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Geochemistry, Origin and Industrial Applications of Kaolin from Getso, Kano State, Northwestern Nigeria.

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Abstract

This study investigates the major and trace-element geochemistry of the Getso kaolin deposit with the aim of constraining its origin and evaluating its industrial potential. The study area is underlain predominantly by low-lying mica schist and psammitic schist, with minor quartzite occurrences confined to the southeastern part near Getso town. These schistose lithologies have undergone intense tropical weathering, resulting in the development of thick regolith profiles composed mainly of kaolin and lateritic clay. Geochemical analyses indicate that the kaolin is enriched in SiO_2 and Al_2O_3, with concentrations ranging from 57.50–68.60 wt.% and 22.80–36.00 wt.%, respectively. In contrast, alkali and alkaline-earth oxides, particularly Na_2O and CaO, are markedly depleted, reflecting extensive leaching during prolonged chemical weathering. The Chemical Index of Alteration (CIA) varies from 71.25 to 98.76, with an average of 90.99, while the Chemical Index of Weathering (CIW) ranges from 98.94 to 99.99, averaging 99.88. These values indicate advanced weathering intensity and extensive kaolinization of the parent rocks. Trace-element distributions and elemental ratios, including elevated Al_2O_3/TiO_2 values and variable concentrations of Zr, Rb, Sr, Cr, and Ni, suggest derivation from felsic to quartz-rich metasedimentary protoliths rather than mafic sources. The elevated SiO_2 content reflects quartz dilution, whereas Fe_2O_3 and TiO_2 concentrations indicate that some samples may require beneficiation for high-brightness applications. The Getso deposit is interpreted as a residual in-situ weathering product of mica schist and psammitic schist, formed under prolonged tropical weathering conditions. The kaolin exhibits significant potential for ceramic, refractory, and filler industries, although beneficiation may be necessary for paper coating, pharmaceutical, and other high-whiteness applications.

Keywords
Kaolin;
Nigerian Basement Complex,
Malumfashi Schist Belt;
Geochemistry;
Getso,
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1. Introduction

Kaolin is one of the economically significant clay minerals with wide range of industrial applications. The increasing demand for this high-quality clay mineral use in the manufacture of ceramics, paper coating and filling, paints, rubber, plastics, pharmaceuticals, catalysts and cosmetics has stimulated considerable interest in understanding the mineralogical and geochemical characteristics that control its genesis, beneficiation requirements, and industrial suitability (Murray, 2007; Dill, 2016). Recent studies have further highlighted the significance of kaolin deposits as potential repositories of rare earth elements (REEs), zirconium, lithium, and other critical raw materials, thereby expanding their economic importance beyond traditional industrial uses (Boxleiter et al., 2023; Abedini and Khosravi, 2025; Aljabbab et al., 2025).

Economically important kaolin deposits typically originate through a variety of geological processes, including residual weathering, hydrothermal alteration, supergene enrichment, and diagenetic transformation of aluminosilicate precursor minerals (Dill, 2016). In tropical and subtropical environments, prolonged chemical weathering of feldspar-rich rocks commonly results in the formation of thick kaolinitic profiles through progressive hydrolysis and leaching of alkali and alkaline-earth elements (Abedini and Khosravi, 2025). Hydrothermal kaolin deposits, on the other hand, are produced by the interaction of acidic fluids with feldspar-bearing rocks, often generating mineral assemblages distinct from those formed by weathering processes (Dill, 2016; Abedini and Khosravi, 2025).

Major- and trace-element geochemistry provides valuable information regarding the origin, weathering history, and potential of kaolin deposits. During kaolinization, mobile elements such as Ca, Na, K, and Mg are progressively removed, whereas relatively immobile elements including Al, Ti, Zr, Hf, Nb, Th, and the rare earth elements tend to be retained or residually enriched. Consequently, the distribution of these elements can be used to evaluate weathering intensity, provenance, and alteration processes. (Hayashi et al., 1997; Abedini and Khosravi, 2025).

In addition to their genetic significance, major and trace elements exert a strong influence on the industrial quality of kaolin. High Al_2O_3 contents are generally desirable for ceramic and refractory applications, whereas elevated concentrations of Fe_2O_3, TiO_2, MnO, and other colouring oxides adversely affect brightness, whiteness, and firing behaviour. Consequently, detailed geochemical characterization is necessary not only for understanding deposit genesis but also for evaluating suitability for industrial applications and determining beneficiation requirements (Dill, 2016).

Nigeria hosts numerous kaolin occurrences distributed across both the Precambrian Basement Complex and the sedimentary basins. Many of these deposits are associated with tropical weathering profiles developed on granitic, gneissic, schistose, and sedimentary parent rocks (Wright et al., 1985). Despite their economic importance, many Nigerian kaolin deposits remain poorly characterized in terms of trace-element geochemistry, weathering intensity, provenance, and genetic evolution.

Accordingly, the present study investigates the major- and trace-element geochemistry of the Getso kaolin deposit in order to constrain its genesis and evaluate its industrial potential. Specifically, the objective of the are to:

(i) characterize the major- and trace-element composition of the kaolin;

(ii) (ii) determine the provenance and nature of the parent materials using immobile-element geochemistry; (iii) evaluate the geochemical processes responsible for kaolinization; and (iv) assess the suitability of the deposit for industrial applications. The results contribute to the growing database of African kaolin deposits and provide new insights into the evolution of residual kaolin deposits developed within the metasedimentary belts of the Nigerian Basement Complex.

2. Geological Setting of the Getso Kaolin Deposit

The Getso kaolin deposit is located within Gwarzo Local Government Area of Kano State, northwestern Nigeria, and forms part of the Malumfashi Schist Belt. The Malumfashi Schist Belt is one of the eleven recognized schist belts of western and northwestern Nigeria and consists predominantly of metasedimentary rocks that have undergone low- to medium-grade regional metamorphism during the Pan-African Orogeny (Turner, 1983; Ajibade et al., 1987). Unlike several kaolin occurrences elsewhere in Nigeria that have been linked to granitic or volcanic parent rocks, field observations indicate that the Getso deposit is developed principally on metasedimentary schistose rocks belonging to the Malumfashi Schist Belt. The geology of the study area is dominated by low-lying schist with subordinate quartzite **(Fig. 1)**. The schistose rocks constitute the most extensive lithological unit and occur mainly as mica schist and psammitic schist. The mica schist is characterized by abundant muscovite, biotite, and quartz, whereas the psammitic schist is relatively quartz-rich and represents metamorphosed sandy sedimentary precursors. The quartzite occurs as isolated ridges and resistant outcrops and is largely restricted to the southeastern part of the study area around Getso town.

One of the most distinctive geological characteristics of the Getso area is the extensive weathering of the schistose bedrock. Both the mica schist and psammitic schist have been altered to thick regolith profiles comprising lateritic clay, kaolinitic clay, and weathered saprolite.

In many parts of the study area, weathering has progressed to such an extent that fresh bedrock exposures are scarce, and original mineralogical textures have been largely obliterated. Consequently, fresh schist samples suitable for petrographic and whole-rock geochemical analysis were largely unavailable during field investigations.

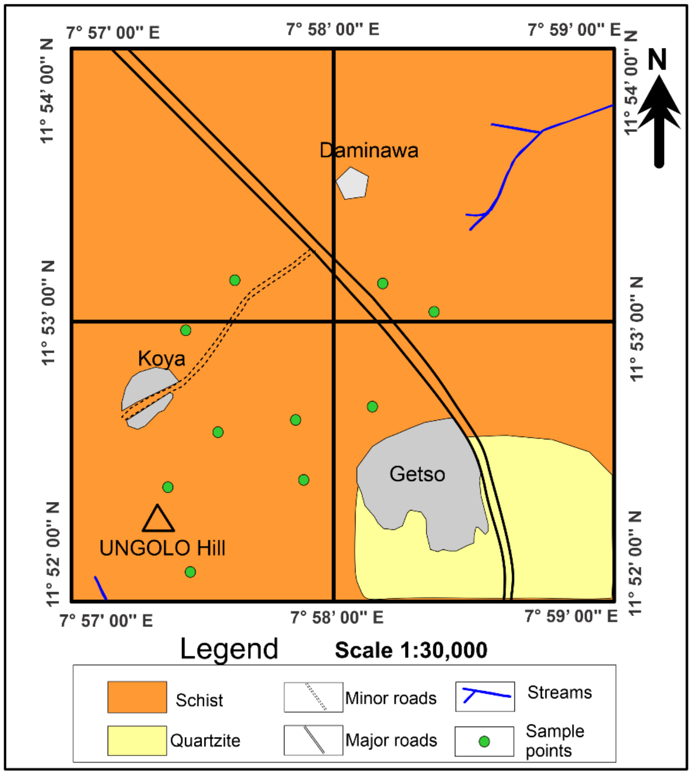

Figure 1: Geological map of Getso

3. Methodology

Field investigations were conducted within the Getso kaolin deposit located in Gwarzo Local Government Area, Kano State, northwestern Nigeria. Geological mapping was undertaken to identify lithological variations, weathering characteristics, structural features, and the spatial distribution of kaolinized zones. Particular attention was given to documenting the relationship between the kaolin deposit and the underlying schistose parent rocks of the Malumfashi Schist Belt. Representative kaolin samples were collected from active and abandoned exposures distributed across the deposit.

Prior to sampling, the uppermost weathered surface and organic-rich materials were removed to minimize contamination. Samples were obtained from fresh kaolinitic horizons exposed within pits, trenches, and natural outcrops. Variations in colour, texture, and degree of weathering were considered during sample selection to ensure that the collected materials adequately represented the geochemical variability of the deposit.

The collected kaolin samples were air-dried and subsequently oven-dried at approximately 105°C to remove moisture. Dried samples were manually disaggregated and homogenized before crushing. The samples were then pulverized using an agate mill to obtain fine powders passing a 75 µm sieve. Pulverization was carried out using non-contaminating equipment to avoid the introduction of extraneous elements. The powdered samples were thoroughly mixed and stored in airtight containers prior to analysis. Homogenization was undertaken to ensure that the analysed aliquots were representative of the bulk samples. Similar preparation procedures have been widely adopted in studies of kaolin and clay mineral deposits because they minimize analytical variability and improve reproducibility (Murray, 2007; Dill, 2016). Major oxide and trace element concentrations were determined using X-ray fluorescence spectrometry (XRF). For major-element analysis, representative aliquots of pulverized samples were fused with lithium tetraborate flux to produce homogeneous glass beads. Trace-element concentrations were determined using pressed powder pellets prepared from finely ground sample powders.

4. Results

4.1 Major Element Geochemistry

The major oxide compositions of the Getso kaolin samples are presented in **Table 1.** The analysed samples exhibit considerable variation in major oxide concentrations, reflecting differences in mineralogical composition and weathering intensity within the deposit. Silica (SiO_2) is the most abundant oxide, ranging from 57.50 to 68.60 wt.% with an average value of approximately 63 wt.%. Alumina (Al_2O_3), the second most abundant oxide, ranges from 22.80 to 36.00 wt.% with an average value of approximately 30 wt.% **(Table 1).** The elevated SiO_2 and Al_2O_3 contents indicate that the kaolin is composed predominantly of kaolinite and quartz. The inverse relationship observed between SiO_2 and Al_2O_3 suggests variable quartz enrichment within the deposit. Iron oxide (Fe_2O_3) concentrations range from 0.269 to 4.25 wt.%, whereas TiO_2 contents vary between 0.022 and 0.38 wt.%.

The relatively low concentrations of these colouring oxides indicate generally moderate impurity levels within the deposit, although some samples contain elevated Fe_2O_3 values. Manganese oxide (MnO), magnesium oxide (MgO), calcium oxide (CaO), sodium oxide (Na_2O), potassium oxide (K_2O), and phosphorus pentoxide (P_2O_5) occur in relatively low concentrations. The alkali and alkaline-earth oxides are generally depleted. CaO varies from 0.001 to 0.636 wt.%, while Na_2O ranges from 0.0002 to 0.136 wt.%. Potassium oxide exhibits greater variability, ranging from 0.357 to 10.10 wt.%.

The elevated K_2O values recorded in some samples indicate the persistence of potassium-bearing phases within portions of the weathering profile. Overall, the major-element composition of the Getso kaolin is characterized by enrichment in SiO_2 and Al_2O_3 and depletion of CaO and Na_2O, indicating advanced alteration of the parent materials.

Table 1: Major Elements composition of Getso Kaolin

Samples	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	Fe2O3	CIA	CIW
S 001	0.001	0.002	31.1	60.9	2.06	0.357	0.202	0.238	0.002	4.25	98.76	99.99
S 002	0.001	0.001	31.2	61.7	2.28	1.83	0.636	0.0822	0.001	1.42	94.02	99.99
S 003	0.001	0.001	33	58.4	1.95	1.19	0.279	0.309	0.002	4.23	96.23	99.99
S 004	0.001	0.001	32.4	60.7	2.01	1.55	0.269	0.271	0.0089	2.11	95.07	99.99
S 005	0.001	0.002	33.7	58.7	2.0	1.1	0.316	0.38	0.002	3.43	96.58	99.99
S 006	0.001	0.002	22.8	68.6	1.88	3.69	0.327	0.248	0.0083	1.78	85.08	99.99
S 007	0.001	0.002	24.1	66.8	1.81	4.34	0.306	0.227	0.0063	1.7	83.68	99.99
S 008	0.001	0.001	27.1	59.4	1.93	10.1	0.343	0.023	0.001	0.416	71.25	99.99
S 009	0.001	0.001	32.1	57.5	1.95	3.4	0.556	0.316	0.0077	3.32	89.71	99.99
S 010	0.001	0.002	29.9	64.3	2.07	1.31	0.397	0.0697	0.0044	0.96	95.46	99.99
LK002	0.121	0.258	28.9	65.3	0.0507	3.68	0.061	0.129	0.0079	1.37	87.07	98.94
HK004	0.001	0.001	32.4	65.7	0.128	1.09	0.028	0.0446	0.0175	0.473	96.48	99.99
LK005	0.04	0.262	28.1	66.5	0.0506	3.48	0.001	0.11	0.0087	1.33	88.18	99.99
HK005	0.136	0.0359	36	62	0.105	1.29	0.01	0.0216	0.001	0.269	95.65	99.33
HK006	0.002	0.0486	32	65.2	0.108	1.55	0.001	0.101	0.0019	0.84	95.00	99.98
LK007	0.001	0.257	29	65.3	0.0482	3.76	0.027	0.117	0.0084	1.37	87.68	99.99

4.2 Chemical Weathering Indices

The calculated Chemical Index of Alteration (CIA) values range from 71.25 to 98.76, with an average value of 90.99 **(Table 1).** Most samples record CIA values greater than 85, indicating extensive chemical alteration of the precursor minerals. Similarly, the Chemical Index of Weathering (CIW) values range from 98.94 to 99.99, with a mean value of 99.88. The uniformly high CIW values demonstrate substantial depletion of Ca and Na relative to aluminium within the weathering profile. A comparison of CIA and CIW values shows that the CIW values are consistently higher than the corresponding CIA values **(Table 1).**

Samples displaying relatively lower CIA values are characterized by elevated K_2O contents, indicating that potassium-bearing minerals remain present within parts of the kaolinized profile. The weathering indices collectively indicate that the Getso kaolin experienced intense chemical weathering and extensive transformation of primary aluminosilicate minerals.

4.3 Trace Element Geochemistry

The trace-element concentrations of the Getso kaolin are presented in Table 2. The analysed samples contain variable concentrations of both mobile and immobile trace elements. Rubidium (Rb) ranges from 36.1 to 1820 ppm, whereas strontium (Sr) varies from 16.4 to 554 ppm **(Table 2).** Zirconium (Zr) exhibits a wide concentration range of 11.8–519 ppm. Chromium (Cr) concentrations vary between 17 and 120 ppm, while nickel (Ni) ranges from 27.6 to 294 ppm.

The rare earth element dataset indicates measurable concentrations of light rare earth elements, particularly lanthanum (La) and cerium (Ce). Lanthanum ranges from approximately 26 to 83.7 ppm, whereas cerium ranges from 16.4 to 135 ppm. The preservation of these elements indicates that significant trace-element signatures remain within the kaolin despite extensive weathering. The trace-element data reveal considerable variability among samples, particularly for Rb, Sr, and Zr. Such variability reflects differences in the abundance of accessory minerals and the degree of weathering within the deposit.

Table 2: Trace Elements composition of the Getso Kaolin Deposits

Samples	Zr	Nb	Y	Rb	Sr	Cr	Ni	La	Ce
S 001	63.4	23.7	186	36.1	149	48.2	91.7	37	59.8
S 002	109	15.5	122	240	554	64	34.3	39	86
S 003	240	41.5	121	106	165	73.3	63	53	38
S 004	519	22.6	120	86.5	109	86.5	294	62	37.9
S 005	298	52.1	121	114	241	114	67.4	48	53
S 006	223	34.8	45.4	483	19.7	120	57.3	26	44.4
S 007	218	33.3	56.5	516	25.3	95.3	39.8	29	86
S 008	22.2	31.2	32.7	1820	88.7	89	190	72	56
S 009	77.8	7.83	35.7	310	231	51.1	36.5	54	64
S 010	213	117	196	136	549	47.7	46.9	84	135
LK002	134	24.3	35.5	352	21	39.3	39.6	29	16.4
HK004	33.4	29.4	82.1	132	110	17.6	46.6	31	24
LK005	123	24.4	28.9	341	16.4	17	27.6	30	27
HK005	11.8	13.1	46.9	119	75.2	21.9	54.2	33	25
HK006	12.7	220	42.4	367	61.6	20.3	42.2	32	23
LK007	143	25.4	36.4	368	26.8	31.2	39.8	35	29

5. Discussion

5.1 Role of Chemical Weathering in Kaolinization Process in Getso

The geochemical characteristics of the Getso kaolin indicate that the deposit formed under conditions of intense chemical weathering. This interpretation is supported by the exceptionally high Chemical Index of Alteration (CIA) values (71.25–98.76; mean = 90.99) and Chemical Index of Weathering (CIW) values (98.94–99.99; mean = 99.88).

According to **Nesbitt and Young (1984)**, CIA values above 80 indicate advanced weathering, whereas values approaching 100 reflect near-complete alteration of feldspars and extensive removal of alkali and alkaline-earth elements. Similarly, Harnois (1988) noted that CIW values greater than 90 are characteristic of highly weathered regoliths developed under prolonged leaching conditions. Most of the Getso samples record CIA values exceeding 85, indicating advanced kaolinization and substantial destruction of primary aluminosilicate minerals. The consistently high CIW values further suggest near-complete removal of Ca and Na from the weathering profile. Such depletion is characteristic of mature kaolinitic weathering systems where plagioclase feldspars have undergone extensive hydrolysis and dissolution (Nesbitt and Young, 1984; Fedo et al., 1995).

The weathering trend observed on the A–CN–K diagram supports this interpretation **(Figure 2).** Most samples plot close to the Al_2O_3 apex, indicating progressive depletion of CaO and Na_2O and enrichment of residual aluminium. Similar trends have been reported from residual kaolin deposits in Ethiopia, Iran, Turkey, and Egypt, where intense weathering transformed feldspar-rich rocks into kaolinite-dominated assemblages (Karakaya et al., 2022; Abedini et al., 2025; Ali and Meshasha 2025). However, several samples exhibit relatively lower CIA values despite their high CIW values. This discrepancy is attributed to elevated K_2O concentrations resulting from the persistence of potassium-bearing minerals within portions of the weathering profile. Residual muscovite, illite, or incompletely altered mica may have contributed to the retention of potassium during weathering.

Similar behaviour has been documented in weathering profiles developed on mica-rich metasedimentary rocks, where K-bearing minerals commonly survive longer than plagioclase feldspars during chemical alteration (Fedo et al., 1995; Dill, 2016). Overall, the weathering indices demonstrate that the Getso kaolin represents a mature residual weathering deposit that experienced prolonged chemical leaching under tropical climatic conditions.

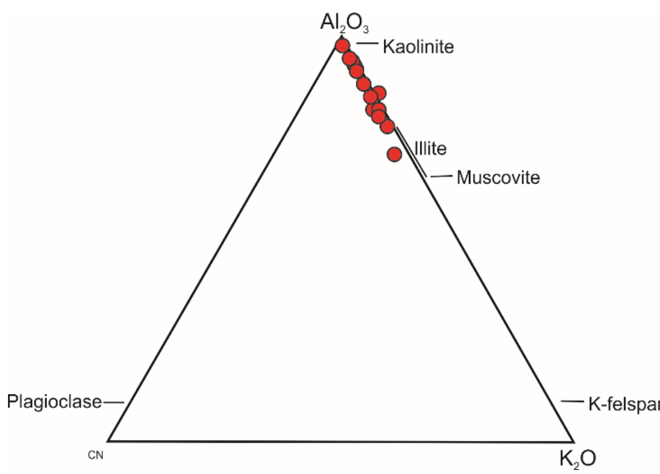

Figure 2. A–CN–K ternary diagram showing weathering trends of the Getso kaolin samples.

5.2 Provenance and Nature of the Parent Materials of Getso Kaolin

Field observations indicate that the Getso deposit is developed predominantly on mica schist and psammitic schist of the Malumfashi Schist Belt, with minor quartzite occurring in the southeastern part of the study area. The geochemical data strongly support this interpretation. The Al_2O_3/TiO_2 ratios obtained from the Getso kaolin range from 88.68 to 1666.67, significantly exceeding the threshold value of 21 proposed by Hayashi et al. (1997) for felsic source rocks. These exceptionally high ratios indicate derivation from quartz-rich and aluminium-rich parent materials rather than from mafic lithologies.

The results are therefore consistent with weathering of mica schist and psammitic schist, both of which are enriched in quartz, feldspar, and mica. Additional support for a felsic-metasedimentary source is provided by the relatively low concentrations of Cr, Ni, and TiO_2. Mafic rocks generally contain elevated concentrations of these elements because of their abundance in ferromagnesian minerals. In contrast, the low TiO_2 concentrations and high Al_2O_3/TiO_2 ratios observed in the Getso kaolin are characteristic of felsic and quartz-rich sedimentary protoliths (Taylor and McLennan, 1985; Rollinson, 1993). Futhermore, the high SiO_2 contents (57.50–68.60 wt.%) further support the contribution of quartz-rich parent rocks. The persistence of abundant quartz is consistent with the psammitic schist and subordinate quartzite exposed within the study area. Quartz is highly resistant to chemical weathering and commonly becomes residually enriched during kaolinization (Murray, 2007; Dill, 2016).

Trace-element distributions also support a metasedimentary provenance. Zirconium concentrations of up to 519 ppm suggest the concentration of resistant zircon grains during weathering. Similarly, elevated Rb concentrations correspond with high KO values and likely reflect inheritance from mica-rich precursor rocks. The strong depletion of Sr is consistent with the destruction of feldspar minerals during weathering and further supports a metasedimentary source dominated by quartz and mica. Collectively, the field and geochemical evidence indicate that the Getso kaolin was derived principally from the weathering of mica schist and psammitic schist within the Malumfashi Schist Belt rather than from volcanic or granitic parent rocks proposed for some other Nigerian kaolin occurrences.

5.3 Genesis of the Getso Kaolin Deposit

The geochemical characteristics of the Getso kaolin indicate that the deposit is a residual weathering product formed through in-situ alteration of schistose basement rocks. Several lines of evidence support this interpretation. Importantly, the deposit occurs within a deeply weathered regolith profile developed directly on mica schist and psammitic schist. Moreover, the high CIA and CIW values indicate prolonged chemical weathering and extensive leaching of mobile elements (Dill, 2016). In addition, the marked depletion of CaO and Na_2O reflects the destruction of feldspars, while the enrichment of Al_2O_3 is consistent with the formation of kaolinite. Finally, the preservation of immobile elements such as Ti, Zr, and Nb indicates residual enrichment during weathering rather than introduction by hydrothermal fluids.

The kaolinization mechanism most likely resulted from supergene process involving hydrolysis reactions affecting feldspars and micas within the schistose parent rocks **(Figure 3)**. During weathering, meteoric waters infiltrated fractures, joints, and foliation planes, promoting the dissolution of feldspars and release of alkali and alkaline-earth elements. Continued leaching resulted in the formation of kaolinite-rich horizons while resistant quartz and accessory minerals accumulated within the weathering profile (e.g Dill, 2016; Murray, 2007).

Although hydrothermal alteration is an important mechanism for kaolin formation worldwide, there is little geochemical evidence to suggest a dominant hydrothermal origin for the Getso deposit. Hydrothermal kaolins commonly display strong alteration zoning, distinctive trace-element enrichments, and close association with volcanic or intrusive centres (Abedini et al., 2025). In contrast, the Getso deposit exhibits geochemical characteristics typical of residual weathering systems developed under tropical climatic conditions. The genesis of the Getso deposit therefore resembles that of many tropical residual kaolin deposits reported from Brazil, Ethiopia, India, Iran, and West Africa, where prolonged weathering of aluminosilicate-rich rocks produced economically significant kaolinite accumulations (Murray, 2007; Nouri et al., 2020; Karakaya et al., 2022).

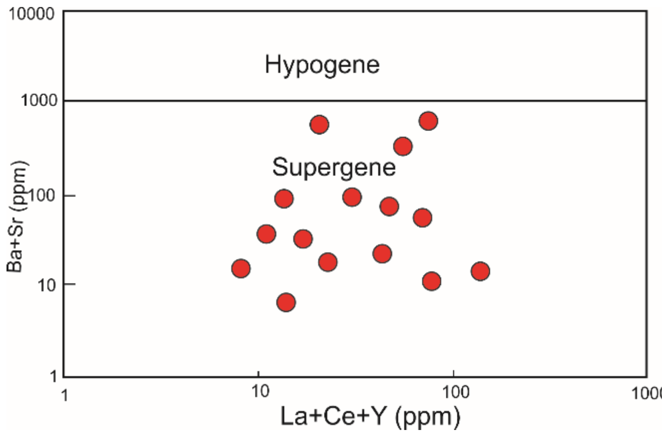

Figure 3. Ba + Sr versus Ce + La + Y discrimination diagram of the Getso kaolin

5.4 Comparison with Selected Kaolin Deposits Worldwide

The major-element composition of the Getso kaolin compares favourably with many residual kaolin deposits reported worldwide. The SiO_2 and AlO_3 contents fall within the range reported for kaolin deposits in Ethiopia, Iran, Turkey, Egypt, and the United States (Nouri et al., 2020; Karakaya et al., 2022; Abedini et al., 2025, Table 3). The weathering indices obtained from the Getso deposit are particularly noteworthy. The mean CIA value of 90.99 is comparable to values reported for highly weathered kaolin deposits developed on felsic and metasedimentary rocks in Ethiopia and northwestern Iran, where intense tropical to subtropical weathering resulted in extensive feldspar destruction and kaolinite formation (Abedini et al., 2025; Ali et al., 2025). However, the Getso kaolin generally exhibits higher SiO_2 contents than many hydrothermal kaolin deposits described in the literature **(Table 3).** This enrichment is attributed to the abundance of quartz-rich psammitic schist and subordinate quartzite within the study area. Consequently, the Getso deposit retains a stronger quartz signature than many hydrothermal kaolins developed on volcanic rocks.

Table 3: Assessment of the Industrial Suitability of the Getso Kaolin Deposit

Parameter	Getso Kaolin	Ceramic Industry	Paper Coating	Refractory	Pharmaceutical Grade
SiO_2	63.05	Acceptable	High	Acceptable	High
Al_2O_3	30.12	Suitable	Moderate	Suitable	Moderate
Fe_2O_3	3.44	Moderate	Limiting	Moderate	Limiting
TiO_2	0.16	Suitable	Moderate	Suitable	Moderate
CaO	Very low	Suitable	Suitable	Suitable	Suitable
Na_2O	Very low	Suitable	Suitable	Suitable	Suitable
Overall Assessment	Good	Suitable	Requires beneficiation	Suitable	Requires beneficiation

5.5 Industrial Implications

The geochemical composition of the Getso kaolin provides valuable information regarding its industrial potential. The relatively high AlO contents and low concentrations of CaO and NaO are favourable characteristics for ceramic and refractory applications. High alumina content generally improves refractoriness and firing performance, whereas low concentrations of alkali oxides reduce undesirable fluxing effects (Murray, 2007).

The principal limitation of the deposit is the relatively high SiO_2 content. Excess silica reflects quartz dilution and may reduce plasticity and alumina grade in certain industrial applications. Consequently, beneficiation processes such as particle-size separation and quartz removal may be necessary where high-purity kaolin products are required. Iron oxide and titanium oxide represent the most important colouring impurities within the deposit. Samples containing elevated Fe_2O_3 concentrations may produce undesirable colour changes during firing and may not satisfy the requirements for high-brightness applications such as paper coating, paint production, pharmaceuticals, and cosmetics. Beneficiation techniques including magnetic separation, froth flotation, selective flocculation, and chemical bleaching could therefore improve the industrial quality of the material (Murray, 2007; Ali et al., 2025).

Despite these limitations, the geochemical characteristics of the Getso kaolin indicate substantial potential for utilization in ceramics, refractories, structural clay products, fillers, and selected industrial applications. With appropriate beneficiation, portions of the deposit may also be suitable for higher-value applications requiring improved brightness and reduced impurity levels.

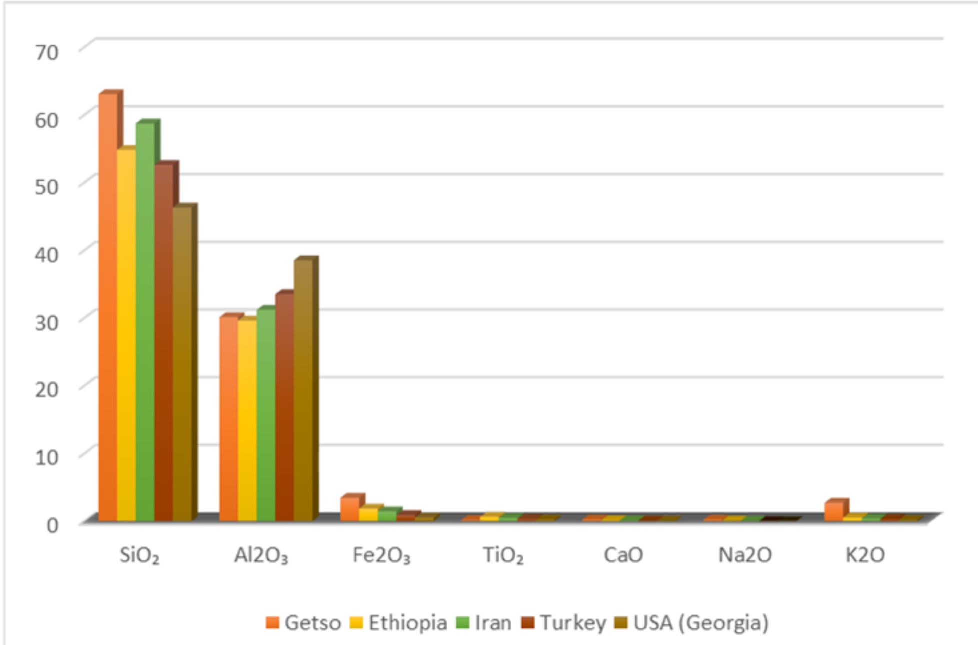

Figure 4: Comparison of the Average Chemical Composition of the Getso Kaolin with Selected Kaolin Deposits Worldwide

6.0 Conclusions

Field relationships, weathering indices, major-element chemistry, and trace-element signatures, indicate that the Getso Kaolin deposit originated through prolonged tropical weathering of mica schist and psammitic schist belonging to the Malumfashi Schist Belt.

Weathering fluids exploited fractures, joints, and foliation planes within the schistose rocks, promoting hydrolysis of feldspar and mica. Progressive leaching removed Ca, Na, and other mobile elements, while aluminium and relatively immobile trace elements accumulated within the regolith profile.

Continued weathering produced thick kaolinitic horizons enriched in kaolinite, quartz, and resistant accessory minerals such as zircon. The resulting deposit represents a mature residual kaolin system whose geochemical characteristics preserve evidence of its metasedimentary parent rocks and prolonged tropical weathering history.

From an industrial perspective, the Getso Kaolin deposit possesses several favourable characteristics, including relatively high Al_2O_3 contents and low concentrations of CaO and Na_2O. These features indicate potential suitability for ceramic, refractory, filler, and structural clay applications. However, elevated SiO_2 contents resulting from quartz enrichment and variable Fe_2O_3 concentrations may limit its direct utilization in high-whiteness applications such as paper coating, pharmaceuticals, and premium ceramic products. Beneficiation techniques aimed at reducing quartz and iron-bearing impurities are therefore recommended to improve the quality and commercial value of the deposit

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