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Evidence of komatiitic basalt enclaves in the Téra-Ayorou pluton (Liptako, West Niger) (West African Craton)

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Abstract

The present study focuses on the basic enclaves (amphibolo-pyroxenites) of the Téra-Ayorou pluton in Niger Liptako (NE portion of the Man Ridge of the West African Craton). The methodology used includes field observations, supported by polarizing microscope observations of thin sections and geochemical analyses of whole rock. These enclaves are characterized by high MgO, low Na_2O, K_2O, and TiO_2 contents, high CaO/Al_2O_3 ratios, depletion of light rare earth and enrichment in Ni and Cr. These basic enclaves are thought to come from certain basic to ultrabasic Pogwa and Ladanka plutonites in the Diagorou-Darbani greenstone belt, with which they share the same geochemical characteristics. This suggests that these enclaves were ripped out by the pluton as it was being emplaced. The basic enclaves and basic plutonites with ultrabasites have different signatures from those of the birimian basites of the West African Craton, which are tholeiitic and calc-alkaline. The amphibolo-pyroxenite enclaves of the Téra-

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Ayorou pluton and the basic to ultrabasic plutonites of the Diagorou-Darbani greenstone belt constitute a fairly continuous line of komatiitic rocks from peridotites (serpentinites) to basalts (metapyroxenites, amphibolites). This komatiitic lineage results from the fractional crystallization of a magmatic liquid from a mantle source with variable partial melting rates. The komatiitic line and the tholeiitic and calc-alkaline lines are closely intertwined in the field.

Keywords: Basic enclaves of Téra-Ayorou Pluton, Niger Liptako, West African Craton, Komatiitic line, Fractional crystallization

Introduction

The Baoulé-Mossi area of the West African Craton is characterized by alternating granitoids and greenstone belts (Grenholm, 2019). These are characterized by a lithostratigraphic succession comprising a volcanic unit at the base and a sedimentary unit at the top (Baratoux et al., 2011, 2015; Grenholm, 2019). Two magmatic lines have been distinguished within the volcanic complex: the tholeiitic line and the calc-alkaline line (Baratoux et al., 2011; Grenholm, 2019). According to the authors, the tholeiitic lineage characterizes an emplacement in a MORB-type oceanic domain (Lompo, 2009), an oceanic shelf area (Pouclet et al., 1996), or an island arc domain (Ama Salah et al., 1996; Soumaila et al., 2004, 2008). The calc-alkaline lineage characterizes an emplacement in a subduction context (Soumaila et al., 2008). Granitoids are essentially composed of TTGs and are intrusive in greenstone belts (Parra-Avila et al., 2017). The granitoids contain numerous basic and ultrabasic enclaves (Machens, 1973). The Téra-Ayorou pluton (Nigerian Liptako), which is the subject of this study, contains numerous enclaves of amphibolites, pyroxenites, and amphibolo-pyroxenites. These enclaves have not previously been the subject of any detailed, in-depth study. The aim of this study is to determine the petrography, geochemistry and magmatic lineage of these enclaves.

Geological context

The West African Craton is made up of two ridges, the Réguibat ridge to the north and the Léo-Man ridge to the south (Figure 1), each comprising an Archaean western province dated at 3.5 to 2.7 Ga (Kouamelan et al., 2015; Rollinson, 2016) and an eastern Birimian province dated at 2.7 to 1.96 Ga (Grenholm, 2019).

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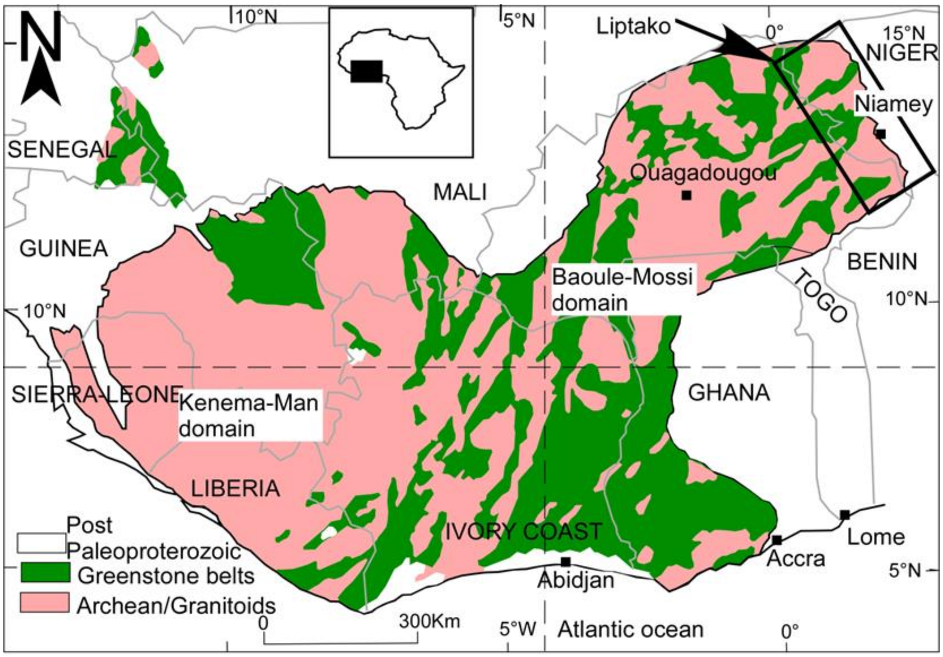

Figure 1: Synthetic geological map of the Man Ridge (from Milési et al., 1989)

The Niger Liptako corresponds to the north-eastern (NE) edge of the Léo-Man ridge (Figure 1). It is characterized by alternating greenstone belts (Gorouol, Diagorou-Darbani, Sirba, and Makalondi) and granitoid plutons (Téra-Ayorou, Dargol-Gothèye, and Torodi) trending broadly NE-SW (Ahmed et al., 2022) (Figure 2). The geological formations in the greenstone belts are metabasalts, amphibolites, ultramafic and mafic intrusive units, often transformed into talcshists and chloritoschists, detrital sediments with little metamorphism, and small volumes of plutonic and volcanic rocks with intermediate to acidic chemistry (Ama Salah et al., 1996; Soumaila et al., 2004; Garba Saley et al., 2021; Hallarou, 2021). Granitoids are mainly composed of TTGs (tonalite, trondhjemite, granodiorite) (Pons et al., 1995).

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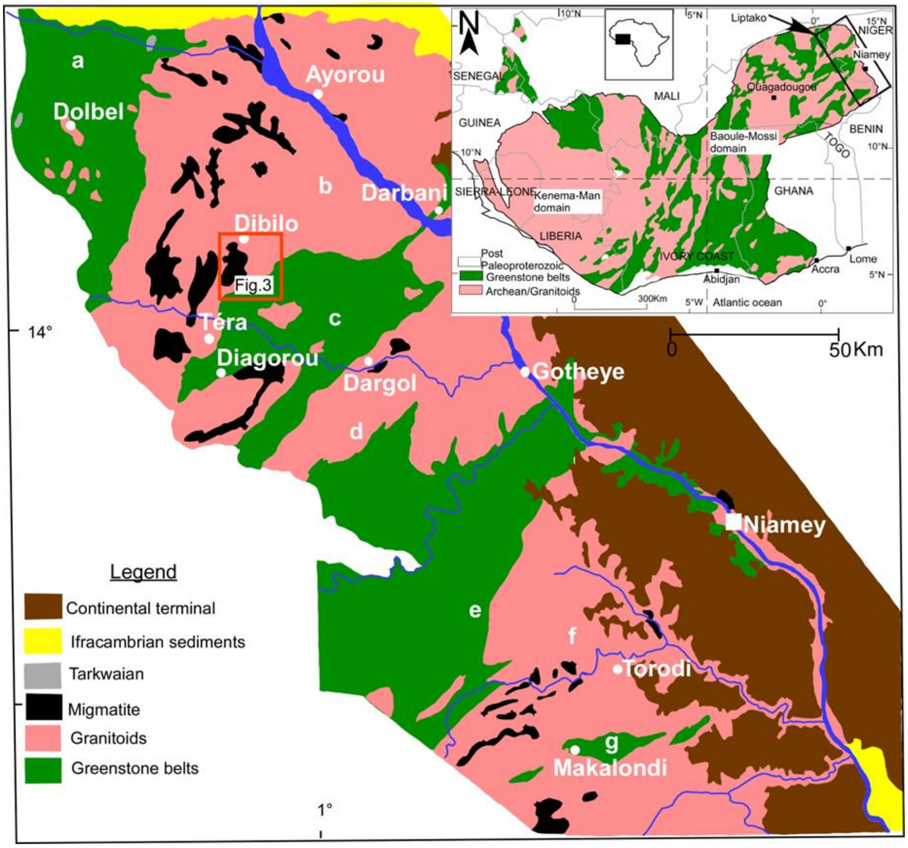

Figure 2: Simplified geological map of Liptako (Machens, 1973; Dupuis et al., 1991, modified). a: Gorouol greenstone belt; b: Pluton of Téra-Ayorou; c: Diagorou-Darbani greenstone belt; d: Pluton of Dargol-Gothèye; e: Sirba greenstone belt; f: Pluton of Torodi; g: Makalondi greenstone belt

The Téra-Ayorou pluton is located in the northern part of the Nigerian Liptako. It is a syn to late-tectonic pluton emplaced during the Paleoproterozoic (U-Pb and K-Ar dating: 2158 Ma ± 9 (Lama, 1993; Cheilletz et al., 1994). The geology of this pluton is represented by migmatites, granodiorites, and calc-alkaline biotite- or 2 micas-bearing granites, with enclaves of amphibolite and pyroxenite (Machens, 1973; Pons et al., 1995). These formations are intersected by veins of quartz and pegmatites (Attourabi et al., 2021; Ahmed et al., 2022) and late dolerites (Noura et al., 2023a) (Figure 3).

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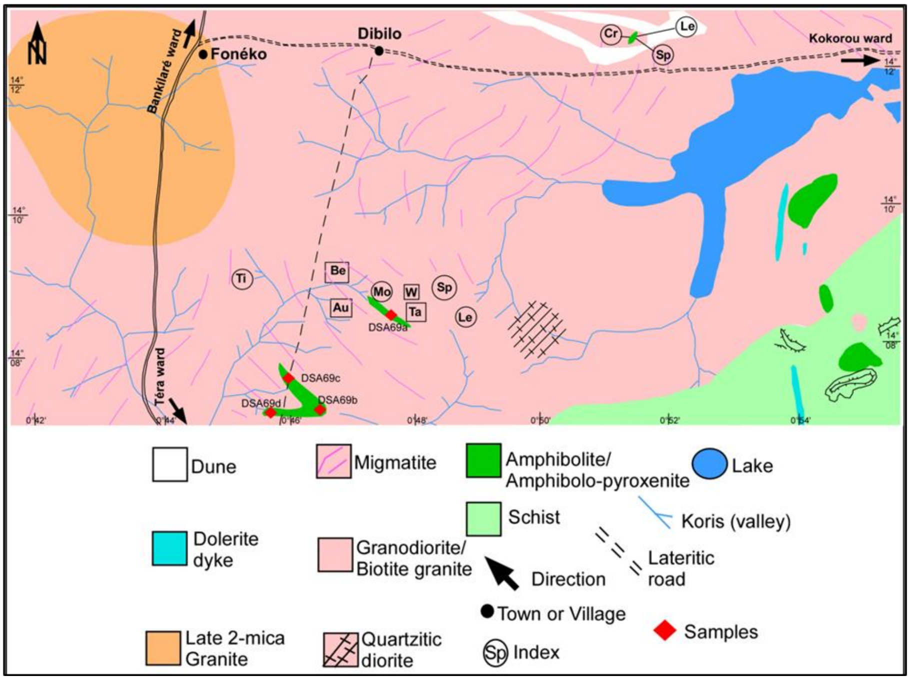

Figure 3: Simplified geological map of Dibilo (Machens, 1961; Attourabi et al., 2021; Ahmed et al., 2022)

Methodology

The methodology used for this study consisted of fieldwork and laboratory work. The fieldwork consisted of a petrographic description of the enclaves and sampling.

The laboratory work involved making 3 thin sections (DSA69b, DSA69c, DSA69d) at the "Centre de Recherche Géologique et Minière" (CRGM) in Niger, and their observations in unanalyzed polarised light (LPNA), analyzed polarised light (LPA) and reflected light using a LEICA DM2700 microscope equipped with five ×5, ×10, ×20, ×50, ×100 magnification objectives and an image capture device connected with computer. These observations were made at the Georesources Laboratory in the Geology Department of the Abdou Moumouni University in Niamey.

One sample (DSA69a) was analyzed at the ‘’Service d'Analyse des Roches et Minéraux (SARM)’’ of the "Centre de Recherches Pétrographiques et Géochimiques (CRPG) " in Nancy, France. Major element (SiO2, Al2O3, Fe2O3, MnO, MgO, CaO, Na2O, K2O, TiO2, P2O5, PF, Total) values were obtained by ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometry) with a Thermo Fischer iCap6500 and trace element and rare earth element (As, Ba, Be, Bi, Cd, Co, Cr, Cs, Cu, Ga, Ge, Hf, In, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sn, Sr, Ta, Th, U, V, W, Y, Zn, Zr, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Li) values were obtained by ICP-MS

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(Inductively Coupled Plasma-Mass Spectrometry) and ICP-OES with a Thermo Fischer iCap6500. The geochemical diagrams were produced using GCDkit 6.1_for R.4.1.3 software (Janoušek et al., 2006).

Results and Discussion

Petrography

In the study area (Téra-Ayorou granitoid pluton), enclaves of greenstone belts were observed to the south of Dibilo, to the south of Fonéko, to the south of Kokorou and to the west part of Téra. These enclaves are represented by amphibolo-pyroxienites. The rock is blackish and shows an N10° to N20° foliation. This foliation is marked by alternating dark beds (amphibole or pyroxene) and light beds (feldspar) (Figure 4). These enclaves are intersected by quartz veins running N-S and N130°.

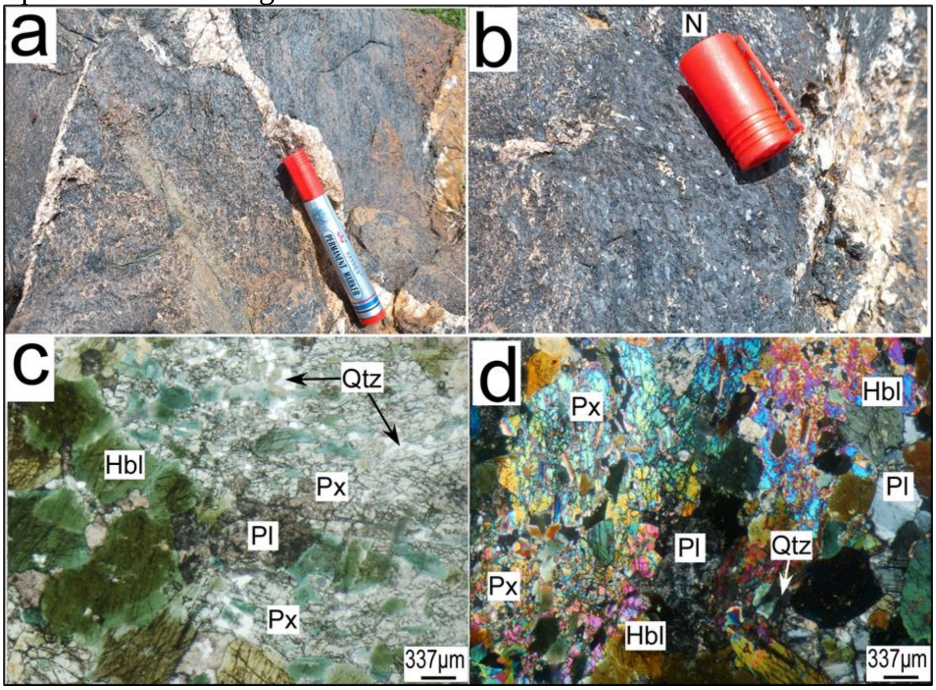

Figure 4: Amphibolo-pyroxenite enclaves crossed by quartz veins south of Dibilo. (c, d, e and f) LPNA and LPA microphotographs of the enclave showing the mineralogical association: Hornblende (Hbl), Pyroxene (Px), Plagioclase (Pl), and Quartz (Qtz)

Microscopically, amphibo-pyroxenites have a granoblastic texture. They are composed of quartz, plagioclase, amphibole (hornblende), and pyroxene (Figure 4). Quartz is present in the form of large mono and/or polycrystalline patches or as small interstitial crystals. It sometimes forms rectilinear inclusions in the poeciloblasts of hornblende. Plagioclase is strongly sericitised and occurs as automorphous, mottled crystals (polysynthetic twins), or as microcrystals included in the poeciloblasts of

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hornblende. Amphibole is green hornblende. It occurs as pleochroic automorphic crystals in green hues (in LPNA). Hornblende sometimes has one cleavage plane (longitudinal section) or two cleavages (transverse section). In the elongated section, extinction occurs obliquely to the cleavage plane. Pyroxene occurs in the form of orthopyroxene crystals, which are largely ouralitized.

Discussion

The amphibole-pyroxenite enclave studied is characterized by a high MgO content (11.60 wt%) (Figure 5a), low alkali (Na_2O: 1.43 wt%; K_2O: 0.72 wt%) and TiO_2 (0.61 wt%) (Figure 5b), a high CaO/Al_2O_3 ratio (1.6) and a depletion in light rare earth and an absence of Eu anomalies (Figure 6a), with negative anomalies in Th, Nb and positive in Pb and U (Figure 6b) (Table 1).

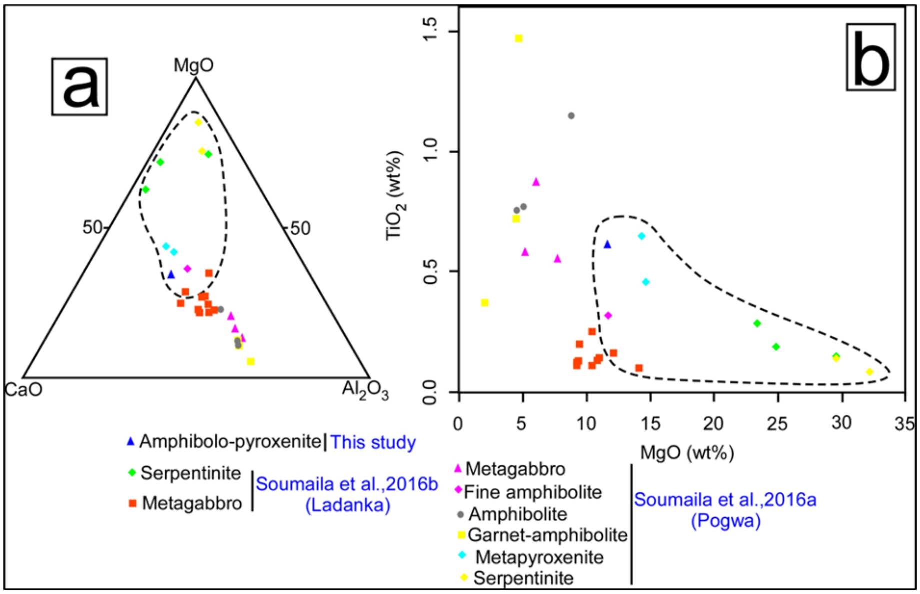

Figure 5: Projection of the amphibolo-pyroxenite enclave of the Téra-Ayorou (this study) and the basic to ultrabasic plutonites of the Diagorou-Darbani belt (Soumaila et al., 2016a, 2016b) in the diagrams of Blais et al. (1977): (a) CaO-MgO-Al2O3; (b) MgO vs TiO2.

Table 1: Majors and trace elements analyses of the Pogwa Rocks (Soumaila et al.,2016a) and the Tera-Ayorou enclaves (this study)

	Soumaila et al., 2016a														This study
Rocks	Metapyrox		Metagabbro			Grt-AmphPg			Grt free AmphPg			F-AmphPg	Ultrabasic		Am-Px
Samples	Fpd-21	Fpd-21	Fpd-3	Fpd-22	Fpd-4	Fpd-5	Fpd-13	Fpd-7	Fpd-17	Fpd-18	Fpd-20	Fpd-12	Th738	Th538	DSA69a
SiO2	49,36	50,42	45,45	46,46	44,57	49,39	43,66	44,79	45,38	44,54	45,63	55,52	39,63	44,46	47,21
Al2O3	7,81	6,63	19,45	20,45	23,06	26,4	21,95	24,18	23,48	17,62	23,31	9,5	3,14	5,78	8,85
Fe2O3	1,31	1,34	1,02	1,02	0,79	0,45	1,28	0,92	0,92	1,28	0,94	0,97	1,25	0,98	13,39
MnO	0,21	0,24	0,13	0,12	0,08	0,06	0,17	0,1	0,1	0,16	0,11	0,18	0,18	0,15	0,29
MgO	14,35	14,66	7,67	5,97	5,13	2,05	4,69	4,49	4,47	8,77	4,95	11,7	32,19	29,5	11,60
CaO	12,06	12,12	11,72	11,88	12,53	13,15	12,33	13,59	13,41	12,11	13,19	11,05	2,57	4,23	13,83
Na2O	0,81	0,76	2	2,4	2,12	2,57	2,04	2,08	2	1,62	2,04	1,37	0,19	0,05	1,43
K2O	-	-	0,51	0,11	1,07	-	-	-	-	0,13	0,05	0,09	0	0	0,72
TiO2	0,65	0,46	0,55	0,87	0,58	0,37	1,47	0,72	0,76	1,15	0,77	0,32	0,09	0,14	0,61
P2O5	0,06	0,09	0,06	0,16	0,09	0,16	0,25	0,16	0,12	0,05	0,08	0,05	0,07	0,05	0,15
Total	98,58	99,87	98,93	99,85	99,87	99,83	99,89	99,81	99,68	99,85	100,1	100,4	98,99	99,43	99,31
Ba	33,26	22,24	139,9	77,25	449,6	112,4	128	54,61	86,36	74,21	72,98	138,7	9,5	0,9	70,43
Ce	18,56	22,6	8,5	21,76	8,76	18,48	22,19	15,27	14,8	16,09	14,97	14,86	1,04	0,66	11,28
Co	53,98	58,51	39,78	36,59	35,56	12,4	33,78	29,36	27,68	54,91	30,39	47,09	117	83,9	82,75
Cr	1499	743,7	198,9	154,1	198,9	154,1	19,16	49,09	9,94	20,24	107	1175	3285	2940	2202,34
Dy	3,39	2,72	1,72	3,92	1,72	3,92	1,55	2,18	5,81	3,49	3,4	1,61	0,36	0,5	1,90
Er	1,8	1,48	0,95	2,11	0,95	2,11	0,87	1,18	3,39	1,94	1,87	0,95	0,23	0,29	1,09
Eu	1,02	0,82	0,8	1,57	0,85	1,21	1,68	1,25	1,16	1,25	1,24	0,58	0,08	0,09	0,69
Gd	3,79	3,21	1,87	4,62	1,76	2,56	5,84	3,71	3,88	4,26	3,69	1,82	0,33	0,29	1,87
Hf	1,07	1,05	0,59	1,23	0,59	0,75	1,32	0,9	1,02	1,21	0,89	0,97	0,16	0,18	1,35
Ho	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,40
La	0,53	6,53	3,28	7,46	3,58	8,34	7,16	5,19	5,43	4,93	5,26	8,34	0,45	0,24	4,42
Lu	0,25	0,24	0,13	0,3	0,12	0,17	0,51	0,26	0,29	0,32	0,26	0,16	0,04	0,06	0,17
Nb	2	2,46	0,99	2,45	0,98	1,75	4,74	1,7	1,79	1,82	1,87	1,45	0,13	0,17	3,37

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Nd	15,77	17,82	6,9	18,72	6,71	12,08	20,28	13,79	13,22	15,35	13,65	9,74	0,69	0,58	7,75
mg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	116,3	127,3	91,49	81,1	29,74	25,74	6,2	7,8	6,58	22,64	45,44	66,2	1229	1234	592,94
Pb	-	-	2,24	2,2	2,88	3,79	2,16	2,63	2,62	-	3,01	8,88	0,47	0,26	2,57
Pr	3,14	3,9	1,33	3,68	1,33	2,65	3,86	2,62	2,51	2,93	2,61	2,33	0,19	0,12	1,73
Rb	1,47	1,28	16,84	3,23	32,46	1,07	0,75	0,72	2,14	1,74	2,41	1,78	1,27	0,72	7,30
Sm	4,14	3,89	1,91	4,94	1,83	2,9	5,61	3,92	3,86	4,35	3,81	2,09	0,2	0,25	1,98
Sr	90,95	49,1	516,5	559,7	747,5	685,6	524,4	612,7	546,5	294,7	507,1	282,8	13,3	20,5	245,62
Ta	0,12	0,12	0,07	0,14	0,07	0,13	0,27	0,1	0,12	0,11	0,12	0,1	0,01	0,02	0,31
Tb	0,57	0,47	0,29	0,67	0,27	0,38	0,92	0,58	0,6	0,67	0,57	0,27	0,05	0,06	0,31
Th	0,12	0,09	0,15	0,26	0,2	0,87	0,12	0,3	0,38	0,2	0,35	0,92	0,03	0	0,33
Tm	0,26	0,23	0,14	0,32	0,12	0,17	0,5	0,28	0,31	0,34	0,28	0,14	0,04	0,05	0,17
U	0,06	0,06	0,08	0,13	0,12	0,41	0,07	0,13	0,14	0,08	0,17	0,35	tr	tr	0,37
V	231,2	382,4	231,1	240,4	250,2	67,65	189,7	209,1	192,4	547,4	172,5	227,1	62,7	101	181,08
Y	17,53	15,56	9,07	21,06	8,49	11,74	31,9	18,33	19,44	22,3	17,85	9,61	2,66	3,24	10,56
Yb	1,69	1,46	0,87	1,95	0,78	1,07	3,26	1,76	1,91	2,13	1,74	0,98	0,23	0,35	1,10
Zr	27,38	25,55	15,14	34,72	18,3	21,31	33,44	23,82	27,9	30,68	23,41	36,34	6,22	6,03	40,20

These characteristics are comparable to those of some basic to ultrabasic Pogwa (Table 1) and Ladanka (Table 2) plutonites highlighted in the Diagorou-Darbani greenstone belt of Niger's Liptako by Soumaila et al. (2016a, 2016b). This suggests that these enclaves come from the plutonites that the pluton ripped out when it was being set up.

Table 2 : Majors and trace elements analyses of the Ladanka Rocks (Soumaila et al.,2016b)

	Soumaila et al., 2016b											
Rocks	Ultrabasic			Metagabbro massif								Metagabbro lited
Samples	Fpd-26a	Fpd-26b	Fpd-25	Fpd-31	Fpd-33	Fpd-27	Fpd-28	Fpd-32	Fpd-34	Fpd-35	Fpd-36	Fpd-29	Fpd-30
SiO2	43,92	44,4	48,13	47,85	48,65	48,69	49,38	44,91	49,6	47,78	49,22	48,67	46,5
Al2O3	1,39	1,61	6,58	13,99	16,55	17,62	18,56	14,87	18,1	15,84	15,87	14,05	18,76
Fe2O3	15,05	13,78	10,31	5,65	5,93	4,76	5,83	9,66	4,99	6,94	6,74	6	6,39
MnO	0,17	0,22	0,13	0,12	0,11	0,1	0,11	0,14	0,1	0,12	0,12	0,13	0,11
MgO	24,85	23,36	29,53	12,12	9,42	9,28	9,27	14,14	10,44	10,98	10,87	10,43	9,36
CaO	8,39	12,33	3,68	16,72	15,84	16,72	14,2	11,78	14,92	14,27	13,59	17,71	15,42
Na2O	0,05	-	-	0,57	1,06	0,59	1,19	1,19	0,83	0,61	0,85	0,73	0,49
K2O	-	-	-	-	-	-	-	-	-	-	-	-	-
TiO2	0,19	0,29	0,15	0,16	0,2	0,11	0,12	0,1	0,11	0,14	0,13	0,25	0,13
P2O5	-	-	-	-	-	0,05	-	-	-	-	-	-	0,05
Total	100,03	99,61	100,14	99,55	99,86	99,87	99,78	99,89	99,93	99,01	99,8	99,41	99,9
Ba	10,28	21,57	3,4	110,1	53,43	32,74	31,86	31,56	21,18	15,78	33,82	27,9	10,45
Ce	1,1	1,19	1,81	1,01	0,86	1,73	1,17	0,98	1,14	1,37	1,33	1,93	1,53
Co	109,2	107,3	90,98	41,63	39,01	35,16	39,49	72,21	35,35	53,57	43,91	36,21	44,45
Cr	1332	1647	3179	922	571	810	126	897	382	983	271	647	435
Dy	0,99	1,26	0,77	0,92	0,83	0,73	0,58	0,59	0,51	0,62	0,55	1,16	0,6
Er	0,58	0,71	0,5	0,55	0,54	0,46	0,37	0,36	0,33	0,39	0,35	0,65	0,36
Eu	0,14	0,31	0,13	0,27	0,28	0,23	0,26	0,22	0,22	0,23	0,23	0,4	0,25
Gd	0,89	1,07	0,63	0,73	0,64	0,6	0,48	0,45	0,42	0,51	0,45	1,06	0,47
Hf	0,18	0,21	0,26	0,12	0,12	0,12	0,1	0,11	0,12	0,1	0,09	0,23	0,1
Ho	0,21	0,26	0,17	0,19	0,18	0,16	0,12	0,13	0,12	0,13	0,12	0,24	0,13
La	0,28	0,27	0,64	0,71	0,34	1,87	0,48	0,48	0,47	0,99	0,6	0,77	1,3
Lu	0,09	0,1	0,08	0,08	0,08	0,07	0,06	0,06	0,05	0,06	0,06	0,09	0,06
Nb	0,13	-	0,36	-	-	0,11	-	-	-	-	-		-
Nd	1,68	1,87	1,49	1,34	1,01	1,67	0,99	0,88	0,96	1,38	1,19	2,36	1,43
mg	0,65	0,65	0,76	0,7	0,64	0,68	0,64	0,62	0,7	0,64	0,64	0,66	0,62

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Ni	646	627	1290	235	154	156	137	333	204	199	139	141	113
Pb	-	-	-	-	-	1,95	-	-	-	-	-	-	-
Pr	0,24	0,28	0,3	0,24	0,17	0,39	0,19	0,17	0,18	0,28	0,23	0,41	0,34
Rb	-	-	-	1,51	1,54	1,03	0,87	2,91	-	0,81	1,12	1,09	-
Sm	0,7	0,77	0,5	0,5	0,43	0,44	0,35	0,32	0,31	0,39	0,39	0,85	0,39
Sr	8	11	17	162	166	165	238	149	226	224	196	257	205
Ta	-	-	0,03	-	-	-	-	-	-	-	-	-	-
Tb	0,15	0,19	0,12	0,13	0,12	0,11	0,08	0,08	0,08	0,09	0,08	0,18	0,09
Th	0,07	-	0,05	-	-	0,09	-	-	-	-	-	-	0,24
Tm	0,09	0,11	0,08	0,08	0,08	0,07	0,06	0,05	0,05	0,06	0,06	0,09	0,06
U	0,05	-	-	-	-	0,08	-	-	-	-	-	-	-
V	137	166	111	132	144	129	97	94	92	129	132	153	103
Y	5,43	6,76	4,6	5,39	5,34	4,54	3,36	3,57	3	3,75	3,29	6,23	3,33
Yb	0,58	0,68	0,52	0,52	0,53	0,45	0,37	0,37	0,33	0,38	0,38	0,6	0,38
Zr	3,77	4,19	8,93	2,62	2,78	3,67	2,53	2,89	2,54	2,75	2,29	4,28	2,08

The basic to ultrabasic plutonites of Pogwa and Ladanka correspond to meta-ultrabasites (serpentinites), metapyroxenites, garnet-bearing amphibolites, and massive or locally bedded metagabbros (massive amphibolites) (Soumaila et al., 2016a, 2016b). These plutonites have high levels of MgO, Ni, and Cr, and are depleted in light rare earths (Soumaila et al., 2016a, 2016b). These plutonites were considered to be the plutonic base unit of a N-MORB ocean floor with an oceanic plateau, having been influenced to a greater or lesser extent by an oceanic arc (Soumaila et al., 2016a, 2016b). These rocks result from the fractional crystallization of a magmatic liquid from a mantle source depleted by partial melting cycles at variable rates (ultrabasites: 80%, basics: 20 to 40%) (Soumaila et al., 2016b). Soumaila et al. (2016a, 2016b) have determined the environment and mode of emplacement of basic to ultrabasic plutonites without determining the nature of the magmatic lineage of these rocks.

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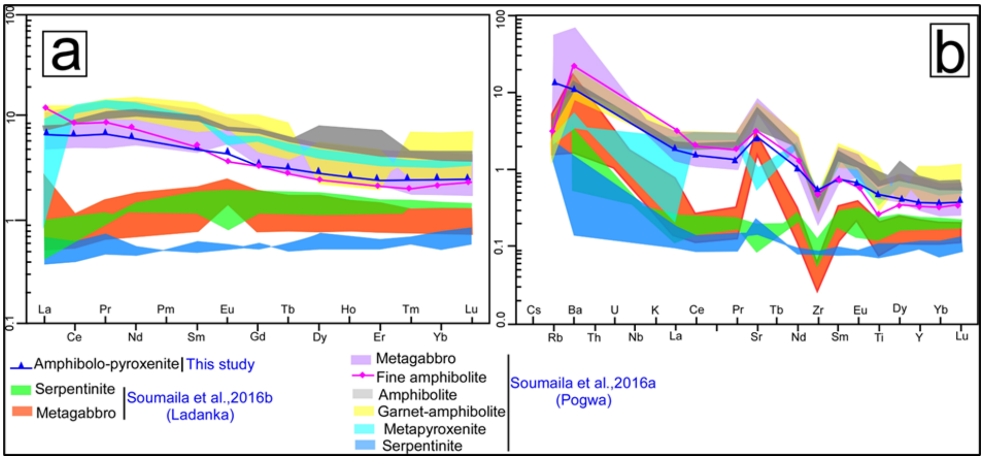

Figure 6: (a) Rare-earth spectra of the amphibolo-pyroxenite enclave and the basic to ultrabasic plutonites normalized to the primitive mantle of McDonough and Sun (1995) ; (b) Multi-element spectra of the amphibolo-pyroxenite enclave and the basic to ultrabasic plutonites normalized to the NMORB of Sun and McDonough (1989)

These basic plutonites to ultrabasites have signatures different from those of most of the tholeiitic and calc-alkaline birimian basites of the West African Craton (Abouchami et al., 1990; Boher et al., 1992). According to the authors, the tholeiitic lineage characterizes an emplacement in a MORB-type oceanic domain (Lompo, 2009), an oceanic shelf area (Pouclet et al., 1996), or an island arc domain (Ama Salah et al., 1996; Soumaila et al., 2004, 2008). The calc-alkaline lineage characterizes an emplacement in a subduction context (Ama Salah et al., 1996; Soumaila et al., 2004, 2008).

The projection of the amphibolo-pyroxenite enclave and the basic to ultrabasic plutonites in the Jensen (1976) (Figure 7) shows that the amphibolo-pyroxenite enclave of the Téra Ayorou pluton and some basic to ultrabasic plutonites of the Diagorou-Darbani greenstone belt fall within the komatite field. This diagram shows that the metapyroxenites, amphibolites, and amphibolo-pyroxenites are komatiitic basalts, while the serpentinites are komatites. This suggests that the amphibolo-pyroxenite enclaves of the Téra-Ayorou pluton and some basic to ultrabasic plutonites of the Diagorou-Darbani greenstone belt constitute a fairly continuous komatiitic line of rocks from peridotites (serpentinites) to basalts (metapyroxenites, amphibolites). This komatiitic lineage is different from the tholeiitic and calc-alkaline lineages with which it is closely intertwined in the field.

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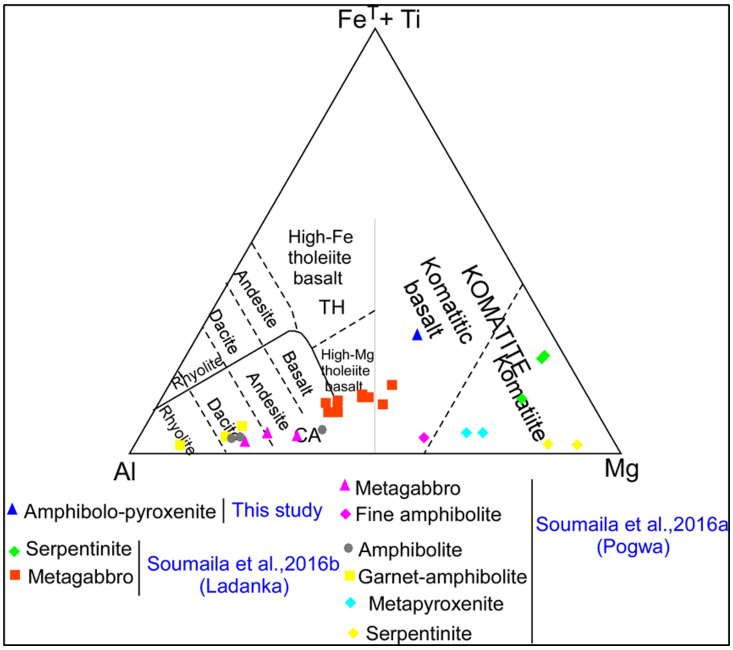

Figure 7: Projection of the amphibolo-pyroxenite enclave of the Téra-Ayorou (this study) and the basic to ultrabasic plutonites of the Diagorou-Darbani belt (Soumaila et al., 2016a, 2016b) in the Jensen (1976) diagram

At the scale of the West African Craton, the basic to utrabasic enclaves of the Tera-Ayorou pluton are comparable to the mafic to ultramafic Birimian rocks of komatiitic affinity of the Boromo (Burkina-Faso) (Aïfa, 2021), Kotiala-Marbadissa (Ivory Coast) (Doumbia et al., 1998; Pouclet et al., 2006; Aïfa, 2021) and the Niandan belt (Guinea) (Milési et al., 1989; Tegyey and Johan, 1989; Grenholm, 2019). These enclaves of the Tera-Ayorou pluton are also comparable to the mafic to ultramafic rocks of the Paleoproterozoic belt of the Paramaca (Guyana) (Marot and Capdevila, 1980; Milési and Picot, 1995; Capdevila et al., 1999).

Conclusion

The enclaves of amphibolites, pyroxenites, and amphibolo-pyroxenites in the Téra-Ayorou pluton are composed of quartz, plagioclase, pyroxene, and hornblende. These basic rock enclaves are characterized by high levels of MgO, low levels of Na_2O, K_2O and TiO_2, high CaO/Al_2O_3 ratios, depletion of light rare earths, and enrichment in Ni and Cr. These enclaves have a geochemical affinity that is very similar to that of the basic to ultrabasic Pogwa and Ladanka plutonites of the Diagorou-Darbani greenstone belt. This suggests that these enclaves were ripped out by the pluton as it was being emplaced. The amphibolo-pyroxenite enclaves of the Téra-Ayorou pluton and the basic to ultrabasic plutonites of the Diagorou-Darbani

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greenstone belt constitute a fairly continuous komatiitic affinity line of rocks from peridotites (serpentinites) to basalts (metapyroxenites, amphibolites). This komatiitic lineage is thought to result from the fractional crystallization of a magmatic liquid from a mantle source depleted by cycles of partial melting at variable rates.

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