Geophysical Investigation of A Suspected Gold Mineralized area of Minna Sheet Using Seismic Refraction Method

Salissou, M.D, Udensi, E.E and Jonah, S.A

Department of Physics, Federal University of Technology, Minna.

Abstract

This study is concerned with the investigation of quartzites of the eastern Minna along Tagwai Dam road. The study area is located within the Nigerian basement Complex. The specific rocks encountered include some schist, quartzite with alluvium along the streams existing over the survey area. Refraction survey was conducted over half (½) km2, along profiles trending north south. A total of 36 seismic lines of 60m each were shot. Data were recorded and analyzed. The analysis was based on the study of velocity pattern from the graphs obtained from the field data. Two layers were identified, the first with velocities 1785 m/s to 2702m/s and the second layers have velocities ranging from 4347 m/s to refractor is situated at a depth of about 9m. The first layer (Overburden) with an average seismic velocity of 2243 m/s is composed of mainly laterite and quartzites in a sandy-clay soil, and extends to an average depth of 9.83m, the variation of the seismic velocities within this layer is due to the variation in lithology, together with their concentration and consolidation. Alluvial fans are believed to exist in this layer from the analysis of the results.

The trending direction of the velocity pattern in the first and second layer is about north south, which is conformable with the quartzites formation trend and the regional direction of the major faults. The delineated areas containing alluvium deposit are located within the first seismic velocity pattern, along the western part of the study are and constitute the area of expectation alluvial gold.

Aims and objectives of Study

The present study at determining the varieties of the shallow layers and the refractor depths so as to get structural information on quartzite deposit and some buried materials in relation to gold materialization. The determination of the velocity trending materials in relation to gold materialization. The determination of the velocity trending direction is of prime importance as the alluvial gold has some spatial relationship with the northeast, southwest to north direction. The present study is also concerned with the identification of the stratigraphic units recognized in the area based on the simulation of seismic velocities with the known geological materials over the study area.

The Geology of the Study Area

The study area (figure 1) is part of a much larger area mapped by Russ. (1957). He established the main rock types to be the older granite, schist and magnetite-gneiss complex, and concluded that the low-grade schist which have been subsequently described as meta-sediments by Oyawoye (1964) and younger meta-sediment complex. The schist belts in the Kaschirki area have been divided by Grant (1978) into older structural complex assemblage and younger assemblage with simple structure.

Alluvium is found in most of the water courses varying in thickness from the thin cover of the sand in the smallest stream to more than 15m thick along the valley for the Kaduna River and probably over 80m thick in part of the River Niger (Ajibade, 1980). Coarse sands are mostly near the source of the River which are exposed (Ajibade, 1971).

Fig. 1: The geology of part of Minna sheet 164SW

The superficial deposits overlying the basement complex are believed to be products of accumulation cycle (Wright and McCurry, 1970) these consists of laterite, alluvial sand, and silt clay. A stratigraphic succession of Nigerian Basement Complex is as shown in Table 1.

Table 1: Strangraphic succession of Nigeria Basement Complex

Recent tertiary	Superficial deposits	Laterite alluvial sand silt and clay gravel
Cambrian to upper pre-Cambrian	Metasediments	Phyllite pelitic schists quartzites hornfelsed schists, amphibolite and calcareous rock
[illegible]	Crystalline igneous complex [illegible]	Migmatite gneiss leucogranite [illegible]

Alluvial Gold

About 90% of Nigeria total gold production has been mainly alluvial deposits derived from the primary gold mineralization within the western part of the Basement Complex where the sheists belts are best developed, and there is a spatial relationship between gold mineralization and some schist belts (Woakes and Bafor, 1983). Minna-Bunin Gravel is one of the four gold fields which have been outlined (Woakes and Bafor, 1983). This gold field covers several thousands of kilometer squares and includes the Kushaka schist belt that have been described by Elueze (1981) as comprising a variety of amphibolite, epidote, chlorite and tale-bearing schist corresponding to least partly to theolentic basalt. Also the gold is believed to have some relationships with the regional North-east, South-West to North-South fault or shear zones.

Method and Interpretation

The equipment used comprises of a 6-channel signal enhancement seismograph operating with three recording units (geophones) that pick the earth motion generated by the strike of a sledgehammer against and aluminium plate on the ground. A total of thirty-six seismic lines of 60m each were shot over six profiles traced at 100m intervals. Six schismic lines spreads compose each profile trending north-south; the different sub profiles are spread at 200m interval over one kilometer. The data analysis procedures consist of plotting graphs based on the collected data with the arrival time as ordinate and geophone distance from the shot point as abscissa. We should notice that at the shot point the arrival time is assumed to be zero, even though no geophone was fixed there. Coherent events were then used to get velocity patterns which define the direct waves and refracted waves. The trend starting from origin represents the direct waves and the inverse of the slope of the line gives the velocity of the first medium while the second trend defines the velocity of the second medium. The velocity of the first medium V_1 and that of the second medium V_2 are used to compute the depth of the refractor for each shot point.

The velocity values of the first and second layer are presented on (Table 2 and 3) and the depths of the refractor on (Table 4).

Table 2: First layer velocity (m/s)

Profile I	Profile [illegible]	Profile II	Profile [illegible]	Profile IS	Profile A
2525	2500	2561	2500	2525	2180
1785	2583	2702	2600	2525	2180
2272	2525	2380	2500	2272	2225
2020	2430	2222	2430	2222	2555
1851	1925	2380	1925	2040	2127
1929	2127	1928	[illegible]	1925	2272

Table 3: Second layer velocity (m/s)

Profile I	Profile [illegible]	Profile II	Profile [illegible]	Profile H	Profile A
5555	5882	5882	5263	5555	4762
5555	5555	10526	5555	5555	[illegible]
5405	5555	5000	5884	5555	5263
4878	5555	5882	6666	5882	[illegible]
5263	5882	5555	5263	4347	5882
5000	5555	5263	5000	7142	5263

From the analysis of data, 2 layers are identified

- The overburden and
- The refractor

Table 4: Refractor depth (m)

Profile I	Profile [illegible]	Profile II	Profile [illegible]	Profile [illegible]	Profile [illegible]
9.2	9.84	[illegible]	[illegible]	[illegible]	[illegible]
10.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7.88	10.1	9.54	8.00	9.40	10.00
8.92	11.7	10.0	9.0	9.74	9.7
9.2	12.28	8.35	9.51	7.8	10.58
10.0	9.18	11.21	9.45	10.97	8.8

The velocity analysis consists of contouring the velocities for each layer this exhibits more the velocity behaviour over the layer, defining the different velocity regions. The first layer (overburden) figure 2 shows velocities ranging from 1785m/s to 2702 m/s. The velocity varies in a symmetrical way along the east-West direction with high almost around the center of the study area, about the line M-N trending north-south. The first velocity pattern comprises velocities from 1785m/s to 2325m/s. The third seismic velocity pattern with higher velocity values determines the area of high concentration of quartzites, over the study area. The velocities range from 2325m/s to 2702 m/s in this pattern and show uniformity in variation of the contour which trend north to south. In the different velocity patterns, the contours vary along the same direction. This is illustrated in the figure (2) the variation in the north-south direction, which defines the trending direction for the mineralization of the geological materials of the first layer over the study area. This correlates with the north-sough direction of the major faults in the region and also the trending direction of the quartzites (dense [illegible]

The closures observed in the northwestern part of the area, with those in the southwestern part also indicate a great lateral variation of the materials within this layer. The velocity obtained here range from 1785m/s to 2190m/s. This is a velocity range conformable with alluvial deposit.

The second layer velocities range from 4370m/s to 7142m/s. These velocity values define a high velocity horizon where materials are highly consolidated. The velocity values vary in the east west direction (the second layer velocity contour map is shown in figure 3) and are almost constant in some locations along the north-south direction. The greatest velocities are however observed along the NW-SE direction at three main points. This is shown on the figure 3 by a straight line XY. Variation of these velocities is observed also in the NE-SW direction with lower magnitudes. The lowest velocities are observed at few locations, and they range from 4347m/s to 5000m/s.

The refractor depths are lower in the northern part of the area, which is in the direction of the observed hill in the region with values of 7 to 9m, while they are deeper in the remaining part of the area, where they reach up to 12m.

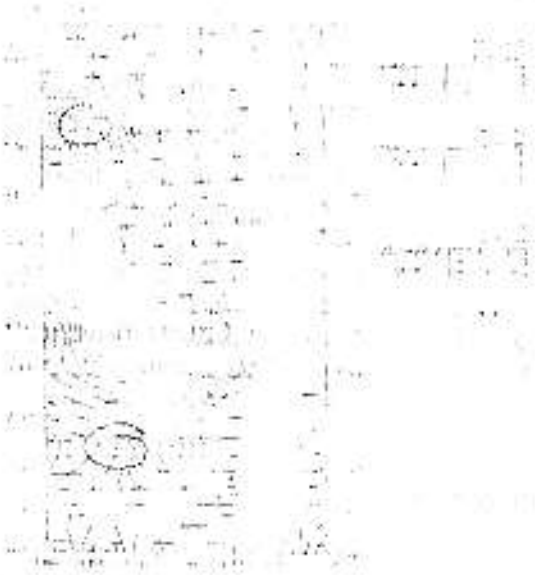

Fig. 2: Contour map of the first layer velocity (units m/s)

Fig. 3: Contour map of the second layer velocity

The prevalent trend of folding lies close to north-south. Over most of Niger state, the variation in this trend is between north-south eastern and north-north south (McCurry, 1976)

Discussion

These velocities vary laterally and are related to the presence of superficial deposits of the recent tertiary which comprises laterite, alluvial sand, silt and clay. The second seismic velocity pattern shows velocity values from 2190m/s to 2325m/s in this pattern sediments are more consolidated, they include both rocks of the recent tertiary and the Cambrian to upper Pre-Cambrian. Sand clay with quartzites compose the soil over this region. The third seismic velocity pattern with velocities ranging from 2325m/s to 2700m/s is formed of a clay-sandy earth with a high concentration of quartzites. Schist are also observed in this region. The overall area is formed with a clay-sandy earth comprising different materials in specific concentration and consolidation at specific locations. Hence laterite was observed along profiles A, E and profile F, whereas quartzites are observed in abundance in the seismic velocity pattern three, located in the northern part of the study area. Laterite and quartzites constitute the main materials within the earthy clay-sand soil of the first layer and they are located in the first, second and third seismic velocity pattern respectively. From the stratigraphic units, the velocities recorded within the second layer are due to the meta-sediments, to meta-volcanic rocks. The velocity values range from 4347m/s to 7142m/s. The velocities of the first seismic velocity pattern range from 4347m/s to 5000m/s, the second pattern has velocity interval 5000m/s to 5880m/s and the third pattern velocities range from 5880m/s to 7142m/s.

From the table 5, the velocity of seismic waves in metamorphic rocks ranges from 3000 to 7700m/s, meanwhile, in the second layer, the seismic velocity pattern are probably due to the schist. Quartzites are more likely to exist because they are observed in the above layer along the same location and are associated with the highest velocities too.

Table 5. Measured Seismic Velocity in some rocks (Sharma Gerhard, 1983)

Rock type	Velocity m/s
Alluvium	150 – 2000
Clay	2500
Dry sand gravel	500 – 1000
Sandstone	1000 – 4300
Limestone	1700 – 4200
Shale	1000 – 3000
Granite	[illegible]
Metamorphic rocks	[illegible]

The superimposition of the two velocities contour maps does not yield enough information about directions above and beneath the refractor, except that on both maps, the contours trending directions are about the North-south. However, the structural deposition of the sediments in the first layer (overburden) are expected to be in fan deposition, due to the closures existence in the area of streams meanwhile alluvial fans may be said to exist in the horizon.

Conclusion

From the analysis of the survey data, two layers were defined. The first layer (overburden) with an average seismic velocity of 2243m/s is composed of mainly laterite and quartzites in a sandy-clay soil and extends to an average depth of 9.83m. The variation of the seismic velocities within this layer is due to variation in the lithology together with their concentration and consolidation. Alluvial fans are believed to exist in this layer from the analysis of the results.

The average seismic velocity value within the refractor is 5744m/s, this value indicates that the basement was reached during the survey. The variation of velocities in this horizon is mainly due to the degree of metamorphism of the schist and quarzites. The trending direction of the velocity pattern in the firs tand second layer is about north-south which is conformable with the quarzites formation trend and the regional direction of the major faults.

Alluvium constitute the specific feature which conform with the data within the study area. The area of expectation of the alluvium are shown on the figure 2. They constitute the areas where alluvial gold is most expected.

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