

Geological and geochemical assessment of coal deposits at Lamja Sama, Yola sub-basin, Northern Benue Trough, Nigeria

¹Amodu, A. and ¹Umoru, W. C.

¹Department of Geology, Modibbo Adama University, Yola, Adamawa State, Nigeria
willychris404@gmail.com

Paper History

Received: 01st June, 2025

Accepted: 24th July, 2025

Published: July, 2025

Abstract:

Coal remains a significant energy resource for socioeconomic development, especially in countries like Nigeria. The work helped unlock the potential of coal deposits in the Northern Benue Trough and assess their suitability for industrial use. This study presents a geological and geochemical assessment of coal deposits at Lamja Sama, Northern Benue Trough, Nigeria. The research aims to characterise the coals, determine their rank, and evaluate their potential industrial applications. The work entailed geological mapping of outcrops, with data systematically recorded and plotted to produce a geological map and lithostratigraphic logs. Sandstone, siltstone, shale, limestone, marlstone and coal are among the lithological units found in the study area. The lithostratigraphic logs explain the position of coal seams and other lithological units. Representative coal samples were collected from seams in two different areas and subjected to proximate and ultimate analyses to determine properties such as moisture content, volatile matter, ash content, fixed carbon, sulfur, nitrogen, oxygen, and hydrogen. The geochemical analyses indicate that the coal samples from Lamja Sama are classified as medium-volatile bituminous coal, with a fixed carbon content of less than 78% and volatile matter content greater than 22%. Based on the results of proximate and ultimate analyses, the coal contains a quantifiable amount of carbon, making it a potential primary heat source for furnaces and boilers. In addition, carbon content is a key determinant of the heating value of coal, making it suitable for power generation. However, owing to the high ash content, this coal may benefit from blending with coals of lower ash content to improve its overall performance.

Corresponding author
Amodu, A.

adeniyamodu@mau.edu.ng

Keywords: Bituminous coal, Carbon, Lamja Sama, Proximate analysis, Ultimate

1. Introduction

Coal possesses significant potential for energy recovery and power generation, which are essential for socioeconomic development and sustainable growth [1]. Coal is an organic sedimentary rock comprising varying amounts of carbon, hydrogen, nitrogen, oxygen, and sulfur, as well as trace amounts of other elements, including mineral matter [2, 3]. It is a solid, brittle, combustible, carbonaceous rock formed by the decomposition and alteration of vegetation by compaction, temperature, and pressure [4]. It is typically stratified as coal beds or seams, ranging in color from brown to black. Coal is present in all geologic ages, from the Silurian to the Quaternary, and varies in thickness from fractions of an inch to hundreds of feet; however, the earliest commercially important coals were discovered in rocks of Mississippian age [5]. Generally formed in either a fluvial environment or in a basin open to marine incursions, coal consists of more than 50% w/w carbonaceous material [5]. The source of the vegetation is often moss and other low plant forms, though some coals contain significant amounts of materials originating from woody precursors. The presence of certain elements in coal can complicate and endanger its

utilization. Many of the heavy metals released during coal mining and combustion are toxic [6]. Coal accumulates some heavy metals and radioisotopic elements such as lead, mercury, nickel, antimony, and arsenic, as well as radioisotopes of thorium and strontium [7].

Despite growing concerns about environmental degradation, global warming, and climate change, coal has significantly contributed to the socioeconomic growth and sustainable development of many countries [8, 9, 10]. According to the United States Energy Information Administration, the world's total coal reserves are estimated at 1.16 trillion short tons, with approximately 75% of the world's proven coal reserves located in five countries: The United States, Russia, Australia, China, and India [11]. Nigeria's estimated coal reserves are 2.75 Gt, while proven reserves are approximately 639 Mt (million tonnes). Nigerian coals consist of 12% lignite, 49% subbituminous and 39% bituminous, primarily located in the Benue Trough basin [1, 12]. The coal deposits in the Benue Trough basin have been the subject of numerous studies such as Jauro, *et al.* [13], Ayinla, *et al.* [14], Akinyemi, *et al.* [15], Obaje, *et al.* [16], Bemgba [17] and Mangs, *et al.* [18].

1.1 Geological Settings

The Benue Trough is believed to have been initiated in the Early Cretaceous, forming a split from the Central West African basement during the separation of the African and South American continents (the breakup of Gondwanaland). This breakup was followed by the separation of these continents, the opening of the South Atlantic, and the growth of the Mid-Atlantic Ridge [19, 20, 21]. The northern section of the Benue Trough is split at the northeastern side into the basins around Gongola and Yola. In the Yola sub-basin as shown in Figure 1, the Albian Bima sandstone unconformably overlies the basement. The Cenomanian Yolde Formation, which marks the beginning of marine incursion into the basin is conformably lies on top of Bima sandstone. The Yolde Formation is regarded as a transitional deposit and consists of interbedded sandstone and shales [22]. The Dukul Formation overlies the Yolde Formation conformably and was described as a series of thick limestone and shale interbeds [23]. It is interpreted as a shallow marine deposit [22]. The Jessu Formation contains alternating successions of mudstone, sandy mudstone and shales.

The Sekuliye Formation conformably overlies the Jessu Formation and displays a similar lithology to the Dukul Formation. It is characterized by thick shales with thin beds of limestones [24]. The Numanha Formation consists of 200 m thick shale, nodular mudstone, and limestone [22]. The Lamja Formation is the youngest lithostratigraphic unit in the Yola Sub-Basin. It comprises shelly limestone, siltstone, sandstone, shale and coal. In the Northern Benue Trough, the coal-bearing Coniacian-Lower Santonian Lamja Formation was exposed at Lamja and Chikila villages, while the Campanian-Maastrichtian Gombe Formation was exposed at Garin Maiganga [13].

This work aims to provide higher-resolution geological data on the geology and geochemical assessment of coal deposits at Lamja Sama. The objectives are to characterize and highlight the geochemical properties, rank and classify the coals, and determine their potential industrial applications. This is in light of the exploration successes within the same rift trend of the Northern Benue Trough of Nigeria, which has drawn the attention of numerous researchers.

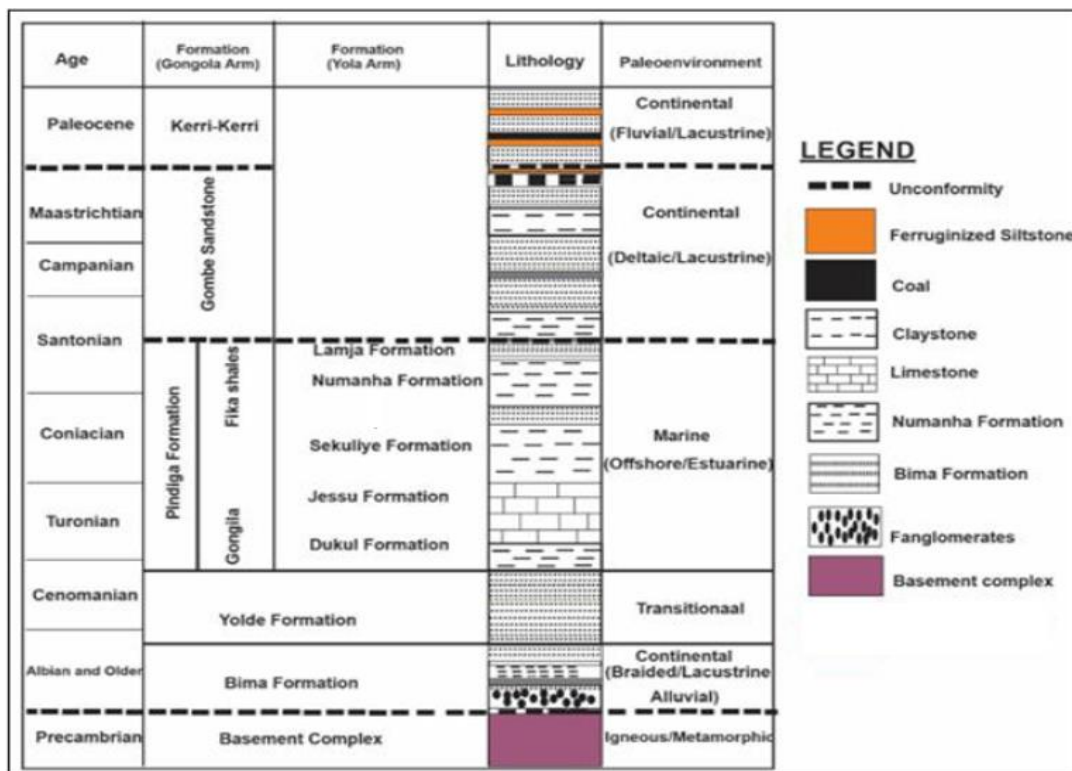


Figure 1: Stratigraphic succession of the Northern Benue Trough [25].

2. Methodology

2.1 The study area

The study area, Lamja Sama, is part of the Yola Arm of the Northern Benue Trough which lies within longitude 11°50' E to 11°55' E and latitude 9°50' N to 9°55' N within topographical sheet 174 of Guyuk NE as shown in Figure 2.

2.2 Field mapping

Comprehensive and high resolution field mapping was done using field mapping equipment and materials.

The method of investigation was the conventional geological mapping of outcrops. The procedures involved location and examination of outcrops for lithological and structural details and recording and plotting of data on a field notebook and base map respectively. These data were used to produce a geological map and lithostratigraphic logs. Representative samples were taken from seams located in two different areas of Lamja Sama and sealed in polyethylene bags for laboratory analyses (proximate and ultimate).

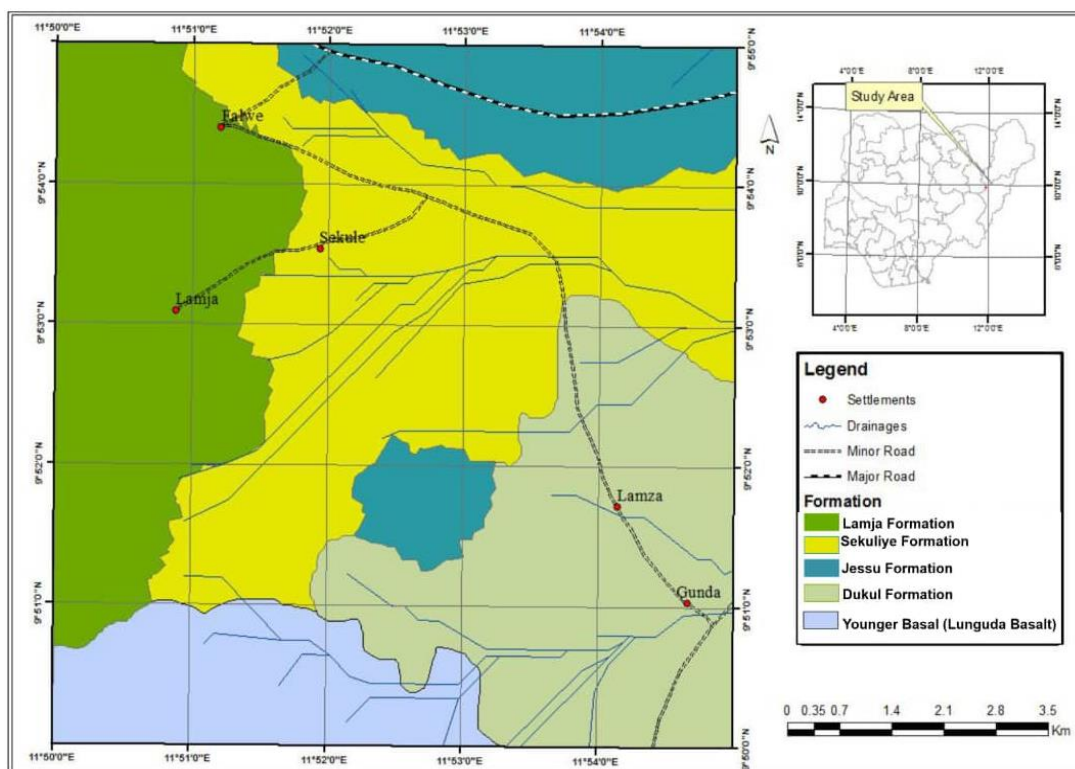


Figure 2: Geological map of the study area

2.3 Laboratory analyses

The representative's samples collected from the field were subjected to proximate and ultimate analyses in the National Steel Raw Materials Exploration Agency (NSRMEA), Kaduna, Nigeria.

2.3.1 Proximate and ultimate analyses

Coal analysis is the process by which the properties of coal are determined and used to project its suitability for various applications [5]. The methods outlined in the ASTM D-2013 [26] standard for proximal and ultimate analyses were followed in preparing the coal samples. For geochemical analysis, seven (7) representative samples were pulverized and sieved into particles of various sizes. Proximate analysis determined the moisture content, volatile matter, ash content, and fixed carbon [27]; these properties are used to classify different types of coal and their potential uses [28]. Ultimate analysis of coal was used to determine the carbon and hydrogen content as gaseous products of complete combustion, as well as to determine the sulfur, nitrogen, and to estimate the oxygen content by difference. The amount of heat generated during the combustion of a unit weight of coal is defined as the calorific value [28].

3. Results and discussion

The logging sections of the study area and the results of the samples analyzed (proximate and ultimate) were presented and discussed below.

3.1 Lithostratigraphic sections

The study area falls within the Lamja Formation, which contains lithological units such as sandstone, silt,

shale, limestone, marlstone and Cretaceous coal. The lithostratigraphic unit description logs explain the position of the coal and other lithologic units in the stratigraphic sections.

3.1.1 Lamja sama 1

The total thickness of this section is about 8.4m (Fig. 3). The section was logged from the bottom and made up of 2.1m of brownish parallel laminated sandstone, overlain by 0.9m of grey to dark flaky shales. This grades upwards into a 0.8m coal seam deposit, which is also overlain by 0.5m of dark to grey flaky shales. The shale is overlain by a layer of limestone facies, which in turn overlies marlstone. This sequence caps the first cycle of deposition in this locality. The start of the subsequent cycle is marked by brown-grey parallel laminated sandstone facies, overlain by a thin layer of marlstone that transitions upwards into shale-limestone intercalation.

3.1.2 Lamja sama 2

The total thickness of this section is 3m (Fig. 4). Logged from bottom to top, this section consists of a 0.8m thick coal seam, which is overlain by dark to grey flaky shales with a thickness of about 1.0m. The shales are conformably overlain by fine-grained, parallel laminated sandstone that is 1.2m thick, and this caps the entire lithological unit in this section. The litho-section exhibits a coarsening-upward trend.

3.2 Proximate and ultimate analyses

Seven (7) representative samples were selected, prepared and analyzed geochemically for the ultimate and proximate analyses. The results obtained were presented in Tables 1 and 2.

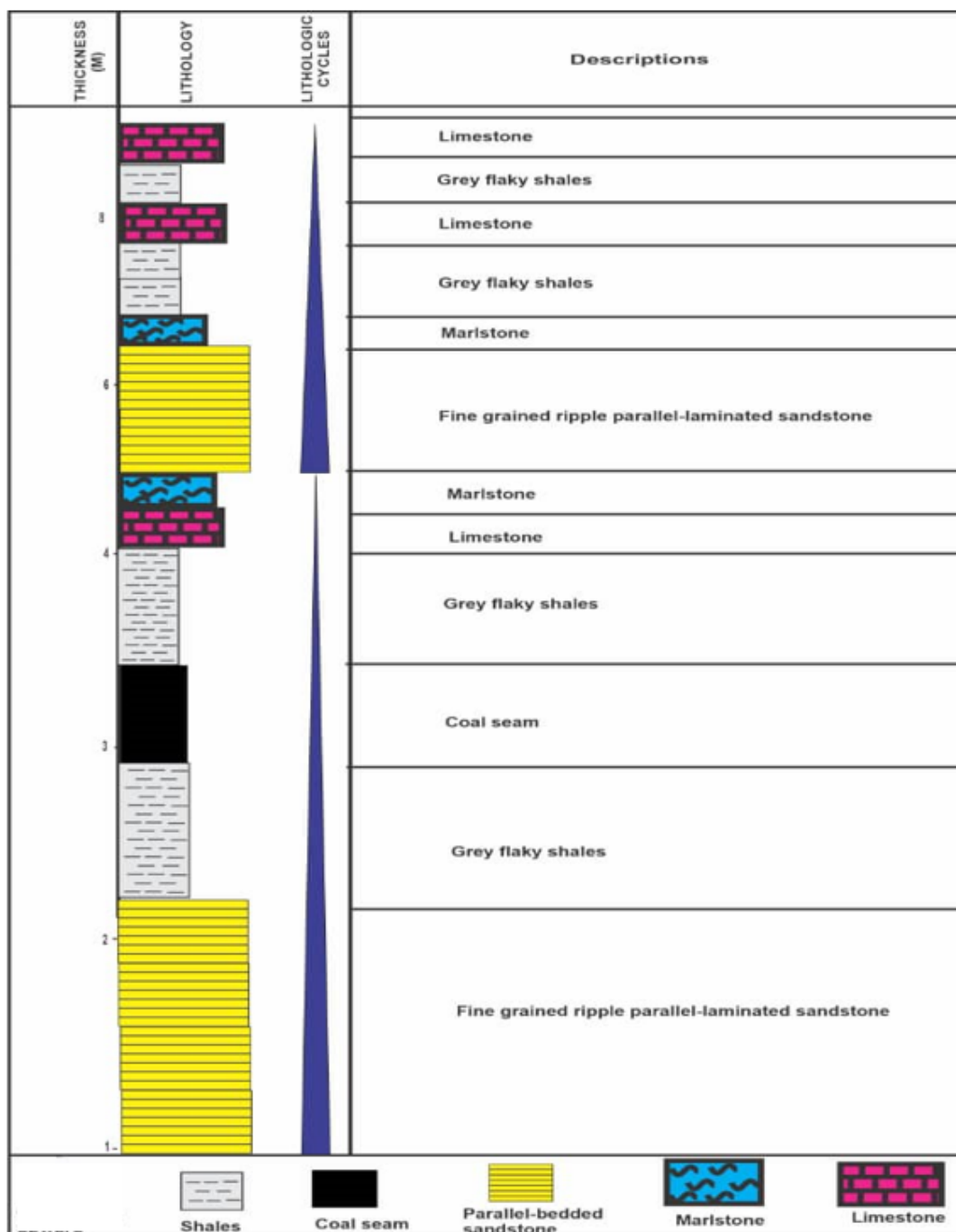


Figure 3: Lithologic section at Lamja sama 1

3.2.1 Proximate analysis

The procedures outlined by the ASTM D3176-15 [29] were followed to determine moisture content, volatile matter, ash content, and fixed carbon; the results are presented in Table 1. Figure 5 showed the variation of the proximate analysis's measured parameters, which included moisture content (MC), volatile matter (VM), ash content (AC), and fixed carbon (FC).

3.2.1.1 Moisture content

The moisture content has maximum values of 18.72% and 18.37% from samples 5 and 6 respectively. The samples 4 and 3 have the lowest values of 3.14% and

6.45% respectively. These values fall within the range of bituminous coal in the composition and property ranges for different ranks of coal [5], as shown in the table 3. This shows the increase in heat loss in the coal due to evaporation and superheating of vapor. The percentage weight of moisture content of this coal also helps to some extent in binding fines as well as aiding radiation heat transfer when used in a furnace.

3.2.1.2 Volatile matter content

The volatile matter content has maximum values of 34.25% and 32.66% from samples 4 and 3 respectively. The samples 7 and 6 have the lowest values of 10.54% and 12.85% respectively.

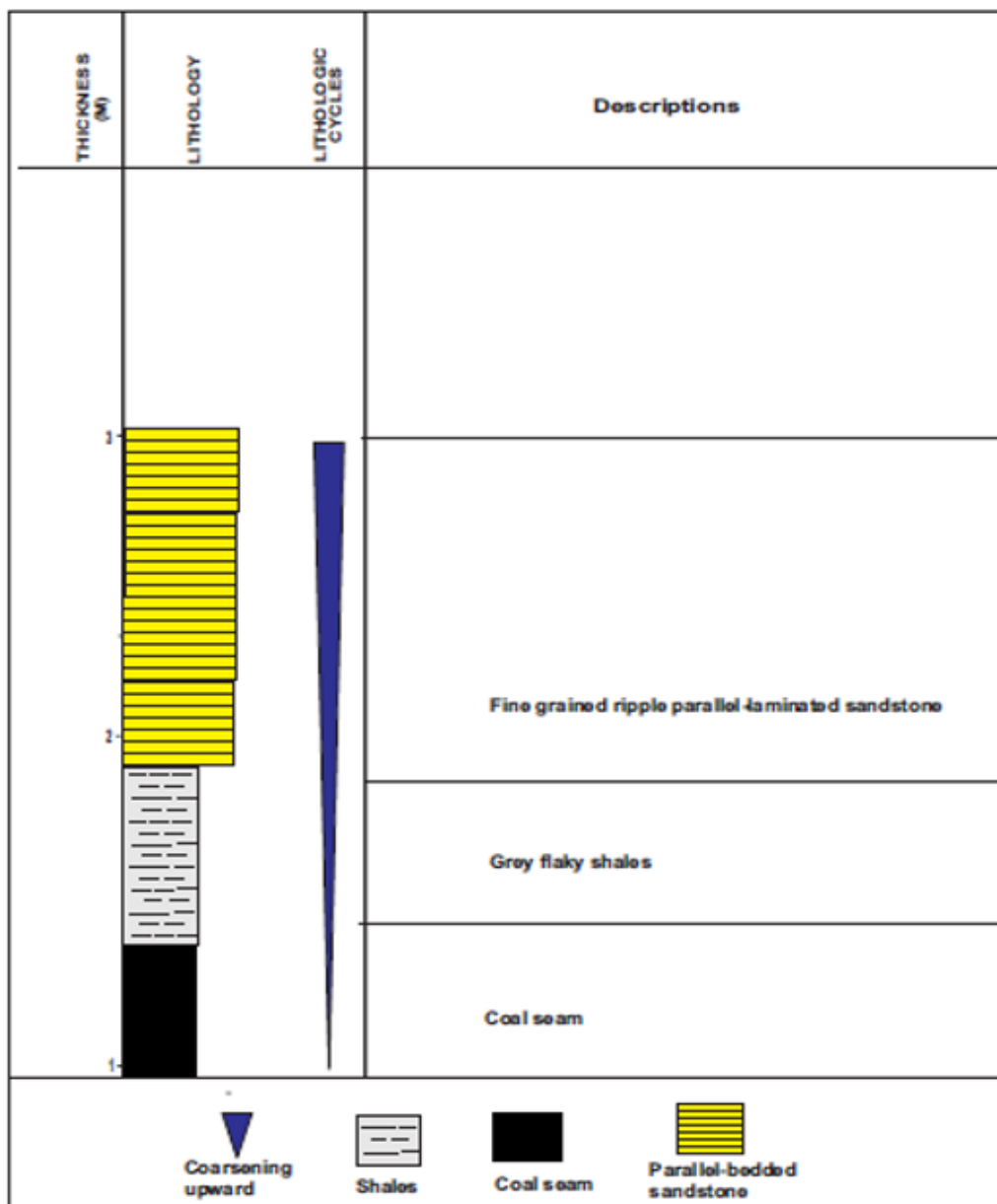


Figure 4: Lithologic section at Lamja sama 2

According to the ASTM D3176-15 [29] composition and property ranges for various coal rankings, these values fall between bituminous and anthracite coal [5]. This is the coal's gaseous fuel. Because there is a fair amount of this in the coal, the flame will remain longer and ignite more easily.

3.2.1.3 Ash Content

The ash content has maximum values of 63.40% and 52.57% from samples 7 and 6 respectively. The samples 3 and 1 have the lowest values of 27.60% and 27.66% respectively. The ash content is very high and this reduces the burning capacity and may result in clinkering and slagging.

Table 1: Summary table for proximate analysis of coal at Lamja Sama

Sample No.	Moisture content (%)	Volatile matter (%)	Ash content (%)	Fixed carbon (%)	Composition (%)
1	7.49	32.01	27.60	32.90	100
2	15.66	16.58	49.13	18.63	100
3	6.45	32.66	27.60	33.29	100
4	3.14	34.25	27.70	34.91	100
5	18.72	15.50	47.90	17.88	100
6	18.37	12.85	52.57	16.21	100
7	12.60	10.54	63.40	13.46	100
Average	11.76	22.06	42.28	23.9	100

Table 2: Summary table for Ultimate analysis of coal at Lamja Sama

Sample No.	Carbon (%)	Hydrogen (%)	Sulphur (%)	Nitrogen (%)	Oxygen (%)	Composition (%)
1	78.26	5.89	0.76	2.54	12.55	100
2	76.24	5.20	0.34	2.41	15.81	100
3	74.80	4.25	0.36	2.06	18.53	100
4	78.50	5.73	0.56	2.50	12.71	100
5	76.30	4.89	0.44	2.44	15.93	100
6	74.10	5.76	0.46	2.35	17.33	100
7	83.37	4.56	0.68	2.41	8.98	100
Average	77.37	5.18	0.51	2.39	14.55	100

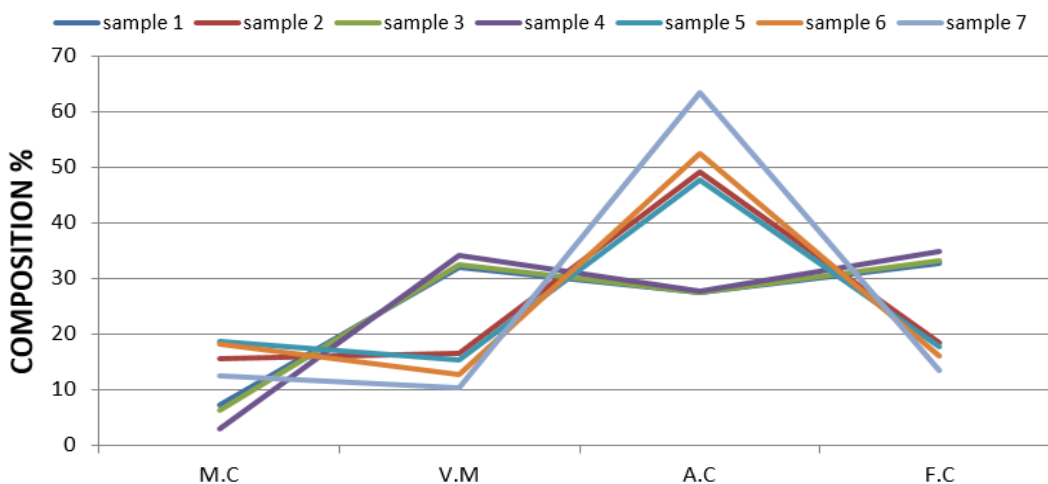


Figure 5: Variation of the measured parameters from the proximate analysis

Table 3 Composition and Property Ranges for Different Ranks of Coal [5]

Parameters	Anthracite	Bituminous	Sub-Bituminous	Lignite
Moisture (%)	3-6	2-15	10-25	25-45
Volatile matter (%)	2-12	15-45	28-45	24-32
Fixed carbon (%)	75-85	50-70	30-57	25-30
Ash (%)	4-15	4-15	3-10	3-15
Sulfur (%)	0.5-2.5	0.5-6	0.3-1.5	0.3-2.5
Hydrogen (%)	1.5-3.5	4.5-6	5.5-6.5	6-7.5
Carbon (%)	75-85	65-80	55-70	35-45
Oxygen (%)	5.5-9	4.5-10	15-30	38-48
Nitrogen (%)	0.5-1	0.5-2.5	0.80-1.5	0.6-1.0

3.2.1.4 Fixed carbon of coal samples

The highest fixed carbon content values from samples 4 and 3 are 34.91% and 33.29%, respectively. The lowest results, 13.46% and 16.21%, respectively, are seen in samples 7 and 6. According to the ASTM D3176-15 [29] composition and property ranges for various coal rankings, these values fall between lignite and sub-bituminous coal [5]. This value represents a rough estimate of the coal heating value, as the coal has a fair percentage of heating capacity.

As indicated in Table 4, the Lamja Sama coal rank classification was established using proximate analysis in compliance with ASTM D388-12 [30]. Because the coal samples' volatile matter is more than 22 and their fixed carbon is less than 78, they are classified as medium volatile bituminous coal.

3.2.2 Ultimate analysis

The ultimate analysis represents the elemental composition of the organic material in coal in terms of

carbon, hydrogen, nitrogen, sulfur, and oxygen. Figure 6 shows the variation of the measured parameters (carbon, hydrogen, sulfur, nitrogen and oxygen) of ultimate analysis.

3.2.2.1 Carbon Content of Coal Samples

Carbon content is an important element in estimating the amount of coke yield from a sample of coal on carbonization [31]. The greater the percentage composition, the better the quality and rank of the coal. It is a major yardstick used in determining the rough estimate of the calorific value of coal, which is also a rank-dependent variable parameter [32].

Considering the carbon content of the seven samples, samples 4 and 7 have the highest values of 78.50% and 83.37% respectively. The samples 6 and 2 have the lowest values of 74.10% and 74.80%. These values fall within the range of bituminous in the composition and property ranges for different ranks of coal [5].

Table 4: Classification of anthracitic and bituminous coals by rank [30]

Rank	Fixed carbon limits (dry mineral-matter-free basis) %		Volatile matter limits (dry mineral-matter-free basis) %	
	Equal or greater than	Less than	Greater than	Equal or less than
Meta-anthracite	98	n/a	n/a	2
Anthracite	92	98	2	8
Semi-anthracite	86	92	8	14
Low volatile bituminous coal	78	86	14	22
Medium volatile bituminous coal	69	78	22	31
High volatile A bituminous coal	n/a	69	31	n/a

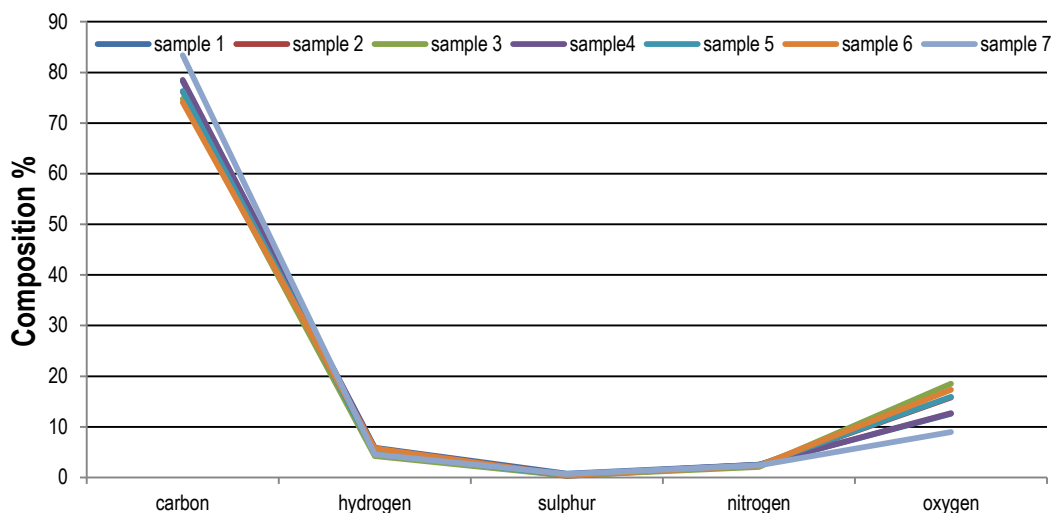


Figure 6: Variation of the measured parameters from the ultimate analysis

3.2.2.2 Hydrogen Content of Coal Samples

It is one of the major constituents but a minor element in terms of effect on coal utilization. Hydrogen occurs in minute content: peat to bituminous contains 3.0-5.6 %, while anthracite contains only 2-4% hydrogen [33]. The hydrogen content has maximum values of 5.89% and 5.76% from samples 1 and 6 respectively. The samples 3 and 5 have the lowest values of 4.25% and 4.56% respectively. These values fall within the range of bituminous in the composition and property ranges for different ranks of coal [5].

3.2.2.3 Sulphur Content of Coal samples

The sulfur content has maximum and lowest values of 0.76% and 0.34% from samples 1 and 2 respectively. These values fall within the range of bituminous coal in the composition and property ranges for different ranks of coal [5]. The percentage composition of sulfur is low, and this implies that the depletion of buffering ability of streams located close to the coal mining site will be very minimal. [34].

3.2.2.4 Nitrogen Content of Coal Samples

The nitrogen content has maximum values of 2.54% and 2.50% from samples 1 and 4 respectively. The samples 3 and 6 have the lowest values of 2.06% and 2.35% respectively. These values fall within the range of bituminous in the composition and property ranges for different ranks of coal [5].

3.2.2.5 Oxygen Content of Coal Samples

The oxygen content is one of the important indexes for coal ranking; the younger coal is richer in elemental oxygen than that of the more mature coal [32]. The Oxygen content has maximum values of 18.53% and 17.33% from samples 3 and 6 respectively. The samples 7 and 1 have the lowest values of 8.98% and 12.55% respectively. These values fall within the range of sub-bituminous to bituminous coal in the composition and property ranges for different ranks of coal [5].

4. Conclusion

The study area lies within the Lamja Formation, which comprises lithological units such as sandstone, siltstone, shale, limestone, marlstone and coal. Lithostratigraphic logs explain the position of coal seams and other lithological units. Geochemical analyses (proximate and ultimate) show that the different coal samples from Lamja Sama have a high percentage of carbon content and hence fall within the rank of bituminous coal. Furthermore, the percentage contents of sulfur, nitrogen, oxygen, and hydrogen contribute to further classification, with some parameters falling within the sub-bituminous to bituminous range, based on compositional and property ranges for different coal ranks. Proximate analysis was used to classify the coal rank in compliance with ASTM D388-12. The coal samples from Lamja Sama are classified as medium-volatile bituminous coal with a fixed carbon content of less than 78% and a volatile matter content greater than 22%. Based on the results of

proximate and ultimate analyses, coal contains a quantifiable amount of carbon, which can serve as a primary source of heat for furnaces and boilers. Additionally, carbon is a key determinant of the heating value of coal, making it suitable for power generation. Owing to the high ash content, coal can be blended with coals of low ash content before use to enhance the coal for better output. Coal can also be used to complement or enhance other coals that have excess fines and require conditioning because this coal has sufficient moisture content to bind fines and improve heat radiation transfer.

References

- [1]. Chukwu, M., Folayan, C., Pam, G. and Obada, D., (2016). Characterization of some Nigerian Coals for Power Generation, *Journal of Combustion*, 1, 1-15
- [2]. VAN Kravelen, O. W., (1961). Coal, Elsevier, Amsterdam.
- [3]. Speight, J. G., (2012). The Chemistry and Technology of Coal, Chemical industries, 3rd ed., Boca Raton, CRC Press.
- [4]. Onoduku, U. S., (2014). Chemistry of Maiganga Coal Deposit, Upper Benue Trough, Northeastern Nigeria. *Journal of Geosciences and Geomatics*, 2(3), 80-84.
- [5]. Speight J. G., (2015). Handbook of Coal Analysis. 2nd ed., New Jersey, John Wiley & Sons.
- [6]. Zhang, X. P., Zhang, C., Tan, P., Li, X., Fang, Q. Y. and Chen, G., (2018). Effects of Hydrothermal Upgrading on the Physicochemical Structure and Gasification Characteristics of Zhundong Coal. *Fuel Processing Technology*, 172, 200-208.
- [7]. Jeff, G., (2006). Big Coal: The Dirty Secret Behind America's Energy Future. *Natural Resources Journal*, 46(4), 1090-1092.
- [8]. Kettanah, Y. A. and Eble, C. F., (2017). Petrology, Mineralogy and Geochemistry of Hemrin Coal Seam, Hemrin South Mountain, Northern Iraq. *International Journal of Coal*, 181, 39-59.
- [9]. McGlade, C. and Ekins, P., (2015). The Geographical Distribution of Fossil Fuels Unused When Limiting Global Warming to 2°C. *Nature*, 517, 187-190.
- [10]. Meinshausen, M., Meinshausen, N., Hare, W., Sarah C. B., Frieler, K., Knutti, R., Frame, D. J. and Allen, M. R., (2009). Greenhouse-gas emission targets for limiting global warming to 2 °C. *Nature*, 458, 1158-1162
- [11]. U.S. IEA, (2023). Coal Reserves. International Energy Statistics, Washington
- [12]. Ohimain E. I., (2014). Can Nigeria Generate 30% of her Electricity from Coal, *International Journal of Energy Power Engineering*, 3, 28-37
- [13]. Jauro A., Obaje N. G., Agho M. O., Abubakar M. B. and Turku A., (2007). Organic Geochemistry of Cretaceous Lamza and Chikila Coals, Upper Benue trough, Nigeria. *Fuel*, 86(4), 520-532.
- [14]. Ayinla, H., Abdullah W. and Makeen, Y., (2017). Source Rock Characteristics, Depositional Setting and Hydrocarbon Generation Potential of Cretaceous Coals and Organic-rich Mudstones from Gombe Formation, Gongola sub-basin, Northern Benue Trough, NE Nigeria, *International Journal of Coal Geology*, 173, 212-226.
- [15]. Akinyemi, S. A., Adebayo, O. F., Nyakuma, B. B., Adegoke, A. K., Aturamu, O. A., OlaOlorun, O. A., Adetunji, A., Hower, J. C., Hood, M. M. and Jauro, A., (2020). Petrology, Physicochemical and Thermal Analyses of Selected Cretaceous Coals from the Benue Trough Basin in Nigeria. *International Journal of Coal Science & Technology*, 7(1), 26-42.
- [16]. Obaje, N. G., Umar, U. M., Aweda, A. K. and Ozoji, T. M., (2020). Nigerian Cretaceous Coal Deposits and their Petroleum Source Rock Characteristics, *International Journal of Petroleum and Gas Exploration Management*, 4(1), 1-14.
- [17]. Bemgba B. N., (2020). Determination of the Combustion Characteristics of Chikila Coal through the Kissinger Kinetics Model, *Chemical Technology*, 14(3), 433-438.
- [18]. Mangs, A. D., Wagner, N. J., Moroeng, O. M. and Lar, U. A., (2022). Petrographic Composition of Coal within the Benue Trough, Nigeria and a Consideration of the Paleodepositional Setting. *International Journal of Coal Science & Technology*, 9(35), 1-24
- [19]. King, L. C., (1950). Outline and Distribution of Gondwanaland, *Geological Magazine*, 87, 353-359.
- [20]. Olade, M. A., (1975). Evolution of Nigeria's Benue Trough: A Tectonic Model. *Geological Magazine*, 112, 575-583.
- [21]. Benkheilil, J., (1989). The Origin and Evolution of the Cretaceous Benue Trough, *Journal of Africa Earth Sciences*, 8 (2-4), 251-282.
- [22]. Carter, J. D., Barber, W., Tait, E. A. and Jones, G. P., (1963). The Geology of parts of Adamawa, Bauchi and Bornu Provinces in north-eastern Nigeria, *Bulletin Geological Survey Nigeria*, 30, 1-108
- [23]. Sarki Yandoka, B. M., Abubakar, M. B., Abdullah, W. H., Maigari, A. S., Hakimi, M. H., Adegoke, A. K., Shirputda, J. J. and Aliyu, A. H., (2015). Sedimentology, Geochemistry and Paleo-environmental Reconstruction of the Cretaceous Yolde Formation from Yola subbasin, Northern Benue, NE Nigeria, *Marine and Petroleum Geology*, 67, 663-667.
- [24]. Nwajide, C. S., (2013). Geology of Nigeria's Sedimentary Basins, Lagos, CSS Publishers.
- [25]. Finthan, B. and Mamman, Y. D., (2020). The Lithofacies and Depositional Paleoenvironment of the Bima Sandstone in Girei and Environs, Yola Arm, Upper Benue Trough, Northeastern Nigeria, *Journal of African Earth Sciences*, 169, 103863.
- [26]. ASTM D2013 (2013). Standard Practice of Preparing Coal Samples for Analysis. ASTM International, West Conshohocken.

- [27]. Donahue, C. J. and Rais, E. A., (2009). Proximate analysis of coal. *Journal of Chemical Education*, 86(2), 222-224.
- [28]. Onyemesili, O. C., Frank, C., Odumodu, R. and Adoro, M. J., (2021). Geochemistry and industrial applications of brown coals of the Ogwashi-Asaba Formation in Parts of Anambra State, Nigeria, *Journal of Natural Sciences Research*, 12(12), 26-38.
- [29]. ASTM D3176 (2015). Standard practice for ultimate analysis of coal and coke. ASTM International, West Conshohocken.
- [30]. ASTM D388 (2012). Standard classification of coals by rank. ASTM International, West Conshohocken.
- [31]. Akpabio, I. O., Chagga, M. M. and Jauro, A., (2008). Assessment of some Nigerian Coals for metallurgical application. *Journal of Minerals and Materials Characterization and Engineering*, 7(4), 301-306.
- [32]. Ryemshak, S. A., Jauro, A., Putshaka, J. D. and Sori, R. M., (2016). Ultimate analysis of some nigerian coal: ranking and suitable application, *International Journal of Engineering and Applied Sciences*, 3(10), 31-35
- [33]. Balsaraf, V. M., (2009). Applied Chemistry 11. New Delhi, I K International Publishing House.
- [34]. Musa, N., Usaku, R., Akinterinwa, A. and Maina, H. M., (2018). Studies on elemental composition and physico-chemical properties of coal deposits in Lamza and Guyuk Local Government, Adamawa State, Nigeria, *Bayero Journal of Pure and Applied Sciences*, 11(2), 267-273.