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Mineralogical and petrochemical characterization of Tambogo serpentinites: Birimian greenstone belt of Kaya-Goren, Burkina Faso

Caractérisation minéralogique et pétrochimique des serpentinites de Tambogo: Ceinture des roches vertes birimiennes de Kaya-Goren, Burkina Faso

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Abstract: The serpentinite massif of Tambogo**,** located in the Northeast of Ouagadougou, Burkina Faso, represents an ultramafic intrusion in the Birimian volcano-sedimentary formations of the greenstone belt of the Kaya-Goren arc, hydrothermalized and bordered by a facies of talc-schist in the sheared portions. The petrographic and geochemical analysis show the total transformation of these rocks into serpentinites, the serpentine remaining the major mineral of serpentinites assemblage with a variety of hydroxyl minerals (tremolite, chlorite, talc) and carbonates; remnants of clinopyroxene and brown hornblende remain locally. The geochemical evolution of the multi-element and rare earth spectra of the ultramafic protolith is especially marked by the splitting or accumulation of plagioclase. The geodynamic setting is similar to island arc tholeiitics based on the geochemistry of immobile trace elements (Y, Zr, Nb, V, Ti).

Key words. Burkina Faso**,** Tambogo, birimian, ultrabasites, serpentinites, talc-schists, MORB.

Résumé: Le massif de serpentinites de Tambogo, situé au Nord Est de Ouagadougou, Burkina Faso, représente une ancienne intrusion ultrabasique dans les formations volcano-sédimentaires birimiennes de la ceinture des roches vertes de l'arc Kaya-Goren. Hydrothermalisé, il est bordé par un faciès de talc-schiste dans les portions cisaillées. L'analyse pétrographique et géochimique révèlent la totale transformation de ces roches en serpentinites, la serpentine restant le minéral majeur des serpentinites en assemblage à une variété de minéraux hydroxyles (trémolite, chlorite, talc) et de carbonates; il subsiste localement des restes de clinopyroxène et de hornblende brune. L'évolution géochimique des spectres multi-éléments et des terres rares du protolithe ultrabasique est surtout marquée par le fractionnement ou l'accumulation du plagioclase. Le cadre géodynamique est apparenté aux tholéiites d'arc insulaire d'après la géochimie des éléments traces immobiles (Y, Zr, Nb, V, Ti).

Mots clés : Burkina Faso, Tambogo, birimien, ultrabasites, serpentinites, talc-schistes, MORB.

INTRODUCTION

In Burkina Faso, ultrabasic rocks are relatively scarce in the main geological units and previous works have shown they are associated with the birimian greenstone belts. They generally correspond to pyroxenolites, websterites, lherzolites (Ouédraogo 1985, Zonou 1982), pargasite clino-pyroxenolites and cortlandites or brown hornblende peridotites (Wenmenga 1986), ortho-amphibolites (Koala 1980), wherlites, dunites (Béziat *et al*. 2000) and serpentinites (Sawadogo 1983). These ultrabasites form sills, dykes or elongated and aligned small massifs or sometimes small lenses, intruding the birimian volcano-sedimentary formations, according to a N140E direction in the Korsimoro-Boussouma-Kaya areas (Wenmenga 1986). Extensive massifs of meta-ultrabasites combining serpentinites with dolomite talc-schists in abnormal contact with eburnean granites were reported by Bos (1967) on the sheet map of Fada Ngourma in the East of the country. Associations of metagabbros, serpentinite and pyroxenolites are described in the Birimian bands of Bogandé, Soubeysa, Kottia and Mogtedo where these facies blend with the birimian schists and sometimes the paleoproterozoic granitoids of the tonalites group dated to 2170 ± 6Ma, (Ouédraogo & Castaing 2003).

The circulation of hot fluids in the tectonized ultrabasites partially or totally leads to the formation of serpentinite and also talc-schist, facies coexisting on the ground. Obviously

the ultrabasites show sequential alterations both in time and space and this hydration results in a redistribution of chemical elements in the rock carrying a total disappearance of igneous minerals and the genesis of numerous secondary phases. Many researchers have been interested in studying the phenomenon of serpentinization of ultramafic rocks (Salem *et al.* 2012, Evans *et al*. 2013). Several parameters are used to characterize the serpentinization scheme, namely: the chemical composition, its paragenesis, the external environmental (static or dynamic) conditions and finally the nature of the system (closed or open), (Laurent 1980). The Tambogo ultrabasic intrusions of the Kaya-Goren birimian belt have the distinction of being completely serpentinized under the influence of hydrothermal fluids, particularly H_2O and subordinate CO_2. The work undertaken here is primarily aimed at conducting a petrographic study on a macroscopic and microscopic scale to identify alteration mineral paragenesis and the relics of igneous minerals and secondly to characterize the serpentinization process of these ultrabasic rocks and establish geochemical correlations with the protoliths.

REGIONAL GEOLOGICAL SETTING

Geologically, the basement of Burkina Faso falls within the Baoule Mossi domain of the Leo shield. Most of the rock units belong to paleo-proterozoic basement. This consists of birimian greenstone belts or grooves, including volcanic, plutonic and volcano-sedimentary, arranged as bands in the west, center, east and rarely in the north (Fig. 1).

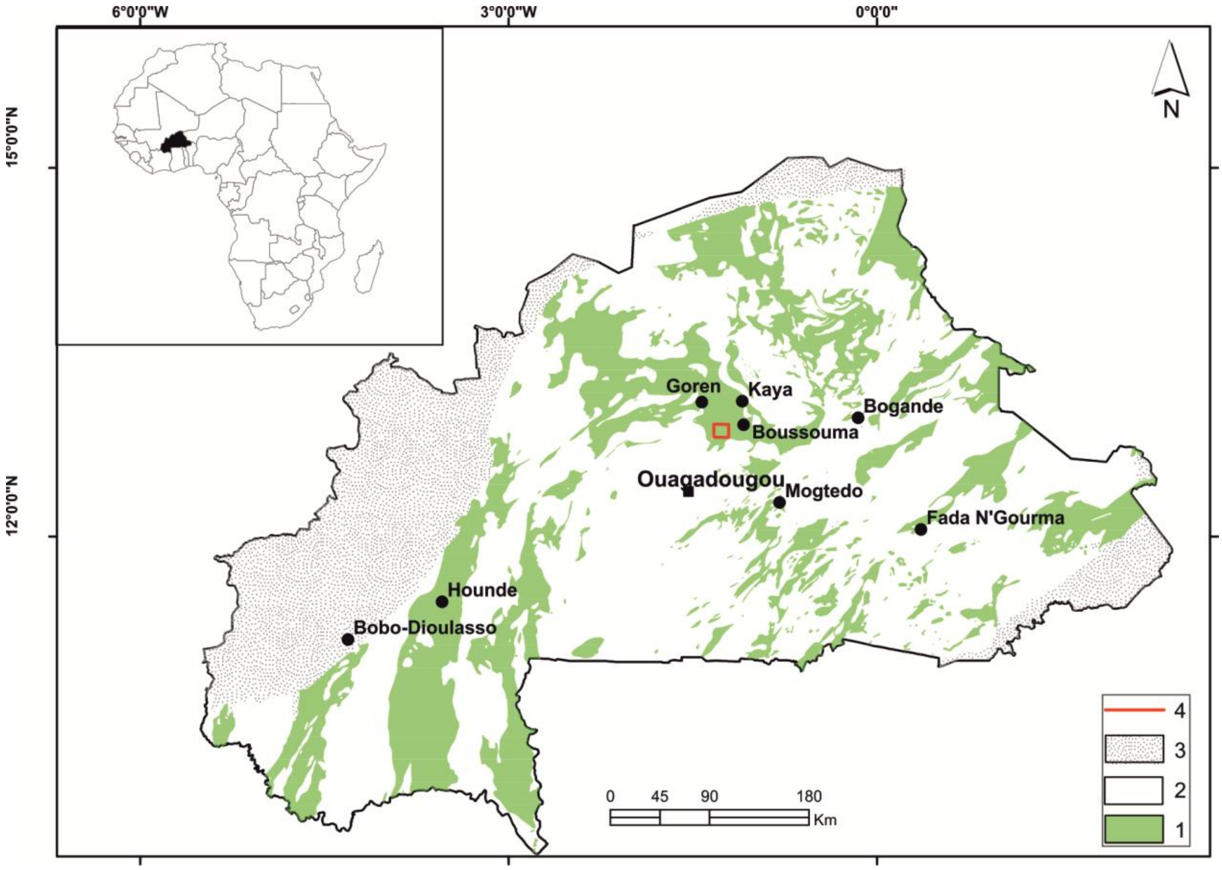

Figure 1. Simplified geological map of Burkina Faso extracted from Castaing *et al* (2003). 1: Birimian greenstone belts, 2: Paleoproterozoic granitoids, 3: Neoproterozoïc to Palaeozoic sedimentary basin, 4: study area.

The arc-shaped of Kaya-Goren Birimian belt (Fig. 2) could result from the interference of transcurent tectonic phases (Feybesse *et al*. 1990). It is based on volcano-sedimentary units affected by several phases of dextral to senestral strike-slip penetrative deformations in metamorphic conditions varying from epizone to mesozone.

These formations include flows and projections of basalt, spherolitic dacites, projections of varied rhyodacitic to rhyolitic composition and infill volcano-sediments of mudstone, chert, greywacke and epiclastites. They are intruded by diorite and microgabbro dykes, by small bodies of tholeiitic gabbro, a system of sills and parallel ultramafic dykes, trented N°140E and particularly extensive in this belt.

These ultrabasic rocks have been described in the Boussouma area in the east of the belt as pargasite cortlandites and plagioclase clino-pyroxenolites, with coarse and grained texture porphyraceous (Wenmenga 1986).

LOCAL GEOLOGICAL SETTING

The study area (Tambogo) is located in the northeast of Ouagadougou between 12° 50 and 12° 53 north latitude, 1° 20 and 1° 15 west longitude. The geological environment of this area is characterized by volcano-sedimentary formations constituting the Birimian greenstone belt of the Kaya-Goren arc. It consists of basaltic flows and breccias, dacite, cinerite associated with panels of epiclastite graphite and black cherts and interbedded sandstone facies.

The intrusions of garnet granophyric, microdiorite, microgabbros and intersertal to ophitic quartz gabbros and a massif circumscribed alkaline granite of 1819 ± 25Ma after Rb/Sr (Wenmenga 1986) locally induce in these formations, a contact metamorphism. Like the Boussouma (Fig. 1) area, there are around Tambogo many small massives of NE aligned serpentinites bordered by talc-schist facies. These types of serpentinites and talc-schist associations have been also reported in Orissa ultramafic complex of India (Tapan *et al*. 1999).

The general metamorphism affecting basic rocks belongs to the green schist facies and varies between hornblende and actinolite isograds (Wenmenga 1986). It takes place in static conditions with albite/oligoclase, chlorite, epidote paragenesis accompanying these amphiboles. Contact metamorphism locally reaches biotite or andalusite isograds notably in graphite epiclastites and biotite hornfels derived from heated dacitic flows.

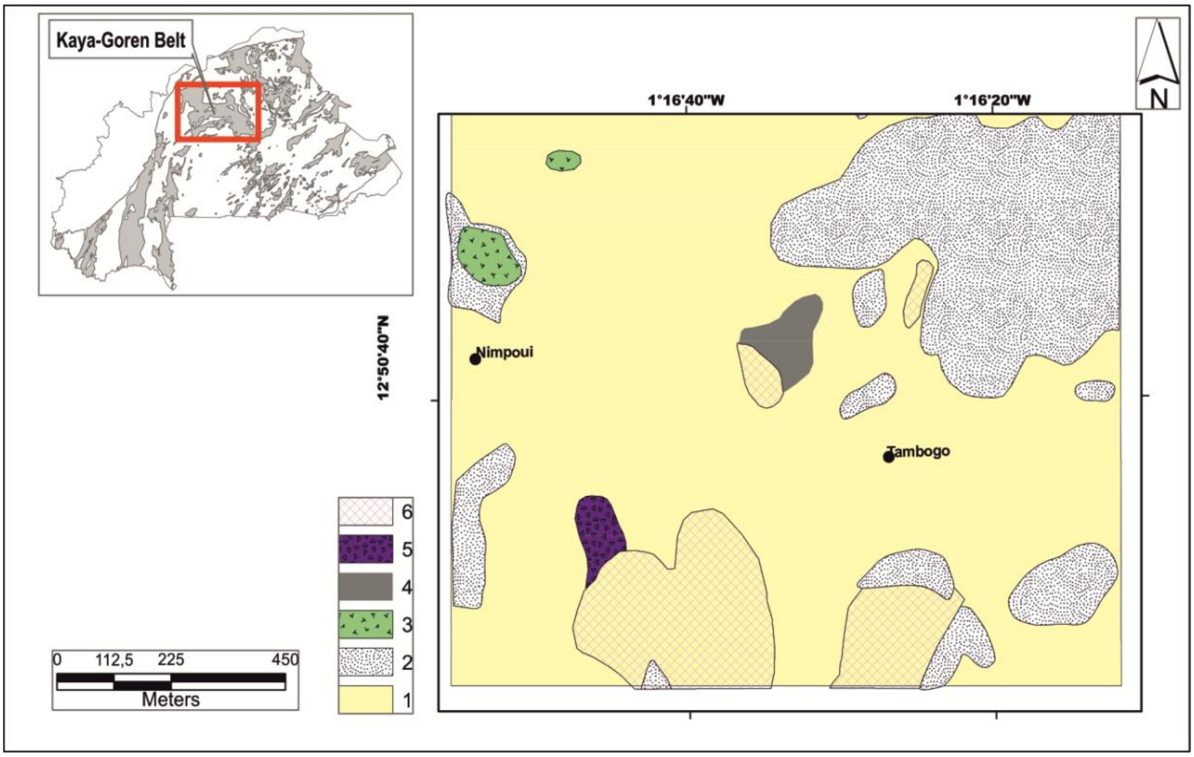

Figure 2. Modified geological map of Tambogo, extracted from the geological map of the license of Yimiougou (High River Gold exploration Burkina Faso). 1: schist, 2 meta-sediments, 3 : meta-volcanites, 4: ultrabasites, 5: gabbro, 6: laterit duricrust.

It is extended in quartzites resulting from recrystallization of cherts and sandstones. Hydrothermal alteration is a major process in this context, and is particularly developed in mylonitized or sheared formations. Several modes of alteration were detected on the basis of mineral associations and their relationship with the nature of the protoliths.

The prophylitic-type alteration (epidote, chlorite, carbonate) is common, while argilitic and potash types are common to basic and neutral rocks. Silicification affects epiclastites and bedded fine projections and turns them into chert by epigenization. Serpentinization of ultramafic rocks or their hydrothermal conversion into talc are also reported in the region of Boussouma (Wenmenga 1986) and in Western Bouré in the belt of Yalogo (Sawadogo 1983). The supergene alteration of the ultrabasic protolith is observed through the development of small iron duricrust associated with the Tambogo serpentinite deposits

METHODOLOGICAL APPROACH

The field work consisted in performing a representative sampling in order to identify the different lithologies, alterations and understand the geological environment. The collected samples were subjected to a study with microscope. About seventeen (17) analysis (Tab. 1) were carried out with electron-microprobe at the Magmas and Volcans Laboratory (LMV) in Clermont Ferrand (France) on serpentine minerals, and allowed to determine their chemistry. In total, eighteen (18) whole rock analysis were carried out on representative rocks of the ultramafic bodies and the surrounding volcano-sedimentary rock. These analysis put in Tab. 2 and Tab. 3 enabled to determine the geochemical character and geotectonic context. The major (%), trace and rare earth elements (ppm) were analyzed for samples of serpentinites, cherts and talc-schists of the Tambogo area using ICP-AES and ICP-MS techniques at the Acmelabs Laboratory in Canada. The results of Kaya and Tambogo metagabbros and ultrabasites samples extracted from works of Wenmenga (1986) were obtained through the fluorescence X techniques in Clermont Ferrand (France).

RESULTS

Petrographic and mineralogical characters

All of the rocks of Tambogo area consist of ultramafic rocks significantly transformed into serpentinites or talc-schists, cherts, epiclastites, volcanites, terrigenous deposits and sometimes epimetamorphic gabbro.

Serpentinites

(samples: ZP05A, ZP05B, ZP05C, ZP08, ZP10A, ZP10B)

Serpentinites derived from fractured and hydro-thermalized holo-melanocrate ultrabasic rocks (Fig. 3a) in intrusion within cherts. They are elongated and show varying degrees of serpentinization coexisting with talc-schists on their border. These serpentinites are greenish massive rocks. They have porphyraceous texture with phenocrystals of ferro-magnesian minerals (3mm-1cm) scattered in fine to medium grain background.

The microscopic analyse reveals that these rocks are peridotites showing rare relics of poecilocristals clinopyroxene and orthopyroxene and remains of brown hornblende clouded by secondary opaque granules and minerals, including altered plagioclase of the ultramafic protoliths of these serpentinites. The mineralogical assemblage of these serpentinites essentially consists of serpentine varying in proportions between 50 to 70%, carbonates, tremolite and small quantity of talc, chlorite and opaques (chromite, magnetite, ilmenite).

Serpentine is the essential constituent of these rocks, showing in thin section various microtextures, in which the serpentines form pseudomorphs with rounded or prismatic sections that remind those of primarily olivine crystal and more or less zoned globular pyroxene.

There are other lamellar, speudo-meshed, crypto-crystalline, needle-like or rosette fibrous microtextures (Fig. 3b, c, d, e) developed from the cleavages, cracks and fissures of igneous olivine and pyroxene and even from secondary tremolite.

The SiO_2 contents of these serpentines range from 38.58 to 43.42%. MgO (28.85 - 36.04%) while FeO_3 is between 6.45 and 13.62%, Al_2O_3 ranges from 0.53 to 4.56% (Tab. 1). The Ni contents, although low (NiO<0.5%), greatly exceed those of the Cr which locally is around 0.3%.

They are probably influenced by the presence of former olivine crystals and locally impose the pyroxene in the protolith.

Tremolite appears in the rock as a product of alteration (Fig. 4a, b). It replaces the igneous minerals of pyroxene and brown hornblende and the other likely ouralites while retaining their poecilitic character. In places, carbonates developed at the expense of the tremolite and remnants of pyroxene, and occasionally olivine (Fig. 4c, d).

Some might be partial and local pseudomorphs of igneous plagioclase in the clinopyroxenites facies. Locally appear chlorite and talc formed at the expense of tremolite the primary zoning of igneous inclusions of pyroxene or olivine are surimposed by alteration zoning of serpentine and tremolite (Fig. 4c, d). The scanty cryptocrystalline chlorite (Fig. 4a) results from the destabilization of the tremolite and acts as a matrix phase of serpentine pseudomorphs and as decomposition phase of primary olivine or pyroxene crystals. On the contrary talc (Fig. 4c) sometimes reaching around 15%, surrounded many serpentine pseudomorphs by forming small ranges of poikiloblastic microcrystallines. It is generated by the pseudomorphic alteration of the tremolite and primary pyroxenes. Locally there is a zonation of the alteration with carbonates in the heart and crowned tremolite. However, biotite displays a scarce phase alteration of the tremolite or the brown hornblende in combination with the other secondary minerals, in particular metallic opaques. The igneous opaque come in coarse automorph to xenomorph crystals and secondary terms in granules scattered or veinlets associated with alteration products of primary igneous minerals (pyroxene, olivine, brown hornblende) or tremolite, often developed from cleavages and cracks of these ferromagnesium minerals and cracks in the rock scale.

Talc-schists

The talc-schists appear in narrow strip parallel to the serpentinites. On the ground, they differ from the serpentinites with their yellowish color, their strongly sheared and laminated structure, and their fat feature to the touch. The rock consists mostly of kinked bands talc (70 to 90%), associated with subordinated alteration minerals such as tremolite, chlorite, biotite and globular or lamellar serpentine. The opaque metals are in scattered granules or ante-kinematic crystals molded by S1 phase.

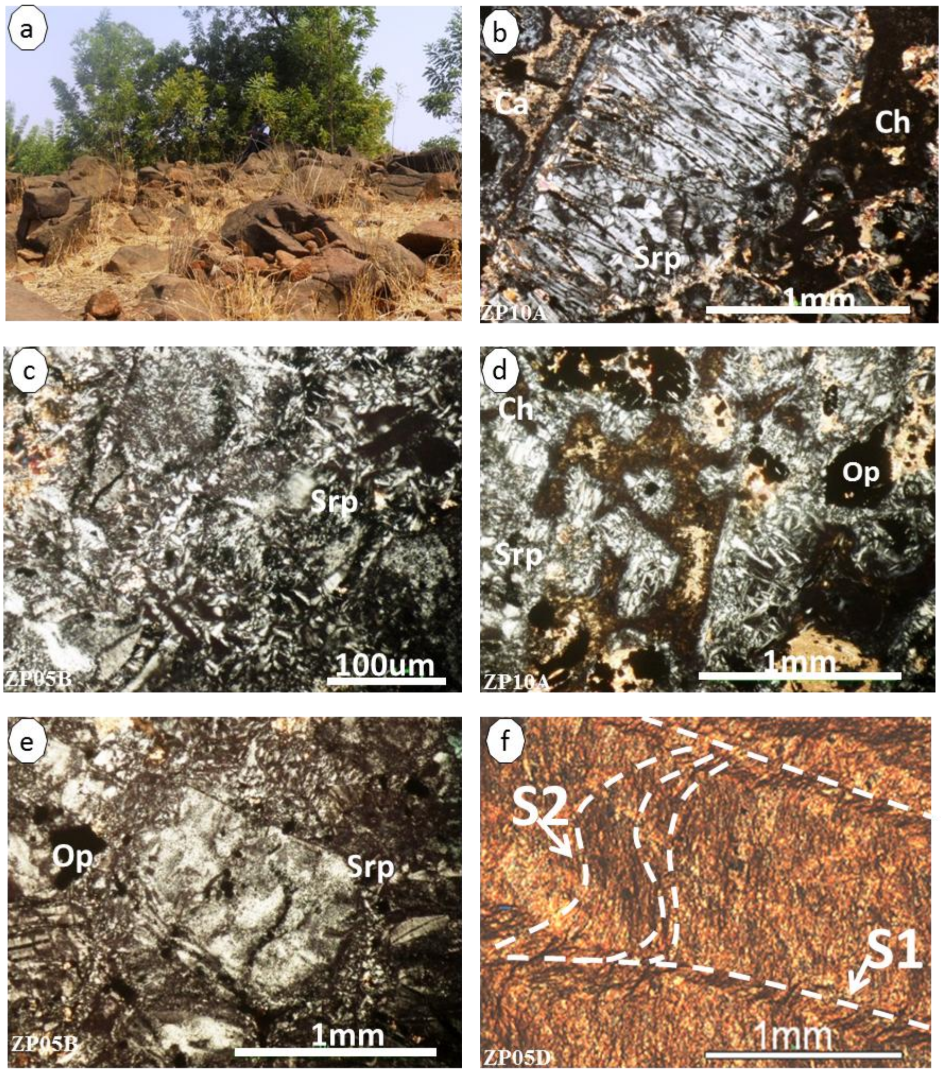

Figure 3. a, Outcrop of dark blocks colored serpentinite in the Tambogo area; b, lamellar microtexture serpentine; c, serpentine needle rosette; d, pseudo-mesh serpentine microtexture; e, cryptocrystalline serpentine pseudomorph texture; f, talcschist microphotograph showing the polydeformed character (S1, S2).

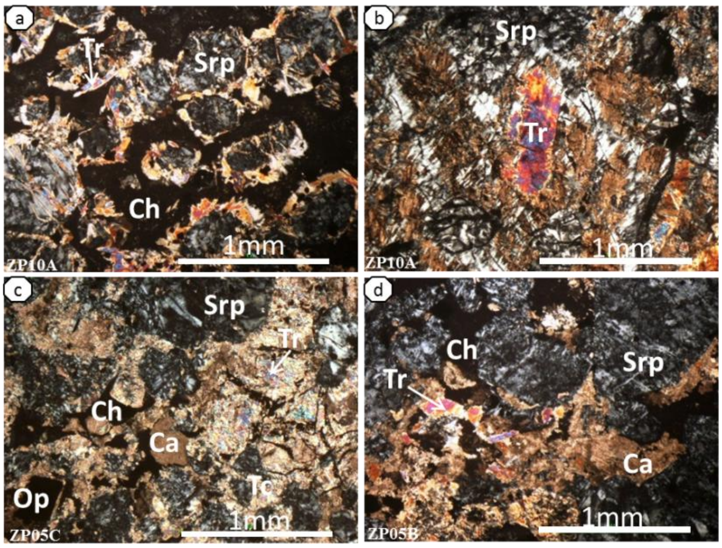

Figure 4. Microphotographs showing alteration processes; a-b, destabilised tremolite in serpentine; c, tremolite transformed into aggregate of talc + carbonate + chlorite surrounding pseudomorphs of serpentines; d, destabilization of tremolite into carbonate and chlorite.

The serpentinites wall rocks

Meta-sediments and basic formations are among of country rocks of these serpentinites. In the area, cherts arranged in large blocks are distinct from graphite epiclastites by their brownish grey color, massive texture and their generally layered and laminated structure.

They display a microcrystalline granoblastic and hetero-granular microtexture, cherts consist of abundant recrystallized quartz (95%), iron oxides occupying the cracks with muscovite in secondary quartz. This rock probably comes from the chertification of felsitic, sedimentary or pyroclastic rock.

Graphite epiclastites contrarily are black colour and sheared texture are underlined by microcrystalline granoblastic.

The rock consists mainly of quartz with fine graphite particles, remnants of feldspaths mostly zoned plagioclase and locally asymmetrical and anisopach quartz vein fold. Grained facies are also found in the area, mostly porphyry microdiorites and metagabbros. They all display an oriented and sheared structure.

Geochemical characterization

The major elements results of geochemical analysis (Tab. 2 and 3) indicate that loss on ignition of ultrabasite samples is high varying from 8.7% to 12.7% reflecting the aqueous hydrothermal alteration related to serpentinization phenomena.

The loss on ignition is low in the altered ultrabasites of Kaya and very low in the samples of metagabbro of Tambogo (Tab. 3). The analytical data of the major elements of serpentinites and talc-schists distinguish itself from metagabbros by high contents in MgO (29.51 - 21.79%), Fe_2O_3 (11.60 - 12.92%) and relatively low and normal in alkaline elements Na_2O, K_2O (<0.01% to 0.02 %) and TiO_2 (0.19-0.30%). High values of MgO in agreement with the Ni (1537 -4136 ppm) and the Cr (4300 - 6190 ppm) are controlled by the high contents in mafic minerals such as olivine and pyroxene.

The alumina contents range from 3.5 to 4.5% in the serpentinites but seem higher in the talc-schists (6.85%). Immobiles elements like ythium (Y) and gallium (Ga) are twice more concentrated in talc-schists than in the serpentinite, suggesting a difference in the nature of the protolith of these two types of rocks. Small anomalies in As (600ppm) are associated with certain samples of serpentinite.

The altered ultrabasites of Kaya show a less siliceous character with SiO_2 contents ranging from 41.9 to 45.2% and are less rich in MgO (17-28%) than the protolith of the Tambogo serpentinite. Their CaO content varies from 3 to 13% significantly higher than in the serpentinite of Tambogo (1.5 - 3.5%). These high values are influenced by those former plagioclase and clinopyroxene of cortlandites and clinopyroxenolites. They are justified for the altered ultrabasites of Kaya by more amounts of plagioclase and for the serpentinite by leaching effects of these minerals in the different facies. Metagabbros of Tambogo have SiO_2 content ranging from 45.2 to 51.3% and have high alumina (14-16%) and CaO (8-12%) contents. Two chert samples whose silica SiO_2 content (96%) are the most silica-rich rocks in the area.

AFM diagram of Kuno (1968) (Fig. 5a) and Al_2O_3-CaO-MgO diagram (Coleman 1977; Fig. 5b) confirm the magnesian nature of the serpentinites and the talc-schist as well as the Kaya altered ultrabasites and slightly differentiated by them. The tholeiitic affinity is obvious for the metagabbros of Tambogo, while a magnesian trend is emerging for the serpentinites and ultrabasites of Kaya (Fig. 5c). The retromorphosis phenomena could account for the behavior of the talc-schist out of the ultramafic cumulate field. On the contrary, the metagabbro sample out of the mafic cumulate field is a different non cumulate facies.

The rare earth element (REE) spectra (Fig. 6), normalized to chondrites of analyzed serpentinites are relatively flat close of those of MORB with ratios standardized to low chondrite (La/Sm) N=0.89-1.46 and (La/Yb) N=0.98-1.61 including the sample of talc-schist (ZP05D) with ratios of (La/Sm) N=1.92 and (La/Yb) N=0.91.

The minor positive Eu anomalies (Eu / Eu * = 1.07-1.24) observed in the REE spectra of serpentinites (ZP05C, ZP10A, ZP10B) indicate a discrete accumulation of plagioclase, in opposite to some facies (ZP05A, ZP05B, ZP08) showing minor negative Eu anomalies (Eu/Eu * = 0.83-0.94) and more significant for talc-schist (ZP05D) due to the deficit of plagioclase.

These minor positive and negative Eu anomalies shown by the samples of Tambogo serpentinites imply the plagioclases in the petrogenetic evolution of the ultrabasic protolithe of the serpentinites and talc-schist of Tambogo. On the contrary, the discordant appearance of the talc-schist (ZP05D) spectrum indicates the probable presence of differentiated ultramafic facies, like pyroxenolites along with peridotites with plagioclase facies.

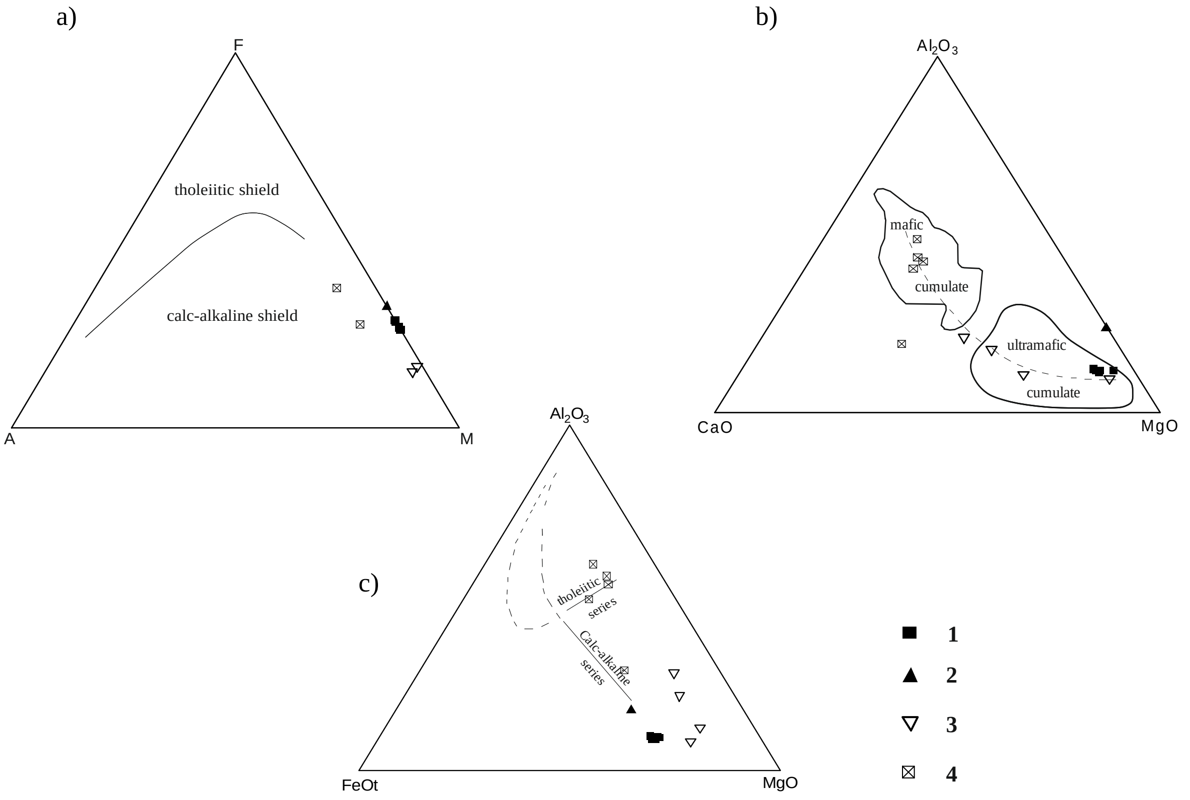

Figure 5. a, AFM diagram (Kuno 1968) ; b) Al2O3-CaO-MgO diagram (Coleman 1977) confirming the magnesium and cumulative nature of the altered ultrabasites of Kaya; b, the serpentinite and talc-schist of Tambogo and associated metagabbros; c, Al_2O_3-FeO_3-MgO diagram (Besson & Fonteille 1974). 1, serpentinites of Tambogo, 2, talcschist, 3, Altered ultrabasites of Kaya, 4, metagabbros.

The signature standardized multi-element spectra to primitive mantle (Sun & McDonough 1989) of the serpentinites and talc-schist of Tambogo, have broadly similar features (Fig. 7). Some serpentinites facies are relatively enriched in some lithophile elements (Cs, Rb, Pb). Sometimes, negative or positive anomalies in Ba and Sr involve respectively the poverty or accumulation of plagioclase in the protolith of the serpentinites and talc-schists. The strong negative anomalies in K are caused by the fractionation of feldspars and/or potassic hydrothermals alteration.

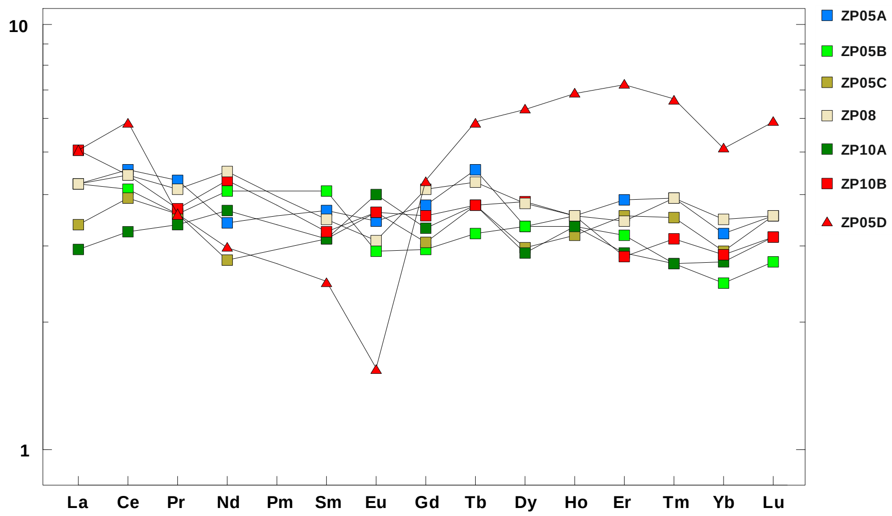

Figure 6: Rare earth element spectra of serpentinites and talc-schists of Tambogo standardized to chondrites (Sun & McDonough 1989). Square : serpentinites, triangle : talc-schist.

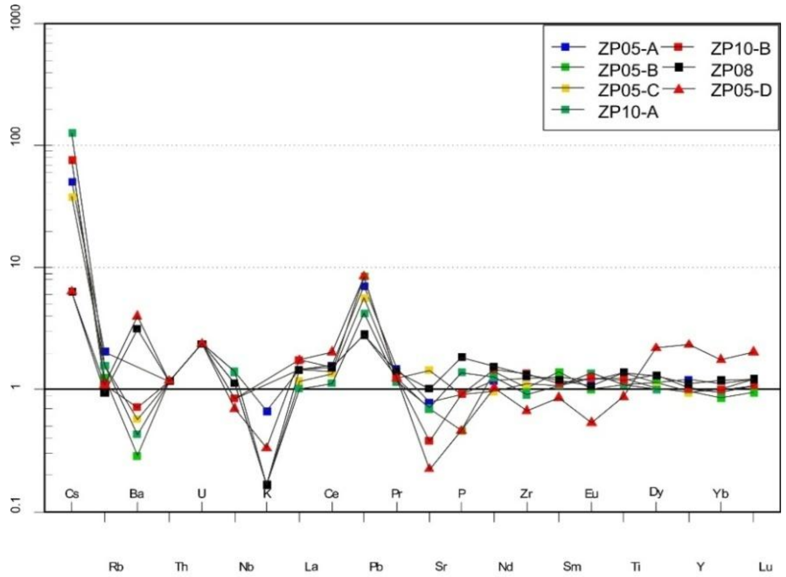

Figure 7. Multi-elements spectra of the Tambogo serpentinites and talc-schists standardized to primitive mantle (Sun & McDonough 1989). Square : serpentinites, triangle : talc-schist.

Geodynamic setting

The geotectonic setting of the Tambogo samples was determined using the triangular diagram Zr-Nb-Y of Meschede (1986)(Fig. 8a). This diagram is appropriate to characterize volcanic arc basalts, and also different types of MORB. The Tambogo samples occupy the field of the N MORB type basalts and volcanic arc basalts.

The discrimination diagram Ti-V of Shervais (1982) (Fig. 8b) uses ratios of Ti / V to distinguish different types of basalt in relation to the different geotectonic contexts. The island arc tholeiits have Ti / V ratios that vary between 10 and 20, between 20 and 50 for MORB, oceanic islands and alkali basalts between 50 and 100. The Tambogo samples show affinity for island arc tholeiites. La/Ba and La/Nb diagram (Saunder *et al*. 1992, Fig. 9) show the mantle source of the serpentinites probably asthenospheric except the serpentinite ZP08 in the field of lithosphere. This behavior would suggest an evolution of its primary magma.

However the talc-schist ZP05-D in the lithospheric field confirms this hypothesis of different source specified in geochemical criteria.

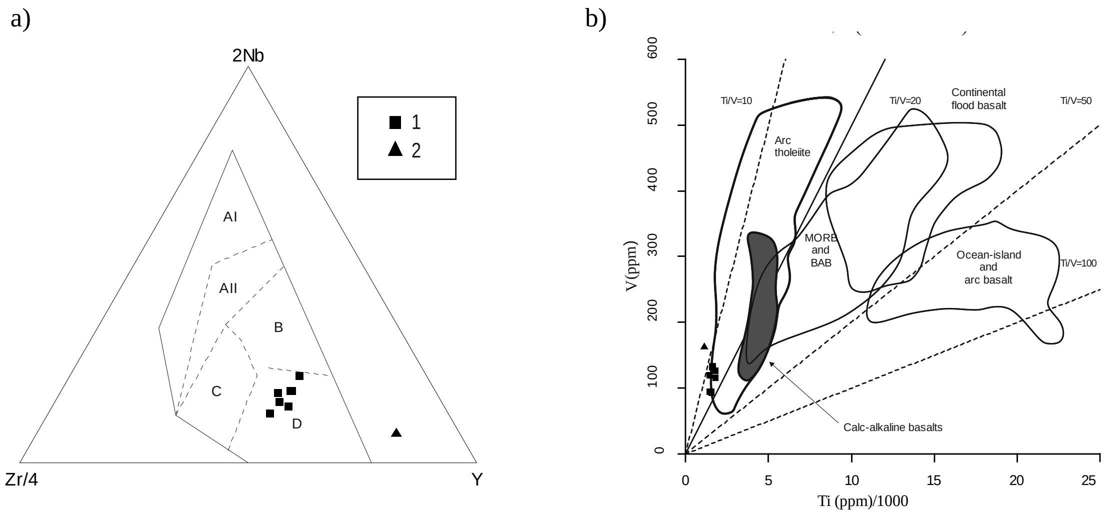

Figure 8. Diagrams of geotectonic discrimination of the serpentinites of Tambogo. a)Geotectonic diagram (Zr-Nb-Y) of discrimination of basalts (Meschede 1986), AI : within-plate alkali basalts, IIA : within-plate alkali basalt and within-plate tholeiites, B : E-type MORB, C : within-plate tholeiites and volcanic-arc basalt, D : N typical MORB and volcanic-arc basalt. b) geotectonic diagram discrimination V vs. Ti (Shervais 1982), BAB : Back-arc basin basalts. 1: Serpentinites, 2: Talc-schists.

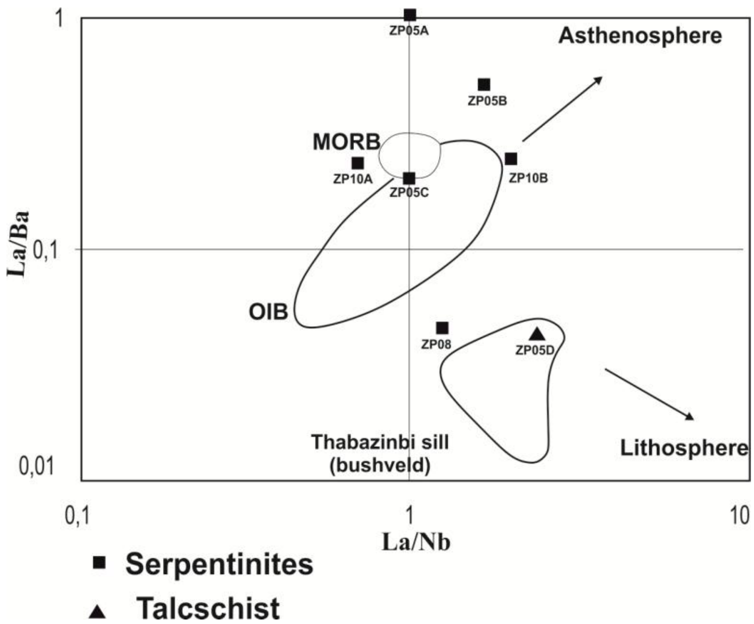

Figure 9. Discrimination diagram La/Ba vs La/Nb (Saunder *et al.* 1992) of asthenospheric and lithospheric contribution.

DISCUSSION

The petrographic analysis suggests that the serpentinite of Tambogo likely come from the hydrothermal alteration of peridotites, whose relics of clinopyroxene and brown hornblende remind of peridotites composition types cortlandites and clinopyroxenites described by Wenmenga & Tempier (1988) in Kaya - Goren greenstone belts around Korsimoro -Boussouma. These rocks imply an endogenous mineral accumulation during a magmatic differentiation process regarding their cumulative texture and facies variation (Wenmenga & Tempier 1988).

Peridotites directly converted into serpentinites, given the indicative micro-textures of the olivine and orthopyroxene (Clark 1978). The absence of olivine relics because of its high sensitivity to the meteoritic and hydrothermal alteration, demonstrates its total transformation into serpentine. Similarly, the destabilization of pyroxenes and magnesian amphiboles (tremolite) into serpentine indicates that the serpentinization stroke these rocks continuously or discontinuously but polyphased process (Scott *et al.* 2011, Nimis *et al.* 2004).

The hydrothermal fluids dominantly aqueous were drained by physical factors (cleavage, cracks, fissures) and facilitating the persistent serpentinization of mafic minerals of original peridotites and pyroxenolites. The carbonatation of ferromagnesian rocks results from CO_2 rich fluids as subordinated phase. The frequency of cleavages cracks and fissures filled with carbonates, chlorite, tremolite and talc to the extent of the rock, highlights the intense hydrothermal activity characterized by a dominant serpentinization and a local talcsification of protoliths. Hydration is the dominant mode of alteration of ultramafic protoliths of the serpentinites and talc-schists of Tambogo. These hydroxylated minerals in order of importance, serpentine, tremolite, chlorite and talc form in these rocks over 80% of alteration phases. Serpentinization and decomposition of amphiboles are accompanied by iron oxides release. The magnetite – serpentine association stems from the following reaction (Dzemua & Gleeson 2012).

$$(Mg, Fe)SiO_3 + (Mg, Fe)_2SiO_4 + 2H_2O \rightarrow Mg_3Si_2O_5(OH)_4 + Fe_3O_4 + 4H$$

Orthopyroxene + Olivine + Water → Serpentine + Magnetite

The samples of Tambogo show that the serpentinization evolved early to late. It primary affects olivine and pyroxene minerals, and amphiboles derived from the destabilization of pyroxene. Then the other phases of transformation chloritisation, carbonation and talcification are later alteration processes bearing by alteration mineral phases (chlorite, carbonate, talc).

The enrichment in lithophile elements (Rb, Cs) are bound to fluids, but some deficits are linked to the leaching (K). The positive and negative anomalies in Pb, Sr, and Eu observed on these serpentinites pointed to feldspars with composition similar to plagioclase.

Serpentinites have magnesian character and show tholeiitic affinity of island arc. It is confirming by the flat rare earth elements spectra similar to MORB. The La/Ba vs La/Nb diagram provides mantle source of these serpentinites, but the positive anomalies of Pb and Cs probably indicate a certain crustal contamination (Taylor 1980). This contamination suggests the presence of igneous basement supporting this idea of insular arc. This geodynamic context was recognizing in birimian system of eburnean orogeny (2250-2100 Ma) in Burkina Faso (Abouchami *et al*. 1990, Castaing *et al.* 2003).

The high contents of Cr (4300 - 6190 ppm) and Ni (1500-4150 ppm) relatively more significant in the serpentinites and talc-schists of Tambogo than those contained in the perioditic cumulates of Baïldjaga, in the serpentinites of West and South South East Bouré (Sawadogo 1983) and in the ultramafic cumulates of Boussouma (Wenmenga 1986) could reveal metallic mineralization related to these type of formations.

CONCLUSION

The ultrabasites of Tambogo belong to Kaya-Goren Birimian belt. These rocks corresponding to peridotites and clinopyroxenites were completely transformed into serpentinite and locally into talc-shists in this area affected by the brittle or ductile tectonics. They find themselves in a birimian country rocks consisting of meta-sediments, meta-volcanics and metagabbros, metamorphosed and/or affected also by hydrothermal alteration.

The olivine and pyroxene have practically disappeared for pseudomorphic serpentine minerals in rounded or prismatic sections. Serpentines are characterized by a variety of microtextures, and are accompanied by secondary phases, particularly carbonates, tremolite, chlorite and talc.

The composition of the main phases in these rocks and the above cited second talc indicates that the fluids enriched in $H_2O \pm CO_2$ and in lithophile elements long acted on the ultramafic protolith, catalyzed by brittle or ductile tectonic drains. The plagioclases controlled the geochemical and petrogenetic development from which the various original ultrabasic lithofacies of the serpentinites and talc-schists. These protoliths corresponding to magnesian cumulates display tholeiitic affinity close to the island arc geodynamic contexts.

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Table 1. Microprobe analysis of major and some trace elements of the Tambogo serpentine minerals.

N° Ech.	ZP05-A				ZP05-C				ZP08				ZP10-A				
	N°1	**N°2**	**N°3**	**N°4**	**N°1**	**N°2**	**N°3**	**N°4**	**N°1**	**N°2**	**N°3**	**N°4**	**N°1**	**N°2**	**N°3**	**N°4**	**N°5**
SiO_2	40.28	40.72	43.42	41.49	39.49	41.85	42.2	41	41.5	39.9	38.6	39.3	42.2	43.58	41.2	40.21	40.392
MgO	32.3	33.23	34.07	33.74	31.17	32.23	33.4	32.52	30.8	30.2	28.9	29.6	35.72	36.04	30.64	31.6	31.558
FeO3	10.54	9.348	9.209	9.24	11.34	10.12	10.2	11.27	12.9	13.1	13.6	13.1	7.21	6.457	9.234	8.778	11.171
NaO	0	0.004	0.024	0.001	0.001	0.017	0.02	0.009	0.03	0.03	0	0.02	0.012	0.001	0.006	0.052	0.1124
Al_2O_3	3.689	3.108	0.697	2.418	3.997	1.143	0.93	2.768	1.32	3.36	4.56	3.95	0.932	0.533	4.211	4.89	3.1092
K_2O	0	0.019	0	0.005	0	0.006	0	0.003	0	0.01	0.01	0.01	0.017	0	0.017	0.005	0
CaO	0.042	0.012	0	0.03	0.03	0.03	0.03	0.03	0.02	0	0.01	0.03	0.044	0	0.252	0.249	0.0262
MnO	0.121	0.102	0.157	0.101	0.079	0.096	0.09	0.107	0.09	0.1	0.09	0.04	0.147	0.179	0.075	0.074	0.1265
TiO_2	0.034	0	0.022	0.018	0.043	0	0	0.018	0.05	0.06	0.04	0.05	0.015	0.009	0.007	0	0.0504
Cr_2O_3	0.151	0.058	0.068	0.047	0.184	0.087	0.1	0.306	0.24	0.4	0.49	0.55	0.085	0.076	0.126	0.141	0.2688
NiO	0.218	0.206	0.152	0.191	0.253	0.096	0.07	0.112	0.13	0.19	0.17	0.14	0.172	0.181	0.195	0.172	0.0895
Total	87.38	86.81	87.81	87.29	86.58	85.65	87	88.12	87.1	87.3	86.4	86.8	86.55	87.06	85.97	86.17	86.9
STRUCTURAL FORMULA																	
Si	1.95	1.971	2.068	1.994	1.939	2.056	2.04	1.974	2.04	1.96	1.92	1.94	2.026	2.066	2.004	1.952	1.972
Mg	2.331	2.398	2.419	2.417	2.281	2.36	2.41	2.334	2.26	2.21	2.14	2.18	2.557	2.548	2.222	2.287	2.297
Fe	0.427	0.378	0.367	0.371	0.466	0.416	0.41	0.454	0.53	0.54	0.57	0.54	0.29	0.256	0.376	0.356	0.456
Na	0	0	0.002	0	0	0.002	0	0.001	0	0	0	0	0.001	0	0.001	0.005	0.011
Al	0.210	0.177	0.039	0.137	0.231	0.066	0.050	0.157	0.080	0.200	0.270	0.230	0.053	0.030	0.241	0.280	0.179
K	0	0.001	0	0	0	0	0	0	0	0	0	0	0.001	0	0.001	0	0
Ca	0.002	0.001	0	0.002	0.001	0	0	0	0	0	0	0	0.002	0	0.013	0.013	0.001
Mn	0.005	0.004	0.006	0.004	0.003	0.004	0	0.004	0	0	0	0	0.006	0.007	0.003	0.003	0.005
Ti	0.001	0	0.001	0.001	0.002	0	0	0.001	0	0	0	0	0.001	0	0	0	0.002
Cr	0.006	0.002	0.003	0.002	0.007	0.003	0	0.012	0.01	0.02	0.02	0.02	0.003	0.003	0.005	0.005	0.01
Ni	0.009	0.008	0.006	0.007	0.01	0.004	0	0.004	0.01	0.01	0.01	0.01	0.007	0.007	0.008	0.007	0.004
Total	2.965	2.921	2.851	2.87	2.956	2.884	2.98	3.011	2.99	2.99	2.97	2.84	2.941	3.001	2.855	2.886	2.967

Table 2. Analysis of major (%) and trace elements (ppm) of the serpentinites and a sample of talc-schist of Tambogo area compared to the ultrabasites of Korsimoro-Boussouma-Kaya.

N°Ech.	Serpentinites						Talc-schist	Altered ultrabasites of Kaya			
	ZP05-A	**ZP05-B**	**ZP05-C**	**ZP08**	**ZP10-A**	**ZP10-B**	**ZP05-D**	**YA91**	**YA10**	**YA5**	**YA54**
SiO_2	39.01	41,46	40.29	38.44	38.77	42,13	49.10	44.5	45.2	44.9	41.9
Al_2O_3	4.41	3,85	4.23	4.31	4.40	3,92	6.85	8.2	7	4.2	3.2
Fe_2O_3	11.98	11,65	11.72	12.30	12.92	12,4	11.60	3.56	4.68	4.83	7.12
MgO	29.17	27,36	29.51	27.47	29.41	27,68	21.79	17.5	21	25.1	28
CaO	3.14	2,79	1.63	3.11	2.81	2,75	0.06	13	11.5	10	2.2
Na_2O	<0.01	<0,01	<0.01	<0.01	<0.01	0,02	<0.01	0.55	0.25	0.2	0.3
K_2O	0.02	<0,01	<0.01	<0.01	<0.01	<0,01	0.01	0.1	0.05	-	-
TiO_2	0.30	0,24	0.27	0.30	0.24	0,26	0.19	0.4	0.4	0.4	0.5
P_2O_5	0.02	0,01	0.02	0.04	0.03	0,02	0.01	-	-	-	-
MnO	0.16	0,15	0.13	0.16	0.18	0,17	0.10	0.19	0.16	0.17	0.22
Cr_2O_3	0.431	0,455	0.461	0.453	0.464	0,47	0.619	-	-	-	-
LOI	10,6	11,3	11	12,7	10,1	9,5	8,7	2,00	4,20	5,19	7,88
Sum	99.48	99,51	99.48	99.51	99.48	99,5	99.61	99,52	100,76	100,64	99,14
Ni	1602	1677	1937	1537	1584	1615	4136	-	-	-	-
Sc	15	15	15	16	17	16	24	-	-	-	-
Ba	<1	2	4	22	3	5	28	0	0	<100	<100
Be	2	<1	<1	<1	<1	<1	<1	-	-	-	-
Co	131.7	117,7	130.6	115.7	128.3	125,7	114.2	90	95	135	160
Cs	0.4	0,6	0.3	<0.1	1.0	0,6	<0.1	-	-	-	-
Ga	5.6	4	4.9	4.9	5.0	4,5	13.5	-	-	-	-
Hf	0.4	0,4	0.3	0.4	0.4	0,5	0.2	-	-	-	-
Nb	1.0	0,6	0.8	0.8	1.0	0,6	0.5	-	-	-	-
Rb	1.3	0,8	1.0	0.6	1.0	0,7	0.7	5	0	0	5
Sn	<1	<1	<1	<1	<1	<1	<1	-	-	-	-
Sr	16.5	14,6	30.5	21.5	15.0	8	4.7	60	10	20	20
Ta	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-
Th	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-
U	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-
V	126	94	132	115	119	93	162	250	180	125	1225
W	19.0	36,7	13.4	12.4	13.9	15	6.8	-	-	-	-
Zr	13.8	11,6	12.5	14.8	10.2	15,1	7.5	-	-	-	-
Y	5.5	4,4	4.3	5.1	4.6	4,7	10.6	-	-	-	-
Mo	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-
Cu	31.3	44	38.5	38.7	31.4	49,4	25.5	55	25	25	130
Pb	0.5	0,6	0.4	0.2	0.3	0,2	0.6	-	-	-	-
Zn	13	12	19	24	12	9	41	60	50	60	65
Ni	1121	1245	1553	907.9	1216	1072,9	3319	375	565	725	1475
As	8.1	5,3	660.9	43.0	8.7	4,1	72.8	-	-	-	-
Cd	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-
Sb	<0.1	0,5	0.1	<0.1	<0.1	0,6	<0.1	-	-	-	-
Bi	<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	-	-	-	-
Au	2.8	3,4	32.0	4.1	1.2	4,7	5.0	-	-	-	-
Hg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
Tl	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-
Se	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	-
La	1.0	1	0.8	1.0	0.7	1,2	1.2	-	-	-	-
Ce	2.8	2,5	2.4	2.7	2.0	2,7	3.6	-	-	-	-
Pr	0.41	0,34	0.34	0.39	0.32	0,35	0.34	-	-	-	-
Nd	1.6	1,9	1.3	2.1	1.7	2	1.4	-	-	-	-
Sm	0.56	0,62	0.48	0.53	0.48	0,5	0.38	-	-	-	-
Eu	0.20	0,17	0.21	0.18	0.23	0,21	0.09	-	-	-	-
Gd	0.77	0,61	0.63	0.84	0.68	0,73	0.88	-	-	-	-
Tb	0.17	0,12	0.14	0.16	0.14	0,14	0.22	-	-	-	-
Dy	0.85	0,85	0.76	0.96	0.74	0,97	1.61	-	-	-	-
Ho	0.20	0,19	0.18	0.20	0.19	0,2	0.39	-	-	-	-
Er	0.64	0,53	0.59	0.57	0.48	0,47	1.20	-	-	-	-
Tm	0.10	0,07	0.09	0.10	0.07	0,08	0.17	-	-	-	-
Yb	0.55	0,42	0.50	0.59	0.47	0,49	0.87	-	-	-	-
Lu	0.09	0,07	0.09	0.09	0.08	0,08	0.15	-	-	-	-

Table 3. Analysis of major (%) and trace elements (ppm) of metagabbros in Tambogo area

n° Ech.	Metagabbro				
	XA25	XA22	XA31	XA35	XB3
SiO_2	48.8	49.3	49.5	51.3	48.7
Al_2O_3	14	14.5	14	14.2	16.1
Fe_2O_3	6.44	3.87	4.02	3.83	4.17
MgO	8.4	7.5	8.35	6.1	8.7
CaO	12.2	11.3	10.5	8.8	12
Na_2O	1.3	2.6	1	3.6	1.9
K_2O	0.05	-	0.1	-	-
TiO_2	1.05	1.3	1.2	1.5	0.9
P_2O_5	-	-	-	-	-
MnO	0.18	0.16	0.2	0.21	0.17
Cr_2O_3	-	-	-	-	-
LOI	2.33	2.22	3.14	1.47	1.62
Sum	99.67	100.57	100.55	99.99	100.32
Ni	-	-	-	-	-
Sc	-	-	-	-	-
Ba	-	<100	-	0	-
Be	-	-	-	-	-
Co	-	85	-	65	-
Cs	-	-	-	-	-
Ga	-	-	-	-	-
Hf	-	-	-	-	-
Nb	-	-	-	-	-
Rb	-	0	-	5	-
Sn	-	-	-	-	-
Sr	-	140	-	145	-
Ta	-	-	-	-	-
Th	-	-	-	-	-
U	-	-	-	-	-
V	-	315	-	400	-
W	-	-	-	-	-

n° Ech.	Metagabbro				
	XA25	XA22	XA31	XA35.	XB3
Zr	-	-	-	-	-
Y	-	-	-	-	-
Mo	-	-	-	-	-
Cu		50		145	
Pb	-	-	-	-	-
Zn	-	95	-	110	-
Ni	-	130	-	65	-
As	-	-	-	-	-
Cd	-	-	-	-	-
Sb	-	-	-	-	-
Bi	-	-	-	-	-
Ag	-	-	-	-	-
Au	-	-	-	-	-
Hg	-	-	-	-	-
Tl	-	-	-	-	-
Se	-	-	-	-	-
La	-	-	-	-	-
Ce	-	-	-	-	-
Pr	-	-	-	-	-
Nd	-	-	-	-	-
Sm	-	-	-	-	-
Eu	-	-	-	-	-
Gd	-	-	-	-	-
Tb	-	-	-	-	-
Dy	-	-	-	-	-
Ho	-	-	-	-	-
Er	-	-	-	-	-
Tm	-	-	-	-	-
Yb	-	-	-	-	-
Lu	-	-	-	-	-