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STRATIGRAPHY AND LITHOLOGICAL CHARACTERISTICS OF AQUIFERS IN THE KANO REGION: THE MISSING LINKS BETWEEN GEOPHYSICAL SURVEYS AND THE CHANCES OF GROUNDWATER DETERMINATION

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Abstract

Observation from stratigraphy of sediment and basement shows the lithological characteristics of the Kano Region and suggest the location of groundwater resource. Using lithology, log data revealed the stratigraphy of the region as safe, the morphology at each point is clearly visible once data are interpreted through Schlumberger (often used method in the region), but the determination of groundwater is not always feasible. The layers of Chad sedimentary formation and Basement complex have been examined through log wells for more than half a century but the results are usually confusing. Boreholes failure rates are on the increasing, and people complains about drilling firms and drilling firms shift blames for dry holes due to serious depleting of aquifers across the region. In view of that, this paper seeks to identify the missing link in the state of art in borehole drillings in the region. The research examines the stratigraphy the region and interviewed borehole drillers as well as examined the instruments used for detecting and interpreting the results. The study sampled VES data and in-depth interviews were conducted in identifying the actual problems.

Key Words: *Kano Region, Stratigraphy, Lithology, Geophysics, Boreholes*

Introduction

Heavy reliance on groundwater is ever increasing due to population growth in the Kano Region for domestic, agriculture and industrial uses. The use of geophysical survey in prospecting groundwater is on the increase in the last few years due to increasing knowledge of computer and Microsoft processing. The use of hand dug wells as major source of groundwater in the last 3 decades have seriously declined (Afremedev Consultants, 1987) and being replaced by the use of boreholes recently. However despite, proliferation of firms practicing geophysical survey, drilling of unsuccessful boreholes is rising too. For many of the newly drilled boreholes, the use of geophysical studies is often neglected. In fact, this may be due to the complex technicalities surrounding the work. It is also due to practical implementation difficulties and cost implication.

Unfortunately, sometimes geologists, physicists and geographers having interest in the field, may have experienced in-appropriate use of geophysics. More unfortunate is the fact that some

practitioners over-sold to contractors under false information, thus leading to not just the poor use of geophysics, but to the delivery of misleading or wrong results.

This paper attempts to find out why abortive boreholes are on the increase in the Kano Region in the recent years? To answer that, the following questions must be addressed:

- Are the survey methods adopted by borehole drillers correct?
- Does the instrument used for the survey give erroneous results?
- Are the technical personnel handling the equipment properly trained?
- What is actually the state of art in prospecting groundwater?

Material and Methods

Types and Sources of Data

A total of 64 contractors who serve in geophysical firms registered with the Ministry of Water Resources Kano and Jigawa states (which largely form the Kano Region) were identified as water prospecting professionals. Qualitative data was generated from 20 firms sampled for in-depth interviews. These are the geophysical survey firms and borehole drilling firms or a combination of both. The interviews were held with some proprietors of the firms. The result is cross tabulated using simple percentage. The results of the interview formed the basis for discussion in this paper. The approach of this paper is to relate geophysical surveys carried out in many places with state of arts of the practitioners.

The Study Area

The population is higher than 14 million people in the region considering the 2006 population census. The region is made up of two states: Kano and Jigawa. Formerly the region has 20 local Government in 1976 which changed to 29 in 1980. After the creation of Jigawa State in 1991, more Local Governments were created for Kano and Jigawa respectively. Today, Kano has 44 Local Government and Jigawa has 27 Local Governments.

The area is located between the latitude $10^0$25'N in the South to$13^0$53'N in the North and longitude $7^0$43'E to $10^0$35'E from East to West, with the total surface area of about 43,000 Km^2: Kano with 20,760 Km^2 and Jigawa with 22,240 Km^2.

Physical Background

Groundwater exploration is a multidisciplinary process, where none of the expert in geology, hydro-geology, geomorphology, geophysics or physics has an upper hand in producing effective results. The value of any geophysical method is measured by the amount of geological information that can be deduced from interpretation of the data obtained (Ariyo and Adeyemi, 2009), which are invariably affected by the background of the interpreter (Olrunfemi, 2009).

It has been observed that groundwater around Kano metropolis is seriously declining (Abdulhamid, 2000). This decline was not limited to Kano Metropolis, but to the entire region as a whole (Abdulhamid, 2008, Rilwanu, 2017). A review of borehole records and reports of geophysical surveys

in the region have also shown that better yields and higher successful rates would be obtained from drilling with good geophysical survey method (MacDonald, Cobbing, and Davies, 2005a, 2005b and Maduabuchi, 2004).In recent year's reports compiled by borehole drilling firms before the actual sitting of boreholes indicated similar trend.

The spatial scope of the research is Kano region, which comprise Kano, and Jigawa states, is hydro-geologically divided. The region is sharply divided in to basement complex geology in the west and Chad formation in the east (figure 1).

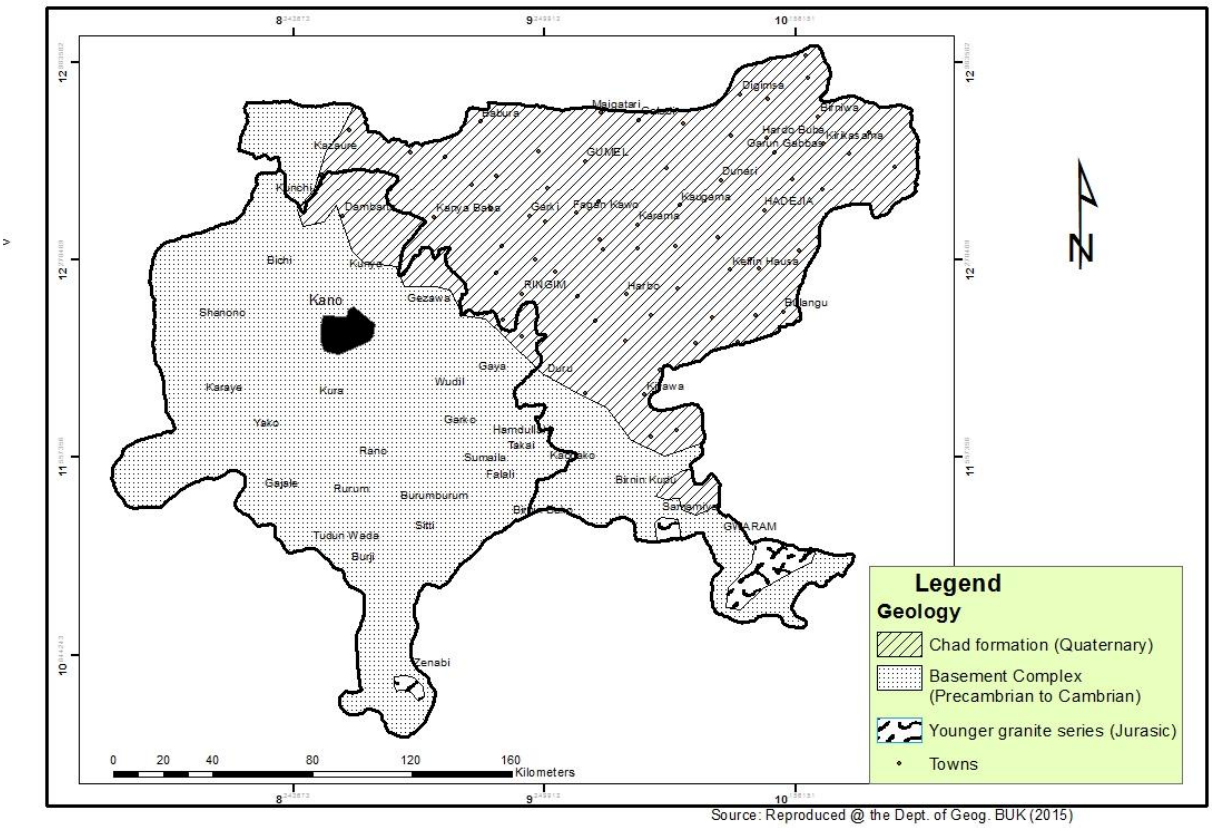

Figure 1: The Geology of Kano Region

The area also falls under the influence of Hadeja-Jama'are basin. This area has been described as having characterized with concentration of rural population, with the combination of drain basins of river Hadejia, Katagum and Jama'are developing in to Yobe system (Olofin, 1987:2). The main rivers in the area which mainly get their water from rainfall are river Gari, river Tomas, river Jakara, river Chalawa-Kano-Hadejia, river Gaya and river Katagum. All these rivers developed within the region, except for the Yobe system which developed in Bauchi state. Since 1973 serious efforts were made to supply portable water to the citizenry of this region. The major development on the main Hadejia-basin was the construction of 22 earth dams, 13 regional water schemes and several borehole based water schemes. It was noted however that the first water treatment plant was constructed in between 1928-1932 with a full capacity of 20 million liters per day (Kano State, 2005).

Kano state remained a province since 1967 when the then military government created twelve states. Many more states were created in Nigeria, but Kano state remained undivided until 1991, when the Jigawa State was created. The two states remained *The Kano Region* as popularly called by geographers. The idea of Kano as a region became popular in Olofin (1987) as having six major landforms formation (figure 2), though other writers have identified it as an area with some degree of homogeneity in functionality, language and pattern of administration (Bennett, et al 1978).

Stratigraphy and Lithological Characteristics of Aquifers

The use of geophysical survey is to reduce risk of drilling dry holes and also a desire to offset the cost associated with poor groundwater production. Observation from stratigraphy of some selected areas of sediment and basement in the region revealed that lithological characteristics vary from place to place. This has already been established by earlier well loggings. The morphology at each point is clearly seen when Vertical Electrical Sounding (VES) results of both

Chad sedimentary formation and Basement complex are examined, coupled with log data. Samples of these results have been drawn on each formation and found to be characterized by different strata (Abdulhamid, 2008).

Sedimentary Stratigraphy

The deepest overburden layer has been observed in Kafin Hausa with mean depth of 75m. It is practically difficult to reach the location of fresh basement underlying the Chad formation. Since the log data reveal where groundwater could be accessed which mostly do not exceed 75m in the area as in Garki, Chaichai, Hadejia and Kanya Babba.

From these borehole drilling locations, it is observed that groundwater was found at the depth of 17.15m in Kafin Hausa (Sarawa Village), 9.0 m in Miga and 7.47m in Chaichai. While the aquifer depths extend up to 125m, 95m and 73m respectively as observed from geophysical surveys. The stratigraphy also revealed the types of layers found. It is clearly seen that all the aquifers are underlain by sands and gravels which are good source of groundwater. Only Hadejia is underlain by clay materials. A Clay material is believed to produce unsuitable aquifer. Luckily for Hadejia, this material is found at relatively high depth, where boreholes do not extend to that depth.

The complex nature of Basement of Kano region is what warrants the name of the regional basement to be called "Basement Complex". It is also complex to interpret. Virtually all the log data gives out different material components. But still, the following arrangement is often common among the weathered regolith zones:

a. Silty clay
b. Silty sand
c. Decomposed/ Weathered/Altered Basement
d. Laterite; laterite sand, laterite clay
e. Clay
f. Sand, medium and coarse.

The depth of overburden does not exceed 70m. The minimum regolith depth is 21m as the case of Janguza, and the maximum is 67m as for Albasu. The general stratigraphy also shows that water table fluctuates mostly within sand and clayey layers and can be found as close as 4m or as deep as 27m as the case may be (Abdulhamid, 2010). It is also observed that groundwater mostly percolate within these weathered zones in both the two formations.

Results and Discussion

Reliability of the results

Buckley and Zeil (1984) reported their findings after resistivity soundings carried out at existing boreholes, both high and low yields to calibrate response to geology and found horizontal features was not correct because no such features for good boreholes existed in the area. They suggested that to have a good view of both lateral and horizontal identification of terrain both lineation interpretations from remote sensing must accompany soundings.

Recent studies (Shashinuzzaman, et al 2016, Marker, et al 2017) reaffirmed that resistivity survey alone cannot produce a better result. This has also being noted by equipment providing companies where the latest equipment such as Supersting Earth imager is calibrated to carry out the dual services. Earth Imager Supersting is the next generation equipment capable of proving highest quality result and produces the lowest noise found so far (AGI, 2017) but still the reliability of its data is still questioned by physicists.

MacDonald (2005b) pointed out that situation with complex geology and hydrogeology requires specific targeting of methods for particular problems. Despites dual geology of basement and chad formation in Kano region, the common water prospecting method is Schlumberger techniques using vertical electrical sounding (VES) arrangement.

1. Boreholes and the Geophysical Survey

Geophysical survey particularly Vertical Electrical Soundings is the most common survey method practice by most of borehole drillers in Kano Region. In the region more especially the basement complex one out of five boreholes constructed fails (Yakudima, 2008). This was revealed from survey conducted on performance of boreholes in 16 villages of Rimin Gado Local Government area, which identified that even among the functional ones many of them failed 8 months or less from the start of operation (Yakudima, 2008: 37). The failure may emanated right from geophysical survey where 30% of failure is directly from the equipment used (Table 1).

Table 1: Responses of Geophysical and Drilling Firms on Borehole Failure Rates

Company specialization	% Rate of Failure of the Total Boreholed Drilled by Companies					Total
	5	10	15	20	NA*	
Geophysical	0	10	5	10	5	30
Drilling	5	0	5	0	0	10
Drilling and Geophysical	0	5	0	0	10	15
General engineering	0	0	5	5	20	30
Construction	10	0	0	0	5	15
Total	15	15	15	15	40	100

Source: Fieldwork, 2017. NA* = Not Available

It is believed that some borehole drillers involved in wild casting and produce fake results, despite the fact that none of the interviewees claim to do such a practice, but on individual conviction, wild casting is a common practice in borehole drilling among firms in Kano Region. Though wild casting cannot be ruled out, because there private drillers who engaged in drilling boreholes only without possessing survey equipment. By virtue of high rate of failure, then there may be problems with the machines or else. The common instruments use in conducting the geophysical survey in the region is Geopulse, ABEM SAS 300C, Supersting RI IP, Omega and newly Chinese equipment. Such instruments are said to be error minimal, with result accuracy of 80 – 95%. The private drillers suggested five major factors responsible for poor results/and poor siting of boreholes that can effectively function and supply adequate water without failing. These are:

i. Geology and geomorphologic factors;
ii. Client factor;
iii. Pressure on boreholes
iv. Drillers factor; and
v. Equipment failure factors.

The State of Art and Groundwater Prospecting

Careful study revealed that 40% of the firms were mere contractor who established their outreaches as the source of business. Where a contract is won, such firm sublet the work to firm which engaged in the actual work in practice. They claimed to have possessed professional certificates in prospecting and drilling water, but the actual works are carried out by some individuals.

About 60% of the firms engaged in the work, and are generally susceptible to all kinds of problems. It has already been established that the techniques used in this region is sending direct current to the ground to get ohms/m (Reynolds, 1997). Still few of them manage to survive due to several factors such as difficulty in accessing credits, inadequacies resulting from highly dilapidated facilities, high operation costs and lack of transparency and corruption. Despites several survey methods, the firm in the region adhered to only one survey method (Table 2).

Table 2: Survey Method and Major Challenges

Survey Method	Major Challenges (% of contractors)					Total
	Machine Failure	Weather	Client Prob	Cost of Equip	Geology	
VES	25	25	0	0	10	60
CONTRACTED	0	5	15	20	0	40
Total	25	30	15	20	10	100

Source: Fieldwork (2017)

Conclusion

The objective of this paper is to find out reasons for increasing failure of boreholes in Kano region in the recent years. The paper highlighted the stratigraphic and lithological characteristic of both sedimentary and basement complex formations *in situ*, already identified through either well logging or from geophysical survey in which many geophysical surveys referred to rather than doing the actual survey.

It is established that some borehole drillers involved in wild casting and produce fake results. And not all the surveying and drilling firms engaged in the activity, some considered the profession as an outreach for getting quick money and engaged in wild casting to produce results. Poor results in survey and drilling suggested to have lied upon five major factors from interviews. They are geology and geomorphological, client, pressure on boreholes drillers, and equipment failure factors. The study also noted that few firms managed to engage in the real works, while many are mere contractors. Those who manage to survive face a lot of difficulties in accessing credits, inadequacies resulting from highly dilapidated facilities, high operation costs and lack of transparency and corruption.

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