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Lineaments Analysis to Identify Favourable Areas for Groundwater in Kano City, Northwestern Nigeria

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Abstract
This work was carried out to investigate groundwater potentials of Kano city using lineament analysis, and to study the relationship between the characteristics and occurrence of groundwater in aquifers of about 200m deep in crystalline basement rocks of the area by examining the possibility of groundwater occurrence at such depths; despite the general understanding that fractures closes with depth. It shows the use of LANDSAT ETM+ imagery and geological map to investigate areas favorable for groundwater development. This was achieved by plotting the lineament trends, and lineament density to know the groundwater potentials. Rose (azimuth-frequency) diagram of the lineaments delineated on the imagery shows trends in the directions of N-S, E-W, NE-SW, and NW-SE. The dominant trend is NW-SE. The analyses have shown that the study area has numerous fractures whose major trends are mainly in north-south and northwestern-southeastern directions. Lineament density map shows the cross-cutting lineaments are relatively high in areas around the north-eastern and south-western parts of the study area but low in the other areas. The zones of high lineament intersection density are feasible zones for groundwater prospecting. The positions of deep boreholes on the map of the area do not coincide with the cross cutting lineaments, and are therefore the yields of the deep boreholes are not sustainable.
Keywords: Lineaments, groundwater, boreholes, aquifer, fractures

Introduction

Detection of structures is an essential element in structural geology. Their conventional method of mapping requires fieldwork investigations. Field work is usually time consuming and may take a longer time to complete, depending on the nature and the accessibility of the area to be investigated. However, remote sensing along with other image processing techniques accounts for a less time consuming and a more cost effective method for detection of geologic structures that could serve as potential aquifer zones.

Structural trends such as discontinuity can be detected in many forms, such as faults, joints, bedding planes or foliation (Mogaji et. al. 2011), and may be detected in the form of a lineament using remotely sensed data such as conventional aerial photographs and satellite imagery.

According to Anudu et. al. (2011), the commonest method used to calculate lineament density is based on the number of lineaments per unit area (number/km²), or the total length of lineaments per unit area (km/km²) or combining both. Areas with higher number of lineaments are considered to be good for water development.

Many boreholes are drilled into the crystalline basement, for the purpose of rural and community water supplies. However, some existing shallow regolith aquifers have a low yield, and prompted the drilling of boreholes into the hard rock in order to tap groundwater in deep fractures of ≥200m. However, some boreholes are unsuccessful, the reason being that, most of these unsuccessful boreholes do not encounter water-bearing fractures.

Geology and hydrogeology of the study area

Kano area is underlain by rocks of the Nigerian basement complex comprising migmatites-gneiss complex, younger metasediments, older and younger granites (Bala 2001). MacDonald and partners (1986) established that, it is dominantly underlain by undifferentiated metamorphic suite, older granite, coarse pink granite and porphyritic biotite granite. The predominant rock type is older granite. The older granite is composed of coarse-grained granite, granodiorite, diorite and aplite. The lithological varieties are less common than in metamorphic suite. They were emplaced during the Pan African orogeny which was dated about 650-850 ma. The most abundant and typical member of the older granite suite is a coarse porphyritic granite (Oyawoye, 1972). It is typified by the abundant large feldspar set in a ground mass rich in biotite or hornblende. The feldspar may be white, purple, pink, yellowish brown and dark grey.

The schists are considered to be Upper Proterozoic supracrustal rocks which have been infolded into the migmatites-gneiss-quartzite complex (Obaje, 2009). They occupy an area within the ‘’walled city’’ to the north central part of Kano. They are reddish to greenish grey in colour and highly weathered. They are found to be associated with diorite. This association indicates that schists have been intruded by small dioritic bodies, and are considered older than diorites in the area.

In the study area, groundwater occurs within the weathered mantle or in the joint and fracture systems of the unweathered or partly weathered rocks (MacDonald and partners, 1986). Dupreez and Barker (1965) proposed that, aquifer is located in the weathered mantle and fractured rock where permeability and porosity are sufficient to allow appreciable amount of water to accumulate in storage. The high groundwater yield in the area is found where thick overburden overlies fractured zones. The aquifer types described by Olorunfemi and Fasuyi (1993) from the study area include:-

- Weathered layer aquifer;
- Weathered/ fractured or partly weathered aquifer; and
- Fractured aquifer.

The older granite has been subjected to many tectonic movements and pressure through geologic history such that they often have several fracture lines.

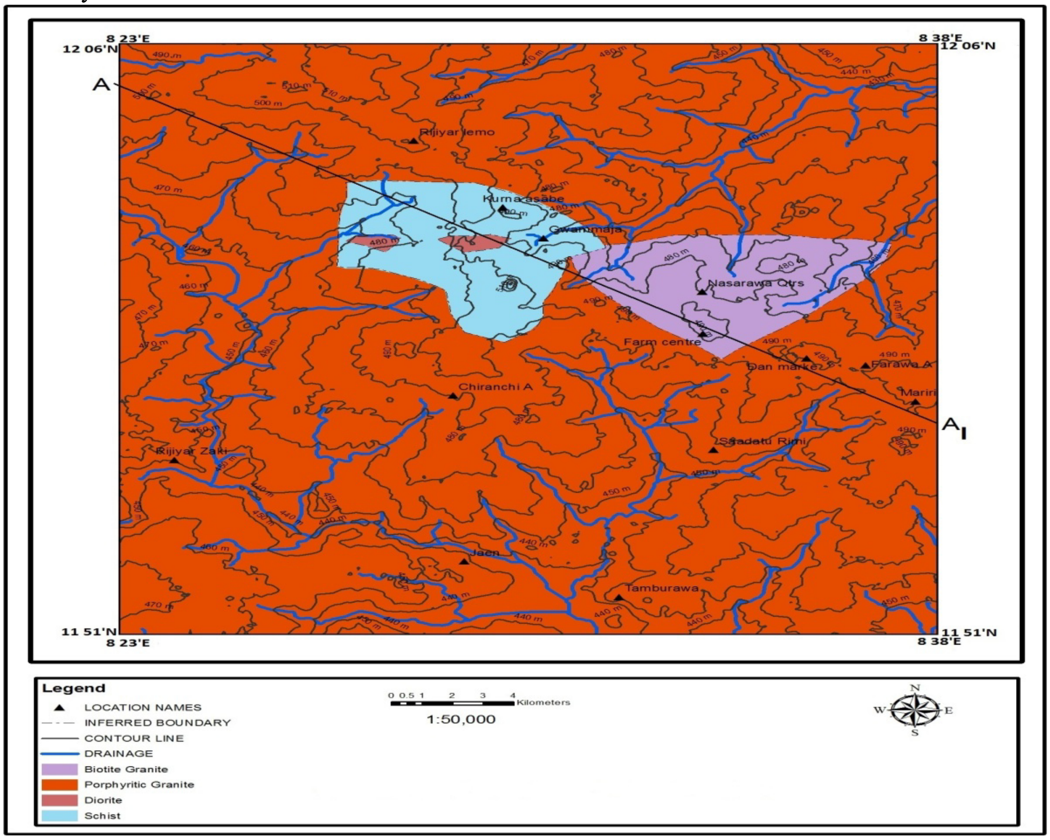

Fig. 1: Geological map of the study area

Methodology

LANDSAT ETM+ imagery of the area was downloaded from global land cover facility site. Lineaments were generated from SRTM DEM by producing shaded relief images. Eight solar relief images were created from the following solar angle; 0^0, 45^0, 90^0, 135^0, 180^0, 225^0, 270^0 and 315^0. Production of shaded relief images was followed by combination of shaded relief images to produce two combined shaded relief images. Production of first and second combined shaded relief images was followed by automatic generation of lineaments with the aid of the Line module of the PCI Geomatica software. After generation of lineaments; buffering was carried out on both automatically generated lineament images and followed by combination of buffered images. A combined buffered image was reclassified into two classes and manual digitization was done to produce final lineament map. The calculation of lineament related values with script files was done using Arc GIS 9.3 software. A Lineament density map was produced. Then rose diagram was generated using Rockworks 15 software to determine lineaments trends.

Results and Discussion

The NW-SE is the major trend of lineaments in the area, as observed from Rose diagram of (fig. 3). This agrees with the structural pattern of the basement complex of Nigeria. The zones of high lineaments density shown in (fig. 4) at the northeastern and northwestern parts of the area could probably be feasible zones for groundwater prospecting in the study area.

With regards to lineaments and rock types in the area; the geological map was superimposed on lineament map (Fig. 5). It was observed that, most of the intersected lineaments are more pronounced on the porphyritic granites. Field observation have proved that, by observing a high fracturing and intensive weathering of the porphyritic granites, which may contain groundwater in appreciable quantity.

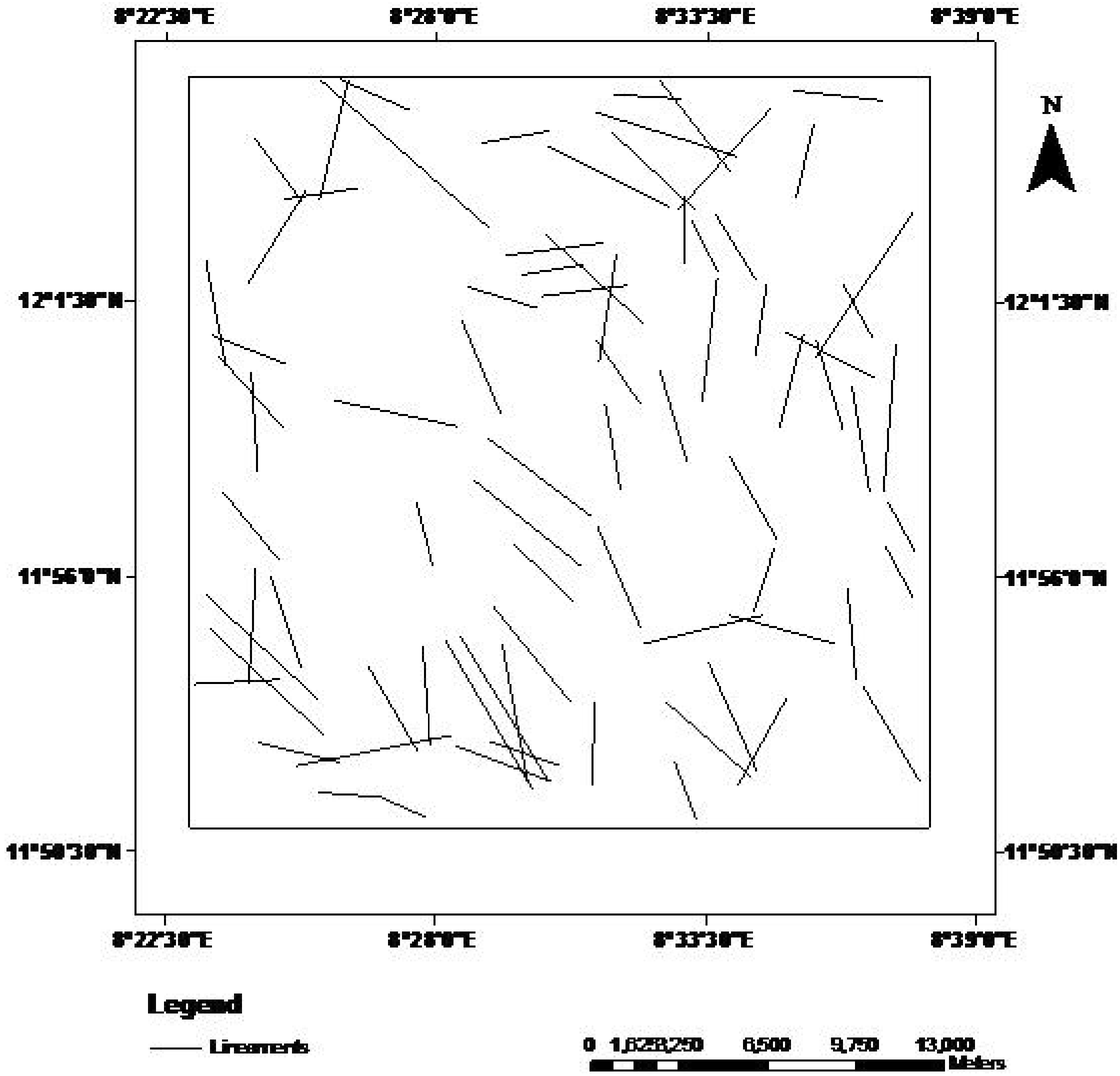

Fig. 2: Lineament Map of the Study Area

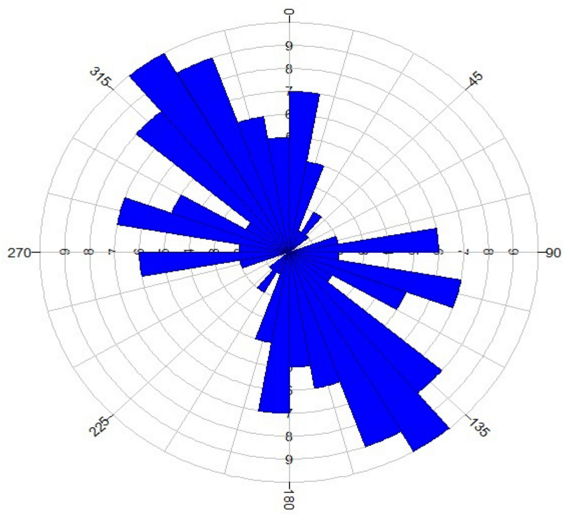

Fig. 3: Rose diagram (Azimuth-frequency) showing Lineaments trends

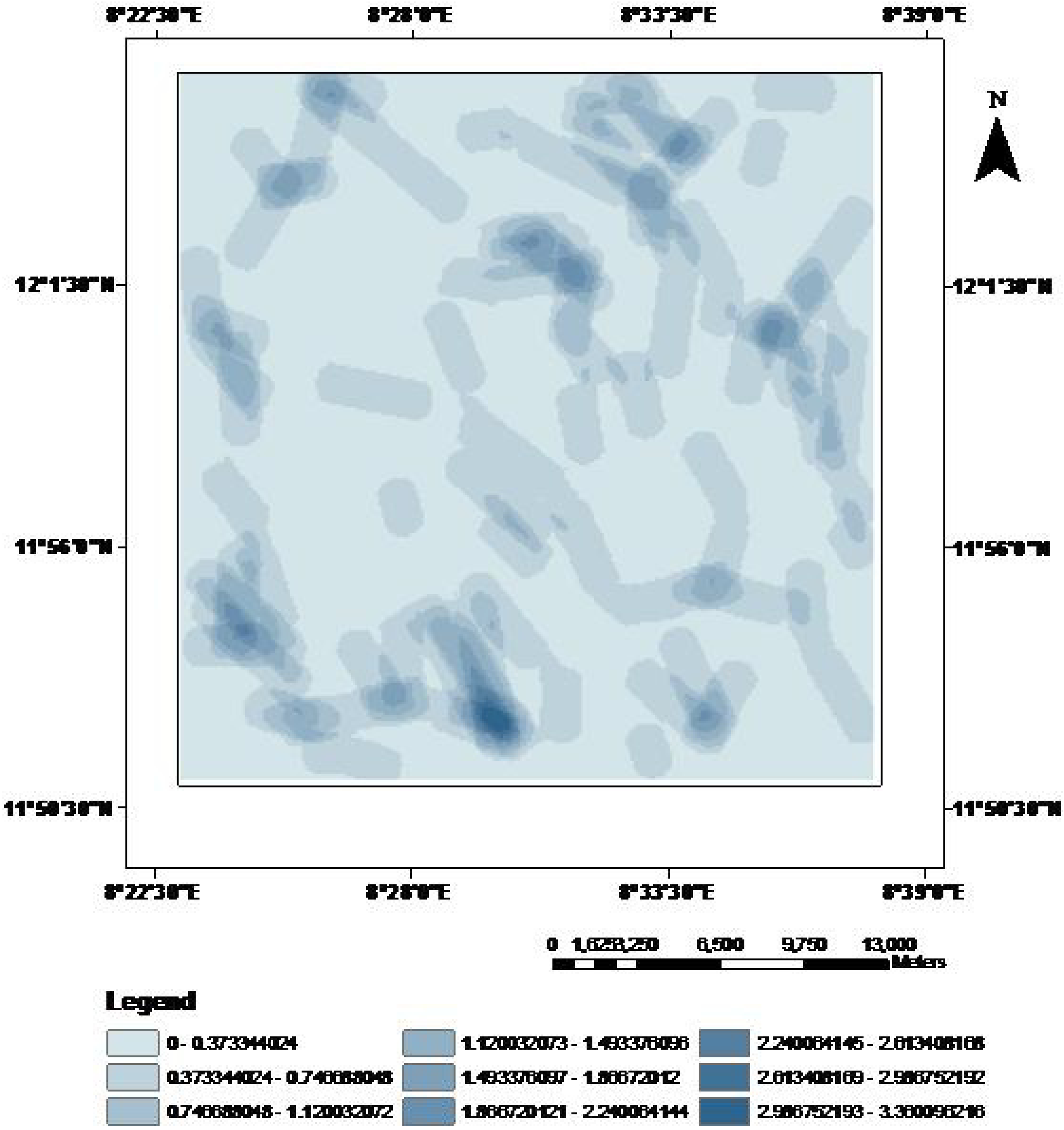

Fig. 4: Lineament density map of the study area

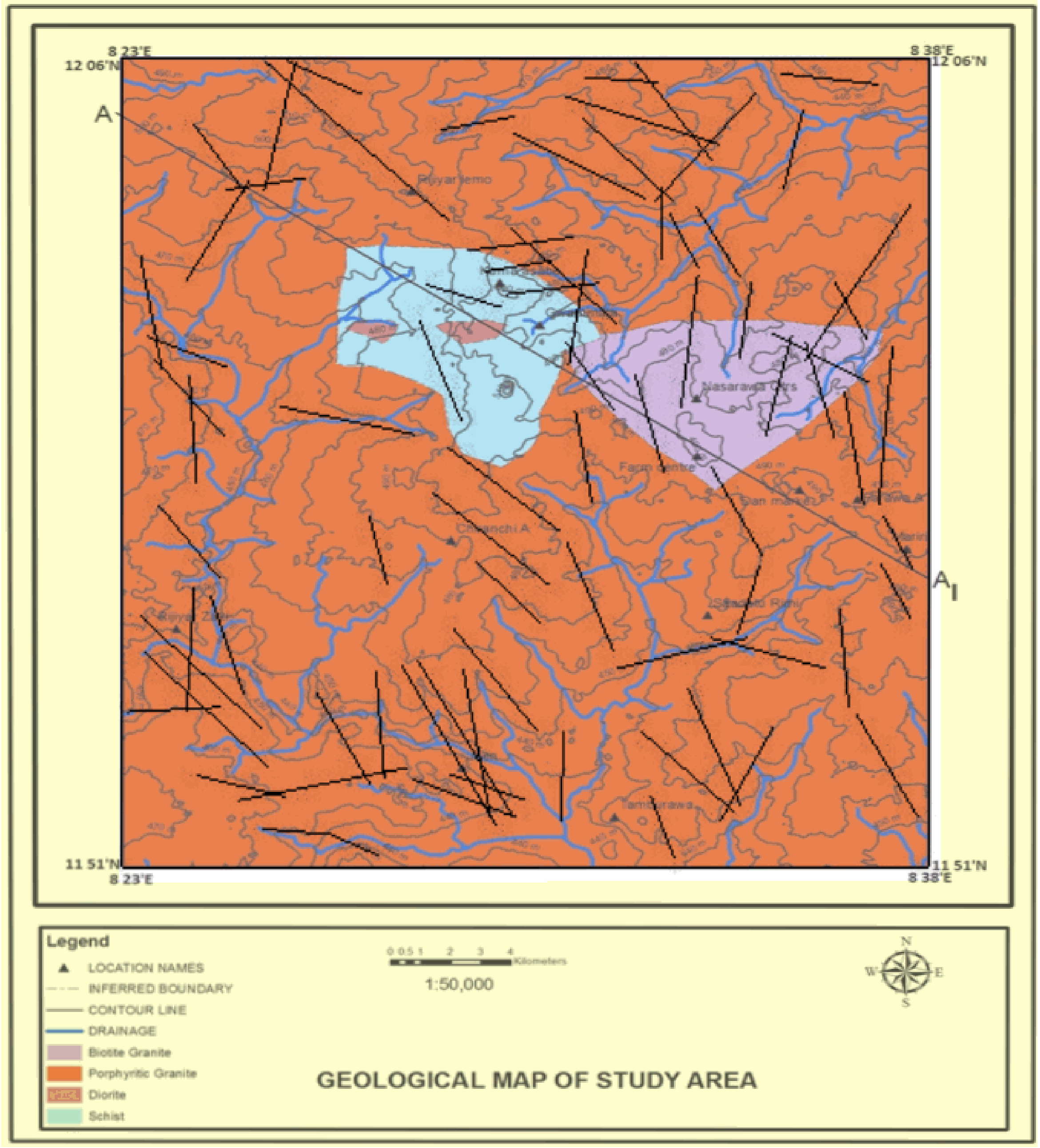

Fig. 5: Lineament Map superimposed on the Geological map of the Study Area

To study the relationship between the deep groundwater productivity and lineament in the area; the positions of deep boreholes are plotted on superimposed lineament map (fig. 6), and are located at northeastern part of the area. Therefore, looking at the proximity of these boreholes to lineaments; it was evident that the deep boreholes may not be tapping the suspected deep seated fractures, as their exploitation potential is poor, signifying low potential.

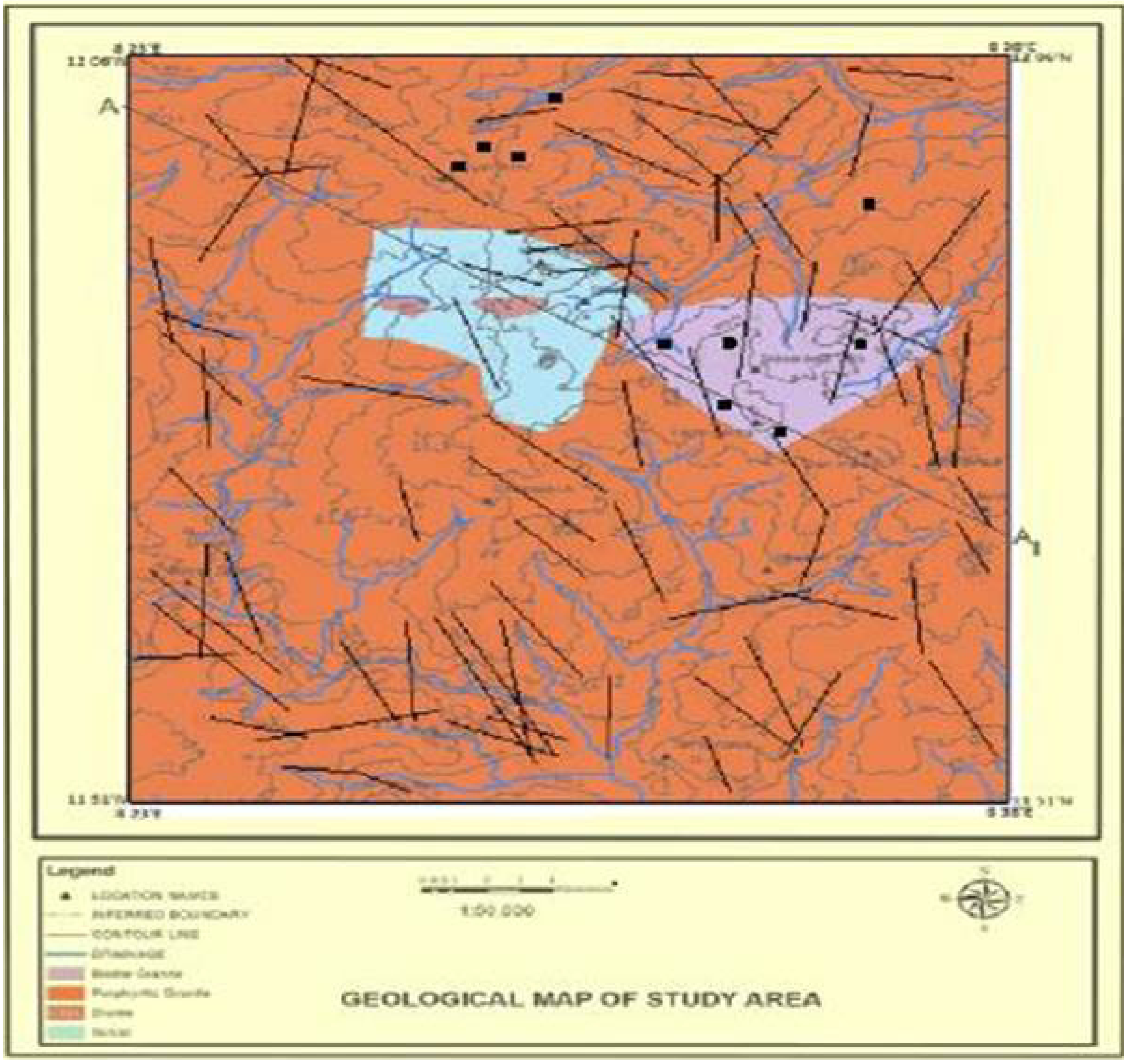

Fig. 6: Lineament map superimposed on geological map showing location of deep boreholes

References

Anudu, G.K., B.I Essien, L.N Onugba, A.E Ikpokonte (2011). Lineament Analysis and Interpretation for Assessment of Groundwater Potential of Wamba and Adjoining Areas, Nasarawa State, North Central Nigeria. *Journal of Applied Technology in Environmental* Sanitation vol 1, no. 2: 185-198.

Bala, A.E. (2001). An Evaluation of Landsat-5 Thematic Mapper (TM) Data as a Tool for Groundwater Investigation in Basement Complex Rocks of Nigeria. Unpublished PhD thesis presented to the Department of Geology, A.B.U. Zaria. Pp3-40.

Dupreez, J.W. and Barker, W. (1965). The distribution and chemical quality of Groundwater in northern Nigeria. Geological Survey of Nigeria Bulletin.

MacDonald and Partners (1986). Rural water Supplies Report, Vol. 1 (Published).Sir MacDonald Press Ltd, Deterner, England.

Mogaji K.A., Aboyeji O. S., and Omosuyi G.O. (2011). Mapping of Lineaments for Groundwater targeting in the basement complex region of Ondo State, Nigeria, using remote sensing and geographic information system (GIS) techniques. *International Journal of Water Resources and Environmental Engineering* Vol. 3(7), pp150-160.

Obaje, N.G (2009).Geology and Mineral Resources of Nigeria. Springer-Verlay Berlin. Pp 19-20.

Olorunfemi, M. O. and Fasuyi, S.A. (1993).Aquifer types and geoelectric/hydrogeologic characteristic of part of the central basement terrain. *Journal of mining geology* 16, pp 309-317.

Oyawoye, M. O. (1972). The basement complex of Nigeria. In Dessauvagie F. and Whiteman J. African Geology. University Press Ibadan, pp 18-27.