American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-10, Issue-6, pp-170-174
www.ajer.org
Research Paper Open Access

Application of Migration in Areas of Complex Geology: Case Study of parts of Basement Complex of Northern Nigeria.

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ABSTRACT: *High resolution seismic reflection survey was carried out in Zaria located in the basement complex of northern Nigeria. The geology of Zaria has revealed that it is made up of Precambrian rocks made up of granite that form the major part of the batholith along with gneiss and migmatite that made up the country rock. The complex geology in Zaria, makes seismic reflection processing and interpretation almost impossible. The aim of this study is to evaluate the extent to which migration process which is well adapted in the sedimentary terrain, can help in improving resolution and overcome the challenges of seismic reflection in the basement complex. The "split spread" and the "End on" mode were employed for the survey. The preliminary result obtained from the un-migrated seismic section showed that the reflectors within the basement complex were characterized by dipping layers and point sources, which gave rise to reflection events that were not displayed in their correct spatial position and observed several diffractions. However the results of migrated sections showed that, some of the subtle features were made sharper and more evident in most of the profiles after applying migration. Seismic events from one of the profile carried out across a borehole, showed striking correlation with the borehole log lithology after migration. This has proved that seismic migration which is well adapted for sedimentary terrain can be effectively applied in the basement complex with substantial complex geology and achieves the same result.*

KEYWORDS: *Migration, Complex Geology, Basement Complex, Seismic Reflection Stack Section*

Date of Submission: 03-06-2021 Date of acceptance: 17-06-2021

I. INTRODUCTION

Processing and interpreting high resolution seismic data without applying migration within the basement complex, could lead to erroneous results. This could be attributed to the complex geology which is very prevalent in the basement complex. The topography of the basement within the basement complex undulates appreciably over a very short distance. This undulation may just be covered by a very flat surface, thereby concealing the undulation within the subsurface. This research was carried out therefore to ascertain the extent to which migration which is well adapted in the sedimentary terrain could help us solve this problem.

The established principles tells us that, migration is the principal techniques for improving horizontal resolution, and in doing so performs three distinct functions. The migration process (1) repositions reflections out of place because of dip, (2) focuses energy spread over a Fresnel zone, and (3) collapse diffraction patterns from points and edges Alistair (2004).

Reflecting points are generally not located vertically underneath midpoints and data are migrated to place reflection events at the locations appropriate to the reflecting points. Migration is not only important in displaying seismic structures but also in making faults and subtle features sharper and more evident. Robert et al (1999).

The conversion of reflection times recorded on non migrated sections into reflector depths, using one-way reflection times multiplied by the appropriate velocity, yields a reflector geometry known as the record surface. This coincides with the actual reflector surface only when the latter is horizontal. In the case of dipping reflectors the record surface departs from the reflector surface; that is, it gives a distorted picture of the reflector geometry. Migration removes the distorting effects of dipping reflectors from seismic sections and their associated record surface. Migration also removes the diffracted arrivals resulting from point sources since every diffracted arrival is migrated back to the position of the point source Kearey et al (2002).

Diffractions appear as hyperbolas on reflection seismic data. Diffractions can be thought of as the natural process that creates and enlarges hyperbolas. Migration is the computer process that does the reverse Anderson and Antinuke (1998).

The instruments used for this research work include, Digital Seismograph, Vertical Geophone, Reels of cable with takeout, Trigger Cable, Sledge Hammer and base plate.

Location of the study area

The study area (Fig. 1) is bounded by latitude 11° 13′ 52.37″N, longitude 7° 41′ 49.26″E and latitude 11° 06′ 16.72″N, longitude 7° 42′ 11.56″E. with average elevation of 650 m. The seismic reflection profile lines are shown with arrows, the direction of the arrows shows the direction of the profile. The geological map of the survey area is shown in figure 2.

Figure 1: location map of the study area showing profile lines in red, adapter from Google earth

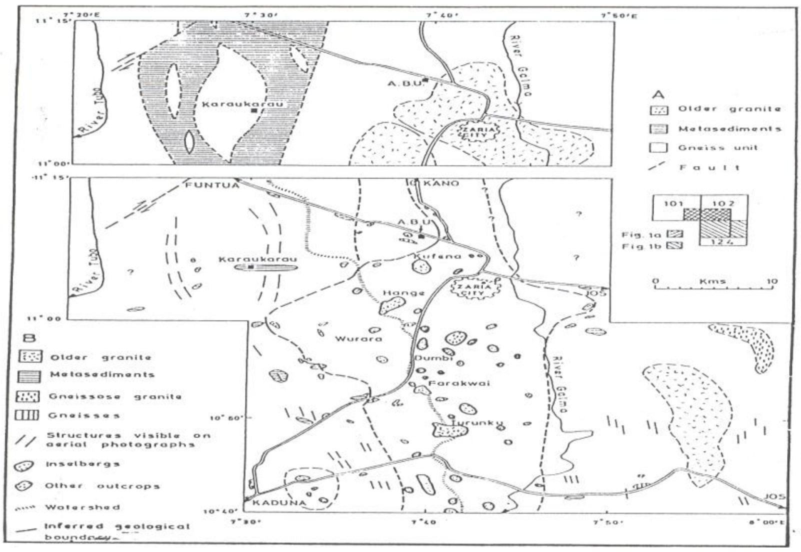


Figure 2: Geological map of Zaria Batholith and it's environ, Map obtains from Geology Department A. B. U. Zaria

Geology of the Area

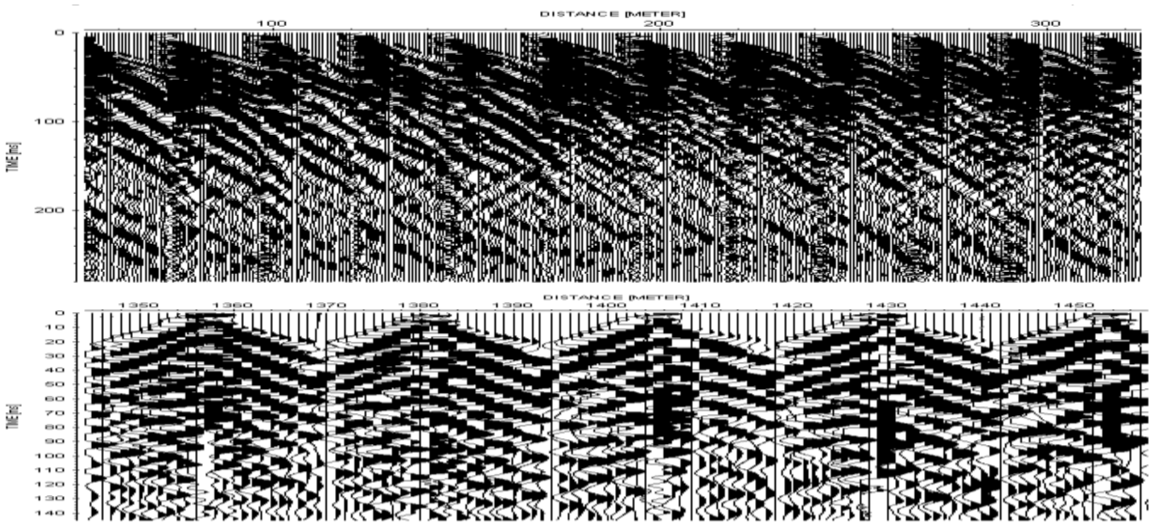
The older granite outcrops in the vicinity of Zaria are exposures of a syntectonics to late-tectonic granite batholiths which intruded a crystalline gneissic basement during the Pan-African Orogeny. This batholith is a north-south oriented body, about 90 x 22 km, extending from Zaria southward to the vicinity of Kaduna. The Zaria granite batholith belongs to a suite of syn and late tectonic granites and granodiorites that marked the intrusive phase of the late Precambrian to early Palaeozoic Pan-African Orogeny in Nigeria (McCurry, 1973). These granites and granodiorites intruded into low grade meta-sediments and gneisses and were collectively called the “Older granites” to distinguish them from the Mesozoic “Younger Granite” of the Jos plateau and surrounding areas (Falconer, 1911). McCurry’s work was based mainly on Photogeological interpretation, supported by selected ground traverses. She distinguished three principal units in the area, namely gneisses, considered to have been metamorphosed more than 2,000 million years ago. The granite batholith (a large, deep-seated intrusive mass) extending northwards and southwards from Zaria, has in fact a western platform, up to 8 km wide, devoid of any inselberg or fresh outcrop more than 4 m high (Webb, 1972).

Data acquisition

The split spread and the “End on” mode was employed for the survey. The receivers (Geophones) were placed at 1m interval. The energy source used for the survey was a 20 kg Sledge Hammer on a base plate. After each shot, the first receiver in the survey was taken ahead of other receivers in the spread, and placed 1 m ahead. the connection to each of the takeout were then swapped in the direction of increasing profile. When the connections were completed, the next shot was taken. The whole process was repeated until the end of the profile length was reached. The generated seismogram was recorded on a digital seismograph for onward processing.

Data processing

The data processing flow started with the edition of the reflection geometry for the seismic raw data (Fig. 3 a and 3b) and the muting of the bad traces. The next step on the processing flow was the application of gain, in other to enhance the amplitude of the traces. F-k filter was then applied to get rid of any undesired onset. Semblance analysis was carried out to generate a 2-D velocity model, which was used for the stacking of the traces sorted into common mid point, to produce a stacked section. Migration was then applied to the stacked seismic section, using the Kirchhoff migration method.



(a)

Figure 3: seismic reflection raw data (a) “end on” and (b) Split spread (b)

II. RESULT AND DISCUSSION

Figure 4 show a stacked seismic reflection section, that was generated close to and out crop. The seismic section was characterized by reflection event out of their correct spatial position and diffraction event from possible point sources. The seismic events appear very incoherent, and one could hardly isolate them for any meaningful interpretation. After the application of migration, the time migrated seismic section (Figure 5) showed coherent and continuous dipping seismic reflection events, with prominent fractures that could act as point sources that may have given rise to the diffraction in figure 4. The reflection event has been made more evident and sharper with the application of migration that one can give conveniently give interpretation.

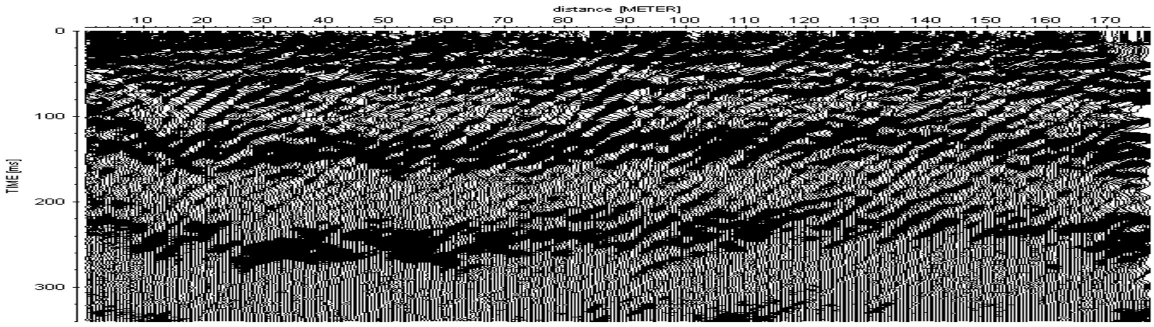


Figure 4: Staked reflection seismic section with diffraction and reflection out of position

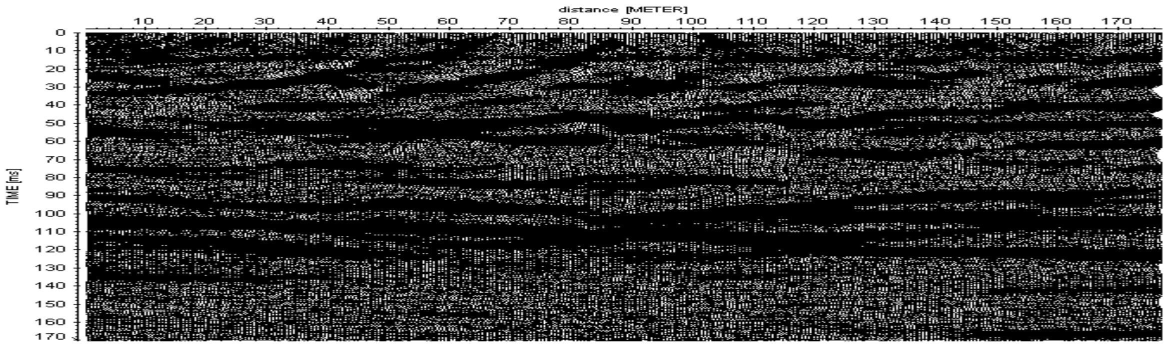


Figure 5: Time migrated reflection seismic section for figure 5

Considering the stacked section of the seismic reflection profile (Fig 2) carried out across a borehole, at Ahmadu Bello University Zaria Nigeria, the near surface reflection showed evidence of distortion of the reflection event, all other reflection events were flat laying, which gave rise to the continues and the coherent reflection events that were observed on the time migrated seismic section (Fig 3). The depth migrated section (Fig 4) gave a outstanding correlation with the various lithologies of the borehole log (Table 1) sited 23 m distance along the profile.

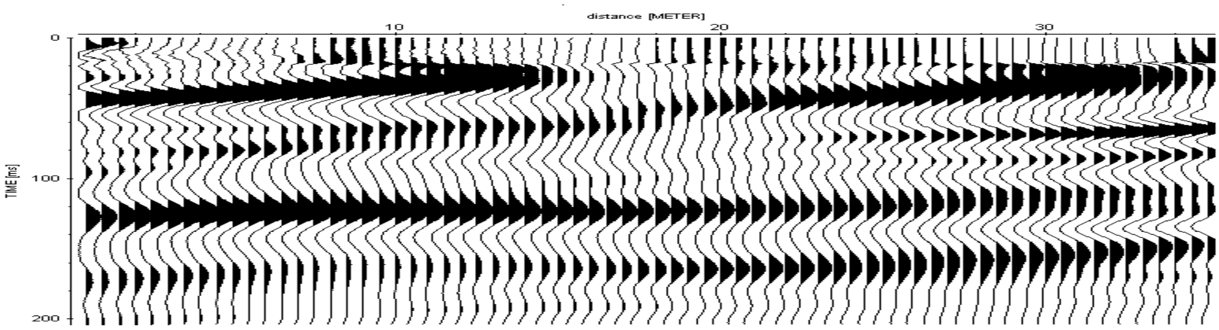


Figure 2: Stacked seismic section of Akenzuwa Borehole

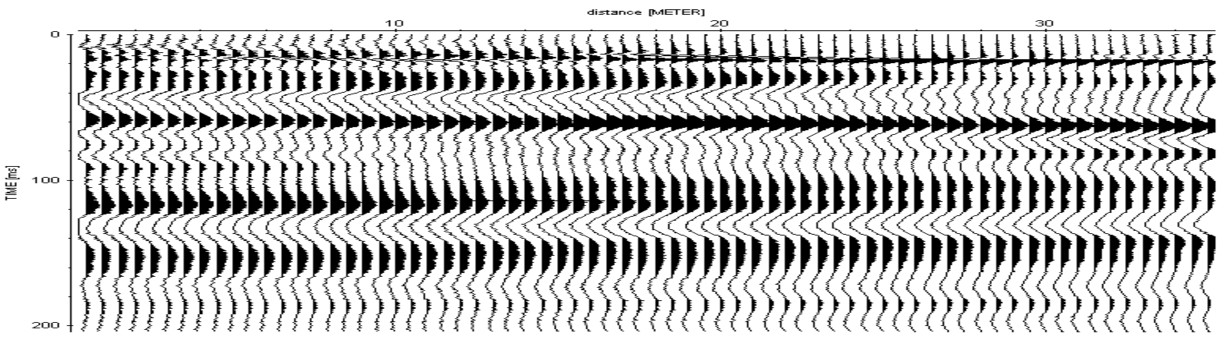


Figure 3: Time migrated seismic section of Akenzuwa Borehole

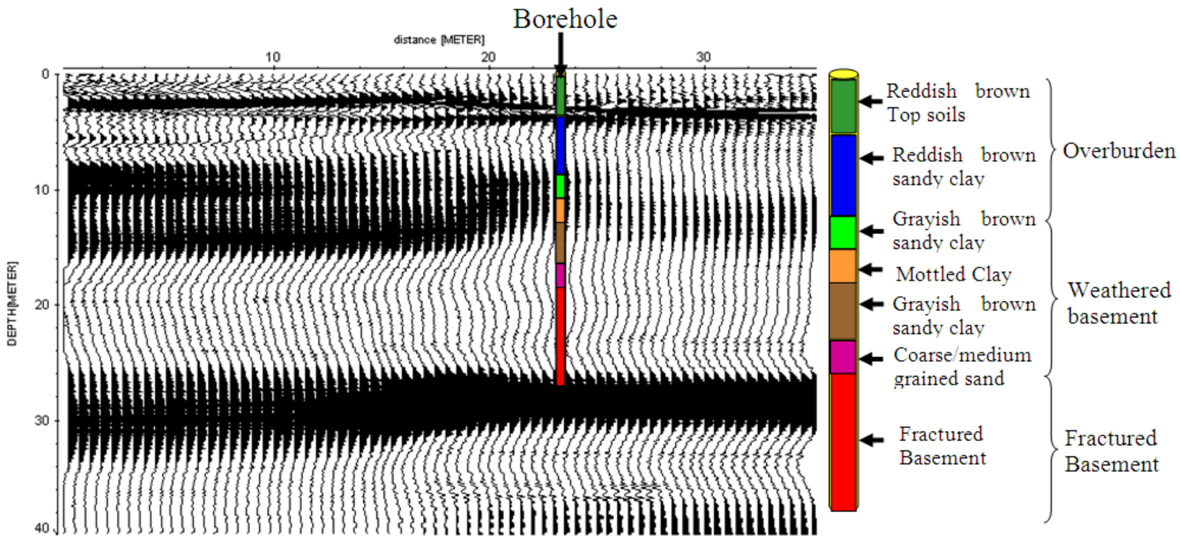


Figure 4: Depth migrated seismic section of Akenzuwa Borehole with borehole log

Table 1 Akenzuwa Lithology Borehole Log

Depth (m) From	To	Thickness (m)	Interpreted Lithology	Hydrogeological characteristics
Overburden 0 – 8 m				
0	3	3 m	Reddish brown Top soils	
3	8	5 m	Reddish brown sandy clay	
Weathered Basement 8 – 18 m				
8	10	2 m	Grayish brown sandy clay	
10	15	5 m	Mottled Clay	
15	18	3 m	Coarse/medium grained sand	Aquifer
Fresh Basement 18 – 27 m				
18	27	9 m	Fractured Basement	Aquifer

III. CONCLUSION

Migration helps in reconstructing a seismic section so that reflection events are repositioned under their correct surface location and at a correct vertical reflection time. Migration also improves the resolution of seismic section.

Stacked section and recorded surface should not be used in area of complex geology for final interpretation, time or depth migration (if the velocity is well determined) should be carried out for a meaningful interpretation.

ACKNOWLEDGEMENT

I wish to express my gratitude to the International Programme in the Physical Sciences (IPPS) Uppsala University Sweden for donating equipment and providing fund for this research,

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