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Mineral Prospecting in Central Part of Kebbi State, Nigeria

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Abstract: ***In this research, landsat Thematic Mapper was processed and analyzed using Remote Sensing and Geographic Information System techniques in order to detect the mineralized zones in the Central Part of Kebbi State. The Chica - Olma ratio (5/7, 5/4 and 3/1) was employed in the analysis. The clay-carbonate-sulfate-Mica, ferric and ferrous minerals were detected and mapped out. The detected clay, ferrous and ferric minerals were classified using ArcGIS. This research can serve as useful guide in mineral reconnaissance and as a supplement to field lithologic and structural mapping.***
Keyword: Mineral, Thematic Mapper, Remote sensing, Band rationing, Landsat, GIS

I. INTRODUCTION

Mapping hydrothermally altered rocks, which are common indicators of mineralization, is integral to reconnaissance mineral exploration [1].

Minerals are chemical elements and compounds that have been formed through inorganic processes. Considerable progress has been made with computer analysis of Landsat digital data and some techniques have definite application to mineral and petroleum exploration Satellite images are providing new views of the earth that can make the geologist's job of finding mineral and energy resources more efficient.

They will not, however, replace the needs for traditional field mapping or geophysical and geochemical survey methods [2].

Despite being no replacement for fieldwork and other more traditional methods, remote sensing can provide essential information from a truly new perspective [3]

The naturally occurring substances are divided into metalliferous ores, such as the ores of copper, gold, iron lead, zinc, manganese and tin and nonmetalliferous minerals, such as, bauxite, trona, coal, quartz, borax, asbestos, phosphate rock. , talc and feldspar etc. [4] used ETM+ bands ratios of 3/1, 5/7, 5/4 in North Korea to analyze for iron oxides, clay minerals and ferrous minerals respectively [5] used ratio image processing techniques as a prospecting tool for mineral deposits in red sea hills, NE Sudan in 2008. [6] investigated clay minerals in Mubi Local Government Area of Adamawa State using the Chica-Olma ratio (5/7:5/4:3/1) RGB.

Band rationing is a useful method of pre-processing satellite image, especially in areas where topographic effects are important. Band rationing means dividing the pixels in one band by the corresponding pixels in a second band. The reason for this is twofold: one is that differences between the spectral reflectance curves of surface types can be brought out.

The second is that illumination, and consequently radiance, may vary, the ratio between an illuminated and a non-illuminated area of the same surface type will be the same [4]

II. GEOLOGY OF THE STUDY AREA

Kebbi State is located in the North-Western part of Nigeria with its capital at Birnin Kebbi. It is bordered by Sokoto State, Niger State, Zamfara State, Dosso Region in the Republic of Niger and the nation of Benin. It has a total area of 37.418.km² and a population of 3,256,541 at the 2006 census (6Yemi 2013). The geological map of the study area is shown in (Fig1).

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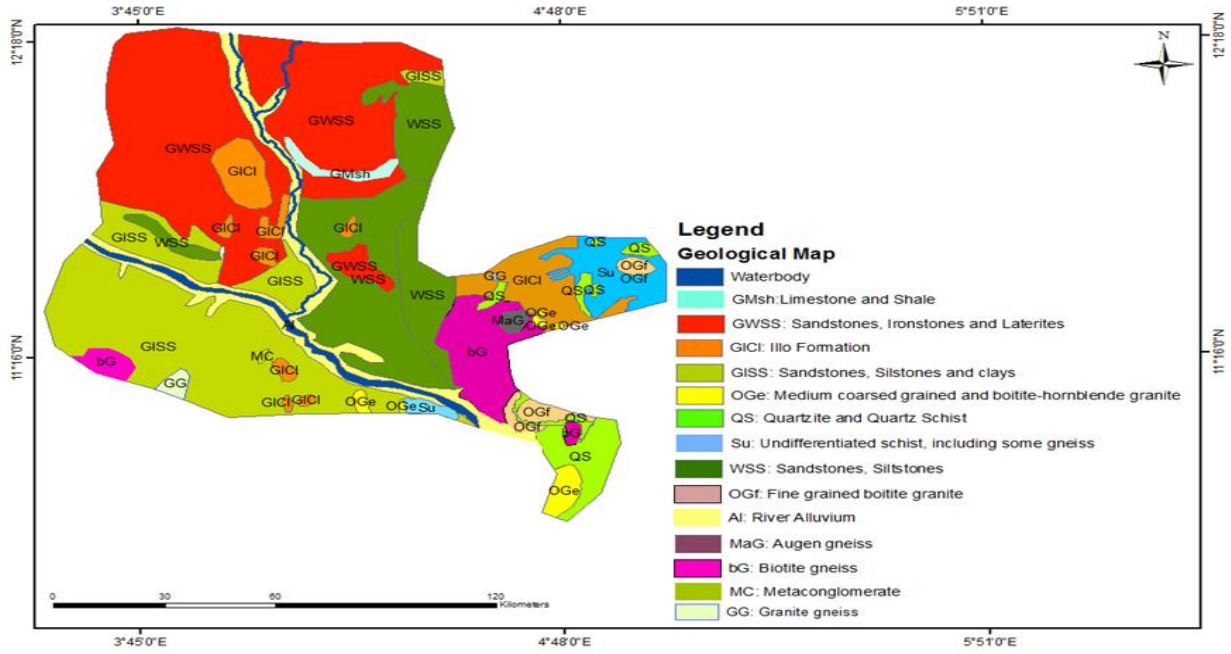

Fig 1. Geological Map of the study Area

III. MATERIALS AND METHODS

The main data used in this research was landsat 5 TM. The image was acquired on the 12th of March, 1986 from USGS website. The wavelength range for the TM sensor is from the visible, through the Mid-IR, into the Thermal-IR portion of the electromagnetic spectrum. The TM sensor has a spatial resolution of 30 meters (table 1).

Table 1. Landsat TM Properties

Sensor TM Mission 4-5	Spectral Sensitivity (µm)	Nominal Spectral Location	Ground Resolution (m)
Band 1	0.45-052	Blue	30 x 30
Band 2	0.52-0.6	Green	30 x 30
Band 3	0.63-0.69	Red	30 x 30
Band 4	0.76-0.9	Near-IR	30 x 30
Band 5	1.55-1.75	Mid-IR	30 x 30
Band 6	10.4-12.5	Thermal-IR	30 x 30
Band 7	2.08-2.35	Mid-IR	30 x 30

A. Image Processing

Radiometric correction of the landsat TM was done using ENVI 5.0 software to reduce the noise in the image in order to enhance its quality. Band 1 to 7 of the landsat TM were used to create a layer stacked image which was clipped to create the image shapefile of the study area using Erdas Imagine. The Chica - Olma ratio(5/7, 5/4 and 3/1) was used to highlight spectral contrast and the RGB channels. Band ratio 3/1 was used to detect ferric iron minerals. Clay mineralization was detected using the ratio 5/7 while band ratio 5/4 was used to detect ferrous Minerals.

B. Data Masking

Before calculating the TM band ratios, pixels dominated by vegetation and water body which obscure the ground surface and limit the reflectance from the rocks, minerals and soils were eliminated using the ENVI software.

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IV. RESULTS AND DISCUSSION

A. Clay minerals

Band ratio techniques can be used to detect the anomaly of a target object by determining the band at which reflectance is high or point of highest absorption because each object has a unique spectral reflectance curve in each wavelength of the electromagnetic spectrum. The TM band 5/7 ratio was used to detect the strong absorption of the clay-carbonate-sulfate-mica group minerals in TM band 7. Because of the strong absorption, the DN in TM band 7 is low, producing high ratio values. Medium to high clay minerals were detected in Dukki, Shiko, Sarafu Mahuta areas and along the river beside Gesheru and Yantala of the state while low clay minerals were observed in eastern part of Kebbi and southern part of Jega. Low clay minerals was also observed between Baguda and Koko areas (Fig 2).

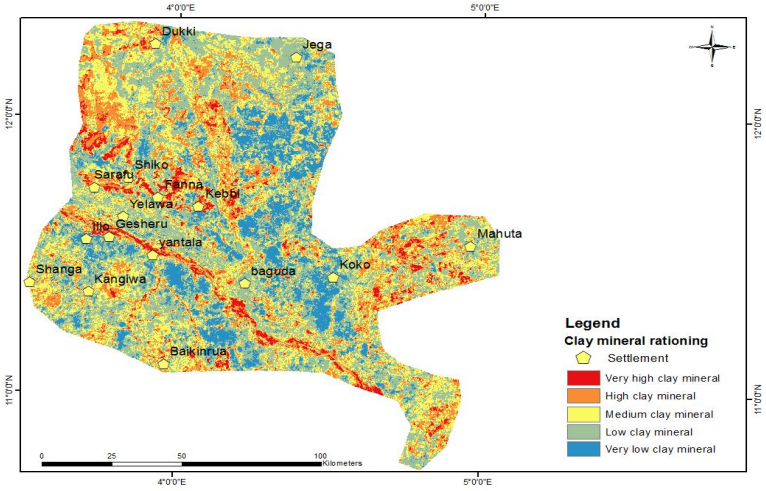

Fig 2. Clay Mineral of the Study Area

B. Ferrous Oxide

Band ratio 5/4 was computed to enhance possible ferrous oxides.Very high ferrous oxide was observed from the analysis in Gesheru, fanna Yantala and Mahuta. High ferrous oxide was also observed in Shiko, Kebbi and eastern part of Koko town. Medium ferrous oxide was observed in koko, Dukki and Jega area while low to very low feroous oxide minerals were observed in Kangiwa and Baikinrua area (Fig 3).

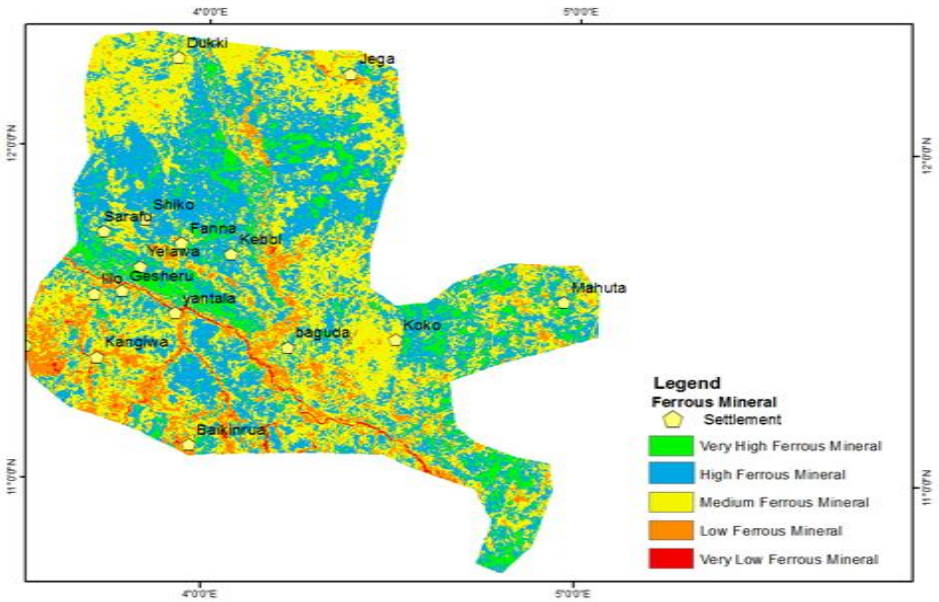

Fig3. Ferrous Mineral of the Study Area

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C. Ferric (Iron) Oxide Rationing

Band ratio 3/1 was used to detect iron oxide and the result indicates high to very high iron oxide minerals in Dukki, Jega, Baguda, Shiko, Koko and Kebbi areas. Medium iron oxide minerals were observed in Sarafu, Illo, Yelawa and Mahuta while low to very low iron oxide minerals were observed in Yantala, Shanga, Kangiwa, and Baikinrua(Fig4).

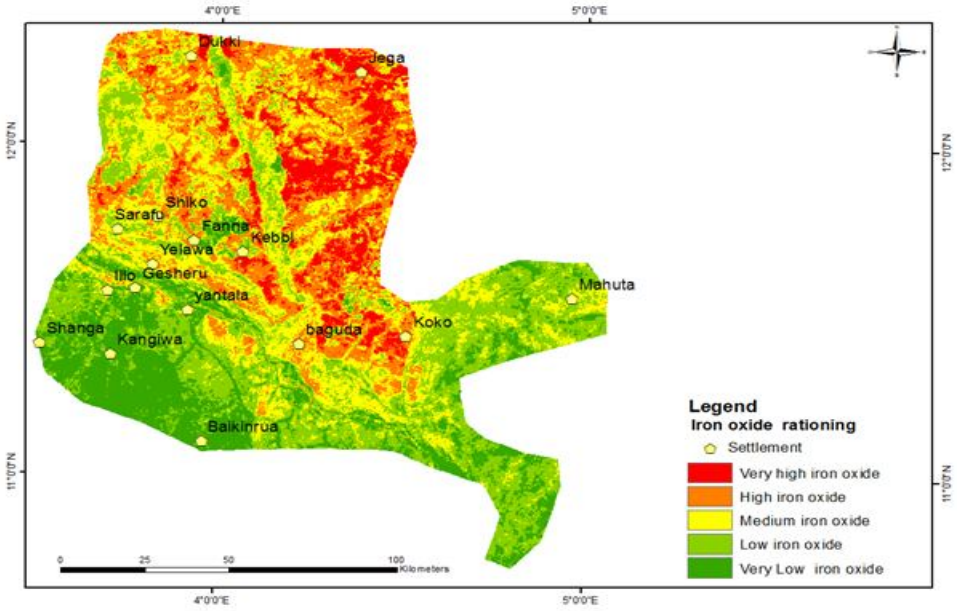

Fig 4.Ferric Mineral of the Study Area

D. Mineral Composite

Band ratio (5/7, 5/4 and 3/1) was used to highlight spectral contrast and the RGB channels. The result indicates red as clay-carbonate-sulfate-mica minerals, green as ferric iron minerals (iron oxides, hydroxides, and sulfates), magenta as clay-carbonate-sulfate-mica minerals, bare rock and soil. Yellow as both clay-carbonate-sulfate-mica and ferric iron minerals, blue to cyan as bare rock and soil with possible ferrous iron, chlorite, or coarse-grained ferric iron (Fig5.).

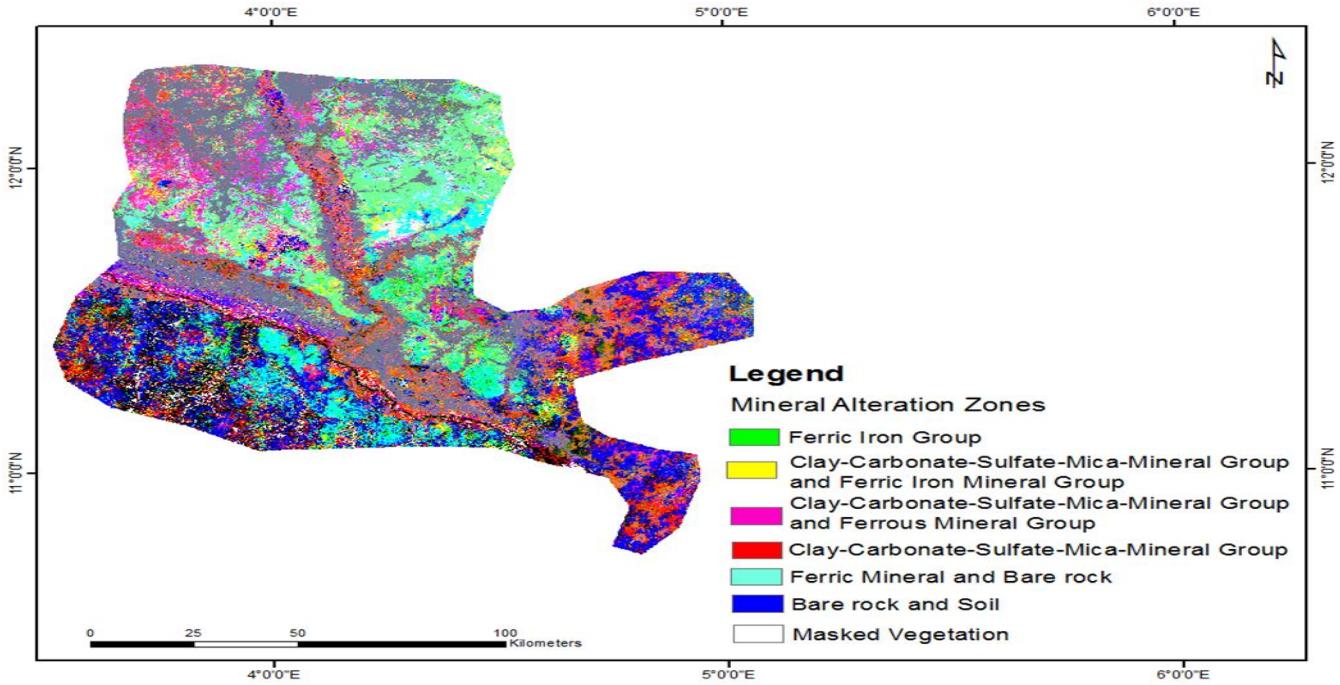

Fig 5. Mineral Composite of the Study Area

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V. CONCLUSION

This research has proved that remote sensing techniques play an extremely significant role in prospecting mineral deposits and identifying mineral targets. The discrimination of these different minerals was made possible as a result of the band ratio image enhancement technique applied on the Landsat 5 TM image. The bands were selected according to their ability to detect specific minerals or anomalies due to mineralization. Detail geophysical and hyper-spectral analysis could be carried out in the order to detect the specific minerals and determine their economic values. Proper harnessing of these mineral resources could boost the economy of the state and Nigeria in general.

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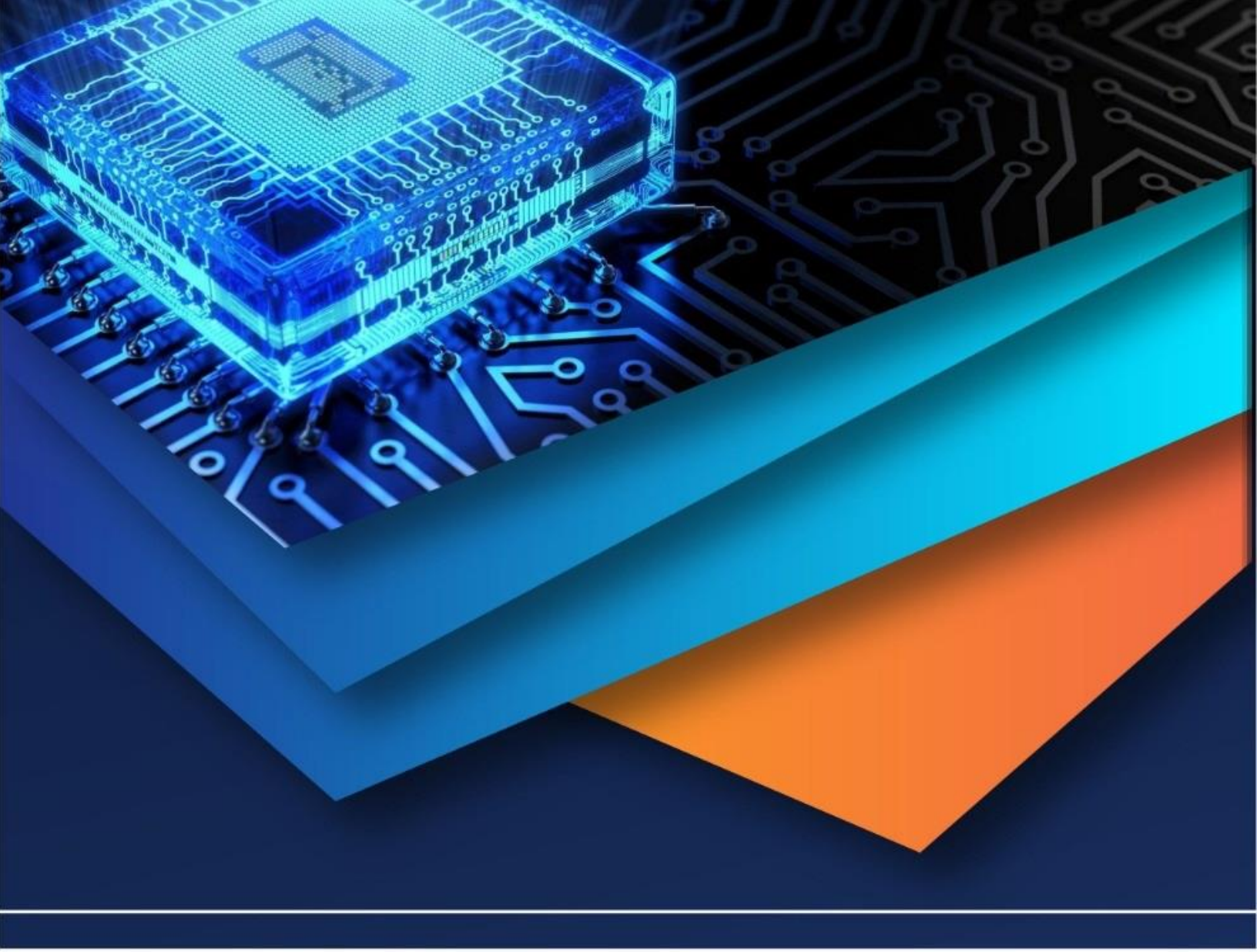

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