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Litho-Structural and Geochemistry Analysis of Granitoids from Mount Fouimba and Goma in Seguela Area (Central-Western Côte d'Ivoire)

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Abstract

The petrogeochemical analysis of the granitoids of Mount Fouimba and Mount Goma in the Seguela region (central-western Côte d'Ivoire) is the subject of this study. This analysis combines remote sensing, geophysics, petrography and geochemistry, in order to determine the major characteristics of the granitoids in the study area, and above all to participate in the detailed mapping of all the Ivorian terrains. The granitoids encountered in this region are essentially two-mica granites, granodiorites and porphyry basalts. Chemical analysis indicates that these granitoids are of the ferrous and magnesian type with peraluminous to weakly metaluminous characteristics. They originate from the mantle and were emplaced in an active continental margin context.

Keywords

Petrogeochemistry, Granitoids, Seguela, Côte d'Ivoire

1. Introduction

Known for its diamond fields fed by kimberlite and lamprophyre dykes, the Séguéla area, located in the central-western part of Côte d'Ivoire, has a certain number of structural, stratigraphic, lithological, magmatic and metamorphic features in its greenstone belts, which at first glance seem to favour the development of significant mineral concentrations [1]. These numerous particular features have recently attracted the attention of major mining companies, notably

RoxGold, which has acquired a mining exploration permit covering an area of 350 km^2 and including the two main mountains in the said zone, namely Mounts GOMA and FOUIMBA. Furthermore, it is clear that Côte d'Ivoire does not yet have detailed geological maps covering the entire country, which would enable all the above-mentioned features to be understood, as few detailed studies have been carried out. It is therefore clear that the establishment of a detailed geological map of the Ivorian terrain is more than necessary [2]. It is therefore in this spirit of necessity that the present study aims to highlight, in a detailed manner, all the petro-structural characteristics of the geological formations in the Seguela area, by means of a 1:50,000 scale map.

2. Study Framework

2.1. Location

Seguela is located in the centre-west of Côte d'Ivoire, Seguela geographic cordoonates are longitudes 6˚30'00"W and 7˚00'00"W and latitudes 7˚45'00"N and 8˚15'00"N, with an average altitude of 350 m above sea level. Séguéla is 516 km from Abidjan, the economic capital, and is above all the capital of the Worodougou region, covering an area of 11,427 km^2 (**Figure 1**).

2.2. Geological Setting

West African Craton (WAC) is, according [1], subdivided into three distinct zones (**Figure 2**): to the north, the Reguibat Ridge formed by Archean formations (3.0 - 2.7 Ga) separated from the Paleoproterozoic formations (~2 Ga) by the Zednes Fault (northern extension of the Sassandra Fault), and outcropping in Algeria, Morocco and Mauritania. In the south, the Man or Leo ridge formed by the Archean series of the Liberian Shield, and the Paleoproterozoic (Birimian) formations of the Baoulé-Mossi Domain covering Ghana, Côte d'Ivoire, Guinea, southern Mali, Burkina Faso, and western Niger. The Liberian basement and the Birimian series are separated by an Archean-Proterozoic transition zone [2], corresponding to a large complex fault: the Sassandra submeridian fault [1] [3]. In an intermediate position between the two ridges are two buttonholes, including the Kayes buttonhole in western Mali and the Kenieba-Kédougou buttonhole on either side of the Senegal-Malian border. These buttonholes are formed exclusively by Birimian series.

The Ivorian Precambrian basement is a characteristic part of the Man Ridge and is essentially composed of a western Archean domain and an eastern Proterozoic domain. The Archean-Proterozoic transition of the Ivory Coast is, according [1] [3], materialised by a large complex fault called the Sassandra Submeridian Fault, with a N-S to NNW-SSE orientation. [4] [5], subdivide this transition zone into three sub-domains, including the Boundiali domain or Northern domain, located north of parallel 9˚; the Séguéla-Vavoua domain or Central domain, located between parallels 7˚ and 9˚, in which the present study area is located; and the SASCA domain or Southern domain, which extends from parallel

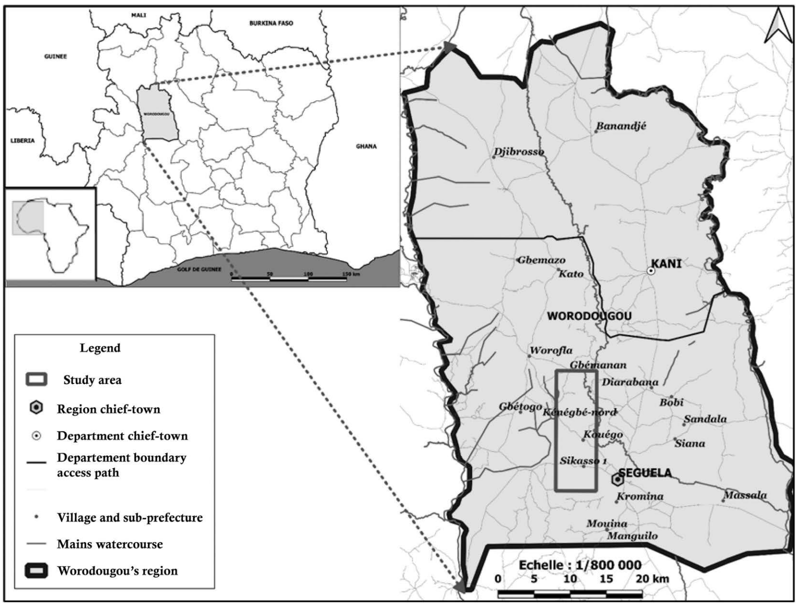


Figure 1. Location map of the study area (extract from the administrative map of Côte d'Ivoire, 2013), Ministry of Urbanisation and Sanitation.

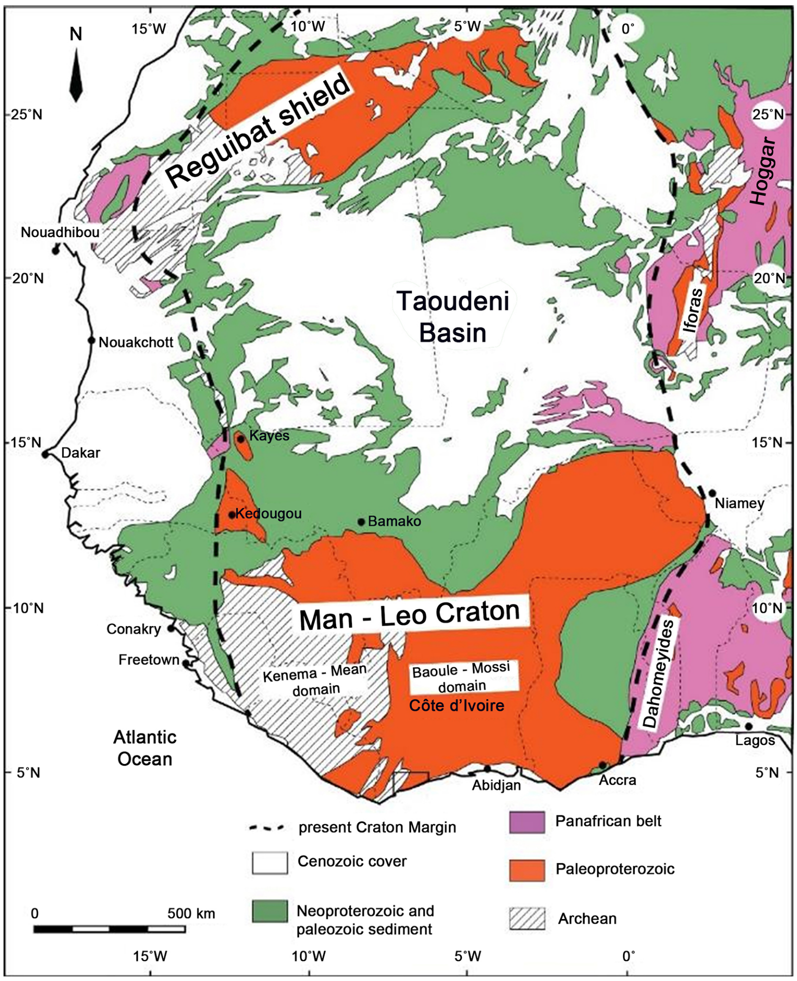


Figure 2. Geological map of the West African craton (Berger *et al.*, 2013 modified).

7˚N, to the Atlantic coast. The present study area is based on a thread-like trench called Séguéla-Vavoua, oriented N-S, and the geological formations encountered there are essentially composed of volcano-sedimentary units (greenstone belt) generally oriented N-S to NE-SW. These are essentially undifferentiated migmatites, metagranites, metamonzonites, biotite and/or hornblende metagranodiorites, gabbros and metagabbros, metadiorites, amphibolites, lamprophyres, tonalites, and biotite granites (**Figure 3**).

3. Analytical Methods

The methodology chosen for the litho-geochemical study of the magmatic formations of the present study area is multidisciplinary. It includes indirect methods using remote sensing data (Landsat 8 OLI image) and airborne geophysics (processing and interpretation of aeromagnetic data). In addition, there are direct methods that started with a field trip, which preceded a number of analytical works in the laboratory. These included the macroscopic and microscopic petrography of the magmatic formations encountered in the study area. Several samples of various rocks were selected during the field mission for thin sections and geochemical analyses on total rock. The thin sections were prepared at the Geology, Mining and Energy Resources Laboratory of the University of Félix HOUPHOUËT BOIGNY-Abidjan and studied under a petrographic microscope to identify the main minerals and the nature of the rock. The samples for geochemical analysis were sent to BUREAU VERITAS for mechanical preparation and then transferred to Canada (Vancouver) for the actual geochemical analysis (**Table 1**).

4. Results

4.1. Petrographic Data

The geological survey carried out in the study area revealed a range of magmatic rock outcrops from which samples were taken for more detailed petrographic and geochemical studies.

These magmatic formations (granitoids) are mainly composed of two-mica granites or leucogranites, pink granites and granodiorites. Mineralogical analysis of these rocks has revealed a regional deformation, materialised by the stretching of biotite and muscovite minerals throughout the study area. It should be noted that the two-mica granites are the most abundant formations in this group.

- Two-mica granites

This formation is widespread in almost the entire study area (Gbena, Gbingoro, Kuego, Mongbaran, Besséla, Kénégbé, Niandozo…). It is presented in the form of a slab, block or dome crossed by numerous fractures and seams filled with pegmatites or variously oriented quartz. The rock has a massive appearance, with a leucocratic colour and a grainy texture. It is moderately to strongly altered. **Figure 4(a)** and **Figur 4(b)** show a block of two-mica granite and a sample from the study area respectively. **Figures 4(c)-(f)** show the mineralogical

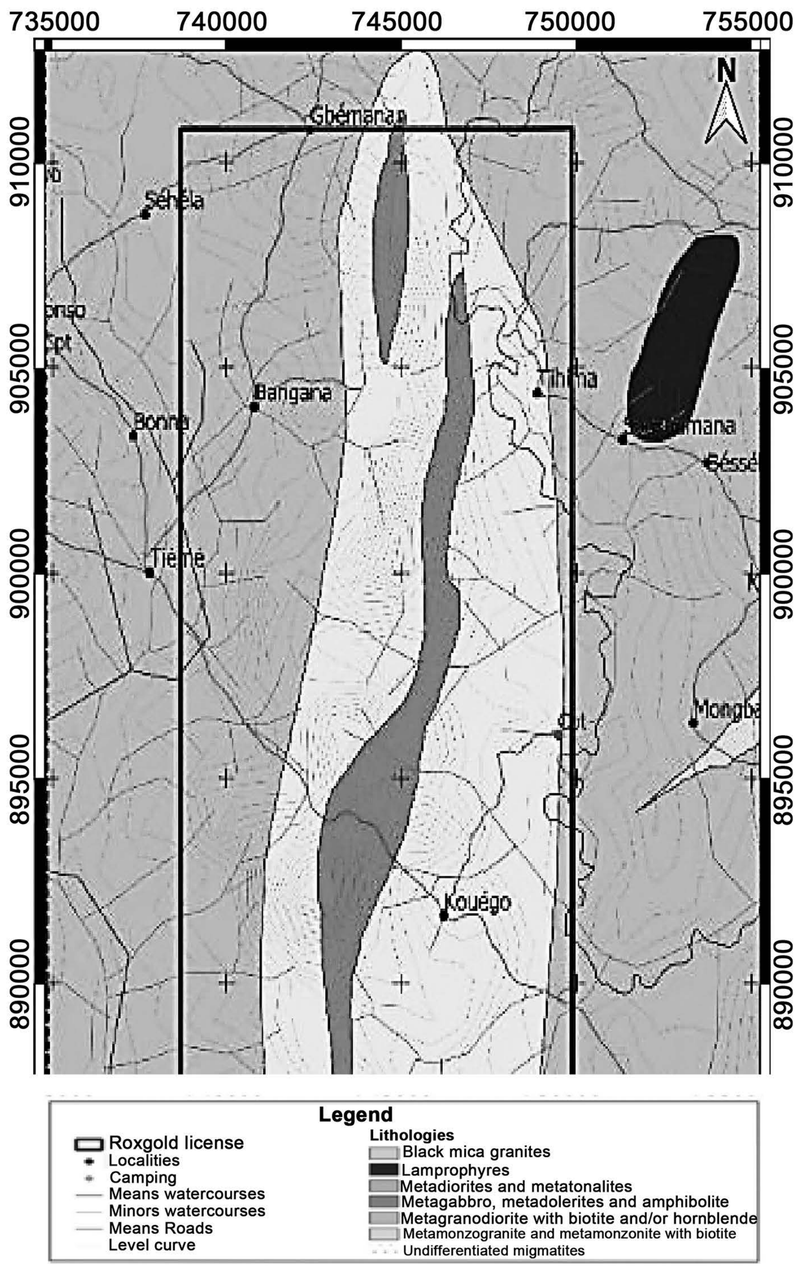


Figure 3. Carte géologique au 1/200,000 de la zone d'étude (extrait de de la feuille MANKONO et SEGUELA; Tagini 1972, modifiée).

Table 1. Geochemical composition of Seguela granitoids.

Sample	SB3	SB10	SB11A	SB11C	SB12	SB14	SB15	SB16	SB23A	SB23B	SB24A	SB25	SB26
SiO_2	67.21	74.48	71.64	70.82	73.58	72.10	60.91	67.16	73.37	68.62	73.02	74.47	73.75
Al_2O_3	16.05	13.81	14.51	14.55	14.13	15.25	15.28	16.03	13.58	15.71	14.17	14.28	14.56
Fe_2O_3	5.29	1.74	2.94	4.16	2.03	2.72	7.47	4.61	2.11	3.19	2.01	1.79	1.95
CaO	2.76	0.92	1.63	2.48	1.32	2.29	6.53	4.22	1.17	2.29	1.38	1.46	1.46
MgO	1.28	0.21	0.66	0.94	0.38	0.73	5.53	1.55	0.30	0.94	0.35	0.26	0.31
Na_2O	4.24	3.68	3.78	4.84	4.00	5.46	3.30	4.55	2.93	4.18	3.70	4.57	4.39

Continued

K_2O	2.03	5.01	4.57	1.79	4.57	1.62	0.42	1.30	6.12	4.26	4.89	3.31	4.05
MnO	0.05	0.03	0.04	0.07	0.04	0.03	0.11	0.06	0.02	0.04	0.02	0.04	0.05
TiO_2	0.67	0.14	0.37	0.43	0.22	0.27	0.64	0.48	0.20	0.38	0.19	0.15	0.17
P_2O_5	0.16	0.03	0.12	0.12	0.07	0.08	0.15	0.11	0.04	0.16	0.07	0.05	0.04
Cr_2O_3	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
LOI	0.35	0.11	0.03	0.04	0.20	0.06	0.45	0.27	0.29	0.23	0.22	0.00	0.12
Total	100.11	100.16	100.29	100.24	100.54	100.61	100.82	100.34	100.13	100	100.02	100.38	100.85
Ba	375	401	1213	681	729	564	290	350	1190	1470	1245	825	728
Be	3	<1	<1	5	2	2	1	2	1	2	1	3	<1
Co	9.7	2.1	4.2	6.0	2.9	5.6	26.3	11.0	2.5	5.7	2.7	1.8	2.1
Cs	2.7	1.9	7.5	8.1	5.6	1.7	0.5	1.0	0.8	2.8	0.9	1.8	3.2
Ga	17.6	17.1	17.6	17.3	18.0	19.9	15.5	16.6	13.9	18.1	15.9	17.6	18.6
Hf	7.2	4.1	7.1	4.7	5.2	3.0	3.3	3.4	6.0	4.4	4.6	3.5	3.0
Nb	10.0	6.8	14.3	13.3	15.8	1.8	6.7	3.0	8.2	8.4	3.3	11.6	9.1
Rb	98.6	203.0	204.5	124.8	272.6	47.1	9.5	34.7	122.3	124.3	112.3	116.9	147.5
Sn	1	2	2	2	2	2	1	2	2	1	2	1	2
Sr	368.4	383.5	297.8	322.9	181.2	693.2	326.0	402.9	303.2	504.0	287.4	246.2	211.5
Ta	0.8	1.2	1.4	1.6	2.0	0.1	0.5	0.2	1.0	0.7	0.4	0.8	0.6
Th	8.9	40.4	19.3	11.2	25.0	2.6	3.7	2.9	27.4	13.9	9.2	9.1	17.0
U	2.7	23.6	3.4	7.3	5.9	0.7	0.8	0.5	5.7	2.1	1.0	2.7	7.1
V	94	12	32	31	16	30	105	61	16	36	19	11	10
W	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.2	<0.5	<0.5	<0.5
Zr	292.7	116.5	282.2	174.4	176.8	111.2	123.8	141.1	203.6	170.1	164.1	108.0	90.5
Y	17.9	14.7	17.4	15.2	19.0	3.5	13.0	8.2	13.4	11.0	3.4	22.4	8.7
La	43.6	42.1	77.1	38.3	55.9	9.6	20.7	22.0	67.8	56.8	26.8	24.0	21.3
Ce	90.0	61.3	155.0	88.6	95.1	17.8	110.0	34.8	129.2	106.7	48.3	40.1	39.2
Pr	10.07	8.43	15.49	8.56	10.82	2.25	4.49	4.08	13.03	11.18	4.78	4.51	3.94
Nd	38.0	29.1	50.4	29.1	36.0	8.5	16.5	14.2	40.3	37.6	15.9	15.7	13.7
Sm	6.39	4.69	7.49	4.80	5.45	1.69	3.01	2.15	5.58	5.47	2.00	3.02	2.67
Eu	1.67	0.79	1.11	1.09	0.74	0.53	0.93	0.77	0.80	1.23	0.78	0.64	0.57
Gd	4.74	3.50	4.75	3.53	3.98	1.36	2.72	1.97	3.71	3.61	1.33	3.00	2.24
Tb	0.63	0.46	0.69	0.52	0.57	0.15	0.41	0.27	0.50	0.42	0.13	0.48	0.33
Dy	3.32	2.35	3.47	2.85	3.13	0.70	2.32	1.44	2.60	2.07	0.58	2.87	1.69
Ho	0.62	0.44	0.68	0.53	0.61	0.11	0.45	0.30	0.47	0.35	0.11	0.65	0.32
Er	1.83	1.19	1.99	1.63	1.76	0.27	1.36	0.74	1.36	0.96	0.31	1.97	0.86
Tm	0.27	0.16	0.28	0.24	0.27	0.04	0.18	0.11	0.20	0.14	0.05	0.29	0.12
Yb	1.69	1.10	1.85	1.58	1.84	0.24	1.29	0.68	1.34	0.90	0.37	1.91	0.70
Lu	0.27	0.17	0.29	0.25	0.27	0.03	0.20	0.11	0.20	0.15	0.05	0.32	0.10
Mo	7.1	0.6	0.4	0.6	0.4	0.5	0.7	0.4	1.5	0.5	0.6	0.4	0.7

Continued

Cu	72.5	3.8	16.2	15.3	7.5	4.7	39.2	30.0	9.2	7.9	5.0	4.6	2.5
Pb	4.8	21.4	7.0	5.7	16.1	1.7	1.3	1.1	9.1	5.1	4.5	4.6	13.0
Zn	56	27	52	64	37	51	17	53	24	59	34	34	44
Ni	17.6	4.9	7.7	8.6	4.5	8.4	52.1	16.5	3.4	8.9	4.4	1.8	3.0
As	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cd	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sb	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bi	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ag	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Au	0.9	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tl	0.6	0.1	0.5	0.6	0.4	0.2	<0.1	0.2	<0.1	0.4	0.1	0.2	0.3
Se	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

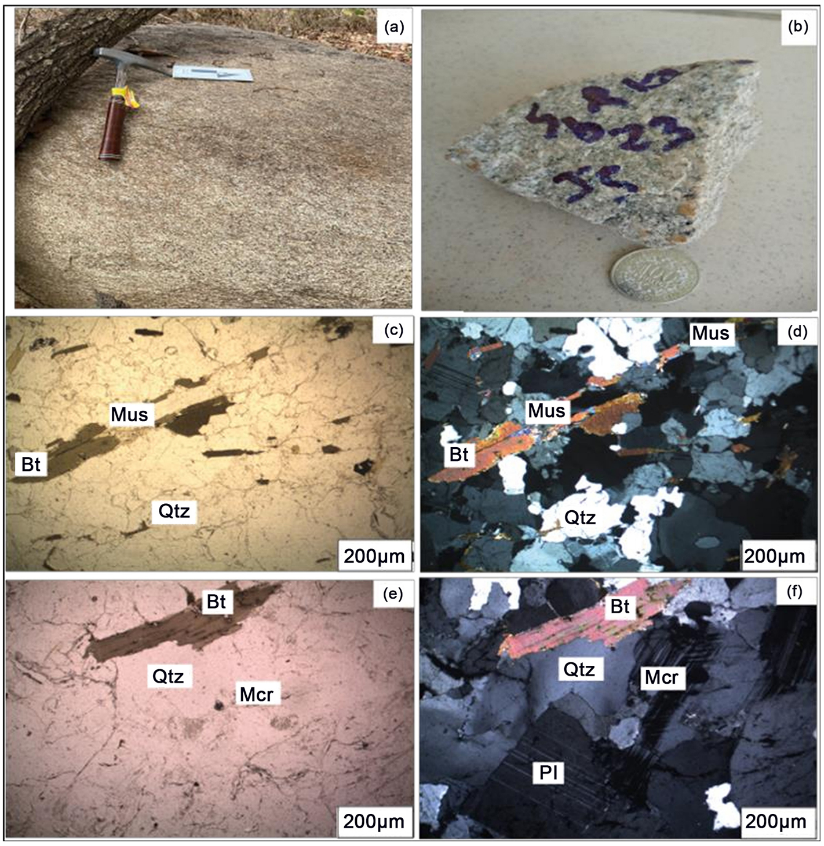


Figure 4. Macroscopic and microscopic aspects of two-mica granites. (a): Two-mica granite block; (b): macroscopic sample of two-mica granite; (c): quartzo-feldspathic assemblage + biotite and muscovite minerals (LPNA); (d): quartz-feldspathic assemblage + biotite and muscovite minerals (LPA); (e): stretched biotite minerals associated with quartz and feldspars (LPNA); (f): stretched biotite minerals associated with quartz and feldspars (LPA). Qtz: Quartz, Pl: Plagioclase, Mcr: Microcline, Bt: Biotite, Mus: Muscovite.

assemblage of these two-mica granites. The grain size is variable (medium to coarse), with some biotite and/or muscovite phenocrysts.

- Potassic granites (with orthoses and/or microclines)

Located in the vicinity of the two-mica granites (Gbingoro), they have almost the same characteristics as the latter, except for a much higher proportion of orthocrysts and microclines in the present formation (Figure 5). Figure 5(a) and Figure 5(b) show a slab and a sample of pink granite from the study area respectively. Figures 5(c)-(f) show the mineralogical assemblage of these pink granites.

- Granodiorites

The granodiorite outcrops encountered are generally slabs and boulders. They were encountered mainly at Souroumana, Dar-es-Salam, Gbetogo, Dirabana and Dualla. They are weakly to moderately altered, mesocrate in colour with a massive appearance and medium to coarse grains (grainy texture). In places they are deformed with very stretched minerals (see Figure 6).

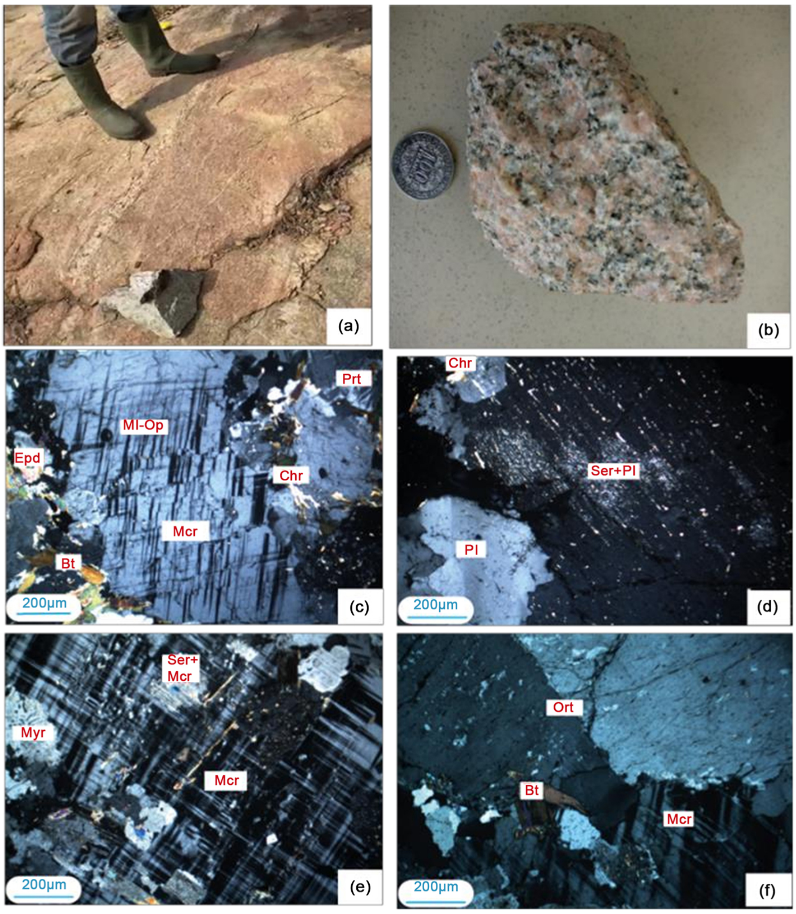


Figure 5. Macroscopic and microscopic aspects of potassic granites. (a): Potassic granite slab; (b): macroscopic sample of pink granite; (c): microcline phenocrysts associated with biotites, chlorites and sericites; (d): progressive sericitisation of plagioclases; (e): sericitisation and myrmekites in the microcline; (f): biotite minerals associated with orthocrysts and microcline. Qtz: Quartz, Pl: Plagioclase, Mcr: Microcline, Bt: Biotite, Ml-Op: Minéral Opaque, Sr: Séricite, Epd: Épidote, Myr: Myrmékite, Chl: Chlorite.

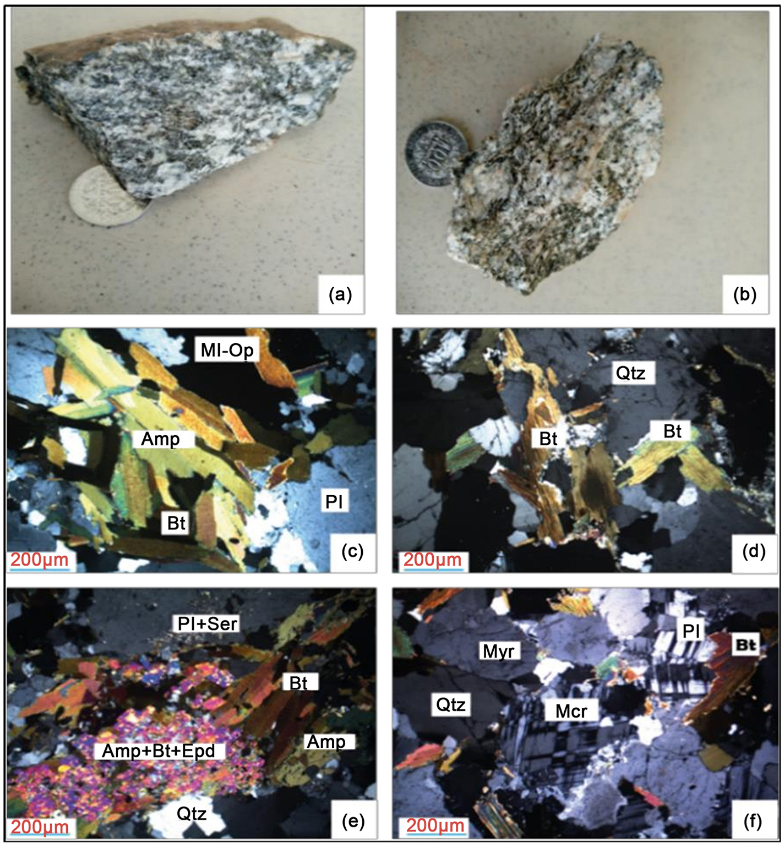


Figure 6. Macroscopic and microscopic aspects of Granodiorites. (a): Macroscopic sample of undeformed granodiorite; (b): macroscopic sample of deformed granodiorite; (c): amphibole rods and oriented biotites; (d): quartzo-feldspathic assemblage + biotite minerals; (e): amphibole rods and oriented biotites associated with epidotes; (f): quartzo-feldspathic assemblage and biotite minerals. Qtz: Quartz, Pl: Plagioclase, Mcr: Microcline, Bt: Biotite, Amp: amphibole, Ml-Op: Minéral Opaque, Sr: Séricite, Epd: Épidote, Myr: Myrmékite.

4.2. Geochemical Data

4.2.1. Classification and Geochemical Characterization of Granitoids

The chemical compositions of the samples from the different intrusions are projected into the different rock classification digrams for their characterization. Inserted into the $Na_2O + K_2O$ (wt%) versus SiO_2 (wt%) diagram [6], all granitoids in the study area show predominantly granitic, granodioritic, and gabbro-dioritic compositions (**Figure 7**). These results appear to be in agreement with the field petrographic data. The effect of alteration and migration of mobile elements, such as Na and K, is tested by the K_2O vs. SiO_2 discrimination diagram of Hugues (1973), with the samples studied falling predominantly into the healthy rock range. This indicates that the samples analyzed are relatively fresh and that the effect of weathering on the mobility of chemical elements can be considered negligible (**Figure 8**).

In the K_2O vs. SiO_2 diagram [7], located at the weakly calc-alkaline/moderately calc-alkaline boundary, the granitoids as a whole show on the one hand calc-alkaline affinities (Medium-K calk-alkalines series) and on the other hand these granitoids

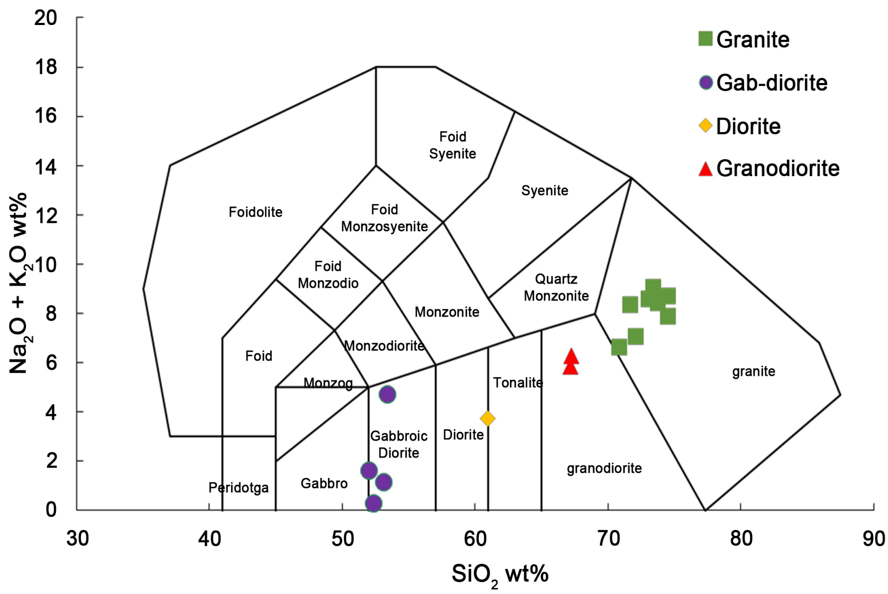


Figure 7. Classification diagram $Na_2O + K_2O$ as a function of SiO_2 from Middlemost (1994).

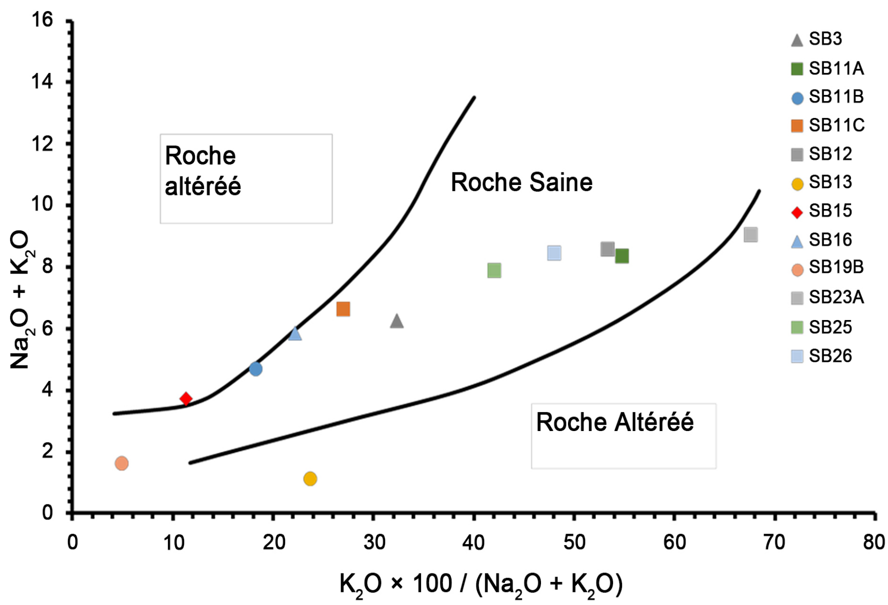
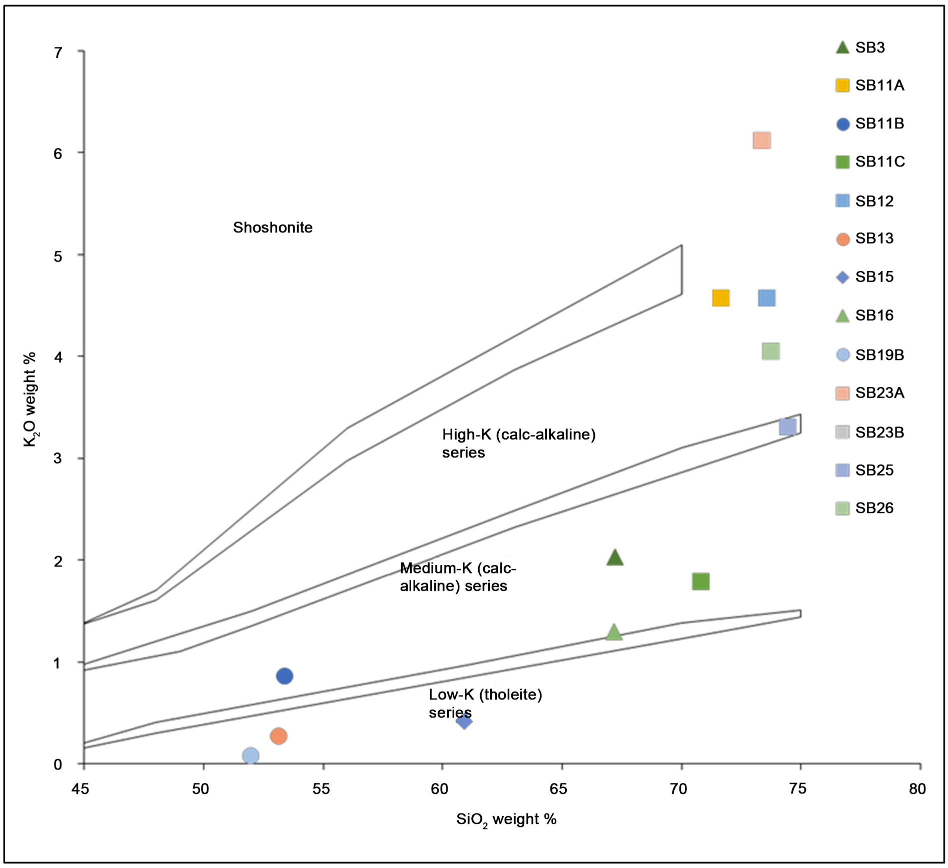


Figure 8. Diagram ($Na_2O + K_2O$) as a function of $K_2O \times 100/(Na_2O + K_2O)$ from Hugues (1973).

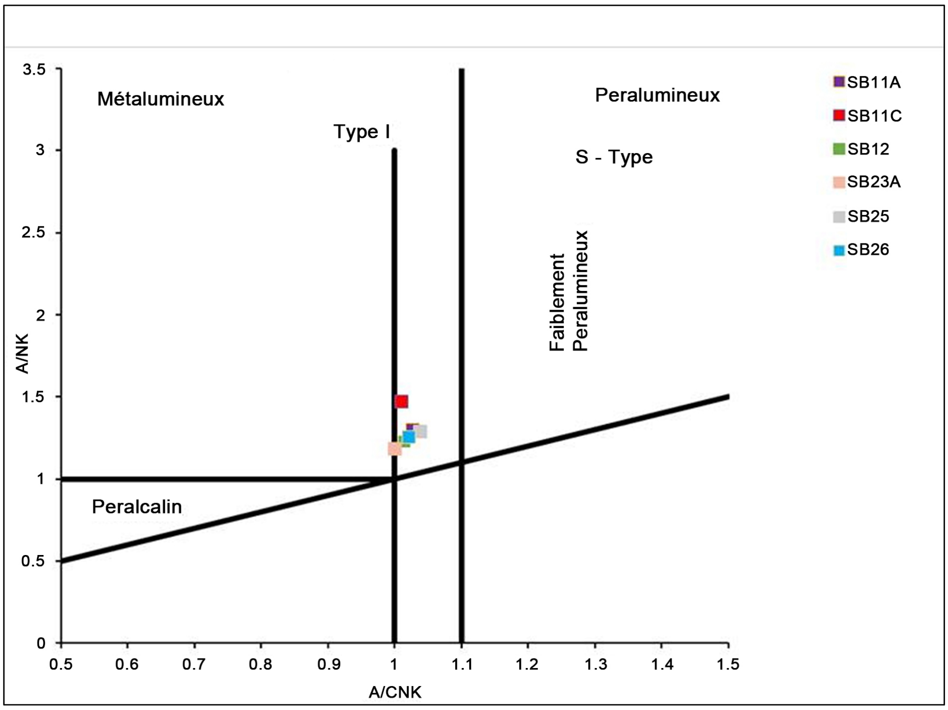
indicate more or less alkaline affinities (High-K calk-alkalines series) (Figure 9(a)). On the A/CNK (mol. $Al_2O_3/CaO + Na_2O + K_2O$) vs. A/NK (mol. Al_2O_3/Na_2O+K_2O) diagram [8], all the rocks of the area fall into the domain of type-I granitoids with a peraluminous to weakly metaluminous signature (Figure 9(b)).

4.2.2. Geochemical Evolution

The SiO_2 vs Oxides Harker plots show a continuous and linear distribution of representative points of the granitoid samples in the study area. This distribution indicates negative correlations between SiO_2 and most elements including Al_2O_3,



(a)



(b)

Figure 9. (a) K_2O versus SiO_2 diagram (Peccerillo & Taylor 1976) and (b) Shand diagram (1922) of the studied granitoids.

Fe_2O_3, CaO, TiO_2, MgO, P_2O_5. A positive correlation exists with K_2O but it is less clear with Na_2O which seems to be negative. In detail, the granitoids of the Seguela area show a continuity of composition (**Figure 10**).

4.2.3. Rare Earth Spectra and Multi-Element Diagrams

Overall, the rare earth spectra all show a negative slope, with light rare earths (LREE)/heavy rare earths (HREE) fractionations that are more or less important. In detail, variations appear between the spectra of each petrographic entity. Granites show rather flat profiles reflecting a low fractionation rate. Normalized to chondrites [9], the fractionation rate in (La/Yb)N is moderate and ranges from 0.05 to 8.63. The spectra show pronounced negative Eu anomalies (Eu/Eu* = 0.32 - 0.53) and negative to positive cerium (Ce) anomalies (**Figure 11(a)**).

Granodioritic facies are more enriched in light rare earths (LREE) than in heavy rare earths (HREE), according [9], hence the smooth appearance of the spectra. Weak positive to negative europium anomalies (Eu/Eu* ratio is about 1), are observed in these granodiorites, which implies a cumulative character of plagioclases in these facies (**Figure 11(b)**).

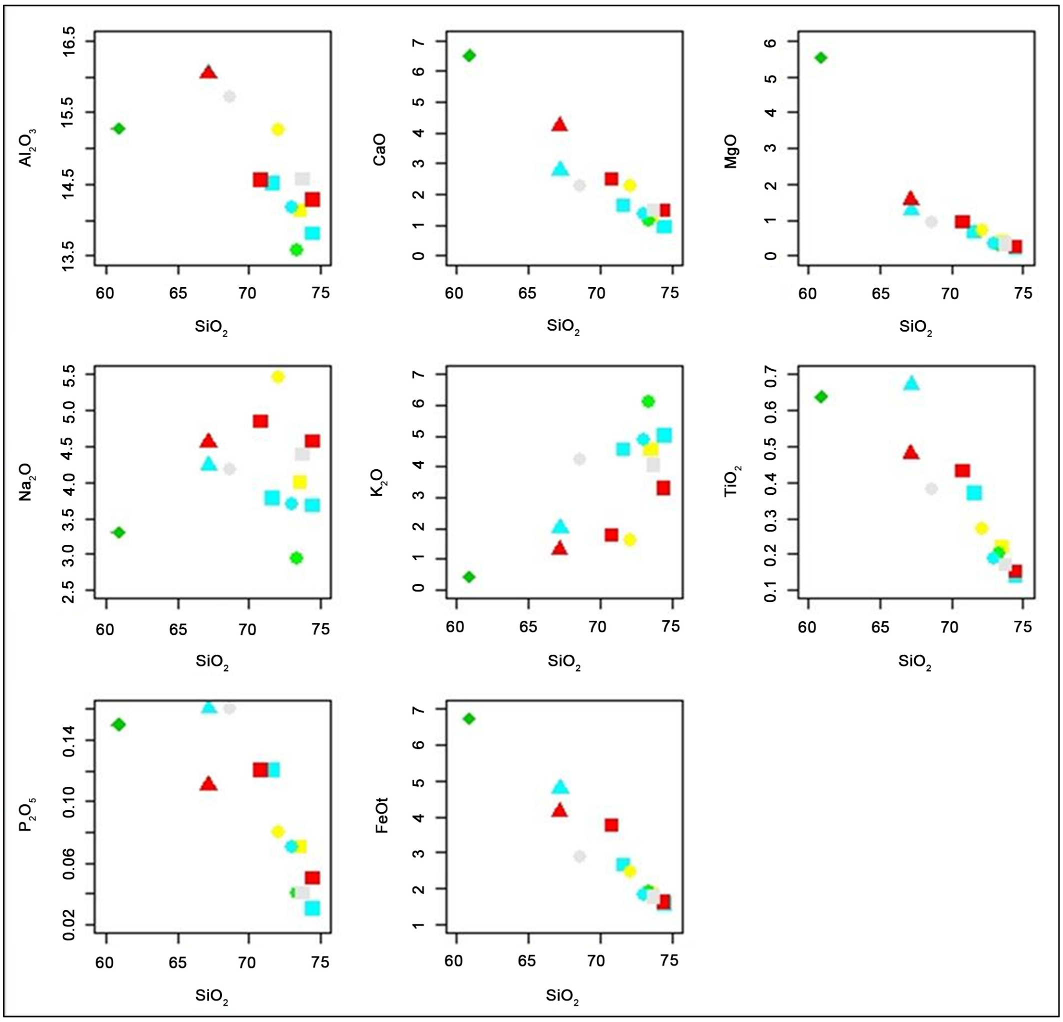


Figure 10. Oxides vs SiO_2 Harker diagrams of the studied granitoids.

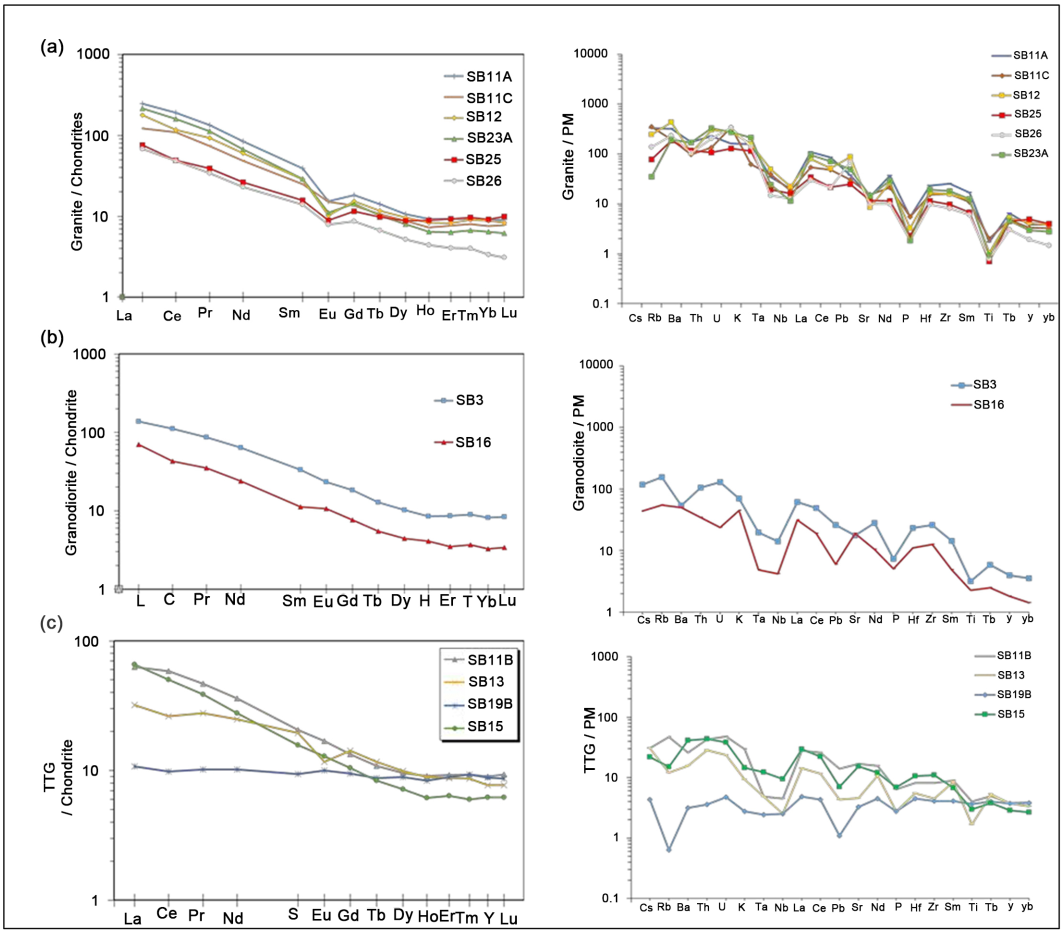


Figure 11. Rare earth spectra normalized to chondrites and trace element spectra normalized to the early mantle (after Sun & McDonough, 1989).

Grabbro-dioritic samples show moderate fractionation of rare earth spectra [(La/Yb)N = 5.04 to 10.26)], slight negative and sometimes zero Eu anomalies (Eu/Eu* = 0.71 to 0.96) due to plagioclase fractionation, and sub-flat HREE spectra (Figure 11(c)). Multi-element spectra normalized to the early granitoid mantle show significant enrichments in LILE (Cs, Rb, Th, and K) and a clear overall depression in Nb-Ta. Therefore, these rocks clearly originate from a subduction environment (or from the remelting of a source from a subduction environment). Negative Sr, P and Ti anomalies are present and a more or less moderate enrichment of HFSE (Hf, Zr) (Figure (11)).

4.2.4. Geochemical Evolution

Chemical data, projected in the Rb versus Y+ Nb binary diagrams [10], provide information on the petrogenetic and geotectonic relationships of the granitoids (Figure 12). Because of their low Ta, Y and Nb contents, almost all granitoids fall into the fields of volcanic arc granites (VAG) and syn-collisional granites (Syn-COLG). The analyzed granitoids show granitic, granodioritic and gabbro-dioritic affinities. Most show calc-alkaline compositions, but some tend towards the alkaline pole (High-K calk-alkaline series). They show peraluminous

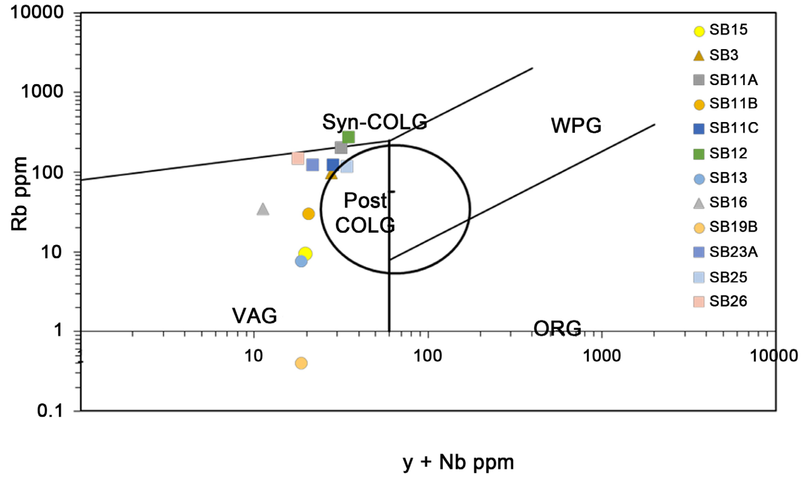


Figure 12. Binary plots of Rb versus Y + Nb from Pearce *et al.* (1984) of the studied granitoids.

to weakly metaluminous tendencies, suggesting crustal sources. The formation of these granitoids involves magmatic mixing, fractional crystallization and partial melting processes. All the granitoids show enrichments in light rare earths, negative Nb-Ta anomalies, typical of subduction zone magmas, and are derived in similar geotectonic environments from volcanic and syn-collisional arc granites.

5. Discussion

5.1. Petrography

The transition zone (Archean-Proterozoic) of Côte d'Ivoire is, according to the studies of Camil (1884) and Kouamelan (1996), subdivided into three domains: the northern domain (Boundiali domain), the central domain (Séguéla-Vavoua domain) and the southern domain (SASCA domain). Compared to the other domains of the transition zone, the present study area (Séguéla-Vavoua domain) has many similarities but, above all, important differences:

In the northern domain of the transition zone, [5] and [11] describe intrusive granitic massifs with characteristics similar to those described in the present zone. In the southern part of the transition zone, [5] and [11] identify as a particularity the coexistence of high-grade formations considered as Archean (anatexts, more or less migmatitic tonalitic orthogneiss) and low-grade formations considered as Birimian (intrusive leucogranites, intrusive granodiorites, micaschists). [12] identifies three major lithological units in this area, and more precisely at Bliéron (Grand-Béréby), not all of which are identified in the Séguéla-Vavoua area: paragneisses whose protoliths are magmatic (granodiorites and diorites) and sedimentary (grauwackes) in nature; orthogneisses with TTG-type composition, granites and quartz monzonites; metabasites characterized by gabbros and dolerites.

In this study area,

The biotite granites studied are identical to those described [13] in the same area, and agree with the descriptions and characteristics given [14], on these same rocks. They differ from those described [15], in the Alépé area, by the relative proportion of minerals and the presence of important phenocrysts of muscovite.

The granodiorites indeed correspond to those described [14] in his recent work in the Séguéla area, and to those described north of the Nanglékoffikro gold zone. However, they differ from those identified [16] in the Nassian domain where they are poor in potassium feldspars and have a composition close to that of rhyolites. They can be assimilated to the granodiorites identified [17], during his work in the Daloa square degree and to the oriented granodiorites described in the central part of the transition zone [5]. Furthermore, [18] describes granodiorites in the Bonikro gold deposit that have the same mineralogical composition and have undergone the same hydrothermal alteration as those in our study area.

5.2. Trace and Major Elements Geochemistry

Geochemical analyses also reveal the peraluminous to weakly metaluminous character of the granitoids of the Seguela region. The marked negative Nb-Ta anomalies coupled with their volcanic arc granitoid chemistry confirm that these granites were formed in a subduction zone type arc environment. Although they have volcanic arc characteristics, their positive and negative Cerium anomaly shows a divergence in geochemical evolution.

These results corroborate work on the plutonites of the Bandaman basin [19], Comoé basin [20]. The weakly negative europium anomalies indicate plagioclase fractionation or melt generation in the plagioclase stability field. These granitoids show chemical compositions almost similar to those from other birimic domains in general, and in particular those from Dabakala, studied by [21] [22] [23]. Most indicate calc-alkaline compositions, but some tend toward the alkaline pole (High-K calkalines series). The Seguela granitoids are associated with volcanic and syn-collisional arc granites, which were emplaced in a subduction environment (**Table 2**).

6. Conclusion

At the end of this analysis, it should be noted that the various works carried out within the framework of the petrogeochemical analysis of the granitoids of Mounts Fouimba and Goma in the Seguela region (central-western Côte d'Ivoire), have allowed a better understanding and refinement of the geology of the study area. This study is therefore a contribution to the detailed mapping of the Ivorian terrain. These different methods applied have indeed allowed the identification of all the magmatic formations of the area. The granitoid formations identified in the study area are essentially two-mica granites or leucogranites, pink granites (with orthoses and/or microclines), and granodiorites. The study area is in fact the site of very significant hydrothermal (pervasive and vein) and meteoric alteration.

Table 2. Geochemical traces elements ratios in Seguela Granitoids.

La/Yb	25.80	38.27	41.68	24.24	30.38	40.00	16.05	32.35	50.60	63.11	72.43	12.57	30.43
Nb/La	0.23	0.16	0.19	0.35	0.28	0.19	0.32	0.14	0.12	0.15	0.12	0.48	0.43
Ce/Sr	0.24	0.16	0.52	0.27	0.52	0.03	0.34	0.09	0.43	0.21	0.17	0.16	0.19
Zr/Hf	40.65	28.41	39.75	37.11	34.00	37.07	37.52	41.50	33.93	38.66	35.67	30.86	30.17
Nb/Ta	12.5	5.667	10.21	8.3125	7.9	18	13.4	15	8.2	12	8.25	14.5	15.17
Nb/Zr	0.03	0.06	0.05	0.08	0.09	0.02	0.05	0.02	0.04	0.05	0.02	0.11	0.10
Ce/Y	**5.03**	**4.17**	**8.91**	**5.83**	**5.01**	**5.09**	**8.46**	**4.24**	**9.64**	**9.70**	**14.21**	**1.79**	**4.51**

Pervasive hydrothermal alteration is illustrated by carbonation, sericitization, chloritization, epidotization, silicification and sulfidation, while vein hydrothermal alteration is illustrated by veins and seams of quartz, carbonates, etc. Meteoric (surface) alteration is certainly not to be neglected in this area, because of the traces of oxidation left on the different lithologies previously listed. The granitoids studied are mostly peraluminous with a calc-alkaline to alkaline affinity (High-K calkalines series). These samples have granitic to gabbro-dioritic compositions. They show an enrichment in LILE and marked negative anomalies in Eu and Nb-Ta typical of arc magmatism.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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