

Geomorphological Transformation of a Granite Rotten in-Situ in Nigeria: Implications for Chemical Weathering, Lateritization and Pedogenesis

Oluwatoyin O. Akinola¹ and Oladimeji L. Ademilua^{2*}

^{1,2}Department of Geology, Faculty of Science, Ekiti State University, Ado-Ekiti, Nigeria.

Correspondence Author: Oladimeji L. Ademilua^{2*}

Abstract:- Nigeria is a sub-Saharan Africa country, its closeness to the equator precipitates tropical type of climate. The consequence of the alternating raining and dry seasons coupled with relatively high humidity throughout the year triggers severe chemical decay which causes rock rot in Ekiti area of SW Nigeria. Decomposition of rocks through intense in-situ chemical weathering and selective leaching resulted in prevalence of laterites, lateritic soils and saprolite in the area. Lateritization and formation of saprolite in the area is consequent on de-silicification processes during which substantial alkali and alkali earth elements are leached from the granite. This paper investigates and report geochemical features of granite weathered in-situ in Ikere-Ekiti, Ado-Ekiti and its environs. Analytical result reveals silica contents of the laterite (55.03-63.22 %; average, 58.98%) is lower than saprolite (59.31-65.41%; average, 62.92%). The ratio ($\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$): SiO_2 for the ferruginous laterite (0.55) and saprolite (0.49) suggests the two weathering products are laterites with varying colours. Fe_2O_3 contents in laterite (7.53-11.03%; average, 9.31%) is higher than saprolite (2.65-4.26%; average, 3.81%). Ternary diagram (SiO_2 - Al_2O_3 - Fe_2O_3) which show maturity of laterites classifies the weathered materials as products of weak lateritization.

Keywords:- Ekiti, Nigeria, Saprolite, Ferruginous Laterite, De-Silicification, Lateritization.

I. INTRODUCTION

Lofty hills dominated by residual chains of granite inselbergs forms main topographic feature of southwestern Nigeria and Ikere-Ado-Ekiti area in particular. Intense chemical weathering of these rock masses produces rock debris over a large expanse of the land. This process is prevalent in sub-Saharan Africa countries like Nigeria. Tropical environments are characterized by serious disaggregation of crystalline rocks to form mineral residues such as quartz, feldspars, micas, clays and a host of others. In addition to these transported materials which are deposited in sites adjoining residual hills forming pediments on which many towns like Ikere-Ado-Ekiti and environs are situated; noticeable *in-situ* chemical weathering also transform these rocks into laterite, lateritic soils and saprolite. During *in-situ* chemical weathering, soluble rock

components are dissolved, leached out or precipitated from solution. The immobile components are left as residue of weathering to form laterite and saprolite. Several water wells sited in Ikere-Ado-Ekiti which fall within the periphery of these granite bodies only penetrated the weathered basement without hitting the fresh bedrock. This suggests that weathering activity is intense, and the profile is quite thick. Lateritization is basically a chemical weathering process in which the least geochemically mobile components are concentrated (McFarlane 1976). The processes of lateritization are greatly determined by combination of several factors ranging from alternating wet and dry seasons, acidity (pH), redox potential (Eh), ionic mobility, ionic potential and parent-rock chemistry (Du Preez, 1949; Baas-Becking et al., 1963; McFarlane, 1989; Nwajide and Hoque 1976; Middleburg et al., 1988; Ollier and Galloway, 1990; Bolarinwa and Elueze, 2005; Silaev et al., 2005; Martin et al., 2007). This research reports *in-situ* chemical weathering and lateritization processes and how the activity affects the granite rocks in Ikere-Ado-Ekiti and environs.

II. GEOLOGICAL SETTING

Nigeria forms part of N-S trending mobile orogenic belt which extends over 4000 km long and hundreds of kilometers wide which begins from the Hoggar Massif of Algeria to Brazil (Caby, 1989) (Fig. 1). Southwestern Nigeria in which the present study lies is one of the five areas where the mobile belt (basement complex) is prominently exposed. Rocks in this domain are categorized into three main units, these are: the migmatite-gneiss complex, the schist belts, and the Pan-African granite (Fig. 2).

The geology of Ikere-Ado-Ekiti area have been reported in the works of Olarewaju, (1981); Kayode, (1988); Oyinloye and Ademilua, (2005); Oyinloye and Obasi, (2006); Talabi et al., (2012); and Afolagboye et al., (2015) among others. These authors reported that the area is dominated by migmatite-gneiss-quartzite complex and granitoids.

However, the current study reveals Ikere-Ado-Ekiti and its environs is underlain by Migmatite-gneiss, quartzite/quartz-schist, granite, charnockite, and pegmatite (Fig. 3). Migmatite is the most widespread unit forming low-lying masses of typically fine-grained texture. Migmatite being the country rock is distinct for its obvious fold structures which vary in geometry and complexity. In few localities, the migmatite grades into biotite-hornblende gneiss and banded gneiss. Granite on the other hand, forms spectacular hills outcropping prominently around Ikere-Ado-Ekiti and neighboring towns. Granite underly about half of the study area, it is concentrated around western and north-eastern parts. Four textural types of granite are recognized, they are: the fine-grained granite (OGf), which is of restricted occurrence and confined to northwestern corner of the study area. The medium grained granite (OGe) occurs in southwest, south and northeast of Ikere-Ekiti town. The porphyritic granite (OGp) is the most-wide spread among the granite types and occurs east and west of Ikere-Ekiti town. The undifferentiated Older Granite (OGu) that is granitized with porphyroblastic gneiss and migmatite occur towards northwest of Ikere-Ekiti and east of Ado-Ekiti (Olarewaju, 1988). Charnockite occupies the central domain forming pediment upon which most part of Ikerre-Ado-Ekiti expressway runs and extends beyond 20 km along north-south direction. The charnockite has been reduced in most places to low-lying masses by prolonged chattering and exfoliation. It sometimes forms isolated rounded bodies within the porphyritic granite and migmatite. Quartzite/quartz schist is characteristically fractured NE-SW trending lithology mainly restricted to Ado-Ekiti town. The Undifferentiated coarse-grained granite and porphyritic granite form the main parent rocks to the laterite in the study area.

III. LOCATION OF THE STUDY AREA

Ikere and Ado-Ekiti lies approximately 35 km north of Akure the Ondo State capital. The towns are the largest between latitudes $7^{\circ}27'N - 7^{\circ}35'N$ and longitudes $5^{\circ}06'E - 5^{\circ}14'E$. The study area covers approximately 316 km² and comprise other smaller localities such as Iworoko towards the north, Ilawe and Igbara-Odo in the west, Awo in northwest; Igbemo, Ijan and Ilupeju in the eastern part while Ise-Emure occur towards the southeast (Fig. 4). The area is characterized by annual alternating raining and dry seasons, a relatively high humidity and rugged topography which has aided increased rate of both physical and chemical weathering.

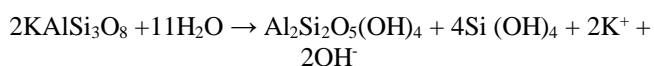
The study area is an undulating terrain with hills and massive rocks with steep slopes, the general terrain stands at a height ranging between 180-425 m above the mean sea level. The Orole and Olosunta Hills which occurs in southwestern corner of the study area forms the two major peaks in the terrain. The rugged geomorphology is directly related to the occurrence of magnificent granite inselbergs that stretches in a north-south direction across the terrain. The granitic masses are intrusive bodies now exposed by pronounced erosion within the migmatite country rock. Due to prolonged exposure of the rock masses to denudation, the

low-lying areas adjoining these hills are constantly fed with rock debris. The topography of the study area is influenced by lithologic variations as migmatite and charnockite underlies the low-lying areas while granite masses form prominent hills that are concentrated in north and western parts. The high gradients on the slope and impervious nature of the granitic bodies, ordinary sporadic rainfalls and light showers sometimes produce enough runoff that effectively recharge the hydrologic system. The speed and volume of the runoffs down-slope constantly promotes erosion along the drainage system which led to formation of V-shaped valleys and gullies. Ikere-Ado-Ekiti area is drained by two major rivers. River Ogbesse and its tributaries which drain the eastern side, and River Owena which drains the west. Other smaller rivers include River Elemi which forms a watershed around Igede-Ekiti. The drainage pattern is mainly dendritic, and most rivers take a general N-S direction of flow draining the entire area and flowing throughout the year. Precipitation is moderate from May to October each year, and the rains decrease both in frequency and intensity from September till March. Annual rainfall ranges between 1250-2500 mm with an average of 2000 mm. Nonetheless, between January and July, the temperature averages between 25.5°C and 28.3°C, respectively.

IV. HISTORICAL UNDERPINNING

The word laterite (from Latin word, *later* which means brick) was credited to Buchanan, (1807). Subsequently, many scientists have used the term laterite to designate weathering products generally formed under tropical conditions, rich in iron and aluminum, and either hard or subject to hardening upon exposure to alternate wetting and drying (Pendleton, 1936; Kellog, 1949). The term also includes all kinds of plinthites which are laterites in the restricted sense but excludes soft kaolinitic lithomarge, fine saprolites and non-indurated ferrallitic soils. However, Prescott and Pendleton, (1952) believed laterites represent tropical weathered products used in making construction blocks. It is described as surficial materials usually red in color and are called brick earth (Maignien, 1966). Laterite is a ferruginous clay-textured soil with a concretionary appearance (Otoko, 2014), its strength characteristics depends on texture (Eze, 2015). Although the term laterite has been used universally with some confusing attributes; most importantly, as materials which possess compositions that may vary slightly from one another. More recently, workers prefer to use some terminologies that reflects specific compositions. Such include ferric or ferricrete (Iron-rich), silcrete (silica-rich), calcrete (carbonate-rich), and alcrete (bauxite or bauxitic) for aluminum-rich (Stephens, 1971; Grant, 1975; Firman, 1994; Fookes, 1997; Ollier and Galloway, 1990; Enaworu et al., 2017).

Weathering profile reveals the in-situ arrangement of rocks from the topsoil to fresh basement. Weathering is the breakdown of rocks by physical and chemical processes involving oxidation, hydration, carbonation, and evaporation to yield products nearly in equilibrium with their environment. It is the physical disintegration and chemical decomposition of rocks to produce sediments and soils. The intensity of weathering is mainly controlled by lithology, climate, and morphology. Rocks that are more prone to weathering are soft, porous, heterogenous or fractured. Climate and morphology are the most significant factors affecting the rate of physical and chemical weathering (Chamley, 1989). Weathering deposits are unconsolidated materials derived through the action of liquid, gases, and atmospheric agents on bedrock. Lateritic deposits are thus formed through weathering on rocks forming materials rich in secondary oxides of iron, aluminum, or both and almost devoid of primary silicates (Bateman and Jensen, 1950). Lateritic deposits are best developed in tropical or forested warm to temperate climate (Chamley, 1989; Narayanaswamy, 1992). Weathering is generally considered to consist of mechanical and chemical action, but usually both operate together. The mechanical action (frost action, wind action, expansion and contraction under temperature changes) does not create new minerals; it only disunites minerals already formed, thereby facilitating chemical decomposition by reducing the particle size and creating greater surface area for chemical attack. Chemical weathering however results in formation of new minerals which remain stable under surficial conditions. Elueze and Kehinde-Phillips, (1993) believed water is the most active agent of weathering in tropical environments as only little decomposition occurs without water. A typical example of weathering is the conversion of K-feldspar into clay in the presence of water according to the equation:



Oxygen permits oxidation, carbon dioxide dissolved in water is an effective solvent, heat is a catalyst for most chemical reactions. Bacteria are active in biochemical processes of decomposition and precipitation. Lateritic deposits originate from release and upgrading of chemically resistant components through saprolization, selective accumulation of stable products mainly through breakdown of silicates with varying extent of leaching of mobile phases, enrichment by vertical or horizontal solution transport, and finally, through the relative concentration of stable compounds through preferential dissolution of alkalis, alkaline earths and silica (Elueze 2003; Elueze and Kehinde-Phillips 1993). Many authors (e.g., Bateman, 1950; Park and MacDiarmid, 1964; Egbogah, 1975) have noted that certain factors affect the geological environment of weathering deposits. These factors are summarized as climate, geographic regions, bedrock composition and crustal stability. According to McFarlane (1991); McFarlane and Bowden, (1992), elevated temperature and humidity favors laterization, so it is characteristic of tropical regions and probably limited to a belt within 30 degrees north and south of the equator.

V. WEATHERING PROFILES OF THE STUDY AREA

A vertical section from the earth surface through weathering zones to the unaltered bedrock, describes the weathering profile. The nature of the profile reflects a complex response to climatic and geologic controls, and to long-term changes in external conditions. The profiles in the study area occur in four distinctive horizons. These are fresh bedrock, fractured basement, saprolite and laterite (Fig. 5). The fresh bedrock which occurs at the base of most profiles in the area is the crystalline granitic rock of coarse-grained to porphyritic texture. The depth to the fresh basement varies considerably throughout the study area and depends on closeness of the profile to the granite outcrops. As revealed from water wells, areas far from the outcrops has greater depth to the fresh bedrock. Above this layer is the fractured basement, which is dominantly granitic rock with intense fracturing, it is intercalated with leached materials from upper layers (Oyinloye and Ademilua, 2005). This layer is subsequently overlain by the whitish chemically altered saprolite which occur *in-situ*. Finally, the topmost layer is the brownish hummocky laterite containing weathering product of mainly hydrated iron and aluminum oxides, hydroxides and clay minerals but also containing some silica. In few localities, the laterite is covered by thin layer of topsoil on which shallow rooted plants grows. Laterite in Ikere-Ado-Ekiti area occurs in different morphological forms ranging from spongy, bulbous, hummocky, mesa-type or capping, or finely laminated or with quartz sand (Figs. 6a-f).

VI. MATERIALS AND METHODS

To establish the relationship between mineralogy and fabric properties of the precursor granitic rock and their weathered products, three types of materials were used in this study. These are, fresh granite (Fig. 7e), granite that are chemically leached and rotted *in-situ* (saprolite) (Figs. 7a, 7b and 7f), and iron-rich weathered product (ferruginous laterite). Samples of fresh rock were obtained as rock chips from outcropping exposures of the granite. Fresh representative samples of granite were obtained and subjected to optical microscopy on a Leica DLM petrological microscope. Geochemical investigation of the weathered rocks was undertaken using X-Ray Fluorescence (XRF) facility at the geology Department, University of Malaya, Malaysia. Ten (10) grams of each sample was weighed and put in a clean digestion bottle. Using a calibrated plastic syringe, 15 ml of 40 % hydrochloric acid was added with the help of an automatic pipette. Subsequently, ten (10 ml) of hydrofluoric acid was added. To prevent the escape of silicon fluoride (SiF₄) gas during mixing of the two acids, a cork was put on the digestion bottle to ensure it is tightly closed. The digestion bottle was put on a warm water bath set at 70°C for about two hours and allowed to cool down to 25–30°C. A 100 ml saturated boric acid was added to the solution and the bottle was tightly closed. The bottle was placed on the water bath until the milky solution became clear. Distilled water was added to it after cooling to make a solution of 250 ml. Part of

distilled sample was put in a sample container and analyzed with a dilution factor of 25.

VII. RESULTS

A. Field Occurrence

The rocks which form main topographic feature of the terrain occurs as residual hills. Three categories of rocks are identified in the study area based on intensity of weathering. These are highly weathered rocks (Figs. 7a and 7b), fresh rocks (Figs. 7c, and 7e), and mildly weathered rock which reflects a hollow sound when struck with a sledgehammer (Figs. 7d and 7f). This rock became soft as the forces of cohesion have been reduced by chemical weathering. However, it is noteworthy that other rock types in the area are equally altered chemically. Geochemical features of the weathering products are presented in Table 1 and Table 2.

B. Petrography

Fresh granite from the study area contains large phenocrysts of feldspar (orthoclase and microcline), quartz, randomly arranged biotite laths, muscovite, and smaller crystals of hornblende all well-interlocked. Quartz occurs as colorless low-relief subhedral crystals with variable sizes which takes up the interstices of the other minerals. The quartz grains lack visible cleavage traces but appear as clear crystals of low birefringence and maximum interference first order grey color. Orthoclase occurs as large greyish-white mineral with faint albite twinning (Fig. 8). Microcline occurs in large sizes with recognizable grid twinning. Microcline is believed to form in granite when there is enough ordering of the aluminum and silicon in tetrahedral sites, during which alkali feldspar becomes triclinic microcline. Biotite is pleochroic with brown to brownish green color, it has nearly parallel extinction and a stippled appearance is the extinction position known as bird's eye texture which is characteristic of all micas. The granite contains randomly oriented biotite laths while the few crystals of hornblende exhibit straw green to dark green color. Other minor constituents of the rock are opaque minerals.

C. Geochemistry

The geochemistry of laterites and saprolite could be much varied as different rock types because its composition can depend on the intensity of weathering, nature of parent material and environmental factors. Laterites and saprolites in Ikere-Ado-Ekiti and environs resulted from de-silicification process during which substantial alkali and alkali earth elements are removed. The weathering process has intensified alumina and iron enrichment. Even though, both laterite and saprolite occur above each other within the same profile, saprolite being overlain by laterite, these two units show marked variation in their alumina and iron contents. Silica being formed under low temperature and pressure conditions in the Bowen's reaction series, its removal only takes place through disaggregation because it forms one of the most resistant silicate minerals during weathering. Analytical result (Tables 1 and 2) shows some discrepancies in the elemental oxide concentration in these

two weathered products. Silica contents of the laterite (55.03-63.22 %; average, 58.98%) is lower than saprolite (59.31-65.41%; average, 62.92%). This trend is expected since saprolite was overlain by laterite. During weathering in tropical environments, fine quartz grains tend to wash towards the lower part of the profile. Oti (1987), indicated that rock type instead of stratigraphy is the major determinant of laterization process in southeastern Nigeria. This value is significantly higher than silica content (43.19-45.12%) reported from lateritic soil from Anambra Basin in Nigeria (Enaworu et al., 2017). This difference may be related to variation in lithologies associated with the two localities. Ikere is underlain by granite while Anambra basin area is underlain by gneisses and sedimentary sequences. Similarly, Alumina contents (20.71-26.03%; average, 23.42%) in laterite is lower than the range of values and mean (24.23-32.46%; average, 27.27%) recorded for saprolite. This variation might have resulted from alumina being a cation that easily goes into solution during weathering and are leached from the upper horizon to basal part of the profile. However, alumina contents of the weathered products from the study area are lower than the value (39.12-39.14%) recorded for Anambra basin. Conversely, iron contents in the laterite (7.53-11.03%; average, 9.31%) is higher than (2.65-4.26%; average, 3.81%) the saprolite. Higher iron content in laterite is reflected by difference in color of the two weathered products. Again, these values are significantly lower than 6.75-8.91% recorded in this type of rock found within the Anambra Basin. According to Enaworu et al., (2017), matured laterite has $Al_2O_3 / (Fe_2O_3 + SiO_2) < 1$. Using the mean values from this research, laterite in Ikere-Ado-Ekiti and environs (value 0.34). could be classified as matured laterite. According to Bell, (1993) the geochemical composition of these weathered products is also valuable in their categorization. The ratio of sesquioxide (iron + alumina) to silica if < 1.33 denotes laterite, if it ranges between 1.33-2.0 it is lateritic soils, and if > 2.0 , it is non-lateritic soil (Winterkorn et al., 1952; Adeyemi, 2002; Enaworu et al., 2017). Using the average values in this research, the ratio $(Fe_2O_3 + Al_2O_3) : SiO_2$ is 0.55 for the ferruginous weathered product and 0.49 for the whitish chemically rotted *in-situ* saprolite. According to Bell's classification, the two products are both laterites. The extensive hummocky and bulbous mesa-like laterite in this study is underlain by a granite bedrock. The brown lateritic cap occurring at the top of a softer whitish and friable weathered product is like those reported from lateritic terrain of Australia (Brook and Twidale, 1984).

VIII. DISCUSSION

In comparison with original bedrock chemistry, K_2O value in the laterite (3.47-5.44%; average, 4.52%) and saprolite (1.53-4.24%; average 2.93%) are lower than the fresh porphyritic granite from Ado-Ekiti (4.96-7.03%; average, 6.11%) area (Oyinloye and Obasi, 2006). Alkali ($K_2O + Na_2O$) contents in laterite (3.79-5.71%, average, 4.75%) and saprolite (1.8-4.7%; average, 3.3%) are also lower than the value (7.6-9.21%; average, 8.52%) recorded for fresh porphyritic granite within the study area. This

imply that alkali and alkali earths are part of the major cations that are leached from the original rock during the weathering. Average CaO content in saprolite (0.4%) and laterite (0.2%) are marginally lower than the value recorded in fresh granite of the same area. Mean MnO, P₂O₅ and MgO contents in saprolite and laterites from Ikere-Ado-Ekiti area are comparable to similar rocks from other parts of southwestern Nigeria and are comparable to the fresh granite as reported in the works of Oyinloye and Obasi, (2006). In comparison with other notable laterite around the world, for instance, those in Cannanore district, Northern Kerala, India with average silica content of 57.33% in partially weathered and 45.03% in completely weathered laterite as reported by Narayanaswamy, (1991) is marginally lower than Ikere-Ado-Ekiti laterite (58.98%). Alumina contents of the Kerala partially weathered laterite (23.46%) is comparable to average value (23.42%) in Ikere-Ado-Ekiti laterite. However, the iron contents in these rock masses (0.46% and 2.27%) are significantly lower than Ikere-Ado-Ekiti laterite (9.31%). This variation may have resulted from lithologic variations as the India laterite were produced from continental granophyre while those in Ikere-Ado-Ekiti and environs were sourced from granite source rocks even though the two regions fall within tropical environments. Generally, the geochemistry of laterite may be more dependent on parent material, intensity of weathering and environmental factors. SiO₂-Al₂O₃-Fe₂O₃ ternary diagram (Fig. 9) (Schelleman, 1981) which show maturity of laterites developed over different litho-units indicating the weathered rocks from Ikere-Ado-Ekiti is classified as product of weak laterization.

A. Chemical Index of Alteration

Chemical weathering results in ultimate transformation of rocks and this reflects in their physical appearance and chemistry. From commencement to intermediate stages of weathering, mobile elements which are often cations of alkalis (K, Na) and alkali earths (Ca and Mg) of major rock forming components of the parent rocks are leached out, leading to significant depletion of these elements. On the other hand, there is enhancement of immobile elements. According to Nesbitt and Young, (1982), during chemical weathering, the intensity of transformation vis-a-vis elemental mobility is reflected by Chemical Index of Alteration (CIA). CIA value is lowest in the parent rock and increase progressively upward towards the surficial part. This suggests that increasing chemical weathering produces conversion of more feldspar into clay and that this transformation does not only affect potassium, but it does for other alkali and alkaline earth elements. The CIA which measures the level at which feldspar is converted to clays near the surface (Feddo et al., 1995; Nesbitt and Young, 1984), has yielded positive results when applied to paleosol studies (Sutton and Maynard, 1992; Budihal and Pujar, 2018). The degree of alteration in any profile can be related to the molecular proportion of certain major (elements) oxides to alkaline elements. By this, the quantitative relationship that changes during weathering are shown in the index value (Budihal and Pujar, 2018). Laterite samples from the study area has mean CIA value of 83, however higher mean (CIA, 88) value occur in the underlying

aluminous laterites (saprolite). This shows that weathering of the parent rocks resulted in less depletion of the mobile alkalis and alkaline earth in Fe-rich laterites than the aluminous laterites. When CIA values exceeds 90%, it signifies extreme weathering conditions. Samples from the weathering profile of Ikere-Ado-Ekiti and environs are plotted on the ternary diagram Al₂O₃-(CaO+Na₂O)-K₂O-(ACNK) (Fig. 10) (Nesbitt and Young, 1982; Feddo et al., 1995), showing alteration trends during the chemical weathering. The clay particles largely resulted from alteration of plagioclase and muscovite.

IX. SUMMARY AND CONCLUSION

Lateritic soils are common in tropical environments like Ikere-Ado-Ekiti and its environs. Laterite and saprolite are the main *in-situ* weathering products of Ikere-Ado-Ekiti granite. The saprolite is whitish and the laterite has brownish color. The laterite forms a protective cap above the saprolite because of its hardness forming bulbous mesa-like masses throughout the study area. The hardness of laterite and the brown color is mainly attributed to a higher concentration of ferrous iron (Fe⁺²) that hardens when exposed to oxidation to form ferric iron (Fe⁺³). Differences in the physical attributes of the two products are linked to differences in the intensity of weathering, laterite being formed through oxidation and saprolite by leaching. As meteoric fluids move from the lateritic zone into deeper horizons by percolation, cations are disaggregated while geologically mobile components that are dissolved becomes progressively enriched in K⁺ and Al⁺³ which gradually concentrate in the saprolite zone thereby enhancing its white color. Weathering is most effective in tropical regions that are characterized by two seasons, the dry seasons allows decomposition while leaching takes place during the wet seasons. With iron + alumina to silica ratio of 0.55, and 0.49 indicate the weathered products in the study area are both laterites. The value of Al₂O₃ / (Fe₂O₃ + SiO₂) which gave an average of 0.34 indicate that the laterite in Ikerre-Ado-Ekiti and environ is matured. So elevated temperature and humidity favors laterite formation, a reason lateritic deposits are mostly restricted to tropical areas. Regions around the periphery of the granite inselbergs that allows water that cascade from the impervious crystalline rocks that are characterized by steep slopes encourages chemical rot which accelerate saprolite formation.

RECOMMENDATION

Laterites are widespread material in tropical environments. The readily available material needs no blasting, and it is useful for construction purposes and can serve as an additive for brick making. The engineering properties of the materials when evaluated can indicate other useful industrial applications. Its compressibility makes it a veritable material for filling in engineering constructions like road as it does not swell. The materials can be mined to benefit the communities where they are found by providing jobs for considerable number of people who are not gainfully employed.

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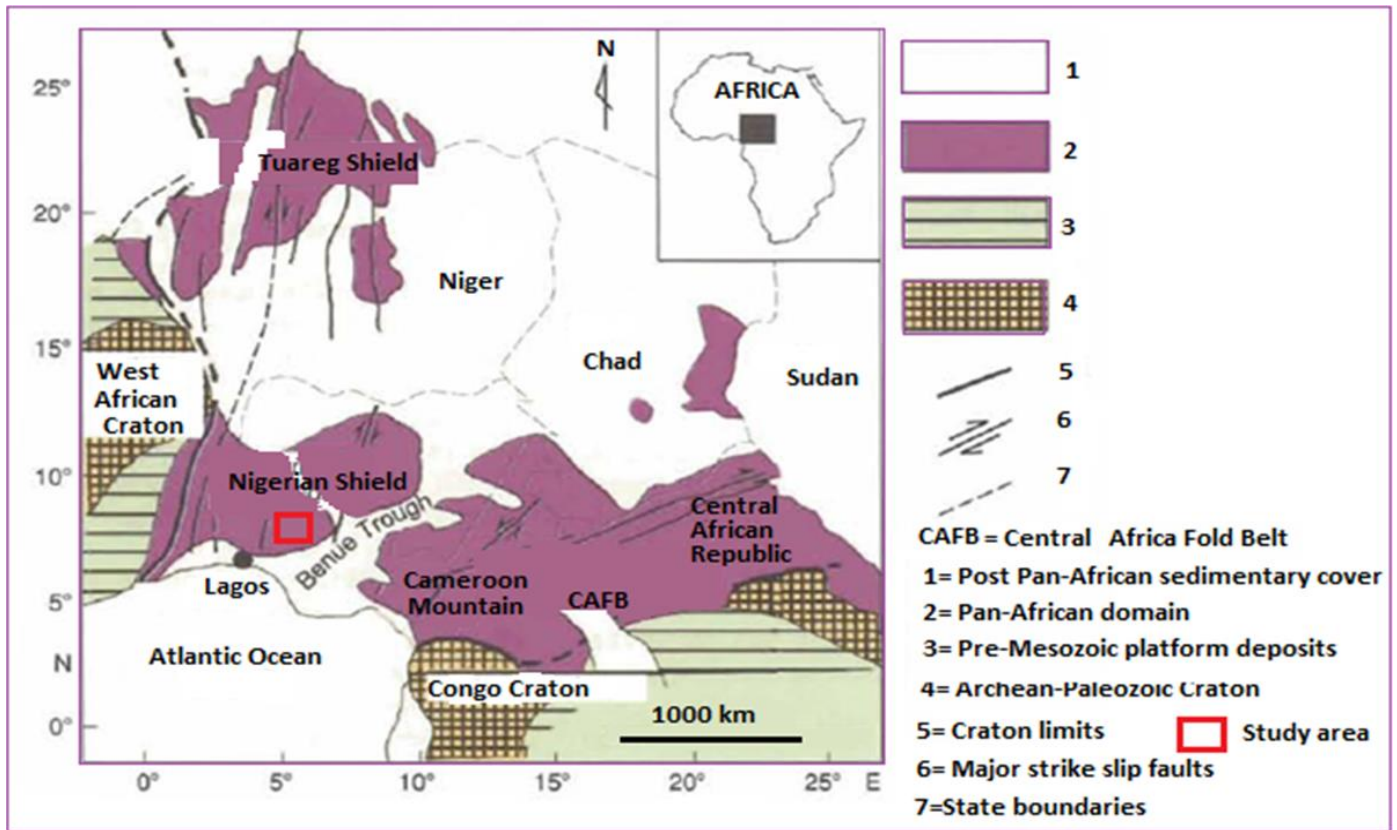


Fig 1 Map Showing the Location of Nigeria in the Heart of Pan-African Reactivated Domain Located between West African and Congo Cratons. (Modified after Turner, 1983).

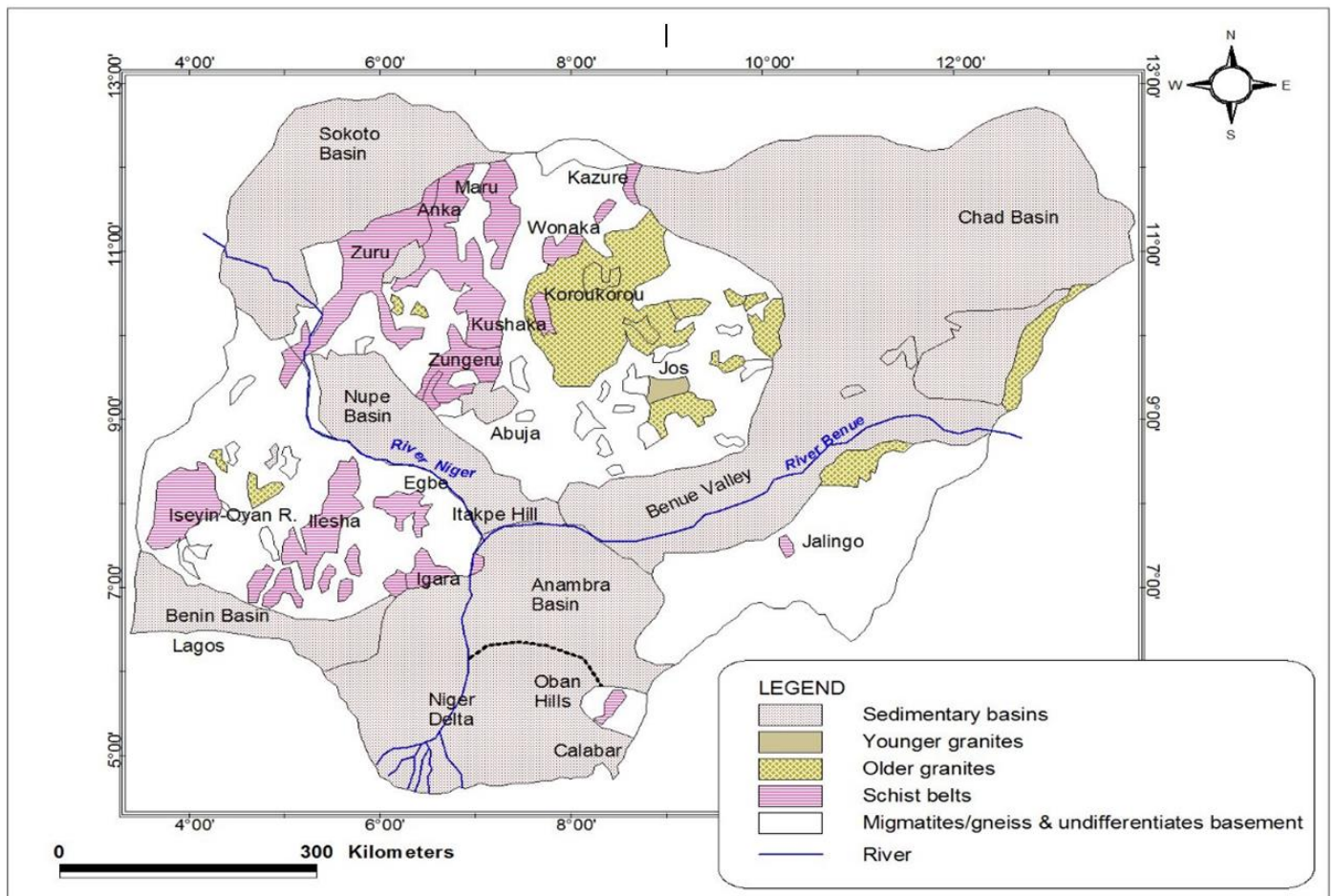


Fig 2 Generalized Geological Map of Nigeria Showing the Basement Complex Rocks and the Sedimentary Basins. (GSN 1994).

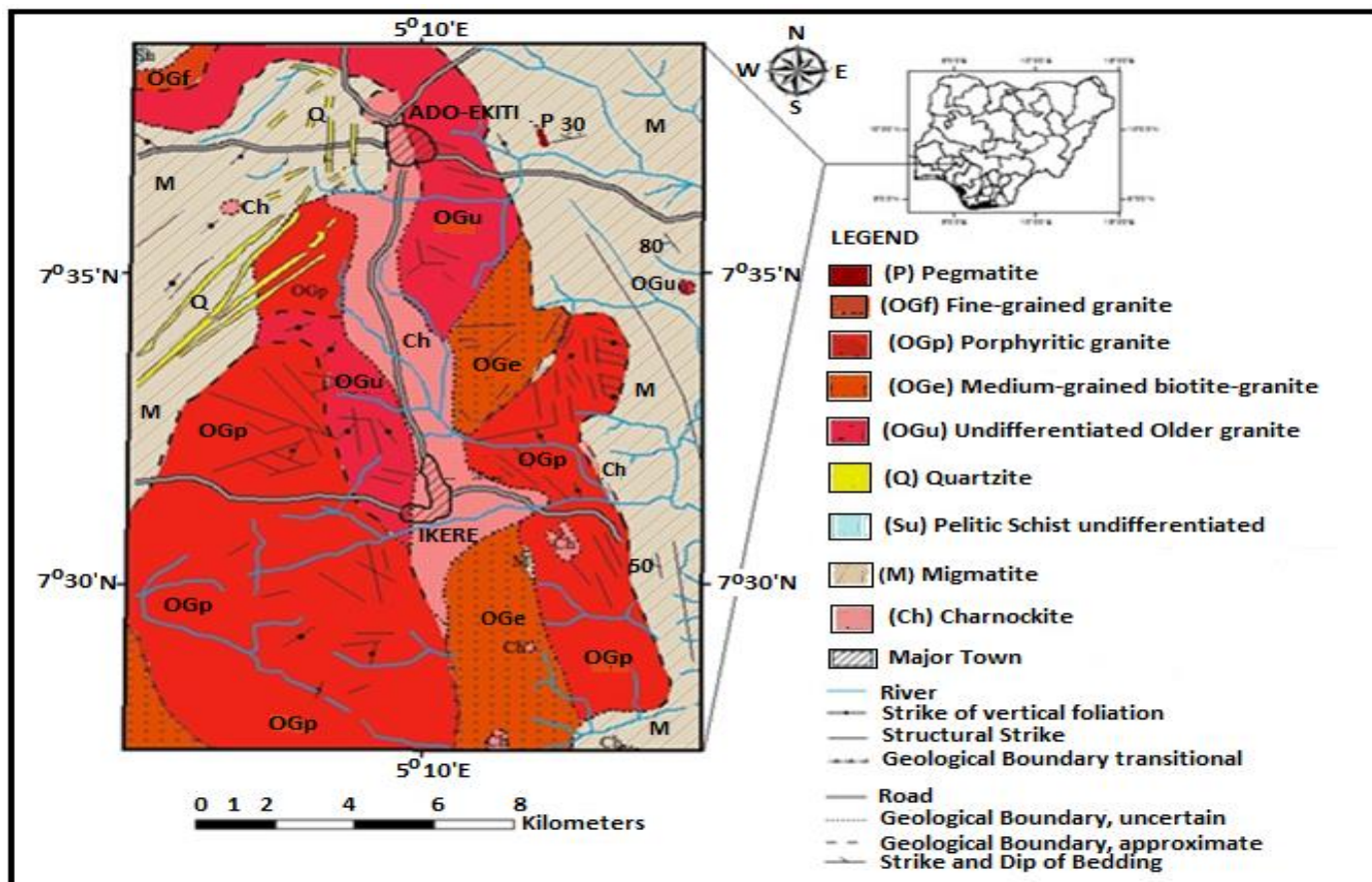


Fig 3 Geological Map of the Study Area

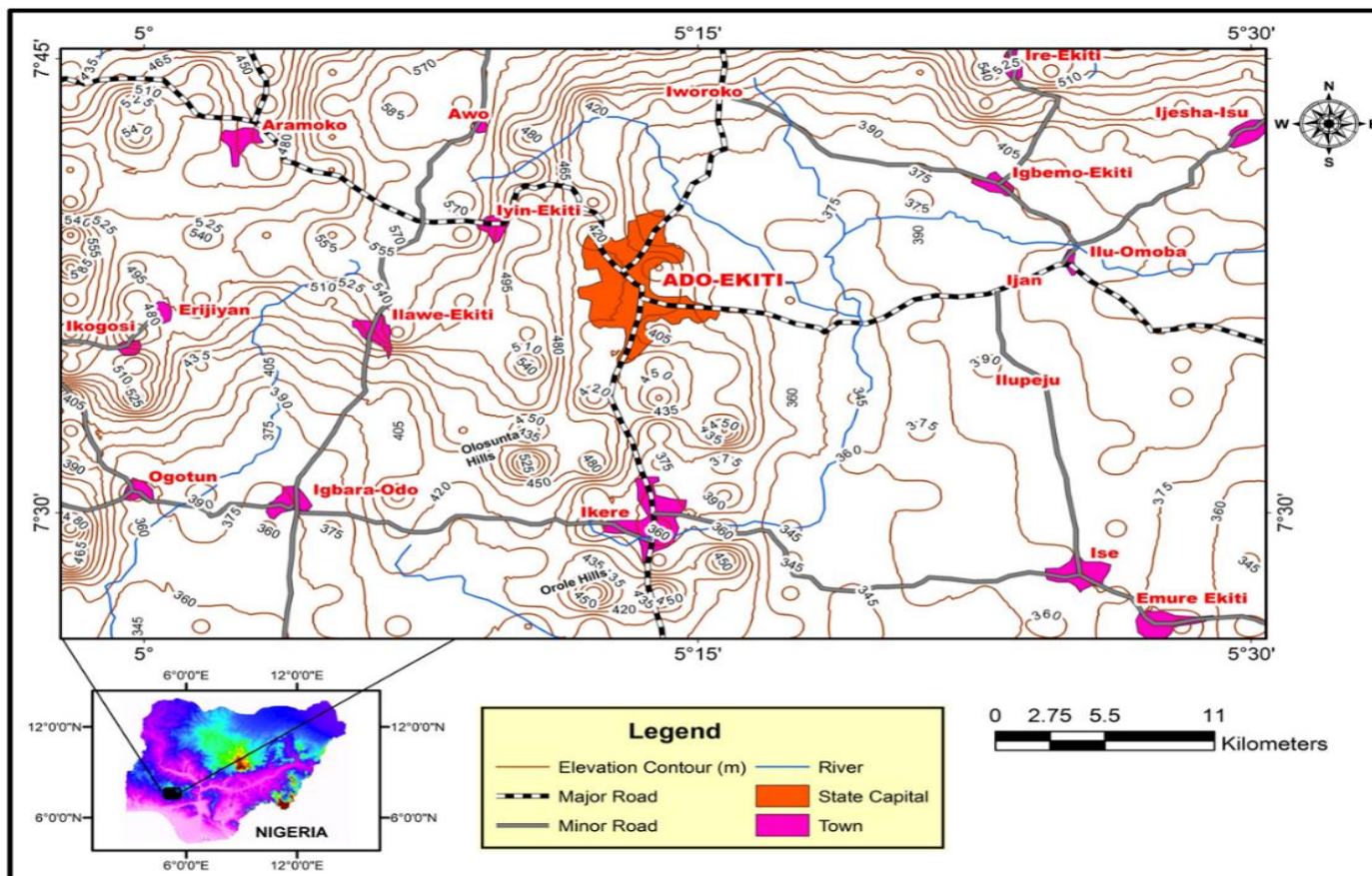


Fig 4 Topographic Map of Ikere-Ekiti, Ado-Ekiti and Environs

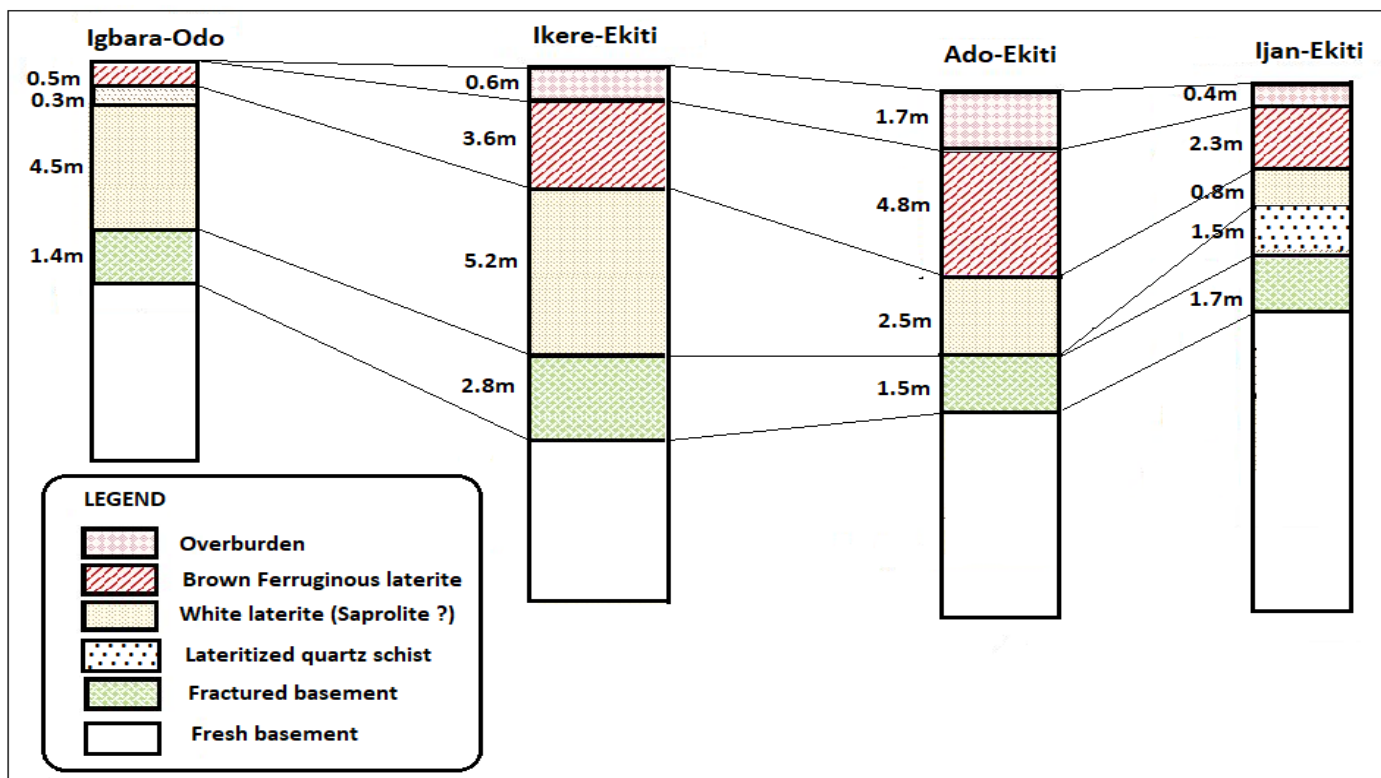


Fig 5 Geological Sections Showing Variation in Thickness of Weathered Profiles above the Fresh Basement in Four Localities within the Study Area.



Fig 6 Field Exposures of the Weathered Products (a) Spongy Laterite Exposed within the Vicinity of Olosunta Hill, Ikere-Ekiti, (b) Bulbous and Erosion Dissected Laterite in Ijede Area, Ikere-Ekiti, (c) a Hummocky Laterite Exposed in Igbara-Odo, (d) A Mesa-Type Laterite (Forming Protective Cap) above the Saprolite Layer (White), (e) Finely Laminated Laterite Exposed in a Ditch Cutting in Ado-Ekiti, (f) Laterite with Gritty Sands Exposed in Ijan-Ekiti.



Fig 7 Impact of Chemical Weathering on Rocks in the Study Area (a) Extensive Exposure of Saproelite (b) Hand Specimen Sample of the Saproelite with Faintly Recognizable Feldspar Porphyries, (c) Extensive Outcrop of Charonockite Chattered into Boulders by Physical Weathering, (d) Chemically Altered *In-Situ* Charonockite Exposed in Dallimore Area, Ado-Ekiti (e) Fresh and Unaltered Granite Outcrop, (f) Early Stage of Chemical Weathering in Granite from the Study Area (the Characteristic Pink Feldspars have Changed to White and the Rock became Soft with a Hollow Sound when Struck with a Hammer).

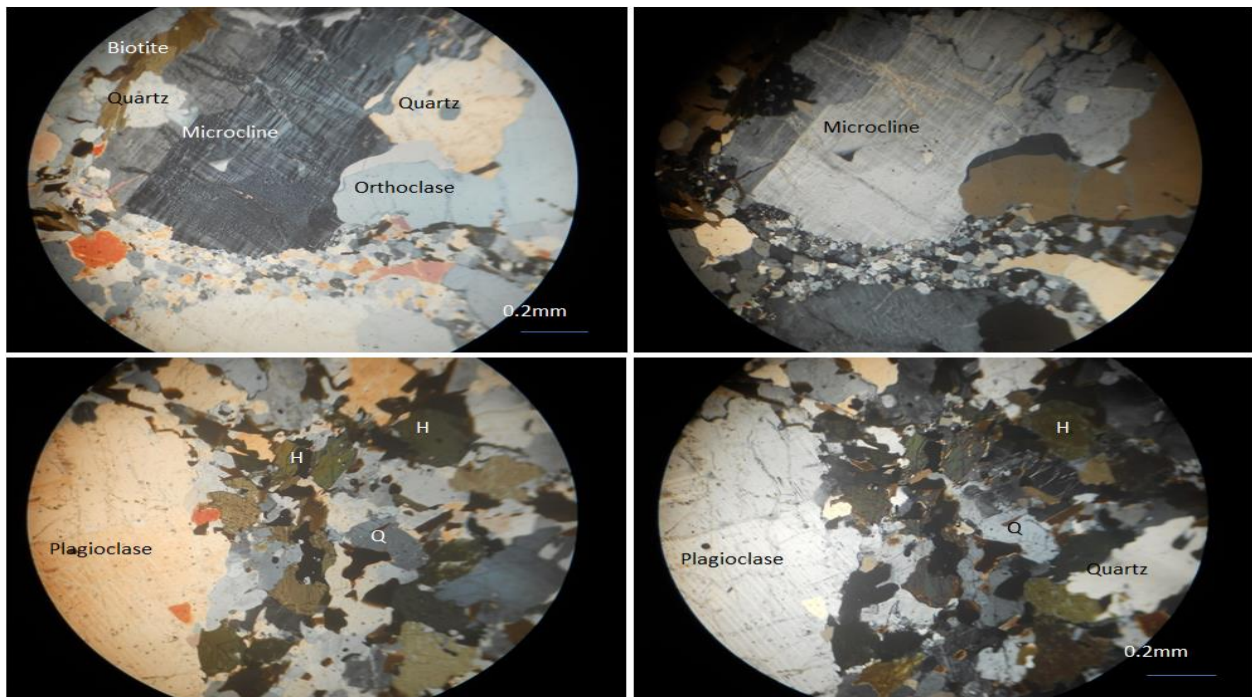


Fig 8 Photomicrograph of Fresh Granite from the Study Area in Transmitted Light cpl (left) and ppl (right) Showing the Constituent Minerals. Quartz (Q), Hornblende (H).

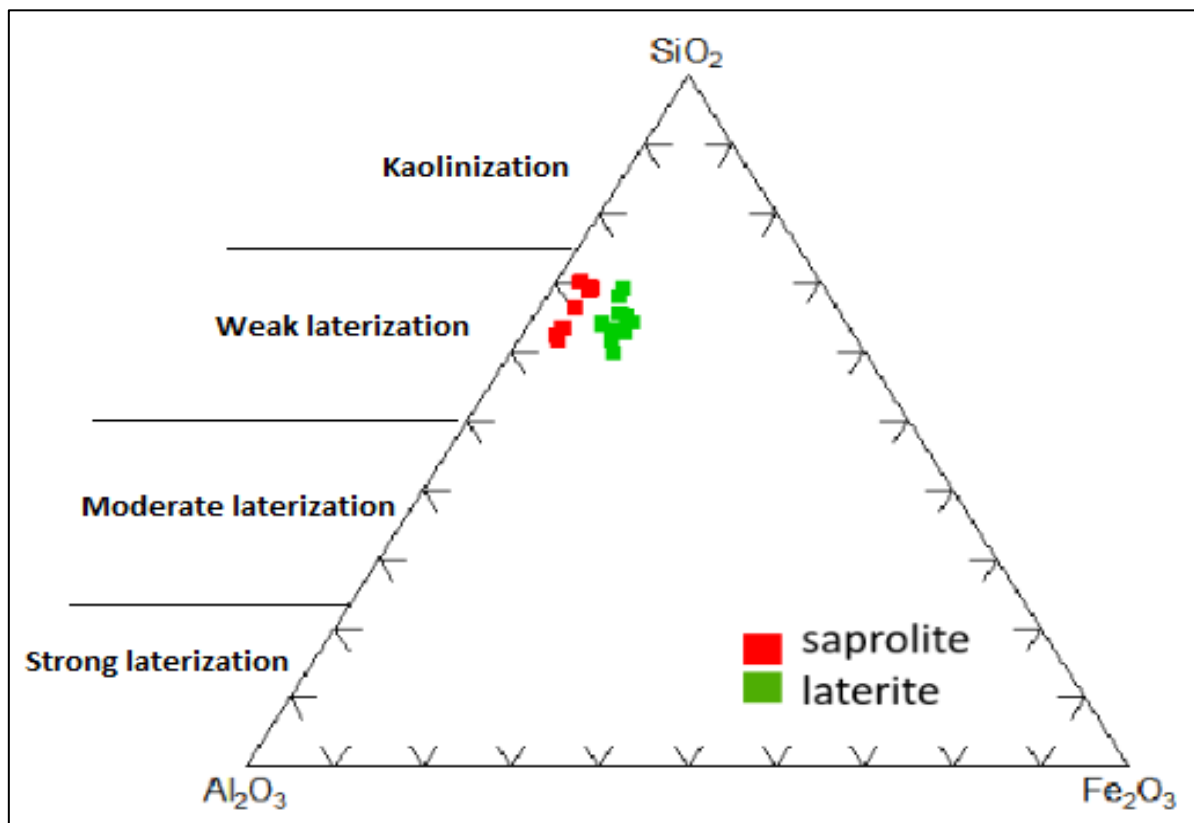


Fig 9 SiO_2 - Al_2O_3 - Fe_2O_3 Ternary Diagram (Schellmann, 1981) Showing Maturity of Laterites Developed over the Basement Complex of the Study Area.

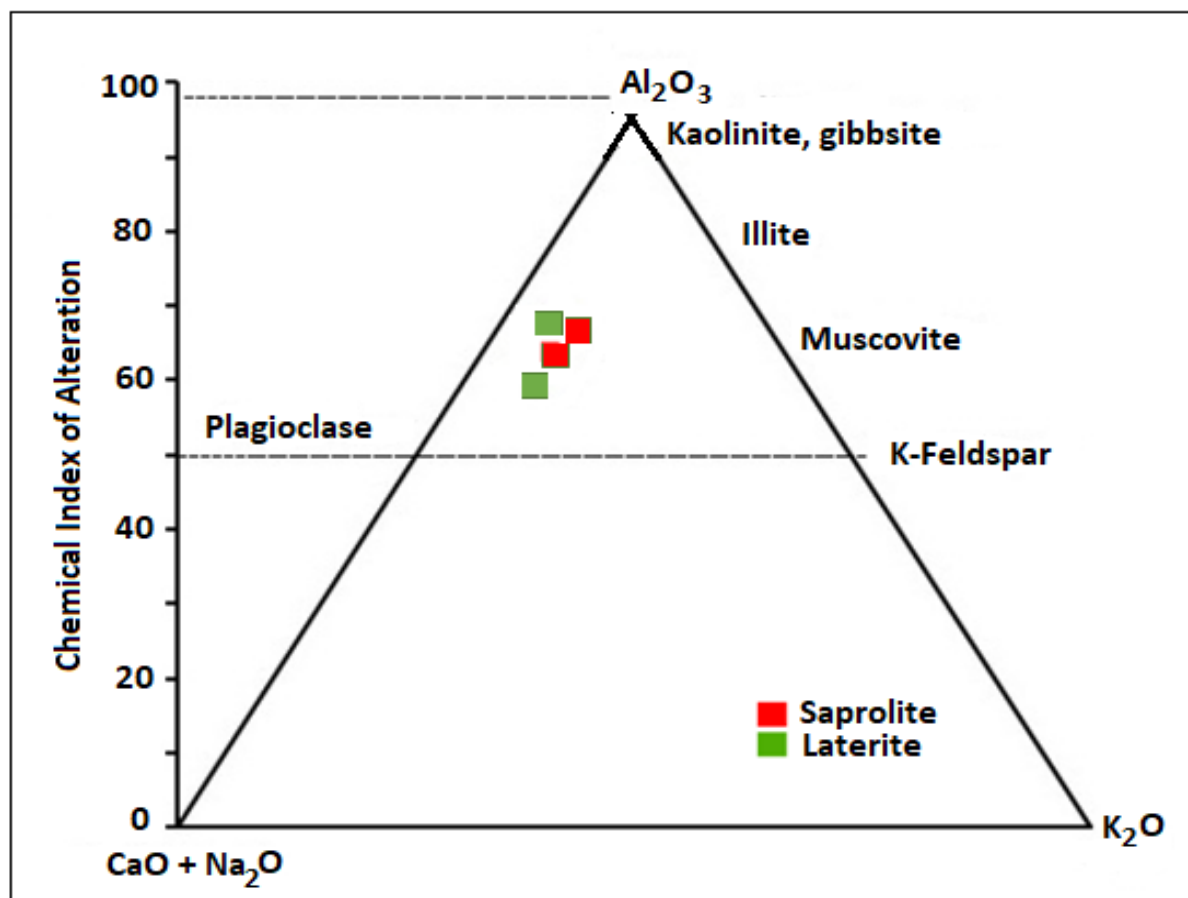


Fig 10 Al_2O_3 -($CaO+Na_2O$)- K_2O (ACNK) Ternary Diagram (Nesbitt and Young. 1982; Fedo et al., 1995) Showing Weathering Trends of the Laterite Profile.

Table 1 Chemical Analysis of the Saprolite

Oxides	WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10	Average
SiO ₂	63.77	63.74	64.51	60.78	65.10	64.27	59.31	59.87	62.41	65.41	62.92
Al ₂ O ₃	24.68	24.23	24.35	31.03	25.30	25.15	32.58	32.46	27.75	25.19	27.27
Fe ₂ O ₃	4.40	4.24	3.94	4.07	2.65	4.01	4.26	3.76	3.98	2.77	3.81
MgO	0.57	0.58	0.51	0.39	0.29	0.49	0.40	0.36	0.45	0.32	0.44
CaO	0.59	0.36	0.47	0.30	0.43	0.50	0.28	0.27	0.46	0.34	0.40
MnO	0.02	0.01	0.01	0.03	0.05	0.01	0.02	0.02	0.02	0.01	0.02
Na ₂ O	0.43	0.46	0.43	0.15	0.48	0.45	0.27	0.28	0.29	0.41	0.37
K ₂ O	3.33	4.24	3.72	1.70	3.79	3.13	1.53	1.53	2.68	3.66	2.93
TiO ₂	1.20	1.31	1.28	0.99	1.32	1.17	0.95	0.95	1.22	1.29	1.17
P ₂ O ₅	0.19	0.21	0.17	0.11	0.11	0.16	0.10	0.09	0.16	0.11	0.14
LOI	0.02	0.62	0.61	0.45	0.48	0.66	0.3	0.41	0.58	0.49	0.46
Total	100	100	100	100	100	100	100	100	100	100	

Table 2 Chemical Analysis of the Laterite

Oxides	BS1	BS2	BS3	BS4	BS5	BS6	BS7	BS8	BS9	BS10	Average
SiO ₂	57.88	63.22	59.75	55.03	58.84	61.67	59.62	57.06	58.48	58.23	58.98
Al ₂ O ₃	23.58	20.71	22.66	26.03	22.13	21.66	22.14	25.48	25.42	24.36	23.42
Fe ₂ O ₃	10.71	7.53	8.80	11.03	10.72	7.64	9.74	9.94	7.53	9.47	9.31
MgO	1.12	0.79	0.91	0.90	0.94	0.82	0.94	0.87	0.87	0.88	0.90
CaO	0.21	0.16	0.18	0.21	0.18	0.16	0.15	0.18	0.35	0.19	0.20
MnO	0.06	0.05	0.03	0.17	0.06	0.03	0.06	0.03	0.03	0.03	0.06
Na ₂ O	0.17	0.27	0.23	0.32	0.18	0.27	0.19	0.19	0.24	0.22	0.23
K ₂ O	3.85	4.66	5.03	3.47	4.64	5.44	4.68	4.22	4.63	4.62	4.52
TiO ₂	1.68	1.95	1.68	1.58	1.61	1.66	1.62	1.23	1.24	1.38	1.56
P ₂ O ₅	0.14	0.10	0.12	0.11	0.13	0.11	0.11	0.12	0.12	0.14	0.12
LOI	0.60	0.56	0.52	0.63	0.51	0.54	0.67	0.68	1.09	0.45	0.63
Total	100	100	99.91	99.48	99.94	100	99.92	100	100	99.97	