International Journal of Science and Research Methodology (IJSRM)

Volume 27, Issue 8, August 2024 pp 23-28. **ijsrm.humanjournals.com** ISSN: 2454-2008

Contribution of LANDSAT 8 Imagery in the Mapping of Iron Ore of the Continental Terminal 3 Formation of the Arewa Region, South-West of the Iullemmeden Basin in Niger

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Received: 2024-08-02 Revised: 2024-08-06 Accepted: 2024-08-10

ABSTRACT

This study was carried out in the South- West part of Niger. The study area corresponds to the Arewa region, which is located in the southwest part of the Iullemmeden basin. The objective of this study is to highlight the effectiveness of Landsat 8 imagery in the mapping of areas showing evidence of iron mineralization of the Continental Terminal 3 (Ct^3) formation. The methodology implemented is based on band reports and indices. Two types of color composite images were produced: (1) pseudo-natural color composite images, designed to display surface materials and geological structures in their natural color, (2) prepared color ratio composite images from the color ratios of band 6/band 7, band 4/band 2 and band 6/band 5, coded respectively in red, green and blue. Indeed, the dark red tone could correspond to identified laterites and/or ferricretes, known to contain coarse-grained goethite, which indicates the presence of $Fe(OH)_3$ ores. The presence of kaolinite, particularly at the base of Ct^3 outcrops, appears in magenta and sands containing ferric iron appear in green. Aeolian sands containing a lot of ferric iron certainly come from the alteration of rocks containing iron.

Keywords: Iullemmeden Basin, Continental terminal 3, LANDSAT 8 image, Arewa. Iron

INTRODUCTION

Earth observation satellites provide an incomparable view of the Earth's surface. Equipped with multispectral sensors, they capture increasingly precise images that are increasingly rich in geographic information. The LANDSAT series is part of a group of medium resolution satellites, suitable for observing geological resources and the environment [6]. Spectral imaging technology is particularly well adopted by many earth scientists because it is sensitive to the physical and chemical properties of materials, allowing the identification of surface mineral constituents within the field of view. instantaneous field of view (IFOV) [2]. This sensor provides detailed information on the mineralogy and geochemistry of rocks on the Earth's surface [3]. The geochemical signature of mineralized rocks is modified by the weathering process [7]. Landsat 8 OLI multispectral data were used in the discrimination of lithological units in the Bas Drâa inlier in the Western Anti Atlas [1]. As part of this work, we use geomatics to direct our research towards areas potentially rich in iron ores. It will offer the possibility of confirming field observations on geology and will also be a decision-making support tool which will have the advantage of being economical, rapid but above all applicable in remote and inaccessible areas. It is in this sense that we propose an integrated approach to digital processing of spatial data to respond to our problem while implementing modern analysis and modeling tools. The objective of this work focuses on the interpretation of OLI from LANSAT 8 in order to make a lithological discrimination of the rocks carrying iron mineralization of the Continental Terminal 3 (Ct^3) formation, southwest part of the Iullemmeden basin in Niger (Aréwa region).

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1.Material and methods

1.1 Material

❖ **LANDSAT 8 data**

The Landsat program has shown good progress in terms of sensors (RBV, MSS, TM, ETM+, OLI, Thermal Infrared (TIRS). As part of its work, the LANDSAT 8 image acquired on December 9, 2023 presents 11 bands The area concerned by this study are located in the Dosso region, which is located in the southwest of Niger between 3°00' and 4°00' North latitude and 13°00' and 14°00'. East longitude (Figure 1).

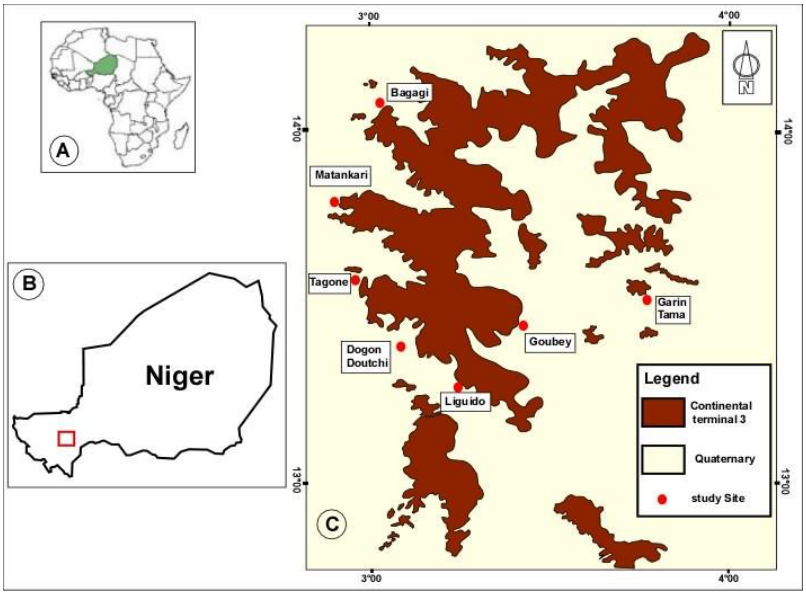

Figure 1: Presentation of the study area. A: Location of Niger on the map of Africa; B: Location of the study area on the map of Niger; C: Geological map of the study area (extract from the Map of [5]).

1.2 Methodological approach

As part of this study, the methodological approach below was adapted (Figure 2):

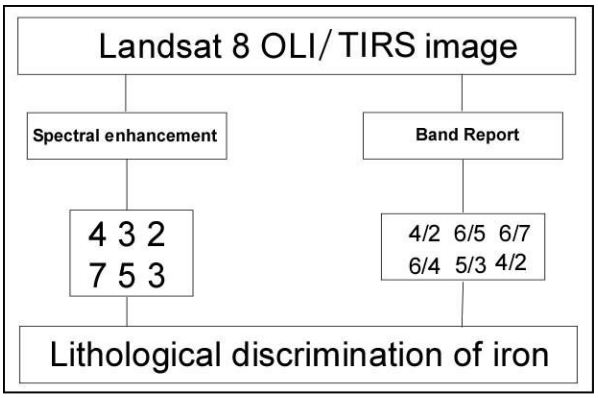

Figure 2: methodology approach

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2. Results and discussion

2.1 Landsat 8 Band Reports

The ratio of bands 6/band 7 (6/7) is used to detect the strong absorption of minerals from the clay-carbonate-sulfate-mica group in band 7. Due to the strong absorption, the DNs of band 7 are low, producing high ratio values. High 6/7 ratio values are also produced by green vegetation. However, these can be distinguished from the clay-carbonate-sulfate-mica group pixels, using a 6/5 ratio at the composite image level of color ratios, as examined in Figure 3. The ratio values between 6/7 are shown in red on color ratio composite images. The brighter the red, the higher the ratio value, and the stronger the absorption of band 7. The band 4/band 2 (4/2) ratio is used to detect red, orange and yellow colors as ferric iron ores give to rocks and soils. Red colors express high DN values of band 4 (red band) and very low DM values for band 2 (blue band), due to the strong absorption in the ultraviolet and blue part of the spectrum. Therefore, high values of the 4/2 ratio indicate the presence of minerals from the ferric iron group of minerals, which includes iron sulfates, hydroxides and oxides. The 4/2 ratio values in the color ratio composite image have tones of green, so that the brighter greens reflect the higher ratio values.

2.2 Contrast adjustment

Calculating band ratios, from 32-bit reflectance data, produces real numbers greater than zero. Usually, band ratio values are approximately between 0.0 and 3.0, although values of 10.0 or greater are not uncommon. To display banding ratio data as a color composite image, the banding ratio values must be registered to 32 bits. The 6/7 and 4/2 ratio values are generally less than 3.0. Therefore, these band ratios were linearly scaled between 0.0 and 2.0. In other words, ratio values greater than 2.0 are fully saturated (set to 255) and values between 0.0 and 2.0 are scaled linearly between 0 and 255. Band ratios 5/4 have usually slightly larger values, usually less than 3.0-4.0. For display purposes, the 6/5 band ratios are linearly scaled between 0.0 (0) and 3.0 (255). Band ratio values equal to or greater than 3.0 are fully saturated (equal to 255) on 6/5 ratio registered images.

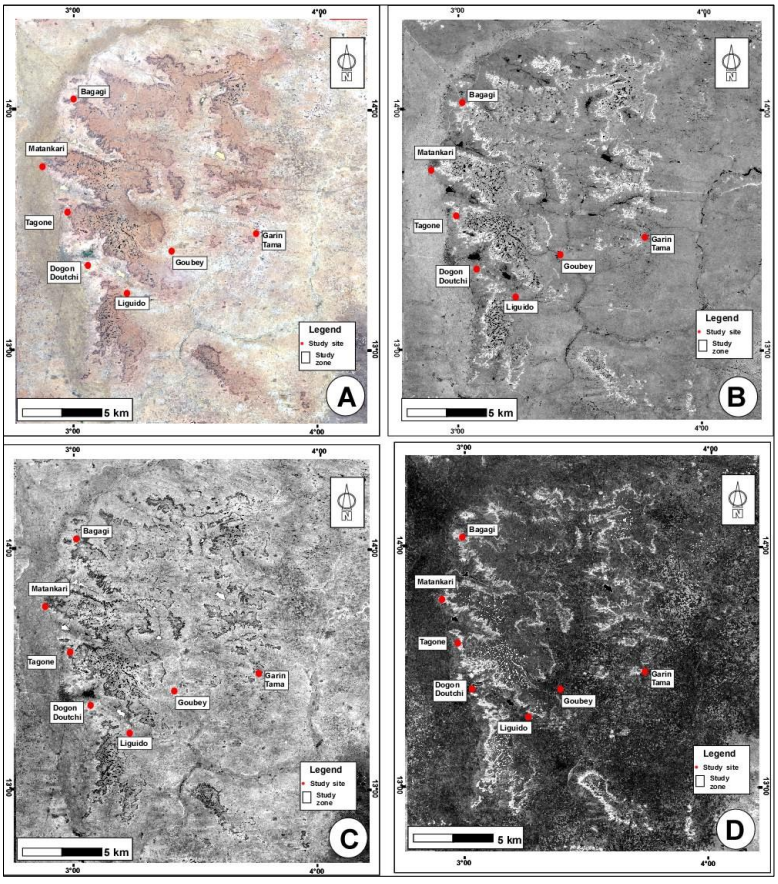

Figure 3: A: composite image in natural colors band ratios B: 4/2; C: 6/5; D: 6/7

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2.3 Analysis of composite images by color ratios

Each pixel of a composite image has a color ratio value of 6/7, 4/2, and 6/5, and these values are displayed in red, green, and blue hues, respectively, in proportion to their adjusted contrast values. The higher the ratio value, the more its color is represented in the pixel. The respective colors for the values of three ratios are combined in the composite images by an additive color process shown. High values of a ratio value are displayed in hues of the respective primary colors: red, green or blue. Two ratios with high values will be displayed as the combination of their two primary colors. For example, a pixel with a high 6/7 ratio (clay-carbonate-sulfate-mica) and a high 4/2 ratio (iron oxide) will display yellow (red + green in the Figure) if both ratios have similar values. If the 6/7 ratio is higher than the 4/2 ratio, the pixel will be orange. If the 4/2 ratio is higher than the 6/7 ratio, the pixel will be yellowish green.

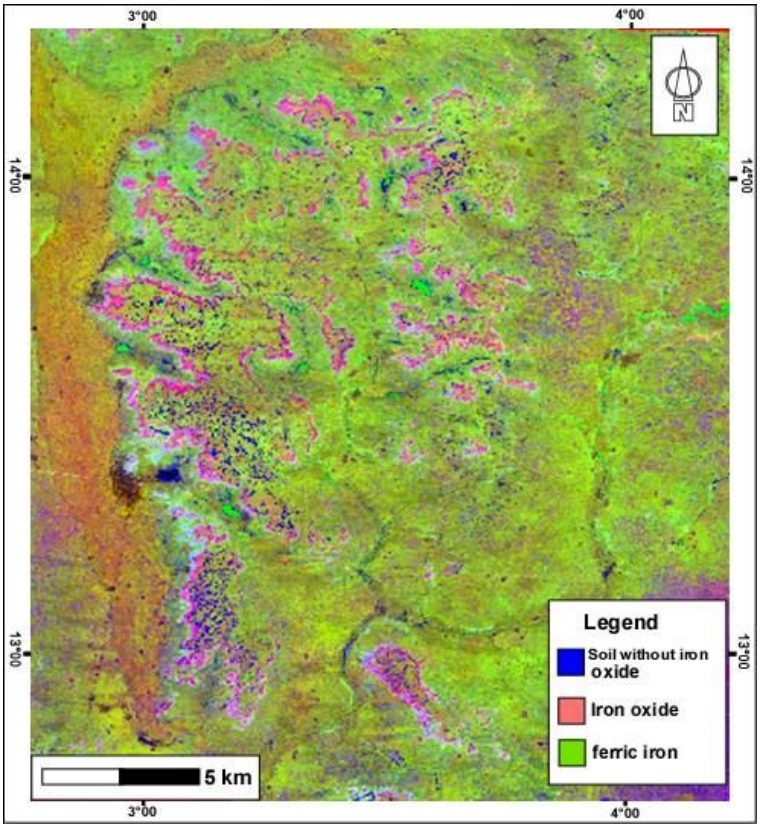

Figure 4: color ratio composite of band 6/band 7, band 4/band 2, and band 6/band 5 (Landsat 8 OLI/TIRS).

The results obtained are similar to the work of [9] in the district of Inchiri, near the town of Akjoujt (Mauritania). Indeed, the dark red tone could correspond to identified laterites and/or ferricretes, known to contain coarse-grained goethite, which indicates the presence of $Fe(OH)_3$ ores (Figure 7). The presence of kaolinite, particularly at the base of Ct^3 outcrops, appears in magenta and sands containing ferric iron appear in green. Aeolian sands presenting a lot of ferric iron, certainly come from the alteration of rocks containing iron.

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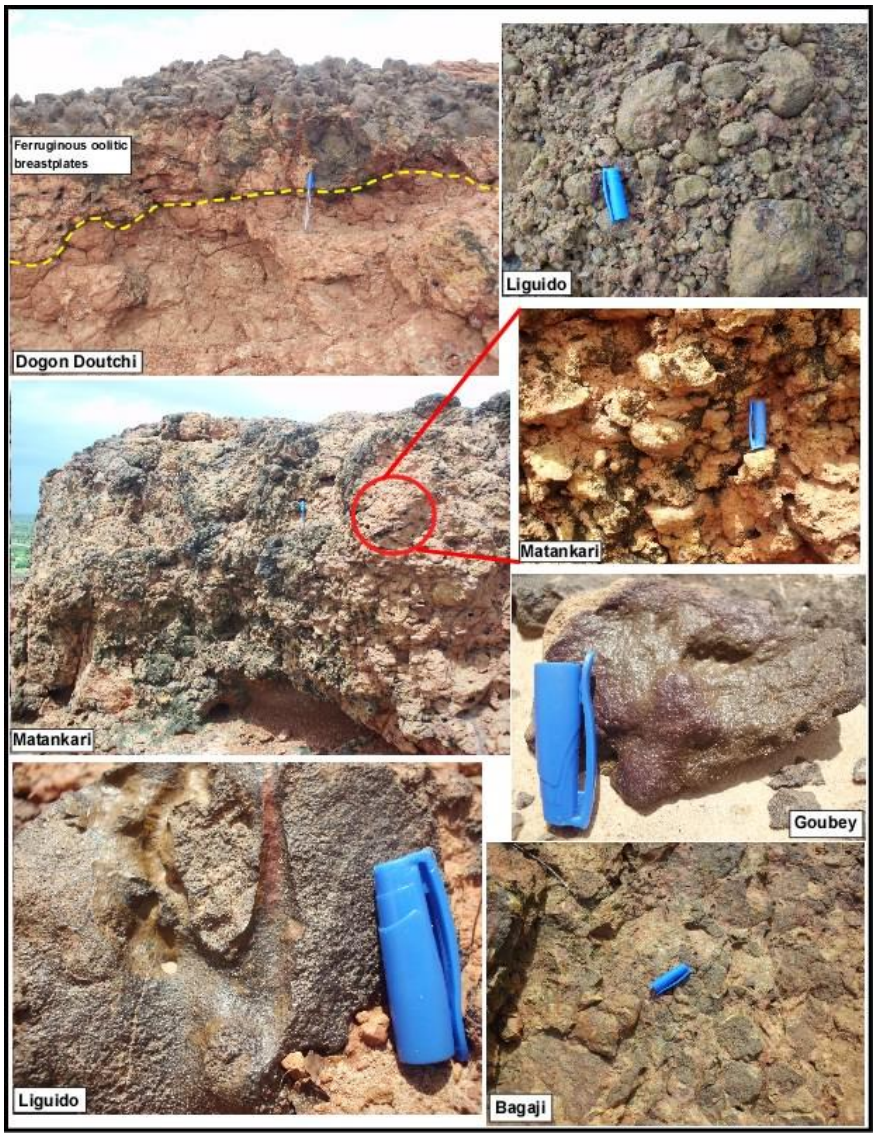

Figure 5: Ferruginous oolitic armor observed in different sectors of the Arewa region.

According to [4] the iron ore of the Kandi basin presents three types of subfacies: the first, stratiform of sandy, ferruginous and oolitic type, the second corresponding to pisolithic ferruginous concretions and the third, characterized by poorly deposited sorted due to later remobilization of oolitic ferruginous sandstone pebbles. The ferruginous oolitic facies, generally occupying the tops of the cuts, in the Niamey region present "indurated surfaces" or "hardened surfaces" [8].

CONCLUSION

The present work provides essential information in the context of this study. The mineral mapping techniques developed using Landsat 8 OLI/TIRS are perfectly suited to evaluating resources from GIS at the scale of the study area. The band ratios and indices were applied to the Landsat 8 OLI/TIRS image of the study area and made it possible to detect and map anomalies linked to the presence of iron in the continental terminal 3 formation (Ct^3). Thus, two types of color composite images were produced. These are pseudo-natural color composite images, designed to display surface materials and geological structures in their natural color and color ratio composite images prepared from band 6/band 7 color ratios, band 4/band 2, and band 6/band 5, coded in red, green and blue respectively. The color ratio composite images show the presence of one or more minerals grouped into two large groups: the clay-carbonate-sulfate-mica group and the iron oxide and hydroxide group.

ACKNOWLEDGEMENT

The authors would like to thank all the members of the Basins and Georesources team of the Geology Laboratory of the Faculty of Science and Technology of the Abdou Moumouni University of Niamey for their collaboration in the writing of this article. The authors would like to thank all the members of the team of the Laboratory of Georesources and Environmental Geosciences (LGGE) of the André Salifou University of Zinder; from the Department of SVT of the Ecole Normale Supérieure of the Abdou Moumouni University of Niamey and the Geology Laboratory of the Faculty of Science and Technology of the Abdou Moumouni University of Niamey for their collaboration in the writing of this article.

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How to cite this article:
Daouda Illia Allo et al. Ijsrm.Human, 2024; Vol. 27 (8): 23-28.

Conflict of Interest Statement: All authors have nothing else to disclose.