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AN EVALUATION OF NIGERIA SAT-1 IMAGE FOR GEOLOGICAL MAPPING OF PART OF PLATEAU STATE, NIGERIA

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ABSTRACT

Remote Sensing and Geographic Information System (GIS) techniques were applied in the geological mapping of part of Jos, Plateau State, Nigeria in this paper. The study was mainly through structural, lithological and topographic analysis of the NigeriaSat-1 image of the study area. Simple digital image processing techniques which involve classification and linear/edge enhancement were applied on the image to enhance edges of linear features. These were followed by computer aided visual interpretation of geological structures and lithological units. The processing led to the production of drainage patterns fractures/lineaments, and geological maps. Younger Granite Ring Complexes comprising of Kagoro and Ganawuri – Kigom complexes) were mapped. The (lineament/fracture, ring dykes) structural analysis indicated that the area has numerous long and short fractures. The geology generated from the integration of various thematic layers show that the area is underlain by Younger Granite rocks of Jurrasaic age, basement complex rocks; older Granites (porphyritic granite) and undifferentiated rocks, newer basalt and Dolerite dykes.

Key words: Nigeria Sat-1 – Geological mapping – Digital Image Processing.

INTRODUCTION

Satellite images have useful geological applications. Several Studies have shown that satellite images from SPOT and LandSat have been used for Geological application (Olowolafe, 2000) and (Karikari, 2002). The Geological set-up of a region which is usually the result of complex processes can be generated from an interpretation of a proper satellite image with the relevant band combinations.

The objective geological elements which can be directly observed on satellite are limited. Their recognition greatly depends on the environmental conditions (vegetation cover and thick over burden) and resolution of image employed. For instance, LandSat of (30m- resolution) TM will show less features than SPOT with 20m resolution. Nigeria Sat 1 has 32 meters resolution, although comparable to LandSat will show less features.

In some areas, outcropping rocks often directly observable and their characters of tone and colour, setting, fracturation, physiography and mutual relationships among different geological units can be recognized. Conversely, in many areas, recognition of geological features by

direct observation is prevented by vegetation cover, the thickness of soil and other activities.

In most cases, recognition of geological features on image is based on the interpretation of surface expression of the underlying geology. One of the most important and reliable surface effects of the geological substratum is landform. These include the tonal variations, structural deformations/lineaments, and topography – drainage pattern.

Therefore this study is to demonstrate the useful geological applications of Nigeria Sat 1 image. Thus this study involve mapping of geological structures, lithological units through various image processing techniques and from computer aided interpretation of the image

METHODOLOGY

The study was carried out using NigeriaSat-1 imagery (figure 1) acquired on 4/12/03 from National Space Research and Development Agency (NASRDA). The raw data was georeferenced using the coordinates of the Nigeria Topographic Map Sheet (No) 168 of Naraguta. The georeference projection is Universal Transverse Marcator (UTM),Minna Datum.

ERDAS imagine software (Version 8.6) was used for image processing, while image enhancement including (filtering and edge enhancement) as well as interpretation and digitization were carried out using ILWIS 3.1. Image enhancement operations carried out include filtering and edge detector. These were to enhance 'sharpness' of the satellite image for better visual interpretation, to reduce noise in the image prior to a multi-band image classification, and to detect line features or edges in the satellite image as will aid structural interpretation amongst others.

Edge detector shadow (linear and non-linear features) was used in delineating lithological boundaries and edges thereby aiding image interpretation. Image classification was in unsupervised classification and was used to classify the image into unique characters comprising of pixels with similar spectral characteristics and unique clusters according to some statistically determined criteria.

Various layers were created from existing topographic and geological maps by on-screen digitization using ILWIS. The layers are drainage, contours and lithological units. Also after enhancement of the image, various layers/segments were extracted from the image of onscreen digitization, including fractures, lineaments, dykes and lithological units.

The Study Area

The geology of Jos - Plateau comprises of plutonic and volcanic rocks belonging to four main age groups. The rocks of Jurassaic age (Younger Granites 140 – 190M.A), Precambrian rocks (>500M.A, crystalline Basement rocks, Migmatites, Gneisses) and intrusive older granites of Pan African Orogeny are the predominant rocks of Jos – Plateau, (Greenwood, 1951). The Pan African Orogeny occurred over the Africa continent. It led to structural deformation and regional metamorphism. Structures such as faults, joints and fractures resulted. Previous studies by Mamven (1990) and Onwusulu (1995) in-

dicate that the major structural trends in the Basement Complex of Jos – Plateau are N – S, NE – SW and NW – SE directions.

The topography of Jos – Plateau comprises of chains of highland of variable heights coupled with flatter topography. The drainage pattern of Jos – Plateau is dentritic. The vegetation of Jos – Plateau area as a whole is tropical wood – lands characterized by tall grasses, shrubs and stunted trees. The mean temperature is between 200 – 22.50c and annual rainfall approximately ranges between 1500mm – 2000mm, (Macledod et al., 1971; Jones, 1975; Alfred et al., 1979).

RESULTS AND DISCUSSION

After the various image enhancement processes; observable structural geological features were carefully traced out. These are; fractures, joints, drainage and dykes as lineation/linear features and ring structures. (Figure 2).

The underlying reason for fracture analysis is that zones of fracture concentrations can be obtained, and through proper interpretation, information on the structural deformations occurring in a region can be revealed.

The result of the structural analysis shows that numerous fractures and lineation occurs at the northwestern, central and southwest of the satellite image (Figure 3). The common orientations of lineation are NW-SE and NE-SW. a dolerite dyke related to a major NE-SW striking fracture occurs in NW of the study area.

The study area according to Wright et al, 1985, produced geological structures with north-south orientation. Some of the fractures in the image bear this strike. Also studies by Mamven (1990) and photogeological interpretation of the area by Onwusulu, (1995) indicated that extensive dyke swarms with trends in north-north-east and northwest directions are found cross-cutting the major lithological units, porphyritic biotite granite and the migmatites.

Identification of lithological units on the image was through supervised and unsupervised classification. Red colours mostly correspond to Younger Granites which correlates well to structural interpretation of ring structure. Blue colour (linear in nature) partly corresponds to dykes and mostly to Basement Complex rocks. Magenta – Older Basalt; Yellow – may generally correspond to the Basement Complex rocks (Figure 5). Similar information/ delineation of various lithological units could be extracted from other enhancement methods such as AVG. Cluster, Edge. From the image, the area comprising of chains of high hills surrounded by lower areas was identified.

Using edge enhancement techniques, the Younger Granite rocks clearly defined boundary from the country rock. The dolerite dykes too has clearly defined boundary from the country rock. The drainage pattern of the area extracted from the image and existing topographic map (Figure 4), revealed a great deal of information concerning the parent rock materials. The dentritic pattern is indicative of lithological, structural and topographic homogeneity. It is also indicative of crystalline rock which is typical of the geology

of the area that consists mainly of crystalline rocks. The drainage texture of the area is coarse. It is characteristic resistant, permeable bedrock materials and coarse permeable soil material, such as the coarse grained porphyritic. This is in conformity with the findings of Olowolafe (2000).

CONCLUSION

This study has demonstrated beyond doubt that NigeriaSat-1 image has a lot of research potentials for geological applications. It can be used for Regional geological surveys/structural geology. The image provides synoptic coverage of the region 1 scene – 600km X 400km. Studies can be conducted using NigeriaSat-1 Image at scales of 1:250,000 or smaller, larger scales 1:150,000, 1:100,000 and even 1:50,000.

For now, Nigeria Sat-1 Image is indispensable for reconnaissance surveys because a lot of geological information can be derived from as interpretation which will guide detailed geological field studies. Integrated approach method is recommended in using Nigeria Sat-1 image for geological studies to derive maximum information from the image. Landform analysis, drainage analysis, structural interpretation image classification, lithological delineation/rock types, vegetation cover analysis, ground truthing, e.t.c.

Limitations and challenges encountered during the process data collection and interpretation include limited spectral resolution, and the fact that various features/ objects tend to display the same colour. The same applies to identification of difficult lithilogical units. Interpreter therefore need a lot of experience to carry out reliable supervised classifications. Intensive research works are required to develop appropriate classification scheme for NigeriaSat-1 image for geological and other applications.

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Fig. 1 NIGERIASAT-1 IMAGE OF THE STUDY AREA

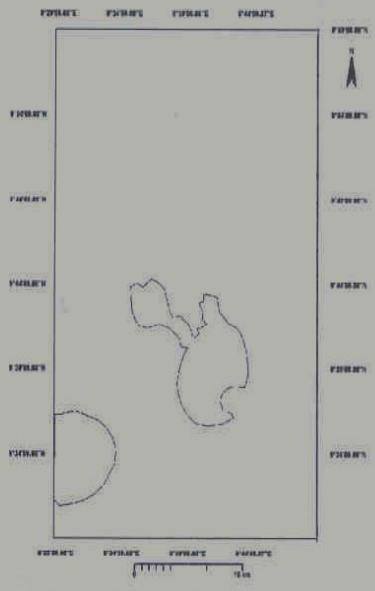

Fig.2 Ring dykes generated from NigeriaSat-1 Image

Fig.3 Lineament/Fractures generated from the Image

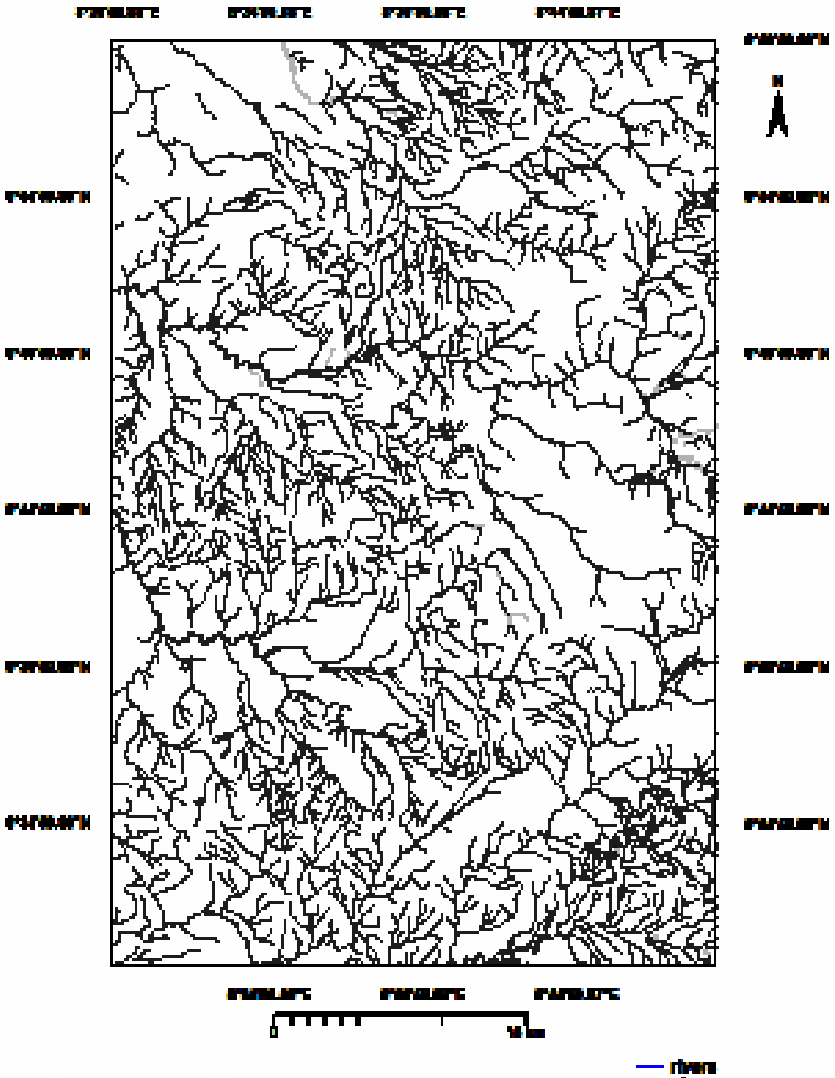

Fig.4 Drainage pattern generated from both Image and existing Topogpaphic map

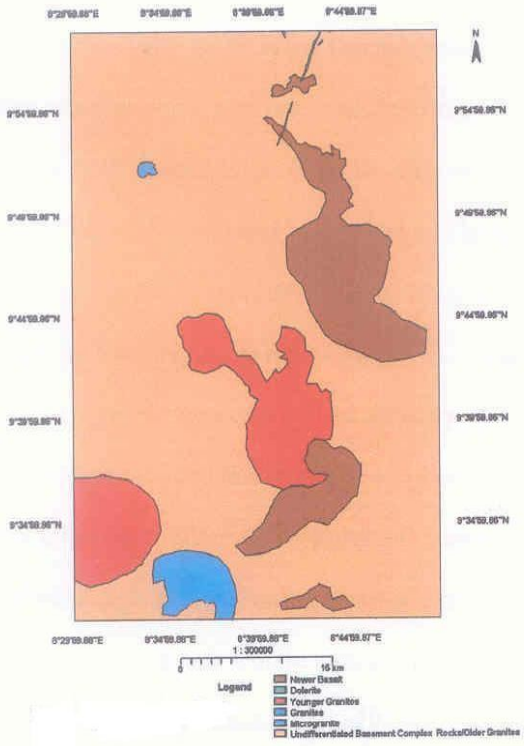

Fig. 5 Different Rock type traced from the Image