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Groundwater availability in south western Nigeria

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ABSTRACT

In urban water supply the importance of groundwater has become very obvious to most water supply agencies of the State Governments, thereby resulting in a tremendous increase in well drilling activities. This paper therefore provides a review of available groundwater information as well as the geological setting of South-Western Nigeria. The degree of groundwater exploitation in each of the hydro-geological units in the study area is assessed in relation to their hydraulic characteristics.

The results of the statistical analysis show that the behaviour of the borehole characteristics is erratic and unpredictable, and that generally the yields from the productive boreholes are very poor. The contribution of the geology of the area to this erratic behaviour and low yields is also discussed.

INTRODUCTION

Of particular importance in South-Western Nigeria is the efficient development and exploitation of groundwater resources, either by the government or individuals. Mostly in this area groundwater is used for domestic purpose.

The study area, Oyo State, is bounded by longitudes 5° 05' and 2° 95'E and latitudes 9° 05' and 6° 95'N (Fig. 1).

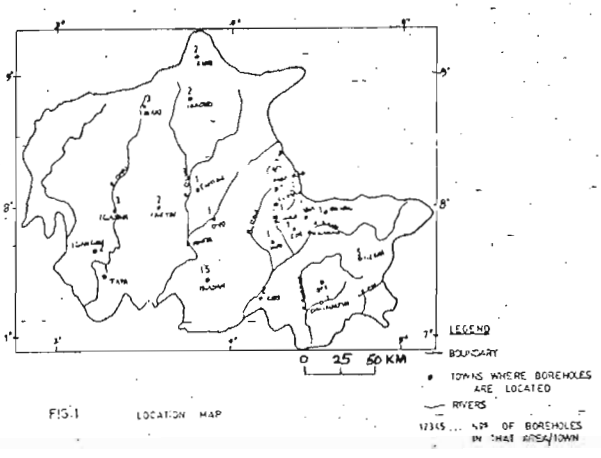


FIG.1 LOCATION MAP

It has an estimated land area of about 37,700 km^2 and a population of about 10 million, about 10% of the population of the whole country.

Some works have been done in South-Western Nigeria. Notable amongst them are those of Wilson (1922), Carter (1954), Jones and Hockey (1964) Asseez (1971), and Rahaman (1974). Systematic water supply investigations were commenced, however, by the Geological Survey in 1928. Asseez (1971) presented a formal publication on the hydrogeology of South-Western Nigeria which embraced the former Lagos, Western and Mid-Western States. A report was written by Carter on the groundwater of South-Western Nigeria. The report is mainly geological with a casual reference to the occurrence of water. Andu (1966) also wrote an open file report on the exploitation and development of groundwater in Western Nigeria, for the Western Nigeria Water Corporation. The report deals with the water supply practice and well completion techniques.

The study area is underlain basically by the Basement Complex rocks. The Basement Complex of Nigeria forms a part of the African crystalline shield. The Basement Complex of South Western Nigeria lies to the east of the West African Craton in the region of late Pre-Cambrian to early Paleozoic orogenesis. The Nigerian Basement Complex extends westwards and is continuous with the Dahomeyan of the Dahomey-Togo-Ghana region. To the east and south the Basement Complex is covered by the Mesozoic - Recent sediments of the Dahomey and Niger Coastal Basins. It is the purpose of this paper to synthesize the available groundwater information and to present the general behaviour of wells/boreholes in South-Western Nigeria, with regards to the well discharge, lithology and geology of the area.

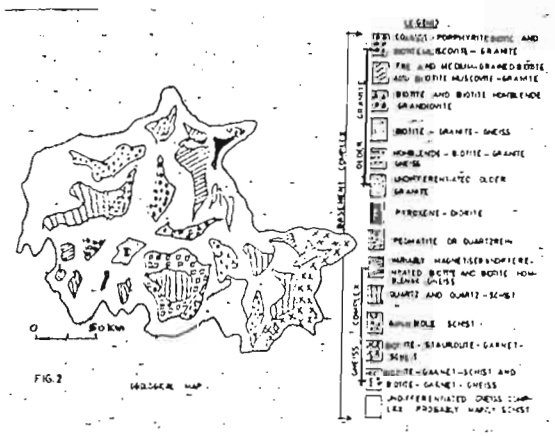
GEOLOGY

The Basement Complex rocks of Nigeria are composed predominantly of migma-

titic and granitic gneisses; quartzites; slightly migmatised to unmigmatised metasedimentary schists and metaigneous rocks; Charnockitic, gabbroic and dioritic rocks; and the members of the Older Granite suite mainly granites, granodiorites and syenites. Two phases of folding believed to be related to the Older Granite Orogeny (Pan African) have been described affecting the gneiss-migmatite quartzite complex and the slightly migmatized to unmigmatised schists and metaigneous rocks.

The Nigerian Basement Complex is believed to have suffered four orogenic episodes in the Pre-Cambrian of Africa (Odeyemi, 1977). These are the Libernan (2700±200 m.y.), the Eburnean (2000±200 m.y.), the Kibaran (1100±200 m.y.), and the Pan African (600±200 m.y.).

In the study area, the Basement Complex is composed of the Older Granites, the Charnockitic Intrusives and the Gneiss Complex (Figure 2).



According to Wilson (1922), Quartzites, Quartz-Schists and some Biotite-Gneisses were believed to be the oldest rocks of the complex existing only as discontinuous relics. The Older Granites include rocks of a wide range of compositions, granites, granodiorites, adamellites, quartz, monzonites, syenites, pegmatites. Granitic-granodioritic compositions are most common. The Charnockitic rocks are mainly of magmatic origin and not the result of high grade metamorphism in the granulite facies. They belong to two generations; the first preceeding the emplacement of the Older Granites and the second emplaced in the last stages of the Older Granite Orogeny.

The oldest known rocks in the area comprise of Gneiss Complex whose principal members include quartzite, quartz-schists, amphibolite schists, hornblende gneisses and mica schists.

Major faulting is not evident and most of those recognised have been traced from aerial photographs. Faulting with constant crushing is present in some districts. There exists a thin discontinuous mantle of weathered rock over most of the area underlain by the Basement Complex. According to Jones and Hockey (1964) the weathered mantle averages 15-20m in thickness which may reach a maximum of about 50m.

Joints and fractures vary greatly in lateral persistence and depth to which they extend. Usually joints in the Basement Complex rocks do not extend beyond 10m in depth while fractures and faults generally to deeper and are better developed in granites and quartzites than in gneisses, migmatites and schists.

HYDROGEOLOGY

The availability of groundwater in any given area depends on the presence of decomposed material which has a sufficient thickness and lateral extent to serve as a reservoir, and also on the presence of joints and fractures in the fresh rock. The quantity of water that can be accommodated under the ground surface depends also on the porosity of the subsurface strata.

The groundwater potential of the study area is dependent mainly upon the tectonic situation of the Basement Complex, that is, the joint patterns and faults; and upon the thickness and composition of the overlying weathering mantle. Both igneous and metamorphic rocks occur but in general they are impermeable except in cleared, sheared, jointed and fissured areas. Although there are some occurrence of folds and faults but they are so localised that they are not of significant importance in groundwater development.

The Basement Complex is a very poor source of groundwater. Its decomposed mantle is often too thin to accommodate large quantities of water and the joints are too poorly developed to compensate for the inadequacy of the zone of weathering overlying them.

The presence of joints in the crystalline rocks does not however, guarantee a sufficient groundwater availability, since joints sealed by mineral precipitations or by fine-grained weathered material, such as clay, may impede groundwater flow considerably.

Other potential areas for groundwater exploration are Alluvial deposits in buried ancient channels, but the location of these may require geophysical techniques (seismic) except where they have been exposed in road cuts as in Shasha River.

Yields of the wells are generally low ranging from about 0.03 $l.s^{-1}$ to about 7.32 $l.s^{-1}$. The well depths vary from 42.0m to 105.0m. Differences in the well yields tend to reflect the difference in the degree of weathering or fracturing rather than inherent differences in mineralogy or fabric within the rock.

YIELD ANALYSIS AND CLASSIFICATION

Available information was obtained for a total number of fifty (50) boreholes all drilled in the study area. Two of these boreholes, located at Idi-Ayunre and Igboho, have no record of yield values. The borehole characteristics include the location, depth, static water level, yield, dynamic water level and duration of pumping test. Statistical analysis was however performed on the well yield.

The first statistical analysis of the 48 borehole yields gave a mean value of 1.660 $l.s^{-1}$ and a standard deviation of 1.735 $l.s^{-1}$. That the standard deviation is larger than the mean value is an indication that an anomaly exists. This called for a deeper inspection of the yields. There are 5 boreholes where yields range from 4.38 $l.s^{-1}$ to 7.32 $l.s^{-1}$ which are much higher than all the yields in the remaining 43 boreholes. These were suspected to be responsible for the anomaly. They were thus removed while the rest were analysed. The mean value was 1.135 $l.s^{-1}$ and the standard deviation was computed to be 0.770 $l.s^{-1}$. Table 1 presents the mass analysis of the yields.

The analysis also revealed that the borehole yields are in three discrete clusters. The first 20 boreholes have yields that range from 0.03 $l.s^{-1}$ to 1.94 $l.s^{-1}$ while the next 21 boreholes have yields ranging from 1.00 $l.s^{-1}$ to 2.27 $l.s^{-1}$ and the last 7 boreholes have yields between 3.00 $l.s^{-1}$ and 7.32 $l.s^{-1}$ (Table 2). The clusters can be classified into three yield zones: Low, medium and high yield zones (Figure 3).

The data obtained from the existing boreholes within the Basement Complex of Oyo State are rather erratic. The unpredictability is further proved by the yield values obtained at Kisi and Igboho, as well as Komu and Otu, the pairs being in the same vicinity. The yield values are 0.94 $l.s^{-1}$ and 0.03 $l.s^{-1}$ at Kisi and Igboho respectively. A discharge of 1.58 $l.s^{-1}$ was obtained at Komu, while at Otu it was 0.39 $l.s^{-1}$.

It may therefore be said that although the exact discharge is uncertain and unpredictable, there exists a general trend for the area showing that the availability of groundwater is always in small quantity. This is so since the highest percentage of the frequency of the yields are in the low and medium zones.

CONCLUSION

The crystalline rocks of the Basement Complex do not permit sufficient retention of water and thus a poor source of groundwater. This is because the water storing properties of the crystalline rocks are very poor. Where there is storage of water, there must exist faults and joints, which on the other hand are not wide enough to store or retain an appreciable amount of water.

Thick sandy-clayey, lateritic overburden serve as potential aquifers. These also are restricted in vertical and lateral extent. Despite the poor availability of groundwater in the Basement Complex, the common notion that the Basement Complex has no water should be discouraged, since the usual practice of locating well sites is by intuition. Indiscriminate siting of boreholes could lead to unproductivity or poor yielding of the wells. Successful location of groundwater storage in the Basement Complex requires very highly specialized personnel, since scientific exploration is the only means of determining potential water zones in the Basement Complex areas. Geophysical exploration would help to locate potential

TABLE 1: MASS ANALYSIS OF YIELDS

ANALYSIS STAGE	NO. OF BOREHOLES	MINIMUM LITRES/ SEC	MAXIMUM LITRES/ SEC	MEAN LITRES/ SEC	STANDARD DEVIATION LITRES/SEC	COEFFI-CIENT OF VA-RIATION LITRES/ SEC	MEDIAN LITRES/ SEC	COEFFI-CIENT OF SKEWNESS
1	48	0.03	7.32	1.660	1.735	1.045	1.170	0.845
2	43	0.03	3.93	1.135	0.770	0.678	1.000	0.506
3	20	0.03	0.94	0.528	0.257	0.486	0.555	-0.315

TABLE 2: DISCRETE ANALYSIS OF YIELDS

ANALYSIS STAGE	NO. OF BOREHOLES	MINIMUM LITRES/ SEC	MAXIMUM LITRES/ SEC	MEAN LITRES/ SEC	STANDARD DEVIATION LITRES/SEC	COEFF-CIENT OF VA-RIATION LITRES/ SEC	MEDIAN LITRES/ SEC	COEFFI-CIENT OF SKEWNESS
1	20	0.03	0.94	0.528	0.257	0.486	0.555	-0.315
2	21	1.00	2.27	1.491	0.369	0.247	1.400	0.740
3	7	3.00	7.82	5.403	1.517	0.281	6.000	-1.181

water zones. This is because groundwater occurs in perched forms in the Basement Complex.

A high rate of recharge is expected into the overburden of the crystalline rocks as a result of the high rainfall coupled with low surface run-off that is typical of the study area. The thickness of the overburden may somehow be regarded as being relatively uniform on a regional scale, but there are rapid variations locally, hence the sporadic and unpredictability of the occurrence of water.

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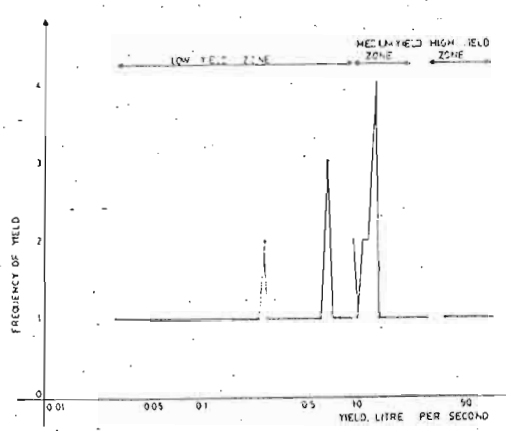

FIG. 3 FREQUENCY OF BOREHOLE YIELD IN THE UNDIFFERENTIATED BASEMENT COMPLEX