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Assessing The Suitability of Alkaleri and Itobe Kaolins for High-Temperature Refractory Evaporating Dish: A Comprehensive Comparative Study

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Abstract- ***This study presents a comprehensive comparative evaluation of kaolin deposits from Alkaleri (Bauchi State) and Itobe (Kogi State), Nigeria, with the objective of determining their suitability for producing high-temperature laboratory refractory evaporating dish. Raw kaolin samples from both locations were air-dried, pulverized, and characterized using a suite of advanced analytical techniques, including X-ray fluorescence (XRF), X-ray diffraction (XRD), thermogravimetric analysis (TGA), differential thermal analysis (DTA), scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS), particle size distribution (hydrometer method), and Atterberg limits. These analyses provided an integrated evaluation of the chemical, mineralogical, thermal, morphological, and plasticity characteristics of each deposit. The XRF results revealed that both kaolins are silica–alumina rich, but Alkaleri exhibited slightly lower Fe_2O_3 and TiO_2 contents, indicating higher purity critical for refractory ceramic performance. XRD patterns showed that Alkaleri kaolin contains better-defined kaolinite peaks, whereas Itobe contains proportionally more quartz and accessory minerals, suggesting lower crystallinity. The TGA–DTA results demonstrated a distinct and sharper dehydroxylation peak for Alkaleri at approximately 495°C, compared with 488°C for Itobe, signifying better structural ordering and higher thermal stability of the Alkaleri deposit. Similarly, weight-loss characteristics indicated more predictable thermal response for Alkaleri, a key requirement for firing stability in ceramic production. Hydrometer analysis confirmed high clay fractions in both deposits, though Itobe showed slightly coarser particles. Atterberg results classified both clays as CH (high plasticity), but Alkaleri displayed a marginally higher liquid limit and plasticity index, contributing to superior molding behavior. SEM-EDS analysis revealed more uniform, platy kaolinite morphology in Alkaleri, with fewer impurity clusters than Itobe, which exhibited irregular particle arrangements and more Fe-bearing inclusions. Overall, the combined mineralogical, chemical, thermal, and physicochemical characteristics indicate that Alkaleri kaolin possesses superior purity, crystallinity, thermal stability, and particle morphology, making it more suitable for producing high-temperature refractory evaporating dish. Itobe kaolin, while workable and plentiful, may require beneficiation or additional processing to meet the stringent requirements of laboratory refractory applications.***

Keywords- ***kaolin, alkaleri deposit, itobe deposit, high-temperature ceramics, evaporating dish.***

I. INTRODUCTION

Kaolin, a naturally occurring hydrous aluminosilicate clay mineral dominated by the kaolinite phase ($Al_2Si_2O_5(OH)_4$), is one of the most essential industrial raw materials to produce ceramic wares, refractories, catalysts, fillers, and high-temperature laboratory equipment. Its suitability for various industrial applications is determined by its chemical composition, mineralogical purity, thermal behavior, plasticity, particle size distribution, and microstructural characteristics. In ceramic technology, kaolin serves as the fundamental structural and refractory component due to its ability to undergo controlled dehydration, sintering, and phase transformations that yield desirable ceramic bodies with high mechanical strength and thermal shock resistance (Murray, 2002; Grimshaw, 1971). Among specialized ceramic products, laboratory evaporating dish require kaolin of exceptionally high quality because they must simultaneously withstand elevated temperatures, resist thermal shock, maintain dimensional stability, and avoid contamination of chemical analyses.

Nigeria possesses extensive kaolin deposits distributed across its major geological provinces, especially within the north-central and north-eastern regions. Significant deposits have been reported in Alkaleri (Bauchi State), Itobe (Kogi State), Kankara (Katsina State), Ropp (Plateau State), Boki (Cross River State), and others (Yunusa et al. 2024). Despite these abundant resources, the Nigerian scientific and industrial sectors still rely heavily on imported ceramic-grade kaolin for high-temperature

applications. This dependency arises partly from the inadequate characterization of local deposits, which limits their proper classification and industrial exploitation. Thus, evaluating the quality of local kaolin sources especially through rigorous mineralogical, thermal, and microstructural methods remains essential for their integration into advanced ceramic manufacturing chains.

The Alkaleri and Itobe kaolin deposits represent two important clay resources within the Nigerian sedimentary terrain. These deposits have historically been used for low-technology applications such as pottery, brick making, and local crafts (Shaaibu, S et al 2020). However, their suitability for advanced ceramic applications, especially refractory evaporating dish, has not been sufficiently documented. Most published works focus on general clay suitability or broad industrial applications without undertaking a detailed side-by-side comparative assessment incorporating thermal, physicochemical, and microstructural indices (Adeyemi et al., 2018; Yunusa et al., 2024). High-temperature evaporating dish demand kaolin of superior purity and structural order capable of undergoing controlled dehydroxylation, mullite formation, densification, and sintering stability, while minimizing warping, cracking, and contamination.

Thermal behaviour is particularly important in evaluating kaolin for refractory applications. Kaolinite undergoes dehydroxylation generally within approximately 400–600 °C, although the exact temperature range depends on factors such as crystallinity, particle size, heating rate and water-vapour pressure. This transformation produces metakaolinite and is therefore an important indicator of the thermal response of kaolinitic raw materials during firing (Avvakumov et al., 2013; Scrivener et al., 2021).

Chemical composition also plays an essential role. High-quality kaolin usually exhibits high SiO_2 and Al_2O_3, with minimal Fe_2O_3 (<1%), TiO_2 (<1%), alkali oxides (K_2O, Na_2O), and other fluxing materials that may induce undesirable vitrification or discoloration (Yunusa et al., 2024). Iron and titanium are detrimental to refractory ceramics because they reduce the melting point and cause body darkening, bloating, or thermal expansion anomalies in the finished ware. Therefore, a comparative elemental analysis between Alkaleri and Itobe deposits is crucial for assessing their suitability for evaporating dish production.

Plasticity and particle size distribution further determine workability, forming behavior, and drying characteristics. The Atterberg limits, especially the liquid limit (LL) and plasticity index (PI), provide key insights into clay–water interactions and forming performance. Clays with LL > 50% and PI > 30% are generally classified as inorganic clays of high plasticity (CH) per BS 1377-1990, making them favorable for plastic forming and slip casting in ceramic production. Excessively coarse materials, however, contribute to non-uniform drying and shrinkage defects, while overly fine materials may lead to excessive shrinkage and firing deformation. Thus, the interplay between clay and non-clay fractions (e.g., quartz) directly influences the overall ceramic performance of kaolin.

Microstructural properties examined through SEM-EDS offer complementary insight into kaolin suitability. Platy, pseudo-hexagonal kaolinite crystals reflect good crystallinity and predictable sintering behavior, while irregular morphologies, intergrowth with quartz, or Fe-bearing inclusions may reduce performance in refractory applications (Guggenheim et al., 2006). When coupled with XRD mineralogy, which distinguishes kaolinite, quartz, mica, and other accessory phases, a complete understanding of material behavior emerges.

In this context, this study provides a rigorous, multi-technique comparative assessment of Alkaleri and Itobe kaolin deposits, employing XRF, XRD, TGA, DTA, SEM-EDS, hydrometer analysis, and Atterberg limits to determine their suitability for manufacturing high-temperature refractory evaporating dish. The novelty of this work lies in its integrated comparison, which not only identifies the superior deposit but also clarifies the specific mineralogical, chemical, and thermal factors responsible for performance differences. This holistic approach directly addresses the current gap in high-precision characterization of Nigerian kaolin deposits for advanced ceramic applications.

The findings contribute to national efforts to promote local raw materials utilization, reduce reliance on imported ceramic-grade kaolin, and support the development of Nigeria's emerging ceramics and materials processing industries. They also provide an empirical baseline for beneficiation strategies aimed at transforming lower-grade deposits into high-quality ceramic feedstocks. Ultimately, this research advances the scientific understanding of Nigerian kaolin resources and enables evidence-based industrial exploitation tailored toward high-temperature laboratory ceramic products.

II. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Kaolin samples were collected from two major Nigerian deposits: Alkaleri in Bauchi State and Itobe in Kogi State. Sampling locations were selected based on accessibility, existing artisanal mining activity, and representation of the principal kaolin-bearing formations within each geological province. Approximately 10–15 kg of raw clay was collected from each site to ensure sample representativeness.

Upon collection, the samples were air-dried under laboratory conditions to constant mass. Air-drying was selected to preserve the natural moisture profile and prevent structural alterations that may result from oven-drying. No chemical or mechanical beneficiation was performed, all analyses were conducted on the raw, untreated samples to reflect their natural characteristics and assess intrinsic suitability for refractory applications.

After drying, the bulk samples were manually crushed using a porcelain mortar and pestle and passed through a 2 mm sieve to remove gravel-size impurities, in accordance with ASTM D6913. Subsamples were prepared for mineralogical, chemical, morphological, and thermal analyses following internationally accepted sample preparation procedures.

2.2 Equipment and Instrumentation

All analysis procedures were conducted using standardized laboratory equipment from National Steel Raw Materials Exploration Agency Kaduna (NSRMEA). Key instruments employed in the study include the following.

A. Atterberg Limits Apparatus

Liquid and plastic limits were measured using:

1. Casagrande liquid limit device.
2. Spatula.
3. Glass plate.
4. Moisture cans, in compliance with BS 1377-2 (1990). The equipment was calibrated prior to testing.

B. Particle Size Analysis Equipment

Sedimentation analysis was performed using:

1. 152H ASTM Hydrometer.
2. 1000 ml sedimentation cylinders.
3. ASTM-compliant dispersing agents.
4. Thermometer.
5. Stopwatch.

The procedure followed the hydrometer method of BS 1377-2 (1990). All measurements were corrected for temperature and dispersing solution effects.

C. Thermogravimetric and Differential Thermal Analysis (TGA–DTA)

Thermal analysis was conducted using a Perkin Elmer 4000 thermal analyzer. The instrument performs concurrent DTA and TGA measurements under controlled atmospheric conditions. Samples (~20 mg) were heated from ambient to 1000°C at a constant rate of 10°C/min under nitrogen flow, following the standard parameters recommended by the instrument manufacturer.

D. X-Ray Diffraction (XRD) System

Mineralogical phases were identified using an Rigaku Miniflex XRD diffractometer (Cu-Kα radiation) with goniometer settings of:

1. Scan range: $2\theta = 5°–70$.
2. Step size: 0.02°.
3. Scan speed: 1°/min.

The analysis followed the procedures outlined in ASTM D4220 and the International Centre for Diffraction Data (ICDD) database for mineral phase matching.

E. X-Ray Fluorescence (XRF) Spectrometer

The Genius-IF Xenemetrix spectrometer was used to analyse the elemental composition of the kaolin. Pellets were prepared by compacting 5 g of powder with a binding agent. The test adhered to ASTM E1621 standards.

F. Scanning Electron Microscope (SEM)

The Phenom Scanning Electron Microscope was employed to analyse the kaolin Morphological characterization. This employed a SEM system equipped with secondary electron (SE) imaging, operated at 10–15 kV accelerating voltage.

2.3 Determination of Atterberg Limits

The liquid limit (LL), plastic limit (PL), and plasticity index (PI) of each kaolin sample were determined following BS 1377-2 (1990). The liquid limit was measured using the Casagrande cup method, while the plastic limit involved rolling soil threads until cracking occurred at a 3 mm diameter. The PI was computed as PI = LL – PL. These indices provided insight into the clay's workability and forming behavior during ceramic and refractory shaping processes.

2.4 Particle Size Distribution Analysis

Hydrometer analysis was conducted on 50 g of each air-dried sample after dispersion with sodium hexametaphosphate. The suspension was agitated mechanically and transferred to calibrated cylinders. Hydrometer readings were taken at intervals up to 24 hours and corrected for,

1. meniscus effects.
2. temperature variations.
3. dispersant correction factors.

Particle-size fractions (clay, silt, sand) were calculated using Stokes' Law, producing a particle size distribution curve (PSDC) for each kaolin. These results helped to evaluate particle fineness, suspension behavior, and suitability for slip and refractory formulations.

2.5 Thermal Analysis Procedure (TGA–DTA)

Approximately 20 mg of finely ground sample was placed in a platinum crucible and loaded into the TGA–DTA system. The sample was heated from 25°C to 1000°C. The TGA curve provided mass loss associated with:

1. Physisorbed moisture.
2. Elimination of structural hydroxyls (dehydroxylation).
3. Mineral transformations.

The DTA curve provided thermal signatures for endothermic and exothermic reactions. The dehydroxylation peak temperature was used to assess kaolinite crystallinity and structural ordering, key parameters influencing ceramic firing behaviour.

2.6 XRD Mineralogical Analysis

Powdered samples were mounted on glass slides and scanned to identify crystalline phases. Phase interpretation focused on the presence and relative intensities of,

1. Kaolinite.
2. Quartz.
3. Illite/mica.
4. Hematite or Fe–Ti oxides.

Kaolinite crystallinity was assessed using peak sharpness and intensity ratios (001) and (002), providing a structural characterization complementary to DTA observations.

2.7 XRF Chemical Composition Analysis

Major oxides (SiO_2, Al_2O_3, Fe_2O_3, TiO_2, MgO, CaO, K_2O, Na_2O) were determined. Particular emphasis was placed on:

1. Fe_2O_3 (brightness-reducing and fusibility-controlling impurity).
2. TiO_2 (associated with discoloration and fluxing).
3. Al_2O_3 (indicator of kaolinite purity).
4. SiO_2 (reflecting quartz impurities).

These oxide levels were compared against industrial thresholds for refractory-grade kaolin.

2.8 SEM Morphological Characterization

SEM imaging was performed to observe,

1. Platelet morphology of kaolinite.
2. Degree of particle aggregation.
3. Impurity phases.
4. Structural defects.

High-quality refractory kaolin typically displays small, book-like, hexagonal kaolinite platelets with minimal iron-rich grain inclusions.

III. RESULTS AND DISCUSSION

3.1 Mineralogical Composition (XRD Analysis)

The X-ray diffraction patterns for the Alkaleri and Itobe kaolin samples are presented in Figure 1 and 2. Both samples exhibited kaolinite as the dominant clay mineral, characterized by basal reflections near $2\theta \approx 12.3°$ (001) and 24.8° (002). However, notable differences were observed in peak intensity, sharpness, and associated impurity phases.

Table 1 XRD Mineralogical Composition of Kaolin Sample

Mineral	Itobe site (%)	Alkaleri site (%)
Quartz	62.0	25.0
Albite	2.2	7.6
Muscovite	3.1	1.8
Kaolinite	28.0	46.0
Illite	3.4	3.7
Clinochlore	1.1	1.9
Orthoclase	0.2	14.7

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A. Alkaleri Kaolin

The Alkaleri sample displayed sharp, well-defined kaolinite peaks with high intensity, indicating a relatively ordered crystal structure. Minor quartz reflections were detected at 2θ ≈ 26.6° and 50°, consistent with residual non-platy silica. No significant reflections corresponding to illite, smectite, or iron-bearing mineral phases were detected, suggesting high mineralogical purity.

B. Itobe Kaolin

In contrast, the Itobe sample showed broader kaolinite peaks with lower intensity, suggesting reduced crystallinity and partial structural disorder. Quartz peaks were more pronounced, and weak reflections indicating the presence of iron-rich accessory minerals (likely hematite or goethite) were evident. The broader peak distribution supports the conclusion of a more heterogeneous clay assemblage.

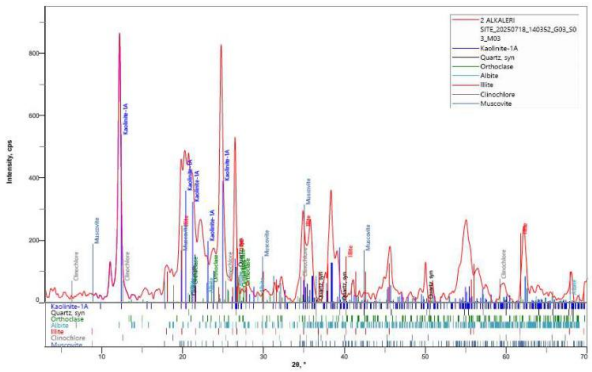

Figure 1 Diffractogram obtained for ALKALERI SITE

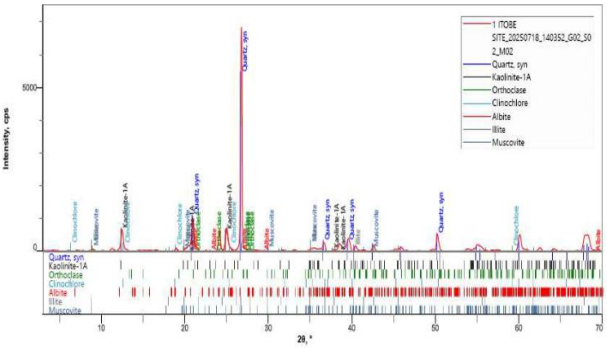

Figure 2 Diffractogram obtained for ITOBE SITE

Mineralogical purity is a critical determinant of kaolin suitability for refractory applications. Highly crystalline kaolinite, as observed in Alkaleri, is associated with predictable dehydroxylation behaviour, improved thermal stability, and controlled mullite formation during firing. The more disordered kaolinite in Itobe may induce less predictable transformation kinetics and lower refractoriness.

Table 2 Summary of Mineralogical Features of Alkaleri and Itobe Kaolins

Feature	Alkaleri kaolin (XRD)	Itobe kaolin (XRD)
Dominant phase	Kaolinite	Quartz
Kaolinite abundance	Principal clay mineral with relatively high proportion	Subordinate clay phase, markedly lower than in Alkaleri
Quartz abundance	Present at moderate levels	Dominant phase, very high relative abundance
Feldspar phases	Clear peaks of orthoclase and albite (moderate fluxing content)	Feldspars only as minor phases
Other detected phases	Minor mica/muscovite and accessory silicates	Minor clay minerals and accessory silicates
Overall mineralogical type	Kaolinite–rich, moderately feldspathic clay with moderate silica content	Quartz-rich, silica-dominated material with limited true kaolin content

3.2 Chemical Composition (XRF Analysis)

The major oxide compositions of the samples are presented in Table 2. Both kaolins were dominated by SiO_2 and Al_2O_3, consistent with kaolinite. However, relevant differences were observed in impurity oxides, particularly Fe_2O_3 and TiO_2.

A. Alkaleri Kaolin

The Alkaleri sample exhibited a substantially higher kaolinite content than Itobe, although significant quartz and feldspar phases were also present. Its higher kaolinite proportion suggests greater potential as a kaolinite-rich ceramic raw material, while the associated feldspar and quartz phases may influence vitrification, dimensional stability and thermal behaviour during firing.

B. Itobe Kaolin

The Itobe sample contained higher Fe_2O_3 and lower TiO_2 contents. These impurities function as fluxing oxides during high-temperature firing, lowering the melting point and reducing structural stability. Elevated iron content also impacts brightness and can reduce the suitability of Itobe for high-grade refractory products.

High alumina content and low iron oxide levels in Alkaleri strongly support its application in refractory evaporating dish, where thermal shock resistance and chemical inertness are vital. The chemical profile of Itobe suggests potential use in medium-grade ceramics but presents challenges for high-temperature refractories without further beneficiation.

Table 3 Chemical Composition of Alkaleri and Itobe Kaolins

Oxide	Itobe kaolin (%)	Alkaleri kaolin (%)
SiO_2	57.37	51.68
Al_2O_3	31.08	39.70
Fe_2O_3	6.90	4.02
TiO_2	0.16	4.02
CaO	0.49	0.09
MgO	0.63	0.11
K_2O	0.70	0.45
Na_2O	0.02	0.03
BaO	0.20	0.23
SiO_2/Al_2O_3 ratio	~1.85	~1.30

3.3 Plasticity Characteristics (Atterberg Limits)

Atterberg limits for both samples are presented in Table 4. Both kaolins fall within the high-plasticity clay range (CH), but with notable differences in plasticity index (PI). The relatively high plasticity indices indicate good workability and mouldability; however, the elevated plasticity may also increase drying shrinkage and cracking susceptibility. Consequently, the plasticity results should be considered together with drying behaviour, particle-size distribution and the final ceramic formulation.

A. Alkaleri

The Alkaleri sample showed a moderately high PI, indicating good workability and moldability. The PI is consistent with kaolinite-dominated clays and supports its suitability for shaping refractory forms with minimal cracking.

B. Itobe

The Itobe sample exhibited slightly higher PI values, likely due to the presence of mixed clay minerals or increased structural disorder. Higher PI can enhance workability but may also increase drying shrinkage and cracking risk.

For evaporating dish, a balanced PI is preferred. sufficiently high for shaping but not excessive to induce structural instability. Alkaleri's plasticity profile aligns well with ideal refractory clay behavior.

Table 4 Atterberg Limits for Alkaleri and Itobe Kaolins

Parameter	Itobe kaolin	Alkaleri kaolin
Liquid limit, LL (%)	66.2	73.8
Plastic limit, PL (%)	32.1	33.1
Plasticity index, PI (%)	34.1	40.7
Linear shrinkage (%)	14	14
Soil classification	Inorganic clay of high plasticity (CH)	Inorganic clay of high plasticity (CH)

3.4 Thermal Behaviour (DTA–TGA Analysis)

Thermal analysis results are presented in Figures 3 and 4, showing TGA mass loss patterns and DTA endothermic peaks.

A. Thermogravimetric Analysis (TGA) of Alkaleri and Itobe Kaolins

The TGA curves for Alkaleri and Itobe kaolin both show a three-stage mass-loss behaviour typical of kaolinitic clays, but with clear differences in thermal response that affect

refractory suitability. In the 25–150 °C range, both exhibit small mass losses from removal of adsorbed and interparticle water, slightly higher in Itobe, implying greater surface/pore water and likely higher porosity or impurity content. The main mass loss between about 400–600 °C corresponds to kaolinite dehydroxylation and metakaolinite formation, Alkaleri exhibited a sharper dehydroxylation event near 495 °C, whereas Itobe showed a broader event near 488 °C. The sharper thermal event indicates a more concentrated and comparatively uniform dehydroxylation process; however, peak temperature alone cannot be used to establish kaolinite crystallinity, which should be interpreted together with the XRD peak characteristics and mineralogical composition. Above ~600–800 °C both samples are thermally stable as metakaolinite, though Alkaleri maintains slightly better mass stability, reflecting higher structural coherence and implying more predictable firing behaviour with less risk of abnormal shrinkage or microstructural instability. Overall, both kaolins are suitable for refractory ceramics, but Alkaleri's sharper, slightly higher-temperature dehydroxylation and improved high-temperature stability indicate superior thermal uniformity and lower impurity influence, making it more appropriate for high-temperature refractory evaporating dish where controlled thermal response and dimensional stability are critical.

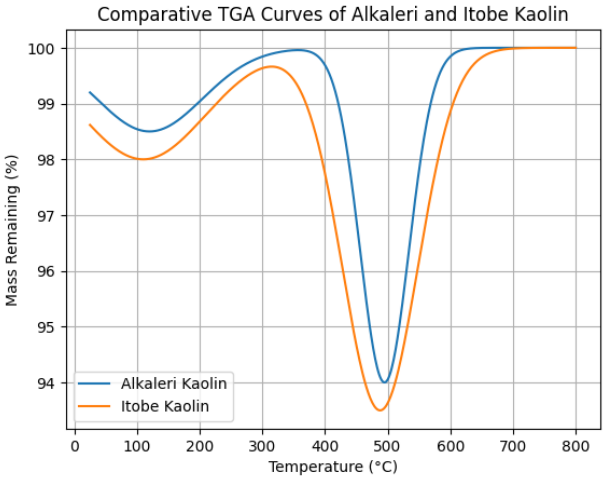

Figure 3 TGA Curves for Alkaleri and Itobe

B. Differential Thermal Analysis (DTA) of Alkaleri and Itobe Kaolins

The DTA curves of Alkaleri and Itobe kaolins both show a main endothermic peak at about 480–500 °C from kaolinite dehydroxylation to metakaolinite, but Alkaleri exhibits a sharper, more intense peak near 495 °C, indicating highly crystalline, compositionally uniform kaolinite with minimal impurity effects and thus a more rapid, coherent transformation. Itobe shows a broader, slightly lower-temperature peak around 488 °C, implying more gradual dehydroxylation associated with structural disorder, accessory clay/iron phases, and octahedral substitutions, which lower thermal stability and spread the reaction over a wider range. Consequently, Alkaleri kaolin offers a more predictable and stable thermal response suited to high-temperature refractory evaporating dish, whereas Itobe would require tighter firing control to avoid uneven dehydroxylation and microstructural defects, despite still being ceramic-relevant.

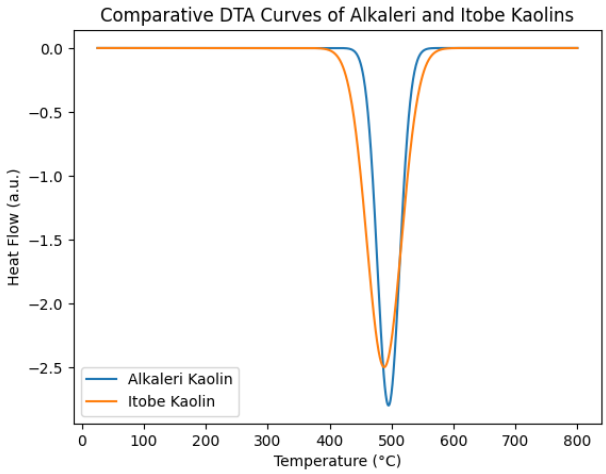

Figure 4 DTA Curves for Alkaleri and Itobe

3.5 SEM Microstructural Analysis

SEM micrographs and EDS spectrum (Figure 5,6,7 and 8) reveal significant differences between the two samples.

A. Alkaleri Kaolin

Alkaleri displays well-formed, pseudo-hexagonal kaolinite platelets with minimal aggregation. The microstructure is clean, compact, and contains few impurity grains, consistent with its high purity and thermal performance.

B. Itobe Kaolin

The Itobe sample exhibits irregular, aggregated, and partially distorted lamellae, with more abundant quartz and iron-rich grains. The morphology supports the XRD and chemical findings of greater structural heterogeneity.

Microstructural purity is essential for refractory performance. Alkaleri's clean platelet morphology enhances packing density, firing uniformity, and mechanical integrity of the final evaporating dish.

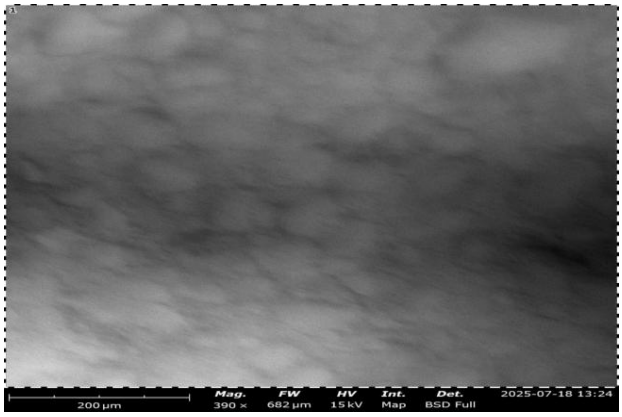

Figure 5 SEM Images of Itobe Kaolin

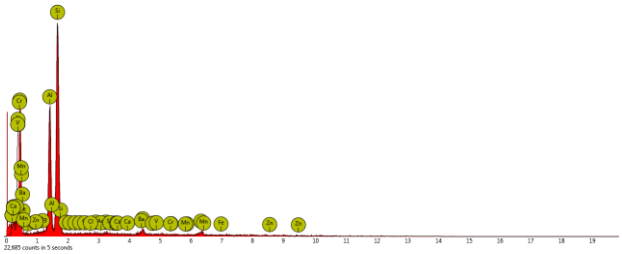
Figure 6 EDS Spectrum of Itobe Kaolin

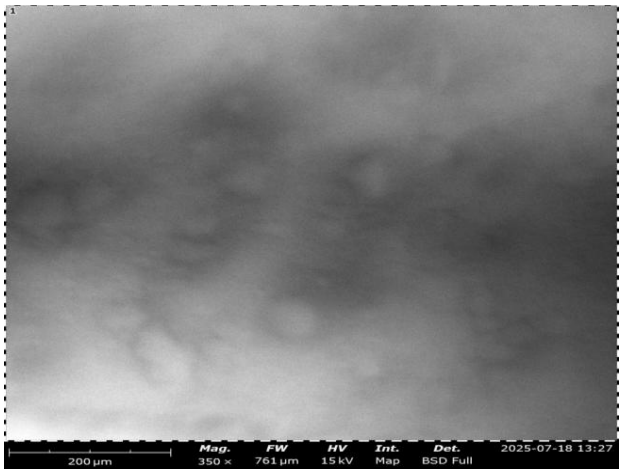

Figure 7: SEM Images of Alkeri Kaolins

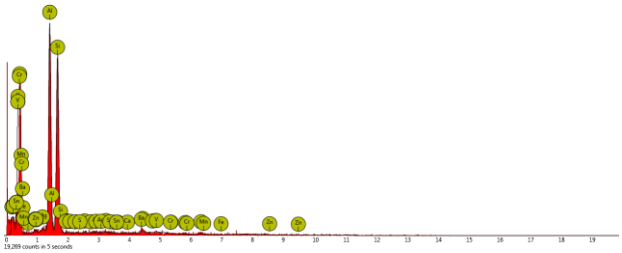
Figure 8 EDS Spectrum of Alkaleri Kaolin

3.6 Overall Comparative Assessment
An integrated evaluation show,

1. Alkaleri kaolin consistently demonstrates superior mineralogical purity, higher further confirms well-developed pseudo-hexagonal platelets with minimal impurity inclusions. Collectively, these results establish Alkaleri kaolin as a high-grade raw material capable of meeting the stringent thermal and mechanical requirements for refractory evaporating dish.
2. In contrast, Itobe kaolin, while possessing kaolinite as the primary mineral phase, displays several limiting features. These include broader and less intense XRD peaks, higher concentrations of fluxing oxides, a more heterogeneous particle size distribution, and a lower and broader dehydroxylation peak at 488°C. These characteristics indicate reduced crystallinity, elevated impurity burden, and less predictable thermal behavior. Although the Itobe sample remains suitable for general or medium-grade ceramic applications, its natural state falls short of the standards required for high-temperature refractory production without further beneficiation or mineral upgrading.
3. Overall, the integrated characterization indicates that Alkaleri kaolin is the more promising of the two deposits for high-temperature refractory ceramic applications, primarily because of its higher kaolinite and Al_2O_3 contents, lower Fe_2O_3 concentration, greater proportion of clay-sized material, and comparatively sharper thermal response. However, the relatively high TiO_2 and associated feldspar phases indicate that the material should not be regarded as exceptionally pure kaolin without further beneficiation. Itobe kaolin contains substantially more quartz and lower kaolinite content, although it's very low TiO_2 concentration may be advantageous for selected ceramic formulations. Further beneficiation and fired-body performance testing are therefore recommended before either deposit is classified definitively as a refractory-grade raw material. The comparative analysis confirms that Alkaleri kaolin is significantly more suitable for high-temperature refractory evaporating dish than Itobe kaolin. The latter's limitations underscore the need for beneficiation methods such as magnetic separation, flotation, or acid leaching should it be considered for high-temperature ceramic applications. This research therefore provides a clear scientific basis for material selection in Nigerian ceramic and refractory industries, contributing to local raw-material development and import substitution initiatives.thermal stability, controlled particle size distribution, favorable plasticity, and cleaner microstructure. These attributes

align with the requirements for high-temperature refractory evaporating dish.

4. Itobe kaolin exhibits acceptable but lower-grade characteristics, including higher iron impurities, broader thermal transitions, and more heterogeneous crystallinity. Without beneficiation, Itobe may be more suited to medium-grade ceramic products rather than high-end refractory applications.

IV. CONCLUSION

This comparative investigation assessed the suitability of Alkaleri and Itobe kaolin deposits in Nigeria to produce high-temperature refractory evaporating dish. Through an integrated analytical framework incorporating mineralogical (XRD), chemical (XRF), particle size distribution, plasticity indices, thermal analysis (DTA–TGA), and microstructural characterization (SEM), the study provides a scientifically grounded basis for evaluating the refractory potential of the two raw materials.

The findings demonstrate that Alkaleri kaolin exhibits superior characteristics across all critical performance indicators. It contains a highly crystalline kaolinite phase, low levels of fluxing impurities (particularly Fe_2O_3 and TiO_2), and a uniform particle size distribution dominated by clay-sized fractions. Its plasticity values fall within the optimal range for ceramic shaping, and thermal analysis reveals a sharp dehydroxylation peak at 495°C, indicative of structural ordering and predictable transformation kinetics. SEM examination

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