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The link to this publication is *https://ajoeer.org.ng/otn/ajoeer/2023/qtr-1/02.pdf*

A REVIEW ON COMPARATIVE STUDY OF LOCAL AND IMPORTED BARITE AS WEIGHTING AGENT IN DRILLING FLUIDS.

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ABSTRACT

Nigeria is blessed with a considerably large deposit of solid minerals, of which barite is one of it. The industrial need for barite has increasedover the period as oil and gas exploration and exploitation grew because barite is used as a weighting agent in drilling fluids. Though, this is not the only application of barite. This resulted in the massive importation of barite for use by oil and gas firms operating in Nigeria. However, we sit on a deposit of barite, and we also import it, losing high foreign exchange earnings owing to some studies that revealed that Nigeria has low grade barite which is not meeting up with the API's specification. In fact, some deposits of barite have not been explored for first time. This review paper has revealed a good number of studies done by researchers in the recent past, showing the rheological properties of local barite measuring up the imported ones and the API's specific gravity is 4.2 and some works reviewed showed high grade barite have specific gravity (S.G) of 4.2 and little above. The previous studies showed that drilling mud treated with local barites have the required rheological properties for safe drilling operation. The fluid loss property of local barite is a little lower that the API standard and the imported barites but improved when 10 g Torkula barite was used to enhance the filter cake quality and reduce the fluid loss (Afolayan, et al., 2021). This review will serve as a boost to Government's and agencies' efforts to go full ball into extraction and processing barite in Nigeria to bridge the gap in the supply chain of local barite in Nigerian oil and gas industry in order to increase foreign exchange earnings.

Keywords: Barite, Drilling fluid, Specific Gravity, Weighting Agent and API Specification.

1.0 INTRODUCTION

Barite has been known and used over the decades as a weighting agent in drilling fluid. It enables the drilling fluids to balance the formation pressure during drilling operation. It is also useful due to its high specific gravity, chemical and physical inertness, relative softness and low solubility (Bosbach *et al*., 1998; Das *et al*., 2020; Ulusoy, 2019). Both the International Oil Companies, IOCs and local operators have spent multimillion US Dollars in the importation of barite for use in Nigeria. More than 80% of barite produced globally are used as a weighting agent in drilling fluids (David *et al*., 2021). It was estimated that 740 million metric tons of barite has been identified out of which about 2 billion tons of world barite resources and could be traced to countries such as China, Morocco, Kazakhstan, Thailand, USA and Turkey and 9.5 million metric tons could

be gotten from other countries as of 2018. These countries who are majors in the exportation of barite, have made great wealth from it.

The foreign exchange obtained from the sales of barite is whopping. For instance, a total sum of about 2.88 billion US Dollars is generated from Brown barite, barite 4.3, residual deposit type barite and oil and gas industry barite (David, *et al*., 2021). However, it is sad that with the large deposit of barite in Nigeria, we have not been able to extract and process barite for use in drilling fluid. Rather, the oil and gas companies based in Nigeria are still importing and paying millions of US Dollars to other nations who have succeeded in harnessing their barite deposits, unsubstantially claiming that Nigeria's barites do not meet the API's standard. Contrary to the above claims and based on records, Nigeria ranks fourth largest barite deposit in Africa. Barite deposits could be found in Nigeria in Northeastern, Northwestern and Southeastern sections of the Nigeria's Precambrian Basement rock (Label, *et al*., 2018).

Some of the barite deposits are of high grades as shown in Table 1. The consumption level of imported barite is very high when compared with other developed nations as shown in the Figure 1, implying that with little we produce and process would not be not able to balance barite demand in Nigerian oil and gas industry. We are therefore left with no other alternative than to keep importing it.

In an attempt to solve the problem of lingering shortage in barite supply chain in Nigeria, Nigerian Content Development and Monitoring Board (NCDMB) came up with a guideline and the NOGICD Act of 2010 to help facilitate implementation of ban on the importation of barite in 2010 to make extraction and processing of local barite to go into full swing but up till date, no tangible progress has been made in that regard. A number of factors contributed to failures of the government or her agencies to implement the ban on the importation of barite. First, there is lack of industry-institution-government synergy (MMSD, 2010; NGSA, 2010).). When there is no cooperation among the government, industry and institution, the research and development drive will be killed.

Also, there has not been adequate evaluation of Nigeria's barite data from numerous works done by various researchers, ranging from geographical distribution of barite deposits to their characterization as to employ same in policy making by Government and Government agencies on how to fully harness barite in Nigeria, hence, the pertinency of this study.

Local barite supply chain in Nigeria can guarantee a sustainable supply of the commodity because we have not been able to extract and process local barite ore to meet the international. This has made the ban on importation of barite to be a futile exercise. So, the way to succeed in closing demand-supply gap is for the relevant agencies and government to collaborate with institutions and industry players so as to embrace the use scientific data and information to regulation the value chain of the local barite.

In this review paper, the characterization of Nigeria's barites by different researchers will be explored. The properties of the local barite were determined and compared with the imported ones and IPA standard by these researchers. The work was intended to foster the value chain of local barites and further encourage government agencies to fully implement NOGICD Act of 2010, thereby creating wealth for our nation through local consumption and exportation.

Table 1: Nigeria barite deposits and associated grade (Michael Oden, 2012).

Low quality	**Medium quality**	**High quality**
S.G: 3.6 – 4.0	**S.G : 4.0 – 4.2**	**S.G : >4.2**
Azara	Ambua	Alifokpa
Wuse	Yandev	Gabu
Kuduku	Lessel	Osina

Pupule	Kornya	Konshisha
Apawa	Kumar	Didango
Tombu	Ihugh	Kumar
Bunde lessel	Orgba	Ibi
Aloshi	Ribi	

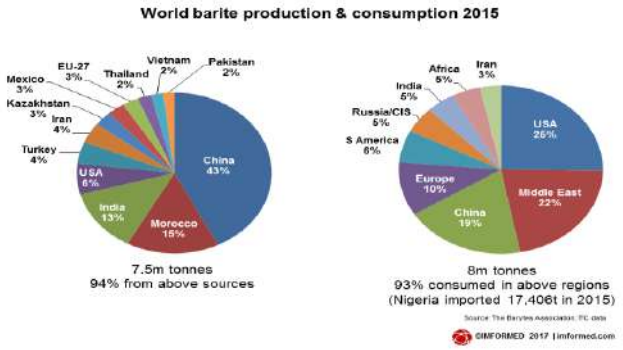

Figure 1: Global barite production and consumption, 2015.

2.0 **Local Barite Quality and Processing**

From some investigations done, there are different types of barites, classified based on their qualities traceable from the depth of extraction. They are low quality, medium and high-quality barites (Essalhi et al. 2018; Oden 2012). The deeper the depth of extraction, the better the quality of the barite. Barite obtained at the depth of between 0 and 5m can be categorized as low-quality barite because of more impurities and low pressured hydrothermal fluids found at this depth. The medium and high-quality barites can be obtained from the depth of 15m and above (Inyang et al. 2013; MMSD 2016; Oden 2012). However, whether or not a barite deposit is of low quality as it is with some in Nigeria, studies have shown that they could be upgraded through different upgrading methods. The upgrading process will help to convert the barite ore to barite with minimum allowable impurities, specific gravity and constituents with properties needed in the drilling fluids and other alternative industrial applications (Chaanda et al., 2010; Labe et al., 2018; Oden 2012). The beneficiation of Barite (BaSO4) through tested and proven method becomes very necessary to improve the quality and thereby increasing its use in the oil and gas industry (Mgbemere et al., 2018a, b). In order to determine the qualities of some selected barite deposit in Nigeria, there is a need to characterize them and devise technologies for the upgrade. According to some onsite beneficiation could be cost effect (API 2004, 2010; Tanko et al. 2015) while others argued it might be difficult to obtain barite of quality that meet American Petroleum Institute (API) standard (David et al., 2021). Comparing the properties of the local barites from specific locations in Nigeria and the foreign/imported one will help to know exactly in which aspects to improve the quality to meet the international standard required for drilling operation. The increasing demand for high quality barite needed for drilling activities have not been met over the years in Nigeria because of the differences in the level and gangue minerals in the ore. Also, the different methods of local processing have reported by a number of works ((Achusim-Udenko et al. 2011; Chen et al. 2019a, b; Deng et al. 2019; Grigorova et al. 2015; Liu et al. 2019; Mgbemere et al. 2018a, b; Nzeh and Hassan 2017; Raju et al. 2016; Wang et al. 2014; Zhao et al. 2014). These methods include floatation, gravity separation and chemical leaching but there has not been any concise proof of a particular technique for the investigation of the performance of the local processing method to unveil the local barite's quality and compare it with generally accepted imported species (David, et al., 2018). Floatation is one of the newest technologies in the separation of fluoride (CaF) from its tightly attached gangue like barite ($BaSO_4$), calcite ($CaCO_3$), and quartz (SiO_2) (Chen, *et al*., 2018; Asadi, *et al*.,2018). Floatation is one of the advanced beneficiations through which all the impurities could be removed from the local, making it fit for industrial use (Zhijie, et al., 2019).

A lot of works has been done in an attempt to characterize the Nigerian Barite deposits. A number of these

investigations would be reviewed in this investigatory study. Extensive work was done on the characterization of Benue barite deposits (Afolayan, *et al*., 2021). It was gathered that the Benue barite deposit was made up of Lessel barite and Guma barite fields. Lessel field consists of mainly veins and are located in the southern part of Gboko, Lessel Bunde, Lessel Mbato and Lessel Mbagwa (David, *et al*., 2021). Guma field has vein deposits in Iye, Kaseyo, Zanzan, Makurdi, and Torkula–Hungwa axis, with Torkula–Hungwa axis having the largest deposit of barite vein (David, *et al*., 2021). Three veins identified in the area were said to have high quality barite of specific gravity of 4.2 amounting to tens of thousand tons barite (Afolayan 2017; Oden 2012). In the characterization studies, the Bruker D8 Advance ECO A25 difractometer with DAVINCI design was employed. The analysis of the samples of the barite ores was done and observable peaks obtained in the analyses were matched and analyzed with ICDD database. The properties of the barite studied include PH, sulphate composition, Cation exchange capacity and methylene blue absorption of Torkula barite, metal content, moisture content, specific gravity (S.G), effects of local barite on mud filtration properties, effects on rheological properties of drilling mud.

The viscosity of the drilling fluid having local barite as a function of shear rate is expected to be stable even at high share rate to be able to meet the globally accepted barite standard for drilling fluid conditioning. From fig. 2., it was observed that the the fluids treated with local barite at different concentration of mass exhibited the same viscosity at some shear rate but responded differently when external force was applied. Fluids 1 and 3 had their viscosities decreased sharply because they could not withstand any further shear force. However, fluid 2 was stable, even at a shear pressure beyond 180 MPa. This shows that increasing mass of the weighting agent from 5g to 70g will improve the viscosity of the fluid treated with it. From the above, information, there is a confirmation of gradual transition from pseudplastic fluid to plastic fluid as the quantity of the weighting agents increases (Afolayan, *et al*., 2021).

Figs. 4 A and B show the specific gravities of the local barite and the API value. The difference is not much and this could be improved upon through some beneficiation process to be able to measure up with the imported ones. The work done by Ibe *et al*., (2016) clearly shows that the high-grade barites in Nigeria, when processed, would have the specific gravity of 4.1 and above which can be worked upon to get 4.2 specific density which is API approved.

Table 1 equally shows that local barite could be used to improve and enhance the fluid properties needed for both ordinary and specialized drilling operations. The responses of the fluids at different mixing speeds were captured. The results showed a decrease in dial reading of 600 revolution per minutes (RPM) and that of 300 RPM when the quantity of barite was increased from 10g to 70g. The reading was bit higher than the minimum for API and that could be traced to the fact the fluid used for the work was a non-Newtonian fluid (Afolayan, *et al*., 2021).

It was obtained also that the fluid loss from the mud prepared with local barite (Torkula barite) was lower than the API standard and the mud treated with the imported barite, though it was within the accepted standard (Afolayan, *et al*., 2021).

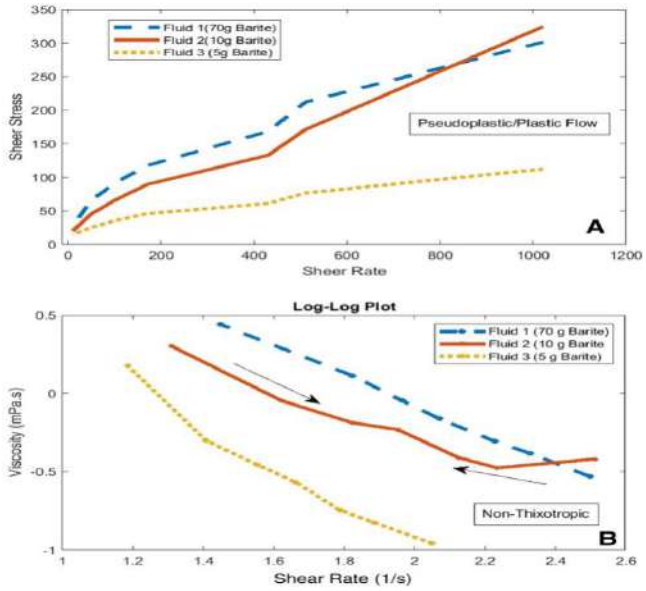

Fig. 2 Thixotropic properties of fluids formulated using local barite (a shear stress as a function of shear rate, b viscosity as a function of shear rate) (Afolayan, *et al*., 2021)

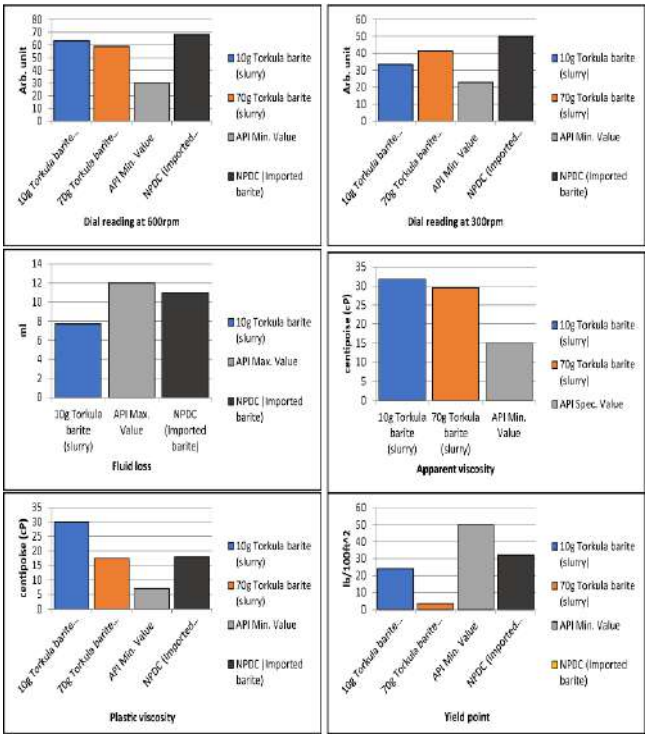

Fig. 3 Rheological properties of local barite and imported ones (Afolayan, *et al*., 2021)

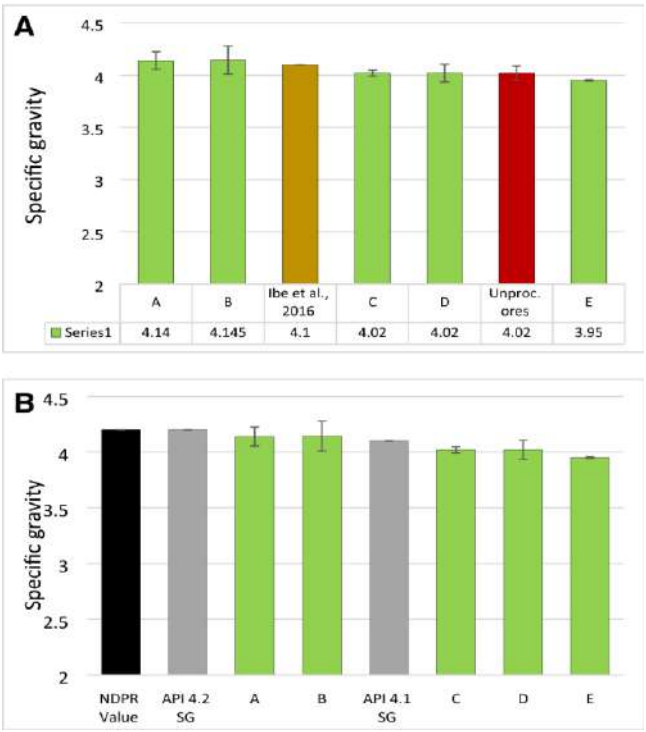

Fig. 4 Specific gravities of the local barite and imported ones (Afolayan, *et al*., 202

Table 2: Summary of rheological properties of water-based drilling fluid based on Torkula barite (Afolayan, *et al*., 2021)

Rheological Properties	**Drilling mud (70g barite)**	**Drilling mud (10g barite)**	**Drilling mud (5g barite)**
600rpm	**59.0**	**63.5**	**22.0**
300rpm	41.5	33.5	15.0
200rpm	33.0	26.0	12.0
100rpm	23.0	17.5	9.0
60rpm	18.0	13.0	7.0
30rpm	13.0	9.0	5.0
6rpm	5.50	4.0	3.0
Gel strenght @ 10s	3.0	2.5	1.5
Gel strength @ 10min	3.5	3.0	2.0
Mud weight(ppg)	9.95	8.65	8.5
pH	10.65	11.76	11.97
Plastic	17.50	30.00	7.00

viscosity			
Yield point	24.00	3.5	8.0
Apparent viscosity	29.50	31.75	11.00

2.1 Grading of Local Barites and Distribution in Nigeria

The results from previous researchers showed that Nigeria's barites vary in quality from low grade to high grade based on their density value. From 2, it was evidently state that barites from Aloshi, Azara, Wuse, Pupule, Mubi, Apawa, Lessel, etc are low quality barite, specific gravity of 3.0 – 4.0. The barites gotten from Ribi, Ambua, Obubra, Kumar, Mayo-Belwa and many others are graded as medium quality with specific gravity of 4.0 – 4.2. Some high-quality barites are Ibi, Afuze, Markurd, Igara, Gabu, Osina, etc.

The medium and high quality barites as shown in table 2 could be used as weighting agent in drilling mud after advanced beneficiation because from the API standard, the density requirement for any barite to be used as weighting agent is 4.2 (Tanko et al., 2015). Onsite beneficiation has not proven effective in upgrading of the medium quality barites (Afolayan, *et al*., 2021).

The quality Barites obtained from the Cross Rivers state, Adamawa, Benue, Taraba, Nasarawa has shown that Nigerian barite deposits have high percentage of high-quality barite which can measure up with imported barite after using effective processing method. From the data gathered from the study carried out by Onwualu, *et al*., (2013a), the specific range of Nigeria's barite is 3.2 – 4.54, which is a good one. Some research works also established that low-high quality barite mineralization cut across whole North East and South-East region (Nigeria Geological Survey Agency, 2011) making it a fortune for the Nigeria state if properly harnessed and processed. The geological surveys carried by some agencies in the recent past have clearly spelt out the places with minor and major mining activities (Heliyon, 2021).

For now, the local barite deposit has not been characterized because mining activities have not kicked started in the area and the areas covered are Ohozara local government areas, Afikpo North and Afikpo South (Onwualu *et al*., 2013a, b). The distribution of barite deposits in Nigeria is well represented in fig. 5, showing different grades and reserve estimation.

Table 3: Quality variation of barite deposits in Nigeria (Afolayan 2017; Inyang et al. 2013; Oden 2012; MMSD 2010).

Low quality (SG: 3.0-4.0)	Medium quality (SG: 4.0–4.2)	High quality (SG: > 4.2)
Aloshi, Azara, Wuse,	Ribi, Afuze, Ambua	Ibi, Afuze, Alifokpa
Pupule, Mubi, Apawa	Ntak, Yandev, Pila-Tandev	Makurdi, Bundin-Kwaj-ali
Tombu, Bunde Lessel	Lessel, Obubra, Kornya	Igara, Yala, Afugo, Guma
Port Harcourt, Lessel	Kumar, Ihugh, Azara	Gabu, Osina, Konshisha
Kuduku, Obubra, Keana	Guma, Orgba, Mayo-Belwa	Didango, Kumar, Torkula

Table 3 Elemental Composition of the Torkula barite and API 2010 (Afolayan et al., 2021)

Composition	**Percentage(%)**	
	API Specification	**Torkula barite**
$BaSO_4$	95.00	87.79
Fe_2O_3	0.03	1.39
CaO	0.01	0.589
MgO	0.04	0.086
Al_2O_3	0.035	0.75
Silicate	0.01	6.66
Total heavy metals	0.001	1.6003
Water-soluble salt	0.1	0.0301
Loss on ignition (LOI)	0.5	1.10

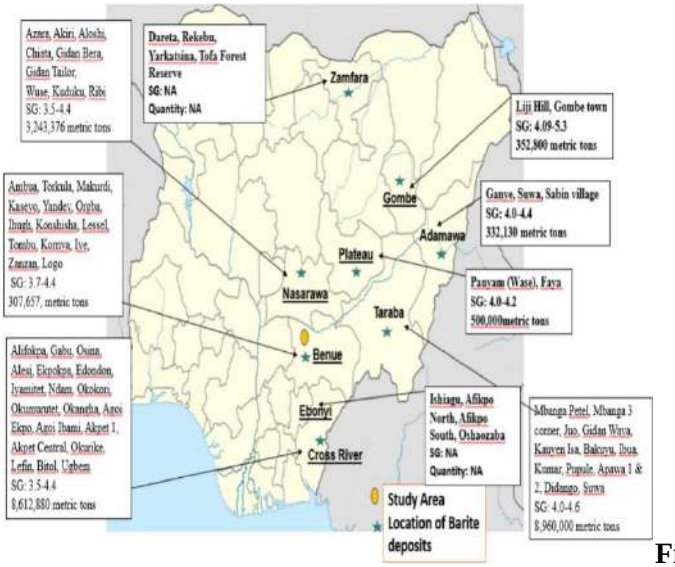

Fig. 2. Fig.5 Barite deposit map of Nigeria showing the locations, quality, and reserve estimates (Afolayan 2017; Inyang et al. 2013; MMSD 2010).

3.0 CONCLUSIONS

This paper review shows that Nigeria's barite is of three grades low, medium and high which through appropriate processing methods could be upgraded to API standard, thereby having the required quality to compete favourably with the imported barites.

Also, through processing methods (advanced beneficiation like floatation method), the elemental composition of the local barite can be worked upon to tally with API's approved percentage elemental compositions.

The Nigeria's high-grade barites have API's specifications on rheological properties as explored in this work and specific gravity requirement which is 4.2 and little above the stated benchmark.

A good number of Nigeria's barite deposits have not been fully explored, many under artisan mining activities while others never had any form of mining activities like the Afikpo barite deposit in Ebonyi State. It

therefore becomes necessary to go into full exploration, extraction and refining of barites in Nigeria.

4.0 ACKNOWLEDGMENTS.

The authors would like to thank the University of Port Harcourt for their support for this work.

5.0 REFERENCES

API (2004) Specification for drilling–fluid materials, API specification 13A, 16th edn, February, 2004, pp 13, 165.

Asadi M, Mohammadi MT, Moosakazemi F, Esmaeili MJ, Zakeri M. (2018) Development of an Environmentally Friendly Flowsheet to Produce Acid Grade Fluorite Concentrate. J Clean Prod 186:782–98.

Abraham Ighoro Ebunu, Yusuf Afolabi Olanrewaju, Oghenerume Ogolo, Adelana Rasak Adetunji, Azikiwe Peter Onwualu(2021). Barite as an industrial mineral in Nigeria: Occurrence, Utilization, Challenges and Future Prospects.

Bosbach, D., Hall, C., & Putnis, A. (1998). Mineral Precipitation and Dissolution in Aqueous Solution: In-situ Microscopic Observations on Barite (001) with Atomic Force Microscopy. Chemical Geology, 151(1-4), 143–160.

Chaanda MS, Obaje NG, Moumouni A, Goki NG, Law UA (2010). Environmental impact of artisanal mining of Barytes in Azara Area, Middle Benue Trough Nigeria. J Earth Sci 4(1):38–42

Chen Z, Ren Z, Gao H, Qian Y, Zheng R (2018). Effect of Modified Starch on Separation of Fluorite from Barite Using Sodium Oleate. Physicochem Probl Mi. 228–37

David Oluwasegun Afolayan, Adelana Rasak Adetunji, Azikiwe Peter Onwualu, Oghenerume Ogolo & Richard Kwasi Amankwah (2021). Characterization of Barite Reserves in Nigeria for Use as Weighting Agent in Drilling Fluid. Journal of Petroleum Exploration and Production Technology volume 11, pp. 2157–2178

Das, S., Essilfie-Dughan, J., & Hendry, M. J. (2020). Characterization and environmental implications of selenate co-precipitation with barite. Environmental Research, 109607.

Essalhi M, Mrani D, Essalhi A, Toummite A, Ali-Ammar H (2018). Evidence of a high-quality barite in Drâa-Tafilalet region, Morocco: a nonupgraded potential. J Mater Environ Sci 9:1366–1378

Labe NA, Ogunleye PO, Ibrahim AA, Fajulugbe T, Gbadema ST (2018). Review of the occurrence and structural controls of Barite resources of Nigeria. J Degrad Min Lands Manag 3:1207–1216.
MMSD (2010) Ministry of mines and steel development: barytes exploration opportunities in Nigeria, September mineral handbook, printed at MMSD, Abuja, Nigeria, pp 3–10

Mgbemere HE, Obidiegwu EO, Obareki E (2018). Beneficiation of Azara barite using a combination of jigging, froth flotation and leaching. Niger J Technol 37(4):957–962

Nigeria Geological Survey Agency (NGSA) (2010) Baryte: exploration opportunities in Nigeria, Revised edition. Printed by Ministry of Mines and Steel Development, Abuja, pp 1–14.

Nigeria Geological Survey Agency (2011). Mineral Resources Inventory of Gold, Barite, Gypsum and bentonite.
Oden MI (2012) Barite veins in the benue trough: field characteristics, the quality issue and some tectonic implications. Environ Nat Resour Res 2(2):26

Onwualu AP, Inyang AE, Olife IC, Obassi E (eds) (2013) Unlocking the potentials of Nigeria's non-oil sector. Raw Materials Research and Development Council, Nigeria

Onwualu, A. P., Olife, L.C., E. Inyang, A (2013a). Raw Materials Developmemt for the Transformation of Manufacturing Section in Nigeria. RMRDC, Abuja, Nigeria.

Tanko IY, Adam M, Shettima B (2015) Petrology and geochemistry of barite mineralisation around Azara, North Central Nigeria. Int J Sci Tech Res 4(5):1. ISSN 2277-8616 44.
Ulusoy, U. (2019). Quantifying of Particle Shape Differences of Differently Milled Barite Using a Novel Technique: Dynamic Image Analysis. Materialia, 100434.

Zhijie Chena, Zijie Rena,b, Huimin Gao, Renji Zheng, Yulin Jinc, Chunge Niu(2019). Flotation Studies of Fluorite and Barite with Sodium Petroleum Sulfonate and Sodium Hexametaphosphate; JMAT ER R E S T E CHNOL. 2 0 1 9;8(1):1267–127