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Aluminosity and Potassic Trends in Metasediments and Igneous Rocks of the Igarra Schist Belt: A Petrogenetic Approach Using Major Oxide Geochemistry

Modestus Chijioke Ohaegbulem[a*], Nonyelum Stella Iloanya[b], Uwem Bassey Abia[c], Michael Monday Inyang[b]

[a.] *Department of Geology, Gregory University Uturu, Abia State, Nigeria.*
[b.] *Department of Geology University of Port Harcourt, Rivers State.*
[c.] *Department of Geology Akwa Ibom State University, Mkpat Enin- Akwa Ibom State*

Abstract
Aluminosity and Potassic Trends in Metasedimentary and Igneous Rocks in the Igarra Schist Belt have been investigated. This polycyclic schist belt represents a segment of the Proterozoic Nigerian Basement Complex characterized by metasedimentary and igneous lithologies that have undergone multiple deformational episodes and metamorphism. This study was carried out in order to investigate Aluminosity and potassic trends in representative granites, gneisses, and schists samples from the study area, employing major oxide geochemical data to infer magmatic and metamorphic processes. Potassic classification using K_2O vs. SiO_2 diagram distinguishes calc-alkaline to high-K calc-alkaline trends in granitoids, while metasedimentary rocks show variable K_2O contents indicative of differential mineral breakdown and metasomatic enrichment. Alumina Saturation Index plots (A/CNK vs A/NK) classify the rocks into peraluminous and metaluminous fields, suggesting varying degrees of crustal involvement and sedimentary origin. These geochemical indices, complemented by petrographic observations, point to the role of feldspar and mica evolution during progressive metamorphism and partial melting. The data suggest significant crustal recycling, with metasedimentary components contributing to the genesis of peraluminous granitoids. This study contributes to understanding the relevance of crustal differentiation and magmatic processes in Proterozoic mobile belts.

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I. INTRODUCTION

Geochemical investigations of basement rocks in the Nigerian section of the Pan-African belt have historically focused on petrogenetic classification, tectonic setting, and crustal evolution (Rahaman, 1988; Ajibade et al., 1987; Ekwueme, 1994). However, some few studies have explicitly discussed the aluminosity and potassic behavior of coexisting metasedimentary and igneous rocks within a section of a tectonic basement domain like the Igarra schist belt. The Igarra Schist Belt, which is situated in the eastern flank of southwestern Nigeria, is a key component of the Precambrian Basement Complex and forms part of the extensive Pan-African mobile belt system that stretches across West Africa. This belt is composed of a heterogeneous assemblage of metasedimentary and igneous rocks, including schists, gneisses, and granitoids, which have been subjected to polycyclic deformations, metamorphism, and magmatism during the Neoproterozoic Pan-African orogeny (Rahaman, 1988; Dada, 2006; Olarewaju, 1988).

These events led to the reactivation, reworking, and partial melting of crustal materials, producing varied lithologies that now exhibit distinct geochemical and mineralogical signatures. Aluminosity, as expressed by the Alumina Saturation Index (ASI) A/CNK and A/NK ratios can distinguish peraluminous, metaluminous, and peralkaline rocks, which offer insights into source rock composition, mineral equilibria, and magmatic processes (Maniar & Piccoli, 1989; Chappell & White, 1974). In the other hand, K_2O vs. SiO_2 plot provide the basis for distinguishing between magmatic affinity (e.g., calc-alkaline, high-K, shoshonitic), particularly in granitoid rocks (Peccerillo & Taylor, 1976).

The classification of rocks of the Igarra Schist Belt based on their potassic and alumina saturation trends using major oxide geochemistry will therefore examine the implications of feldspar, mica, and clay mineral evolution for metamorphic and magmatic processes. It will also interpret the geochemical data in terms of source rock characteristics, crustal recycling, and tectonic evolution. By integrating petrographic and whole-rock geochemical data, this research will therefore enhance our understanding of crustal differentiation mechanisms and metamorphic reconstitution within the Igarra Schist Belt and its broader implications for the Pan-African orogenic framework.

Geological Setting

The Igarra Schist Belt forms part of the southwestern sector of the Nigerian Basement Complex, which is itself a segment of the broader Pan-African mobile belt that extends across much of West and Central Africa. This schist belt is located within the eastern margin of the western Nigerian schist belts(fig.1). Geologically, it is characterized by an assemblage of metasedimentary and metaigneous rocks, intruded by Pan-African granitoids, and has been affected by polyphase tectonothermal events.

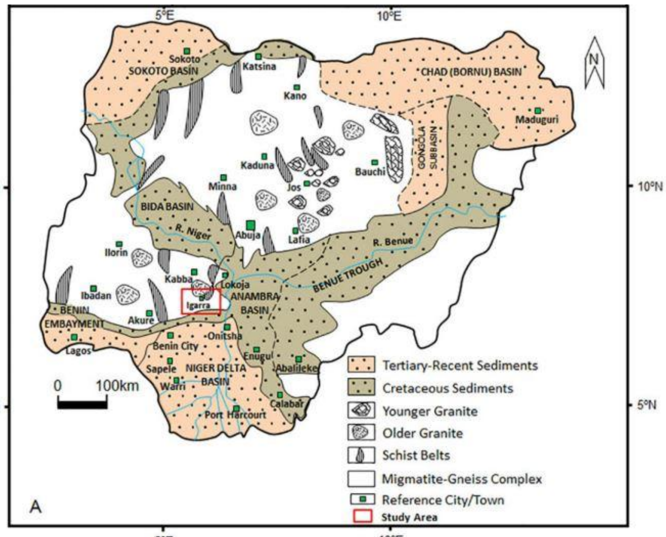

Fig.1 Ogbe et al: study area in a geologic map of Nigeria.

The basement complex in this region comprises migmatitic gneisses, granite gneisses, quartzites, mica schists, amphibolites, and variably deformed granitoids. These rocks have experienced medium to high grade regional metamorphism, typically reaching the amphibolite facies, with localized granulite and greenschist facies overprints (Rahaman, 1988; Dada, 2006). Structural elements include tightly folded and sheared metasediments with dominant NE–SW trending foliations (fig.2), reflecting Pan-African compressional regimes (Ajibade & Wright, 1989).

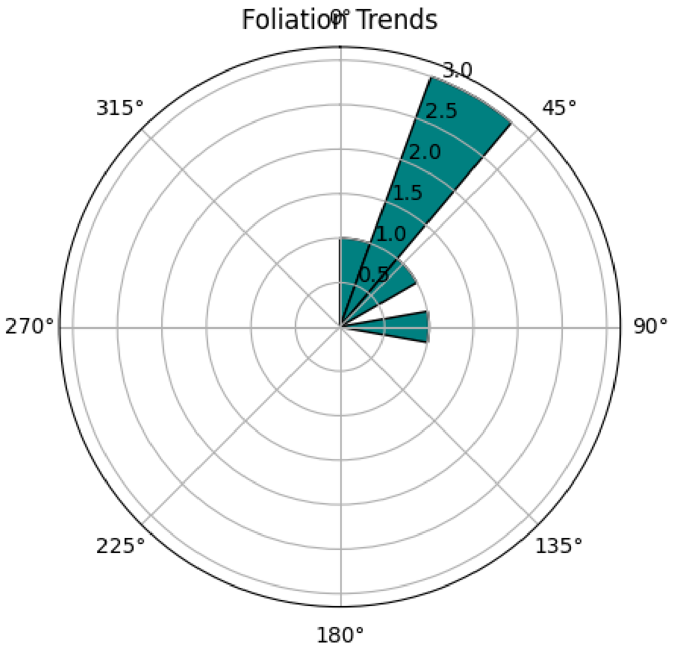

Fig.2 Dominant NE–SW trending foliations, show Pan-African compressional regimes in the area

The schistose units, interpreted to be derived from pelitic to psammitic sediments, occur as narrow linear belts enveloped by gneisses and granitic bodies. The granites in the region are mainly coarse-grained, porphyritic to equigranular, and vary from biotite granite to muscovite–biotite granite, occasionally exhibiting S-type peraluminous signatures (Olarewaju, 1988). The gneisses, particularly the muscovite–biotite gneiss and granite gneiss, often show signs of migmatization and partial melting, suggesting their derivation from crustal sources. Geochronological constraints from similar basement terranes in Nigeria indicate that the metasedimentary rocks may be Paleoproterozoic to Mesoproterozoic in depositional age, with Pan-African overprinting and reworking around 600 Ma (Dada, 2006; Ekwueme & Kroner, 1994). These rocks were likely deposited in marginal basins associated with continental arc or back-arc settings and later underwent deformation and metamorphism during Pan-African collisional events. This diverse lithological and structural setting provides an ideal framework for evaluating the geochemical behavior of alumina and potassium across different rock types. In particular, the interaction between igneous and metasedimentary components within the same tectonothermal regime makes the Igarra Schist Belt a unique environment for studying crustal recycling, partial melting, and metasomatic processes.

II. Materials and Methods

Field Sampling and Petrography

A total of 20 representative rock samples comprising granites, gneisses, and schists were collected from various outcrops across the study area during a detailed geological field mapping. Sampling was guided by lithological boundaries, mineralogical variation, and structural orientation to ensure coverage of both metasedimentary and igneous suits. Fresh and unweathered samples were selected and georeferenced using a GPS unit. Thin-sections were prepared from selected samples and studied under a polarizing microscope. Petrographic analysis focused on identifying primary and secondary mineral assemblages, textural relationships, and metamorphic overprints. The abundance of feldspars, micas (biotite and muscovite), quartz, and accessory minerals was assessed semi-quantitatively to support geochemical interpretations.

Geochemical Analysis

Samples were carefully pulverized in order to avoid contamination in the laboratory, packaged with sterilized packs and sent to Zirconex Mining Limited Laboratory Abuja Nigeria for major oxides geochemical analyses using the Inductively Coupled Plasma Mass-spectrometry (ICP-MS) method. CIPW normative plots and analysis were done using Python libraries and Chrome-Colab visual platform. All measurements were conducted on pulverized whole-rock powders (<75 µm), and data were reported in weight percent (wt.%) on a loss-on-ignition (LOI) corrected basis. Quality control was ensured throughout the analysis in order to maintain both internal and international rock standards.

Geochemical Classification and Ratios

To evaluate potassic and aluminosity trends, the following geochemical indices were computed which includes, K_2O vs. SiO_2 following the classification scheme of Peccerillo and Taylor (1976) to identify high-K, calc-alkaline, and shoshonitic affinities. Alumina Saturation Index (ASI) was analyzed on the bases of, A/CNK = molar Al_2O_3 / (CaO + Na_2O + K_2O), A/NK = molar Al_2O_3 / (Na_2O + K_2O). These indices distinguish between peraluminous, metaluminous, and peralkaline rock types (Maniar & Piccoli, 1989). Calculations were based on molecular proportions derived from oxide weight percent values.

III. RESULTS

Major Oxide Geochemistry

The analyzed samples exhibit a wide range in SiO_2 content, from approx. 62.3 wt.% in some schists and gneisses to over 66.1 wt.% in granites, indicating compositional variability across metasedimentary and igneous domains. Al_2O_3 values are generally moderate to high (12.62 to16.22 wt.%), with moderate values observed in schists, reflecting their semi-pelitic protoliths which suggest a proximal continental margin setting with mixed felsic and quartz-rich sediment supply (Maniar, P.D., &Piccoli, P.M. (1989), Herron, M.M. (1988). K_2O concentrations range from 1.5 to 6.0 wt.%, with the highest values occurring in granites and biotite gneisses. Na_2O shows moderate variability (2.0 to 4.5 wt.%), while CaO and MgO tend to be higher in gneisses and schists compared to granitic samples. These patterns suggest mineralogical control by feldspars, micas, and amphiboles. The oxide data suggest that the granites are peraluminous to slightly metaluminous, while the gneisses and schists show greater compositional scatter.

Potassic Classification (K_2O vs. SiO_2)

The K_2O vs. SiO_2 plot (Peccerillo & Taylor, 1976) classifies the majority of granitic samples as high-K calc-alkaline to shoshonitic (fig.3), while a few falls within the calc-alkaline field. Gneisses occupy a transitional position, overlapping both granitic and metasedimentary fields. Schist samples, although variable, tend to fall below the high-K boundary, suggesting limited potassic enrichment or post-depositional leaching. These trends reflect differences in source material and fractionation history, with the granites likely derived from crustal melts enriched in K-feldspar and muscovite, while the schists retain signatures of their clay-rich sedimentary origins

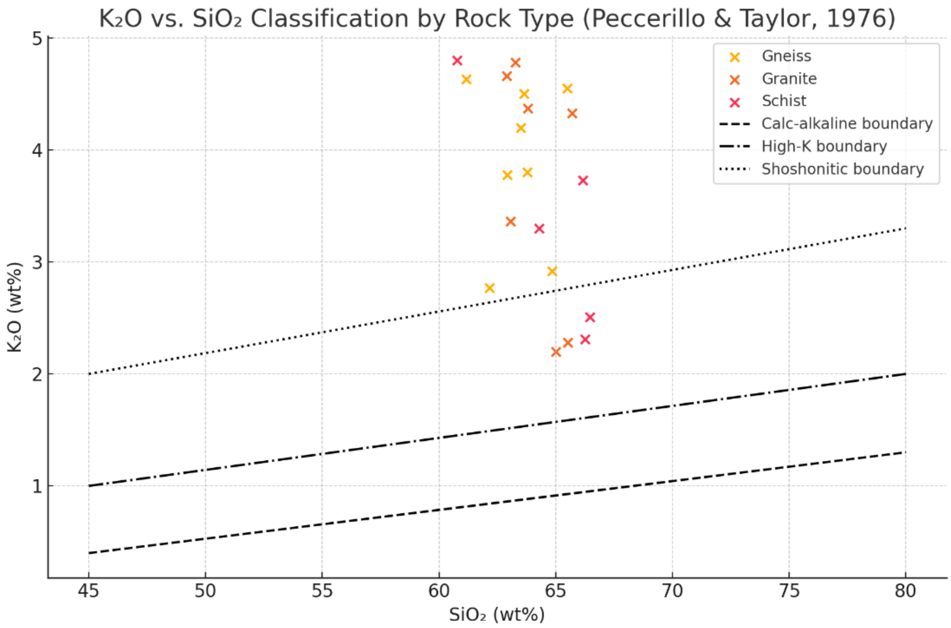

Fig.3 K_2O vs. SiO_2 Classification by Rock Type (Peccerillo & Taylor, 1976)

The plot shows that the Granites samples (fig.3) mostly plot in the high-K calc-alkaline to shoshonitic fields, indicating strong potassic enrichment which is consistent with crust-derived melts. They are likely S-type or hybrid granitoids, often formed in post-collisional orogenic settings. In the other hand, Gneisses spread across the calc-alkaline to high-K fields. This reflects variable protolith composition and degrees of metasomatism or feldspar/mica reconstitution. Intermediate K_2O levels may indicate partial melting or reworking of sedimentary layers. The analyzed Schist samples tend to cluster near or below the high-K boundary. K_2O variation likely controlled by the presence of muscovite/biotite and original clay-rich protoliths. Some lower K_2O values may suggest leaching during metamorphism or low-grade mineral stability.

Alumina Saturation Index (A/CNK vs. A/NK)

The Plotting of A/CNK against A/NK ratios distinguishes three compositional fields between the three types of rocks studied. Granites plot dominantly in the peraluminous field (A/CNK > 1), consistent with crustal derivation and presence of muscovite/biotite. Gneisses show variable aluminosity, spanning metaluminous to weakly peraluminous compositions while Schists are strongly peraluminous, reflecting their derivation from aluminous shales and pelitic protoliths. Close observation shows that several schist samples plot well above A/CNK = 1.1, (fig.4) indicating potential for corundum normativity (in the CIPW sense) or presence of aluminous index minerals such as garnet or sillimanite.

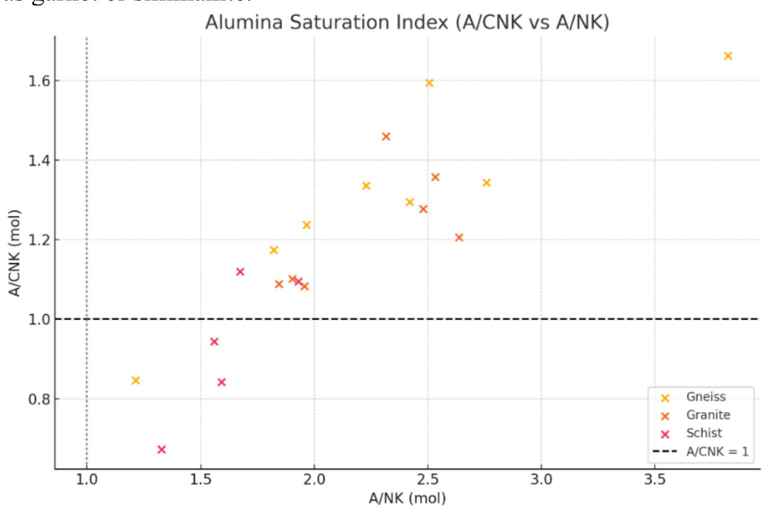

Fig.4 A/CNK vs. A/NK Plot (Alumina Saturation Index)

This diagram (fig.4) classifies rocks based on their alumina saturation, helping to distinguish between peraluminous, metaluminous, and peralkaline types. From the plot, Granites mostly plot in the peraluminous field (A/CNK > 1), indicating derivation from metapelitic or crustal sedimentary sources. This is consistent with S-type granites formed by partial melting of aluminous materials. Samples of Gneisses analyzed show a spread across peraluminous and metaluminous fields, suggesting mixed source signatures, possibly including mafic components. There appears to be variable degrees of partial melting, restite incorporation, or feldspar breakdown. From the plot, Schists show cluster in the strongly peraluminous field, reflecting clay-rich sedimentary protoliths. The A/CNK > 1 values support the dominance of peraluminous mineralogy (e.g., muscovite, garnet, cordierite). The peraluminous granites and schists suggest a crustal melting and recycling origin, typical of collisional orogenic belts like the Pan-African domain. Gneisses show transitional signatures, indicating either protolith diversity or melt-residue interactions

Harker Variation Diagrams (SiO_2 vs. Major Oxides)

These plots help to assess magmatic differentiation trends and geochemical behavior of oxides during crystallization or metamorphism.

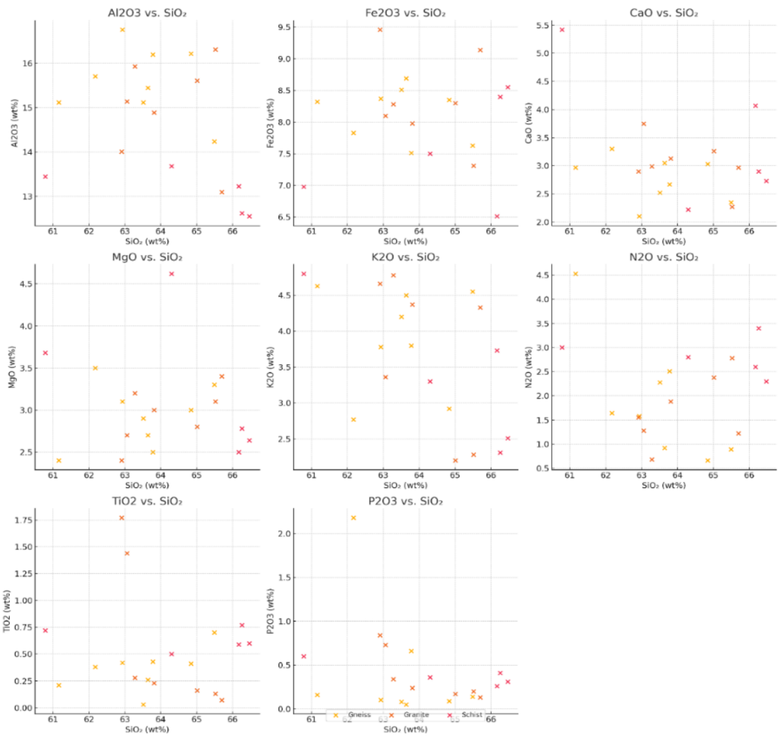

Fig.5 Harker Variation Diagrams

From the Harker's diagram plot (fig.5), Al_2O_3 vs. SiO_2 shows a weak negative trend, especially in schists and gneisses. This suggests a decreasing aluminous phase (e.g., feldspar, mica) with increasing silica, consistent with fractionation or melting of clay-rich source rocks. Also, Fe_2O_3 and MgO vs. SiO_2, display a strong negative correlation which indicates mafic mineral fractionation which is a characteristic of magmatic differentiation from mafic to felsic compositions. Calcium Oxide vs Silicon Oxide (CaO vs. SiO_2) decreases with increasing SiO_2, which is typical of plagioclase fractionation. Granites show lower CaO, consistent with more evolved compositions. K_2O vs. SiO_2 plot shows an increasing trend, especially in granites. This reflects accumulation of K-feldspar and muscovite in evolved magmas. From the plot, Schists vary more, likely due to mica or clay reconstitution. In the plot of Na_2O (N_2O) vs. SiO_2, there is no consistent trend which is possibly influenced by alteration or variable plagioclase composition. Sodium (Na) mobility during metamorphism may obscure magmatic trends. TiO_2 vs. SiO_2 plot shows negative correlation in which Ti-bearing phases (e.g., ilmenite, biotite) reduce with silica enrichment. This supports a fractional crystallization pathway. P_2O_3 vs. SiO_2 plot shows decreases with SiO_2 which suggest loss of apatite or incompatible behavior during evolution. These patterns collectively reflect magmatic differentiation, where mafic components crystallize early, enriching residual melts in SiO_2 and K_2O.Gneisses and schists show more scattered behavior, likely due to metamorphic overprinting and source rock variability. Granites follow typical felsic trends, confirming evolved, crust-derived origins.

AFM (Granites, Gneisses, Schists)

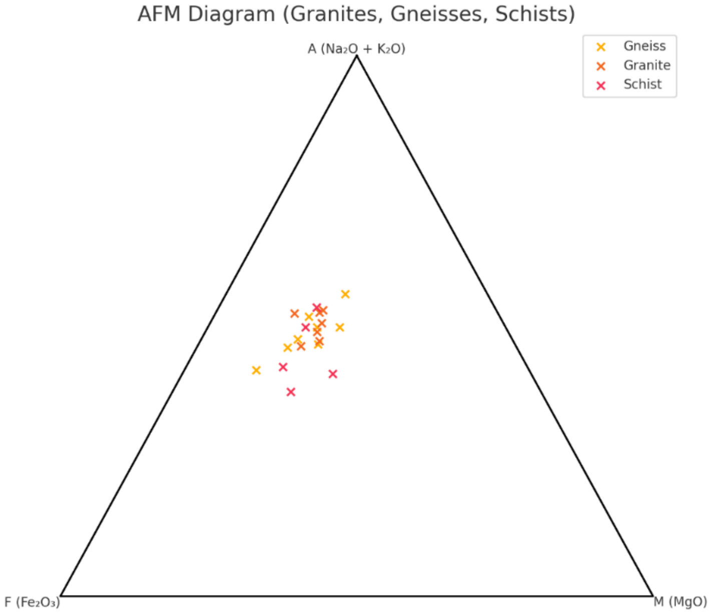

Fig.6 AFM Diagram (Granites, Gneisses, Schists)

The AFM ternary plot (fig.6) is used in investigating magmatic series evolution which distinguishes between tholeiitic trends and Calc-alkaline trends. From the AFM diagram, granites cluster toward the Apex A ($Na_2O + K_2O$). This reflects the dominance of alkali feldspars and micas, consistent with felsic, evolved compositions and S-type magmatism. Also, gneisses are shown to scatter between M and A, suggesting variability in protolith composition (mafic to felsic). This could be attributed to the influence of amphibole, biotite, and alkali feldspars during metamorphism and partial melting. The analyzed schist samples show more alignment toward the F and M axes, indicating Fe and Mg-rich phyllosilicates like biotite and chlorite. This also represent metapelitic derivation with mafic phase stability under greenschist to amphibolite conditions. The AFM trends confirm that granites are evolved, felsic rocks, consistent with melt derivation from crustal sediments. Gneisses and schists record more heterogeneous evolution, possibly reflecting both original sediment chemistry and metamorphic reconstitution. No clear tholeiitic trend which supports a calc-alkaline to S-type affinity, consistent with continental collisional magmatism.

IV. Discussion

Aluminosity and Petrogenetic Implications of this study

The predominance of peraluminous compositions (A/CNK > 1) among the granites and schists from the Igarra Schist Belt suggests a crustal origin, particularly from metasedimentary sources rich in Al-bearing minerals such as muscovite and biotite. This aligns with the presence of S-type granite signatures, where melt generation occurs via partial melting of pelitic rocks during high-grade metamorphism (Chappell & White, 1974). The high A/CNK values in the schists likely reflect the retention of original sedimentary compositions, characterized by clay-rich protoliths (e.g., shales), which are inherently alumina-rich. In contrast, some gneisses exhibit metaluminous signatures, consistent with mixed protoliths or the involvement of more mafic sources during their genesis. The A/CNK vs. A/NK plot shows that while both gneisses and granites span metaluminous to peraluminous fields, the schists cluster tightly in the peraluminous zone, reinforcing their derivation from aluminous sediments rather than igneous sources.

Potassic Trends and Mineral Evolution

The distribution of samples on the K_2O vs. SiO_2 diagram indicates a high-K calc-alkaline to shoshonitic affinity for many granitoid samples, a feature commonly associated with crustally derived melts or melt-percolated lower crust during continental collision (e.g., Pearce et al., 1984). The elevated K_2O contents are consistent with the presence of K-feldspar and white mica, as confirmed by petrography. In metasedimentary rocks, K_2O variations are largely governed by the abundance and stability of muscovite and biotite, with low K_2O in some samples suggesting possible alkali leaching during retrograde metamorphism or fluid interactions. The interplay between K-feldspar crystallization and mica breakdown also controls the K_2O enrichment in gneisses.

Feldspar/Mica/Clay Dynamics in Metamorphism

Petrographic and geochemical evidence suggests that feldspar, mica, and clay mineral evolution play a central role in controlling both potassic and aluminous trends. In schists, the high aluminosity is associated with white mica (muscovite), derived from metamorphism of illite/smectite-rich clays. In gneisses, the presence of both plagioclase and biotite reflects a more complex metamorphic overprint, with partial melting and recrystallization. In granites, the dominance of K-feldspar and muscovite reflects fractionation trends and a S-type petrogenetic affinity, often linked to metapelite melting. These mineral transitions are key to understanding geochemical indices, particularly in metasedimentary terranes.

Crustal Recycling and Tectonic Implications

The combined geochemical signatures point to extensive crustal recycling in the evolution of the Igarra Schist Belt. The peraluminous granites and gneisses likely represent melts derived from or contaminated by older sedimentary crust. The metasedimentary schists preserve the chemical memory of their sedimentary origin, supporting a supracrustal derivation deposited in a continental margin or back-arc basin (Rahaman, 1988; Dada, 2006).

The geochemical data also reflect the effects of tectonic reworking during the Pan-African orogeny, where deformation and partial melting facilitated mobilization of alkalis and reconstitution of aluminosilicate phases. These features are consistent with collision-related magmatism, and the generation of crustally contaminated, high-K granitoids under moderate- to high-pressure conditions.

V. Conclusion

This study investigates the aluminosity and potassic trends in metasedimentary and igneous rocks of the Igarra Schist Belt using major oxide geochemistry supported by petrographic observations. The findings offer new insights into the petrogenesis, metamorphism, and crustal evolution within this segment of the southwestern Nigerian Basement Complex. The Alumina Saturation Index (A/CNK vs. A/NK) plot reveals that schists and many granitoids are peraluminous, indicating derivation from aluminous crustal sources, likely pelitic sediments. In contrast, some gneisses show metaluminous affinities, suggesting either mafic input or derivation from more mixed sources. This diversity reflects complex source rock compositions and varying degrees of partial melting and metamorphic differentiation.

The K_2O vs. SiO_2 classification (after Peccerillo & Taylor, 1976) further distinguishes the granitoids as high-K calc-alkaline to shoshonitic, consistent with crustal anatexis in a continental collisional setting. The schists show variable K_2O content linked to the stability of micas and feldspars during metamorphism. The geochemical trends are reinforced by petrographic evidence, highlighting the pivotal roles of feldspar, mica, and residual clay minerals in controlling both potassic and alumina signatures. The presence of muscovite, biotite, and K-feldspar in both igneous and metamorphic rocks confirms their importance in trace element behavior and elemental redistribution during metamorphic reactions.

Overall, the data reflect extensive crustal recycling, where older sedimentary materials were reworked, melted, and recrystallized during Pan-African Orogeny. These processes produced a spectrum of geochemically distinct but genetically related rock types, unified by their shared thermotectonic and metamorphic history within a continental collisional regime.

References

[1]. **Ajibade, A.C., & Wright, J.B. (1989).** The Togo-Benin-Nigeria shield: Evidence of crustal aggregation in the Pan-African belt. *Tectonophysics*, 165(1–4), 125–129.

[2]. **Ajibade, A.C., Woakes, M., & Rahaman, M.A. (1987**). Proterozoic crustal development in the Pan-African regime of Nigeria. In Kogbe, C.A. (Ed.), *Proterozoic Lithospheric Evolution* (pp. 259–271). American Geophysical Union.

[3]. **Chappell, B.W., & White, A.J.R. (1974).** Two contrasting granite types. *Pacific Geology*, 8, 173–174.

[4]. **Dada, S.S. (2006).** Proterozoic evolution of Nigeria. In: *The Basement Complex of Nigeria and its Mineral Resources*. Akin Jinad & Co. Publications, pp. 29–44.

[5]. **Ekwueme, B.N., & Kroner, A. (1994).** Rb–Sr geochronology and geochemistry of Precambrian rocks from Obudu Plateau, Southeastern Nigeria. *Precambrian Research*, 66(3–4), 269–286.

[6]. **Ekwueme, B.N. (1994).** Structural features of Southern Obudu Plateau, Bamenda Massif, SE Nigeria. *Journal of Mining and Geology*, 30(1), 45–59.

[7]. **Herron, M.M.(1988).** Geochemical classification of terrigenous sands and shales from core log data. Journal of Sedimentary Petrology, 58(5), 820-829

[8]. **Le Maitre, R.W., Streckeisen, A., Zanettin, B., Le Bas, M.J., Bonin, B., & Bateman, P. (2002).** *Igneous Rocks: A Classification and Glossary of Terms* (2nd ed.). Cambridge University Press.

[9]. **Maniar, P.D., & Piccoli, P.M. (1989).** Tectonic discrimination of granitoids. *Geological Society of America Bulletin*, 101, 635–643.

[10]. **Olarewaju, V.O. (1988).** Petrology and geochemistry of the Ilesha amphibolites and implications for the Nigerian Basement Complex. *Precambrian Research*, 38(3–4), 227–246

[11]. **Peccerillo, A., & Taylor, S.R. (1976).** Geochemistry of Eocene calc-alkaline volcanic rocks from the Kastamonu area, northern Turkey. *Contributions to Mineralogy and Petrology*, 58, 63–81.

[12]. **Pearce, J.A., Harris, N.B.W., & Tindle, A.G. (1984).** Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. *Journal of Petrology*, 25(4), 956–983.
[13]. **Rahaman, M.A. (1988).** Recent advances in the study of the Basement Complex of Nigeria. In: *Precambrian Geology of Nigeria* (pp. 11–43). Geological Survey of Nigeria Publication.