International Journal of Science, Environment and Technology, Vol. 5, No 2, 2016, 295 – 305

ISSN 2278-3687 (O)
2277-663X (P)

APPLICATION OF DIGITAL IMAGE PROCESSING USING NIGERIA SAT1 AND GIS TO THE STUDY OF LINEAMENTS IN PARTS OF JEMA'A SOUTHWEST (1:50,000, SHEET 188SW)

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Abstract: The study area covers, Wasa station and its environments in Sanga local government area of Kaduna state, which is part of the basement complex rocks of North Central Nigeria; this area falls within Jema'a Sheet 188SW. The aim of this study is to examine the geology of parts of Jema'a sheet 188SW and produce a detailed geologic map of the area showing the distribution of different rock units, furthermore, to assess the economic mineral potential of the area, by mapping structural features such as faults and fractures that can be pathways for mineralizing fluids, using Remotes Sensing and GIS.
Digital image processing was carried out on NigeriaSat-1 image, and total magnetic intensity field map of parts of Jema'a Southwest. Lineament map for the area was derived from the satellite imagery; NE-SW trending lineaments are more dominant than the NW-SE and N-S trending lineaments. The lineaments vary in length from 500m to 4km. Application of hill shade and shaded relief techniques to the digitized aeromagnetic data revealed major geological discontinuities (fractures, faults, lithologic contacts). An integration of the lineament map, the aeromagnetic map, the geology map and the water shed map in a GIS environment showed remarkable agreement between some of the magnetic discontinuities and prominent lineaments on the satellite image. The points of intersection of the lineaments (some of which are fractures) are potential zones for mineralization and ground water storage.
Keywords: Nigeria Sat1, Spatial filter, Lineament, Mineral potential.

Introduction

Since the first aerial photographic surveys, remote sensing has provided geologists with much useful information. Over time there has been tremendous increase in remote sensing data source, particularly from satellites, each with its own unique features and specific areas of application. Nigeria Sat-1 was launched in 2003, like most satellites, it has been used by different professions for various studies and has yielded impressing results.
The study area covers, Wasa station and its environments in Sanga local government area of Kaduna state which falls within NE portion of Sheet 188, Jema'a SW, this area is part of the basement complex rocks of North Central Nigeria. It is located between Latitudes

*Received Feb 3, 2016 * Published April 2, 2016 * www.ijset.net*

9°12'02.18''N and 9°06'50.33''N and Longitudes 8°09'39.41''E and 8°14'59.45''E. The area has dimensions of 9.7km by 9.7km and a total area of 94.09km^2. Figure 1 shows the location of the study area within Kaduna state in Nigeria. The area is about 50km north of Akwanga through Moroe and about 18km, south of Kogum river via an existing railway.

The relief of the area is generally low and undulating with a few elevations here and there, the highest point is about 518.16m above sea level while the lowest point is about 441.96m above sea level. The drainage pattern of the study area is generally dendritic. The major river that passes through the area is River Mada with its tributaries (figure 2).

The pegmatite veins which intrude the basement complex rock of this area are the major exploration target. The pegmatites are low lying discordant dykes in a weathered basement environment. It is a known fact that the pegmatite veins of Nigeria have provided host for many economic rare metallic minerals and gemstones like tantalum, tungsten, lithium, niobium, amethyst, tourmaline, garnet, to mention but a few. The interests in the study of these pegmatite veins have always been continuous and this is clearly due to its present day economic importance which cannot be over emphasized.

The aim of this study is to examine the geology of parts of Jema'a sheet 188SW and produce a detailed geologic map of the area showing the distribution of different rock units, furthermore, to assess the economic mineral potential of the area, by mapping structural features such as faults and fractures that can be pathways for mineralizing fluids, using Remotes Sensing and GIS. In the present study, the lineaments generated from Nigeria Sat-1 were integrated with digitized aeromagnetic data of the study area using GIS to achieve desired results.

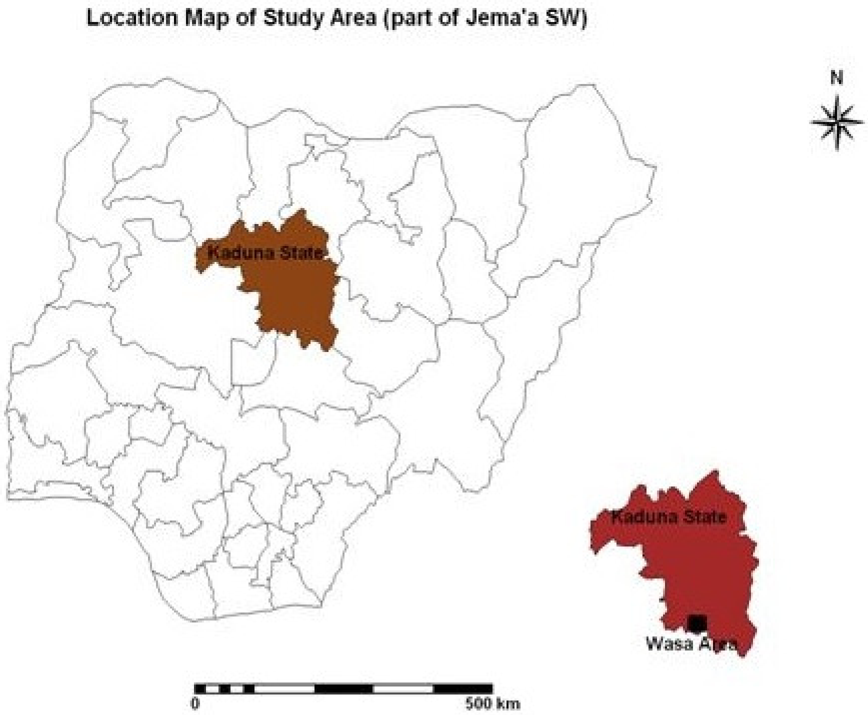


Figure 1: Location Map of Study Area

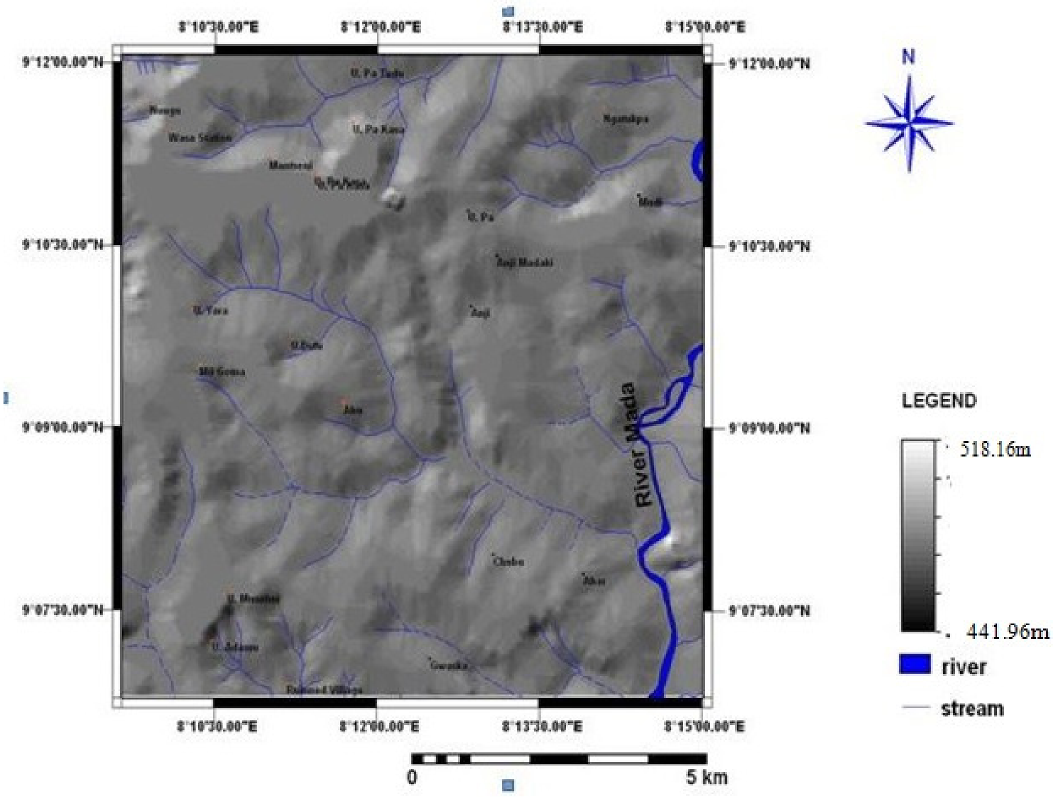


Figure 2: Relief and Drainage of Parts of Jema’a SW

Materials and Method

Digital Image Processing

The first step of any GIS-based approach is to provide a spatial database. Much of the success of a GIS project depends on the quality and nature of the data that is entered into the system. Thus the nature and provenance of datasets for this study as well as the software used are discussed here.

Available Data

The available data sets for this study are; a hardcopy of topographic map of study area 1:50,000, hard copy of airborne magnetic map covering the study area, 1:100,000, hardcopy of interpreted airborne magnetic map covering the area, 1:100,000, a digital set of Nigeria Sat-1 imagery covering the area. Finally, a hard copy of geologic report covering the area by Jacobson and Webb (1946). The softwares used are; ILWIS, Arcview and Surfer. ArcView and ILWIS are GIS softwares, ILWIS was used for; 1) digitizing and editing of geophysical maps, topographic maps geological map. 2) Extraction and analysis of spatial features. 3) Modeling (data integration). ArcView was used basically to compose the maps created for appreciable presentation. Surfer was used to plot some terrain models.

Data Processing

Remotely-sensed spectral data were obtained from Nigeria Sat-1 image, the area of study was subset from a full scene covering most of north central Nigeria. The sub-scene obtained was georeferenced using control points identified both on the images and on 1:50,000 scale topographic maps. The scene was corrected for atmospheric, geometric and radiometric effects. Image enhancement was performed to extract lineaments that would not have been apparent from the images.

Digital filtering was applied to Nigeria Sat-1 imagery of the study area (see fig 3a.) to enhance its spectral resolution. Edge enhancement filter was also applied to the image to enhance lineament edges; unsupervised classification was carried out on the image to classify the rocks of the area into different lithologic classes (see fig 3b). These lithologic classifications revealed some information about the geology of the environment before the fieldwork was carried out; this information was used as a guide in the composition of the final geologic map of the study area (figure 5). Lineaments were extracted from the imagery for lineament analysis (figure 3c), rose plot for the lengths and directions of the lineaments were plotted, shear zones were also digitized (figure 3d).

Hard copies of total intensity magnetic field map, interpreted aeromagnetic, and topographic maps were scanned and imported into ILWIS, they were geo-referenced using tie-point, and digitized. Further digital processing was carried out on the digital data, the contour lines were interpolated (see figure 3b), and afterwards shaded relief operation was applied to the interpolated data (figure 3c).

Results and Discussion

From the digital processes carried out above, interpretations of the hill-shade and shaded relief operations revealed major geologic discontinuities as lineaments (fractures, faults and lithologic contacts) (see figure 4c), lineaments were extracted from the interpreted aero magnetic map, hill-shade view of the aero magnetic data of the area (E-H and G-H in figure 4c). The lineaments are ENE-WSW and NW-SW trending.

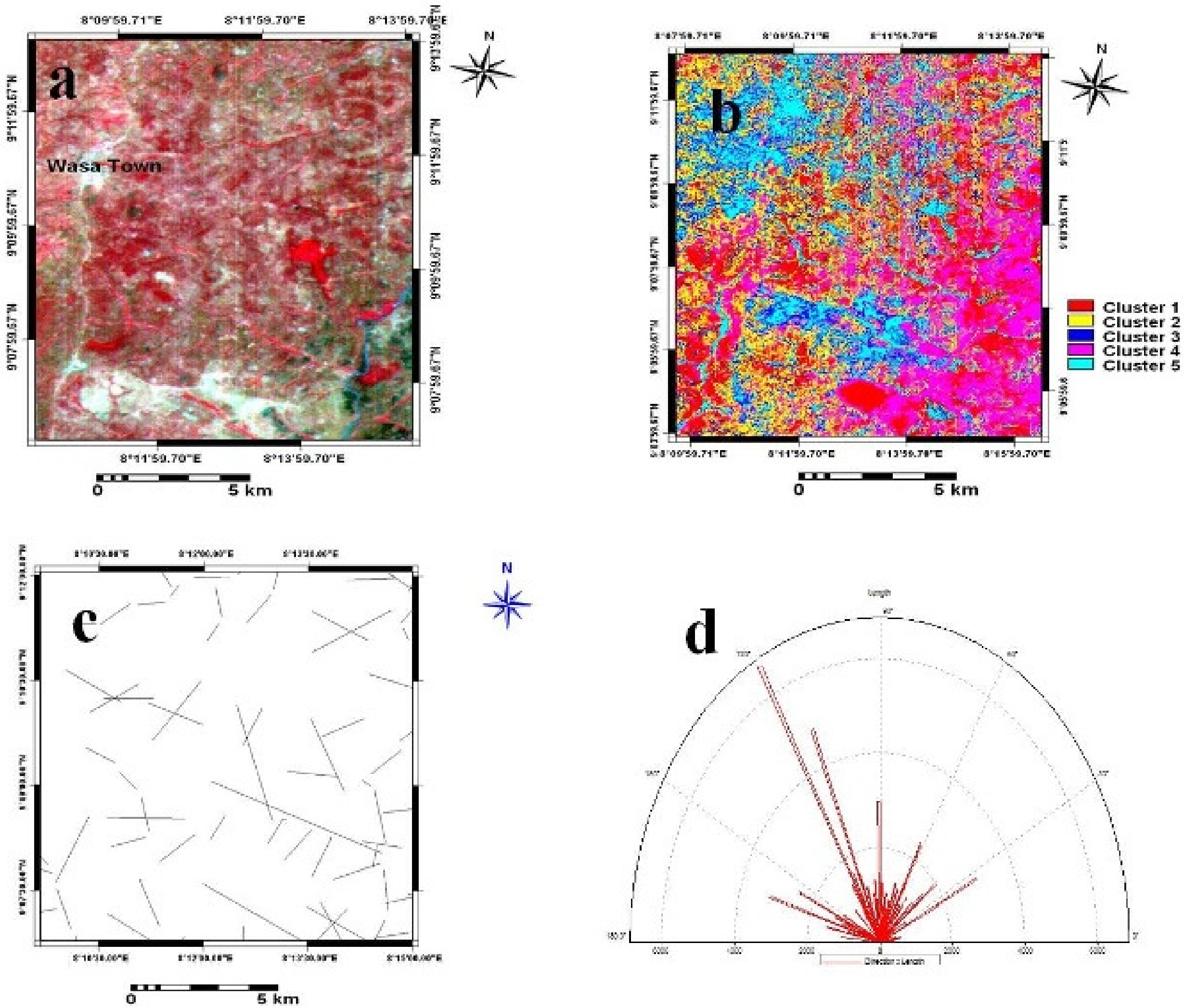


Figure 3: (a) Nigeria Sat1 image of study area, (b) Unsupervised classification of Nigeria Sat1 (c) Lineament map of study area extracted from Nigeria Sat1, (d) Rose diagram generated from the Lineament map

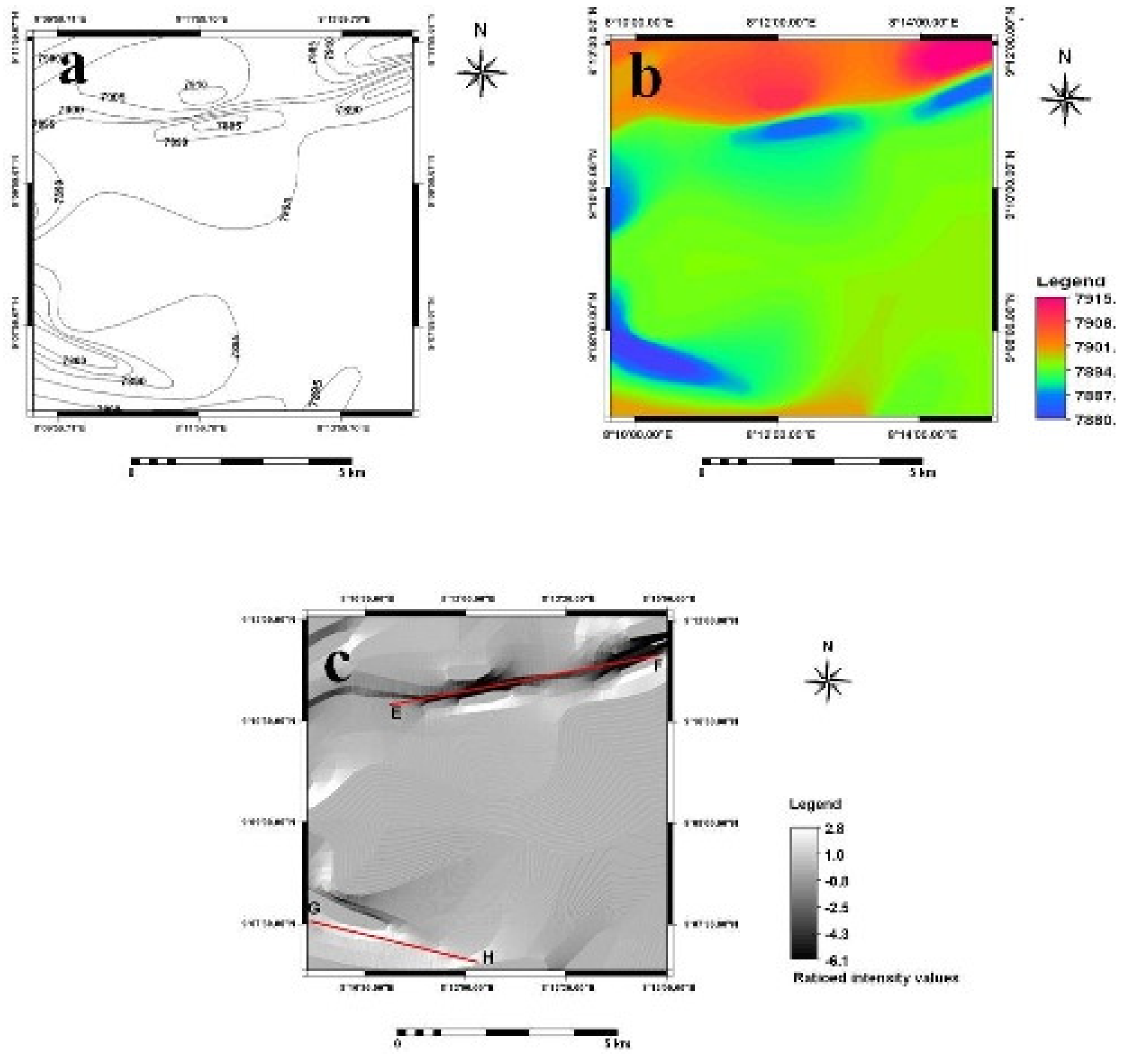


Figure 4: (a) Total Magnetic Intensity Map of study area, (b) Interpolated Total Magnetic Intensity Map of study area, (c) Hill shade filter applied to the Total Magnetic Intensity Map of study area, (E – F, G – H) in figure 4c, are inferred magnetic lineaments.

The rose plot (figure 3d.) shows the strike directions of the lineaments. NE-SW and NW-SE trends account for 80% of the strike directions with NE-SW dominating the trends. A few N-S, E-W trends also occur.

Geology of the study area

Detailed geological mapping of the study area revealed the following as the major rock types within the area; migmatite-granite-gneiss, banded gneiss, biotite-granite-gneiss, pegmatites and basalt. The rocks are mostly low-lying, outcropping to about 5m high in some areas. The pegmatites are observed as intrusions into the older rocks (migmatite granite gneiss and biotite granite gneiss) as veins and dykes (figure 5).

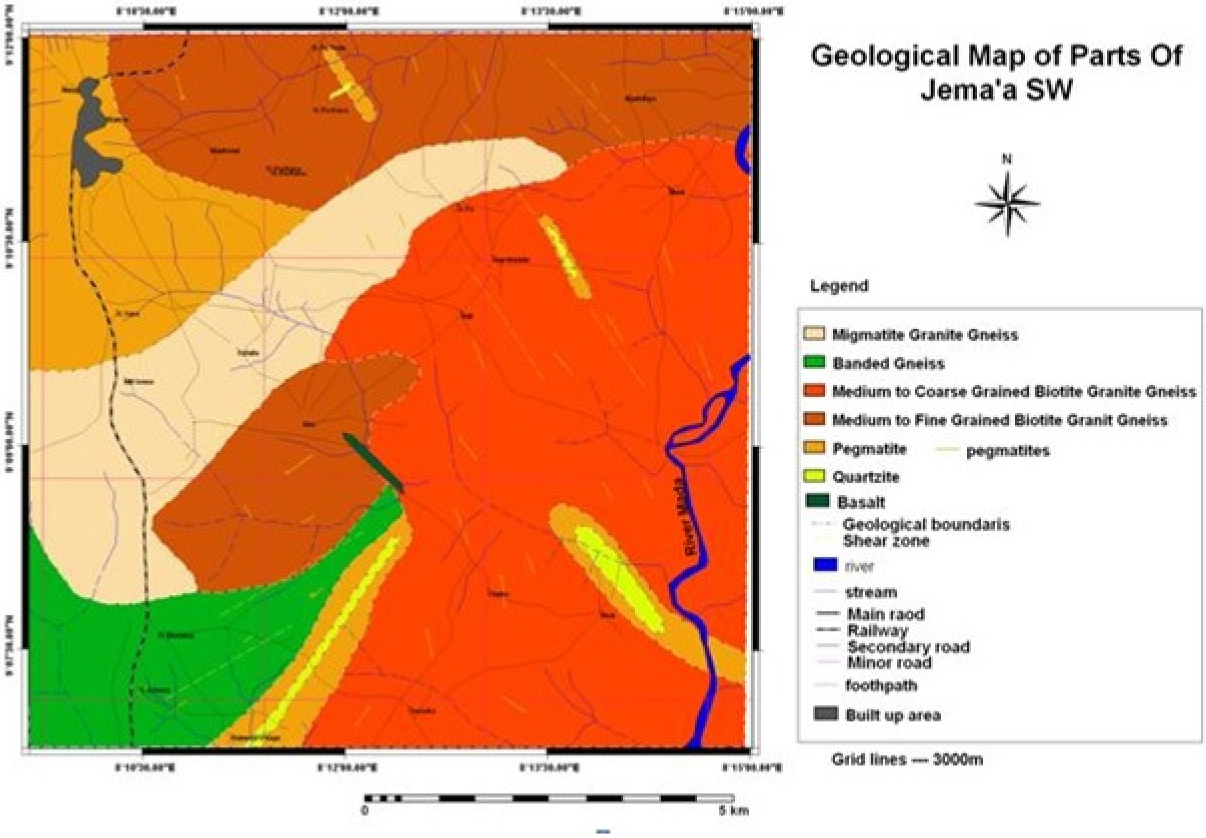
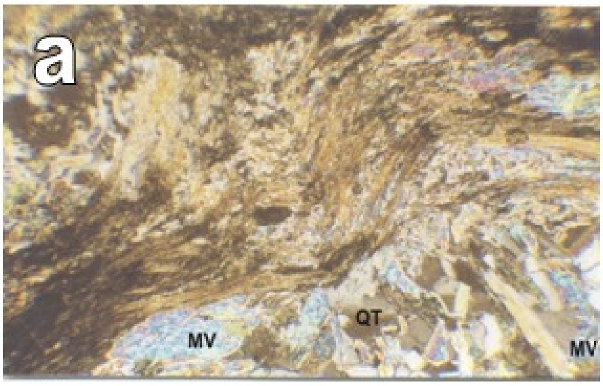


Figure 5: Geologic map of Wasa and Environs

The major structural trends of the study area (faults, fractures, joints folds, dykes and veins) are; N – S, NE – SW, NW – SE, NNW – SSE and WNW – ESE. Most of the folds observed are NE-SW trending, the pegmatite intrusions (veins and dykes) trend mostly NW –SE and NE-SW, with NW trend dominating. The joints are mostly NW-SE trending, while the faults have dominating NW-SE trends with a few NE-SW trends. The lineaments extracted from the satellite imagery and the aeromagnetic data, agree with the lineaments of the basement as observed from the fieldwork. These multiple directions of strikes indicate multiple deformations over millions of years.

Petrography

From the field, samples were taken from; medium grained biotite-granite-gneiss, medium to fine grained biotite-granite-gneiss, banded gneiss and pegmatite rocks of the area for thin section, to determine the mineralogy, relationship between mineral alignments and mineral grain texture. The thin section of a pegmatite sample taken from a location ($9^0$11’54’’N, 8^0 11’44”E) close to E – F in figure 4c, interpreted from digital processing of aeromagnetic data as a geologic discontinuity, viewed under the microscope shows intense deformation in form of micro-brecciation of quartz and muscovite crystals, micro-folds and stretched fibrous textures of muscovite and mica, and other micro-structures, (Plate 1 a & b). According to Hobbs etal (1976), fault planes are usually filled with fragmental material known as fault breccia or micro breccia, if the fragments are microscopic. Some micro breccias are soft and are designated by terms such as pug or gouge, others particularly in metamorphic rocks, are hard and characterized by a platy or streaky "flow" structure in thin sections. Such micro breccias, which occur in wider zones of intense deformation, are called mylonites (Lapworth (1885); Waters and Campbell (1935); Christie (1960)). The structures observed from the thin section as seen bellow, under plane and cross polarized microscope, confirms that E – F in figure 3c is a fault.



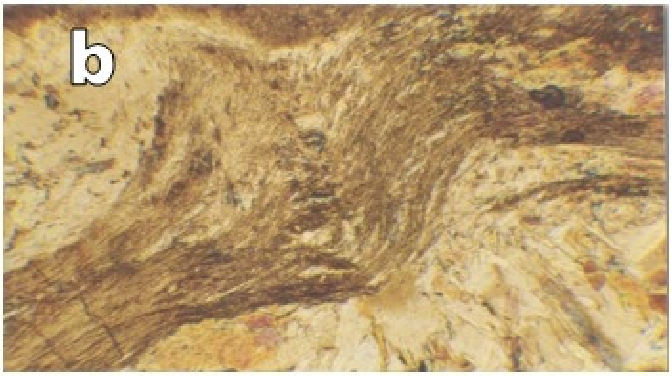


Plate 1 a & b. photo-micrographs showing micro breccias and flow structures (x10 XPL & PPL)

Data Integration

The geology map of the area was compared with the total magnetic intensity map of the area, revealing the different rock units and their relative magnetism. An overlay of the total magnetic intensity field map of the study area on the geological map (figure 6a), helped to establish some geologic boundaries. The qualitative interpretation of the aeromagnetic data, agrees generally with the underlying geology. Data obtained from the unsupervised classification of the Nigeria Sat-1 of the area (figure 3b), also helped in the composition of the geological map.

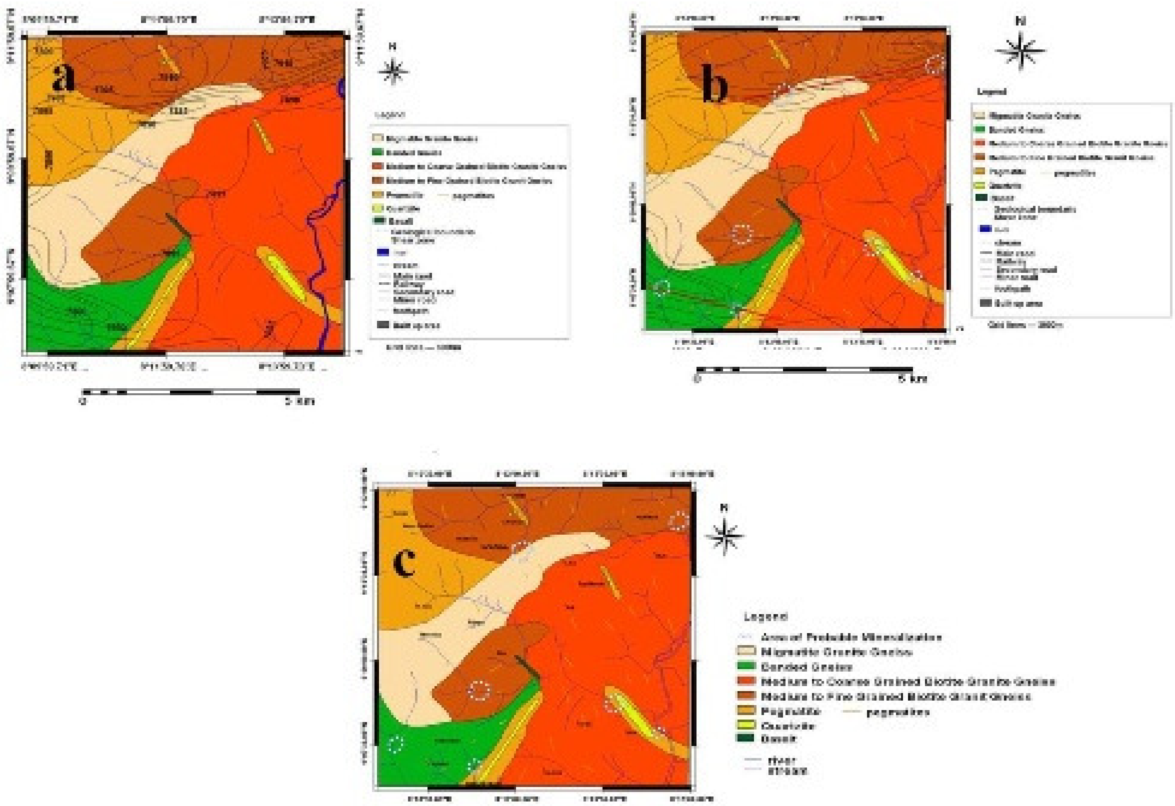


Figure 6: (a) Overlay of the Total Magnetic Intensity field on the geological map of the study area over, (b) Integration of the lineament, the aeromagnetic and geology map of study area, (c) mineral potential map of the study area generated from the integrated data.

Finally, the lineaments extracted from Nigeria Sat-1 (figure 3c), the geological map and the interpreted aeromagnetic map of the area (E-F and G-H in figure 4c) were integrated together (figure 6b). The integration of the lineament map, the aero magnetic map, the geology map and the water shed map in a GIS environment using overlay operation, showed remarkable agreement between some of the magnetic discontinuities and prominent lineaments on the satellite image. The points of intersection of the lineaments (some of which are fractures) are potential zones for mineralization and ground water storage.

A resulting mineral potential map (figure 6c) was generated from the integrated data based on; i.) lithology: areas that are characterized with rocks intruded widely by pegmatites, because pegmatites are known to host most the mineral occurrences within mineralized pegmatite areas. ii.) Lineament: lineaments and intersection of lineaments reflect rock structures through which fluids rich in minerals can percolate and gradually crystallize.

Conclusions

1. From the structural relationship of rocks of the basement, it could be said that the pegmatite rocks of the study area were emplaced along pre-existing structures.

2. Nigeria Sat1 imagery was useful in delineating lineaments not previously mapped in the area.

3. The total magnetic intensity map of the area was very useful in delineating some of the geologic boundaries of the area.

4. Processing and interpretation of aeromagnetic data, combined with previous works covering the area has helped to establish structures that could be pathways for mineralization.

5. Data extracted from geophysical analysis was combined with data from the image and geological facts from the field to create a mineral probability map for the area.

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