FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 10 No. 11, June, 2026, pp 8 – 17
DOI: https://doi.org/10.33003/fjs-2026-1011-5450

Geological, Geochemical and Mineralogical Properties of Tajimi Iron Ore, Lokoja, Kogi State, North Central Nigeria

***Martins Onimisi, Jimoh Onimisi, Olawole O. John, Atodo Ajuma, Danjuma Shaibu and Ekele Paul**

Department of Geology, Federal University, Lokoja.

*Corresponding authors' email: martins.onimisi@fuloka.edu.ng

Received: 28 May 2026

Accepted: 18 June 2026

Published: 04 July 2026

ABSTRACT

Despite its potential as a vital iron ore resource, the Tajimi iron ore deposit in North Central Nigeria remains understudied. The research investigates the geological, geochemical and Mineralogical properties of iron ore in Tajimi, part of Koton Karfe sheet 227SW, North Central Nigeria. Geological Field mapping reveals the study area comprises Banded Iron Formation (BIF), banded gneiss, granite gneiss, and oolitic iron stone. X-Ray Flourescence(XRF) analysis was employed to determine elemental composition, revealing average values of Fe_2O_3(46.50%), SiO_2(47.62%), Al_2O_3(3.40%), CaO(0.11%), MgO (0.03%), K_2O(0.04%) and MnO (0.04%) X-Ray Diffraction and ore Microscopy were used to identify mineral phases and textures revealing hematite (37%), goethite (7.3%), clinochlore(9.2%) and quartz(46.3%) as major minerals. Calculated Fe content of 32.52% classifies the BIF as low grade. High SiO_2 content indicates beneficiation is necessary for steel production. Geochemical analysis suggests a magmatic origin with metamorphism and also acknowledge the possibility of sedimentary origin typical of BIFs. The study provides crucial insights into the Tajimi iron deposit's characteristics, informing future exploration strategies.

Keywords: Geological, Geochemical, Mineralogical, Tajimi BIF

INTRODUCTION

Iron ore deposits around Lokoja and koton karfe North Central Nigeria have been extensively studied due to their significant economic potentials. The Banded Iron Formation (BIF) in this region is part of the Precambrian Basement Complex rocks known for hematite, magnetite and goethite mineralization.

Research shows that the Agbaja Ironstone formation, located near Lokoja is a major iron ore deposit with estimated reserve of over 2 billion metric tons. The ironstone is oolitic and pisolitic with goethite, hematite and Kaolinite as dominant minerals. Also, Itakpe iron ore deposit is hosted in the Precambrian gneiss-migmatite complex of the Nigeria Basement complex and is composed primarily of magnetite, quartz and hematite.

Recent studies have employed advanced techniques such as aeromagnetic surveys, remote sensing and geophysical survey to map and iron ore deposits and understand their structural control. These studies have identified several prospects in the region, including Tajimi.

Research have not adequately been carried out to determine the geochemical properties and the origin of Tajimi iron ore deposit, hence this paper presents a result of the geological, geochemical and mineralogical properties of iron ore deposit which is confined to Tajimi locality in Lokoja area of Kogi State, North Central Nigeria.

The country is endowed with numerous Iron ore deposit, these include Banded Iron Formation (BIF) which occur in metamorphosed folded bands and lenses associated with the Precambrian metasedimentary schist belts Prominently outcropping in the western half of the country; Available data has shown that Nigeria has about 2.5 billion metric tons of iron ore reserve, this placed the country as the 12th largest iron ore resource country in the world and the second largest in Africa, but about 70 percent of the deposits are yet to be proven (Oyelowo *et al.*,2016).

The level of industrialization of a country is measured by its iron and steel development because they are the most widely used engineering materials for production, fabrication, construction and manufacture of most items including ships, automobile, domestic appliances and military hardware. This shows the reason why per capital consumption of steel is an index for measuring development in the economy of every country. The accessibility and development of the iron and steel sector is of principal significance for industrial growth, increased engineering capacity and enhancement of technical skills.

MATERIALS AND METHODS

Study Area

The area falls between Latitude 8^0 1' 20''N to 8^0 3'36''N and Longitude 6^0 35' 33'' to 6^0 36' 32''E, part of koton Karfe sheet 227SW.

Tajimi is bounded to the East by Agbaja plateau and to the South by Obajana. It is accessible by three minor roads from Obajana, Otokiti and Lokoja. The surface geology of the study area is primarily caped by ironstone, a chemical characteristics feature of the Agbaja formation. Beneath this cover lies the Patti formation which is a key unite of the Bida Basin strategraohy.*Ekele et al, 2024.*

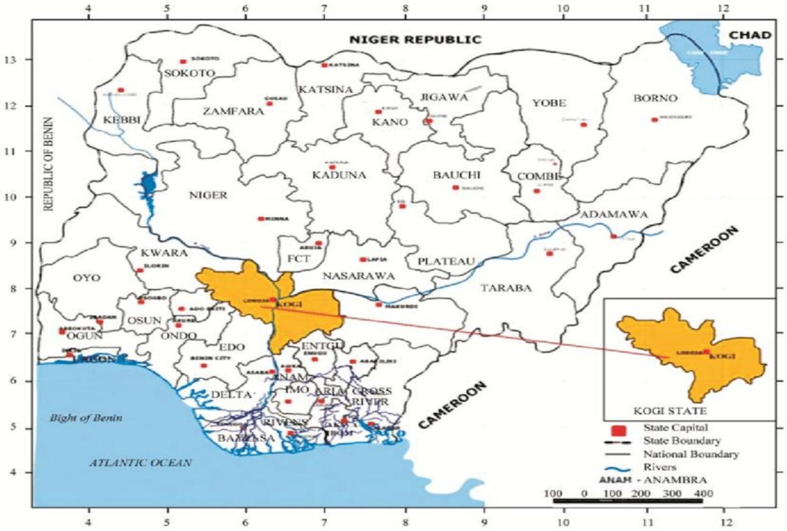

Figure 1a: Map of Nigeria Showing Study Area (Oluwaseyi, 2013)

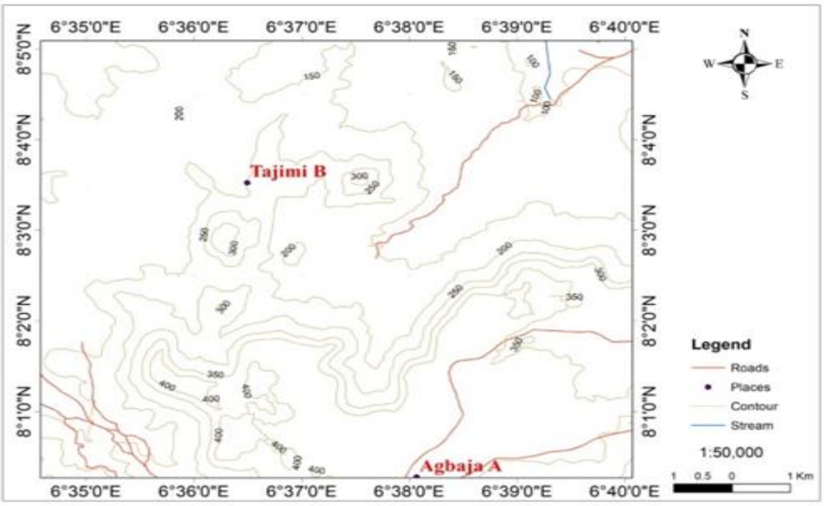

Figure 1b: Topographic Map of the Study Area (Modified from Base Map Obtained from National Steel Raw Materials Exploration Agency, (2020))

MATERIALS AND METHODS

Field Geological Mapping

A comprehensive field geological mapping program was conducted at a scale of 1:50,000 employing a systematic trasverse methodology to ensure thorough coverage of the study area. Trasverse lines were specified at regular intervals of 500m apart during reconnaissance mapping and 100m apart during detailed mapping with outcrop exposures examined and sampled at a density of approximately one sample per 50m square utilizing a geological harmer for collection. Accurate spatial referencing of outcrops and structural features was achieved through the integration of Global Positioning System (GPS) technology. Orientation control was maintained through measurement of strike and dip of planar features with structural data recorded using Brunton compass and subsequently plotted at the base of the map. Samples were selected for further laboratory analysis and meticulous lebeling ensured the integrity of the data set.

Laboratory Analysis

A table top GENIUS-IF Xenemetrix X-Ray Fluorescence equipment was used to analyze fifteen samples of BIF at National Steel Raw Materials Exploration Agency, No. 18 Rabah Road, Malali, Kaduna, Nigeria to determine the elements oxide composition, six representative samples were subjected to X-Ray Diffraction using a Rigatu miniflex Model 600 X-ray diffraction spectrometer to determine the mineralogical composition at National Steel Raw Materials Exploration Agency, No. 18 Rabah Road, Malali, Kaduna, Nigeria while ore microscopy analysis was carried out at geology department, University of Ibadan, Nigeria.

RESULTS AND DISCUSSION

Field Geologic Occurrence

The result of the geological field mapping reveals the presence of four distinct rock types which are Banded Iron Formation (BIF), granite gneiss, banded gneiss and oolitic iron stone. (Fig 2.).

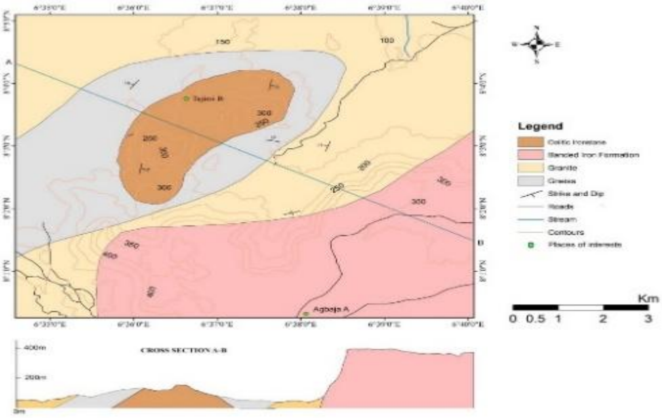

Figure 2: Geological Map of the Study Area

Generally, the BIF outcrops appear in form boulders or as whale-back outlook exhibiting minor fractures, folding, medium to coarse grain texture, grayish to dark gray coloration as well as shining metallic luster suggestive of dominance of mafic minerals. The deposits are directly exposed to the surface. A closer observation of hand specimen reveals mineral bandings. They occupy the central part of the study area generally trending in North-South direction.

Banded Iron Formation (BIF)

The BIF which outcrops at an elevation of 258m above the sea level as dark gray colored medium grained texture. They are metamorphosed and are striking 220^0 NE-SW and dip of 75^0 in the western direction. A closer observation reveals slight banding of bright colored minerals (felsic minerals). It is slightly foliated and fractured with massive grains. The BIF also exhibit rough surfaces suggestive of weathering activities. It shares a defined boundary with the granite and banded gneiss at the northern and southern flank of the study area.

Figure 3: Outcrop of BIF Showing Banding (Latitude $8^0$3'32''N and Longitude $6^0$36'32'' E)

Banded Gneiss

The banded gneiss in the study area are exposed at an elevation of 255m above sea level with fine grain texture and light grey colour. The outcrop exhibits simple folding(Ptygmatitic folding). The folding is an evidennce of the Pan African orogeny that has affected the area.

Figure 4: Outcrop of Banded Gneiss in the Study Area (Latitude $8^0$2'30" N and Longitude $6^0$37'8"E)

The granites in the study area are exposed at 210m above the sea level. is a pinkish, medium to coarse grained and slightly foliated, striking 230^0 with a dip ranging from 60^0 to 70^0in the western direction. The rocks are highly fragmented appearing in form of boulders with rough surfaces suggestive weathering activities. Closer observation shows appearance of dominance of felspar and shining dark bands of mica. They are found bordering the gneiss at the eastern region of the study area and with the oolitic iron stone at the southern boundary

They appear light gray to dark brown in colour. They occur as boulders, fresh with veins trending NW-SE. They occur to as intrusion which is responsible for the metamorphism in the region. The texture is medium to coarse grain with visible quartz, feldspar and biotite minerals. The rock exposed shows rough weathering surface due to preferential weathering of less resistant minerals leaving behind more resistant quartz grains. The weathered surfaces are brownish in colour.

Figure 5: Outcrop of Coarse Grained Granite Gneiss (Latitutude 8^0 4' 5''N, Longitude 6^0 37'10'' E)

Figure 6: Outcrop of Foliated Granite in the Study Area (Latitude 8^0 2' 10"N, Longitude 6^0 37' 30''E)

Structures

Structural features observed in the rocks of the study area includes foliation, folding, veins and joints.

Veins

These are distinct joints or fractures that has been mineralized. They are formed when minerals precipitate out of solutions to fill cavities, fractures or other openings in rocks. The veins exposed in the study area visibly filled with quartz and feldspar, about 3-4cm wide at Latitude $8^0$2'30'' and Longitude $6^0$37'15''. The veins on the mapped area align along the NW-SE direction.

Folds

These are evidence of compression and they are common structural features in the mapped area especially on the iron ore exposures. The areas display simple synclinal folds and the fold axes appear to maintain a constant NNE -NS direction. Prominent among the folded exposures was at Latitude $8^0$2'30" and Longitude $6^0$37'8"

Joints

Fractures or fissure in granite rock were observed without any significant movement or displacement along fractured surface with or without mineralization.

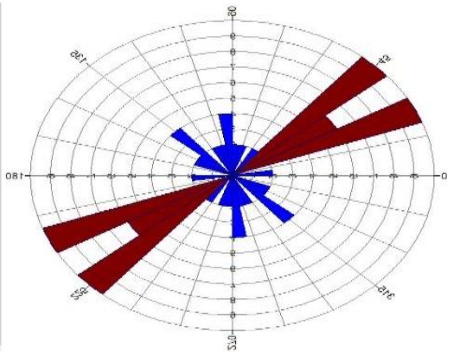

Figure 7: Rose Diagram for Strikes of Structures in the Study Area

Chemical Composition

X-RF analysis was conducted to determine the chemical composition of the iron ore and the host rock.

Sample Preparation

Each of the samples were crushed and split into two equal halves. One crushed portion was pulverized completely to 100% passing through 75µm sieve, split into two portions with one portion further subjected to X-RF analysis while the other half was kept as reference sample.

Duplicate analysis was performed on fifteen (15) BIF samples and average values were recorded. The rationale behind the 15 samples was to obtain overview for a wider coverage.

For ease of understanding, the major element oxides detected from the analysis of the BIF samples and the host rocks were tabulated and the average of each oxide calculated and presented in table 1, the trace element oxides are presented in table 2

The major element composition of the host rocks was also presented in average weight percentage in table 3 and 4 respectively

Table 1: Major Element Oxides in Iron Ore Samples in the Study Area

Sample Locations	**Major Element Oxides (Weight %)**									
	SiO_2	**Fe_2O_3**	**Al_2O_3**	**CaO**	**K_2O**	**MgO**	**P_2O_5**	**SO_3**	**TIO_2**	**MnO**
T1	45.85	50.07	2.45	0.07	0.06	-	-	0.15	0.05	0.05
T2	51.21	43.31	3.62	0.09	0.09	-	-	0.34	0.02	0.03
T3	56.96	38.01	3.26	0.25	0.04	-	-	0.35	0.03	0.03
T4	41.24	52.22	3.86	0.15	0.05	-	0.89	0.21	-	0.03
T5	45.03	48.43	4.36	0.12	0.14	-	0.08	0.43	0.06	0.06
T6	46.39	48.70	3.32	0.06	-	-	-	0.31	0.03	0.03
T7	56.26	37.97	3.33	0.41	0.19	-	0.25	0.24	0.03	0.05
T8	49.16	45.62	3.61	0,11	0.02	-	0,04	0.25	0.01	0.05
T9	44.58	49.44	3.14	0.09	0.01	0.51	0.62	0.06	0.01	0.02
T10	52.32	43.06	3.13	0.07	-	-	0.02	0.27	0.05	0.05
T11	45.60	48.52	3.37	0.02	0.02	-	0.91	0.25	-	0.03
T12	49.43	37.46	2.78	0.08	-	-	-	0.39	0.03	0.0 4
T13	44.89	50.58	2.55	0.07	0.07	-	0.03	0.29	0.05	0.04
T14	36.05	58.24	3.98	0.06	0.02	-	0.04	0.06	0.05	0.03
T15	49.23	45.13	3.32	0.07	-	-	-	0.07	0.01	0.03
MEAN	47.61	46.52	3.34	0.11	0.05	0.034	0.20	0.25	0.27	0.06

Table 2: Trace Element Oxides Composition in BIF in the Study Area

Sample Locations	**Trace Elements Oxides(ppm)**								
	V_2O_5	**Cr_2O_3**	**CuO**	**NbO_5**	**WO_2**	**BaO**	**Ta_2O_5**	**Cl**	**ZrO_2**
T1	800	600	300	1500	30	1500	200	5200	700
T2	300	700	400	1600	400	1700	-	2400	200
T3	200	600	200	-	100	1000	500	7000	400
T4	500	700	700	500	600	1300	-	6700	300
T5	300	600	400	1400	300	800	500	6700	800
T6	300	800	200	100	400	1700	-	4400	10
T7	600	900	300	2300	500	1000	100	5400	700
T8	700	700	300	-	300	1700	1000	5600	300
T9	800	700	400	1800	400	1600	300	6600	200
T10	700	800	300	-	300	1300	-	5600	10
T11	500	800	500	600	200	1400	100	5900	400
T12	400	700	600	100	400	600	100	6400	200

Sample Locations	Trace Elements Oxides(ppm)								
	V_2O_5	Cr_2O_3	CuO	NbO_5	WO_2	BaO	Ta_2O_5	Cl	ZrO_2
T13	500	700	300	1100	400	1300	-	7300	600
T14	800	700	300	600	700	1900	100	4600	500
T15	600	900	300	600	300	1400	-	4900	300

Mineralogical Composition

The powder X-ray diffraction is one of the most powerful techniques used for mineral identification, especially minerals in fine grained rocks.

Sample Preparation for XRD Analysis

The grinded sample (sample powders) of 75 microns were smeared uniformly on the sample holder and analyzed by a Rigatu miniflex Model 600 X-ray diffraction spectrometer employing Cu-Ka radiation. The analyses were carried out between 2 to 70 degrees 2θ as the sample scanning range and the scanning rate was set at 6 degree per minute.

Six (6) BIF samples were analyzed for a more targeted or focused expectations and the result of the analysis recorded. The mineralogical composition of the Banded Iron Formation obtained from the XRD analysis (Figures 8 – 9) are shown below

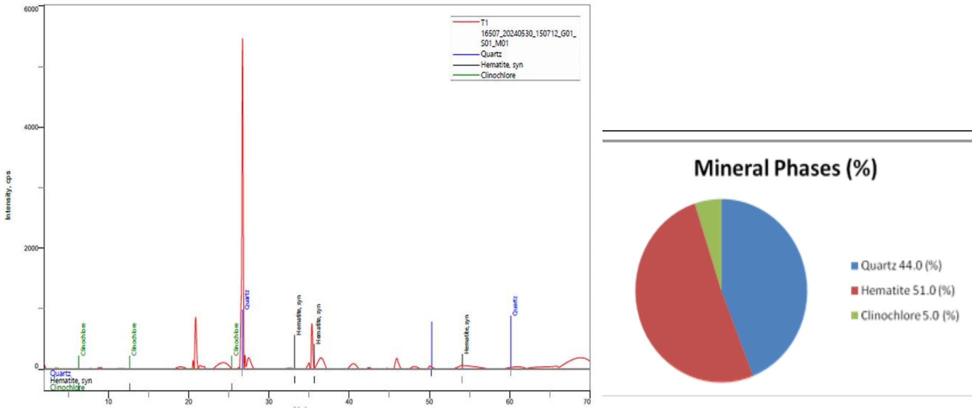

Figure 8: X-Ray Diffractogram of Iron Ore Sample T1

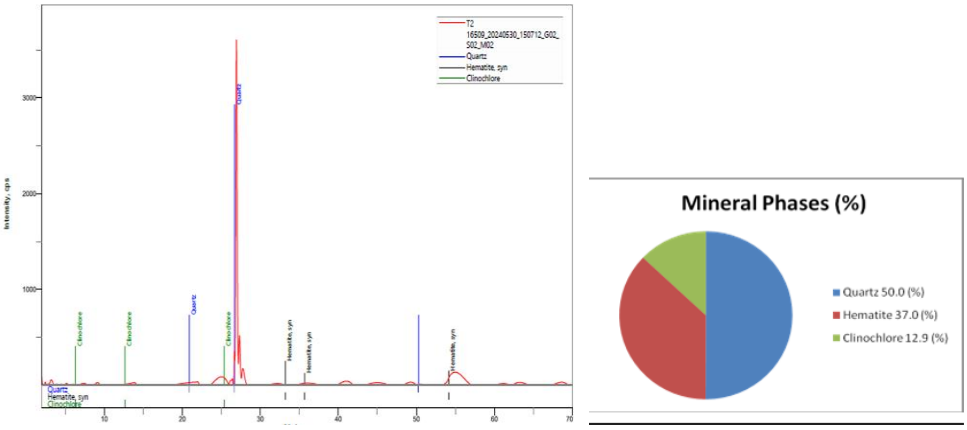

Figure 9: X-Ray Diffractogram of Iron Ore Sample T2

Ore Microscopy

Ore Microscopy analysis is a vital technique in geology and mining for identifying and characterizing opaque minerals in ore deposits. It helps to identify opaque minerals based on properties like color, reflectance, hardness, cleavage and twining. The technique also reveal textural relationships between minerals aiding in understanding ore formation and genesis It involves using a polarizing reflected light microscope to examine polished sections of ore samples. Three samples were selected to further validate the result from XRD analysis

Sample Preparation

i. The iron ore sample were selected and crushed to small size of less than 1mm using mortar and pestle
ii. The crushed sample was mixed with epoxy resin (a mounting medium). It was allowed to harden forming a solid mount.
iii. An abrasive (silicon carbide) was used to grind the mounted sample to obtain a flat surface.
iv. The surface was polished using a diamond paste until a luster free surface was achieved.
v. The polished sample was thoroughly cleaned to remove any residue or debris.
vi. The sample was viewed using ore reflecting microscope and photomicrograph of the ore minerals were obtained.

Ore microscopy of the BIF (plate 1a and 1b) below shows the BIF to be composed of hematite and goethite.

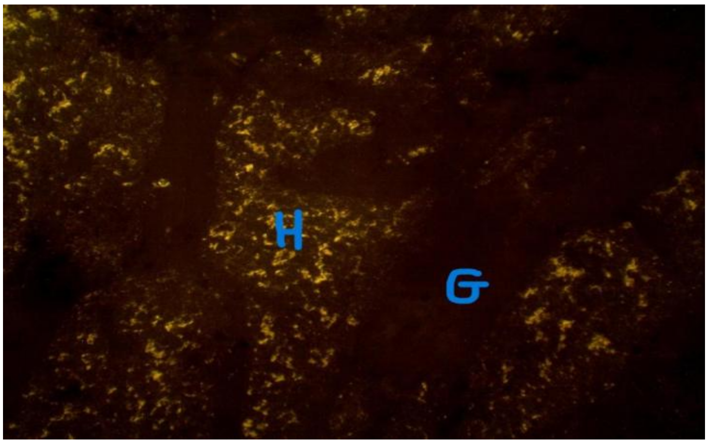

Plate 1: Photomicrograph of Polished section of Tajimi Iron ore (H= Hematite, G=Goethite)

Table 3: Mineralogical Composition of the BIF in Tajimi Area

Minerals	Modal Composition (% Volume)						Range	Mean
	T1	T2	T3	T4	T5	T6		
Quartz(SiO_2)	44.0	50.0	40.1	52.0	41.0	50.0	40.0-52.0	46.3
Hematite(Fe_2O_3)	51.0	37.0	-	45.0	40.0	49.9	37.0-51.0	37.0
Goethite**($Fe_2o_3.H_2o$)**	-	-	44.0	-	-	-	0.00-44.0	7.30
Clinochlore ($Mg_5Al(AlSi_3O_{10})(OH)_8$)	5.0	12.9	15.1	3.0	19.0	0.1	0.1-19.0	9.18
Total	100	99.9	99.9	100	100	100		99.8

Discussions

The data from the XRF analysis of the BIF in table 1to 2 above indicates predominance of silica (SiO_2), Hematite (Fe_2O_3) and alumina Al_2O_3, with other elements oxides present in minor amounts, confirming the BIF composition of the study area as Fe_2O_3 (47%) while SiO_2 (48%) as the most abundant and Al_2O_3contains an average of 3.40%. The other oxides are found in notably small concentrations. CaO is relatively minimal approximately 0.11%, P_2O_5 and SO_3 compositions are 0.20%, and 0.25% respectively. The minor element oxides in the study area includes V_2O_5 ,Cr_2O_5, CuO, NbO_5, WO_2,, BaO Ta_2o_5 and ZrO_2 X-RD and ore microscopy analysis were carried out to determine the mineralogical composition of the samples collected, Table 5 revealed four minerals which are quartz (46.4%),hematite (37.0%) goethite (7.30%) and clinochlore (9.19%).

The result of the X-RD and ore microscopy confirms the result of the X-RF analysis showing that the iron ore type in Tajimi is hematite. Both the X-RD and X-RF results also confirms that highest mineral component of the samples in the study area is quartz, followed by hematite.

Grade Tajimi BIF

The quality of iron ore for steel production and its viability for commercial exploration is mainly determined by its chemical composition (*Abraham et al*.,2012). To determine the grade of the iron ore, the total iron content for hematite is calculated. From table 1, the average of Fe_2O_3 is 46.50 wt%

Fe (iron) =55.845g/mol

O (Oxygen) =16.00G/mol

Fe2O3 = (2X55.845) +(3X16.00)

111.69 +48.00=159.69g/mol

Mass % of Fe in Fe_2O_3 =111.69/159.69 x 100 =69.94%

46.50 x0.6994 =32.52%

The grade of the iron ore is approximately 33 % Fe.

Geochemical Evaluation of the BIF in the study Area.

In order to assess the quality of iron ore deposit in Tajimi, the geochemical results of the BIF was compared with the composition of other iron ores in Nigeria and iron ore from other nations around the world.

Table 4: Comparison of Major Element Oxide Composition of Tajimi BIF with Other BIF Deposits in Nigeria

Locations	Major Element Oxides (wt%)										
	Fe_2O_3	SiO_2	Al_2O_3	CaO	K_2O	MgO	P_2O_5	SO_3	TIO_2	Na_2O	MnO
Study Area	46.52	47.61	3.34	0.11	0.05	0.034	0.20	0.25	0.27	-	0.06
Muro	47.98	50.33	0.10	0.01	0.01	0.01	0.15	-	0.01	0.01	0.06
Maru	44.07	35.81	8.97	0.03	2.49	0.40	0.04	-	0.28	0.01	5.05
Birni Gwari	57.75	30.55	3.78	0.50	0.01	0.01	0.13	-	0.12	0.01	5.63
Wonaka	41.67	50.75	5.29	0.48	0.03	-	-	-	0.87	0.02	4.37
Kazaure	59.71	-	-	0.77	0.29	-	-	-	0.08	-	7.98

Source: Muro (Adekoya,2012) Maru & Birni Gwari (Ibrahim,2008), Kazaure (Adekoya,1998)

Table 5: Comparison of Major Oxide Composition of Tajimi BIF with Sedimentary Iron Ore Deposits in Nigeria

Locations	**Major Element Oxides(wt%)**										
	Fe_2O_3	**SIO_2**	**Al_2O_3**	**CaO**	**K_2O**	**MgO**	**P_2O_5**	**$S0_3$**	**TIO_2**	**Na_2O**	**MnO**
Study Area	46.52	47.61	3.34	0.11	0.05	0.034	0.20	0.25	0.27	-	0.06
Agbaja ironston	62.64	8.55	9.60	0.72	0.00	0.00	-	4.16	0.37	-	0.14
Enugu ironstone	63.14	13.83	10.09	0.00	0.00	0.00	1.55	0.00	0.50	0.00	0.03
Koton-Karfe	67.02	15.49	13.76	0.27	0.007	-	0.07	0.18	0.20	<0.01	0.19
Bassa Nge	67.41	8.29	10.87	0.17	0.00	0.43	1.45	0.05	0.26	0.00	0.13
Agada-Egeneja	69.32	7.63	7.40	0.18	0.02	0.00	2.00	0.01	0.19	0.00	0.32

Source: Agbaja Ironstone (NMGS Conference, 1995), Koton- Karfe(Ferdinand, 2014). Agada Egeneja (Onimisi et al, 2017)

Table 6: Comparison of the Average Chemical Composition of the BIF in Tajimi with BIF in Other Parts of the World

Major Element Oxides (wt%)	Present Study	Pedroda, Brazil (Rebelo, 1985)	Reboredo, Moncora, Spain. (Orey, 1980)
Fe_2O_3	46	51.9	48.2
SiO_2	47.2	36.9	36.7
Al_2O_3	3.40	6	7.3
P_20_5	0.2	1.7	2.4
NaO	-	0.2	0.2
K_2O	0.05	1	1.1
MgO	0.51	0.2	0.2
TiO_2	0.04	0.3	0.4
MnO	0.5	0.1	0.1
Cr_2O_3	0.08	-	-
CaO	0.19	0.1	0.4

The results from table 4 to 5 above shows that the Tajimi iron ore is similar in composition and geological setting with banded iron formation Muro, Maru, Birni Gwari, Wonaka and Kazaure.

However, as seen in table 8, there is a variation composition between Tajimi iron ore and that of sedimentary iron ore deposits in places like Agbaja, Enugu, Koton Karfe, Bassa-Nge and Agada-Egeneja with relatively low SiO_2 ranging from 7.5% to 15.49% and higher Fe_2O_3 ranging from 62.64% to 69.32% . Table 6 and 7 also reveals that the P_2O_5 and SO_3 composition in sedimentary iron ore deposits are higher than that of banded iron ore deposits in metasedimentary environment.

Tajimi BIF is also similar to that of Pedroda, Brazil and Reboredo, Moncora, Spain with Fe_2O_3 of 46.0%, 51.9% and 48.2% as well as SiO_2 of 47.2%, 36.9% and 36.7% respectively. (Table 8)

For the classification and evaluation of quality and grade of iron ore, Dobbins and Burnet (1982) divided the raw iron ores in to three basic classes depending on the total iron content:

(i) High grade iron ores with a total iron content above 65%,

(ii) Medium grade ores with iron content in the range of 62-64% and

(iii) Low grade ore with iron contents below 58% (Table 5.4). Although according to the Natural Resources Canada (2012) an ore that has > 54 weight percent of iron is a high-grade ore.

Table 7: Standard for Major of Elements of Interest in Assessing Iron Ore Quality

Component	**Total Fe Content ($FeO+Fe_2O_3$)**			**SiO_2**	**Al_2O_3**	**P**	**S**
	Low Grade	Medium Grade	High Grade	<6	3-4	0.05-0.07	0.1
Mass%	<58	62-64	>64				

Source: Dobbins and Burnet, 1982

The average total iron in Tajimi ore deposit is 47%, and from table 7 above, it shows that it is a low-grade iron ore deposit.

Its average silica (SiO_2) content is 47.6% which is higher than the SiO_2 content required for good quality iron ore. The higher silica likely precipitated in a low-grade metamorphism when subjected to direct pressure, quartz grains dissolve at high-stress points like grain contacts, the dissolved silica moves via grain-boundary fluid films to low pressure zones behind rigid grains or fracture zones.

The average alumina (Al_2O_3) content in this study is 3.34% which falls within the acceptable range using a generalized percentage of 3-4% by (Dobbins and Burnet, 1982). Phosphorus and Sulfur were found averaging 0.20% and 0.28% respectively standing above the generalized percentage of 0.05-0.07% and 0.1% (Dobbins and Burnet,1982). This shows that the iron ore has contaminant.

Quartz-hematite intergrowth may complicate liberation during beneficiating process because hematite is weakly magnetic, the quartz intergrowth reduces the magnetic susceptibility leading to lost during tailing. To liberate hematite from quartz, fine grinding is required to less than 45µm or even 25µm.

Due to low sulfur content and dominant hematite, gravity separation or magnetic separation technique is recommended

Industrial Application of the Tajimi BIF.

The Tajimi Banded Iron Formation (BIF) contains high SiO_2 (47.6%) and Fe_2O_3 (46.52%) making it of low grade. Hence it requires beneficiation before industrial application.

Origin of the Tajimi BIF.

Guilford and Mackenzie, 1980 are of the opinion that the positioning of various elements given by Goldschmidth classification in the periodic table can form the basis for the relationship between the elements and iron. Terney, 1977 was able to apply geochemical variation diagrams to discriminate the environment of deposition of ore minerals both in basement and sedimentary environment using plots of various major element oxides against others as shown below.

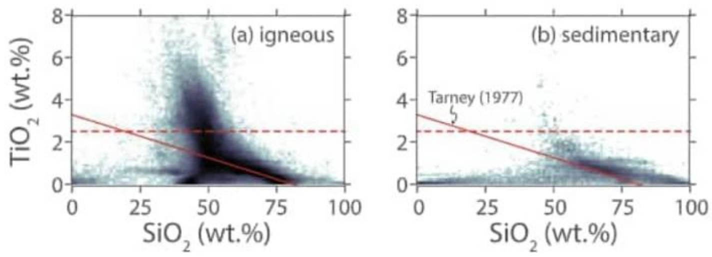

Figure 10a and b: Geochemical Discrimination Diagrams (Terney, 1977)

Figure 12a above shows a plot of TiO_2 versus SiO_2. The pattern of the distribution of the oxides points to the origin of the minerals deposited within the area. Whenever the distribution of TiO_2 versus SiO_2 rises above the horizontal dotted line and extends towards the peak of the Y-axis, such mineral deposit is of Magmatic origin (Fig.12a) but whenever the distribution of TiO_2 versus SiO_2 falls below the horizontal dotted line, such mineral was deposited by sedimentary process (Fig.10b).

Fig. 11 below shows plot of TiO_2 versus SiO_2 from the Tajimi Banded Iron Formation. The distribution of the oxides falls within the environment prescribed by Terney, 1977 in fig 10b to be igneous. This clearly reveals a magmatic origin for the Tajimi BIF.

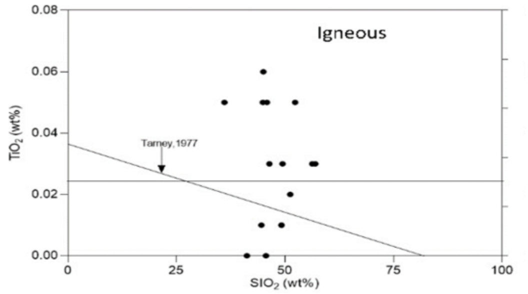

Figure 11: Environment of Deposition of Tajimi BIF

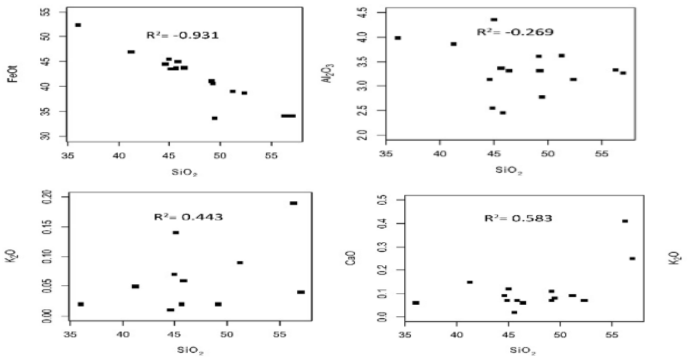

Figure12: Correlation Diagrams of Tajimi BIF.

The regression diagrams of SiO_2 against other major oxides according to Harker(1909) shows a strong negative correlation between SiO_2 and Al_2O_3, Fe_2O_3,(Fig.12).This means as SiO2 content increases, Al_2O_3, Fe_2O_3 and P_2O_5 decreases while the plot shows positive correlation between SiO_2 versus CaO which means as the content of SiO2 increases CaO also increase. This relationship is seen in minerals of magmatic origin.

The magmatic origin is further buttressed by the presence of high silica content (>69%) as seen in table 7 above. The presence of gneiss as one of the host rocks surrounding the iron ore shows initial rocks has been subjected to metamorphism which resulted to formation of gneisses within the environment. Similarly the high content of SiO_2, Al_2O_3 reveals that the gneiss is an orthogneiss which was directly metamorphosed from the granite given the similarity between the composition of the granite and the gneiss.

Minerals in a continental environment account for high SiO_2 and Al_2O.

CONCLUSION

Findings

The iron ore in the study area shows that they are found associated within the Precambrian the migmatite and granite gneiss rocks of the basement complex in the Nigeria.

The Tajimi iron ore is a Banded Iron Formation (BIF) in a magmatic environment.

They are precisely surrounded by orthogneisses which have been metamorphosed from the intrusion of granites as the host rocks with sharp boundary with the gneiss and gradational or inferred boundaries with the granite and the oolitic iron stone found at the Southern part of area.

The iron ore appears in form of hill or ridge. The rock samples are banded, fairly fractured and trending NE-SW with dips of various degrees which suggests reaction to tectonic forces mostly from the Pan Africa orogeny.

Petrographic studies shows that the mineralogical composition of the host rocks, gneiss are microcline (30%) quartz (25%) Feldspar(24%) while granite contains Microcline (35%) quartz(28%) and feldspar (22%).

X-RF analysis reveals high content of silica(SiO_2) and Alumina (Al_2O_3) and some minor oxides.

X-RD result revealed the occurrence of quartz (46%) as the most dominant mineral. The predominant iron bearing mineral is hematite (37%) .

The result of the petrographic, XRF, XRD and Ore Microscopy confirmed hematite as the predominant ore bearing mineral.

Tajimi iron ore is similar to other banded iron formations in Muro, Maru, Birni Gwari, Wonaka and Kazaure.

Tajimi iron ore is also similar to that of Pedroda, Brazil and Reboredo, Moncora, Spain (Table 6)

However, there is a variation composition between Tajimi iron ore and that of sedimentary iron ore deposits in places like Agbaja, Enugu, Koton-Karfe, Bassa- Nge and Agada-Egeneja with relatively low SiO_2 and higher Fe_2O_3 (Table 5)

The P_2O_5 and SO_3 composition in sedimentary iron ore deposits are higher than that of Tajimi banded iron ore deposit.(Table 4 and 6)

The result also shows that the BIF in Tajimi is of low grade.

The Tajimi BIF was formed in a magmatic environment (Fig.10a) The bandings of the minerals was due to metamorphism that has affected the area resulting to mineral alignment in response to heat and pressure.

RESEARCH LIMITATIONS

Some of the research limitations encountered include

1. Limited accessibility and sampling bias. The poor road network and rugged terrain restricted access to some parts of the deposit, hence sampling was concentrated along accessible tracks and stream channels which may not represent the full mineralization.
2. Weather and seasonal constraints on field work. Wet season and nature of the forest restricted the time available for the field work to dry season.
3. Analytical constraints of lab equipment and budget. Availability and cost of analytical techniques restricted the analysis to XRF, XRD and Ore microscopy which may have restricted detection limit especially for trace elements.

RECOMMENDATIONS

1.Future studies should combine field work sampling with drone/aerial LiDAR, satellite imagery and ground geophysical surveys to reduce sampling bias.

2. repeat sampling across dry and wet season to access how rainfall, erosion and weathering affects geochemical signature.

3.Advanced analytical techniques such as ICP-MS, SEM-EDS to allow better detection oftrace elements, REE and mineral phases.

REFERENCES

Dobbins, M. S., & Burnet, G. (1982). Production of iron ore concentrate from the iron-rich. *_Mining and Geology_, _28_, 55-64.*

Ekele P, Onimisi M, Habeeb A.;(2024) Field occurrence and compositional characteristics of clay horizon in the Patti formation, Southern Bida Basin, Northern Nigeria. *FUDMA journal of Science, Vol.8 pp79-88*

Ferdinard, A. (2014). _A Study of dephosphorization of Koton Karfe iron ore by acid leaching_ *(Ph.D. thesis). Ahmadu Bello University, Zaria.*

Garba, A. A., Adekeye, J. I. D., Akande, S. O., & Ajadi, J. (2019). Geochemistry and Rare Metal Bearing Potentials of Pegmatites of Gbugbu, Lema and Bishewa Areas of North Central Nigeria. *_Journal of Environment and Earth Science_, _9_(3).*

Harker. A(1909).Natural History of Igneous Rocks, *Methuen & co.London*

Haruna, I. A., et al. (2017). Geochemistry and economic potential of Jaruwa iron ores, NW Nigeria. *_Imp. J. Interdisciplinary. Res._, _3_, 1067-1074.*

Ibrahim, D., & Biliaminu, K. O. (2010). _Raw Materials Research and Development Council (RMRDC), *Federal ministry of science and technology_. RMRDC technical publication 19.*

Ibrahim, A. (2008). Petrography, geochemistry and origin of banded iron-formation of the Kazaure schist belt, Western Nigeria. *_Journal of Mining and Geology_, _44_(1), 1-6.*

Ladipo, K. O., Akande, S. O., & Mucke, A. (1994). Genesis of ironstones from the Mid-Niger sedimentary basin: evidence from sedimentological, ore microscopic and geochemical studies. *_Journal of Mining and Geology_, _30_, 161-168.*

Onimisi, M., Omada, J. I., & Eko, O. (2017). Field Geologic Occurrence, Petrography and Major Element Geochemistry of Sedimentary ironstone Deposit in Agada-Egeneja, Mid-Niger Basin, Central Nigeria. *_Proceedings of first National Conference of Faculty of Natural and Applied Science_, _1_, 298.*

Oyelowo Bayowa, G., Ogungbesan, R., Majolagbe, & S. Oyeleke. (2016). Geophysical prospecting for iron ore deposit around Tajimi Village, Lokoja, North central Nigeria. *_Materials and Geoenvironment_.*

Nigeria Mining and Geosciences Society. (1995). _Iron ore reserves in Nigeria: *Calabar conference edition_ (Vol. 95).*

Terney, j. (1977). Petrology, Mineralogy and Geochemistry of the Falkland Plateau Basement Rocks, *Deep Sea drilling project report 36, 893-921.*