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Delineation of fracture in Ohofia Agba and it's environs Ebonyi state, southeastern Nigeria using geographic information system (GIS)

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ABSTRACT

Groundwater study in an area requires the detail knowledge structure and geology. This can be well understood with the help of Geographic Information System (GIS). As groundwater exploration is greater controlled by structure, hence GIS and DEM was used in geospatial and hydrological modelling including drainage and watershed delineation, groundwater investigation studies, while elevation data and planimetric features extracted from Google Earth maps and ASTER server was used to derive digital elevation models (DEMs) of the study area in GIS environment. It was observed that the SW part of the study area tends to be more fracture than the other part of the area.

Keywords: Formation, Vegetation, Lineament, Drainage and Groundwater.

1. INTRODUCTION

Water is necessary for our day to day life, but accessing this most important mineral requires the detail knowledge of the structures and geology. As this can achieve through ground investigation using Vertical Electrical Sounding (VES), Electromagnetic (EM) or aerial photography, satellite images. The use of GIS provide detailed information about the large part of the earth in a very short time (Eyankware, 2015) and also require less manpower unlike ground investigation. Water scarcity has been one of the major challenge that the inhabitant of area faced with, as surface water is seasonal, hence the need to exploit the groundwater resource no matter how poor the yield might be (Ugwu, and Nwosu, 2009b). However the occurrence of groundwater is due largely to the development of secondary porosity and permeability by weathering and/or fracturing of the parent rocks especially within the Asu River Group. (Edet and Okereke, 1997, Olayinka et al 1997 and Ugwu, 2009). Hence the use of GIS is needed in delineating area that tends to be fractured, which are the major aquiferous within the study area. The use of GIS and geophysical method has integrated in predicting areas with groundwater prospect and the information obtained has been relevant in the groundwater exploration all over the globe (Akinlalu, et al. 2017a; Sultan, et al., 2017; Boyowa, et al., 2014; Kolawole, et al., 2016; Saumitra, 2008; Singh, et al., 2000; Saraf and Chaudhary, 1998; Mukherjee, S.(1997). GIS interpretation studies help in the showing area that tends to be of groundwater potential via the following:

Identification of geological structures and the hydrophysical properties,

(ii) Water-bearing geological formations and water enrichment,
(iii) Areas of recharge,
(iv) Places of discharge,
(v) Nature of outlet of groundwater to the surface,
(vi) Depth and conditions for occurrence of groundwater,
(vii) Direction of movement and
(viii) Degree and nature of salinity.

Although GIS data acquisition and interpretation do not directly detect deeper subsurface resources, it has been effectively used in groundwater exploration as GIS aid in drawing inferences on groundwater potentiality of the region indirectly.

1.1. Location and Accessibility

The study area geographically lies within $6^0$10 - $6^0$30^{I}N to $7^0$30 - 7^0 48^{I}E as shown in (Fig. 1). The area covers part of Ebonyi state, the major road that link the area is the Enugu-Abakaliki express ways.

1.2. Climate and Vegetation

Balogun, (2005) stated that the climate of Nigeria is classified into meteorological zones with the study area in zone B. The area is characterized by relatively warm temperature days of 27^0C to 32^0C and moderately cool nights of 17^0C to 28^0C. Two major seasons occur within the area namely: dry and rainy season. The dry season prevails from November to March , but between December and early month of February and the Sahara anticyclone from the northern hemisphere causes dry and dust laden air mass blowing from across the desert through parts of the northern Nigeria. The rainy season start from April to October with an August break or little period of no rain. High rain rainfall occurs within the September. The area falls within the rainforest region of southeastern Nigeria. It has a humid climate and evergreen vegetation. The vegetation cover is composed of very dense trees and undergrowth of creepers. These trees are mostly tall, with buttress roots. The vegetation is controlled by many factors, including the drainage, topography, geology and rainfall. The area has been described as part of the low land rainforest region (Igbozurike, 1975).

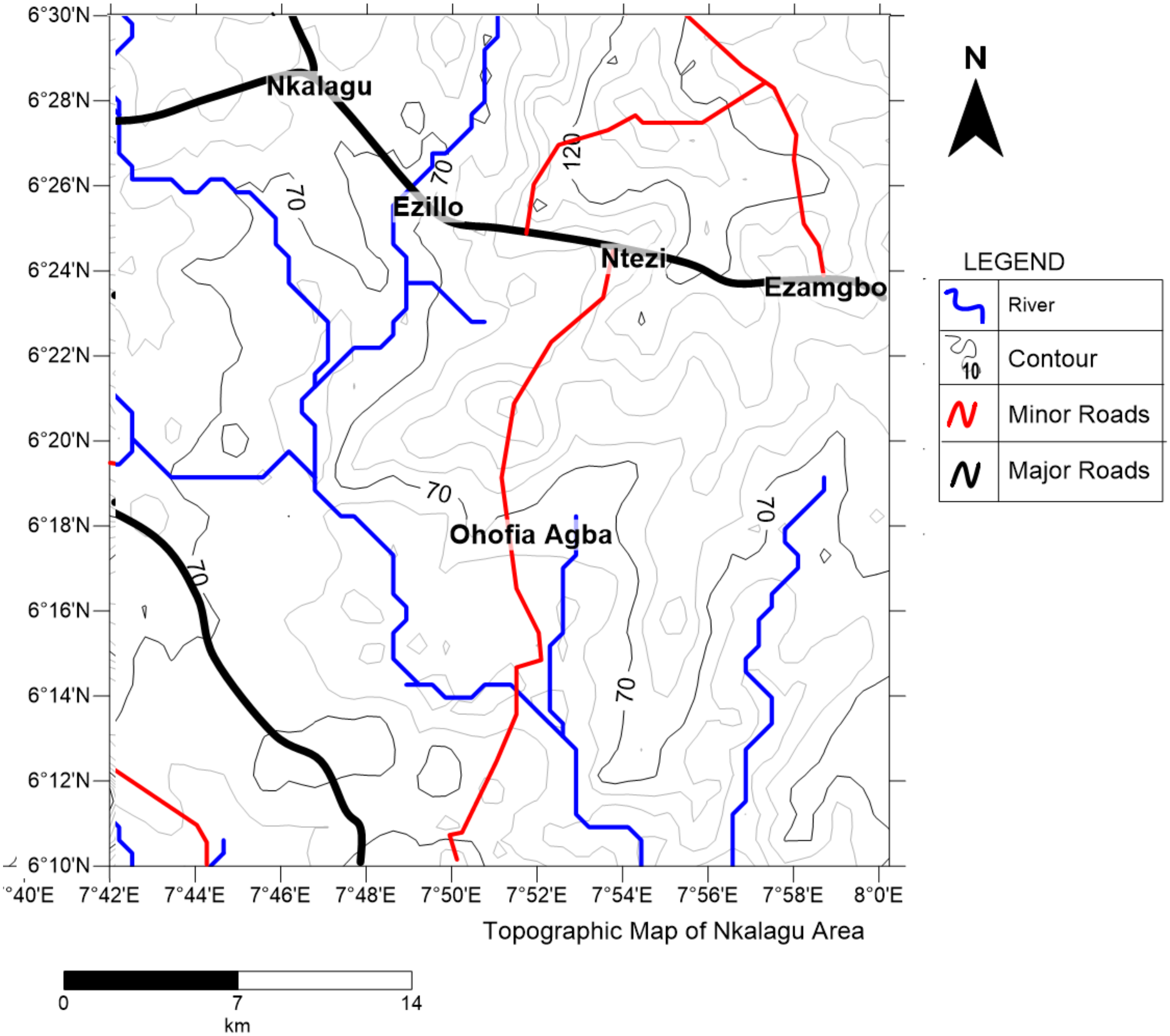


Figure1 Accessibility Map of the Study Area

1.3. Drainage and Topography

Two drainage pattern was observed namely dendritic and trellis like pattern. The dendritic patterns, a tree like branching of tributaries join the mainstream at acute angles. Usually this pattern occurs in homogeneous rocks such as soft sedimentary or volcanic tuffs. Trellis is a modification of dendritic, with parallel tributaries converging at right angle. It is indicative of bedrock structure rather than material of bedrock. It can be associated to tilted or interbedded sedimentary rocks, where the main channels follow the strike of the bed. In the study area dendritic pattern is usually observed and toward the southeast region of the study area can be observed the trellis like pattern as shown in Fig. 2a and 2b. Which indicate the area is mostly made up of homogeneous rocks such as soft sedimentary or volcanic tuffs and towards the southeast region made up of tilted or interbedded sedimentary rocks.

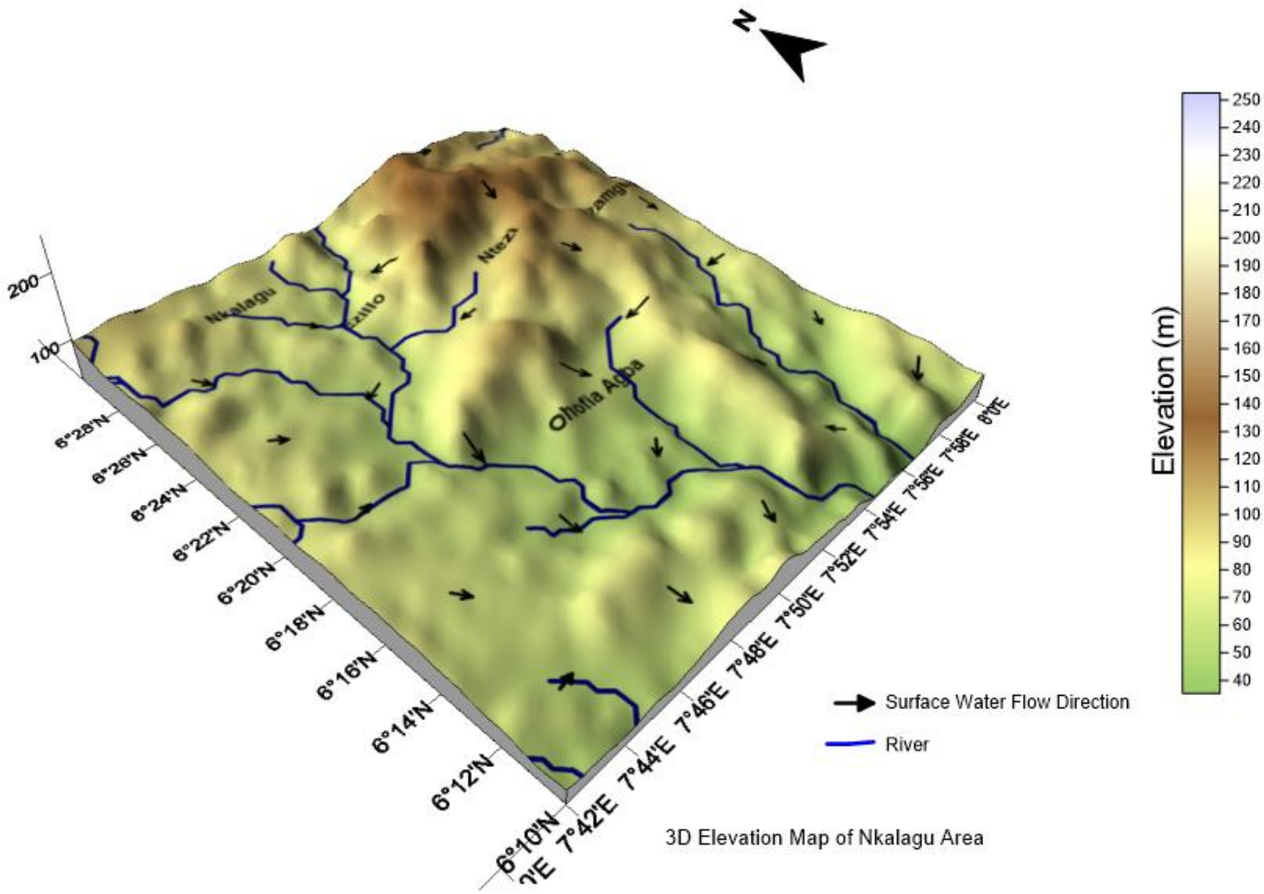


Figure 2a Accessibility Map of the Study Area in 3D

1.4. Regional Stratigraphic Setting Benue Trough

The study area lies within the southern Benue Trough and the Anambra Basins. The South Benue Trough has been referred to as Benue Valley Cratchley and Jones,(1965); Benue Trough (Grant, 1971) and Benue Aulacogen. It is known to be an intracontential rift basin which is part of the Gulf of Guinea, South Atlantic, Benue triple junction with its centric occupied by the Niger Delta. The Benue Trough is divided into three stratigraphic setting based on geographical namely: Upper Benue Trough, Central and Southern Benue Trough. The basin is mainly filled with Pre Santonian (Late Aptian to Coniacian) sedimentary rocks which have undergone regional burial metamorphosed at the anchonizonal to lower greenschist grade (Benkhelil, 1986; 1987, Obiora, 2002, Obiora and Umeji, 2004; Simspon, (1954); Reyment, (1965) and other team of researchers has carried out research within the Southern Benue Trough sedimentary fill.

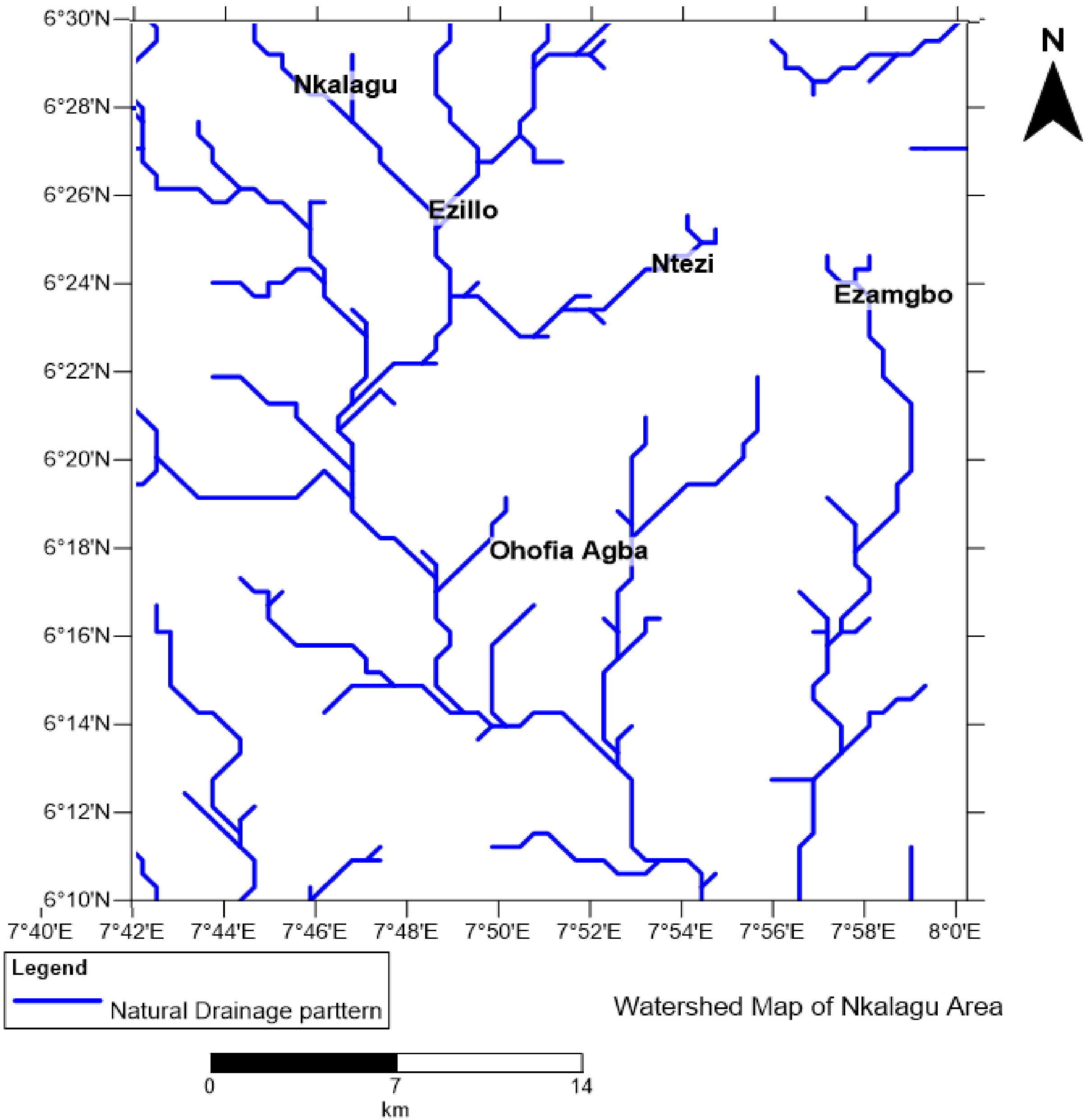


Figure 2b Drainage Map of the Study Area

2. GEOLOGY/HYDROGEOLOGY OF THE STUDY AREA

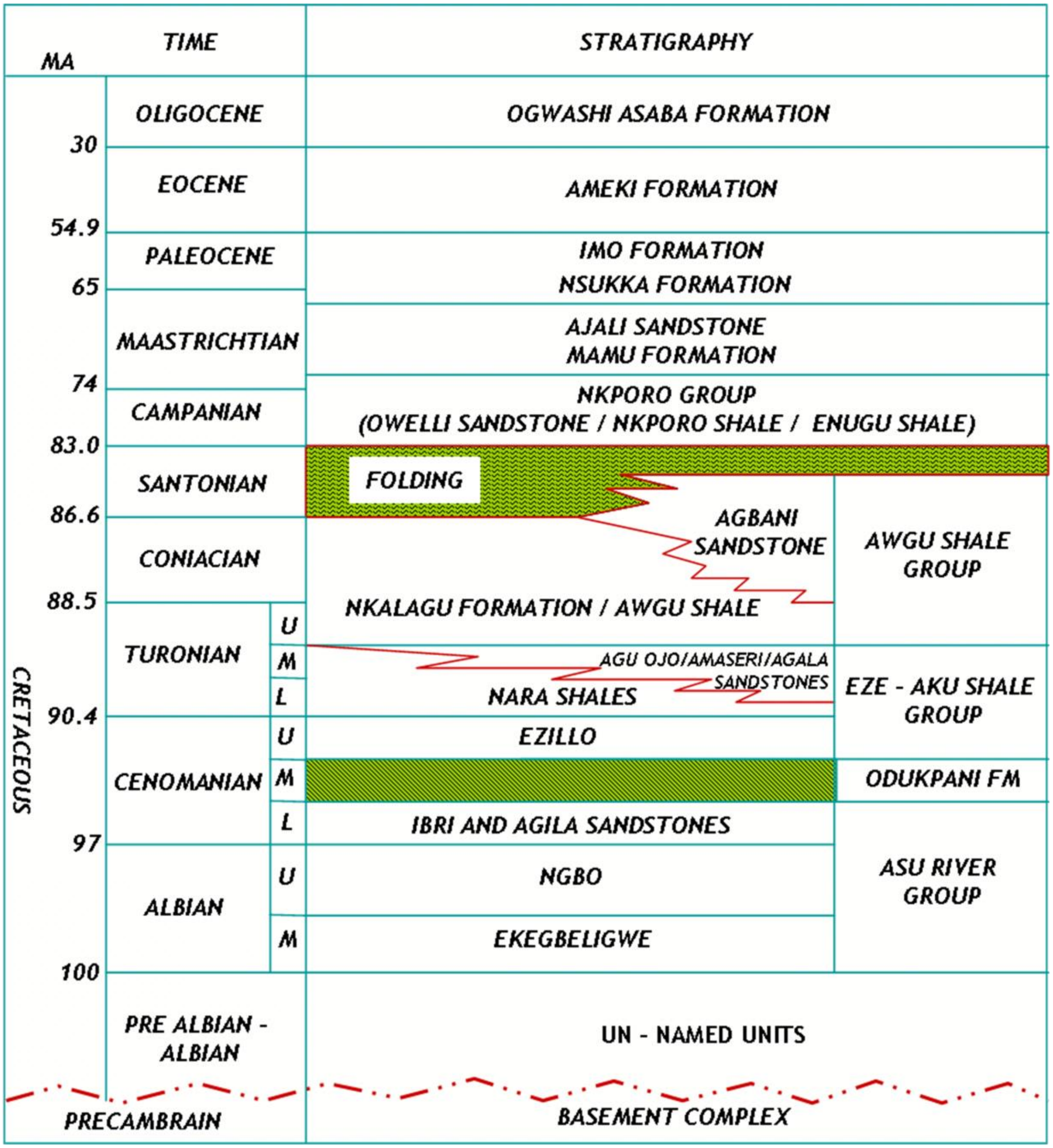
2.1. Awgu Formation (AF)

The Awgu Formation overlies the Eze Aku Formation and it Coniacian in age as shown in Table 1. According to Reyment, (1965) this unit has various names; Benue Shales, Awgu Sandstone and Ndeboh Shale. It covers larger part of the Southern Benue Trough, from surface mapping its thickness is estimated to be 900m (Simspon, 1954 and Reyment 1954). Agagu, et al., (1985) estimated its thickness from well data to be 1,100m. Succession of log borehole this units consists of shale, sandstone and limestone (Nwajide, 2013).

2.2. Eze Aku Formation (EZG)

The Eze Aku Formation overlies the Asu River Group as shown in Table 1.This group is one of the major stratigraphic unit erected by the Shell D' Arcy geologist in 1950s. Murat, (1972) introduced the name Eze Aku Shale Group. This unit includes all the stratigraphic units deposited from the Late Cenomanian to Turonian in the Southern Benue Trough. The group consists of extensive shales interbedded with sandstones, siltstones, limestones and marls (Reyment, 1965; Whiteman, 1982; Nwajide, 2013). This unit covers certain part of Nkalagu as shown in Fig.3. Umeji, (1984) subdivided this lithofacies of this unit into: limestone, siltstone, shale and sandstone. . The aquiferous units of the Eze Aku Group is found in the sandstone and occasionally fractured limestone Nkalagu area.

Table 1 Lithostratigraphic framework for the Early Cretaceous-Tertiary period in southeastern Nigeria. (after Nwajide, 1990).



2.3. Asu River Group (ASG)

The Asu River Group directly Overlie the Basement Complex (Table. 1). This unit describe as lower Shale and Cross River-Benue Shale by Bain (1924), Simpson, (1954) referred to the unit as Asu River Series, while Offodile , (1976) assigned it as the Asu River Formation. This group is Albian in age and is the oldest of the sedimentary succession in the Southern Benue Trough (Obrike, et al., 2012). The group comprises mainly of olive-brown or bluish grey shales and sandy shales, fine-grained micaceous sandstones and micaceous mudstones with thin limestones around Abakaliki (Simpson, 1954) to dark grey- black pyritic micaceous shales with thin sandstone and siltstone beds, magnesitic and dolomitic horizons at Ngbo, with an estimated thickness of about 2500m (Agumanu, 1989).

ASG is considered to extremely poor in groundwater prospect (Nwajide, 2005), the area is underlain by the facies of the group has largely been by water holes dug to catch off. Normally such supplies easily dry up during the dry season. The surface sources of water in the area is seasonal, hence the need to exploit the groundwater resource no matter how poor the yield might be (Ugwu and Nwosu, 2009b). Consequently the occurrence of groundwater is due largely to the development of secondary porosity and permeability by weathering and/or fracturing of the parent rocks (Edet and Okereke, 1997, Olayinka, et al., 1997 and Ugwu, 2009). While the weathering profiles are highly variable in the formation concerned especially in thickness, the fracture pattern which is the target of exploration is unpredictable. The target aquifers (fractures) are concealed by thick overburden especially along unpredictable fracture zones.

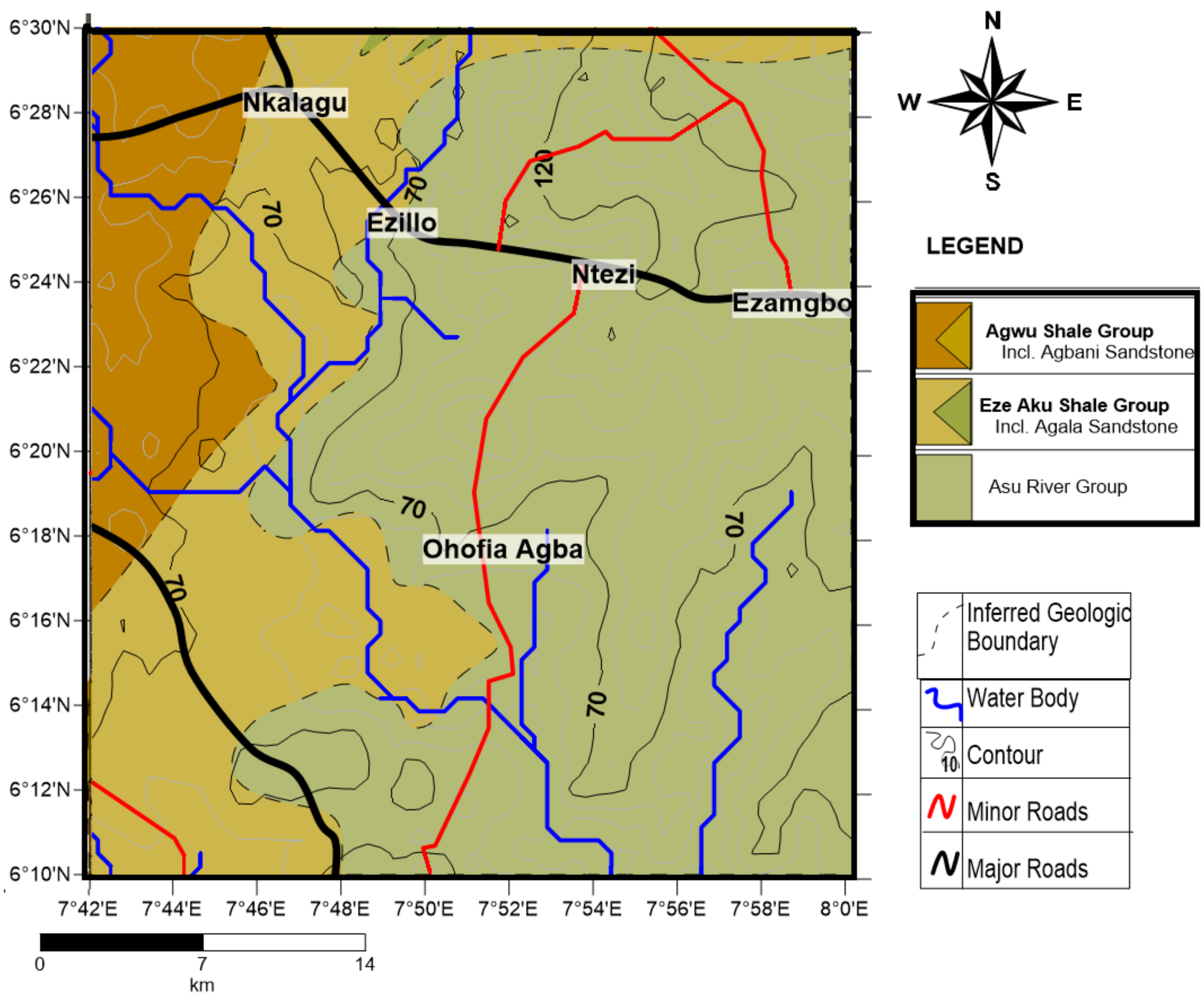


Figure 3 Geology Map of the Study Area

3. METHODOLOGY

Geographical information system and Digital Elevation Model was used in geospatial and hydrological modelling including drainage and watershed delineation. While elevation data and planimetric features extracted from google earth maps and ASTER server were used to derive digital elevation models (DEMs) of the study area in GIS environment. In the study two categories of DEMs were developed with 5m contour and planimetric topographic data; bare earth DEM. These derived DEMs were used as terrain inputs for performing spatial analysis and obtaining derivatives products. The generated DEMs were used to produce drainage patterns and watershed map, lineament map, topographic map, geological map and accessibility map of the study area using Didger 5, Surfer 14 and Map viewer 8 of Golden Software also QGIS 2. 1 and Google Earth pro.

4. RESULTS AND DISCUSSION

Groundwater is usually been influenced by the physical processes acting upon because it is a reflection of the area (Sikakwe, *et al*., 2015). The physical processes caused by land use / land cover is attributed to climate change, geologic and topographic conditions on the distribution of soils, vegetation and occurrence of water (Ndatong and Yadev 2014). Landuse is the totality of land usage in an area for different purpose. For example agriculture, education and other commercial purpose, while landcover is the extent of land coverage by vegetation, landcover can also be referred to as biophysical attribute of the earth's surface. Landcover can be analyzing from satellite imaginery/aerial photography. Zones in water and wetland areas are graded as very good for groundwater potential. This views square with findings of Das (2002) went further to described wet lands as favourable groundwater potential sites. Forested areas were described as in this study as moderate to good groundwater potential zones. Vegetation can affect groundwater storage either positively by trapping water on foliage and causing the water to go down through the roots to recharge ground water or negatively through evapotranspiration where water droplets is frequently intercepted by vegetation thereby decreasing recharge (MAB CONSULT (2002). Cultivated grassland was graded as good due to the furrows created by farming operations that enhance the residence time of water on the surface and so enhance infiltration to recharge aquifers. Settlements were described as poor groundwater areas due mostly to concretization. Land with different vegetation cover can benefit groundwater infiltration through roots that help loosen the rock and soil for easy water percolation (Sikakwe, *et al*., 2015) as shown in Fig. 6.. Teixera, et al., (2008) stated that organic matter in soil heightens the formation of structural composition resulting to elevated hydraulic conductivity decrease direct runoff by vegetation and increasing the chances of infiltration to recharge aquifers.

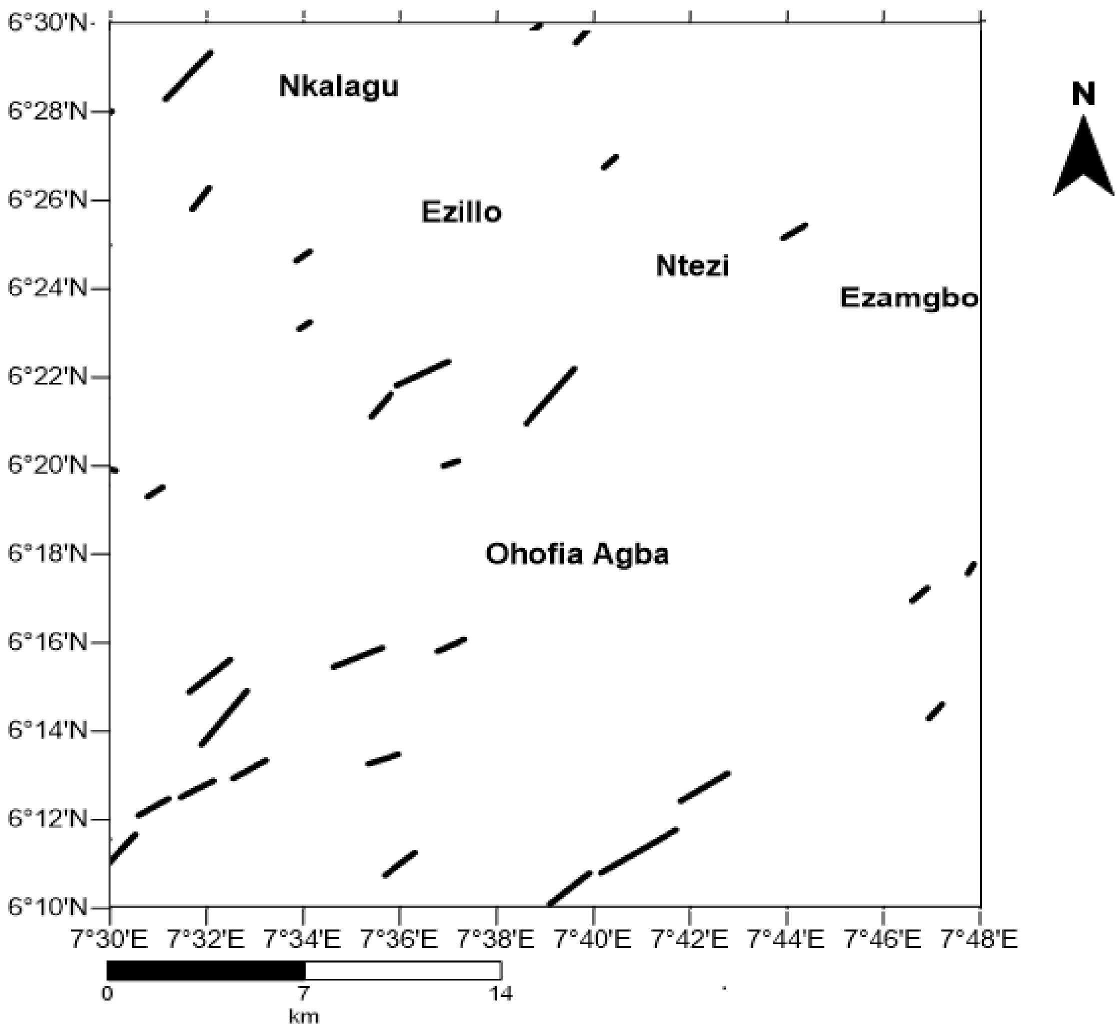


Figure 4 Lineament Map of the Study Area

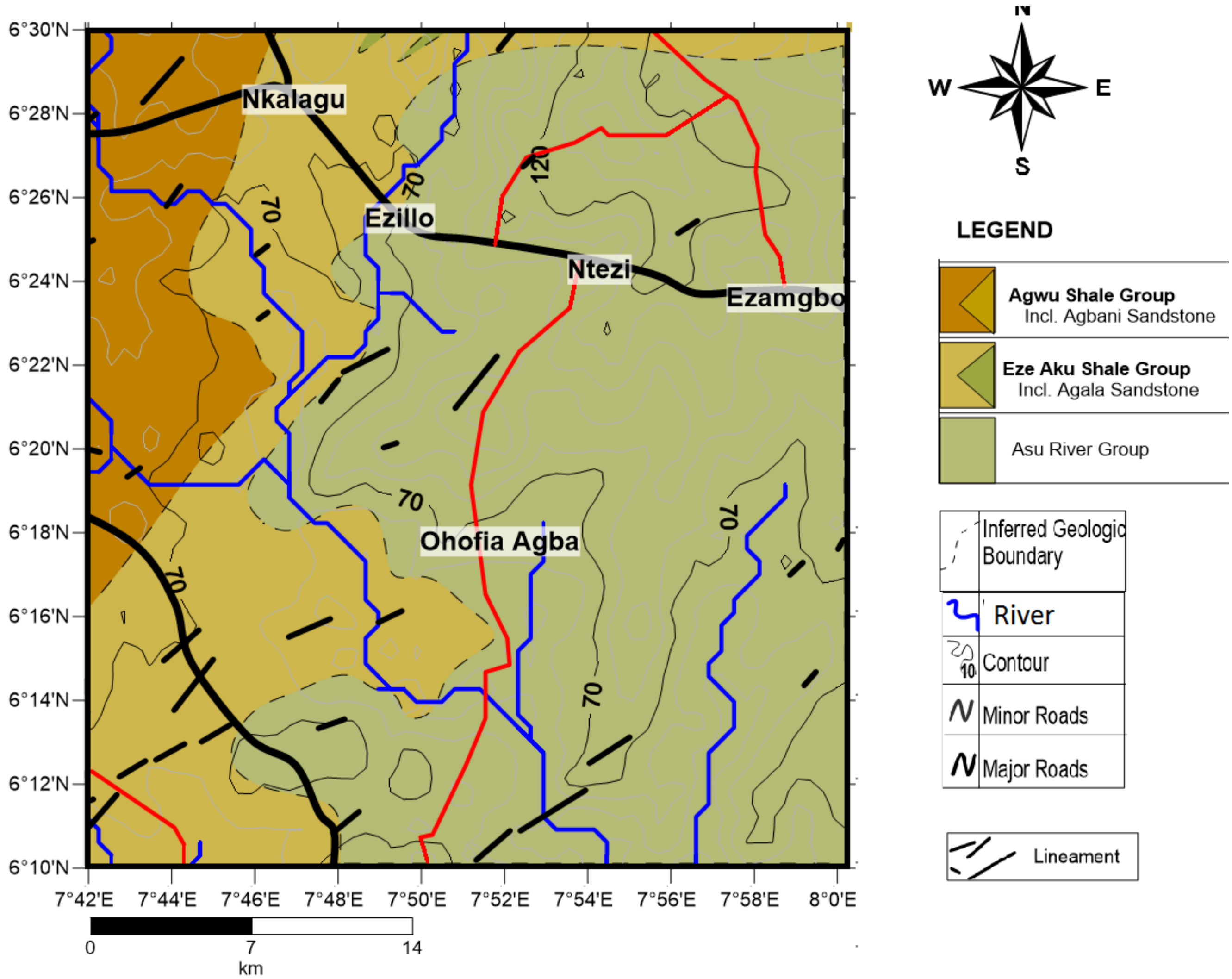


Figure 5 Map of lineament superimposed on Geology

5. CONCLUSION AND RECOMMENDATION

Nkalagu, Ezillo, Ntezi, Ezamgbo and Ohofia Agba tend to be less fractured compared to south west area of the map, this could be attributed to geological activities as shown in Fig. 4 and 5. While the SW area tend to fractured, compared to other part of area. However it recommended that for better understanding and determining of area with groundwater potential a detail ground investigation is required such as; Electrical Resistivity Sounding and integration of other method and geophysical method. Moreso, detail relationship between groundwater to the landscape and land use is not well understood by most people, especially policy makers, engineers and managers without a geological training. This is because aquifers outcrop over such a wide area, groundwater cannot be seen, and most people have no understanding of the subsurface environment, and so it is out of sight and largely out of mind. Therefore training and re-training of these policy makers in necessary to in other to meet the demand for portable water for the inhabitant of the study area. The fractured zones within the study area have been delineated to guide future drillers in their subsequent operations.

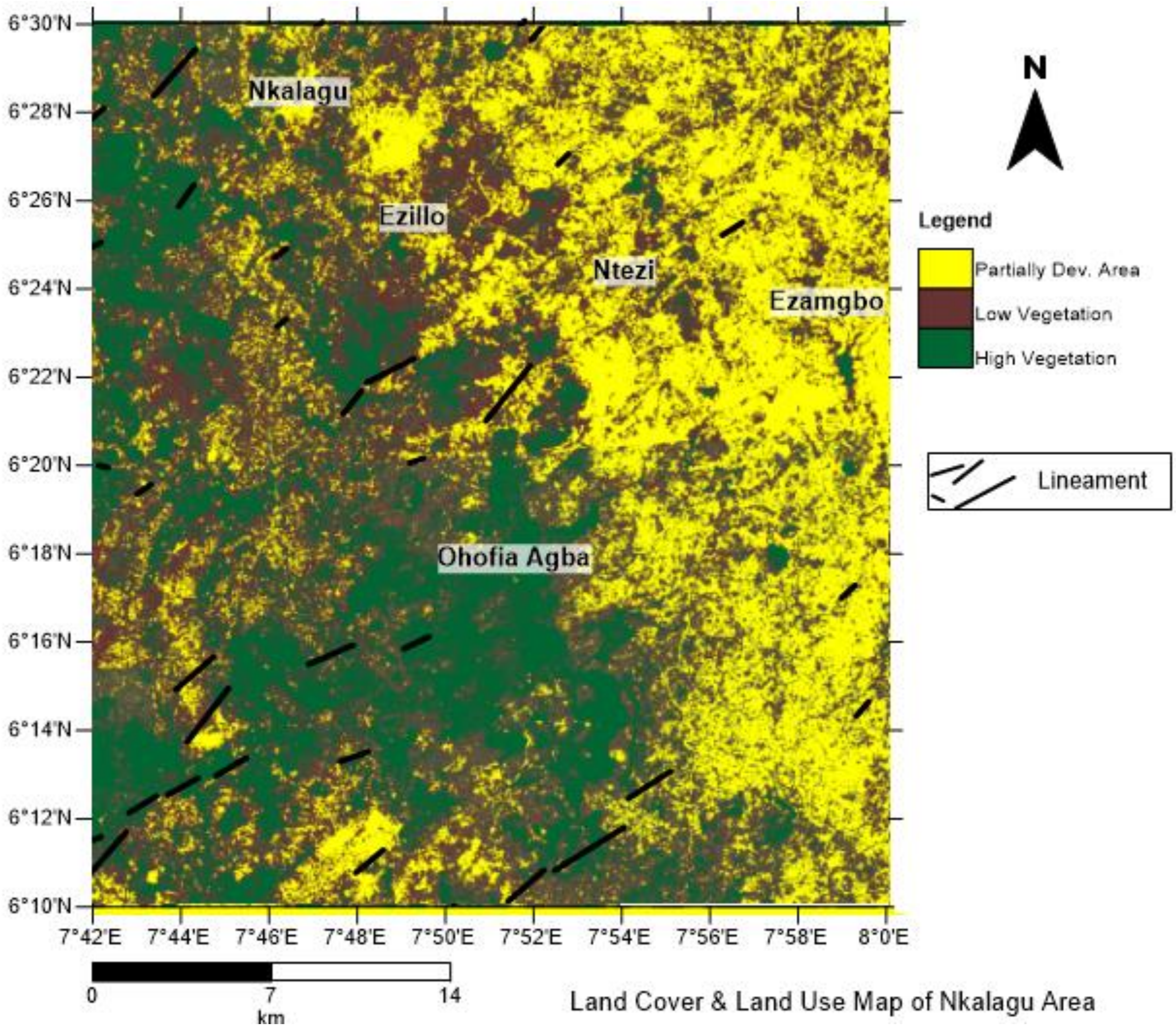


Figure 6 Land Cover and Land Use Map of the Study Area

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