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Potential Source Rocks of Ngaye Clayed Deposit (Northern Cameroon)

Soureiyatou Fadil-Djenabou

Department of Life and Earth Sciences, Higher Teachers' Training College, University of Maroua P.O. Box 55 Maroua, Cameroon

Abstract: ***The aim of this paper is to identify the parent rocks of Ngaye clay deposit. To this end, mineralogical and geochemical analysis has been done, on the lithological formation found around the deposit and on the samples of clay deposit. The mineralogical analysis have been done by X-ray diffraction, specific treatments ethylene glycol, the hydrazine test and heating between 550°C and 600°C have confirmed the mineralogy of clay materials. For the geochemical analysis major, trace and rare earth elements have been analyzed. The rocks consist of granits, gneisses, amphibolites and quartzites. The metamorphic rock is mainly composed of amphibole, plagioclase and quartz. On its part, granits are constituted by plagioclase, feldspar, biotite and garnet. Mineralogical results of clays samples showed that it made by kaolinite, feldspar, quartz and muscovite. Positive correlation between major elements and barium in the clay sample compared to rocks suggested that gneisses could be the source rocks of these clay materials. The high contents of REE in clay compared to rocks contents, shows that there would have been an upgrading of REE during the supergene alteration of parent rocks.CIA values showed that the lithological formation have undergone moderate chemical alteration. This is in accordance with mineralogical procession of clay deposit, and the climate of the region.***

Keywords: clayed deposit, Ngaye, source rocks

1. Introduction

The clay material is a product resulting from the responses of their source materials. The processes of weathering, acting on pre-existing minerals, or material to form clay minerals. Therefore the chemistry of lithology determines the kind of clay minerals in a soil [1] [2] [3]. Highly basic parent material or poor drainage induces montmorillonite formation. Kaolinite-halloysite formation is favoured by a highly based depleting environment such as high rainfall, good drainage and high permeability. Intermediate conditions are conducive to vermiculite formation either by synthesis or mica alteration. Clay minerals in a soil may originate by inheritance from parent material, alteration and degradation of primary minerals, and synthesis [4][5][6][7].These mechanisms operate under different environmental conditions together with the process of the translocation of material result in soil clay mineral composition becoming a function of soil depth. In this paper it is desired to determine the potential parent rock of Ngaye clay deposit. Attention, therefore, will be focused on the lower horizon of clay profile sampled and the rock surrounding the clay deposit (Figure 1). In the vast majority of cases this is a C-horizon, the soil parent material. Despite the moderate alteration, It is here that the contribution of the parent rock would be least complicated by weathering processes.

2. Materials and Methods

The investigated Ngaye clayed deposits are located at 7°11'04"N and 14°58'50"E (Figure 2). The climate is semi-arid, with a mean annual rainfall of 970 mm, and a mean annual temperature of 27 °C. The lithologies include granits, gneisses, quartzites and amphibolites, the surface rock ranged from Pre-Cambrian to Tertiary-Pliocene [8]. Gneisses appears like flagstones and have foliated structure. They are gray and composed of alternating white beds rich in feldspars between 1 to 4 mm thick and dark beds rich in amphibole (Figure 3a). Amphibolites appears underground or sometimes in the middle of gneiss (Figure 3b). Quartzites are less represented in the area, and are lined with phyllitous minerals consisting mainly of quartz (Figure 3c).The granits are light gray and also appear as flagstones in the area (Figure 3d). For mineralogical and geochemical analyses, 20 g of powders of five samples of rock and 4 samples of clay material samples were treated with cold 1 M HCland H_2O_2 to remove organic matter. Adding sodium hexametaphosphate deflocculated the samples. The mineral compositions were determined by X-ray Diffraction (XRD) analysis. Samples for geochemical analysis were crushed using a jaw crusher with steel plates, and pulverized in a ball mill made of 99.8% Al_2O_3. Powders were first heated at 105 °C in the presence of oxygen to drive off remaining volatile components and oxidized Fe. The loss on ignition (LOI) was determined at 1000 °C on dry (105°C) samples. X-ray Fluorescence (XRF) was used to determine the major element concentrations after LOI measurement. The sample powders were first ignited and melted with a lithium tetraborate flux and then analyzed with a Rigaku RIX-3000 wavelength dispersive X-ray Fluorescence spectrometer. Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) was used to quantify trace and rare-earth element concentrations. Sample powders for ICP-MS analyses were digested with a mixture of HCl and HClO4 at 120 °C in sealed Teflon containers for one week, and then rinsed out of their containers with dilute HNO3 and dried. The residue was again dissolved in a mixture of three acids (HNO3, HCl and HF) at 100°C. Sample solutions were analyzed in a Perkin Elmer Elan 9000 ICP-MS instrument. The geochemical results (major, trace and rare-earth elements) of rocks samples were compared to clay samples.

3. Results and Discussion

Mineralogy

Metamorphic rocks of Ngaye are constitued by amphibole, plagioclase and feldspars. Amphibolite also has sphène and opaque minerals (Figure 4a).Gneiss has orthose in their mineralogy, and has granoblastic texture showing their magmatic origin. (Figure 4b). Amphibolite are also granoblastic, however granits has porphyritic grained texture (Figure 4c). The absence of kyanite in these metamorphic rocks showed that they can results to the metamorphism of magmatic rocks [9].The collection of clays samples are made by kaolinite, smectites, feldspars and quartz. They are also few presences of muscovite, goethite and hematite. Specific analysis with glycol, hydrazine and heating at 550°c [10] confirmed the presence of smectites, kaolinite and illite (Figure 5).These clay samples are sandy clays with clay content between 15-43%, and sand between 48and 58% (Table I). The uniform texture would be related to hydrolytic processes that affect source rocks [11] [12]. The presence of different types of clay minerals could be related to the several types of rocks and hydrolytic process [13].

Geochemistry

SiO2 contents of gneisses and amphibolites are moderate, compared to higher contents of this element in quartzites and granits (Table II). However Al_2O_3 and Fe_2O_3 contents evolve in the opposite direction (table).The alkaline earth contents (MgO, CaO) evolve in the same way as Fe-Al pair (table). Therefore, alkalis contents are close to silicium contents, there are slightly up in amphibolite (table). MnO and P_2O_5 has low contents in these rocks (Table II). Positive trend between SiO_2 with some oxides likes Al_2O_3, Na_2O and K_2O (Figure 6) confirmed their higher presence in the rocks. However, negative trends with the other oxides suggested that feldspars are little weathered [14] [15]. Trace elements contents of granits and gneisses are similar (Figure 7), suggesting that gneisses of Ngaye are situated in grinding area in contact with granits. Positive trend of some trace elements with silica shows a compatibility with these elements. High contents of SiO_2 in clay samples (Table III) could be correlate to quartz content in potential source rocks [16] [17]. Moderate content of MgO could be related to the presence of smectites from weathering of mafic rocks [11]. Moderate contents of CaO, Na_2O and K_2O (Table 2) are correlated to the presence of illite or feldspars [17] [18] and indicators of immaturity of clay sediments. Variation of Na_2O content in clay samples could be related to the solubility of sodium [19]. High content of barium in this material could be related to is content in parents rocks [8].

Figures

High contents of chromium and vanadium in this clay are probably related to their substitution in clay minerals [19] [20] [21]. The values of Chemical Index of Alteration (CIA) confirmed that the potential source rocks (Table II) have undergone moderate chemical alteration [22] [23].This assumption is confirmed by rare earth patterns with the spider diagram (Figure 8). There are high contents of Rare Earth Elements (REE) in clays sample than in the potential source rock, this suggested that there would have been an upgrading of REE during the supergene alteration (Table IV). Spider diagram of REE of clay samples normalized with PAAS (Post Archaean Australian Average Shale) of McLennan, 1989 [24] and with the potential source rocks, showed that fractionation of REE, enrichment in LREE compared to HREE. There is also a similarity between spider diagram of clay samples normalized with PAAS and with Ngaye gneisses (Figure 8). These suggested that gneisses could be the parent source rocks of Ngaye clay deposit. The gneisses cover a fairly large area and amphibolites and granites appear as enclaves and veins in gneissic bedrock.

4. Conclusion

The presence of different types of clay minerals in Ngaye clayed deposit confirms the presence of several types of rocks as founding in the surrounding area. Major elements and some trace elements contents of clay samples and potential source rocks associated with CIA values confirmed the moderate weathering of source rocks. The normalization of rare earth patterns of clays deposits with the potential source rocks showed that gneisses could be the parent source rocks of Ngaye clay deposit.

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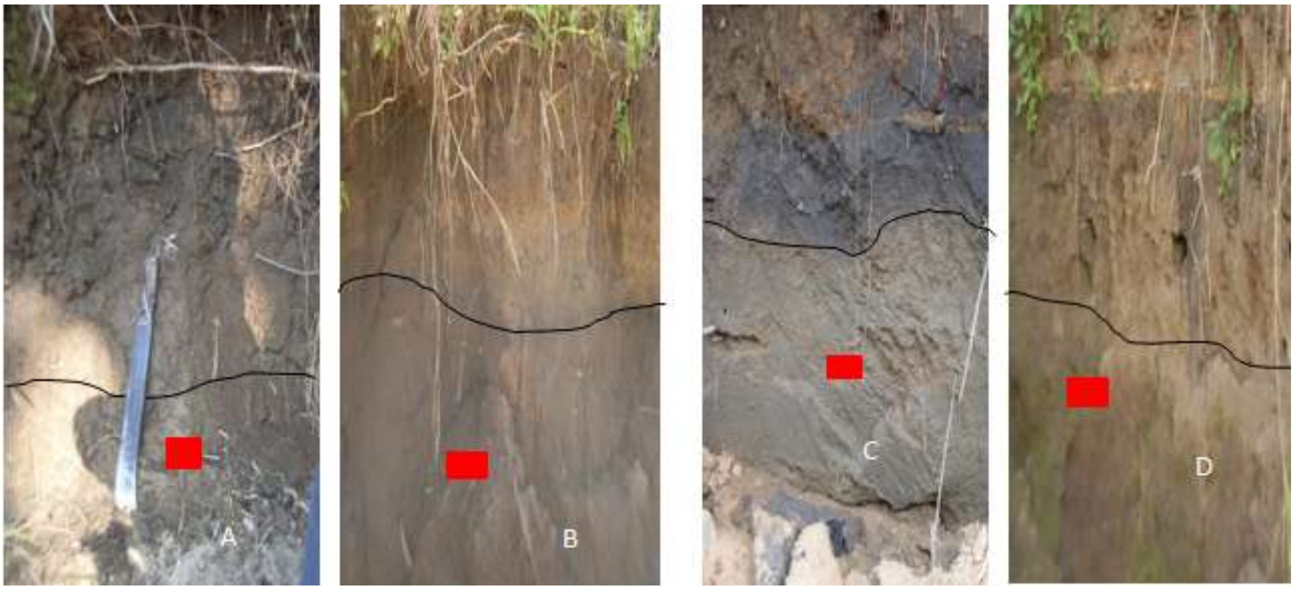


Figure 1: Profiles representing clay samples .A for sample A,B for sampleB, C for sample C and D for sample D

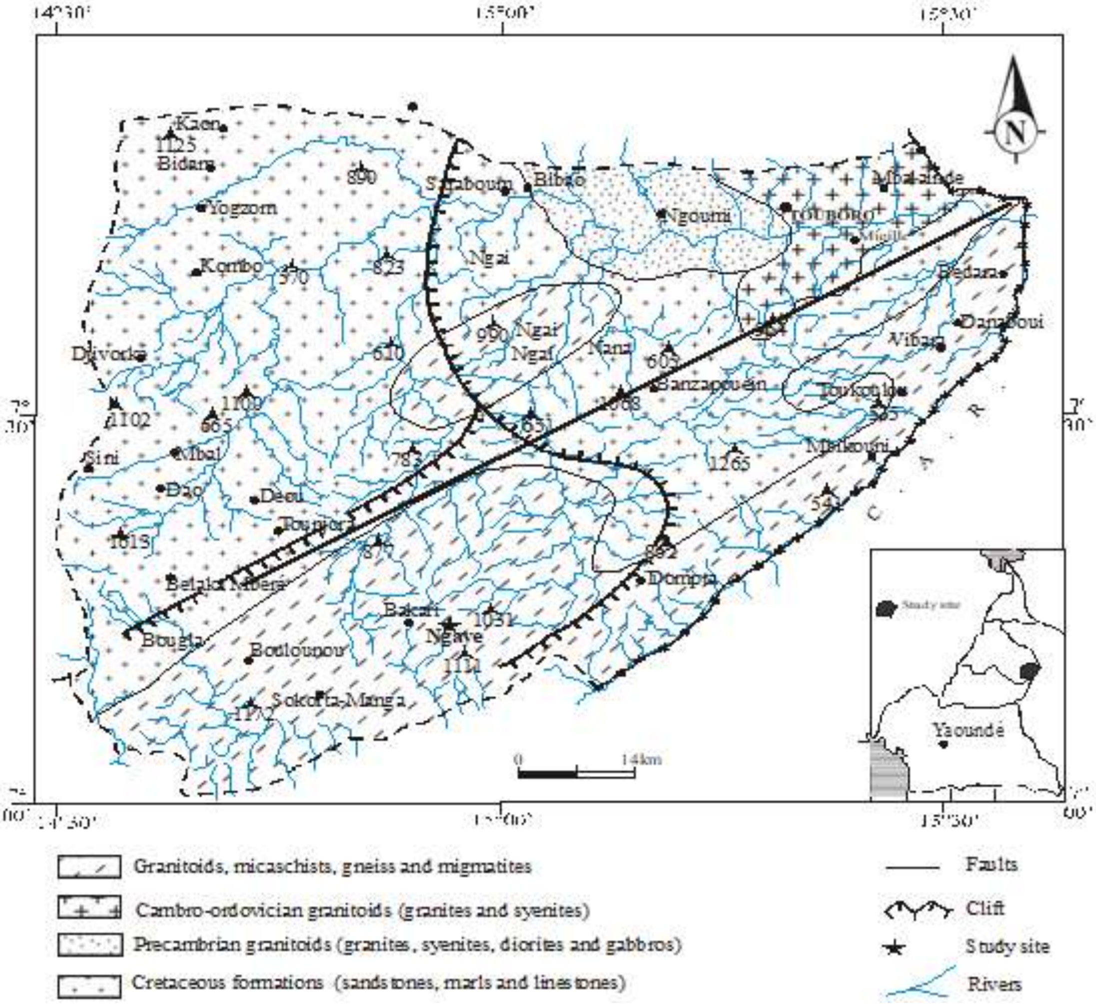


Figure 2: Location map combined with geology of the study site

Figure 3: Pictures of potentials rock source: a) Gneiss ;b) Amphibolite ; c)Quartzite; d) Granite

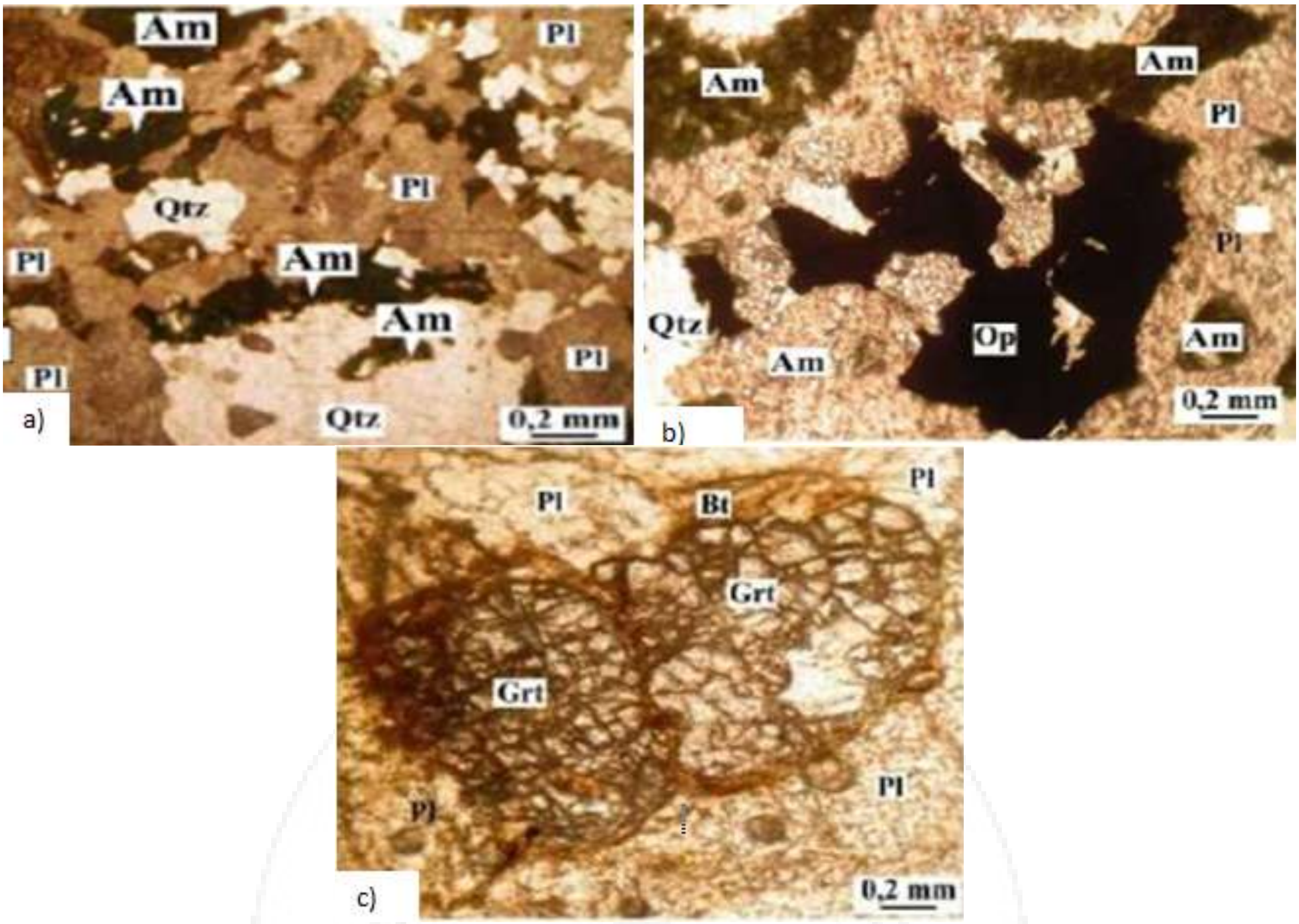


Figure 4: Tin sections of rocks observed with polarized and analyzed light: a) amphibolite; b) gneiss; c) granit; Am=amphibole; Qtz=quartz; Pl=plagioclase;Bt=biotite;Grt=garnet;Op= opac

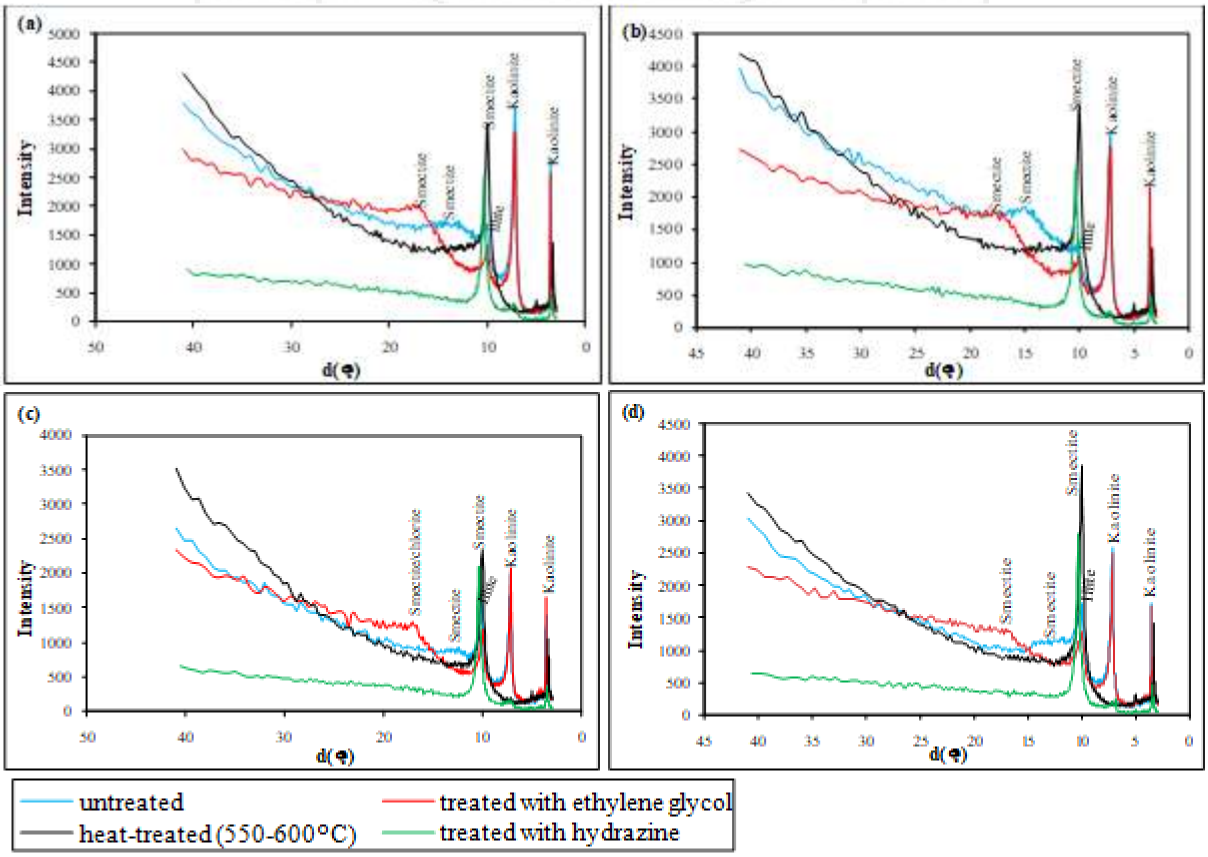


Figure 5: XDR patterns of the samples; (a)for sampleA;(b) for sample B;(c) for sample C;(d) for sample D

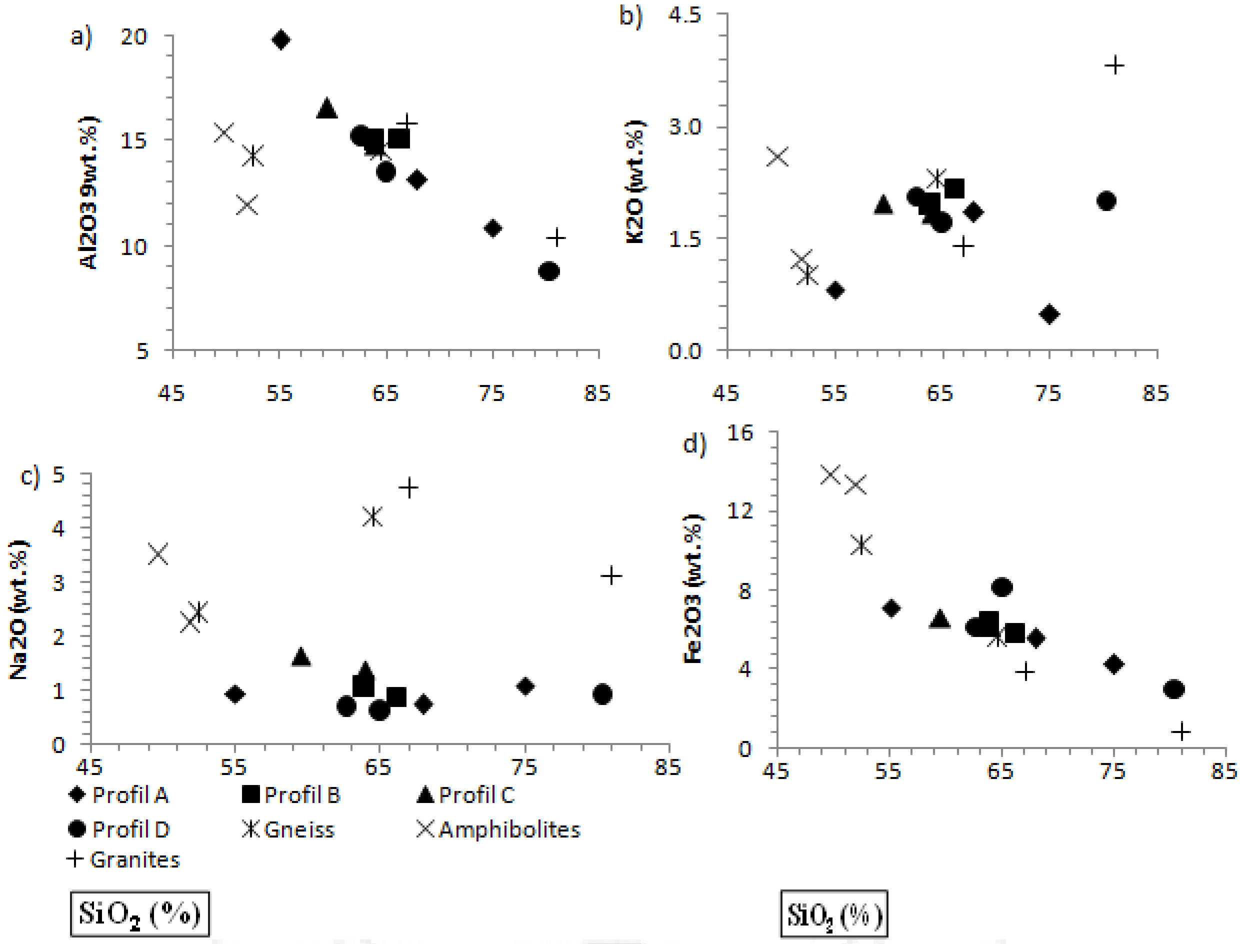


Figure 5: Geochemical Harker diagram of some majors elements of rocks and clays samples a) SiO_2 wt%vsAl_2O_3wt%; b)SiO_2wt%vs Na_2Owt%;c) SiO_2wt%vsK_2Owt%;SiO_2wt%vsFe_2O_3wt%.

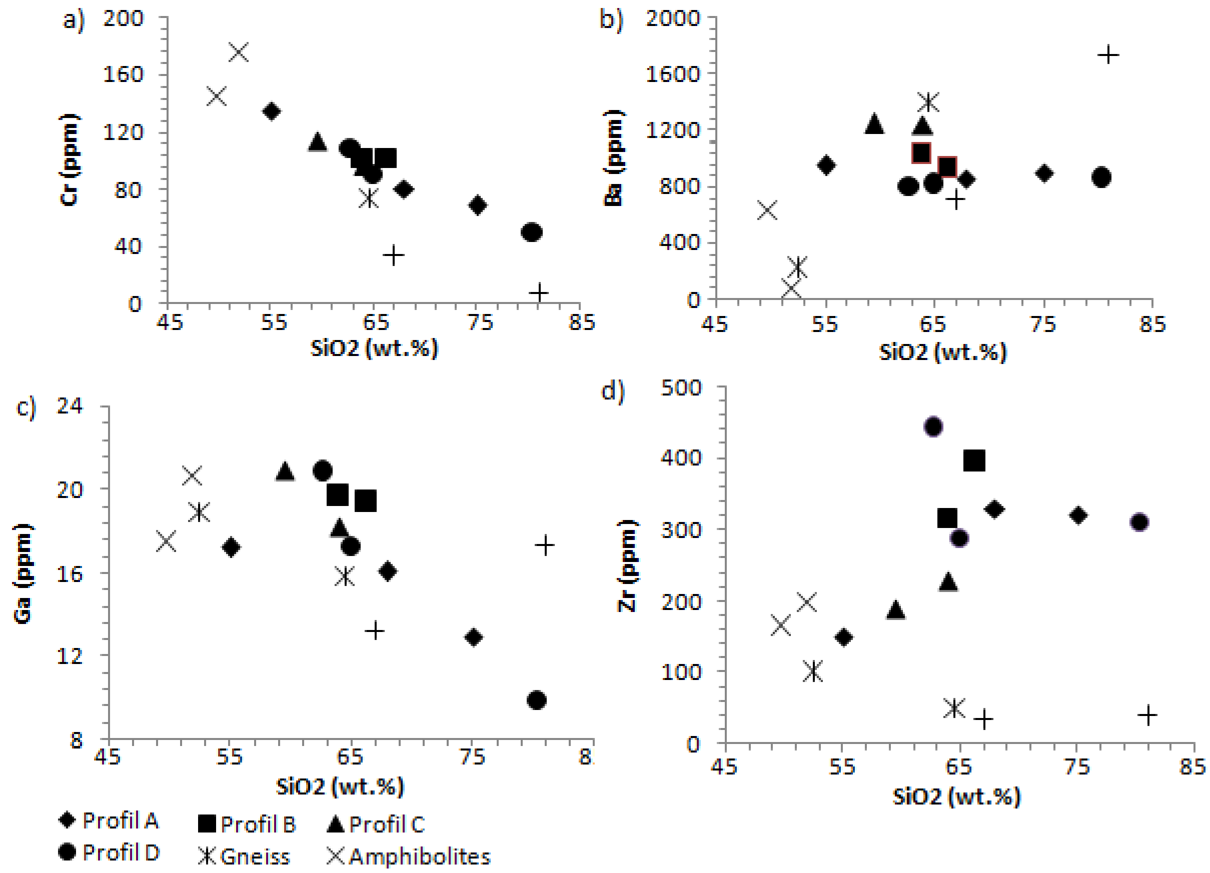
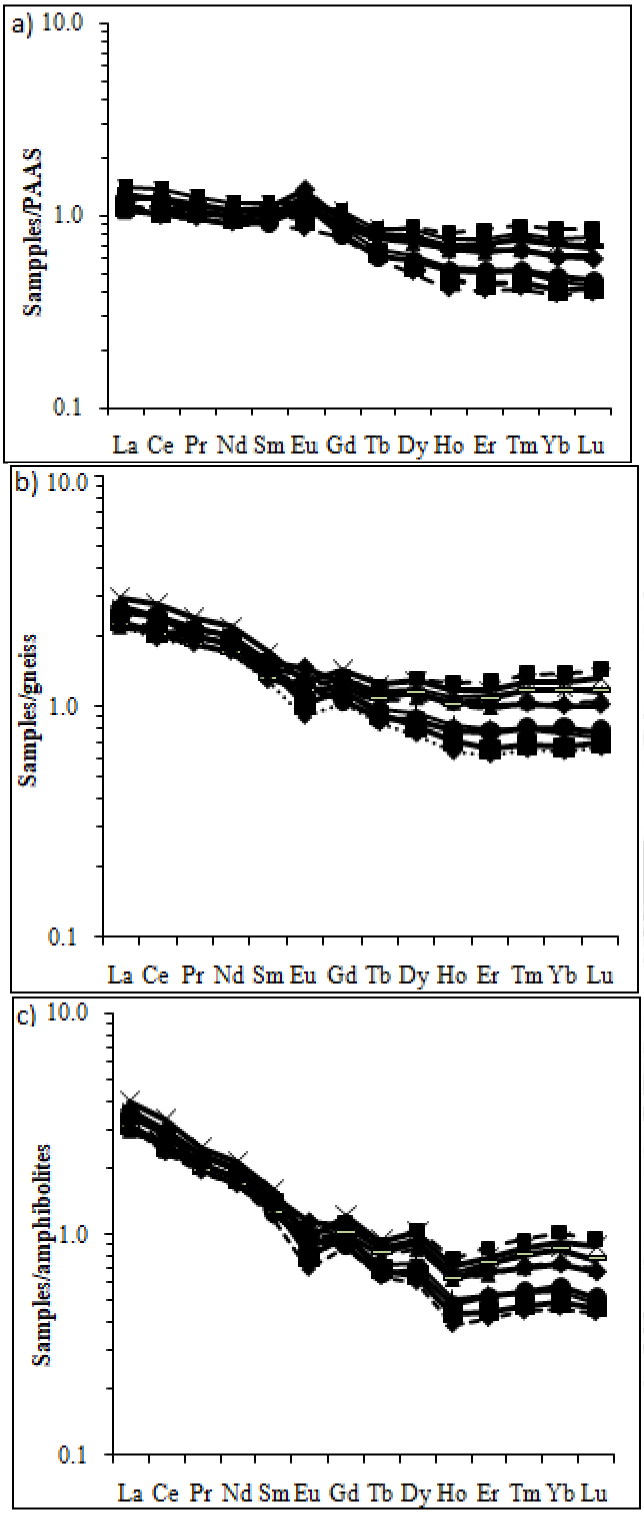


Figure 6: Geochemical Harker diagram of some trace elements of rocks and clays samples a) SiO_2 wt% vs Cr ppm; b)SiO_2wt%vs Ba ppm; c) SiO_2wt%vsGa ppm;SiO_2wt%vs Zr ppm.



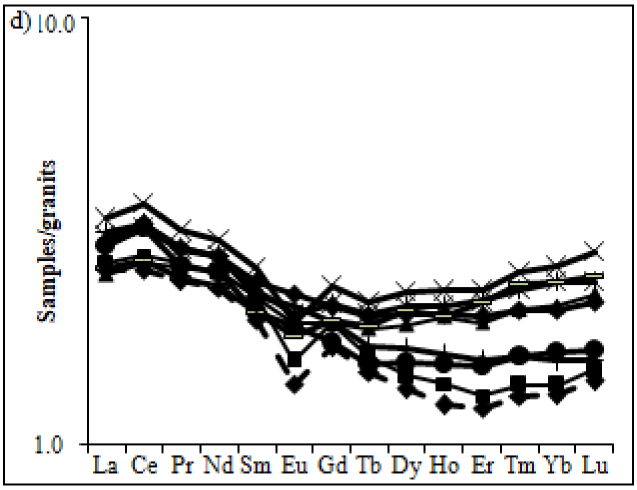


Figure 7: Geochemical spider diagram of clay samples :a)normalized with PAAS; b)normalized with gneiss; c) normalized with amphibolites; d) normalized with granites

Tables

Table I: Particles sizes distribution (%) and texture of clay samples

Samples	Particles sizes		Texture
	Clay	Sand	
A	43.15	55.49	Sandy clay
B	49.93	52.39	Sandy clay
C	44.63	55.03	Sandy clay
D	41.73	57.85	Sandy clay

Table II: Major elements (%) of rocks and clay samples of Ngaye

	Gneisses		Amphibolites		Quartzites	Granits		Clay samples			
	NGY1	NGY2	NGY3	NGY4	NGY5	NGY6	NGY7	A	B	C	D
SiO_2	52.53	64.54	51 .97	49.75	91.67	81.04	67,02	55.05	66,22	63,97	65,01
Al_2O_3	14,27	14,54	11,94	15,37	3,40	10,37	15,86	19,80	15,05	14.77	13,51
Fe_2O_3	10.30	5,67	13,28	13,83	1,36	0,86	3,91	7,16	5,84	6,16	8,11
MnO	0,16	0,10	0,11	0,20	0,01	0,01	0,06	0,07	0,029	0,076	0,067
MgO	5,78	2,90	7,93	3,73	0,10	0,07	1,37	1,21	1,15	1,17	0,93
CaO	10.65	3,95	9,29	7,05	1.32	0.50	3,95	1,04	0.776	1,463	0,636
Na_2O	2.44	4,20	2,25	3,51	0.54	3,12	4.74	0,92	0,86	1,37	0,61
K_2O	1,00	2,28	1,22	2,59	0,29	3,82	1,39	1.78	0 ,76	0,67	0,67
TiO_2	0,41	0,20	1,43	1,61	0,18	0,02	0,25	0,82	2,16	1,83	1,71
P_2O_5	0,07	0,03	0,08	0,19	0,03	0,004	0,06	0,07	0,052	0,053	0,075
LOI	1,87	1,25	1,05	1,93	0,61	0,14	1,39	11,16	6,42	7,14	7,33
Total	99.48	99.64	99.75	99.76	99.51	99,96	99.80	99,08	99.32	98.67	98.66

CIA(%)	-	-	-	-	-	-	-	87.69	79.86	76.00	85.02

Table III: Trace elements (ppm) of rocks and clay samples of Ngaye

	Gneisses		Amphibolites		Quartzites	Granits		Clay samples			
	NGY1	NGY2	NGY3	NGY4	NGY5	NGY6	NGY7	A	B	C	D
Cr	411,0	73	34	145,0	30,0	07,0	33,0	135,00	101,00	96,00	90,00
V	146,6	64,6	175,2	277,7	19,2	7,6	56,9	116,00	110,80	93,40	97,90
Ni	112,2	42,7	278,7	45,7	10,1	6,6	28	73,20	42,30	47,00	39,40
Zn	91,0	56,0	256,0	117,0	27,0	<dl	42,0	72,00	56,00	57,00	51,00
Cu	18,4	19,5	414,0	26,2	6,5	7,7	8,5	49,50	36,80	35,52	33,90
Co	35,6	15,2	46,1	27,4	2,0	1,8	9,9	24,85	16,34	20,29	21,94
Sc	26,4	16,1	23,9	37,7	3,1	<ld	11,8	14,50	13,60	11,10	13,30
Ba	222,1	1395,6	360,4	630,7	69,4	>1740	704,2	947,90	933,40	1236,90	817,00
Zr	100,0	49,0	76,0	165,0	104,0	38,0	33,0	149,00	396,00	228,00	287,00
Sr	245,4	422,0	198,0	259,8	73,8	107,3	434,2	147,20	131,30	225,90	102,00
Y	20,86	13,87	11,83	42,7	4,2	0,5	13,5	15,90	21,02	14,64	19,37
Li	4,8	2,4	3,0	3,6	3,9	3,4	1,5	26,01	11,60	10,00	10,20
Ga	18,9	15,8	5,7	17,5	4,6	17,3	13,2	17,20	19,41	18,24	17,27
Pb	5,1	9,5	20,6	8,2	4,8	2,8	6,7	41,73	16,90	15,20	14,00
Rb	40,0	34,3	3,9	59,2	10 ,5	0,1	3,3	11,71	89,27	56,64	73,30
Nb	5,2	3,2	15,0	13,1	9,2	3,3	2,1	3,84	12,88	8,31	11,98
Hf	2,8	1,4	10,8	4,3	2,5	1,0	6,7	0,78	10,11	5,33	7,30
Mo	0,5	0,3	2,2	2,8	1,0	0,3	0,4	14,51	1,41	0,61	2,14
Th	47,3	0,4	1,0	5,5	3,3	3,4	0,7	1,21	20,27	11,22	15,53
U	1,3	0,08	0,9	1,5	0,5	0,1	0,5	0,61	1,89	0,91	1,39
Ta	0,4	0,2	0,62	0,14	0,3	0,1	0,4	1,72	0,78	0,41	0,76
Be	1,5	1,5	0,5	0,9	0,4	1,3	0,4	0,07	1,07	1,25	0,20
Cd	0,1	0,07	3,8	0,1	0,05	0,06	0,02	0,76	0,05	0,05	0,06
Cs	0,07	0,2	0,1	0,3	0,02	0,1	0,3	0,06	0,66	0,48	0,58
Sn	1,3	1,0	0,05	1,9	0,8	<ld	1,0	0,38	1,23	1,24	0,94
W	0,43	<ld	2,0	0,79	0,30	0,05	0,06	0,33	0,39	0,25	0,37
Tl	0,12	0,13	0,22	0,23	0,04	0.33	0,1	0,05	0.39	0,25	0.34

<dl=inferior to detection limit

Table IV: Rare Earth elements (ppm) of rocks and clay samples of Ngaye

	Gneiss		Amphibolites		Quartzites	Granites		Clay samples			
	NGY1	NGY2	NGY3	NGY4	NGY5	NGY6	NGY7	A	B	C	D
La	22.54	14.05	4.97	22.13	8.91	10.43	8.08	48.35	54.37	47.11	41.8
Ce	50.09	29.77	10.31	57.3	17.95	16.34	20.27	99	111.4	98.07	82.37
Pr	5.83	3.32	1.36	7.52	2.14	1.63	2.95	10.16	11.14	9.26	8.62
Nd	22.12	13.64	5.74	31.31	7.78	4.68	12.93	36.61	39.93	33.52	31.1
Sm	4.54	3. 2	1.65	6.54	1.41	0.51	3.15	6.07	6.57	5.19	5.16
Eu	0.94	1.08	0.73	1.89	0.28	0.69	0.95	1.49	1.28	1.25	1.19
Gd	4.04	2.96	2.04	6.23	1.07	0.26	2.99	4.5	5.04	3.72	4 .19
Tb	0.62	0.46	0.37	0.85	1.15	0.02	0.45	0.62	0.67	0.48	0.59
Dy	3.37	2 .83	0.38	7.43	0.85	0.11	2.59	3.55	3.99	2.73	3.52
Ho	0.73	0.55	0.44	1.66	0.16	0.02	0.45	0.67	0.75	0.51	0.68
Er	2.15	1.59	1.12	4.45	0 .46	0.05	1.38	1.9	2.2	1.46	2.05
Tm	0.3	0.22	0.14	0.02	0.07	0.01	0.19	0.27	0.33	0.25	0.31
Yb	1.94	1.46	0.82	3.86	0.45	0.06	1.13	1.72	2.17	1.36	2
Lu	0.29	0.22	0.11	0.66	0.07	0.01	0.16	0.26	0.33	0.2	0.3
REE	119.5	75.27	30.18	15.89	23.76	34.82	57.72	215.87	240.17	205.11	248.57
LREE	106.06	64.98	24.16	126.52	22.65	34.28	48.33	202.58	213.29	174.6	233.92
HREE	13.44	10,29	5.42	25.37	1.11	0.54	9.39	13.29	26.88	30.51	14.65
LREE/HREE	7.89	6.31	4.57	4.99	20.41	64.48	5.15	15.24	7.93	5.72	15.96

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