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Assessment of Mineral Potential Using Remote Sensing and Geographic Information System in Central Part of Kogi State, Nigeria

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Abstract: ***Remote sensing technology plays a vital role in mineral exploration. In this research, landsat 5 TM was analyzed using band rationing method. The spectral bands from the visible bands, near infrared and far infrared were used to detect the mineral potential in the study area. The software used in this research include: ArcGIS, Erdsas Imagine 2014 version, ENVI 5.0 and PCI Geomatica. The satellite data were preprocessed to avoid errors due to atmospheric influence. The data were also checked for any geometric correction. To understand the nature of topography of the study area, the digital elevation model was analyzed using shuttle Radar Topography Mission (SRTM). The lineaments were also delineated to unravel the structural disposition of the area. The lineaments in the study area are characterized by N-E and S-W direction. The mineral groups identified in this research include: Clay-carbonate-sulfate-Mica mineral, ferric iron mineral and the ferrous mineral groups. The Clay-carbonate-sulfate-Mica mineral group are more dominant in the north-eastern and south eastern part of the study area. The ferric iron mineral group are widely distributed in the study area while the ferrous mineral occurred in the north western part of the study area. The pixels for vegetation and water which could obstruct the reflection from the rocks and minerals were eliminated to minimize errors in the final result. This research reveals the mineral potential of the study area and could serve as a useful guide for detail exploration of the economic mineral deposits. The economic metallic minerals extracted from these mineralized zones would serve as raw materials for the manufacturing industries.***
Keywords: Remote sensing, mineral potential, band rationing, lineaments, DEM

I. INTRODUCTION

Satellite remote sensing images have been widely and successfully used for mineral exploration since the launch of Landsat in 1972[1]. Mapping hydrothermally altered rocks, which are common indicators of mineralization, is integral to reconnaissance mineral exploration [2].

The discrimination between hydrothermally altered and unaltered rocks is one of the most significant aspects in mineral exploration programs [3]. Analysis of specific reflectance bands of satellite images can enhance the reflectance signature of minerals (such as certain clays) that might be associated with ore deposits. Today remote sensing and digital image processing enable us to detect spectral bands for mineral exploration.

In regions where bedrock is exposed, multispectral remote sensing can be used to recognize altered rocks because their reflectance spectra differ from those of the unaltered country rock [4]. In geologic terms Landsat provides data are especially useful for mineral exploration. It can be used to identify areas containing minerals useful in the search for mineral deposits, including iron oxides and/or hydroxides (hematite, goethite and limonite), clays (kaolinite, dickite and montmorillonite), micas (illite, sericite and muscovite), sulfates (jarosite and alunite) and carbonates (calcite and dolomite) [5]. Band ratio combination has been proven to be one of the most useful image processing methods for lithological discrimination, as discussed by many researchers in the past [6].

II. GEOLOGY OF THE STUDY AREA

The study area covers about 77.4% of the total area of Kogi state and it is located between latitudes $6^0 33' 2.29''$ and $8^0 44' 57.33''$ and longitudes $5^0 34' 20.07''$ and $7^0 33' 24.17''$ .It is one of the states in the central region of Nigeria. It is popularly called the Confluence State because the confluence of River Niger and River Benue is at its capital, Lokoja, which is the first administrative capital of modern-day Nigeria. The geological map is indicated in Fig 1

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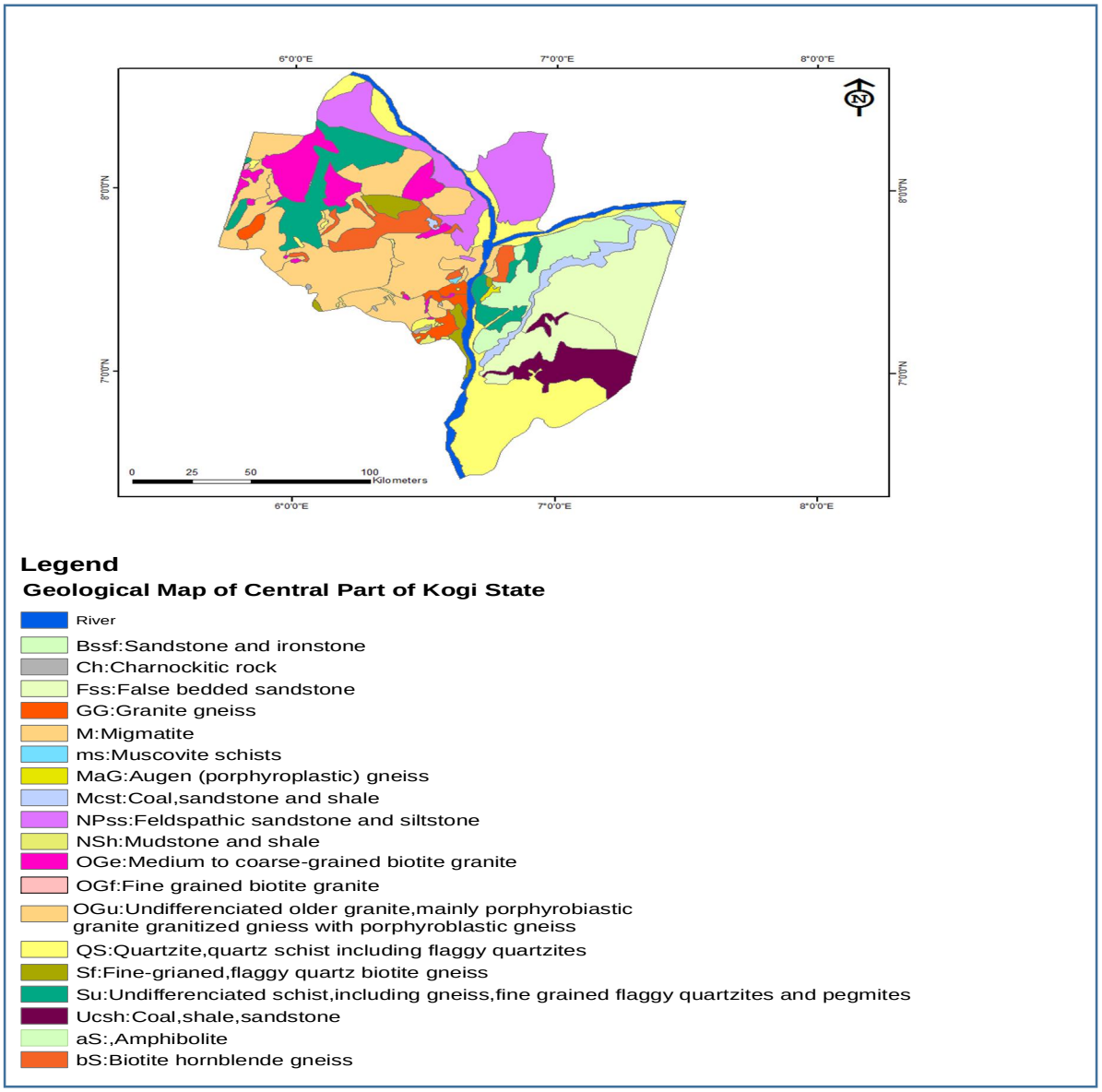


Fig 1. Geological Map of the study Area

III. MATERIALS AND METHODS

The data used in this research include landsat TM image and Shuttle Radar topography Mission (SRTM).The landsat TM was acquired on the 2nd of January, 1987.It has 7 bands which cover the visible and the infrared region of the electromagnetic spectrum. The path and rows covering the study area are P89/Row 054 and P189/Row055. The data were preprocessed to ensure that they are atmospherically and geometrically corrected for further analysis.

A. Digital Elevation Model (DEM)

The digital elevation model was extracted from the Shuttle Radar Topography Mission (SRTM) to understand the topographical nature of the study area.

B. Data Masking

Because vegetation obscure the reflectance from the ore body, it was masked in the course of the image processing to obtained correct reflectance from the ground surface. The Normalized Difference Vegetation Index (NDVI) was generated and used to identify the vegetation pixels in order to eliminate them from further analysis while the water body was digitized and masked out.

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C. Band Ratios for Mineral Composite

Landsat band 5/7, 5/4, and 3/1 ratio was done to generate the colour composites for mineral groups in study area. The ratio images (5/7, 5/4, 3/1) were combined as red, green, and blue, respectively.

D. Lineaments Mapping

Principal components analysis (PCA) was carried out for Landsat5 TM Image to reduce the dimensionality in the data and compress as much of the information in the original bands into fewer bands. Line module of PCI Geomatica was used to extract lineaments from the image. The lineaments were generated using the bands containing most of the information in the PCA analysis.

IV. RESULT AND DISCUSSION

A. Mineral Composite

In this research, band rationing of landsat 5 TM was used to detect the mineral groups of the central part of Kogi state. The Clay-carbonate-sulfate-Mica mineral group are found in the north-eastern and south eastern part of the study area. The ferric iron mineral group are widely distributed in the study area while the ferrous minerals are more dominant in the north western part of the study area (Fig2).

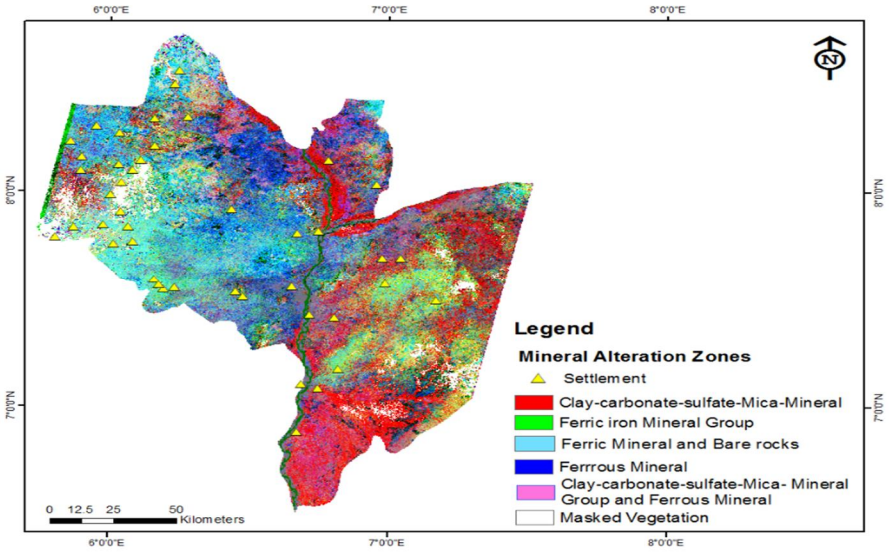


Fig 2. Mineral Composite of the Study Area

B. Lineaments Mapping

Principal components analysis (PCA) was carried out for Landsat5 TM image using band 1, 2,3,4,5 and 7 to reduce the dimensionality in the data and compress as much of the information in the original bands into fewer bands. Line module of PCI Geomatica was used to extract lineaments from the image. The lineaments were generated using the bands containing most of the information in the PCA analysis (Table1). Lineament mapping in mineral exploration is important because faulted and structurally complex areas could serve as permeable zones for hydrothermal fluids, resulting in concentrated areas of base and precious metal ore deposits.

	Eigen Values	%Eigen Values	Cumulative Eigen Values
PCA1	6004.78591	98.3175	98.3175
PCA2	80.62137	1.32	99.6376
PCA3	14.42766	0.2362	99.8738
PCA4	5.32292	0.0872	99.9609
PCA5	2.18114	0.0357	99.9967
PCA6	0.20389	0.0033	100

Table 1.Eigen Values of PCA Analysis

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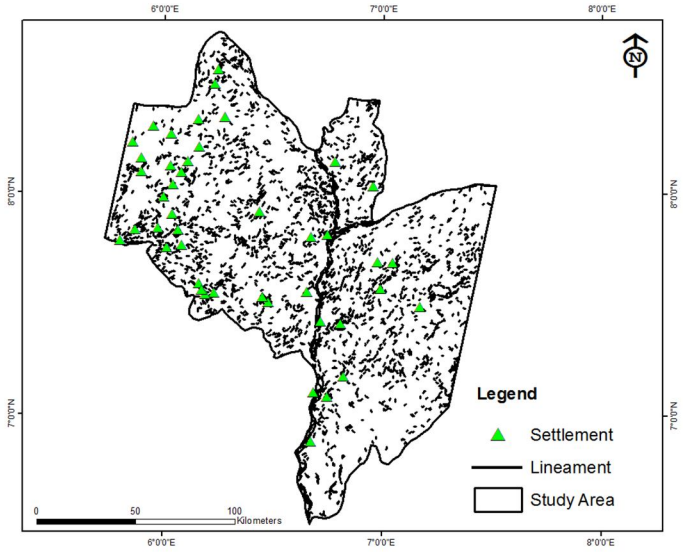


Fig 3. Lineaments Map of the Study Area

C. The Rose Diagram

The essence of generating the rose diagram of the lineaments is to show the overall trend in the analysis. In this research, the lineaments indicates N-E and S-W orientation.

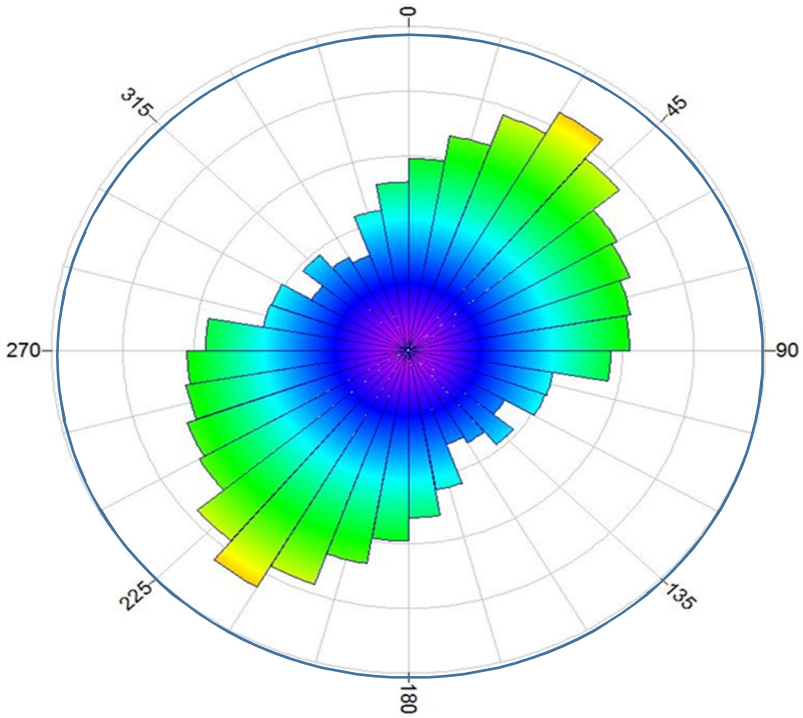


Fig 4. Rose Diagram

D. DEM

The digital elevation model also deliver useful information on hilly, mountainous and the low lands. In this research, most of the mineralized zones occur in the hilly and mountainous regions of the study area. Some clay minerals also occur in the low land area of south eastern part of the study area.

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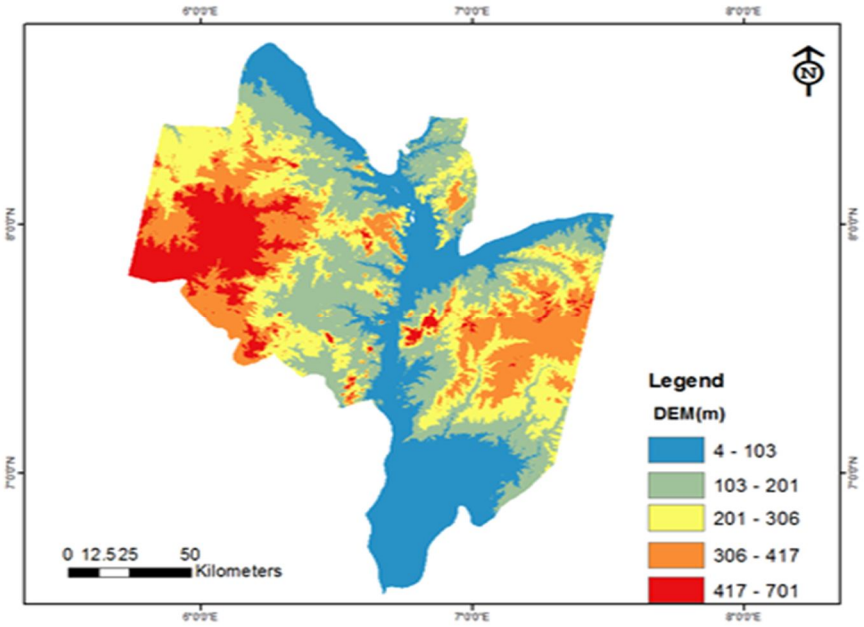


Fig 5. Digital Elevation Model of the Study Area

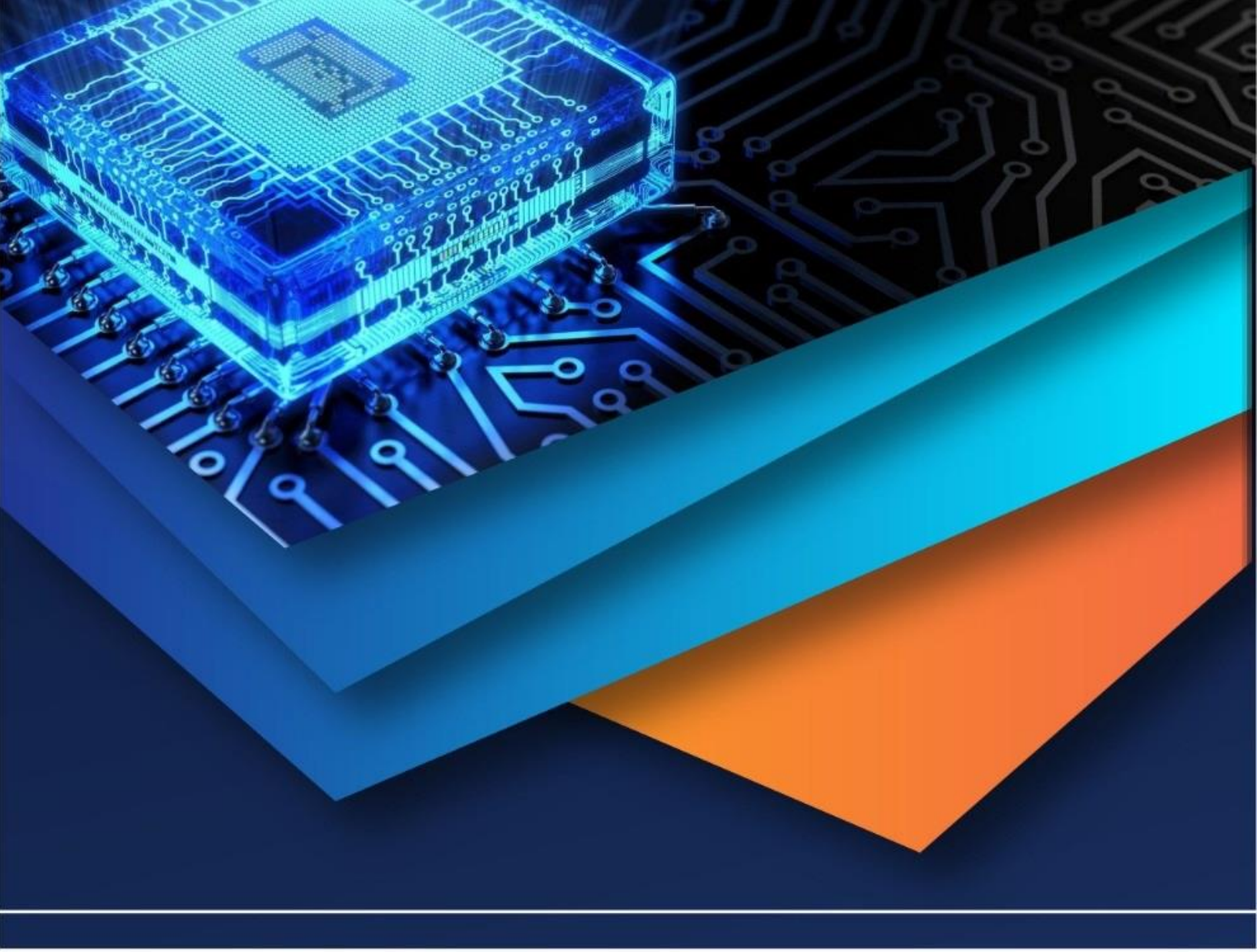
V. CONCLUSION

The main aim in mineral prospecting is to locate anomalies due to mineral deposit. Remote sensing technology is very essential in mineral alteration exploration because of its wide range of spectral bands. This research has shown the capability of remote sensing technology and the role it plays in mineral exploration. The visible and the infrared bands of the landsat image was processed in order to assess the ore deposits in the central part of Kogi State. The results from the research indicate enormous mineral potential in the study area. The mineral groups identified include: Clay-carbonate-sulfate-Mica mineral. These minerals occur mainly in the hilly and mountainous regions of the study. The mineral composite model generated in this research could serve as a useful guide in the detail exploration by the Geoscientists and Engineers. The exploitation of the economic minerals from, ferric iron mineral and the ferrous mineral groups. The exploitation of the economic minerals from the study area could provide raw materials for the local foreign industries.

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