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Analysis and Interpretation of Lineaments for Evaluation of Groundwater Potential in Shendam and Environs, North Central Nigeria

C. O. Abusu, U. M. Ma'aji, M. I. Ancho, and M. M. Iliya

ABSTRACT

This study was done to evaluate the groundwater potentials of Shendam and environs using lineaments analysis. The trends of field joints were measured during mapping and using satellite remote sensing to generate lineament. The area is underlain by crystalline basement rocks of biotite granite, medium grain granite, and syenite. Assessment was carried out to depict the possibility of groundwater occurrence in the area. LANDSAT ETM+ imagery was used, together with the geological map to investigate areas favorable for groundwater development. This was achieved by plotting the lineament trends, superimposing the lineament on the geological map, superimposing the lineament on the drainage map, furthermore by plotting density map to know the groundwater potentials of the area. Lineament was used in drawing the respective rose diagrams for each rock type. Structurally, the area is characterized by a predominant NE to SW trend which also affects or controls drainage and groundwater occurrence with major groundwater recharge areas trending NE- SW of the study area. Analyses have shown that the study area has numerous fractures whose major trends are mainly in NE-SW directions. Lineament density maps shows the cross-cutting lineaments to be relatively high in the areas around the northeastern to southwestern parts of the study area but low in the other areas. Zones of high lineament intersection density are feasible zones for groundwater prospecting.

Keywords: geology, groundwater, lineament, prospecting.

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I. Introduction

Current methods for analyzing remote sensing data to delineate fractures and discontinuities in hard-rock terrains could be used to improve water-well siting strategies. Groundwater recharge and/or discharge zones may be detected using satellite remote sensing techniques that enhance temperature, vegetation, and water content variations [6]. The application of remote sensing technology may cover many fields of studies, especially in structural geology, mineral exploration, even groundwater exploration, where the remote sensing is useful for lineaments and structure features extractions. Lineaments are linear features which provide information about the underlying geological structure [1]. Remote sensing and GIS possess new possibilities for hydrogeological studies [10], [5]. High-resolution satellite imageries are widely used in groundwater studies due to their high spectral and spatial resolution. They are used to identify the geology, geomorphology, soil, lineament density, drainage density, rainfall and land use for maps that indicate the occurrence of groundwater [8]. [10] studied the integration of groundwater resources evaluation using the remote sensing. Groundwater potential zoning means using the surface and sub-surface indicative parameters either by direct or indirect scientific methods for determining the potentiality of the groundwater zones in an area by quantitative and qualitative assessment. The surface features can easily be accessed through remote sensing and field verification, whereas the sub-surface information can be obtained through observatory wells and electrical resistivity methods. Epuh [4].

II. Study Area

The study area lies between latitudes 8º45'N to 9º00'N and longitudes 8º15'E to 8º30'E and forms part of Shendam Sheet 212 NW (Figure 1). The area extent of the study area is about 748.02 km^2 with Shendam being the largest settlement. Other settlements include Yelwa, Kawo, and Tengzet, among others. The area is characterized by a continental tropical climate, a climatic condition characterized by wide seasonal variations of temperature [7]. The rainy and dry seasons caused by two prevailing winds define the seasons experienced in the area. The north-easterly wind is responsible for the harmattan season, while the second is the southwestern wind, which is responsible for the rainy season.

The area is well drained by network of rivers and streams which are mostly annual. The drainage pattern is dendritic in nature and is controlled by mountain and hills, it develop in region underlain by homogeneous materials, which means that the subsurface geology has similar resistance to weathering, so there is no apparent control over the direction of the tributaries [9]. River Shendam, Kogi-Papa and other smaller rivers in the area provide water to the people during the rainy season and dries up as soon as the rainy season is over (Fig. 1).

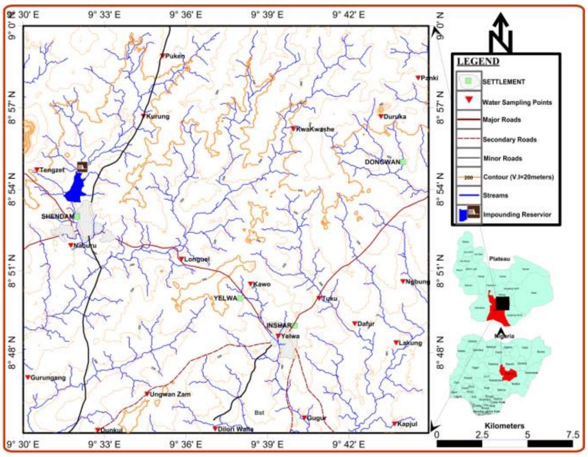

Fig. 1. Location map of the Study Area.

III. Geology and Hydrogeology

Shendam and its environs are underlain by biotite granite which covers about 56% of the total area studied. Medium grained granite mostly outcrops on the central and south eastern parts and covers about 43% of the study area. Syenite also occurs in the area and appears to have intruded into the biotite granite in the northeastern portion of the study area (Fig. 2). Trends of joints and veins within all the rock types indicate NE-SW orientation (Fig. 6, 7 and 9).

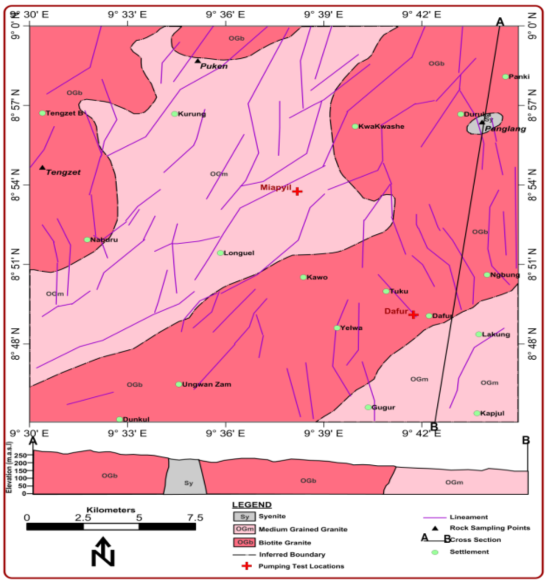

Fig. 2. Geological map of Shendam and its environs.

IV. Methodology

The lineament map was prepared using the automatic line extraction from shaded relief images using PCI Geomatica 10.0. However, prior to automatic lineament extraction, shaded relief images were prepared in ArcMap 10.2. Successive shaded relief images were created by varying the azimuth (Sun Angle) of DEM from 0º to: 45º, 90º, 135º, 180º, 225º, 270º, and 315º. Solar Azimuth was set at 0^0, solar elevation at 30 and ambient light at 0.2 to ensure good contrast as shown by [3]. Two combined shaded relief images were created by respective overlay of shaded relief images with azimuth 0º, 45º, 90º, and 135º; and azimuth 180º, 225º, 270º, and 315º. ArcMap 10.3 software was used to determine the coincidence between the lineaments extracted from the two combined shaded relief images and these points formed the lineaments that were digitized and used for the lineament density thematic map. X coordinates of line start and line end, and Y coordinates of line start and end were calculated from the attribute in ArcMap 10.3. Values were exported to Rockworks Software which was used in drawing the respective rose diagrams. A combined buffered image was reclassified into two classes and manual digitization was done to produce final lineament map (Fi. 3). The calculation of lineament related values with script files was done using Arc GIS 10.3 software. A lineament density map was produced (Fig. 4), followed by the superimposition of the lineament on the drainage map (Fig. 5). Then rose diagram was generated using Rockworks 15 software to determine lineaments trends (Fig. 6-9).

V. Results

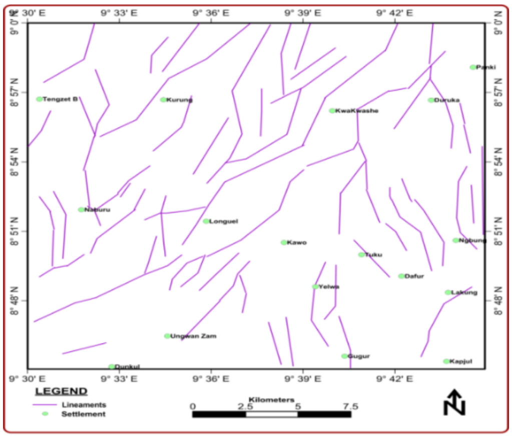

Fig. 3. Lineament Map for the Study Area.

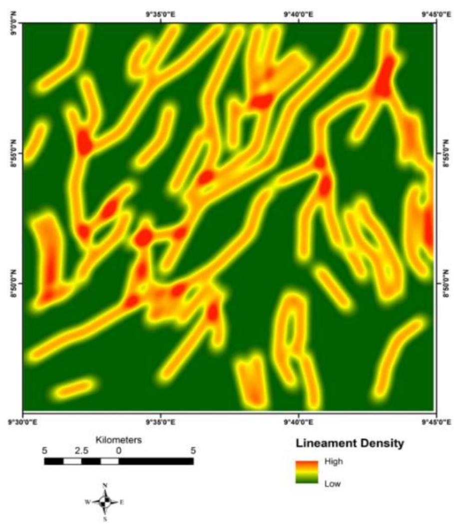

Fig. 4. Lineament density map.

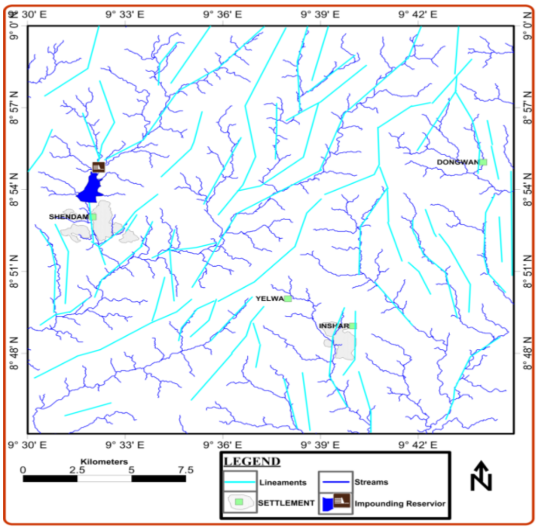

Fig. 5. Map of lineaments superimposed on drainage map.

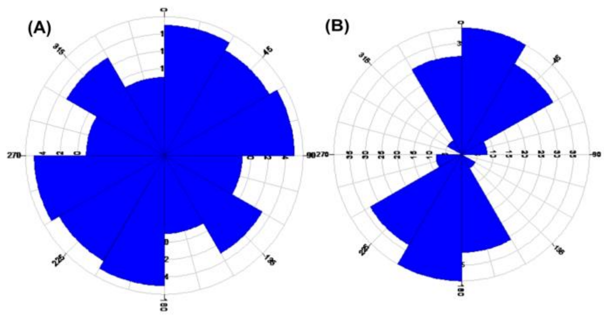

Fig. 6. Structural trend in the area (A) Field Data; (B) Remote sensing data.

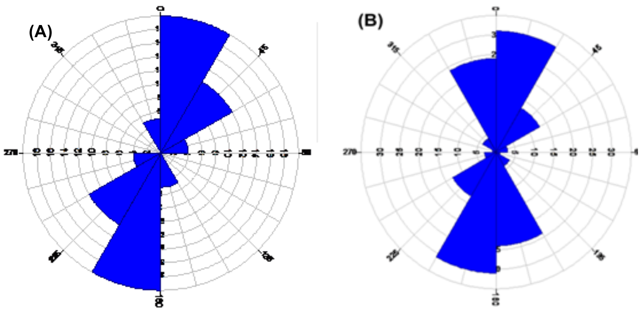

Fig. 7. structural trend in biotite granite (A) Field Data; (B) Remote Sensing data.

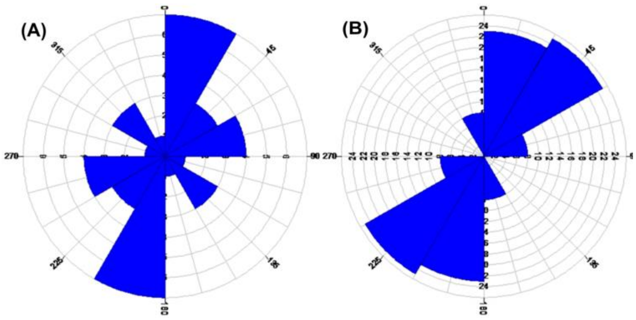

Fig. 8. Structural trend in medium grained granite (A) Field Data; (B) Remote Sensing data.

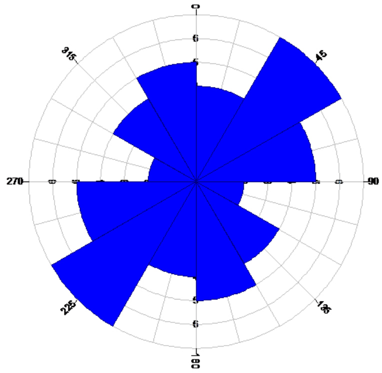

Fig. 9. Rose diagram showing structural trend in Syenite on the field data.

VI. Discussion

The dominant trends of lineaments in the area as can be observed from the Rose diagram are from N E and SW (Fig. 6-9). This is in agreement with the geology of the study area being predominantly occupied by biotite granite. The areas of high lineaments density (Fig. 4) cover the north-eastern and south-western parts and are the most probable feasible zones for groundwater prospecting in the study area. One major groundwater recharge area trends NE-SW, from west of Panki (in the NE) down to the SW of Yelwa. Other recharge areas occur around isolated hills in the NW of the study area and NW of Tengzet. Results of thickness of dry zone which is an estimation of the depth at which groundwater can be obtained in the dry season within the study area ranged from 0-21 m. Thickness of dry zone map drawn from the dry season depth to water table and points where surface contours intersect dry season groundwater configuration contours, indicate that the dry zone thickness in most of the study area range from 5-10 m. The NE portion of the study area (west of Panki) however has areas with dry zone thickness of up to 21 m which apply that those part of the study area has more ground water potential (Fig. 10). In respect of the geology and lineaments of the area, the geological map was superimposed on the lineament map (Fig. 11).

The observation made was that, most intersected lineaments are common on biotite granite.

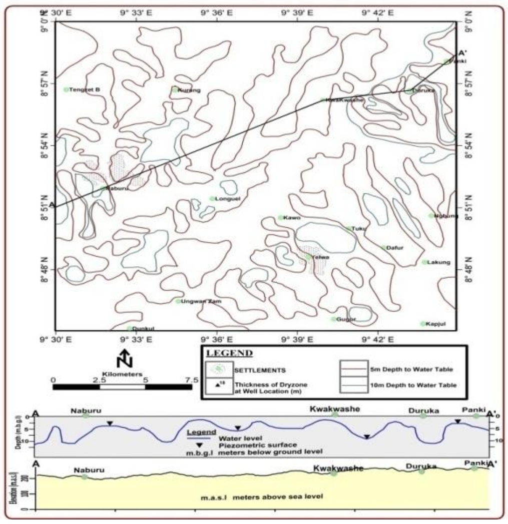

Fig. 10. Thickness of Dry zone Map.

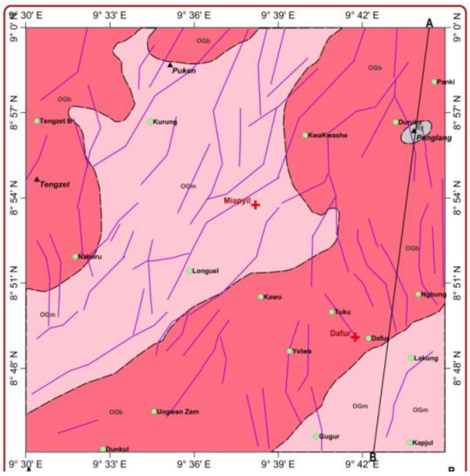

Fig. 11. Lineament map superimposed on geological map.

VII. Conclusion

Lineament analysis for groundwater exploration in Shendam and environs shows that the study area is underlain by biotite granite, medium grain granite and syenite. Plots of the lineaments observed on the imagery show dominant trends in NE-SW directions. The lineament density of the area was calculated using the number of lineaments per unit area (number/km2) of grid. Two forms of lineaments density maps were produced; they are lineament map and lineament density map of the area. These maps show that lineament density is high in areas underlain by biotite granite. Result from the lineament analysis shows that groundwater potential is high in the areas with high lineament density. Exploitation of groundwater can now be considered in places in the study area with high lineament structures that is, high Lineament density for groundwater potential in the study area.

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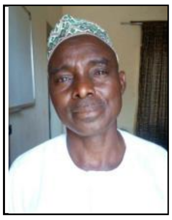

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