DEPTH AND VELOCITY ESTIMATES FROM SEISMIC WAVES REFRACTION PATHS AT EBONYI STATE UNIVERSITY STAFF SCHOOL, ABAKALIKI, NIGERIA

Agha, S. O.
Dept. of Industrial Physics
Ebonyi State University
Abakaliki, **NIGERIA**

Agha, C.
Dept. of Industrial Mathematics
Ebonyi State University
Abakaliki, **NIGERIA**

ABSTRACT

Depths of refractors and velocities of beds have been estimated for crustal layers at Ebonyi state university staff school, Abakaliki, Nigeria through seismic refraction surveying. The study area is located on the Abakaliki anticlinorium (latitude $6^0 17^{'}$N-$6^0 20^{'}$N; longitude $8^0 05^{'}$E-$8^0 20^{'}$N) situated within the sedimentary basin of south eastern Nigeria. The instrumentation used consists of a digital - type signal enhancement seismograph, electromagnetic - type compressional wave geophones, geophone cable,hammer, metal plate, piezoelectric starter and measuring tape. The objective of the survey was to obtain information on the seismic velocities and thickness of beds at different depths which would be useful for engineering and hydrogeological purposes in the area. Three locations within the staff school were surveyed and three layers of the subsurface were delineated in each location by the waves. The result showed that the average compressional wave velocity for the first three layers from the earth's surface were 575m/s, 971m/s and 2593m/s for the first, second and third layers respectively. These layers were interpreted to be made up of sandy clay, moist clay and limestone accordingly. The depths to the horizons measured from the surface of the earth were estimated to be 6m and 12m for the first and second refractors respectively.

Keywords: Anticlinorium, sedimentary basin, piezoelectric, hydrogeological.

INTRODUCTION

Seismic prospecting is directed primarily at finding the depth to horizons and the seismic velocities of sub-surface rock layers (Kearey and Brooks, 1991). It is broadly divided into two viz reflection and refraction seismics.

In reflection seismology, seismic signals are produced at a known place at a given time, and the echoes reflected from the boundaries between rock layers with different seismic velocities and densities are received and analyzed. Compactly designed robust electromagnetic seismometers or geophones are spread in the region of sub-critical reflection within the critical distance from the shot point, where no refracted arrivals are possible. Beyond the critical distance however, both reflection and refraction are possible (Lowrie, 1997).

Refraction ray paths are not always as easy to predict as reflection paths. It may not be obvious that in a layered earth, rays refracted along the tops of the high –speed layers travel down to them from their source along slant paths, approach them at the critical- angle, and return to the surface along a critical –angle path rather than along some other path (Dobrin,1976).

However, the method of refraction seismology is hereby presented for the case of a flat horizon between two beds (Fig.1). Let the depth to the horizon be d and the seismic velocities of the upper and lower beds be V_1 and V_2 respectively ($V_1 < V_2$). The direct ray from the shot point at

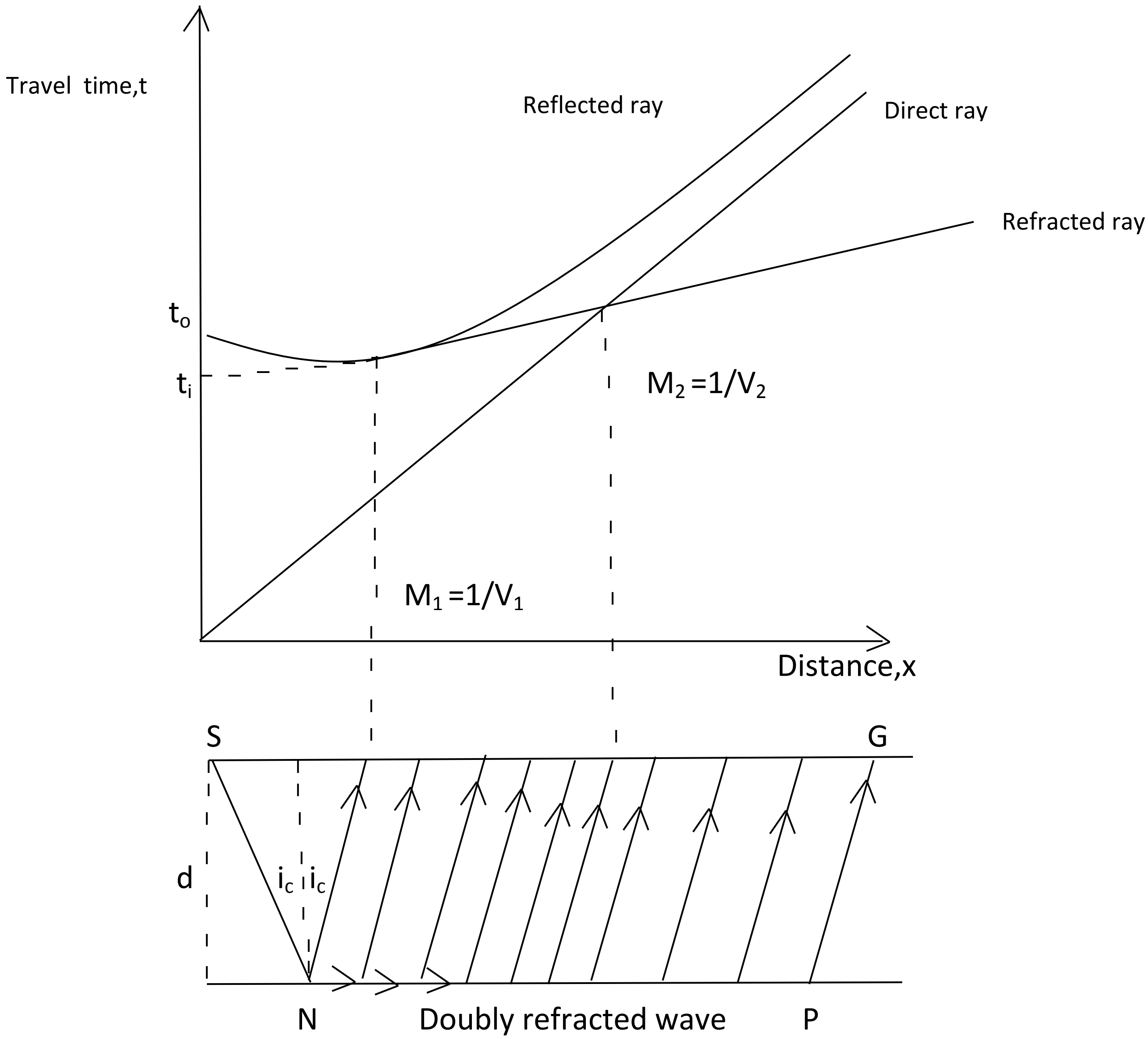

Fig.1: T-X curves showing the direct, reflected and refracted rays at a horizontal interface between two beds with seismic velocities,V_1 and V_2 ($V_2 > V_1$) (After Lowrie,1997).

S is recorded by a geophone G at an offset, x on the surface. The travel time, t versus distance, x (i.e t-x) graph is a straight line through the origin with slope, $M_1 = 1/V_1$. For the reflected ray, the t-x curve is the hyperbola whose intercept with the vertical axis is $t_{o,}$ the echo time. The doubly refracted ray propagates along the path SN with speed, V_1 of the upper layer, impinges with critical angle, i_c on the interface at N passes along the segment NP with velocity V_2 of the lower layer and returns to the surface along PG with velocity ,V_1.The travel time for this ray also called head wave is given by

$$t = \frac{}{V_2} \quad \frac{}{V_1} \qquad \text{.....................(1)}$$

Equation (1) means that a graph of t against x is a line with slope $=1/V_2$ and vertical intercept, t_i given by

$$t_i = \frac{2d}{V_1} \cos i_c \text{.........................(2)}$$

(Lowrie, 1997)

Thus, both the depth, d and seismic velocity, V of underlying layers can be deduced. The refraction ray paths of seismic compressional waves were utilized at the premises of Ebonyi state university staff school, Abakaliki to estimate the depths of interfaces and velocities of the beds for engineering and hydrogeological applications.

LOCATION AND GEOLOGY OF STUDY AREA

The Ebonyi state university staff school (Nursery/Primary), sited at the main campus of the university is located within the Abakaliki anticlinorium (latitudes 6^0 17´ - 6^0 15´N and longitudes 8^0 05´ - 8^0 20´E whose stratigraphic succession consists basically of the Lower Cretaceous(Albian) Asu River Group. The study area is part of the Southeastern Nigerian sedimentary basin. The oldest sedimentary rocks in the basin are Cretaceous sandstones, shale and limestone. Due to the lithology and the geo-structural framework of the area, the hydrogeology is intriguing. The zone of saturation in the shales is usually shallow(lower than 65m) and occurs only in areas with a fair network of joints, fractures or fissures(Kogbe,1989).

MATERIALS AND METHOD

The materials used in the study include a 3- channel signal enhancement seismograph, P-wave geophones, sledge hammer/metal plate, hammer cable, geophone cable and piezoelectric starter and measuring tape. The method employed was the seismic refraction method. A compressional wave source was used and twelve electromagnetic geophones were coupled to the ground along a straight line at uniform intervals of 5m.The geophones were connected to the seismograph through the geophone cable. One end of the hammer cable was connected to the seismograph and the other to the sledgehammer through the piezoelectric starter. The sledgehammer was used to hit the metal plate to provide enough seismic energy needed to propagate into the ground. The ground vibrations due to the hammer's blow were detected by the geophones. The survey was conducted in three locations within the study area and the profile length was 60m.Both the forward and the reverse profiles were run. Arrival times, t of the primary waves and offsets(x) of geophones from the shot were measured and recorded.

RESULTS AND DISCUSSIONS

Fig. 2 shows a typical t-x curve from the study area. At location 1, the p- waves delineated three layers whose seismic velocities were 400m/s for the first layer, 783m/s for the second layer and

2730m/s for the third layer. The depths to the refractors were 5.9m for the first refractor and 18.5m for the second refractor.

At the second location, depth to the refractors(first and second) were 5.om and 18.om respectively while the velocities of the first three layers from the earth's surface were 742m/s, 1360m/s and 2700m/s respectively.

At the third location, the depth to the refractors (1st and 2nd)were 7.1m and 11.5m respectively.The seismic velocities were 583m/s, 722m/s and 2348m/s for the first, second and third layers from the surface respectively. Table 1 shows a summary of the refractor depths and velocities of layers in the three locations surveyed.

CONCLUSSION

From the foregoing, the average depths to the refractors in the study area therefore are 6.0m and 12.0m for the first and second refractors. The average P-wave velocities estimated to be 575m/s, 971m/s and 2953m/s for the first, second and third layers from the earth's surface respectively. The probable lithologies of the layers are therefore sandy clay, moist clay and limestone for the first, second and third beds respectively.

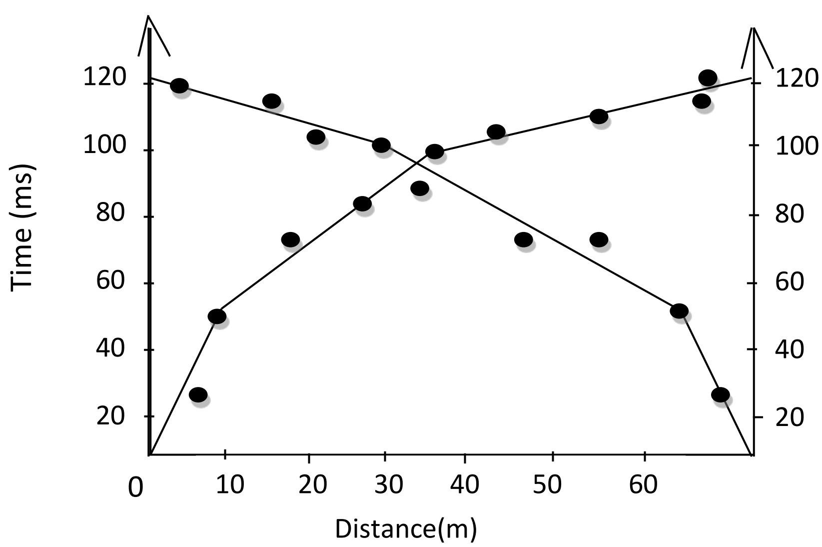

Fig 2: A typical t-x plot from the study

ISSN 2056-5860

Table 1: Refractor depths and seismic velocities at various locations in the study area

LOCATION	REFRACTOR DEPTH		SEISMIC VELOCITY		
	d_1(m)	d_2 (m)	V_1(m/s	V_2(m/s)	V_3(m/s
1	5.9	18.5	400	783	2730
2	5.0	18.0	742	1360	2700
3	7.1	11.5	1583	722	2348

REFERENCES

Dobrin, M. B. (1976). An introduction to geophysical prospecting(1st ed.), McGraw-Hill Book Company, New York.

Fowler, C. M. R. (1990).The solid earth: an introduction to Global Geophysics, Cambridge University press,Cambridge.

Kearey, P. & Brookes, M.(1991). An introduction to GeopysicalExploration (2nd ed.),Black well scientific publications, Oxford.

John, J . R. (1979). Physical Geology (3rd edition), McGraw-Hill, New York. PP.193-215

Kogbe, C. A. (1989).The Geology of Nigeria. Rock View Limited, Jos, Nigeria.