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*RESEARCH ARTICLE*

# GEOCHEMICAL CHARACTERIZATION OF ORTHO-DERIVED GNEISS AND GRANITOIDS OF THE PAN-AFRICAN PROVINCE OF DAMAGARAM (SOUTH-EAST NIGER)

**Badamassi Kadri Mahaman Mansour[1], Boubacar Abdou Fati[2], Moussa Issaka Abdoulkader[1], Sanda Chekaraou Mahamane Moustapha[3], Maman Hassan Abdourazakou[4] and Konaté Moussa[2]**

1. Andre Salifou University, Faculty of Science and Technology, Department of Geological and Environmental Sciences, Georessources and Geosciences of Environnement Laboratory; BP: 656 Zinder/ Niger.
2. Abdou Moumouni University, Faculty of Science and Technology, Geology Department Groundwater and Georesources Laboratory, BP:10662 Niamey/ Niger.
3. Djibo Hamani University, Faculty of Education, Department of Didactics of Disciplines, Tahoua/ Niger.
4. School of Mines, Industry and Geology (EMIG), Department of Geosciences, Niamey/ Niger.

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## Abstract

The Pan-African province of Damagaram, object of this study, corresponds to the north-eastern extension of the Benin-Nigerian Shield. The main geological formations that outcrop in this region consist of migmatitic gneiss, banded gneiss, mylonitic gneiss, porphyritic granites, two-mica granites, biotite granites and alkaline granites. The petrogenesis of ortho-derived gneisses and granitoids of Damagaram province was studied using the methods of geochemistry on total rock (major elements, trace elements and rare earth elements). The chemical composition (major elements and trace elements) shows that the precursor magmas come from the subalkaline series. The analyzed samples are characterized by a high SiO2 content (≥ 65%) and show a calc-alkaline potassium to shoshonitic affinity typical of the subduction zone. The high alkaline content (Na2O + K2O) and the A/CNK and A/NK parameters indicate that these rocks are aluminous to hyperalumino. Enrichment in certain large lithophilic elements (LILEs) (Rb, Ba, Th and Sr) and depletion in certain high field intensity elements (HFS) such as Nb, P and Ti are favorable criteria for the involvement of the crust in the genesis of these rocks. The light rare earth enrichment (LREE) and heavy rare earth depletion (HREE), as well as the negative europium (Eu) anomaly, suggest that these rocks as a whole would come from either fractional crystallization or partial melting of a pre-existing continental crust. The geochemical characteristics indicate that the geodynamic domain of these formations corresponds to the syn-collisional and intraplate volcanic arc geotectonic environments.



## Introduction:-

The Pan-African province of Damagaram, located in the south-east of Niger, occupies the central eastern portion of the Trans-Saharan chain, between the Tuareg Shield to the north and the Benin-Nigerian Shield to the south (Figure 1).

**Corresponding Author:- Badamassi Kadri Mahaman Mansour**
Address:- Andre Salifou University, Faculty of Science and Technology, Department of Geological and Environmental Sciences, Georessources and Geosciences of Environnement Laboratory; BP: 656 Zinder/ Niger.

This province is the result of a pan-African orogenic cycle between 750 and 450 Ma (Ajibade and Wright 1989; Ferré et *al*., 1996, 2002).It is part of the pan-African terrain remobilized in the Neoproterozoic by the convergence and continental collision between the West African, Congo, São Francisco cratons and the Saharan metacraton. This amalgamation of Precambrian soils leads to the placement of medium to high grade metamorphic rocks, tectonic syn to tardicalc-alkaline granitoids and post-tectonic alkaline granitoids (Baba, 2011).

In the pan-African province of Damagaram, two main geological groups have been distinguished: (i) ortho-derived and para-derived metamorphic terrains and (ii) pan-African granitoids or "older granites". These two groups are intruded by younger granites (or "Younger granites") dated from the Carboniferous to the Permian (Chékaraou and Konaté, 2021; Chamsi, 2023).

This pan-African province of Damagarama is the subject of very few geochemical studies (Mignon, 1970; Badamassi, 2021), compared to the equivalent province of Northern Nigeria (Abaa, 1985; Baba et *al*., 1996; 2006 ; Baba, 2008; 2011 ; Bolarinwa and Bute, 2016).

The present study focuses on the geochemical characteristics of major elements, trace elements and rare earths in the Pan-African Damagaram formations, in order to discuss their importance in the petrogenesis of rocks.

These include:
- Determining the chemical origin and nature of precursor magmas;
- Proposing the geodynamic context of the placement of these rocks.

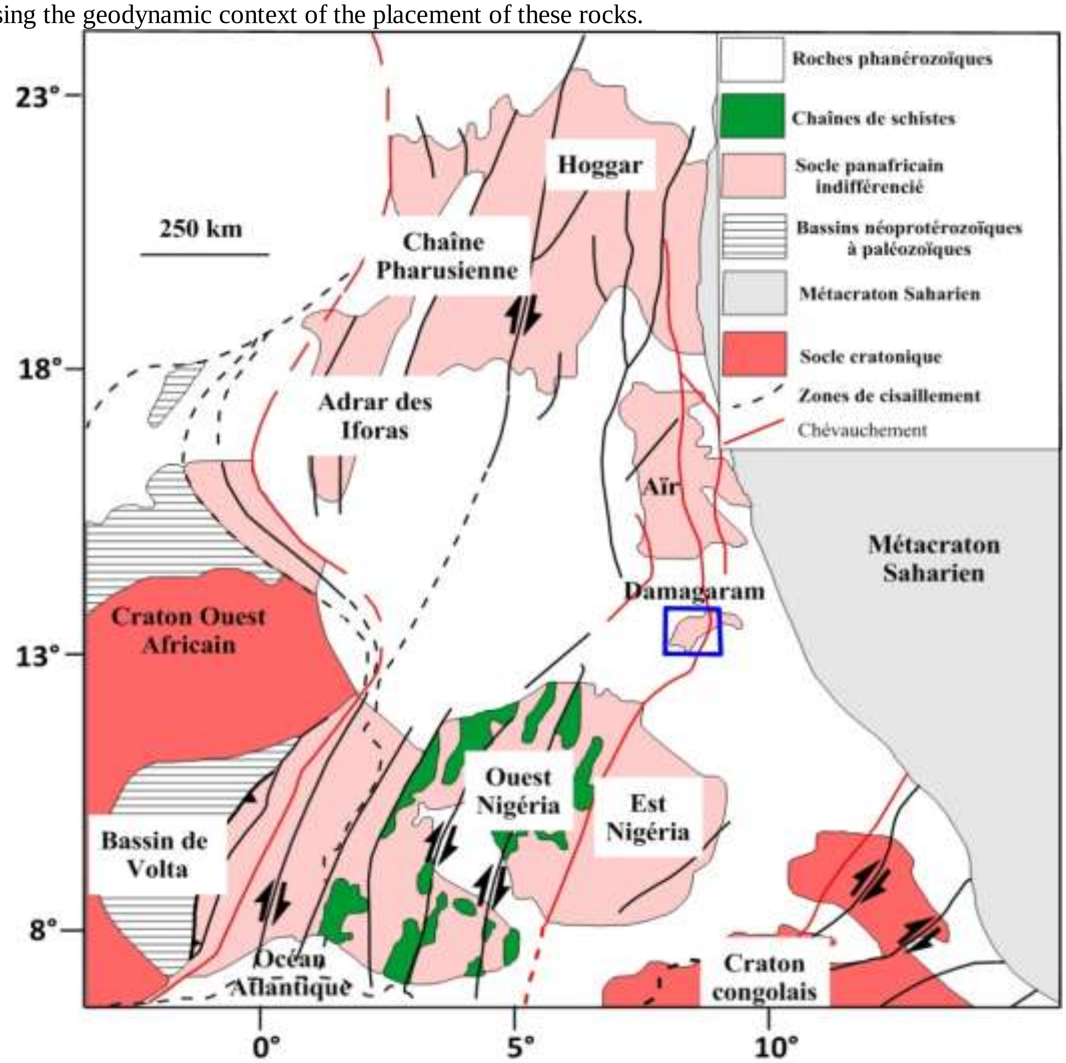


**Figure 1:-** Location of the pan-African province of Damagaram in the Trans-Saharan chain (Ferré et *al*., 1996).

**Geological context**

In the Pan-African province of Damagaram, the pan-African syn-tectonic terrains are represented by: migmatitic gneiss, banded gneiss, calcium gneiss, quartzites, schists and deformed molasses (BadamassietKonaté, 2021; Badamassi, 2021; Boubacar 2022). All these rocks are intruded by a large volume of late to post-Pan-African granites.The latter, called 'older granites', are in turn intersected by Mesozoic granites or 'Younger granites', corresponding to the anorogenic ring complexes of Damagaram (Rahaman, 1976; Joo' and Franconi, 1983; Chékaraou and Konaté; 2021 ;Chamsis et *al*., 2022).

Four major phases of deformation have been identified in the pan-African province of Damagaram (Badamassi andKonaté, 2021; Badamassi, 2021): an extensive pre-pan-African Pre-D1 phase and three pan-African compressive phases D1, D2 and D3. The extensive Pre-D1 phase, with N20°E elongation, characterized by undulating mirrors and normal microfaults N95° to N110°, would be concomitant with the opening of the Neoproterozoic Ocean between 870 Ma and 800 Ma (Black et *al*., 1979). The D1 deformation phase includes two episodes, denoted D1a and D1b (Badamassi andKonaté, 2021; Badamassi, 2021). The D1a episode, with shortening N130°E, marked by S1 foliation N50°, symmetrical flanges, lineations and isoclinal folds, is characteristic of a coaxial ductile deformation.The D1b episode, with ENE-WSW shortening (N80° on average), is at the origin of the straightening of the S1 schistosity and the development of dextral semi-ductile shear corridors in the gneiss, and dextral R/C brittle shear corridors in the quartzites. The D2 phase, with NE-SW shortening, is associated with the development of a flow and/or fracture schistosity S2 N130° and brittle shear corridors (Badamassi, 2021).In the province of Damagaram, as well as in the Benin-Nigerian shield (Caby and Boessé, 2001; Ferré et *al*., 2002; Toteu et *al*., 2004; Nzenti et *al*., 2006; Affaton et *al*., 2013; Chala et *al*., 2015; Bassey and Udinmwen, 2019), the D2 phase would correspond to transcurrent tectonics. The last phase D3 is marked by conjugate brittle shear corridors N135° to N170° and N00° to N20° and by the development of a fracture schistosity S3 N90°. These phases of compressive deformation, associated with the late-collisional event, have been identified in the contiguous Northern Province of Nigeria (Turner, 1983; Fitches et *al*., 1985; Grant, 1970; Ajibade et *al*., 1987; Dada, 1998).They have been described as corresponding to the pan-African thermo-tectonic event that affected the Benin-Nigerian shield (Abdelsalam et *al*., 2002; Liégeois et *al*., 2003; Caby, 2003), during the period from the Neoproterozoic to the Cambrian (750 Ma - 500 Ma).

**Petrography**

**Migmatitic Gneiss**

The migmatitic gneisses (migmatites) are underlined by an S1 foliation with variable direction N20° to N40°, marked by an alternation of quartzo-feldspathic bands and biotite-rich mafic bands. They are made up of paleosomes and leucosomes (Figure 2a). The migmatitic gneiss is marked by a concordant contact with the anatexic granite in the transition zone (Figure 2a).Paleosomes and leucosomes are distinguished by their texture and mineralogical composition, reflecting the physical conditions of the original rock and the deep amphibolite-type metamorphic facies, represented by plagioclase, biotite, muscovite and microcline paragenesis, associated with partial melting. Granitic veins of lenticular shapes appear in places (Figure 2b). The micaceous mafic band is marked by a preferential orientation of biotite and muscovite.

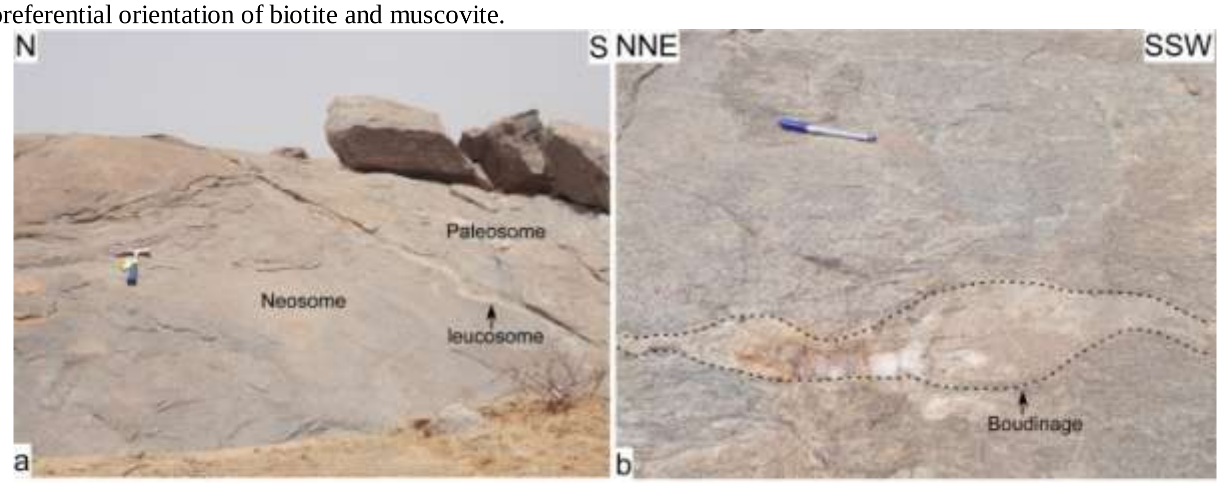


**Figure 2:-** Migmatitic gneiss outcrop in the Zarnouski area. In a: Outcrop of migmatitic gneiss enclose a paleosome, a neosome and a leucosome. In b: granitic veins of lenticular shapes.

**Banded Gneiss**

Banded gneisses are less abundant in the study area. They are made up of granitic levels (quartzo-feldspatic) alternating with mafic levels (hornblende), defining a foliation S1 N30° (figure 3). Subsymmetric socks, crenulation lineations defined by the microfolding of the S1 foliation have been observed in some places. These types of gneiss are made up of quartz, plagioclase, microcline, and hornblende.


**Figure 3:-** Banded gneiss outcrop.

**Mylonitic Gneiss**

These rocks, outcropping to the south-east of Kissambana, are made up of isolated crystals of feldspar, presenting a dextral sigmoid geometry, highlighting an episode of mylonitization. Quartz, plagioclase, microcline, biotite and the rare amphibole crystals constitute the essential minerals of these mylonitic gneiss.

**Porphyry granites**

Porphyry granites are made up of orthose phenocrysts, giving a porphyritic structure to the rock. The minerals that make up this rock are: quartz, plagioclase, orthosis and biotite. While the accessory minerals are represented by sphene and zircon (Badamassi, 2021). Enclaves of biotite, sometimes with reactive halos, were raised by the alkaline granite (Figure 4). The latter would have passed through the migmatites.


**Figure 4:-** Porphyry granite with biotite enclaves.

### Granites with two micas
These granites have a relatively homogeneous mineralogical composition. These are melanocrat granites with fine and medium grains. Under the microscope, these granites are composed of xenomorphic quartz with undulating extinction, biotite, muscovite and plagioclase. The alkaline feldspar, consisting of orthosis and microcline, is little altered.

### Biotite granites
The biotite granites, outcropping in the study area, are also melanocratic, with a heterogranular grainy texture. They are made up of undeformed crystals of quartz, biotite, microcline and plagioclase. It should be noted that biotite most often occurs in flakes occupying the interstices (Badamassi, 2021).

### Alkaline Granite
These types of granite are distinguished by their pinkish color. Quartz that is xenomorphic, orthosis and the rare plagioclase crystals constitute the essential minerals of these granites.

### Geochemistry
Ten (10) representative samples were separately crushed and pulverized to approximately 75 microns at the Geological and Mining Research Center (CRGM) of Niger. From each sample, 30 g of powder was then collected and sent for chemical analysis on whole rock to Activation Laboratories ACTLABS in Canada. Major elements, trace elements and rare earth elements were determined by inductively coupled plasma emission spectrometry (ICP-AES) and mass spectrometry (ICP-MS). The analytical accuracy is greater than ±2% for major elements and ±5% for trace elements.

The analytical results of the major elements are presented in Table 1. The chemical composition of the main major elements does not show any significant variation except for that of banded gneiss. The $SiO_2$ content in all samples (65.77-73.68) is comparable to the standard silica content in felsic rocks (≥ 65%).

**Table 1:-** Major elements determined in different rocks of Damagaram province.

| Samples | Banded gneiss | migmatite | Ortho-gneiss | Biotite granite | 2 micas granite | Biotite granite | Porphyric granite | Ortho-gneiss | Alkaline granite | Biotite granite |
|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 65,77 | 70,38 | 70,45 | 73,68 | 68,61 | 72,93 | 69,64 | 69,7 | 71,77 | 72,7 |
| $Al_2O_3$ | 8,2 | 14,68 | 11,95 | 12,95 | 14,68 | 11,96 | 14,79 | 11,99 | 14,53 | 14,56 |
| $Fe_2O_3$(T) | 3,61 | 2,28 | 4,89 | 2,81 | 3,44 | 3,22 | 3,05 | 5,61 | 1,53 | 1,11 |
| MnO | 0,072 | 0,069 | 0,118 | 0,039 | 0,131 | 0,046 | 0,028 | 0,193 | 0,041 | 0,121 |
| MgO | 6,26 | 0,41 | 1,76 | 0,09 | 0,7 | 0,06 | 0,88 | 2,21 | 0,22 | 0,19 |
| CaO | 9,6 | 1,12 | 1,33 | 0,17 | 2,33 | 0,64 | 2,68 | 4,08 | 1,4 | 1,11 |
| $Na_2O$ | 0,96 | 3,3 | 1,57 | 5,23 | 3,04 | 4,62 | 3,73 | 1,69 | 4,15 | 3,99 |
| $K_2O$ | 2,88 | 5,3 | 5,04 | 3,15 | 4,55 | 4,42 | 3,99 | 2,87 | 5,01 | 5,01 |
| $TiO_2$ | 0,43 | 0,26 | 0,713 | 0,171 | 0,376 | 0,239 | 0,529 | 0,809 | 0,196 | 0,111 |
| $P_2O_5$ | 0,11 | 0,16 | 0,2 | 0,02 | 0,12 | < 0.01 | 0,26 | 0,2 | 0,09 | 0,03 |
| LOI | 0,49 | 0,61 | 0,72 | 0,4 | 0,53 | 0,36 | 0,39 | 1,23 | 0,83 | 0,46 |
| Total | 98,37 | 98,56 | 98,74 | 98,72 | 98,52 | 98,5 | 99,96 | 100,6 | 99,78 | 99,39 |

The $Al_2O_3$ content is higher in porphyry granite, then decreases successively in two-mica granite, biotite granite, orthogneiss, migmatitic gneiss, alkaline granite, and is lower in banded gneiss (Table 1). The aluminous nature is most illustrative when these samples are projected into the A/CNK-A/NK diagram (Figure 5c) by Shand (1943). Thus, Figure 5c shows that these rocks are peraluminous to metaluminous in nature.The orthogneiss have the highest Fe2O3 (5.61-4.89) and MnO (0.193-0.118) contents, while the lowest levels are observed in alkaline granite with $Fe_2O_3$ (1.53-1.11) and MnO (0.041). The banded gneiss sample shows a high CaO enrichment (9.8%) but also a low SiO2 content compared to the other rock samples in the region (Table 1). The concentration of alkali ($Na_2O$ and $K_2O$) is much lower in banded gneiss (0.96 and 2.88 respectively) than in migmatites, orthogneiss, and granites. The latter have similar mean values in alkaline terms (Table 1).

Concentrations of trace elements and rare earth elements are shown in Table 2. The abundances of certain trace elements in the samples studied show considerable variations. Thus, Ba ranges from 761 ppm to 20 ppm, Sr ranges from 243 ppm to 8ppm, Sr (315 ppm to 6.6 ppm), Th (193 ppm to 7.6 ppm). Other elements, such as Sn, show limited variation. In the granitoids and ortho-derived gneisses of Damagaram Province, the contents of high-intensity elements (HFS) such as Zr, Nb and Y are relatively high. They range from 10 ppm to 1177 ppm, 2 ppm to 197 ppm, and 17 ppm to 197 ppm for Zr, Nb, and Y, respectively.

Rare earth element data (Table 2) show that these granitoids and orthogneiss are enriched in light rare earths (LREE) and depleted in heavy rare earths (HREE). The concentrations of rare earths, normalized to the Nakamoura chondrite, show considerable variations.

**Table 2:-** Trace elements and rare earths determined in different rocks of Damagaram province.

| Samples | Banded gneiss | migmatite | Ortho-gneiss | Biotite granite | 2 micas granite | Biotite granite | Porphyric granite | Ortho-gneiss | Alkaline granite | Biotite granite |
|---|---|---|---|---|---|---|---|---|---|---|
| Sc | 7 | 4 | 13 | 1 | 9 | 1 | 6 | 14 | 2 | 2 |
| Be | 2 | 3 | 2 | 14 | 5 | 13 | 3 | 3 | 2 | 2 |
| V | 41 | 17 | 85 | 13 | 41 | 5 | 42 | 87 | 17 | 6 |
| Ba | 629 | 459 | 761 | 95 | 621 | 25 | 731 | 80 | 20 | 20 |
| Sr | 173 | 92 | 106 | 8 | 243 | 6 | 227 | 25 | 27 | 26 |
| Y | 17 | 18 | 38 | 60 | 42 | 182 | 22 | 20 | 20 | 20 |
| Zr | 206 | 139 | 185 | 213 | 256 | 1177 | 377 | 30 | 10 | 10 |
| Cr | 50 | 20 | 50 | 20 | 30 | 30 | 40 | 50 | 30 | 50 |
| Co | 8 | 4 | 11 | 2 | 5 | < 1 | 7 | 15 | 14 | 16 |
| Ni | 20 | < 20 | < 20 | < 20 | < 20 | < 20 | < 20 | 1,7 | 1,1 | 1,9 |
| Cu | 130 | 80 | 80 | 50 | 210 | 30 | 20 | 5 | 5 | 5 |
| Zn | 60 | 60 | 50 | < 30 | 90 | 330 | < 30 | 101 | 98 | 180 |
| Ga | 10 | 19 | 14 | 28 | 20 | 45 | 18 | 94 | 94 | 171 |
| Ge | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 41,6 | 15,4 | 111 |
| As | < 5 | < 5 | < 5 | 5 | < 5 | < 5 | < 5 | 282 | 144 | 122 |
| Rb | 101 | 315 | 168 | 377 | 244 | 190 | 127 | 9,3 | 6,6 | 11 |
| Nb | 5 | 12 | 7 | 54 | 12 | 197 | 17 | 2 | 2 | 2 |
| Mo | 2 | 2 | 2 | 3 | 2 | 4 | 3 | 0.5 | 0.5 | 0.5 |
| Ag | 0,8 | 0,5 | 0,6 | 0,7 | 0,9 | 3,6 | 1,3 | 0,1 | 0.1 | 0.1 |
| In | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | 0,2 | < 0.2 | 5 | 1 | 1 |
| Sn | 8 | 18 | 7 | 12 | 14 | 19 | 3 | 0,2 | 0,2 | 0.2 |
| Sb | < 0.5 | < 0.5 | < 0.5 | 1,5 | < 0.5 | < 0.5 | 0,5 | 3,2 | 0,2 | 1,5 |
| Cs | 3,7 | 7,2 | 5 | 3,9 | 12,9 | < 0.5 | 1 | 797 | 997 | 1127 |
| La | 26,1 | 55,7 | 32,6 | 207 | 45,4 | 202 | 76,9 | 36,7 | 22,2 | 31,9 |
| Ce | 48,4 | 116 | 63,5 | 468 | 91,1 | 376 | 138 | 74,4 | 39,4 | 38,2 |
| Pr | 5,37 | 13,3 | 7,97 | 36 | 10,3 | 51,5 | 13,8 | 8,4 | 3,96 | 5,31 |
| Nd | 20,3 | 46,8 | 29,9 | 106 | 38,7 | 200 | 47,5 | 33,3 | 13,8 | 20,6 |
| Sm | 4 | 9,9 | 6,6 | 16,1 | 8,2 | 48,4 | 7,2 | 7,29 | 2,44 | 4,48 |
| Eu | 0,76 | 0,72 | 1,08 | 0,82 | 1,28 | 1,17 | 1,44 | 1,1 | 0,626 | 1,16 |
| Gd | 3,2 | 6,4 | 6,2 | 10,6 | 7,3 | 41,5 | 5 | 6,01 | 2,09 | 7,69 |
| Tb | 0,5 | 0,9 | 1 | 1,8 | 1,3 | 7 | 0,8 | 1,12 | 0,36 | 1,29 |
| Dy | 3,1 | 4,1 | 5,8 | 11,4 | 7,4 | 39,6 | 4,1 | 7,04 | 2,33 | 8,81 |
| Ho | 0,6 | 0,6 | 1,1 | 2,3 | 1,5 | 7,4 | 0,8 | 1,45 | 0,47 | 2,18 |
| Er | 1,8 | 1,7 | 3,3 | 6,9 | 4,3 | 20,1 | 2,4 | 4,04 | 1,49 | 6,93 |
| Tm | 0,28 | 0,23 | 0,47 | 1,13 | 0,64 | 2,69 | 0,33 | 0,588 | 0,243 | 1,01 |
| Yb | 1,9 | 1,4 | 2,9 | 8,2 | 4,2 | 16,5 | 2,2 | 3,98 | 1,79 | 6,47 |
| Lu | 0,29 | 0,22 | 0,47 | 1,23 | 0,67 | 2,46 | 0,36 | 0,616 | 0,303 | 0,978 |
| Hf | 4,9 | 3,9 | 4,2 | 8 | 7 | 32,1 | 9,8 | 6,7 | 3,7 | 4,2 |
| Ta | 0,4 | 2,4 | 0,9 | 5,5 | 1,3 | 12,5 | 1,3 | 0,99 | 0,58 | 0,89 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| W | 1 | 1 | < 1 | 2 | < 1 | < 1 | < 1 | 113 | 183 | 215 |
| Tl | 0,5 | 1,5 | 0,7 | 0,4 | 1,1 | 0,5 | 0,4 | 0,41 | 0,2 | 0,74 |
| Pb | 21 | 38 | 11 | 21 | 32 | 66 | 12 | 6 | 5 | 25 |
| Bi | < 0.4 | < 0.4 | < 0.4 | 0,4 | < 0.4 | < 0.4 | < 0.4 | 0,2 | 0.1 | 0.1 |
| Th | 7,6 | 35,4 | 12,7 | 193 | 20,3 | 33,6 | 25,1 | 15,6 | 9,64 | 13,6 |
| U | 1,6 | 7,7 | 2,2 | 31,3 | 4,4 | 10,5 | 6,4 | 2,42 | 1,33 | 3,33 |

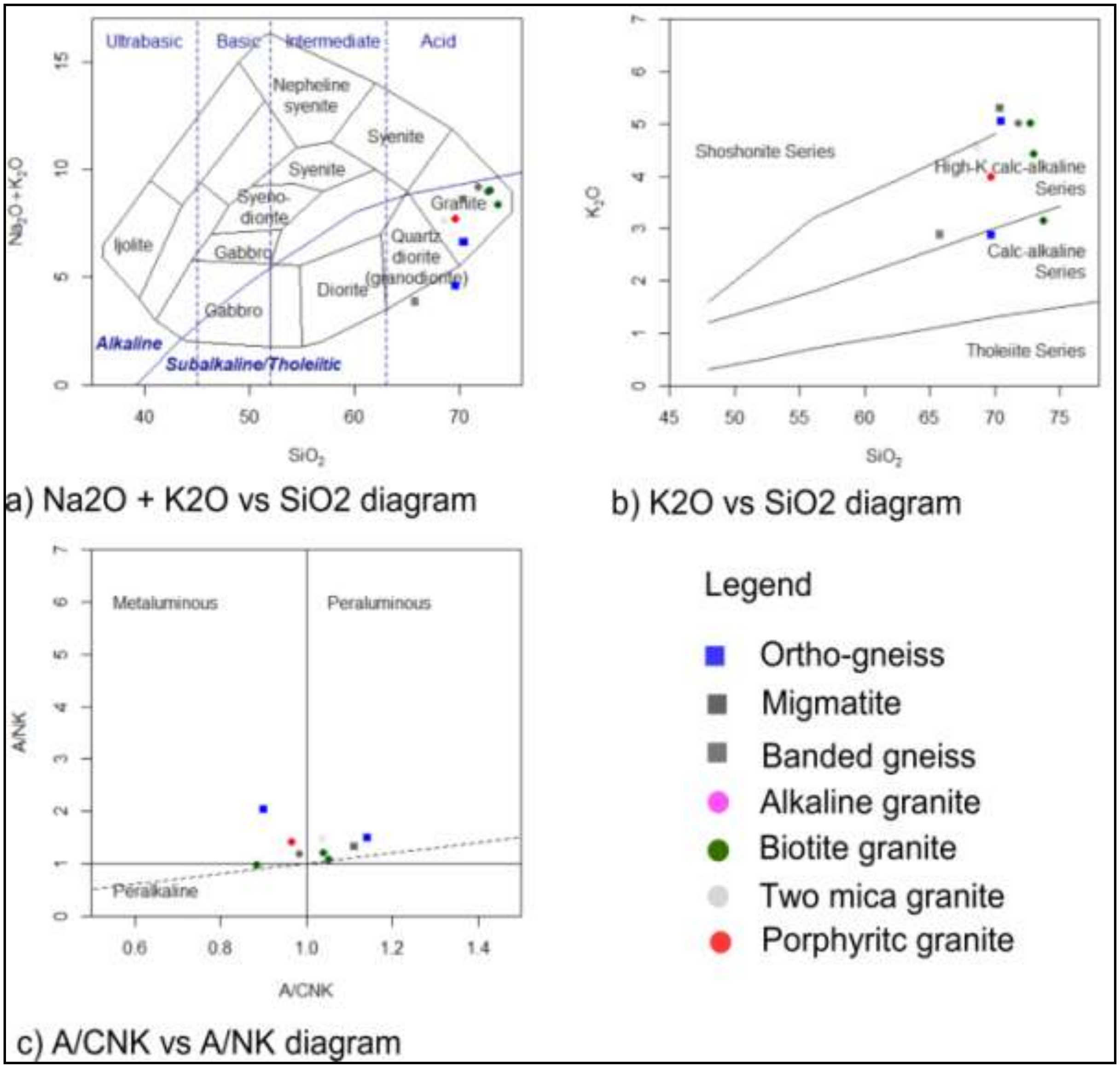


**Figure 5:-** Classification diagrams of ortho-derived granitoids and gneisses from the Damagaram Province: a) $Na_2O + K_2O$ vs $SiO_2$ (Cox et *al*., 1979); b) $K_2O$ vs $SiO_2$ (Peccerilo and Taylor, 1976); c) A/CNK vs. A/NK (Shand, 1943).

Trace elements of ortho-derived granitoids and gneisses from Damagaram province vary widely [Ba (761 ppm to 20 ppm), Sr (243 ppm to 8 ppm), Rb (377 ppm to 6.6 ppm), Th (193 ppm to 7.6 ppm)] and have a higher Rb/Sr ratio (0.22-0.28) than the continental crust of Rudnick and Gao. (2004). Projected in Pearce's (1983) multi-element diagram and normalized to MORB values (Figure 7), these samples show negative Sr, Ba, Ta, Nb, P and Ti anomalies, consistent with the fractionation of apatite and titanium oxide. These anomalies are typical of a continental crustal origin (Rollinson, 1993; Rudnick and Gao, 2004).Trace element data are also used to determine the different geotectonic contexts (Figure 6). Plotted in the Rb vs (Y + Nb) diagram of Pearce et al. (1984), the samples analyzed are between the syncollisional volcanic arc domain and the intraplate granite domain (Figure 6a).

The same observations were made in the diagram giving the Nb vs Y contents for all the samples studied (Figure 6b).In the Rb vs (Ta + Yb) diagram, most of the samples appear in the volcanic arc granite and intraplate granite fields (Figure 6c), while in the Ta vs Yb diagram by Pearce et al. (1984), these same samples occur in the syn-collisional granite domain (Figure 6d).

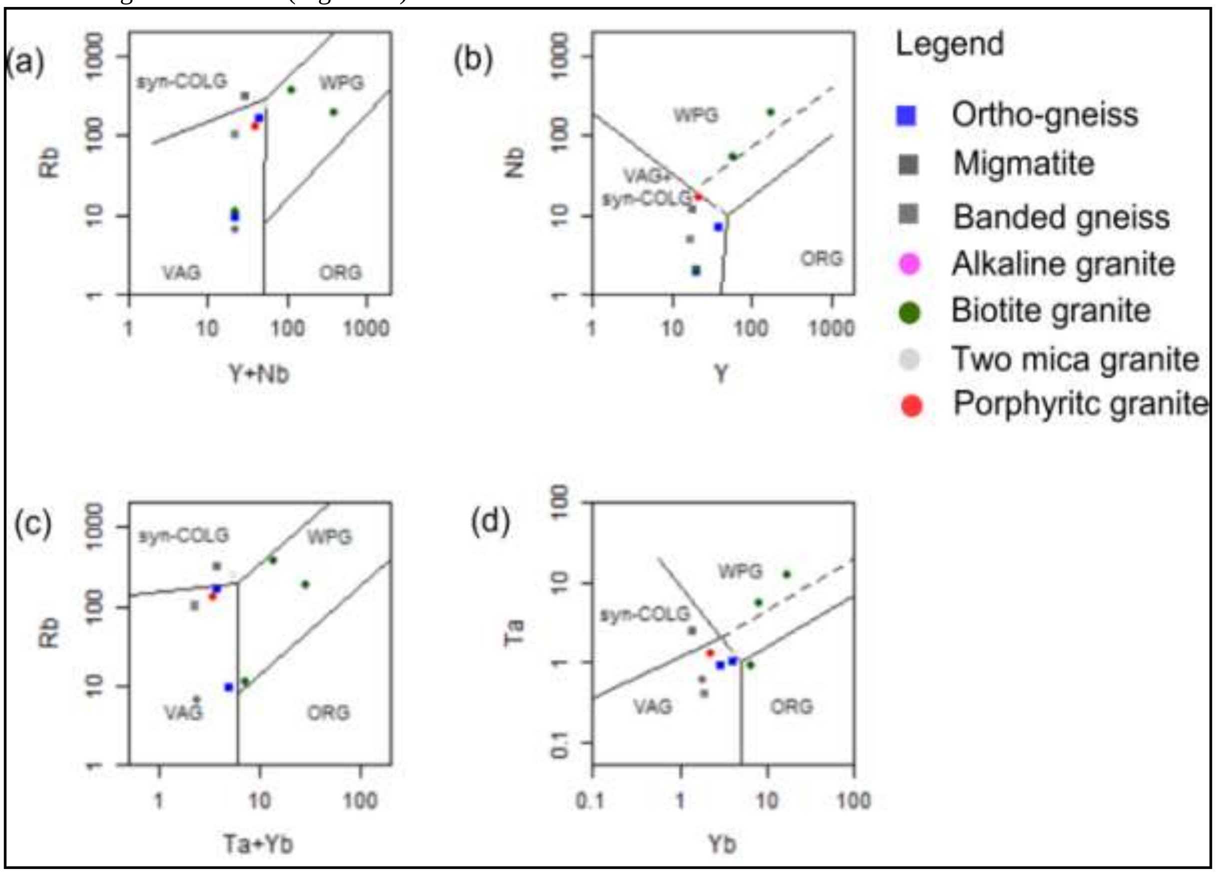


**Figure 6:-** Diagrams of the geodynamic contexts of the different crustal rocks, showing the fields of volcanic arc granites (VAG), syn-collisional granites (syn-COLG), hotspot granites (WPG) and oceanic ridge granites (ORG): a) Rb vs (Y+Nb); b) Nb vs Y; c) Rb vs (Ta+Yb); d) Ta vs Yb.

Rare earth spectra normalized to the chondrite values of Nakamura (1974) show a broadly similar appearance (Figure 8). They show light rare earth enrichment (LREE) and light heavy rare earth depletion (HREE) with a sub-flat spectrum (Figure 8). Such a spectral signature is classically observed at the level of the continental crust (Taylor and McLennan, 1985; Rudnick and Foutain, 1995). A very pronounced negative anomaly in europium (Eu), characteristic of rocks of the calc-alkaline series, was highlighted.This negative anomaly in Eu (Figure 8) is thought to be due to the fractionation of plagioclase (Rollison, 1998). This is explained by the fact that the Eu is preferentially distributed in the plagioclase which crystallized as magmatic differentiation progresses (Bolarinwa and Bute, 2016).

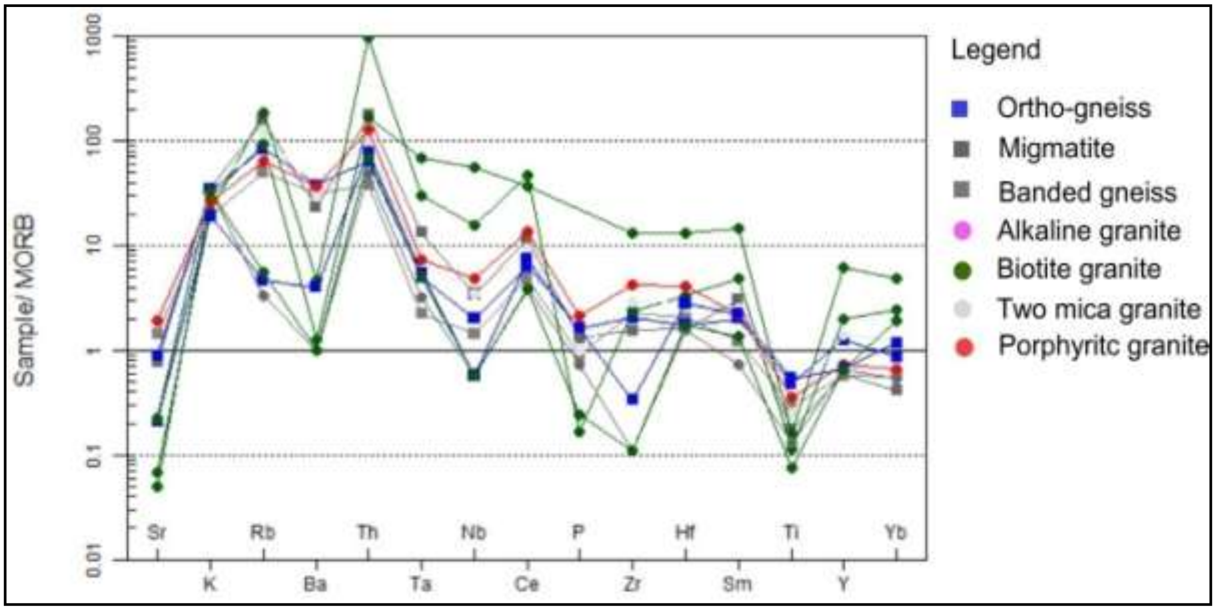


**Figure 7:-** Multi-element spectra normalized to MORB values of (Pearce, 1983).

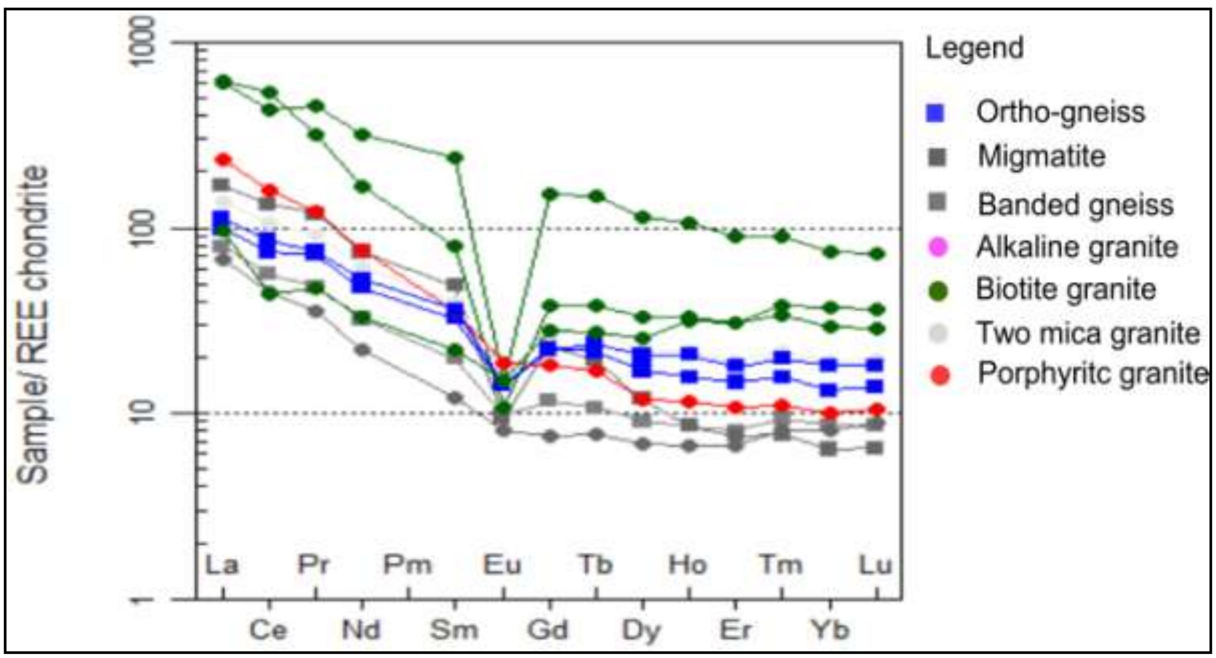


**Figure 8:-** Spectra of rare earths normalized to chondrite values of (Nakamura, 1974).

## Discussion:-

The high concentration of $SiO_2$ in these rocks highlights their acidic characteristics (Cox et *al*., 1979) (Figure 5a). The $Na_2O+K_2O$ vs $SiO_2$ diagram of Cox et *al*. (1979) places all samples in the subalkaline rock domain with a granite chemical composition with the exception of two samples (banded gneiss and orthogneiss) which appear in the granodiorite field (Figure 5a). The projection of these samples in the discriminant diagram of Peccerillo and Taylor (1976) shows a calc-alkaline to shoshonitic affinity (Figure 5b). Plotted in the diagram A/CNK vs A/NK of Shand (1943), these rocks are peraluminous to metaluminous (Figure 5c).The hyperaluminous character is presence underlined by the of muscovite flakes in the rock (Badamassi, 2021). The high $SiO_2$ (>65%), $Al_2O_3$ and K2O contents suggest that these rocks originate mainly from the continental crust. Investigations of Pan-African formations in northeastern Nigeria (Okonkwo and Winchester, 1996; Baba, 2011; Bolarinwa and Bute, 2016; Mohammed and Mohammed, 2017) and northern Benin (Chala, 2019), highlight their acidic character and their calc-alkaline potassium to shoshonitic affinity.These observations are similar to those obtained in the province of Damagaram. However, the presence of calc-alkaline granitoids characterizes a plutonism of subduction zones (Bolarinwa and Bute, 2016, Chala, 2019), shoshonitic affinity implies a continental or insular volcanic arc context (Chala, 2019, Badamassi, 2021).

## Conclusion:-

The geochemical characteristics (major elements, trace elements and rare earth elements) suggest that the granitoids and ortho-derived gneisses of the Damagaram province originate mainly from the materials of the continental crust. The analysis of the major elements reveals the hyperaluminous to aluminous character and that these rocks derive from calc-alkaline potassic to shoshonitic magmas. The geodynamic contexts of the formation of the basement formations of the Damagaram province correspond to the geotectonic environments of syn-collisional and intraplate volcanic arc.

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