1} and has an average depth of 4.74m. The wide range of velocity variations can be attributed to the in-homogeneity of this region. This shows that the refractor layer's lithology composed of Granites. The sites that are appropriate for the sinking of borehole are at the north–east and north – west portion of the survey area. The aquifer systems have the characteristics of 100m width, 6.6m depth and thickness of 2.4m in the north–east and 2.8m in the north-west. And the site most appropriate for high–rise building is at the south-western part of the survey area with a shallow depth of 1.88m.

Keyword: Seismic refraction, Seismograph, Refractor Depth, Velocity, Lithology and Aquifer.

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Introduction

The growth of any community is a function of availability of basic infrastructural needs like water, roads, electricity and industries among others. Ground water is of significant importance to Northern Nigeria where the amount of rainfall is limited to very few months of the year with annual rainfall of 1000-1500mm [Eduvie, 1998], and surface water sources are often inadequate or non existent [Baimba, 1978 and Perez and Barber, 1965]. There is need for scientific identification of parameters governing ground water resources occurrence, assessment and management, particularly if satisfactory living conditions of the inhabitants are to be met. The F.U.T Minna has relocated three out of four schools or faculties from Bosso Campus to Gidan Kwano Campus. Consequently, there would be an increasing demand for portable water supply to complement the existing one on campus, and the need to delineate the areas that would be suitable for civil-environmental development. Therefore, there is need to conduct hydro-geological and geophysical studies of the area to identify possible sites for ground water development and areas suitable for erection of high rise buildings.

The Federal University of Technology (F.U.T), Gidan Kwano Campus, Minna, is located at Km 12 along Minna-Kateregi Bida road. The study area is located within the Gidan Kwano campus and is about 1.8 km away from Minna-Kateregi Bida road, directly behind the student hostel, Figure 1. Federal University of Technology, Gidan Kwano Campus, Minna, is part of Minna NW sheet 42, on a scale of 1:250,000. It lies between latitude 9^{0}28'N and 9^{0}37'N and longitude 6^{0}23'E to 6^{0}29'E. The site covers an area of about 100,000 hectares with three defined sectors; North, Central and Southern sectors [Works Department, Federal University of Technology, Minna, 1983]. The study area is displaced from a minor road that passes besides girls' hostel block which is about 65m south of the road and covers 500m x 250m as shown in Figure 1.

The rock types found in the study area are believed to be part of the older granite suite and are mostly exposed along the river channel

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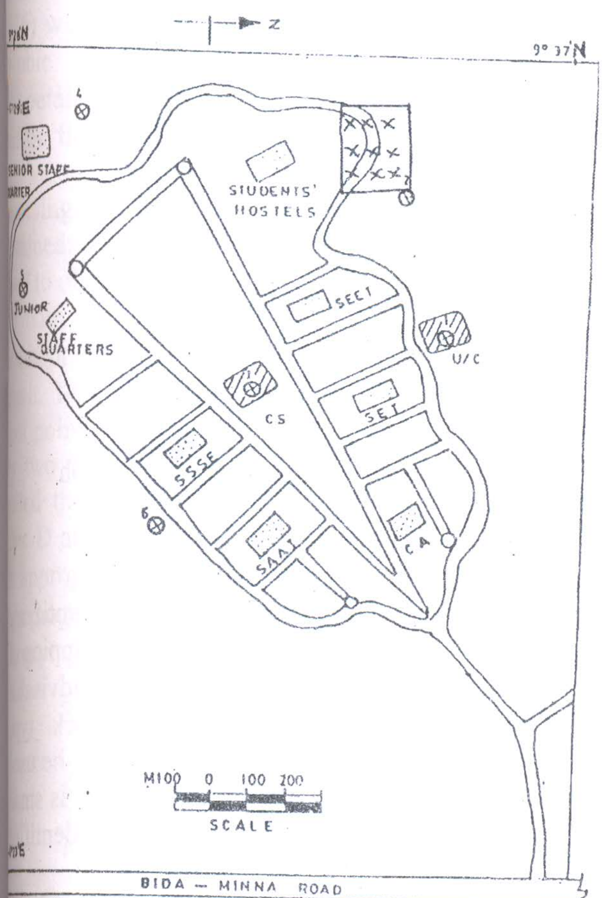
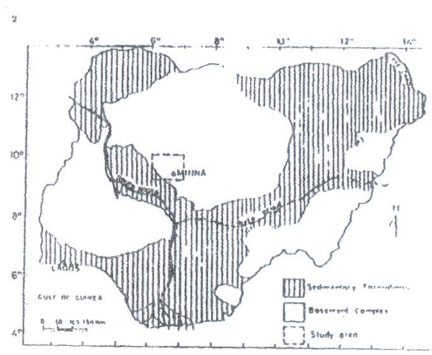
re they appear in most cases weathered ensi *et al*, 1986]. The major rock types are phyritic, medium to fine grained granite esoye, 1986 and Adeniyi, *et el*, 1998]. The lts of the borehole log from the area show the area has a good potential for ground er development [Jimoh, 1998].

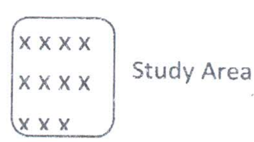
geophysical method used in this survey is seismic refraction method because it is stantially less expensive compared to ection, particularly when used as onnaissance tool in frontier area like the of this survey. The seismic method is by the most important geophysical techniques terms of expenditure and number of geophysicists involved. The predominance of the seismic method over other geophysical methods is due to various factors, the most important of which are the high accuracy, high resolution and great penetration of which the method is capable. Furthermore, dramatic advances in seismic recording and data processing have improved the ability of the seismic method in overcoming the problem of interference from noise. Also seismic refraction method is best suited for groundwater search and civil engineering work. These are the basic reasons why it is considered suitable for this survey (Telford, et al, 1976).





(Udensi *et al*, 1986)

KEY



re 1: Map of Federal University of Technology, Gidan Kwano Campus, Minna. Showing the Location and Accessibility of the Study Area and The Geologic Map of Nigeria (Adesoye, 1986).

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Data Collection

The instrument used in this survey is the three-channel enhancement seismograph. As shown in figure 2, the survey area was covered by six traverses profiles, each 500m long and spaced 50m apart. Eleven-shot points were recorded on each profile. The wave was generated using hammer with a block metal plate. At each shot point the arrival times for each of the geophones were recorded. Successive shots were taken at uniform intervals along each line and successive detector spreads are shifted about the same distance as the corresponding shot points in order to keep the range of shot-detector distance approximately the same for all shots. This arrangement is chosen such that the first arrivals will be refracted from formations of interest such as basement.

Since the seismograph used is three-channel, the three geophones were laid three times for each shot point with 5m interval, so that at each shot point a total distance of 45m was covered and nine geophones reading were recorded.

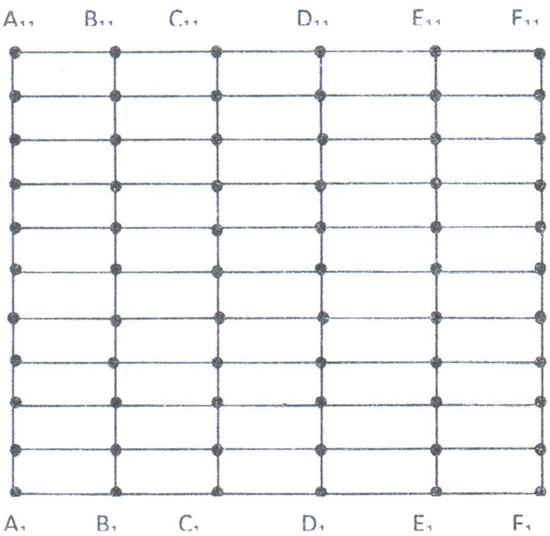

Figure 2: The survey Layout

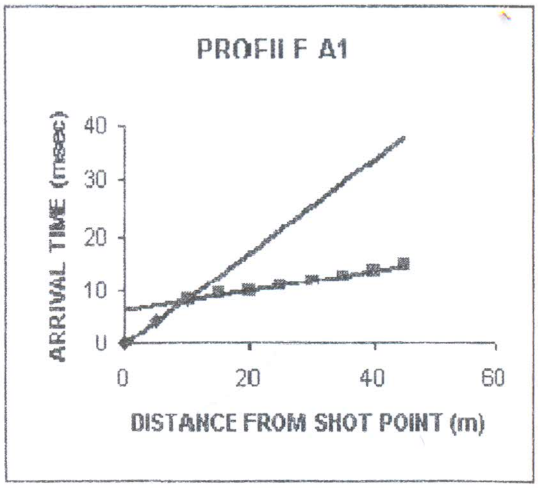

Figure 3: A typical time distance graph

(Sources: The Author)

Data Analysis

The velocity of seismic wave in a homogeneous solid medium is a function of the elastic constants and the density of the materials making up the medium (Gardner, *et al*, 1974).

From Table1 below, seismic velocity information can be correlated with rock type and can therefore be used in identifying subsurface materials. Due to the overlapping of velocities for different rocks, it is not advisable to restrict the identification of rock type exclusively on velocity. It can however be used in a small area where range of velocity is small and therefore certain rocks can be identified based on velocity.

le 1: Measured seismic velocity in rocks (Telford et al, 1976)

ROCK TYPE	VELOCITY
LLUVIUM	350 – 2000
LAY	UP TO 2500
RY SAND/GRAVEL	500 – 1000
NDSTONE	1000 – 4300
MESTONE	1700 – 4200
HALE	1000 – 4300
RANITES	UP TO 7700
ETAMORPHIC ROCKS	3000 – 7700

e processing of the data is often based on the st arrivals, since it permits accurate erpretation and easy recording of their travel nes. The Wyrobek method (Telford, et al, 76) was used to analyze the data. This uses phic aids to facilitate the routine mputations. Based on the Wyrobek approach d on the field data, a plot of the travel time) versus the detector position of all the ceiving stations along each traverse was tained. The slopes of these graphs were then ed to obtain the average velocities, V_1 and V_2 r both the first layer and the refractor. The ercept time was also determined from the aph. To obtain the depth to refractor at each ot point, the intercept time above is divided two to give the half-intercept time often lled the delay time D. Values of the delay me D at each shot point is thus multiplied by appropriate factor F to obtain the depth. For homogeneous overburden as assumed for this rvey:

$$\text{Slope} = \frac{\text{Changein time}}{\text{Changein distance}}$$

$$V = \frac{1}{slope}$$

This procedure is carried out for all the ot points to obtain V_1 and V_2, the velocities f the first layer and the refractor respectively. hese two velocities along with the intercept time yield depth to refractor as giving in the equation below

$$Z = \frac{T_i}{2} \cdot \frac{V_1 V_2}{\sqrt{\left(V_2^2 - V_1^2\right)}}$$

Data Interpretation

Interpretation of Survey Profiles

The most important parameters to be used in interpretation of this survey work is the velocity. This is the rate at which the acoustic energy propagates through the various units of the sub surface. This seismic velocity information within certain limits is converted into rock type in an attempt to identify the sub surface materials. The time distance graph was plotted (using Excel package). Figure 3 is a sample of the resulting time-distance graph plotted with data from shot A_1. The graphs show a two-layer case. The slopes of the two layers were calculated, and the inverse of the slopes gives the values for V_1 and V_2. The depth to refractor was also calculated using the relation in the above equation. This was done for all the shot points.

For example, table 2 shows a two-layer case for profile A. The velocity of the first layer V_1 varies from 716.33 m/s to 1538.46 ms^{-1} with an average of 1149.70 ms^{-1}. The second layer velocity varies from 1935.36 ms^{-1} to 6666 ms^{-1} with an average of 4616.93 ms^{-1}. The depth to refractor varies from 3.7 m to 6.62m with an average of 4.60m. This process was repeated for all other profiles, however, following this process, summary table; table 3, 4 and 5 were obtained.

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Table 2: Interpreted Parameters along Profile A (Sources: The Author)

SHOT POINT	FIRST LAYER VELOCITY V_1 (M/S)	REFRACTOR VELOCITY V_2 (M/S)	DEPTH TO REFRACTOR Z(M)
A1	1190.48	5405.41	4.27
A2	1149.43	4906.77	4.73
A3	716.33	3145.64	6.62
A4	1204.82	6622.52	3.98
A5	1176.47	1935.36	3.70
A6	1111.11	4570.38	4.87
A7	1176.47	3236.25	5.05
A8	1538.46	6666.67	3.95
A9	1086.96	3571.43	4.91
A10	1315.79	5476.45	4.07
A11	980.39	5249.35	4.49

Interpretation of Contour Maps.

Table 3, shows the summary of the first layer velocity for all the profiles. Based on the values on this table, the first layer velocity throughout the entire survey area varies between 716.33 ms^{-1} to 2024.29 ms^{-1}. It is clear from Table 1 that the velocity values obtained for the first layer over the entire survey area can be easily correlated with the materials found in the superficial layers. It was also observed on the field that this superficial layer is composed of clay, dry sand and gravel.

The contour map of the first layer velocity V_1, figure 4.1 was produced by the use of surfer 8 contouring package.

Figure 4.1 show that there are closures around the fourth and six shot point on the third profile (i.e. around north, south and central portion of the survey area). We can also observe some closures at the boundaries of the entire area. The points marked H are the areas of high closures at the centre of which we obtain the highest velocity. Also the point's marked L are point of low closures.

Table 3: First Layer Velocity, V_1 (m/s) (Sources: The Author)

Short point	PROFILES					
	A	B	C	D	E	F
0	1190.48	1666.67	1111.11	1582.28	1492.52	961.54
50	1149.43	1234.57	1190.48	1492.54	1219.51	1488.10
100	716.33	1369.86	909.09	1201.92	1388.89	862.07
50	1204.82	1052.63	2118.64	847.46	1412.43	1510.57
200	1176.47	1666.67	1366.12	877.19	1428.57	1201.92
250	1111.11	1190.48	2024.29	1333.33	847.46	1000
300	1176.47	869.57	1538.46	740.74	1392.76	1250
350	1538.46	1250	1052.63	1052	1084.60	1312.34
400	1086.96	1250	1187.65	1146.78	1666.67	1428.57
450	1315.79	1063.83	934.58	1250	1282.05	1250
500	980.39	1176.47	1000	847.46	1388.89	1587.30

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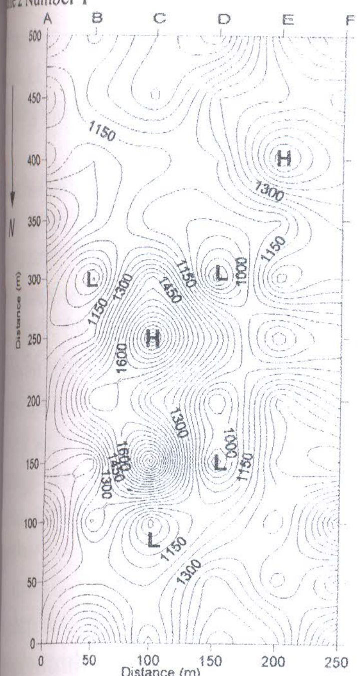

Fig 4.1: Contour map for first layer velocity
(Contour Interval is 50m)

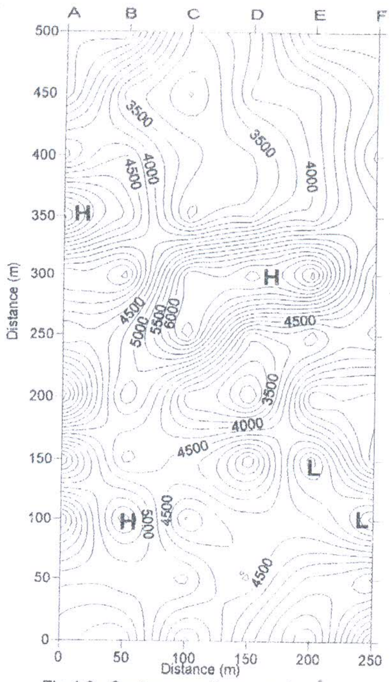

Fig 4.2: Contour map for second layer velocity
(Contour Interval is 250m)

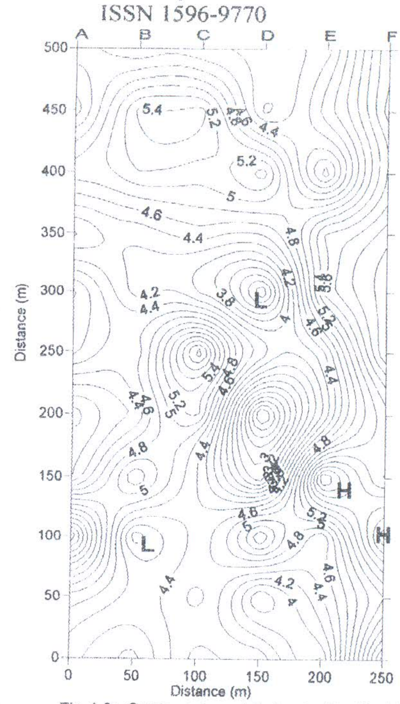

Fig 4.3: Contour map of Refractor Depth (z)
(Contour Interval is 0.2 m)

(Sources: The Author)

...values in table 4 shows the velocity of the ...d layer throughout the survey area, it vary ... 1935.36 ms^{-1} to 7485 .03 ms^{-1}. The ...ur map for V_2 (second layer) was ...ned, figure 4.2.

The points marked H on this contour map are the areas having high velocities. The points marked L are the areas of low velocities. High concentrations of closures were also observed around the eastern and western portion of the survey area.

...e 4: Second layer velocity V_2 (ms^{-1}) (Sources: The Author)

...t	PROFILES					
	A	B	C	D	E	F
0	5405.41	5770.34	3623.19	5109.86	6305.17	3544.84
...0	4906.77	4837.93	5096.84	4217.63	5330.49	5834.31
...00	3145.64	5973.72	3680.53	4374.45	4293.69	3076.92
...50	6622.52	4130.52	4714.76	6049.61	3271.18	5931.20
...00	1935.36	5216.48	3293.81	2431.32	5800.46	5668.93
...50	4570.38	4784.69	6706.91	3541.08	3573.93	3906.25
...00	3236.25	2828.05	6480.88	6666.18	7485.03	4116.92
...50	6666.67	4995.00	2888.50	3468.61	4081.63	4965.24
...00	3571.43	4516.71	3397.89	3240.44	4078.30	5599.10
...50	5476.45	3317.85	2707.83	4078.30	4154.55	5030.18
...00	5249.34	5476.45	3204.10	3810.98	5518.76	5405.41

The depth to refractor contour map figure 4.3 was obtained from table 5. The overburden depth ...s from 1.88m to about 6.66m with an average of 4.72m over the entire survey area.

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Table 5: Depth to the refractor (Z) in m (Sources: The Author)

Shot point	PROFILES					
	A	B	C	D	E	F
0	4.27	3.92	4.67	3.40	3.76	6.50
50	4.73	4.34	4.28	3.59	4.38	5.38
100	6.62	3.87	4.46	3.53	4.40	6.58
150	3.98	5.40	4.36	3.00	6.66	5.36
200	3.7	4.22	5.25	1.88	4.05	5.53
250	4.87	4.48	3.80	4.32	5.85	6.42
300	5.05	5.6	3.96	2.79	3.60	6.30
350	3.95	4.26	4.52	4.42	5.63	6.12
400	4.91	5.20	5.07	5.52	5.70	5.62
450	4.07	5.45	5.48	3.94	4.72	5.9
500	4.49	4.20	4.21	4.13	4.31	5.81

The points marked H on it are indicating the areas with the high depth to the refractor. The points marked L are the areas where the low depths to the refractor were observed. High concentrations of closures were also observed around the western, portion of the survey area.

Discussion

The time-distance graphs show two geologic sections throughout the entire survey area. The first layer velocity ranges from 716.33 ms^{-1} to 2024.29ms^{-1} (Table 3) and the refractor layer of seismic velocity ranges from 1935.36m5 to 7485.03 ms^{-1} (Table 4). The wide range of velocity variations can be attributed to the in-homogeneity of this region. The range of the first layer velocity indicates that the principal constituents of the rock found in the first layer are clay, dry sand and gravel. The proportions of these deposits vary at the various shot points within the survey area. The velocity variation is reflected in the contour map of figure 4.1. The existence of several closures both high and low is an indication of in-homogeneity at the first layer. The high velocity closures may be as a result of variation in consolidation rather than lithological differences. It is also confirmed from geologic point of view that the variations in the level of consolidation at the various shot points, may be responsible for the differences in the seismic velocities witnessed throughout the entire survey area.

Considering the contour map of the refractor velocity (figure 4.2), it is observed that at the south-west portion of the survey area we have high closures. It can also be observed at north-eastern part of the survey area. The positions marked H on the contour map (figure 4.2) indicates high closures. The points marked L on the north-west portions of the survey area, indicates the areas of low closures. The velocity variation is reflected in the contour map of figure 4.2. The existence of several closures both high and low is an indication of in homogeneity at the refractor layer. The high velocity closures may be as a result of variation in consolidation rather than lithological differences.

The contour map of the depth to refractor (figure 4.3) also shows closures indicating variations of depth to the bedrock. High concentrations of closures are observed along the Eastern and western margin of the contour map. The positions marked H on the contour map corresponds to the area having the maximum depth to the refractor and the points marked L are the areas of lower depth to the refractor. The depth variation is reflected in the contour map of figure 4.3. The existence of several closures both high and low is an indication of in-homogeneity of the depth to efractor. The high depth closures may be as a esult of variation in consolidation rather than ithological differences.

Conclusion

Two geologic sections were detected and delineated in the survey area. The respective velocities of the two sections are from 716.33 ms^{-1} to $2024.29ms^{-1}$ for the first layer and from 935.36 ms^{-1} to $7485.03m^{5-1}$ for the second layer. The range of depth to refractor within the survey area is between 2.79m to 6.66m with an average depth to refractor of 4.74m. All the above-mentioned parameters combined together led to the conclusion that the refractor is mainly composed of granites, when compared to the standard values in Table1. The variations in concentrations of these parameters are shown in the contour maps of figure 4.1, 4.2 and figure 4.3. All these variations were as a result of geologic processes such as weathering that is taking place continuously.

The area that is most suitable for sinking of borehole was detected in profile A and profile E. The best area for the location of high-rise building was detected in profile D (all, which can be seen in figure 4.3).

Recommendation

The University is situated on a wide expanse of land most of which is yet to be developed. This calls for more geophysical surveys with a view to identifying suitable areas for various development projects on the campus. With such surveys, reliable geophysical information about sites will be known. This will save the management a substantial amount of money in terms of borehole construction and location of buildings of different capacities and also ensures their optimal performance.

Although aquifers have been identified in profile, A and E other reliable geophysical method such as electrical survey can be used to support this claim. This is often necessary to avoid waste of funds.

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