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Full Length Research Paper

Morphological, physico chemical, mineralogical and geochemical properties of vertisols used in bricks production in the Logone Valley (Cameroon, Central Africa)

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ABSTRACT

A detailed knowledge of soils is a prerequisite for their valorization and their suitable use. In the present paper, vertisols of the Logone Valley have been characterized on morphological, physico chemical, mineralogical and geochemical point of view, in view of their promotion as good building materials. These studies show that those vertisols are characterized by dark color, clayey texture, massive structure, deep, open superficial desiccation cracks and micro-reliefs (gilgaï). They are neutral to slightly basic (6.4 to 7.4), with low organic matter content, an average cation exchange capacity (CEC ~ 22,8 méq/100g) and a high C/N ratio (up 39%) suggesting the organic matter is not well mineralized. Their exchangeable cations are dominated by Ca and K. They are constituted mainly by smectites associated to some amount of kaolinite, illite, quartz and feldspars, and they display high content in SiO_2 (61.07 – 77.78 %), average content in Al_2O_3 (7.08 – 15.54) and low amount in Fe_2O_3 (1.78 – 6.92). The Si/Al ratio is greater than 2 and the mineralogical indice of alteration is higher than 60%. All those characters suggest that bisiallitisation is the main cristallo chemical process acting in the studied region. The clayey character of the studied vertisols can be judiciously exploited in view to promote competitive crude earth bricks.

Keywords: Logone valley, vertisols, clayey materials, smectite, kaolinite, bisiallitisation.

INTRODUCTION

Vertisols are reported to cover worldwide more than 320 million hectares or 2.4% of the global land surface (Dudal and Eswaran, 1988). The most important areas are localized in Australia (70.5 million hectares), India (60 million hectares), Soudan (40 million hectares), in the Lake Chad depression (16.5 millions) and in Ethiopia (10 million hectares). They are described as soils with dark color that have a crumbly structure of the surface layer or gilgaï (micro-relief) (Dudal and Eswaran, 1988). They can develop in situ from the products of rock weathering or can be formed from alluvial deposits, under widely varying climatic conditions, but usually with alternating wet and dry seasons. According to Dudal and Eswaran (1988), the most frequent physiographic position for vertisols is flat alluvial plains.

In the Lake Chad depression, vertisols cover about 60% of the land surface (Pias, 1970; Vizier et Sayol, 1970; Vizier et Fromaget, 1970; Boulvert, 1975; Brabant et Gavaud, 1985). They occur essentially in the Logone Chari basin and in the northern part of the Chad basin (Jones et *al*., 2013). They are presently used for rice and sorghum culture (*mouskouari*) (Ambassa-Kiki et *al.*, 1996) and more and more for bricks production to build houses. But the problem is that most buildings built with only basic earth materials suffer relatively rapid deterioration due to low dry strengths which decrease to zero under wet conditions and also have high porosities and water absorption. They also show the development of shrinkage cracks under dry conditions, swelling under wet conditions and a generally high susceptibility to damage due to periodic wetting and drying. It is the reason why the fired earthen bricks are replacing the traditional crude earthen ones as building material. But the earth brick firing process needs large amounts of wood and their manufacture greatly contributes to the degradation of the environment. Therefore there is a need to develop competitive crude earth bricks in term of durability and reliability, aesthetics and cost. But prior to this, knowledge of the properties of these vertisols is very vital and represents an important step for their suitable use as building materials. The present study aims at characterizing these vertisols on morphological, physico chemical, mineralogical and geochemical point of view. This study forms part of a wider research program aimed at investigating and developing local clay materials for industrial applications and uses. The investigations based on pedological field observations were supported by detailed physico chemical, mineralogical, and geochemical analyses.

GEOGRAPHIC AND GEOLOGICAL SETTING

The Logone Valley (Figure 1) is located between 6°05’ et 13°50’ Nord latitude and 14° et 17° East Longitude ; it covers an area of 118065 km2 which is shared between Cameroon (49140 km2), Chad (53969 km2), Central Republic of Africa (11449 km2) and Nigeria (3597 km2). This area is covered by savannas and experiences a Sudano-Sahelian climate type (Suchel, 1987) with a mean annual rainfall of 871 mm. The rainy season extend from June to September, registering maximum rainfall in August. The dry season stretches from October to May. The mean annual temperature is 28°C. The landscape is characterized by gentle slopes and slow runoff conditions. The lithological basement (Pias, 1970) is made up of Precambrian formations (granite, gneiss), volcanic formations and different sedimentary formations of recent quaternary (old fluvio lacustrine serie, recent fluvial serie, and recent lacustrine serie). Soils in this area are dominated by the vertisol type (Figure 2). The mains crops are rice, corn, millet, onion and sorghum.

SAMPLING AND LABORATORY TECHNIQUES

Sampling techniques

The field work was carried out on three types of sedimentary formations: old fluvial - lacustrine serie, recent fluvial serie, and recent lacustrine serie. The soil morphology is based in the present study on 03 hand boreholes open in each type of the above sedimentary formations. After the macroscopic description, soil samples were collected for laboratory analyses: particle size, pH, organic carbon, exchangeable cations, cation exchange capacity, and total nitrogen, mineralogical and geochemical analyses.

Analytical techniques

Particle size was determined using the Robinson pipette method. Prior to this, the organic matter present in the sample was destroyed by oxygenated water (H2O2) using sodium hexametaphosphate $(NaPO_3)_6$ as dispersal agent. Soil pH was measured in water and in KCl, with a pH meter equipped with a glass electrode in 1:2.5 soil-water suspensions. The quantity of total nitrogen was evaluated by titration after mineralisation of organic matter and distillation. The cation exchange capacity was also evaluated by titration after qualitative desorption by K^+ and distillation. Exchangeable cations are shifted by ammonium acetate (CH_3COONH_4) at pH 7. The proportions of K^+ and Na^+ were evaluated by flame photometry. Those of Ca^{2+} and Mg^{2+} were determined by complexometry. The proportion of organic carbon was obtained after oxidation in a highly acid medium (H_2SO_4) with potassium dichromate ($K_2Cr_2O_7$). The percentage of organic matter was calculated by multiplying the organic carbon values by the factor 1.72 (Sprengel factor). The bases saturation corresponds to the ratio of the sum of exchangeable cations (S) and cations exchange capacity (CEC).

X-ray diffraction (XRD) analysis was performed on randomly powder of bulk soil samples and on oriented clay samples using a BRUKER type diffractometer with Cu-Kα radiation, λ: 1.5418Å, with a scan mode between 2θ: 5 - 90°, with 2θ step of 0.002° and a scanning speed of 1°2θ/min. Relative amounts of each mineral in the soil sample were obtained from the intensity of its principal

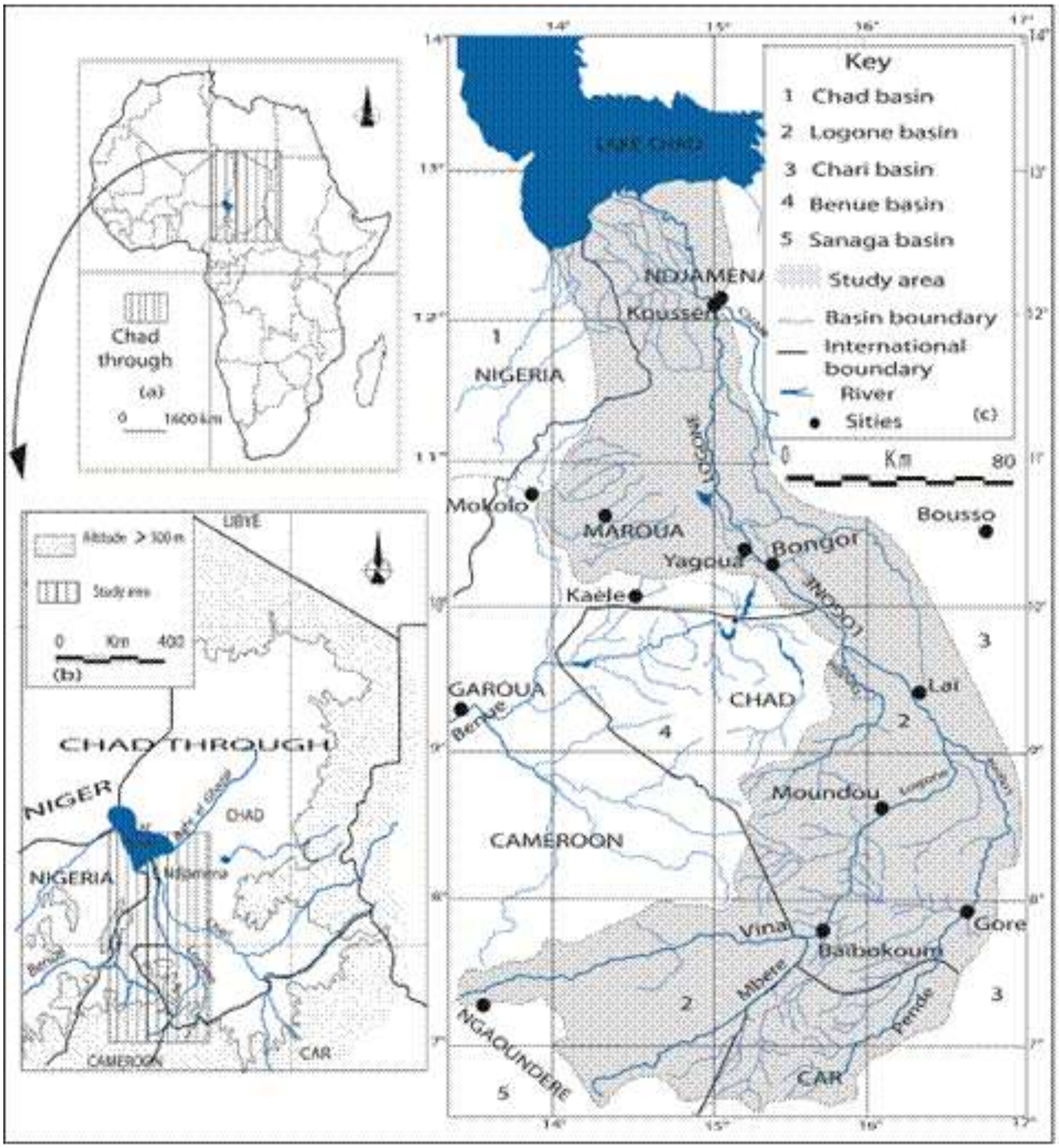

Figure1. Geographic location of the studied watershed: (a) Chad through, (b) study area and (c) Logone basin

basal reflection. For further characterization, clay fraction was treated with glycol and heated à 550°C during 1 hour (Robert and Tessier, 1974).

Chemical analysis was performed on bulk soil samples by the X-ray fluorescence spectrometry method using a Philips XRFSPW1404 spectrometer. Mass contents of major elements are reported as percent of oxides (%). The mineral index of alteration (MIA) was inferred from the major element data (Nesbit et Young, 1982; Fedo et *al*, 1995; Voicu et Bardoux, 2002; Price et Velbel, 2003).

$MIA = 2 ([Al_20_3 / (Al_20_3 + Ca0 + Na_20 + K_20)] \times 100) -50)$

This indice allows calculating the transformation rate of primary minerals into secondary minerals.

RESULTS

Vertisols morphology

Three main profiles are described below; they are profiles DE, LA and ND.

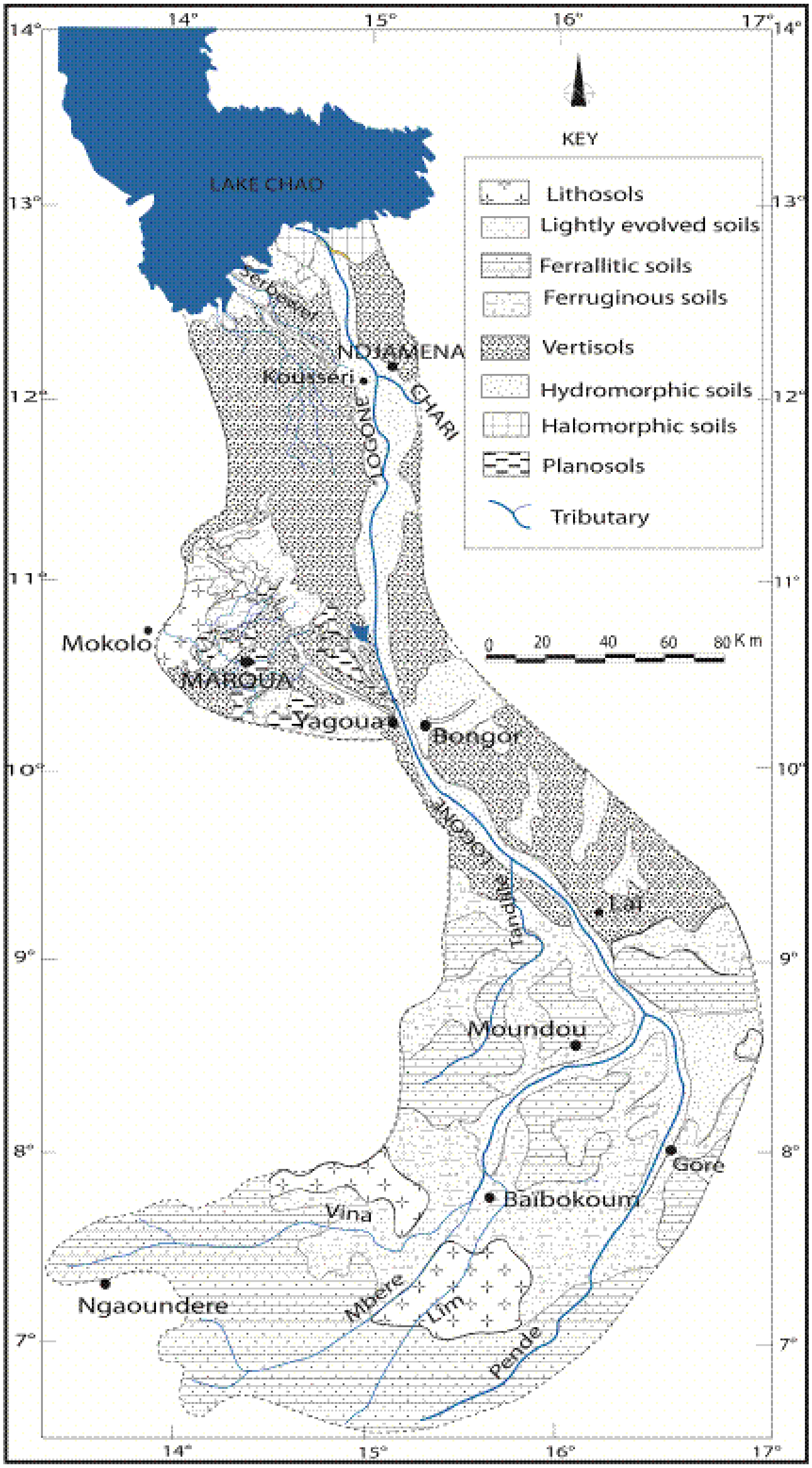

Figure2. Major soil group in the Logone basin (Pias, 1970; Brabant and Gavaud, 1985, modified)

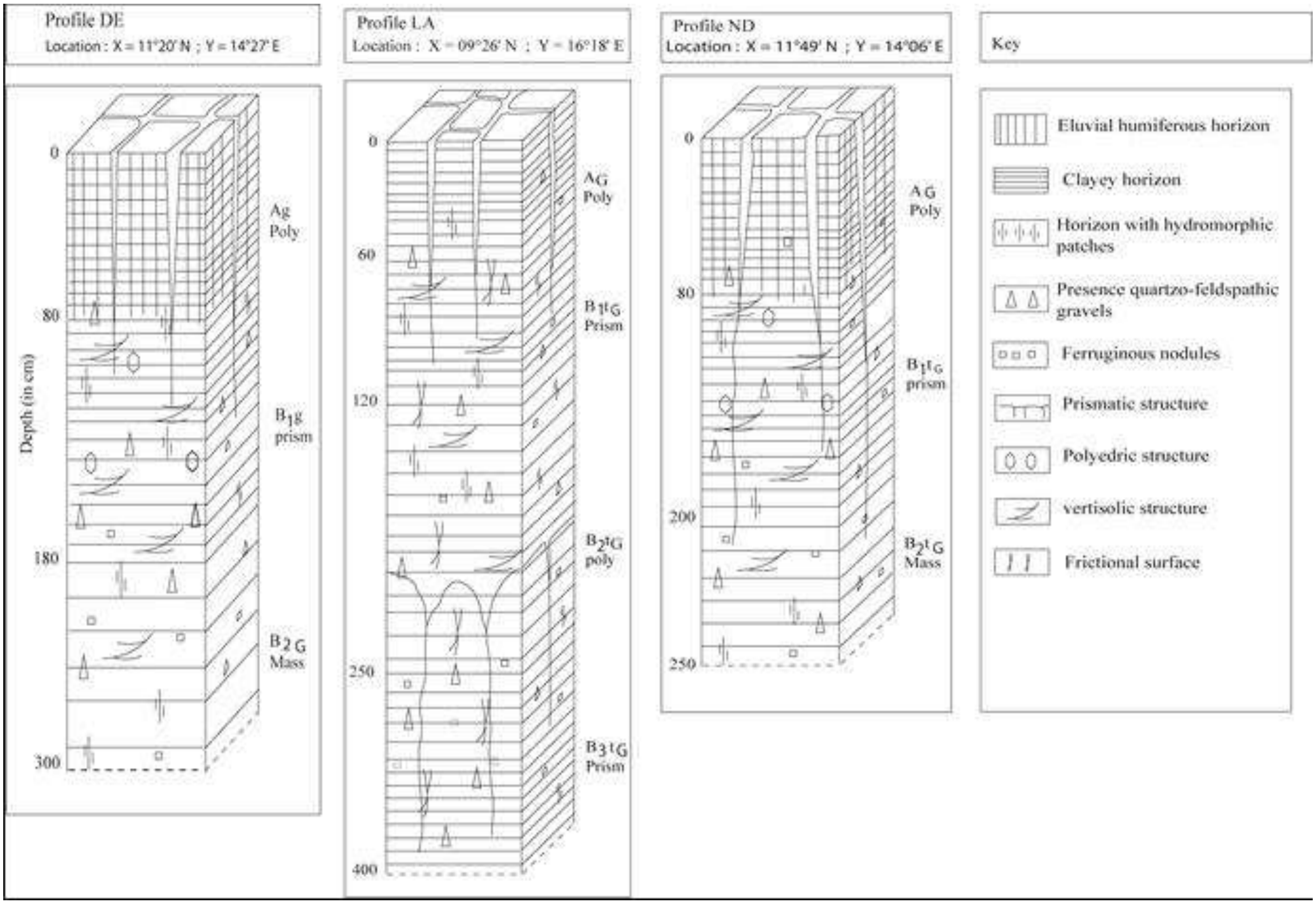

Figure3. Morphological organization of the studied vertisols: profiles DE, LA and ND.

- **Profile DE** is located at the North of Doublé (11°20' N and14°27' E) on sediments of old fluvial-lacustrine serie. Micro relief and numerous desiccations cracks are observed at the surface. From top to bottom, one can observe:
  0 – 30 cm: horizon Ag, grey brown (10YR 4/1-2/1), clay sandy, polyedric, firm, porous, slightly plastic, lower boundary is diffuse and irregular;
  30 – 180 cm: B_1g horizon, brown (10YR 5/8), sand clayey, sub angular blocky (prismatic structure), presence of slickensides, firm, diffuse and irregular lower boundary;
  180 - 300 cm: horizon B_{2G}, yellow brown (10YR 5.5/4), sand clayey, massive, firm, porous (Figure 3).

- **Profile LA** is located at 2 Km at the North of Laï (9°26' N and 16°18'E) on sand sediments of recent fluvial serie. This profile is observed at the middle of a flooded depression. Desiccations cracks are observed at the surface. From top to bottom, one can observe:
  0 – 60 cm: horizon A_G, grey brown (10YR 5/2, 10YR 3.5/2), clayey, polyedric structure, desiccation cracks, firm, plastic, slightly porous, diffuse and irregular lower boundary;
  60 – 120 cm: Horizon B_1t_G, brown (10 YR 5/5; 10 YR 4/5), with yellow brown spots (10YR 8.1) and some black concretions, clayey, massive, firm, slightly plastic, porous, diffuse and irregular lower boundary;
  120 – 250 cm: B_2t_G horizon, light brown (10YR 7/4; 10YR 5/4), clayey with polyedric structure, massive and hard, slightly plastic, distinct and abrupt lower boundary;
  250 – 400 cm: B_3t_G, light yellow brown, (10 YR 7/5; 10YR 6/6) with red yellow spots (5YR 4/6) and spherical black concretions, clayey, prismatic structure, presence of slikensides, massive and firm (Figure 3).

Table1. Physical and chemical characteristics of vertisols

Profile	**DE**			**LA**				**ND**		
Horizon Depth (in cm)	**Ag (0-80)**	**B_1g (80-180)**	**B_{2G} (180-300)**	**A_G (0-60)**	**B_1t_G (60-120)**	**B_2t_G (120-250)**	**B_3t_G (200-400)**	**A_G (0 - 80)**	**B_1t_G (80 - 160)**	**B_2t_G (160 - 250)**
Particle size distribution (%)										
Sands	25	61	65	42	37	37	35	18	15	20
Silts	30	19	16	17	16	14	15	35	25	17
Clay	45	20	19	41	47	49	50	43	60	63
pH										
pH H_2O	6.8	6.9	6.9	6.7	6.4	6.5	7.1	7.3	7.2	7.4
pH KCl	5.7	5.3	5.6	4.8	4.8	6.2	6	6.1	6.4	6
ΔpH	1.1	1.6	1.3	1.9	1.6	0.3	1.1	1.2	0.8	1,4
Organic Matter (%)										
OM (%)	1.2	1.01	0.71	1.51	1.32	0.83	0.71	1.01	0.83	0.95
TOC (%)	0.69	0.59	0.41	0.87	0.77	0.48	0.41	0.59	0.48	0.55
TN	0.04	0.03	0.02	0.03	0.06	0.03	0.02	0.08	0.04	0.03
C/N	17.37	19.6	20.49	29.1	12.76	16.03	20.37	7.34	12.02	18.41
TAP (ppm)	2.05	1.72	0.54	1.6	0.9	1.37	0.77	2.39	1	0.85
Exchangeable bases and Cation exchange capacity (meq/100g)										
Ca^{2+}	8.96	18.56	25.6	30.72	24.48	9.92	23.68	5.92	16	31.84
Mg^{2+}	4	2.88	5.28	2.08	3.52	1.28	1.92	5.44	4.22	2.72
Na^+	1.29	0.55	0.36	0.08	0.2	0.08	0.08	0.2	0.2	0.08
K^+	0.13	0.15	0.12	0.12	0.12	0.11	0.2	0.17	0.15	0.12
S	14.38	22.14	31.36	32.99	28.32	11.38	25.88	11.74	20.57	34.75
CEC	21.2	17.6	16.8	14.8	19.52	17.6	15.6	19.2	15.4	13.4
S/T (%)	68	126	186	223	145	65	166	61	133	260
Mg/Ca	44	15	20	0.6	14	13	8	44	15	20
Na/T (%)	0.6	3	2	0.6	0.4	0.5		0.6	3	2

Table2. Minerals and their relative abundance in the studied vertisols

Sample	**Smectite**	**Kaolinite**	**illite**	**Quartz**	**Feldspaths**	**Disorganised minerals**
Profile DE						
DE – Ag (0 – 80 cm)	++++	++	-	+	+	++
DE – B_1g (80 – 180 cm)	+++++	++	-	+	+	++
DE – B_{2G} (180 – 300 cm)	++++	++	-	+	+	++
Profile LA						
LA – Ag (0 – 60 cm)	+++	++++	+	+	+	-
LA – B_1t_G (60 – 120 cm)	+++	++++	+	+	+	-
LA – B_2t_G (120 – 250 cm)	++	+++++	+	++	+	-
LA – B_3t_G (250 – 400 cm)	++++	+++	+	+	+	-
Profile ND						
ND – A_G (0 – 80 cm)	++++	+++	-	+	-	++
ND – B_1t_G (80 – 200 cm)	+++++	++	-	+	-	++
ND – B_2t_G (200 – 250 cm)	++++	+++	-	+	-	++

++++ = Very abundant   +++ = Abundant   ++ = Lightly abundant   + = Trace   - = absent

- **Profile ND** is located at the North of Waza (11°49' N et 14°06' E) on sediments of recent lacustrine serie. Desiccations cracks are observed at the surface. From top to bottom, one can observe:

0 – 80 cm: horizon A_G, dark grey (10YR 4/1 -2/1) with red spots, clayey, polyedric to prismatic; presence of dessication cracks; hard, massive and very firm; porous; plastic; diffuse and irregular lower boundary.

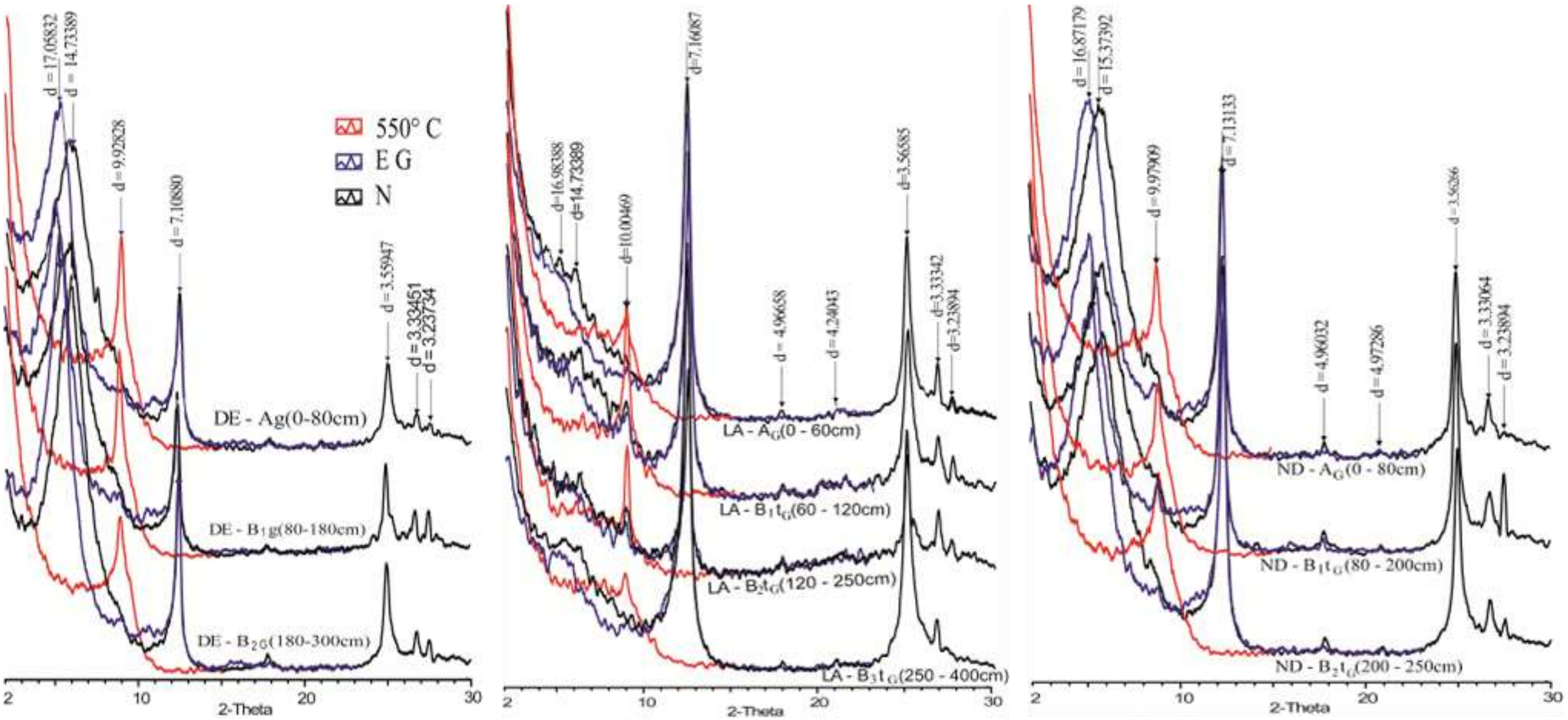

Figure4. X-ray diffraction of clay fractions: natural (N), treated with glycol (EG), and heated at 550°C

80 – 200 cm: horizon B_1t_G, dark brown (10YR 5/8), clayey, prismatic structure, presence of dessication cracks and slickensides, hard, massive and very firm, diffuse and irregular lower boundary.

200 – 250 cm: horizon B_2t_G, brown yellow (10YR 5.5/4), clayey, massive, firm, porous (Figure 3).

The soils of three studied profiles display specific features which are characteristics of vertisols: dark color, desiccation cracks and microrelief at the surface soils, and presence of slikensides within the profiles.

Table3. Chemical composition of the studied vertisols from the Logone valley (Expressed in Percentage Oxide)

Profile	DE			LA				ND		
Horizon Depth (in cm)	**Ag (0-80)**	**B_1g (80-180)**	**B_{2G} (180-300)**	**A_G (0-60)**	**B_1t_G (60-120)**	**B_2t_G (120-250)**	**B_3t_G (200-400)**	**A_G (0 - 80)**	**B_1t_G (80 - 160)**	**B_2t_G (160 - 250)**
PAF	9.10	10.41	10.16	10.08	15.06	10.36	10.51	8.28	13.28	2.53
SiO_2	71.46	68.18	66.27	71.12	61.07	77.78	72.86	77.14	64.45	76.84
Al_2O_3	13.70	15.54	14.18	13.15	14.11	7.08	11.42	8.85	13.16	10.13
Fe_2O_3	1.79	2.77	2.33	2.18	6.92	2.85	4.50	1.78	2.27	1.77
CaO	1.98	1.93	1.92	3.71	1.18	1.20	1.06	1.82	1.85	1.23
MgO	0.06	0.02	0.01	0.04	0.29	0.01	0.03	0.41	0.40	0.19
SO_3	0.10	0.10	0.10	0.10	0.09	0.10	0.10	0.12	0.10	0.09
Na_2O	0.22	0.14	0.12	0.07	0.33	0.06	0.08	0.34	0.42	0.46
K_20	1.11	0.87	0.69	0.47	1.34	0.33	0.33	1.06	1.46	1.58
TiO_2	0.33	0.21	0.16	0.17	0.70	0.35	0.19	0.94	1.46	0.68
P_20_5	0.01	0.01	0	0.01	0.22	0.02	0.02	0.03	0.03	0.02
Mn_2O_3	0.05	0.07	0.03	0.07	0.16	0.03	0.03	0.03	0.07	0.03
Total	100.5	100.69	95.97	101.17	101.47	100.17	101.13	100.86	98.95	98.55
Si/Al	3.07	2.58	2.75	5.4	4.33	3.97	6.47	5.13	4.46	2.88
MIA	61.09	68.18	67.71	51.15	66.40	63.32	77.19	46.64	55.83	51.20

Vertisols physical and chemical characteristics

The physical and chemical characteristics of the studied vertisols are shown in Table 1. It appears that the clay content, higher in the top horizon (45%) of profile DE, greatly decreases towards the bottom where its content is less than 20%. Therefore the top soil of profile DE displays a clayey texture while the middle and the bottom have a sand clayey texture. In opposite, on profiles LA and ND, the clay content higher in top horizons (41-43%) increases towards the bottom (50-63%), and all the horizons display a heavy clayey texture. Globally, the clay content in profiles LA and ND is higher than that of profile DE (Table 1).

These soils are slightly acid to neutral (Table 1) with significant values of net charge (ΔpH: 0.8 to 1.9). The content of organic matter is low in the profiles (> 1%) and globally decreases from the top to the bottom. The C/N ratio is higher in profiles DE and LA (>15%) while in profile ND, its value is less than 15 %, notably in the surface and subsurface horizons (Table 1). The cation exchange capacity (CEC) of soils is in general average in all the three profiles, and Ca^{2+} is the most dominant exchangeable cation, follow by Mg^{2+}. The bases saturation is high (S/CEC > 60%).

Soil mineralogy

The studied soils are made up of smectites, kaolinite, quartz, feldspaths and illites (Table 2). The XRD patterns of the clay fractions (oriented aggregates) are presented in Figure 4. The clay fractions of the various horizons mainly contain smectite, identified by its broad basal spacing d_{001} at 14.7 - 14.9 Å (Figure 4). These basal spacings shifted to 16.9 - 17.3 Å when the fine fraction was solvated with ethylene glycol and collapsed to 10 Å after heating at 550ºC (Figure 4). Kaolinite is identified by its basal spacing at 7.2 Å and 3.6 Å where a sharp peak is observed in all the samples (Figure 4). The kaolinite peak dissapears after heating at 550° C. Quartz (4,242 – 3,335 Å) and feldspar (3,476 – 3,232 Å) are associated to smectites and kaolinite in all samples (Figure 4). Based on the intensity of their principal basal reflexion, it appears that smectites are more abundant and well expressed in profiles DE and ND, while kaolinite seems to be important in profile LA (Figure 4, Table 2).

Soils geochemistry

The results of Bulk geochemical analysis are gathered in table 3. They reveal that soils of all the three profiles display higher contents in SiO_2 which vary globally between 61 and 77 wt %. Nevertheless, the SiO_2 content is slightly higher in profiles LA and ND than in profile DE (Table 3). Their content in alumina is average (7 to 15.5wt %), but horizons of profile ND display lowest values compared to that of profiles DE and LA. The soil content in Fe_20_3 isrelatively low in all the three profiles, varying between 1.78 to 6.92 wt % (Table 3); profiles DE and ND display the lowest values. The proportion of alkali and alkali earths in all the studied soils are very low (< 1wt %), excepted for CaO which has values varying between 1 and 3.71 wt%. The values of loss of ignition (LI) are relatively high and vary globally between 8.28

and 15.06 % (Table 3). Within each soil profile, its value increases in general with depth. The Si/al ratio decreases with the depth and its values are higher than 2 (Table 3), being consistent with the presence of smectites in the studied soils. The MIA values are higher than 50% in all the soils and increase form the top to the bottom within the profiles (Table 3).

DISCUSSION

Morphological characters of the studied vertisols

Morphology is the most important feature used to differentiate vertisols from other soil orders (Simonson, 1954; Eswaran et al., 1988). The major morphological markers of vertisols are gilgai (micro-relief), color, surface cracking upon desiccation, and slickensides (Soil Survey Staff, 1994). The color of the studied vertisols is gray to dark gray and range between 2.5Y and 10YR in the Munsell Color Charte. Despite the fact that their total organic matter content is relatively low, their dark color, common to vertisols, can be attributed to the complexation or chelation of organic colloids with smectite (Dudal, 1967; Duchaufour, 1977). Cracks and micro reliefs (gilgaï) are present at the surface of the studied soils and slickensides are described within the profiles. The presence of cracks can be explained by the capacity of vertisols to swell and shrink. According to Hallsworth et al. (1955), the development of gilgai is due to the shrinking and swelling of the vertisols. The argument is that on wetting and swelling, the soil mass cannot re-occupy the original volume since surficial material has fallen into the cracks during the dry season. As such, part of the soil mass is forced upwards forming the mounds. The formation of slickensides within requires the material to be in a plastic state (Eswaran et al., 1988). During the drying cycles, cracks develop, whereas, on moistening, shear stresses form which result in slickensides. Hubble (1984) noted that the formation of these specific features , characteristics of vertisols, are caused by a heavy texture, a dominance of swelling clays in the fine fraction and marked changes in moisture content. Such features are already been described in some vertisols in North Cameroon (Ekodeck, 1976; Nguetnkam, 2004; Djoufac et *al.,* 2006; Temga, 2008; Azinwi et *al*., 2011).

Physico chemical characters of the studied vertisols

Particle size analysis has revealed the clayey character on the vertisols of the Logone valley, with clay content reaching up to 63%. The predominance of fine particles is common to many vertisols (Dudal, 1967 ; Duchaufour, 1977 ; Podwjewski, 1988 ; Irana et *al.,* 1996 ; Aydinalp, 2001 ; Kamga et *al*., 2001 ; Nguetnkam, 2004 ; Azinwi, 2012 ; Djoufac et *al*., 2006 ; Temga, 2008 ; Azinwi et *al*., 2011) and is consistent with the formation of special features mentioned above and generally observed in vertisols such as gilgaï, crack dessication, slickensides. The pH of the studied soils is slightly acid to neutral, and their content in organic matter is low. Such values of pH and organic matter are generally mentioned in vertisols formed on alluvial materials in tropical zone (Ekodeck, 1976; Rossignol, 1983; Esu et Lombin, 1988; Mamo et *al.,* 1988; Righi et *al.,* 1998; Aydinalp, 2001; Nguetnkam, 2004; Azinwi et *al*., 2011; Djoufac et *al.,* 2006; Temga, 2008). The cation exchange capacity of the studied soils is average to high, and can be linked to the clay content and the type of clay mineral which is dominated by smectites, associated to some amount of kaolinite. In fact, smectites are known as clay minerals that have a high CEC. The exchange sites of the CEC of these soils are mainly occupied by calcium and magnesium as it is generally the case in neutral vertisols (Desta, 1987; Wilson, 1994, Djoufac et *al*., 2006; Azinwi et *al*., 2011; Azinwi, 2012). The Mg/Ca ratio of vertisols is higher than 14, indicating that they are calci-magnesium soils (Podwjewski, 1988).

Mineralogical and geochemical characters of the studied soils

X-Ray diffraction analysis revealed that the studied soils are made up mainly by smectites associated to kaolinite, illites, quartz and feldspars. Such mineralogical composition is generally common to vertisols (Ekodeck, 1976; Rossignol, 1983; Esu et Lombin, 1988; Mamo *et al.,* 1988; Aydinalp, 2001; Nguetnkam, 2004; Azinwi, 2005; Djoufac *et al.,* 2006; Azinwi et *al*., 2011; Kamgang Kabeyene et *al*., 2011; Azinwi, 2012). The factor that smectites are the major component of these soils influences their physic chemical properties and is responsible of the formation of specific features described above: crack desiccation, gilgaï and slickensides. The formation of smectites requires some environmental conditions such as flat zones, poor drainage and contrasting dry and wet seasons (Paquet, 1969; Bocquier, 1973; Duchaufour, 1977; Rossignol, 1983). All these conditions are fulfilled in the studied zone.

The geochemical composition of the studied soils revealed that they display high content in silica, average mount in alumina and low content in iron. This geochemical trend has been pointed out by many authors who worked on vertisols (Ekodeck, 1976 ; Rossignol, 1983; Esu et Lombin, 1988 ; Mamo *et al.,* 1988 ; Aydinalp, 2001 ; Nguetnkam, 2004; Djoufac *et al.,* 2006;

Azinwi et *al*., 2011; Kamgang Kabeyene et *al*., 2011; Azinwi, 2012) seems to characterize vertisols. The presence of relative amount of alkaline and alkali-earths elements, notably Ca and K, is indicative that all the bases are not leached and suggesting that the process acting is a bisiallitisation (Pédro, 1966; Paquet, 1970; Bocquier, 1973; Esu et Lombin, 1988; Mamo et *al.,* 1988; Righi et *al.,* 1998). This deduction is consistent with the ratio Si/Al which values are higher than 2 (Pédro, 1966; Ruxton, 1968). The MIA values of the studied soils are higher than 50% and this is suggesting that those soils are highly weathered (Chittleborougth, 1991; Voicu et Bardoux, 2002; Price et Velbel, 2003).

The observed discontinuity between horizons, the weak slopes combined to poor drainage and contrasting seasons suggest that these soils are formed from sediments which are products of alteration of rocks by bisiallitisation.

CONCLUSION

This paper focused on morphological and physico chemical properties of vertisols of the Logone Valley used in bricks, along with their mineralogical and geochemical characterization. The following conclusions can be draw:

- The studied vertisols have dark color, clayey texture and, cracks desiccation along with slickensides are present; They are neutral to slightly basic and display low content in organic matter which is not well mineralized.
- Smectites are the main phylosilicates, associated to kaolinite, illite, quartz and feldspars;
- They display high content in silica, average content in alumina and low content in iron.

Overall, the studied vertisols, thanks to their clayey character, can be judiciously used in view to produce competitive crude earth bricks.

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