FULL LENGTH RESEARCH ARTICLE

EVOLUTIONARY TREND OF THE JARAWA YOUNGER GRANITES RING COMPLEX, JOS PLATEAU, CENTRAL NIGERIA

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ABSTRACT
The Jarawa Younger Granites Ring Complex which occupies the eastern flank of the popular Jos-Bukuru Ring Complex in Central Nigeria was geologically and geochemically investigated in order to identify the different lithologic units that make up the formation, as well as understand its geochemistry. These were used to unravel its mode of emplacement. Geological field studies revealed that the Jarawa Younger Granites evolved from two major phases of intrusions, the Hornblende Porphyry phase that was accompanied by the Hornblende Biotite Granites and the coarse grained Biotite Granite phase associated with the Biotite Microgranites. Results from geochemical studies supports the above findings, indicating high CaO and MgO content that decreases from the Hornblende Porphyry through the Hornblende Biotites to the coarsed grained Biotite Granites and the Microgranites respectively. Also, all the lithologic units exhibited high alkali content (Na_2O + K_2O) suggesting secondary magma source for the Jarawa Younger Granites Ring Complex.

Key words: Geology, Lithology, Granites, Akali, geochemistry, Grain sizes

INTRODUCTION

The Jarawa younger granite is one of the several granite ring complexes of Central Nigeria. It occupies the eastern and northeastern parts of the Jos-Bukuru younger granites ring complex, a good representative of the typical younger granite ring complexes in Nigeria. The Nigerian younger granites ring complexes are a series of petrologically distinctive crystalline igneous rocks of granitic composition. Several individual complexes have been identified with varying sizes and named after their localities, individual massifs range from 640km^2 to less than 1.68km^2. Ogezi (1986) referred to them as Cenozoic (jurassic) igneous granitic rocks suites that occur in a north – south trending belt, restricted to the northern part of the country, indicating that the suites extend from Afu (near River Benue) in Central Nigeria to Zinder and A'ir in Niger Republic and covers an area of about 1300km^2 within Nigeria – enclosing parts of Plateau, Bauchi, Kano and Kaduna states. (Fig.1) They are emplaced as non volcanic intrusions from high level magmatic activities and controlled by ring fracturing, faulting and cauldron subsidence (Turner 1971) and hence, there evolution as near ring (circular) complexes. They are however, known to be associated with earlier acid volcanoes such as ryholites, gabbros and syenites (Elebe 1990).

The Nigerian younger granite complexes are known to be mineralogically heterogenous with variations in their textures that are attributable to the proximity of the roofs of the batholiths (Falcorner 1921). They are composed of a wide variety of rock types including, but not limited to hornblende poprphyry, hornblende biotite granites, biotite granites, fayalite granites, riebeckites granites and some basic to intermediate rocks (mostly named after the most abundant mafic mineral content). Individual younger granite suites are known to contain different rock types in the various sub provinces despite their age differences that decrease towards the south, suggesting that their emplacement was fundamentally controlled by thermal anomaly in the mantle or lower crust but not related to any orogenic activity and are thus referred to as unorogenic (Garba 1987). This is also supported by their non-foliated and un-fractured surfaces (Idumah 2005), in contrast to the foliated calc-alkaline older granites (Turner 1989).

MATERIALS AND METHODS

Location and Field Occurrence: The study area is located at the central part of the Jarawa younger granites ring complex and encompasses all the different lithologic units within the complex. It lies within the Maijuju sheet no.138; covering an area of about 28.62km^2 and bound by latitude 9^o 53' to 9^o 56" N and longitude 9^o 08'and 9^o 11' E (Fig. 2.) The Jarawa younger granites ring complex is exposed on high lands of the Jos Plateau where the granitic ring dykes stand out as steep ridges from the plains (Shuaibu 1985). Early geologic investigations (Buchanan *et al*. 1971; Macleod *et al*. 1971) and geochemical investigations of part of the granite complex was carried out by Imoekparia (1985), Shuabu (1985) and Adubok (1987) in order to identify the different lithologies and to understand the evolutionary trend of the different rock units within the complex.

Field investigations confirmed the findings of the above investigations, revealing two major younger granite intrusions in the Jarawa granite complex; the hornblende porphyry granites and the biotite granites. The earlier, is accompanied by the hornblende biotite granites while the later is associated with the fine grained biotite microgranites (Imoekparia 1985; Adubok 1987). The younger granites are found to discordantly intrude into the basement complex with very sharp defined contacts. These boundaries are also noticed between the hornblende biotite granite and the biotite granites, overlapping transition also exists, such as those between the biotite granites and the hornblende porphyry that forms the external periphery of the ring dykes and characterized by very coarse-grained minerals, they form the immediate contact with the basement complex. There is an observed thinning of the porphyrytic layer arising from successive intrusions of hornblende biotite granite and the biotite granites, which occupies the central portion of the complex. The coarse mineral grains of the hornblende porphyry tend to decrease with distance from the basement probably due to increased rate of magmatism at the center. The hornblende porphyry and the hornblende biotite granites exhibit different mineral colors, the porphyry being darkish green while the later is composed of light colored minerals. They are however made up of similar meralogic composition- plagioclase feldspar, quartz, hornblende and biotites, with greater hornblende content in the porphyry. Likewise, the coarse grained biotite granite and the biotite microgranite are similar in mineralogy but different in texture, predominantly composed of orthoclase feldspar, biotite, quartz and hornblende The coarse grained biotite granite is the most voluminous, covering the southern part of the study area while the microgranite is enclosed within the central part and is composed of relatively medium to fine grained minerals. Biotite microgranites sampled near contacts exhibited porphyritic character indicated by the sparsely distributed large phenocryst of feldspar (up to 2cm long) and some elongated quartz crystals.

At the contacts, between microgranites and the hornblende biotite granites, banded boulders of rock samples were observed with the upper part having the petrologic characteristic of the former, while the lower layer has coarse-grained mineral texture of the later. This could be due to an overflow of the microgranites on the preexisting hornblende biotite granite units. The hornblende biotite granites also contained xenoliths of basic to intermediate composition that ranges up to 3cm. they may be remnants of preexisting hornblende porphyry preserved within the granites as they intrude the basement. This could portray that the origin of the granites itself is can be attributable to partial melting of the preexisting rocks (Macleod *et al*. 1971).

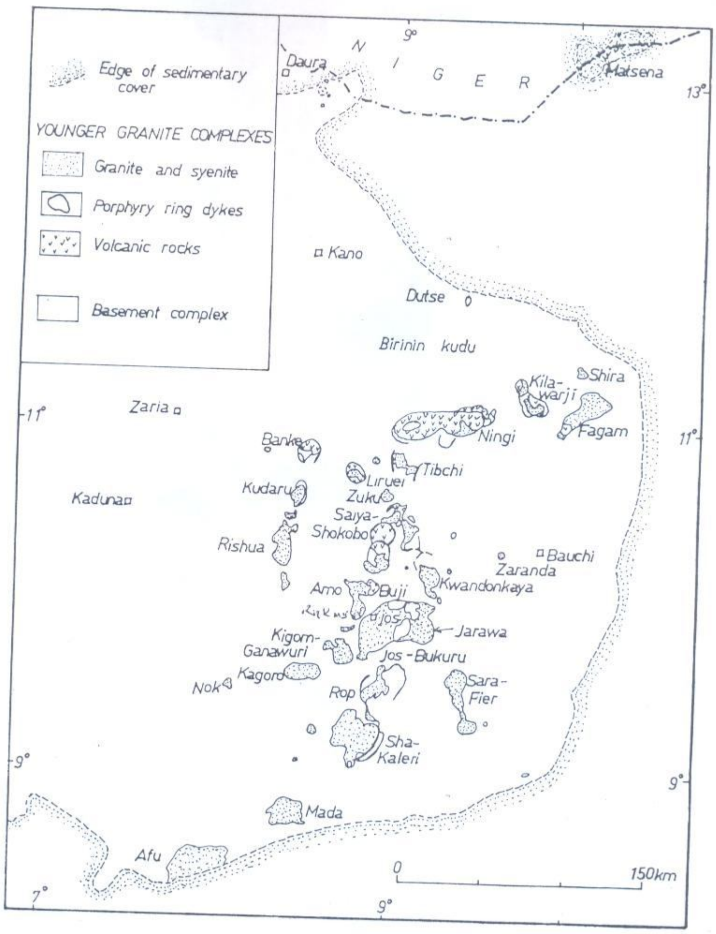

FIG. 1. GENERALISED GEOLOGICAL AND DISTRIBUTION MAP OF THE YOUNGER GRANITE OF NIGERIA

Geochemistry: Geochemical investigations were carried out on the different rock units and used to decipher the physiochemical conditions under which the different petrologic bodies were emplaced. Twenty six (26) whole rock samples from the different rock units were randomly collected and analysed. Eight (8) samples each were collected from the hornblende porphyry granites and the hornblende biotite granites while five (5) samples each were collected from the coarse-grained biotite granites and the biotite microgranites. The samples were decomposed by hydrofluoric and perchloric acid and the solution of each sample was evaporated to near dryness. The resulting solution was analysed for calcium (Ca), magnesium (Mg), iron (Fe), sodium (Na), potassium (K), aluminium (Al) and lead (Pb) following the method of Elsie (1982). Samples analyses were carried out by the Atomic Absorption Spectrophotomoter (AAS) and results obtained are presented in tables 1- 4. Interpretation of the data was done using variation diagrams. Kuno solidification index with empherical formular 100MgO/MgO+Fe_2O_3+Na_2O+K_2O Vs CaO and MgO respectively were used to assess the solidification stages of the different rock units. Results obtained are presented in figures 3a and 3b respectively. Triangular variation diagram (fig.4) of MgO Vs Fe_2O_3 Vs NaO+K_2O was also used to assess the genetic relationship between the different rock units.

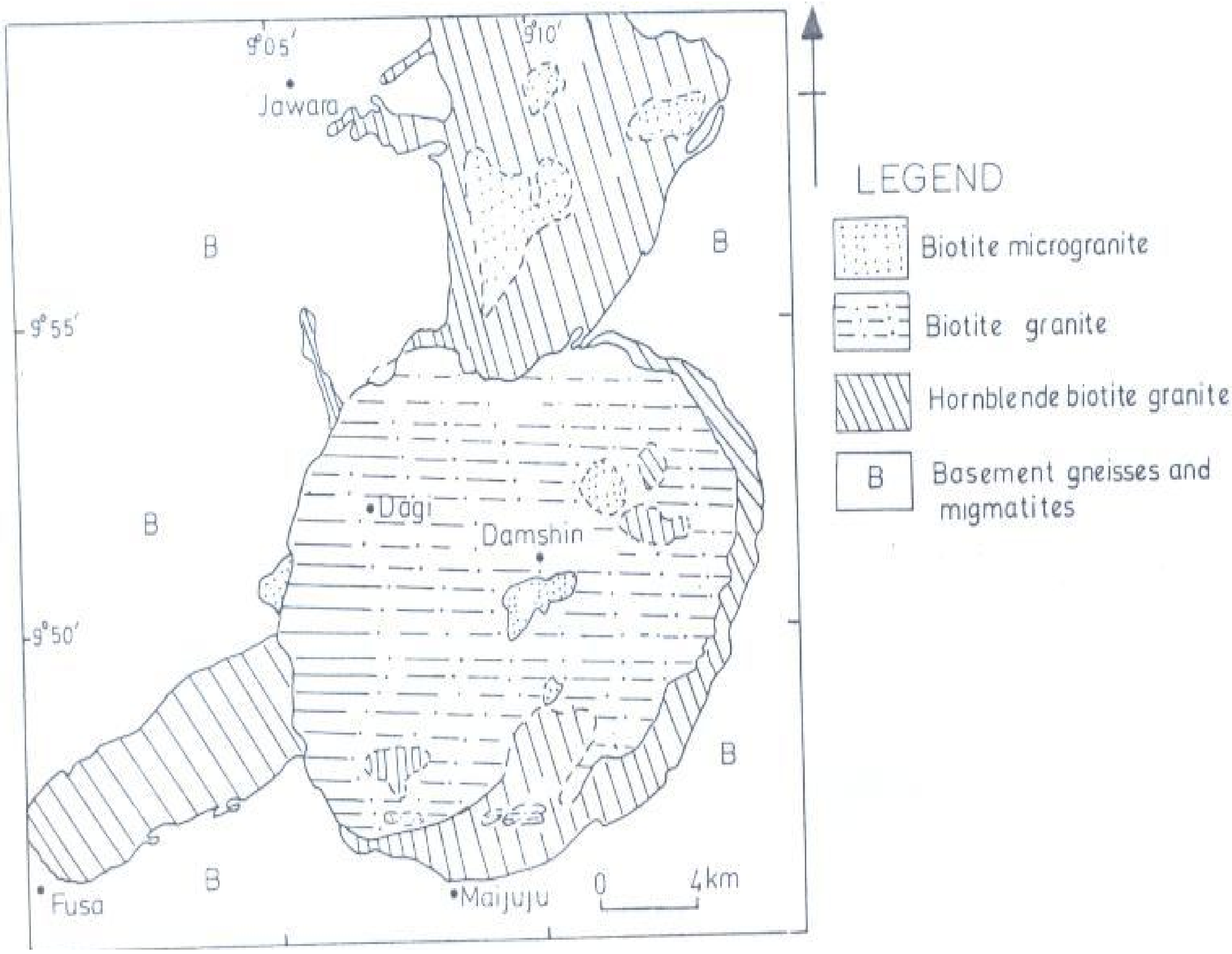

FIG. 2. GEOLOGY OF THE JARAWA COMPLEX (AFTER BUCHANAN *et al*. 1971)

TABLE 1. CHEMICAL COMPOSITION OF HORNBLENDE PORPHYRY GRANITES

Sample	Oxide (%)							
No	K_2O	CaO	MgO	FeO	Fe_2O_3	AL_2O3	Na_2O	PbO
JA-HP	4.90	1.20	0.44	3.16	3.51	11.58	4.59	0.010
JA-HP2	4.94	0.97	0.42	3.22	3.58	12.58	4.54	0.012
JA-HP3	4.62	0.97	0.45	2.86	3.18	11.34	3.99	0.015
JA-HP4	5.21	1.20	0.39	2.49	2.77	11.42	4.73	0.015
JA-HP5	5.18	0.47	0.39	2.84	3.26	11.34	4.33	0.037
JA-HP6	5.18	0.09	0.27	2.24	2.49	11.10	4.58	0.015
JA-HP7	5.25	1.05	0.43	2.34	2.60	11.58	4.36	0.048
JA-HP8	5.44	0.94	0.34	2.70	3.00	11.50	4.53	0.039

TABLE 2. CHEMICAL COMPOSITION OF HORNBLENDE BIOTITE GRANITES

	Oxide (%)							
Sample No.	K_2O	CaO	MgO	FeO	Fe_2O_3	Al_2O_3	Na_2O	PbO
JA-HB1	3.20	0.33	0.11	0.72	0.80	4.18	2.28	0.017
JA-HB2	5.17	0.84	0.23	3.26	3.63	12.63	4.64	0.018
JA-HB3	5.22	0.84	0.23	3.13	3.48	11.34	4.44	0.017
JA-HB4	5.21	0.70	0.26	2.96	3.29	11.90	4.38	0.017
JA-HB5	5.26	0.70	0.26	3.18	3.54	12.14	4.55	0.018
JA-HB6	5.27	0.71	0.28	3.18	3.54	12.39	4.39	0.017
JA-HB7	5.29	0.77	0.24	3.01	3.35	11.82	4.59	0.018
JA-HB8	5.23	0.76	0.28	3.08	3.50	12.12	4.30	0.015

TABLE 3. CHEMICAL COMPOSITION OF COARSE GRAINED BIOTITE GRANITES

	Oxide (%)							
Sample No.	K_2O	CaO	MgO	FeO	Fe_2O_3	Al_2O_3	Na_2O	Pb
JA-BTI	4.80	n.d	0.11	1.49	0.66	10.93	4.61	0.018
JA-BT2	4.11	0.33	0.13	1.31	0.46	11.09	4.71	0.017
JA-BT3	5.06	0.32	0.12	1.52	0.69	12.02	4.15	0.012
JA-BT4	4.97	0.34	n.d	1.34	0.49	11.98	4.80	0.012
JA-BT5	4.59	0.33	n.d	0.77	0.86	10.70	4.57	0.010

n.

FIG. 1. GENERALISED GEOLOGICAL AND DISTRIBUTION MAP OF THE YOUNGER GRANITE OF NIGERIA

	Oxide (%)							
Sample No.	K_2O	CaO	MgO	FeO	Fe_2O_3	Al_2O_3	Na_2O	Pb
JA-M1	5.45	0.23	0.07	1.10	1.22	11.50	4.85	0.020
JA-M2	5.41	0.23	0.11	1.16	1.29	12.55	4.78	0.018
JA-M3	5.47	0.23	0.09	1.10	1.22	11.74	4.49	0.017
JA-M4	4.44	n.d	n.d	0.47	0.86	11.74	4.42	0.020
JA-M5	5.52	n.d	n.d	0.95	1.06	11.90	4.37	0.018

RESULTS AND DISCUSSION

Field investigations revealed the Jarawa younger granites ring complex as one of the best example of large-scale cauldron subsidence. From the results, the Jarawa younger granites ring complex is made up of four different rock units, belonging to two major intrusive phases as earlier proposed by Berrrdge *et al.* (1971) and Imoekparia (1985), comprising of the Hornblende Porphyry Granite phase with an accompanying Hornblende Biotite Granite suite and a Biotite Granite Porphyry phase, associated with Biotite Microgranite suite. The above findings are supported by results of the geochemical investigations illustrated by the Kudo's solidification index (Figs.3 & 4), indicating the four different rock units within the mapped area to have been emplaced at different stages, supporting the multiple emplacement mechanism. The percentage calcium oxide (CaO) content varies for the different rock units (Fig.3) decreasing from the Hornblende Porphyry through the Hornblende Biotite, to the coarse grain Biotite Granites and the Biotite Microgranites. This sequence portends that the Hornblende Porphyry was first to be emplaced and the sequence continued to the last member of the intusion, the Biotite Microgranite. Fig. 4 also supports the emplacement mechanism, agreeing to the fact that the rock units can be grouped into two – a Hornblende group comprising Hornblende Porphyry and Hornblende Biotite Granite and a Biotite Granite group, made up of coarse grained Biotite Granite and the Biotite Microgranites with their varying MgO contents.

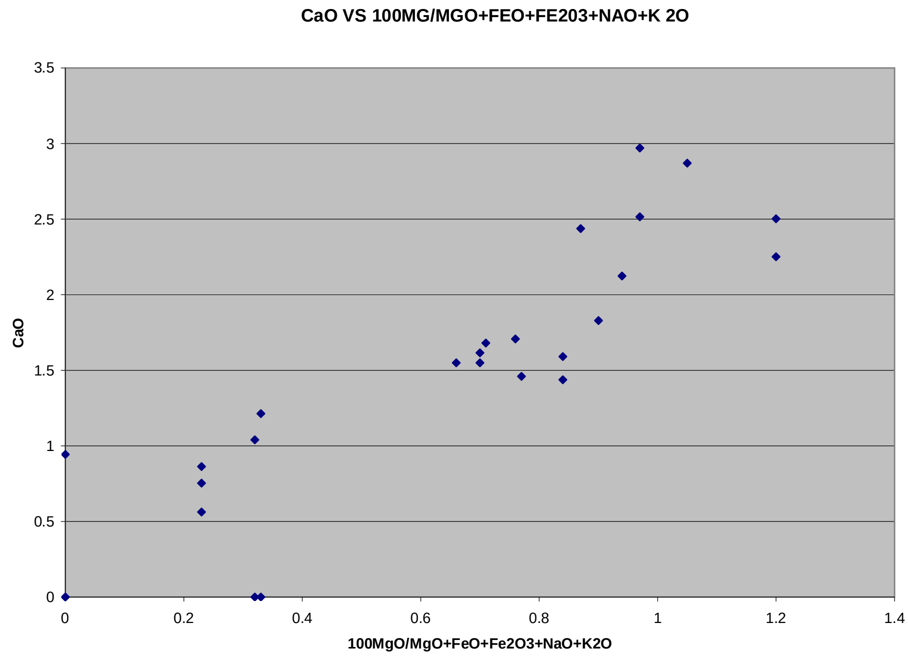

FIG.3. KUNO SOLIDIFICATION GRAPH

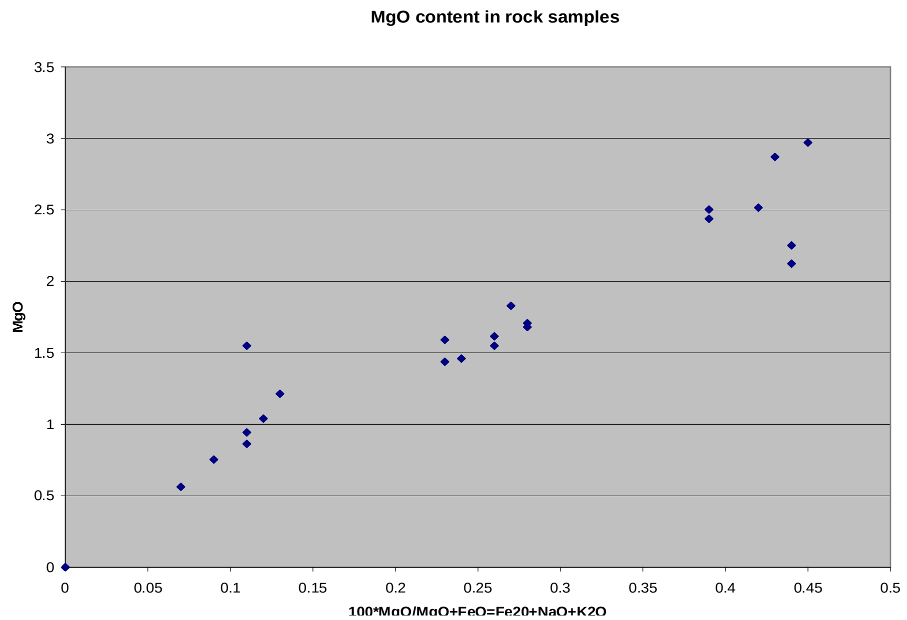

FIG. 4. KUNO SOLIDIFICATION GRAPH

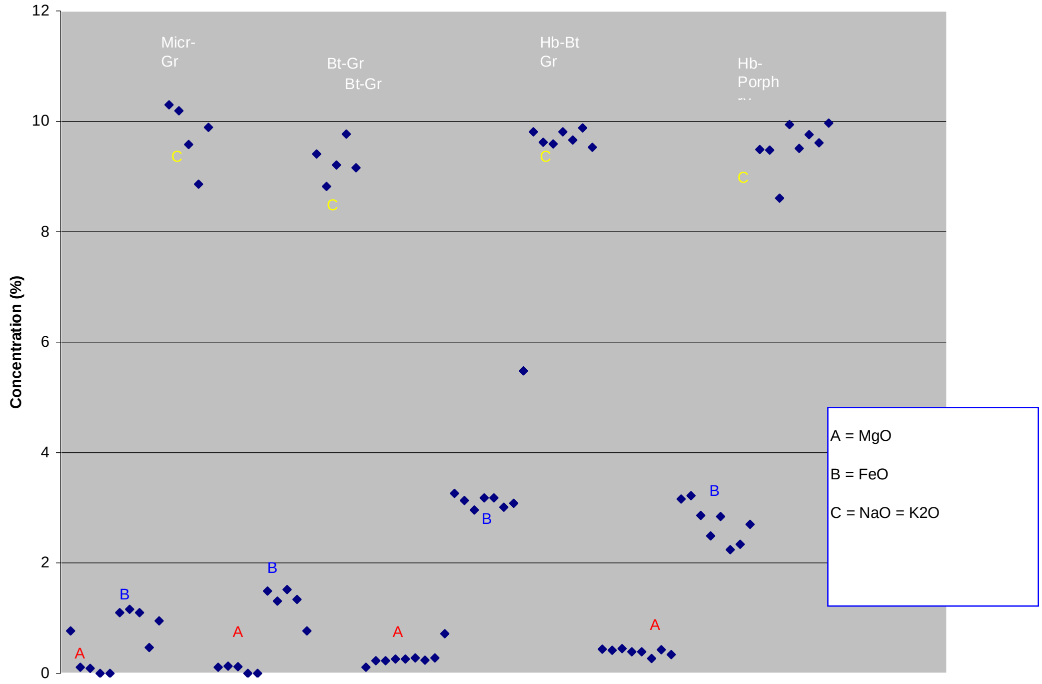

FIG. 5. VARIATION IN MnO, FeO & NaO + K_2O CONTENT

The Variation in Fig. 5, depicts that the four rock units evolved from a single magma with very low MgO content but relatively richer in alkali (Na_2O + K_2O). The low MgO content portrays a secondary magma source, which had earlier differentiated. Primary magmas are characterized by higher MgO, FeO and CaO content. Hence, the rocks were probably formed through subsequent re-melting and emplacement of earlier formed magmatic materials that were controlled by peace-meal stopping mechanism. This process supports the cauldron subsidence nature of the evolution of the Jarawa younger granite complex.

In conclusion, the field and geochemical characteristics of the four rock units within the Jarawa younger granite ring complex revealed close genetic relationship between them. However, the geochemical characteristics showed that the rocks evolved from a secondary magma, considering the low MgO content. Consequently and in line with the cauldron subsidence evolutionary mechanism of the ring complexes, the four rock units in Jarawa complex were formed through re-differentiation of earlier formed molten igneous materials controlled by discontinuous stopping mechanism.

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