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Geochemical Assessment of Charnockitic Rocks in A Localised Area of Ado Ekiti, Nigeria

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Abstract:*Five Charnockitic rock samples were collected from Idemo, Balota community, Ado-Ikere Road, Igirigiri Road and Ado-Ijan Road in Ado Ekiti. The samples were geochemically analysed using atomic absorption spectrophotometer (Unicam 969 model) with a precision of + 0.5. AFM diagram of $Na_2O+ K_2O$; MgO and Fe_2O_3, and plotting of K_2O +Na20 versus SiO_2 were done. Results of analyses show that the Charnockitic rocks fall within the shoshonitic series of magmatic rocks along the subduction zones. They also belong to the Calc-alkaline rock suite. These rocks can be correlated with ryholite, dacite, andesite and basalt rocks types in New Zealand.*

Keywords; *Charnockitic , Cal-alkaline, Shoshonitic ,Magmatic ,Subduction*

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I. Introduction

Charnockitic rocks are broadly defined as granitoids in terms of Quartz-Alkali feldspar Plagioclase (QAP) ternary space but contain orthopyroxene (or fayalite + quartz) and, typically, perthite, mesoperthite or antiperthite (Le Maitre, 2002). Although not included in the formal definition, charnockitic rocks are typically characterized by meso- to melanocratic colour indices, being commonly described as having a dark green, greasylustre and in contrast to the leuco appearance normally expected of granitoids.

Charnockitic rocks generally have diverse origins, spanning within range of metamorphic and igneous derivations (Kilpatrick and Ellis, 1992), which implies that igneous or metamorphic fabric can be exhibited. In Nigeria, charnockitic rocks constitute one of the major petrologic units of the Precambrian basement complex (Olarewaju, 2006). The rock suite has been of interest to the earth scientists partly because of aesthetic value particularly when polished and partly because of the controversy surrounding the origin. Oyawoye (1962, 1964), presented a model of metasomatic origin, Olarewaju (1988), presented the fractional crystallization model while Rahaman et al. (1988) presented the tectonic model and Dada et al. (1989) presented an igneous origin model.

Charnockite is applied to any orthopyroxene bearing granite composed mainly of quartz, perthite, or anti-perthite and orthopyroxene (usually hypersthene as an end member of the charnockite (Deeret al 1997). The charnockite suite or series is a group of igneous rocks variably metamorphosed and of wide distribution and of great importance especially when categorizing them on the basis of their origin.The charnockitic series include rocks of many different types, some being acidic, rich in quartz and microcline, others being basic full of pyroxene and olivine (fayalite and forsterite) while there are also intermediate varieties corresponding mineralogically to norites.

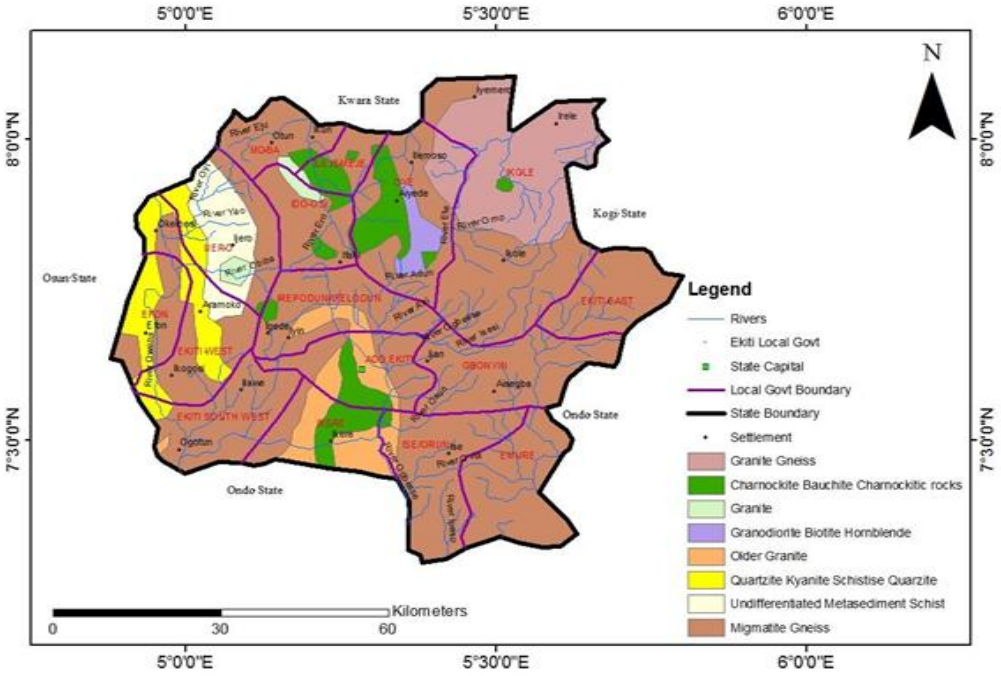
The term charnockite is consequently not the name of a rock, but of the assemblages of rock types (Rahaman 2001).The charnockitic rocks in all the basement complex areas of Nigeria have been recorded from the northern, eastern, western and southern parts of the country (Cooray 1999). These rocks occur generally as low lying outcrops with smooth rounded boulders and few hills all forming oval to sub-circular and elongated bodies (Streckeisen 1994).

The charnockitic rocks are important and cover about 70% of the total area of Ado-Ekiti (Mc Curry 1999). According to Boluwade et al (2013), Ado Ekiti terrain is one of the important basement complex in Nigeria that is characterized by crystalline rocks among which charnockites are the dominant.Charnockites are generally dark greenish in colour and contain plagioclase, antiperthite, biotite, hypersthene (Rahaman 2001) and the different rocks units indicates that the coarse grained variety is youngest. The coarse grained charnockite cover the central portion of Ado-Ekiti.

Various geological studies on charnockitic rocks of Ado – Ekiti had been accessed by various geologists, who suggested different origin for these rocks. According to Oyawoye (1962), he described a metamorphic origin, Donald (1992) suggested an igneous origin and Olarewaju (2006) also suggested metamorphic origin through petrographic analysis of these charnockitic rocks. Further study of their geochemical properties will reveal more information about their origin and as it affects the fabric.

Ado Ekiti is blessed with abundant minerals and industrial rocks of Precambrian origin (Fig. 1) which includes Charnockites" Different studies have been carried out on these rocks that is one of the most abundant industrial rocks in Ado Ekiti and there is still the need for further study of their formations and origin since their exploitation in particular would help boost Ekiti State internally generated revenue.

Fig. 1. Geological Map showing the Industrial Rocks of Ekiti State



Geochemical study would be carried out to determine the percentage concentration of metallic oxides in the charnockitic rocks collected from some locations in Ado – Ekiti. The percentage occurrences of metallic oxides in each sample would be used to plot geochemical diagrams to help describe the origin of the rocks. Such petrogenetical approach could also help to assess the rocks" applicability in polishing, building and dimension stoning. The genesis of charnockitic rocks was widely debated during the 80's and 90's with numerous models revolving around the modes of genesis between magmatic and metamorphic varieties and the distinction of these (e.g. Bohlenderet al., 1992) and particularly in the role of CO_2 in the fluid phase (Newton et al., 1980; Janardhanet al., 1981; Kumar, 2004; Santosh and Omori, 2008; Huizenga and Touret, 2012). Carbon isotopic composition of fluid inclusions and graphite have served as distinct markers in identifying the mantle signatures of carbonic fluids in many occurrences of charnockite formation (Jackson et al., 1988; Farquhar and Chacko, 1991; Santosh et al., 1991; Luqueet al., 2012). A number of variations of these genetic models have been put forward over the years, including: Primary magmatic charnockite generated, with the crystallization of orthopyroxene, from high temperature magmas with low aH_2O (Saxena, 1977; Martignole, 1979; Wickham, 1988; Stern and Dawoud, 1991; Kilpatrick and Ellis, 1992).

Charnockite occurs in many parts of South Western Nigeria. Jones and Hockey (2000) and Hubbard (1998) highlighted areas of its occurrence. Notable areas are Oke – Patara, Ara, Osuntedo and Wasimi. Others are Ikole – Ekiti, Ado – Ekiti, Otun, Egosi, OsiIdanre and Akure. Charnockites occur along the margins of older granite Charnockites are rock, with mineralogical characteristics indicating that they have crystallized under high temperature and medium to high pressure conditions. They contain orthopyroxene, clinopyroxene, quartz and are remarkable for their dark greenwish aspect Haslam (2005), Stern and Dawould (2001) Kilpatrick and Eliss (1992) and Thomas et al (1992). Vans Beeman et al (1999) described charnockites as rocks whose chemical composition falls within the range of plutonic rock (acidic, basic and ultramafic) whose texture resembles those of corresponding plutonic rocks, but with hypersthene as the charnockitic mafic phase (with or without some of clinopyroxene hornblendes or almandine).

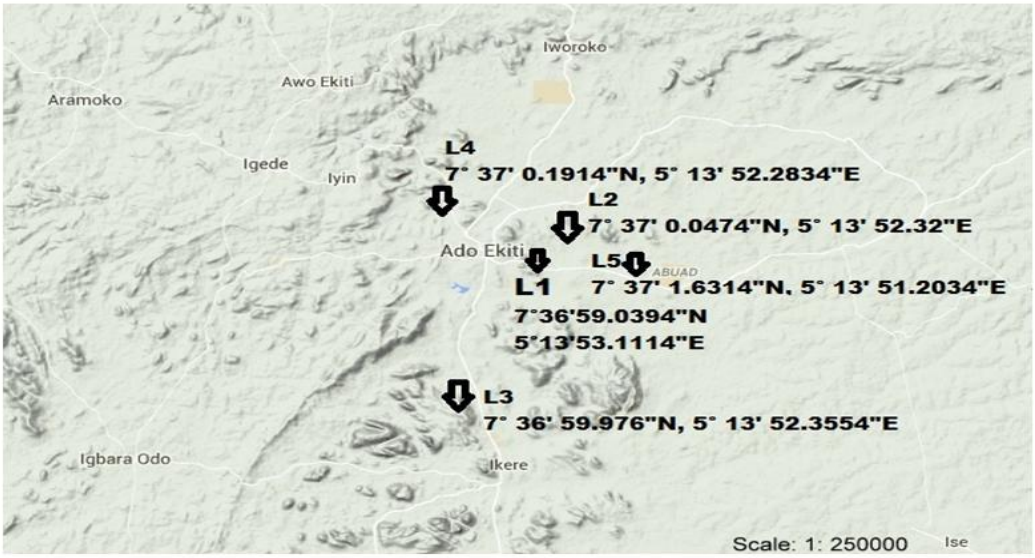
Most charnockite bodies in the basement complex of Ado – Ekiti occurs as low – lying outcrop in form of smooth rounded bounder and elongated bodies. The charnockitic rocks appear to have three mode of occurrence in the area under views. The first mode of occurrence is within what seems to be the "core" of one granite rock as exemplified by the Ikere – Ado – Ekiti body and a few smaller bodies. The second is along the MARGINS of the granite bodies as seen in the Idemo charnockite bodies. These charnockite bodies are mainly

the coarse grained charnockite variety. The last mode of occurrence is represented by discrete bodies of the gneissic fine grained charnockitic rock as seen in Ilara.

II. Materials And Methods

Five samples of Charnockitic rocks were collected from five locations, as shown in (fig. 2). The locations are: Idemo area ;Balota Community ;Ado-ikere Road ;Igirigiri Road; Ado -Ijan Road

Fig. 2: Map of the Study Area showing location of samples.



III. Geochemical Analysis

The rock samples were dried at temperature of 60^0C and crushed using a jaw crusher and pulverized with the ball milling machine and sieved to 80 mesh. Elemental compositions of the rocks were determined using Atomic Absorption Spectrophotometer (Unicam 969 model). 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 avoid the escape of silicon fluoride (SiF_4) gas during mixing of the two acids, the digestion bottle was tightly closed. The digestion bottle was later put on a water bath and warmed up to 70^oC for about two hours and allowed to cool down to 25^0C–30^0C. A 100 ml saturated boric acid was added to the solution and the bottle was tightly closed. The bottle was put on a water bath up to 70^0C 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 which was then analyzed with a dilution factor of 25.Percentage occurrence of the major elemental oxides such as SiO_2, Al_2O_3, K_2O, Na_2O, CaO, MgO, Fe_2O_3 and TiO_2 were obtained using Atomic Absorption Spectrophotometer (Unicam 969 model) with a precision of +0.5. The geochemical results were subjected to variation plots to infer the petrogenesis of the rocks.

IV. RESULTS

Table 3: RESULTS OF THE GEOCHEMICAL ANALYSIS

Oxides {weight%}	Idemo Charnockite {weight%}	Balota comm. Charnockite {weight%}	Ado-Ikere Rd Charnockite {weight%}	Igirigi Charnockite {weight%}	Ado-Ijanroad Charnockite {weight%}
K_2O	6.00	6.07	5.93	6.08	6.04
Na_2O	5.37	5.42	5.52	4.96	5.33
CaO	14.95	14.34	12.52	18.30	15.34
MgO	15.45	16.07	16.14	16.63	15.64
SiO_2	27.17	26.89	28.09	24.74	26.90
TiO_2	0.31	0.24	0.15	0.07	0.24
CrO_2	1.57	1.40	1.43	0.80	1.56
MnO	2.70	2.63	2.51	2.78	2.78
Fe_2O_3	10.65	10.44	10.77	10.11	10.52
NiO	0.99	0.89	0.93	0.79	1.10
CuO	8.70	8.83	9.21	8.23	8.69
ZnO	6.09	6.73	6.78	6.50	6.13
Total	**99.95**	**99.95**	**99.98**	**99.99**	**99.99**

The table shows percentage of oxides that are present in the charnockitic rock samples. Silicon oxide (SiO_2) has the highest percentage ranging from 24.74% - 28.09 % followed by Calcium oxide that ranges from 12.42 % - 18.30 %, Magnesium oxide (MgO) from 15 – 45 % to 16.62 %, Iron oxide from 10.11% - 10.44 %. Potassium oxide (K_2O) ranges from 5.93 to 6.08 %, Sodium oxide (Na_2O) ranges from 4.97 % to 5.52 %. The percentage weight of Titanium oxide (TiO_2) is the lowest, ranging from 0.07% - 0.31%

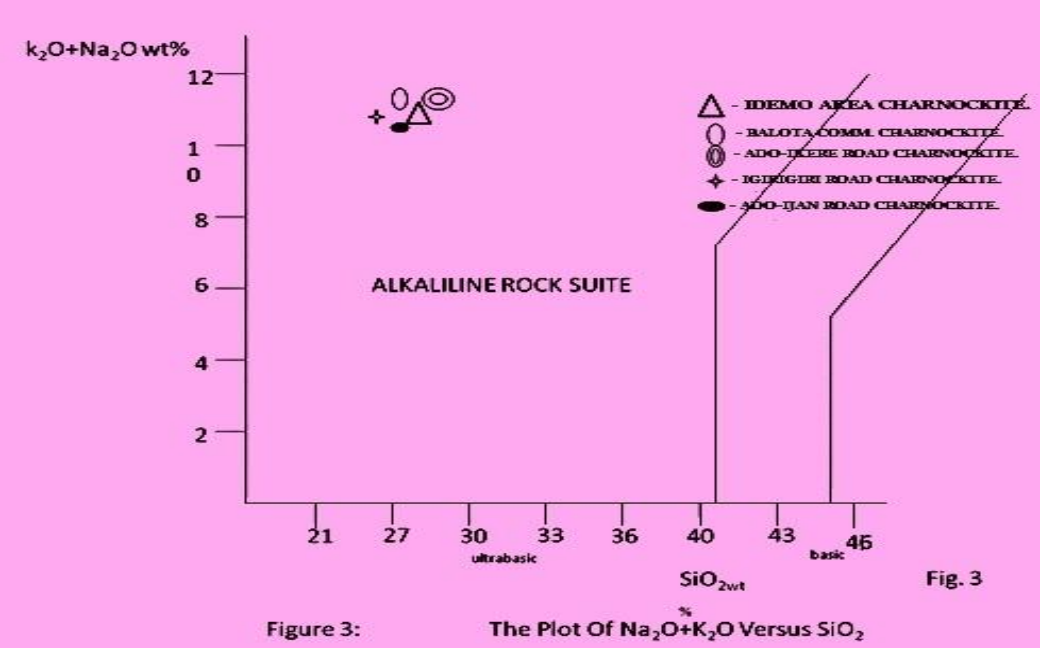


Fig.3 Showing the Plotting of Na_2O+K_2O versus SiO_2

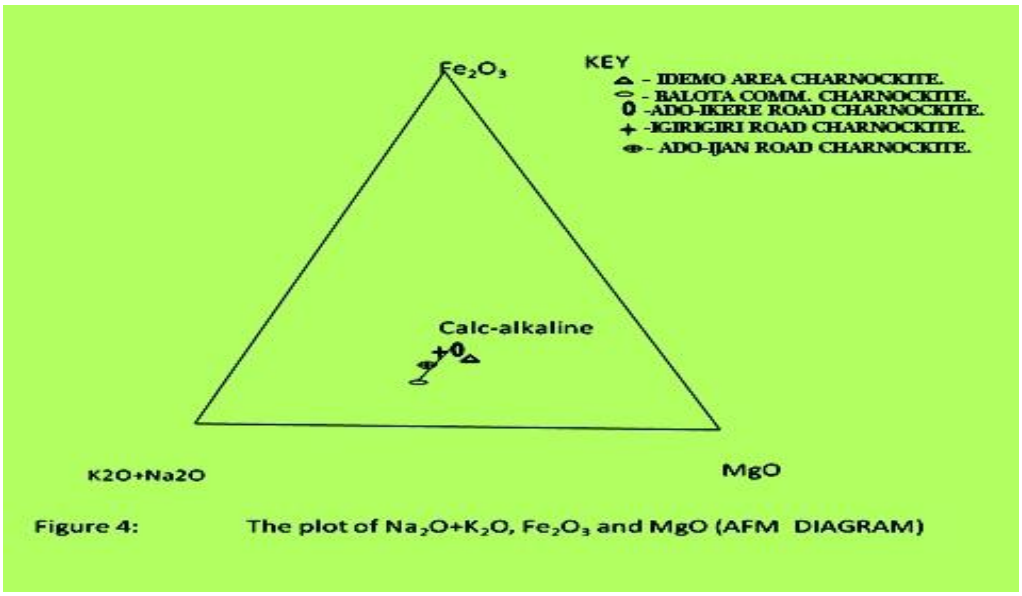


Fig. 4 Showing the plot of Na_2O+K_2O, Fe_2O_3 and MgO (AFM Diagram)

V. Discussion

The plot in figure 3 is compared with the plot of Anthony (1996) and it can be deduced that the charnockitic rock samples of Ado – Ekiti falls within the shoshonite series of magmatic rocks. The shoshonite series has more k – enriched rocks and can be found in a few subduction zones in the thick continental crust and in some Island arcs. Shoshonite series is any tranchyandesiste composed of olivine and augitephenocrysts in a groundmass of labradorite with alkali feldspar, olivine, augite, a small amount of leucite, and some dark-coloured glass. Shoshonite series can be categorized as either absarokite with an increase in olivine or into

banakite with more sanidine. Such subduction occurrence could be associated with an ancient volcanism, earthquakes and mountain building that could have occurred during the formation of the Ado – Ekiti charnockitic rocks. The shoshonitic suite is Absarokitic in nature with higher potassic concentration.

According to Anthony (1996), the plot of $Na_2O + K_2O$ versus SiO_2 in figure 3 reveals that the Ado – Ekiti charnockitic rocks are Alkaline in Origin but with higher percentage occurrences of sodic and potassic oxides, showing that the rock belong to alkaline rock suite. This is also an expected characteristic feature of rocks of volcanic oceanic island near the intersection of the Mid – Atlantic and Walvis Ridges in the South Atlantic Ocean (Bowen N.L 1958). The tenary plot of Alkalis ($Na_2O + K_2O$), Iron oxide (Fe_2O_3) and Magnesium oxide (MgO) in figure 4 reveals that Ado – Ekiti charnockite are calc – alkaline in origin; as the rhyolite, calcite, andesite and basaltic rock types in New Zealand. According to Bowen, (1958), trend of limited Fe enrichment and greater production of felsic end products is, exemplified by calc – alkaline rocks. It could be noted that there is a range of differentiation processes that can operate on primitive basaltic magmas, producing a continuous spectrum of rock suites and trends whose end members are of the skaergaard and calc – alkaline trends.

VI. Conclusion

It can be concluded from this study that the charnockitic rocks of Ado – Ekiti are shoshonitic in nature and the study based on the K_2O content in relation to silica (SiO_2) reveals that the Ado-Ekiti rocks belong to cal-alkaline rock series and volcanic suite of the active continental margin. They could also be described as volcanic rocks of the orogenic rock association. The magma body that gives rise to these rocks could have belongs to calc – alkaline rock suite which can be correlated with rhyolite, dacite, andesite and basalt rock types of New Zealand.

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