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RESEARCHARTICLE OPENACCESS

A Reconnaissance Study of Marble Mineral using Satellite Imagery in Kuje Area Council, Abuja, Nigeria.

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Abstract:

Exploiting mineral resources requires first and foremost locating suitable locations for its development. Remote sensing offers a synoptic capability of covering wide areas in real time and can be cost effective over a vast area of land. The marble location in Kuje Area Council Abuja, was assessed using Landsat 8 images and a number of GIS software's namely: ARCGIS, ERDAS IMAGINE, ENVI, ROCKWORK, MODEL. The study employed a combination of established Band ratios from literature on visible near infrared to shortwave infrared (VNIR-SWIR). Bands of Landsat 8 and innovative digital image processing techniques which enhanced surface mineralogy such as, carbonates zones related to marble deposits were revealed. The results of the ratios corroborate also the identification of carbonate minerals which serve as surrogate to locating marble deposits. A total of 106 training site locations was employed during the supervised image training and classification. Field validation was carried out, 80 points coordinate tracks were used as training sites to validate and also determine the accuracy and we discovered,78 points represent marble. Kappa co-efficient revealed 84% of marble location and the generated map of Kuje has shown spartial geographic distribution of marbles in unexplored locations.

Keywords:Marble, Landsat 8, Band Ratio,Georeferenced, Satellite Imagery.

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I. INTRODUCTION

It is no longer news that Nigeria largely depends on mineral resources for its major source of revenue which accounts for over 90 percent of the country's total foreign exchange earnings depends on Crude prices [1].

Diversification according to [2] presents the most competitive and strategic options for Nigeria in the light of her developmental challenges. Diversification has a lot of benefits for Nigeria to maximally utilize her abundant resource-base to rebuild the ailing economy and to grow national technology and foreign investment profile, build human capita, explore new frontiers, in order to increase the standard of living and confidence of the citizens for national rebirth.

Nigeria is endowed with various solid mineral types in commercial quantities found in more than 450 different locations [3]. In view of this, the need for reconnaissance mineral survey using satellite imageries for accurate and proper mineral resource inventory in order to create mineral deposits map, vital in helping planners to meet planning policy requirements. This database also will help the government in implementing laws in mining activities thereby increase the country's economic growth. Marble in Kuje Area Council of Abuja regrettably, add virtually little or nothing to the economy, as a result of non-implementation of policies which should discourage the activities of illegal miners [4]. In the FCT, the mining activities is carried out in small scale by untrained artisans (miners), and the operations themselves are unregulated and without guidelines which has resulted in loss of minerals due to environmental degradation [5]. Hence, there is need for a reconnaissance survey of marble using satellite image since its usually time efficient and relatively inexpensive. Satellite imagery is used for the surficial detection, identification and mapping of hydrothermally altered rocks commonly serve as pointer to the locations of mineral deposits.

Remote sensing is a valuable means in mineral exploration, saves money and time in providing useful information. Usually, it is best used for the detection of high-value minerals commodities which are difficult to locate in recent time. While it may detect exactly where significant deposits are, data collected through sensors can be used to restrict field prospects to smaller area which lowers the risk of a project and help to prioritize which area to investigate first [6]. Costly operations such as drilling and field work can be done after much information is obtained. So far the significant advancement in mineral exploration has been the capacity to combine several data forms gathered. Usually, ascertained drill results can be integrated with air photos (satellite images), ore grade data, structural maps, topographic maps, and greatly increasing the accuracy and effectiveness of an exploration survey.

Information on extent, distribution and quality of potential economic mineral resource is vital for an effective and informed decision which is important to satisfy the objectives of national Socio-economic development.Marble is a metamorphosed limestone. Limestone and marble are carbonate rocks, dominated by the mineral calcite (CaCO3) essential for a rapid growing Nations across the globe. It is certain that remote sensing approach makes possible the availability of mineral of interest in remote area to be known through instrumentality of Satellite images. Remote sensing has advantages of spatial, spectral and temporal accessibility of data acquisition of large-highly forested inaccessible areas in a short time, which makes it remarkable and approachable device in tracking and evaluation of potential mineral resources. such that data information on spatial patterns are identified and demarcated in the Basement.

This study focuses on marble locations in Kuje using satellite imagery to provide data that will help ascertain the coordinates for easy accessibility of the area so as to reduce the hazard of traditional traverses in search of mineral deposits.

II. LITERATURE REVIEW

The first marble deposit discovered in Nigeria is the Jakura marble according to [7]. It was discovered in 1908 by the mineral survey of Northern Nigeria, but was well investigated between 1949 and 1951. Exploration in this deposit commenced in 1963 when the Nigeria marble industry produced about 40 tons.[8] noted that the marble in Obajana has high calcite and low dolomite content as observed from its geochemical data.

In the article, hydrothermal altered mineral deposits using Landsat 7 ETM image in and around Kuju Volcano, Kyushu Japan. [9]described how very little was known about the Geology of the Itobe marble body. The Itobe marble is located about 1km from Itobe town along the Ajaokuta-Anyigba road, Kogi state, Nigeria. The study area lies between longitudes 60º40' E and 60º48'E and latitudes 70º22'N and 70º30' N. The study contributed to the knowledge of the Itobe marble and thus;

[10] described the methodology for high-resolution aero-radiometric data from three radio-elements (Uranium, Potassium and Thorium) and processed independently to investigate the Southern, Anambra basin for the prospect of producing radiogenic heat. The rock types of the study area were showcased while processing the elements in each rock to evaluate the values of the radiogenic heat produced. The results of the analysis of the radiogenic heat production of the study area were between 0.01 – 5.43 µWm-3. The highest heat produced came from the sedimentary rocks (Shale) with radiogenic heat production value up to 5.43µWm-3. The highest radiogenic value of the heat production in the basin had a value of 5.43 µWm-3 around Aimeke and Ogobia. The total airborne radiometric count of radio-elements and radiogenic heat maps were produced. The study covered the processing of aero-radiometric data and obtained the radio-elements present in the area under investigation by carrying out qualitative, quantitative analysis and interpretation of the radiogenic heat map to determine the radio element mineralization, production of a Ternary map to locate productive area for geothermal energy and radiogenic heat production were obtained.

In the work high resolution Aeromagnetic data and Satellite Imagery for Mineral Potential over parts of Nasarawa and Environment, North-central Nigeria.

[11] described the methodology for exploration designed to take care of the peculiarities of all observable surface geological evidences that could be utilized to identify areas of probable mineralization. The use of Landsat Remote Sensing was aimed at digitally manipulating the information stored in the imagery in other to extract those that could be directly linked to the surface processes such as weathering and alterations that were associated with mineral deposits. [12] described the methodology on how to use remote sensing technology in lithological mapping and identification of hydrothermal alteration zones of the Gold mineralization using Landsat 8 for the detection in Red Sea Hills in Sudan. The study area was part of the Arabian Nubian Shield (ANS) that exposed a Precambrian crystalline rock on the flanks of the Red Sea (Neoproterozoic age). Although Gold cannot be directly detected by any Remote Sensing method, the presence of minerals such as iron - oxide and clay mineral have diagnostic spectral signatures. The area had three Gold mines; part of Arab mining district in Red Sea Hills, Northern Sudan. Three types of Gold deposits found in the area were (Supergene, Polymetallic massive Sulphide and the Ganaet deposits) mined in HadalAuatibmine, Hassai mine and Kamoeb mine. The objective of the study was to find new high potential areas for Gold mineralization in the area. Colour composite, Band Ratio, Principal Component Analysis, Directional Filtering Minimum Noise Fraction (MNF), Spectral Angle Mapper (SAM), Matched Filtering (MF), and Mixture – Tuned Matched – Filtering (MTMF) were used for the Geological study. Obtained results indicated that Landsat 8 data proved the ability and capability to identify lithological units and alteration zones at regional scales.

[13] used Crosta and mapped the distribution of hydrothermally altered mineral deposit zones in the urban area of Abuja as a means of initiating a

mineral deposit inventory database for Nigeria. Band ratio was used to emphasize the anomaly of target object that determined the band at which reflectance was high or point of highest absorption. Band ratios 3/1 and (4/5-4/3) suggested the presence of ferric iron 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 alterations.

[14]proposed a Reconnaissance study of igneous with subordinate sedimentary and metamorphic rocks in a catchment area of a main stream in Iraqi Kurdistan Region. Usually concentrations of heavy metals could be quite high in stream sediments located close to a deposit, and this is because of weathering processes of mineral deposits, and usually the concentrations decrease with increasing distance from the upstream deposits. The work showed that 14 samples was collected from 14 sub-basins. The collected stream samples underwent X-Ray Fluorescence (XRF) analysis and 4 of those samples were further subject to XRD analysis as well. The results obtained from XRF analysis showed that the average concentrations of Ag and Cd are 6 mg/kg and 16 mg/kg, respectively, indicating that the concentration of Ag is 80 times higher than the Ag concentration in the crust. The XRF results of the collected stream samples also showed anomalous concentrations for the remaining elements (Ni, V, Zn, and U), which were most probably derived from the exposed igneous rocks in the study area.

[15]conducted a reconnaissance study of monazite and xenotime which can be considered as Rare Earth Element (REE) which consists of mostly pegmatites and granite bedrocks and alluvial plains from Kedah, Malaysia. Monazite is a common accessory mineral in peraluminous granites, syenitic and granitic pegmatites, quartz veins and carbonatites while Xenotime is also a phosphate mineral but abundant particularly in Ca-poor peraluminous granites. In the methodology, samples were collected from current and seasonal stream beds, stream banks and gravelly layers on stream banks, weathered granites and pegmatites also, samples of different magnetism were then taken for Quantitative Mineral Estimation (QME) analysis under stereo microscope aided by mineral lists. The result of the work showed that for QME analysis for monazite content in samples from recent fluvial environment is from none to 8.43% and the xenotime content in samples from the same environment is from none to 6.05%. While for weathered bedrock samples, the highest monazite and xenotime content is in pegmatite, which is 13.70% and 1.45% respectively, compared to weathered granite. Therefore, sandy layers in pits have considerably greater amount of heavy concentrate minerals compared to silty and clayey layers. The monazite and xenotime content in samples from pits is ranging from none to 3.16% and none to 2.91%, respectively.

[16] proposed a remote sensing and GIS techniques for exploring hydrothermal mineralization areas in central Eastern Desert of Egypt. In the work, several maps as evidence were highlighted the plausible areas with high concentrations of argillic and phyllic, key hydrothermal minerals that shows intensity of hydrothermal effects and the probable sites of ore bodies. Also, Landsat-8 Operational Land Imager (OLI) data was used, which consists of visible near infrared (VNIR), shortwave infrared (SWIR), and thermal infrared (TIR) data. Six bands, including bands 2, 3, 4, 5, 6, and 7, with a 30 m resolution, were processed and combined. ASTER data was collected on-board the TERRA spacecraft. Image transformation techniques using Landsat-8 OLI and ASTER data represent a powerful and cost effective approach for application during the reconnaissance stage of mineral exploration. The use of band ratios and mineral indices for ASTER data through GIS spatial analysis techniques allowed the identification of the location of high grade hydrothermal alteration zones. This was achieved by combining ranked thematic predictor maps. The resulting predictive map was assessed using existing mining data with significant consistency. The results obtained showed that remotely sensed data represent a valuable mapping tool for geological and mineral resources reconnaissance

in the arid regions.

[17] performed a Reconnaissance study of Geodesic Condition of Zarband Marble Mining Area, geodetic points reconnaissance was carried out at the Zarband quarry, where geodetic points coordinates were performed using Stonex S900A (developed by the Italian company Stonex) to intensify the satellite geodetic network located at different distances from the prospecting area. During the reconnaissance, the pyramids absence in the main part of the geodetic points for deformations and classical angular measurements was found, the work purpose was to assess the geodetic points condition described on the topographic map obtained by triangulation and leveling methods. During the points reconnaissance, it was found that many geodetic pyramids had not been preserved, but the centers had been preserved in their original form. This provides the basis for the ability to determine the centers coordinates by satellite navigation methods. The basis of the primary geodetic network survey was a horizontal survey by measuring the area contours where the objects are located and measuring the control points connections between them using the polar method. Thus, the work shows that Reconnaissance near mining sites is an integral part of geodetic work, which allows to reduce the amount of earthworks associated with the restoration and reconstruction of starting points. In addition, a scheme of combined geodetic network was developed in which measurements were made using angle measurements and navigation instruments. The right-angled coordinates of these points were obtained in the conventional coordinate system with subsequent abbreviations to the global geodetic network, and the elevations were calculated in the Baltic Altitude System (BAS-77).

III. METHOD AND MATERIALS

The methods involved image acquisition, image transformation, image processing, field mapping/validation to observe the rock outcrops, their disposition characteristics such as folds and joints.

A. Methodology and Field Procedure

The methodology consisted of a desk study and field investigation. The investigation to determine marble potentials was carried out in stages:

1) Study of physical and geological map of the study area.
2) Field reconnaissance survey.
3) Processing, analysis and interpretation of data.

The desk study involved compiling and assessing the following data sets: Topographic and geological maps. Existing and previous geological work undertaken within and outside the study area. The reconnaissance survey is meant to locate and target areas for marble investigations. The points that were selected from the maps will now be identified on the ground with the aid of Global Positioning System (GPS).

The ground truths also involve to ascertain topography, geology and structural features.

Throughout this work, two ground validation exercises were carried out for field mapping and validation of Kuje Area Council of the Federal Capital Territory Abuja. Taken into consideration was the colour, texture, coordinates, topography, composition and pictures. It was found that most of the mining sites are exploring marble for construction in economical quantities. In order to carryout effective and efficient field mapping, a Global Positioning System (GPS) was used to take the elevation and coordinate readings at several location points, a camera to take pictures of the outcrops, a compass clinometer to record dip and strike. A total of 106 points (coordinates) were taken at different locations. A geological hammer to break fresh rock was used. However, to explore the full value of these data, the appropriate information has to be extracted and presented in standard format to import it into geo-information systems and thus allow efficient decision processes. Figure 1, shows the topography of Kuje Area Council, Abuja which is the area under investigation.

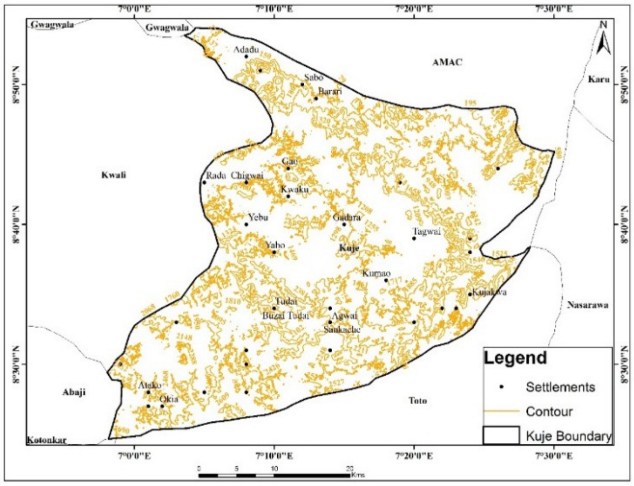

Fig. 1: Map of Kuje showing the Topography.

B. Remote Sensing Data

The Landsat 8 image used in this work (path 55and row 20), was launched on the 4th of February, 2013 from the Vanderberg Air Force Base in California USA as part of the Landsat Data Continuity Mission (LDCM).The Satellite has two sensors; the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). The OLI acquires image data in nine (9) bands or channels ranging from the Visible Near Infrared (VNIR) to Short Wave Infrared (SWIR) region of the Electromagnetic Spectrum (EMS).The image was downloaded in a package containing 11band images (in Geo TIFF), because OLI band 8 (panchromatic) was designed for visualization and band 9 (citrus) was for high altitude cloud detection, they were removed from further analysis. We created a nine-band image stack, including OLI bands 1-7 TIRS bands 10-11 (Table I) below. The technique of Landsat 8 is robust with a high resolution multispectral high quality visible and infrared images of all landmass including, near coastal regions of the Earth. It has a life-span design of five years and stocks ten years of fuel consumables. Its designed for a 705 km spectral and high-volume data, by periodically acquiring 650 scenes per day opposed to 400 scenes in past Landsat missions The Operational Land Imager Sensor acquires image data for nine shortwave spectral bands over a 190 km swath width with a 30 m spatial resolution for all bands apart from the 15 m panchromatic band. The width of various Operational Land Imager bands is refined in order to prevent atmospheric absorption features in the Landsat bands. The greatest change occurs in OLI band 5(0.845-0.885) to exclude a water vapour absorption feature at 0.825 µm in the middle of the Enhanced Thematic Mapper. The panchromatic band of the Operational Land Imager, band 8 is relatively narrower to the ETM+ panchromatic band to produce bigger contrast between vegetated area and land without vegetation cover.

Images of Landsat 8 are available to the public which can be downloaded from USGS Websites, including the Earth Explorer. These images (referred to as products) are available at various processing levels. In this work, raw images were downloaded and processed for systematic geometric and radiometric correction using ground control points with the corresponding Digital Elevation Model. The Landsat 8 image used in this work was captured under perfect weather conditions (< 10% of cloud cover) as ground validation was underway. The downloaded image was in a package containing 11 band image (in Geo TIFF), and 1 metadata file (in ASCII). Immediately the package was downloaded the band images were processed.

TABLEI
LANDSAT 8 OLI SPECTRAL BAND.

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)	Bands	Wavelength (Micrometers)	Resolution (Meters)
	Band 1 - Coastal aerosol	0.43 – 0.45	30
	Band 2- Blue	0.45 – 0.51	- 30
	Band 3 - Green	0.53 – 0.59	30
	Band 4 - Red	0.64 – 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 – 0.88	30
	Band 6 SWIR 1	1.57 – 1.65	30
	Band 7 SWIR 2	2.11 – 2.29	30
	Band 8 - Panchromatic	0.50 – 0.68	15
	Band 9 - Cirrus	1.36 – 1.38	30
	Band 10 – Thermal Infrared (TIRS) 1	10.60 – 11.19	100
	Band 11 – Thermal Infrared (TIRS) 2	11.50 – 12.51	100

C. Database Creation, and Vectorization

The geological and topographic maps were scanned and imported into the ArcGIS software. The shape file/geometry of the study area was used to subset or delineate the extent of the study area from both maps. The data were projected using Projected Coordinate System WGS 1984 UTM Zone 32N. Feature classes were created for the purpose of digitizing the features like the geology and rock formation, rivers, contours.

D. Georeferencing

The maps were then georeferenced to give it a reference system, using ground control points selected from topographic sheets of scale 1: 50,000. Geologic map of the study area was obtained from Nigerian Geological Survey; this will be use to compare locations of target area detected with using remote sensing technique to locate potential marble deposits given in the geological map.

E. Image Correction

The image was corrected for geometric, radiometric distortions using ground control points with the corresponding Digital Elevation Model and projected to geographic (latitude/longitude) coordinate system and WGS-84 datum. The study area was sub-setted from raster image (Landsat 8 data) using the shape-file of the Kuje Local Government Area. The image was atmospherically corrected using Internal Average Relative Reflectance (IARR) method and converted to surface reflectance.

F. Band Ratio

Band ratios are very useful for highlighting certain features or materials that cannot be seen in the raw image. This operation was performed by selecting the band with high reflectance for a mineral as the 'numerator' and another band with high absorption as the 'denominator' in the ENVI software band ratio interface. The ratios were performed and each pair was assigned to RGB respectively. The ratio 4/2 is useful for mapping iron oxides because it has absorption in the blue region and high reflectance in the red region. The ratio 5/6 were used for mapping ferrous minerals due to high reflectance of those minerals in the band ratio.5/7was used for carbonate minerals. Either of ratio 6/7 or 7/5 can highlight clay minerals in multispectral images. All ratios were merged using RGB colour representation to produce a band ratio map.

IV. RESULTS AND DISCUSSIONS

In the study area, two main groups of rocks occur. These include rocks of the migmatite gneiss complex and the sedimentary rocks. The gneisses occur as hilly, massive and low-lying outcrops and some places where they have contacts with other rocks, the contacts are marked by the development of the cataclasites and mylonites. The grey gneiss is dark in colour with a gneissic foliation revealed by felsic and mafic minerals and medium grained in texture. The granite gneiss is medium to coarse grained, having a poor gneissic foliation and very light in colour. The rocks vary in colour depending on the nature and the amount of feldspars and the ferromagnesian minerals present.

A. Single Band Combination

Natural Red, Green and Blue (RGB) colour combination image can highlight geological features including textural characteristics of rocks, structural features and vegetation at regional scale. Image enhancement using a band combination of 4, 3, 2 RGB to extract features by image interpretation. Based on laboratory spectra of minerals related to carbonate and clay minerals, ferric ion and ferrous ion minerals, several Red - Green - Blue colour combination images can be created using Landsat-8 data.

Figure 2, 3 and 4 shows the geographical location of the study area under investigation.

Fig.2: Showing Outcrop of Marble in Kuje Area of Abuja. Lat 8° 56' 3.748", Long 7° 16' 52.7458" E.

Fig. 4:Showing Marble in Kuje Area of Abuja. Lat 8° 50 3.5582", Long 7° 14' 52.7568" E.

Fig. 2: Showing Marble outcrop in Kuje Area of Abuja. Lat 8° 56' 3.743", Long 7° 16' 52.7458" E**.**

The marbles occur at some depths beneath the surface and they are well exposed at some quarry locations where the over-burden has been removed and currently mining is on-going at some depths below. The Kuje marble is of two major types namely:

1) ***The coarse:*** Grained white coloured, with inter-locking calcite grain which is dominant at the quarry pit and as well extends across the major road.
2) ***The fine:*** Grained, grey type which occur at the centre of the pits. Another distinct type of marble in the Kuje Area is the reddish - brown marble which occur at Mappi area in a large quantity and extends across the road.

The marble and the associated metamorphic rocks have been deformed and folded together.

the band ratio 7/3,5/2,4/7 is equivalent to band ratio 7/4, 6/3, 5/7 in Landsat 8 RGB. The resulting image as shown in figure 4.6, indicates yellow as hydrothermal alteration areas, black identifies water, the green indicates vegetation (dark green) and clay rich rocks (light green), blue shows sand, white indicates some mineral rocks-iron oxides. Figure 5 shows the Landsat 8 band ratio of Kuje, Abuja Nigeria.

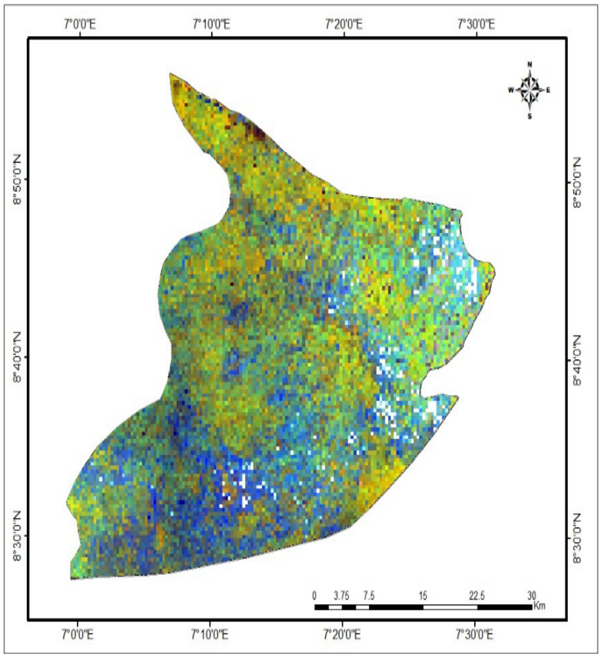

Fig. 5: Map showing Landsat 8 Band Ratio 6/7, 4/3, 5/6 in R.G.B. of Kuje.

Band ratios 5/7, 3/2 and 4/5 of Landsat TM used in (Abrams et al.,1983) are selected for the red, green and blue (RGB) channels equivalents 6/7, 4/3 and 5/6 on Landsat 8 which corresponds to wavelength regions 1.65/2.2μm, 0.66 / 0.56 μm and 0.83 /1.65 μm in EMS. The results of the band combination show iron oxide - rich areas displayed as green, due to the presence of ferric iron charge transfer band in the ultraviolet, and clay - rich areas are shown as red, due to presence of hydrous mineral absorption indicated as red, due to presence of hydrous minerals absorption band near 2.2 μm. Green or brown areas represent the areas where both clay and iron oxide minerals are present.

Figure 6 shows the Landsat 8 Band Ratio 7/4, 6/3, 5/7 in R.G.B. of Kuje.

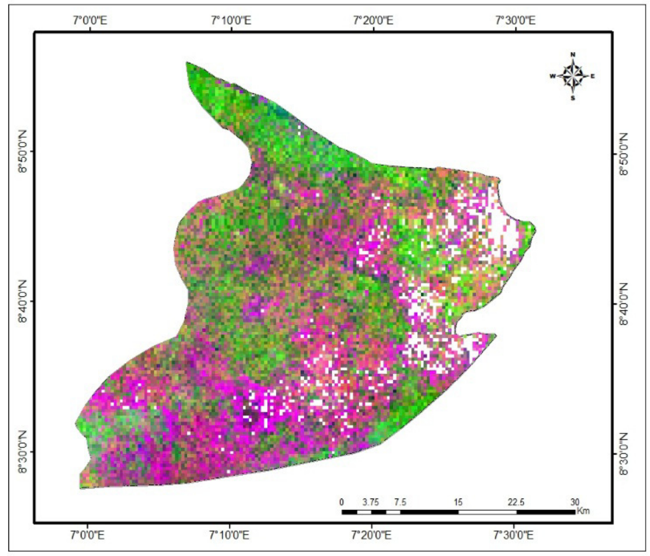

Fig. 6: Map showing Landsat 8 Band Ratio 7/4, 6/3, 5/7 in R.G.B. of Kuje scene.

The ratio 7/4, 4/3 and 5/7in Landsat TM corresponds to ratio 7/5, 5/4 and 6/7 using Landsat 8 bands. The results indicate band 5/4 highlights vegetation in bright tones caused byhigh reflectance in near infrared (NIR) band.

B.Spectral Distinctive Feature of Marble inthe Study Area

Generally, it is not easy to differentiate between the Marbles in the study area based on this spectral analysis because some absorption features which could be as a result of low reflectance, and the presence of opaque minerals weakened the spectral absorption features of other minerals associated with Marbles. The Figure 7 and 8 below shows spectral of the iron oxide minerals which have low blue reflectance band 1andhigh red reflectance.

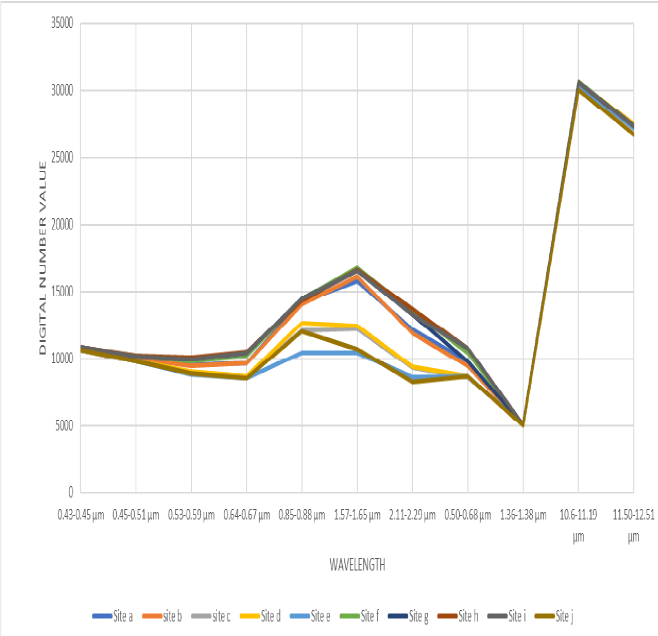

Fig. 7: Spectral profile of Marble.

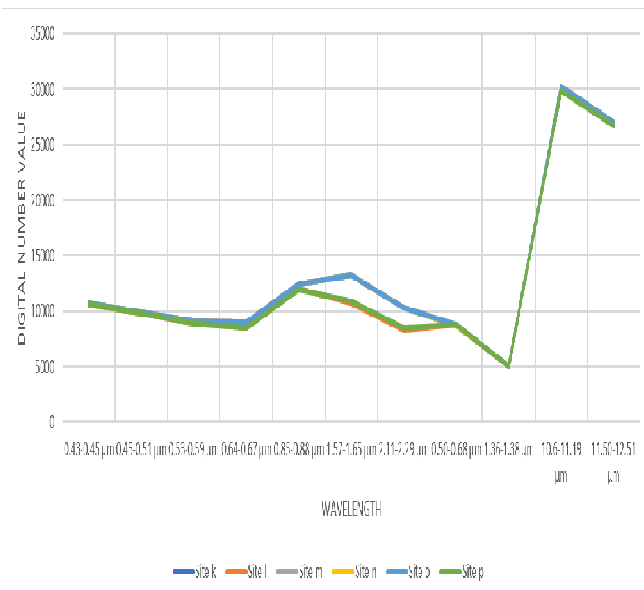

Fig. 8: Spectral profile of marble.

V. CONCLUSION

Marbles are amongst the most important natural resources that dictate the industrial and economic development of a Nation, since they provide raw materials to the primary, secondary and tertiary sectors of the economy. Marble occurs in several locations of Nigeria and there is need to harness its maximum potential, however, due to lack of proper inventory, these deposits are not fully utilized. This work has presented reconnaissance mineral survey mapof Marble in Kuje, Abuja using satellite imagery, and has further revealed undiscovered marble locations with their coordinates for ease of accessibility. This will reduce the hurdles of traditional way of traversing the field during mapping that led toseveral valuable minerals being lost, since we cannot depict with our eyes what spectral signatures is present.

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