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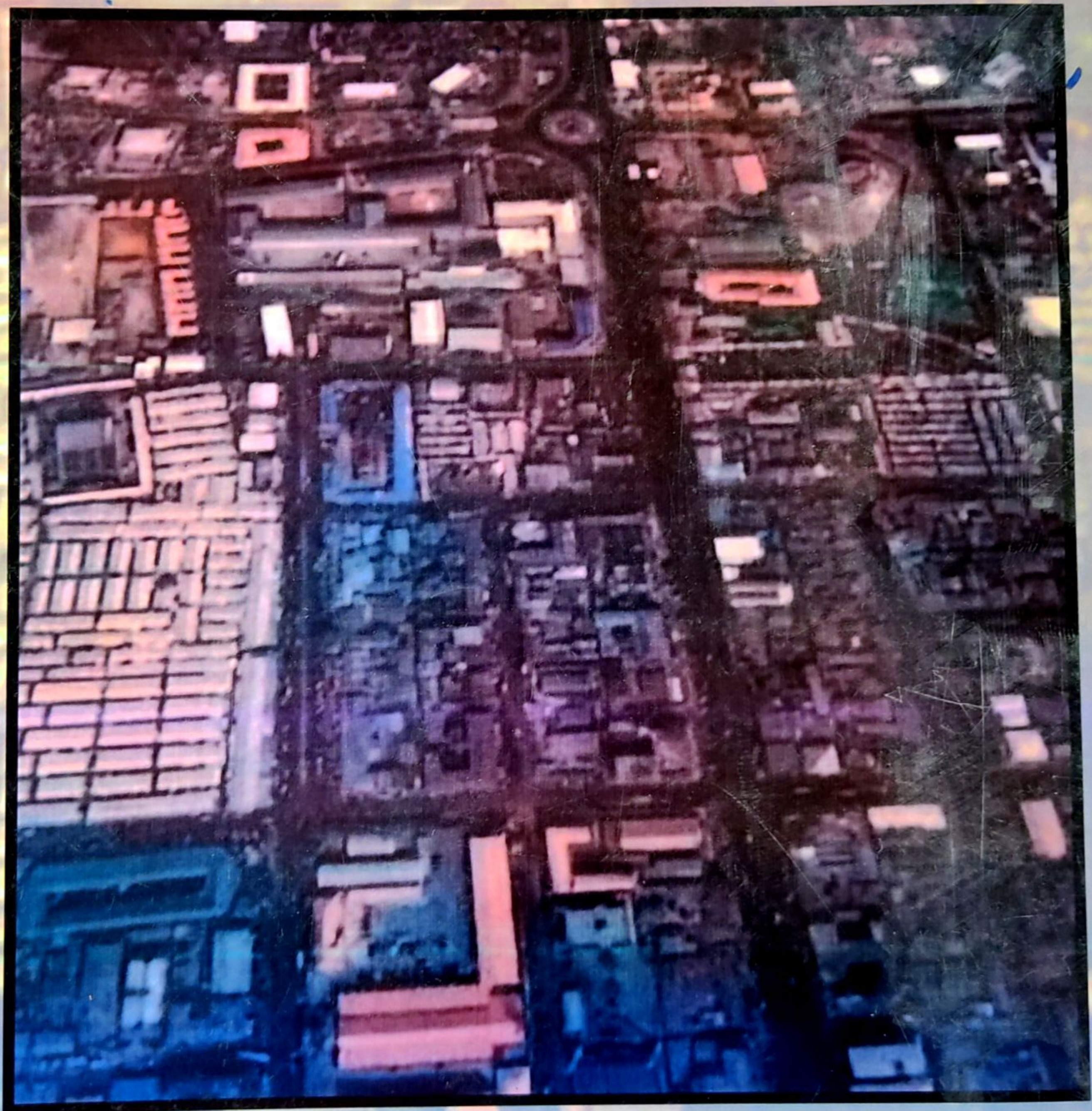

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Table of Contents

Content **Page**

MAPPING OF HYDROTHERMAL ALTERATIONS ZONES FOR MINERAL EXPLORATION IN KOKONA AREA OF NASARAWA STATE, NIGERIA

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Abstract

Hydrothermal alteration is a change of pre-existing rocks or minerals caused by the activity of hot solutions, such as fluids accompanying or heated by magma. Landsat 7ETM+ of Kokona local government area of Nasarawa State of Nigeria was used to determine and map zones of hydrothermal alterations. Image processing methods used includes image enhancement, band ratio, false colour composition. Band ratios 3/1 and 5/4 suggested the presence of iron-oxides minerals and hydroxyl minerals respectively. Clay mineralization was detected using band ratio 5/7. While false colour composite of bands 7:4:2 was employed to delineate potential locations of hydrothermal alteration zone. NigeriaSat-X of the same study area was used to identify zones of lineament locations. The bands were layer stacked and band 3 was found suitable for the extraction of lineaments and the red lines show zones of lineament and it was also overlaid on the RGB colour composite image. NigeriaSat-X was also used for the landuse/landcover analysis through supervised classification techniques which shows the various land use patterns in the study area. The satellite image map gotten from the identification of the hydrothermal alteration zones were compared with the pre-existing geology of the study area, which shows other detected potentially interesting sites that are absent in the geological map of the study area. It is envisaged that the incorporation of intelligent systems in GIS would particularly stimulate the application and realization of the simulation, modelling and investment decisions capabilities for mineral exploration in Nigeria.

Keywords: Hydrothermal, Alteration zones, Mineral, Exploration, Remote sensing.

Introduction

A 'Mineral Resource' is a concentration or occurrence of material of intrinsic economic interest in or on the earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction (www.wikipedia.org.com). Much information about potential areas for mineral exploration can be obtained from interpretation of surface features on aerial photographs and satellite images (Lilesand *et al*, 2004).The exploration and exploitation of minerals in countries like the Republic of South Africa, Congo, have brought a lot of income and profit to the countries. (Ajibade, 1979). "While to the developed world, geospatial technology is a cost saving method of acquiring raw data to update existing information, for developing countries especially those in Africa, it has provided an opportunity to obtain the first generation of information on some of their earth resources", (Abiodun, 2000).

The study of mineral deposits in Nigeria shows that 90% of the country's natural resources are unexploited, yet many are still uncovered (Kankara, 2011). Despite the fact that Nigeria is blessed with a lot of mineral resources of which Nasarawa State is among, it was noted that there are still some lapses in the full utilization of these mineral resources. There are tons of minerals in Nigeria but the local and illegal miners have taken over the locations where the resources are deposited (Drury, 1991).

The few studies done in Nigeria using modern remote sensing include that of Ananaba and Ajakaiye (1987) which show evidence of tectonic control of mineralization in Nigeria from lineament density analysis. Goki *et al.* (2005) used digitally processed Landsat 5 imageries to map mineralized pegmatities around Nasarawa State. Sadiya *et al.* (2014), used Landsat 7 ETM+ of Bwari local government area of Abuja federal Capital Territory located in the middle belt of Nigeria to detect and map locations of hydrothermal alterations. Other studies that focused on hydrogeological applications include those of Bala (1997), Edet *et al.* (1994), Odeyemi *et al.* (1999), Bala*et al.* (2000b) and Ayok (2009). . Landsat ETM multispectral data have been processed to discriminate the different rock types present such as altered and unaltered rocks because different rocks have a characteristic spectral signature as a finger-print (Karimi, 2003).

This study was aimed at mapping mineral resources in Kokona Local Government Area with the objectives of determining the various hydrothermal alteration zones, identify zones of lineament locations and compare the satellite image maps with pre-existing geological map of the study area.

Location, Climate and Geomophology of the Study Area

Kokona is situated at Latitudes $09^0 15^I 00^{II}$N to $09^0 17^I 40^{II}$N and Longitudes $007^0 47^I 43.33^{II}$E to $007^0 50^I 26.67^{II}$E (figure 1). The climate is the tropical sub humid climate with two distinct seasons. The wet season spans from May and ends in October. The dry season is experienced between November and April. Annual rainfall ranges from 1100mm to about 2000mm. About ninety percent of the rain falls between May and September, the wettest months being July and August. The rain comes in thunderstorms of high intensity, particularly at the beginning and towards the end of the rainy season. Temperatures are generally high during the day, particularly between the months of March and April. The mean monthly temperatures in the area range between 20^0C and 34^0C, with the hottest months being March/April and the coolest months being December/January.

The southern landscape of the state falls on the low plains of the Benue. Other parts of the state are composed of undulating lowlands and a network of hills developed on granites, migmatites, pegmatities and gneisses. Around the salt mining village of Awe are a number of worn volcanic cones. Most parts of the state that lies within the Benue (valley is composed of sandstones. However,) around the salt bearing districts of Awe, Keana and Akiri, are detached synclinal areas formed by localized folding. The brine springs of Awa, Azara and Bomanda are associated with anticlinal axes along which salt bearing beds within the synclines) approach the surface. The state is drained by numerous fast flowing streams/rivers that take their source from the Jos Plateau and flow into the River Benue which also marks the state's southern boundary. Prominent among these are the Mada, Dep, Ayini, and Farin Ruwa rivers.

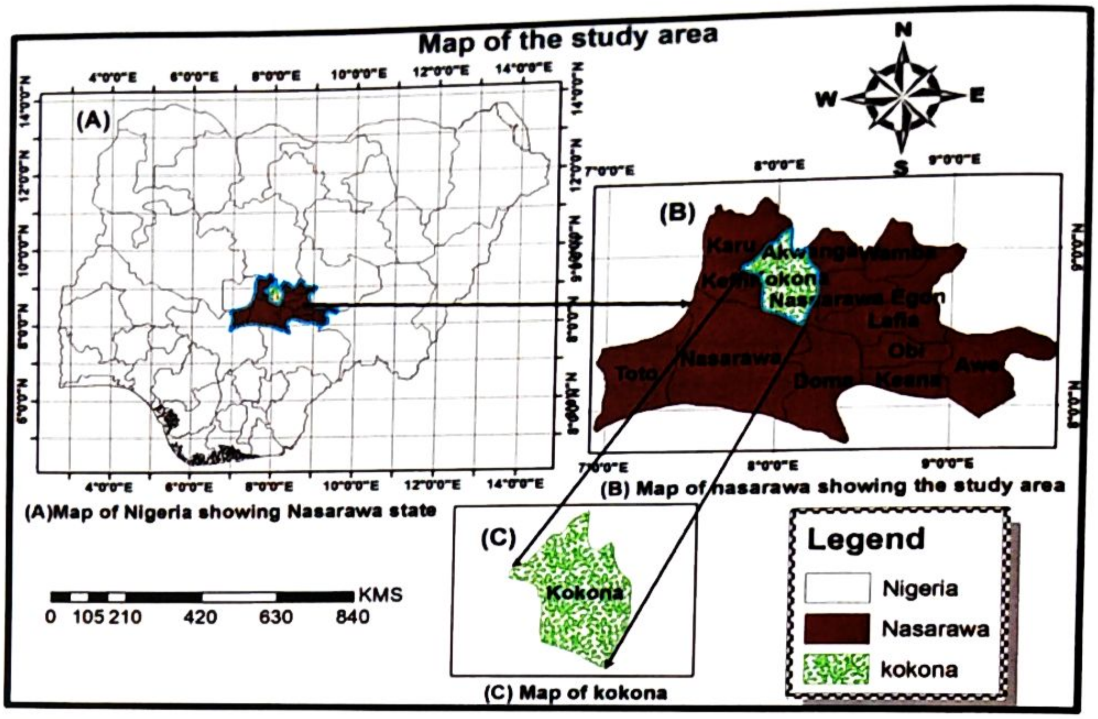


Figure 1: Kokona, Nasarawa State, Nigeria

Literature

Akbari, *et. al* (2015) examines the utilization of spectral image processing methodologies to ASTER data for mapping hydrothermal alteration zones connected with sedimentary facilitated Pb-Fe Ahangaran store and related host rock in the north-western part of the Malayer-Esfahan Metallogenic belt (MEMB) in the west of Iran. Assessment and handling of ASTER Image of the study location, helped by consequences of field work over and XRD examination, demonstrate that change of minerals identified with mineralization incorporate dolomitic and silicic changed rocks that contain confined regions of iron oxide minerals (gossan zone). These can be utilized as an investigation guide for Fe-Pb mineralization like huge Ahangaran and Shams abad Fe-Pb stores in the MEMB of Iran.

Similarly, Ghulam, Amer, and Kusky (2010), proposes a technique to discover gold stores in the Eastern Desert of Egypt. Diverse strategies including different grouping techniques, standard segment change (PCT), band proportions, and an obliged vitality minimization procedure are assessed for their execution for aqueous adjustment zone mapping. They connected different systems to various territories to hunt down locales that have comparable indistinct and different marks in the prepared imageries, with the possibility that they may have conditions like those of the known gold stores. Next, the most up to date strategies in remote sensing in detecting of change zones and related minerals are talked about and contrasted, and the best procedures are distinguished. Results demonstrate that created gold related change zone maps got from recently created techniques in this examination are in great concurrence with known marks of gold mines in the area and distributed geologic and minerals maps.

Materials and Methods

A combination of Landsat ETM+ and NigeriaSat-X imageries were acquired, coupled with the topographic and geological map of the study area. Field survey was also conducted to acquire data for updating the land use maps. This was done using GPS to get the coordinates of mining locations and base maps of the study area. ArcGIS 10.1, Geomatica and ENVI 4.8 (digital image processing software) were used to Geo-reference the data after it was scanned and digitized. This allowed for classification of the data into land use categories based on the signature of the imageries obtained. Field survey was used to compliment the remote sensing analysis. The identified mining sites were mapped out on the imagery using their geographic coordinates. Landsat ETM+ imagery was projected to the UTM projection (WGS-84, zone 32). Path and Row of the image were 188 and 54 respectively. A subset from whole scene covering only the study area was extracted. The Landsat ETM+ data were corrected for haze and atmosphere interference using ENVI 4.8 software. A false colour composite of the study area was displayed in RGB 7:4:2 respectively as a first step to detecting the hydrothermally altered rocks. Band ratios of 5/7, 5/4 and 3/1 and their colour combinations in RGB sequence of ETM+ images were created for the detection of hydrothermal alteration zones The images were carefully inspected for such features and subsequently subjected to Lineament Density Analysis utilizing a pixel size of one square kilometer. Area of highest density which was thought to be of greatest potential for mineralization was read off after assigning appropriate thresholds. All the data sets were then compared in the context of geology and modification of the existing geological map was carried out following field check (ground truth) and coordinate recording. Band 3 of Nigeria Sat-X was used, the red lines shows zones of lineament locations in the study area. Thus, Geomatica software was used to automatically extract lineament from Nigeria Sat-X (2011) image of the study area and the digital number was converted to reflectance for each bands. The bands were layer stacked to see which band was suitable for extraction of lineament (See Table1).

Table 1: Data Set, Source and Type

Data Set (Resolution)	**Data Source**	**Data Source Type**	**Year**
GPS	Fieldwork	Primary	2015
Pictures	Fieldwork	Primary	2015
Geological Map	NSUK	Secondary	
NigeriaSat-X (22m)	NASRDA	Secondary	2011
LandsatETM+ (30m)	GLCF	Secondary	2014

Results and Discussion

Combination of band 7:4:2 in RGB locations with purple to pinkish colouration suggest possibility of alteration zones. The location of this mineral are called hydrothermal alteration zones.

Landsat ETM+ imagery of the study area analyzed using environment for visualizing Images (ENVI 4.8) software gave the following results

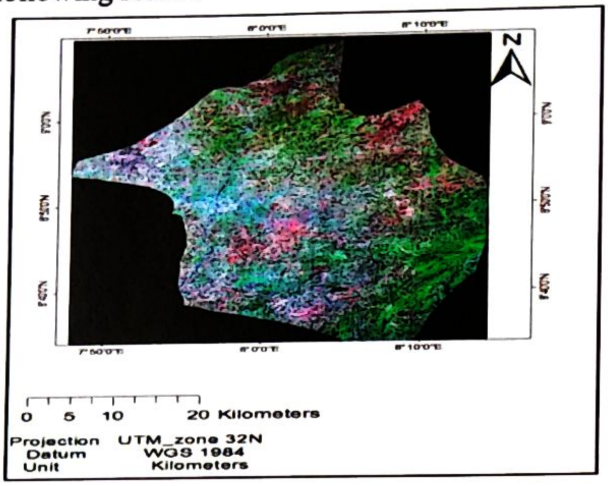


Figure 2: RGB colour composite of study area in Bands 7, 4 and 2 respectively.

Band Ratio

Figure 3a shows the band transformations process of band ratio 3/1 in grayscale. It depicts high iron oxide minerals in bright pixels which appear over the whole image.

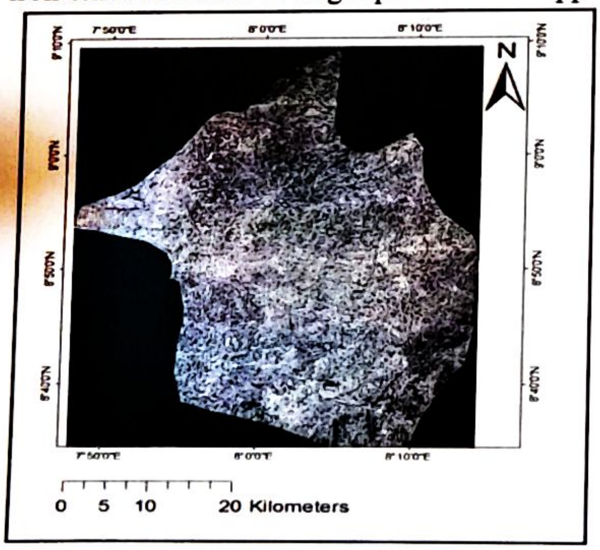


Figure 3a

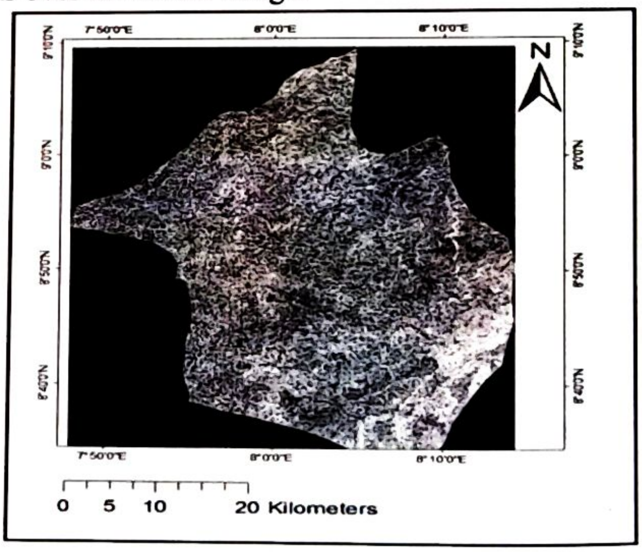


Figure 3b

Figure 3a; Band 3/1 showing iron-oxide mineralization in white pixels and figure 3b: Band 5/4 showing hydroxyl mineralization in white pixels

This is because iron-oxide mineral is ubiquitous in Kokona landscape which is attributed to basement migmatite gneiss older granites complex associated with undifferentiated older granite.Hydroxyl-bearing minerals using band ratio 5/4 and these are confined to certain zones depicted by the white patches in SE and NE of the study area as shown in figure 3b.

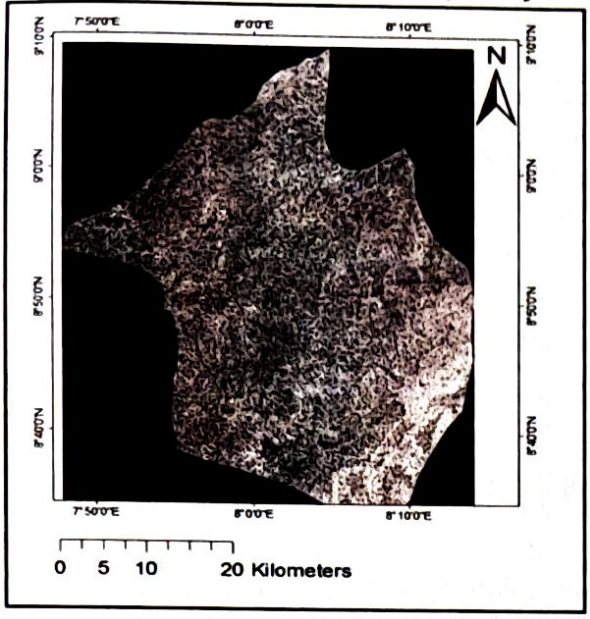


Figure 3c

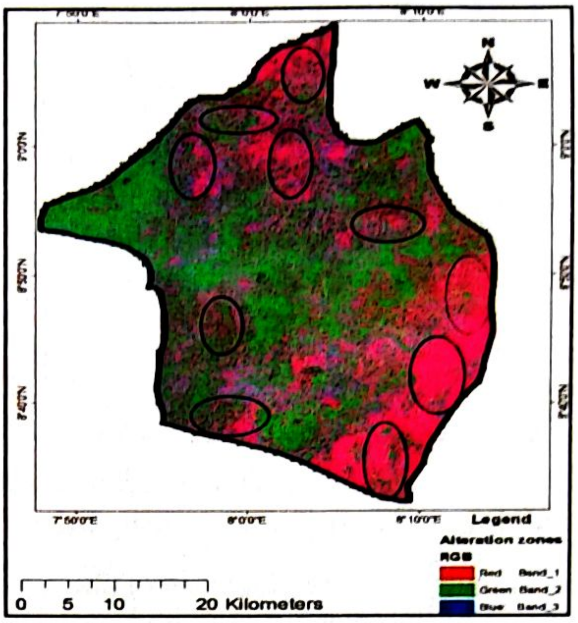
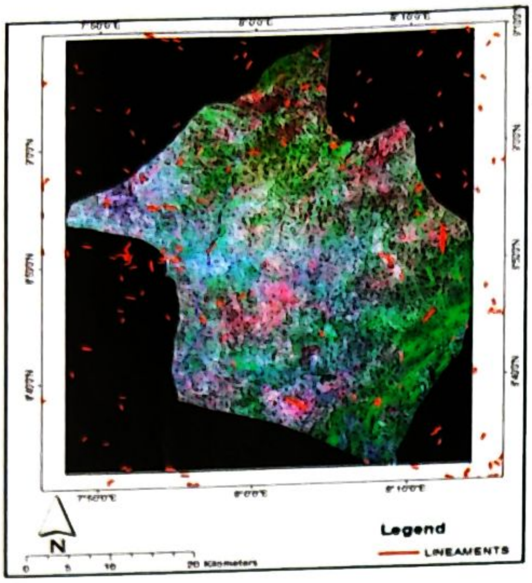


Figure 4

Figure 3c: Band 5/7 showing high deposition of clay minerals in white pixels and Figure 4: RGB colour composite of band ratios 3/1, 5/4 and 5/7 respectively

While detection of clay mineralization using band ratio 5/7 is shown as bright pixels covering most of the image with cluster of small white patches in Northern and SE of the study area (figure 3c). Figure 4 on the other hand, shows the produced Sabin's rationing colour composite image (band ratios 3/1 in red, 5/7 in green and 4/5 in blue) displays target zones in distinguishable purple hues. The alterations identified are attributed to the alteration zones and others related to weathering products of the granite complex associated with undifferentiated older granite in the study area.



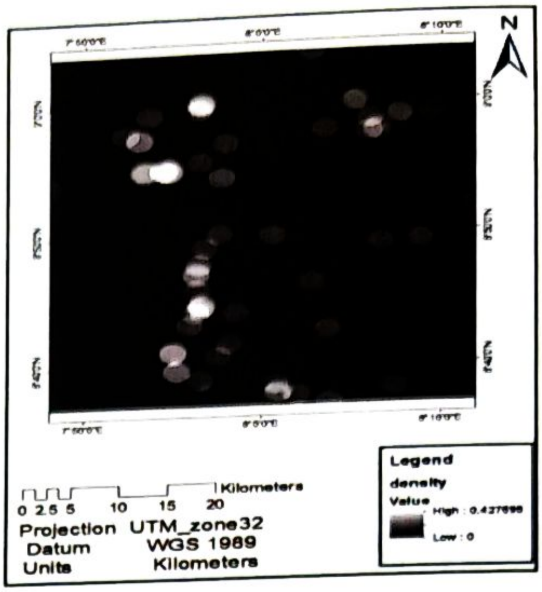


Figure 5 **Figure 6**

Figure 5: Lineament extraction overlaid on RGB colour composite 7, 4 & 2 of the study area and Figure 6: Lineament Density map

Figure 5 shows the measurement of the total length of lineament in each grid and plotted in the respective grid centers. The red lines depict zones of lineament locations and were overlaid on the RGB colour composite of the study area. The generations of lineament density map was to highlight areas with high prevalence of the structures and this was overlaid on the image by dividing the study area into 1km/1km grids is presented in figure 6. The density depicts both high and low value in the study area.

Comparison of satellite image maps and Pre-existing Geological Map

Figure 7 reveals corresponding mineral deposits location on satellite image and those observed on the geological map. Hydrothermal deposits are products of hydrothermal processes. These deposits form economic reserves when they are concentrated in veins, and other voids.

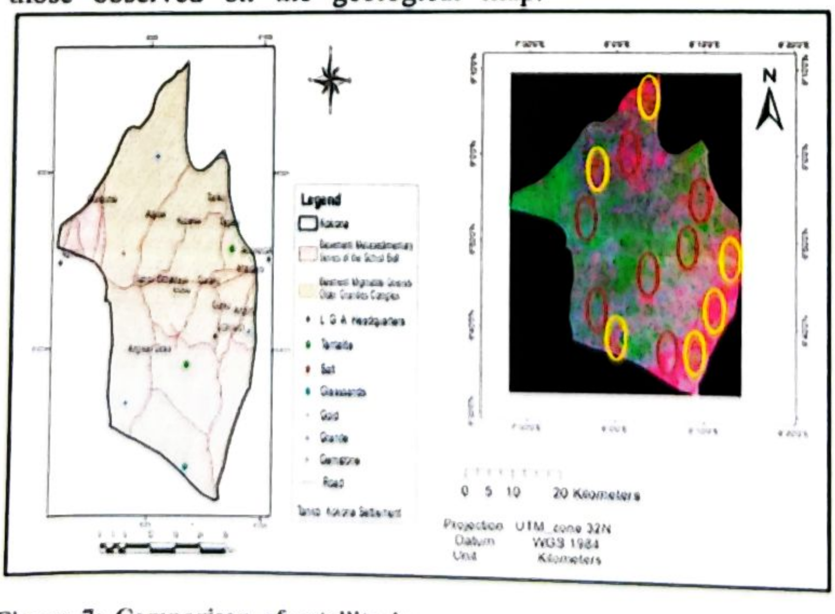


Figure 7: Comparison of satellite image maps and pre-existing geological map on location of mineral deposits.

Locations' being mined for granite, tantalite, and gemstones (as observed during the field survey exercise) also corresponds with the geological map (maroon polygons). From Figure 7, the yellow polygons represent newly detected potentially interesting sites that are absent in the geological map of the study area. Minerals such as quartz, pegmatite, feldspar, and tourmaline are commonly associated with basement migmatite gneiss older granites complex. Just as obtained from the geology of the study area, metals which are commonly associated in this way with acid rocks glassands, tantalite, gemstone, gold and granite. Hydrothermal alteration zones which comprise the primary source of tourmaline are presently being mined while Quartz, granites and gravels are majorly being mined for construction purposes.

The results obtained was in agreement with the findings of Sadiya *et al.,* (2014) who used Landsat 7ETM+ of Bwari local government area of Abuja federal Capital Territory located in the middle belt of Nigeria to detect and map locations of hydrothermal alterations. Clay mineralization was detected using band ratio 5/7. While false colour composite of bands 7:4:2 was employed to delineate potential locations of hydrothermal alterations and the study has established that the combined use of spatial and spectral resolution of satellite data could result in the detection and mapping of locations with known and unknown mineral deposit.

Conclusion

The study area was able to reveal that remotely sensed data can be used in mapping the various hydrothermal alteration zones and identifying zones of lineament locations for tourmaline exploration. Using band ratio technique, one spectral band by another was able to produces an image that provide relative band intensities. It has been demonstrated that GIS and remote sensing (geospatial technology) can provide a very reliable tool for geological mapping, and comparism with existing map of mineral deposits in the study area.

Recommendations

1. Government should invest more in satellite technology to boost the exploration and exploitation of mineral resources.
2. Public information and enlightenment on satellite technology should be encouraged for effective and efficient mineral mapping.

References

Abiodun, A.A (2000) *Development and Utilization of Remote Sensing Technology on Africa's Development,* OAU/ECA experts Group meeting, Mbabane. Swaziland.

Ajibade, A.C., Fitches, W. R., Wright, J. B., (1979).*The Zungeru mylonites, Nigeria:* Recognition of a majorunit. Rev de Geol Geog Phys 21:pp. 359–363.

Akbari, Z., Rasa, I., Mohajjel, M., Adabi, M. H., & Yarmohammadi, A. (2015). Hydrothermal Alteration Identification of Ahangaran Deposit , West of Iran Using ASTER Spectral Analysis. *International Geoinformatics Research and Development Journal Hydrothermal*, *6*(1), 28–42.

Ananaba, S.E. and Ajakaiye, D.E.(1987): Evidence of Tectonic Control of Mineralization in Nigeria from Lineament Density Analyses. *Intl. Journal of Remote Sensing,* 8 (10),1445- 1453.

Ayok, J. (2009). *Digital Lithological Mapping of The Eastern Gongola Basin, northeastern Nigeria,* from Landsat 7. Dept. of Geology, Ahmadu Bello University Zaria-Nigeria.

Bala, A. E. (1997).*Remote Sensed Groundwater Potential of The Basement Complex Around Dutsinma,* Katsina state, Nigeria. Unpublished MSc. Theses, Inter University Program in water resources Engineering, Vrije Universiteit, Brussels, 70.

Bala, A. E., Batelaan, O. and De Smedt, F. (2000b).*An Appraisal of Remote Sensed Natural Resources around Dutsinma,*northwestern Nigeria. Journal. Sc. Engr. Tech. 7 (4) 2860-2869.

Drury, (1991).Image Interpretation in Geology, Second Edition. HChapman and Hall, London. 283pp

Edett, A. E.,Teme, S.C., Okereke, C.S. and Esu, E.O.(1994): *Lineament Analysis for Groundwater Exploration in Precambrian Oban Massif and Obudu Plateau, SE Nigeria*. Journal of Mining and Geology, 30 (1), 87-95.

Goki, N.G.,Oha, I.A., Ike, E.C. and Bala, E.A. (2005). *The Use of Digitally Processed Landsat 5 TM Imagery to Map mineralized Pegmatites around Nassarawa*, Central Nigeria. First international Workshop on Geodesy and Geodynamics in Toro, Bauchi State.

Ghulam, A., Amer, R., & Kusky, T. (2010). MINERAL EXPLORATION AND ALTERATION ZONE MAPPING IN EASTERN. *ASPRS, 10th Annual Conference, San Diago, California, April 2010.*

Kankara, I.A. (2011): *Geology and Geochemistry of Rocks in Funtua NE, Sheet 78, Scale 1:50,000*, PhD Thesis, Federal University of Technology, Minna.

Karimi. M, (2003).*Design and Implementation of a GIS for copper mines in the detailed stage*, Msc thesis, K.N. Toosi University of technology, Iran, 120p.

Lillesand T M, Kiefer R W and Chipman J W (2004)*Remote sensing and image interpretation*; 5th edition, John Wiley and Sons Inc., New York, ISBN 0-471-25515-7, 763p.

Odeyemi O, I.B.,Anifowose, Y.B. and Asiwaju Y. A. (1999). *Multi-Technique Graphical Analysis of Fractures from Remote Sensing Images of Basement Regions of Nigeria.*Journal of Mining and Geology, 33(1).

Sadiya T. B., Ibrahim O.,Asma T. F., Mamfe V., Nsofor C.J., Oyewmi A. S., Shar J.T., Sanusi M., and Ozigis M.S. (2014).*Mineral Detection and Mapping Using Band Ratioing and Crosta Technique in Bwari Area Council, Abuja Nigeria.* International Journal of Scientific& Engineering Research (5) 12, 1100 ISSN 2229-5518 http://www.ijser.org

Wikipedia, the free encyclopedia.www.wikipedia.org.com; Accessed on 24th June 2015.