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Research paper

On the occurrence of bérem dolerites dyke swarms (north east adamawa plateau, Cameroon)

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Abstract

Petrography and geochemical outline studied carried out on Bérem dolerites have shown that they crosscut the local granitoıds of the basement toward N100-120, EW and N160E directions. Individual dyke may have 5 m to 50 m wide and extend along strike on 200 m to 3 km. Microscopic observations have distinguished the lavas of doleritic textures of ophitic to sub ophitic types. ICP-AES and ICP-MS geochemical analyses of representative samples have distinguished the lavas of basaltic trachyandesite of normative quartz-hypersthene compositions. All lavas belong to the same lavas series of continental tholeiites affinity which have undergone the fluids circulation and crustal contamination processes. Mantle of Bérem dolerites should be E-MORB mantle component which have experienced the relatively high partial melting rate. Bérem dolerites should be considered as imprints of late Pan African relaxation phase which cracks should have been filled by dolerite lavas.

Keywords: *Geochemistry; Continental Tholeiites; E-MORB; Bérem; Cameroon.*

1. Introduction

Dolerites dyke swarms are known worldwide as time markers of geological events and sometimes the occurrence of those rocks is considered as key elements for geodynamic interpretation (Strivastavar 2011). In the Adamawa-Yadé domain in central Cameroon (Fig. 1A), doleritic dykes are widespread in Bérem locality. In reminding, AYD in central part of panafrican fold belt chain is known to have been the result of the from the Pan-African collision of several cratonic blocks, including the Congo Craton (CC), the West African Craton (WAC) and the Pan-African mobile belt (Castaing *et al.* 1994, Fig. 1A). Many others models of Pan-African Food Belt Chain evolution have been proposed (Toteu *et al*. 2004, Ngako *et al.* 2008, Tchakunté *et al.* 2017). The origin and functioning scenario of the panafrican fold belt chain remain questionable and requires many more contribution though significant works have been carried out on the subject (Castaing *et al.* 1994, Abdelsalam *et al.* 2002, Oliveira *et al.* 2006, Ngako *et al.* 2008, Liégeois *et al.* 2013). The occurrence of doleritic dyke swarm in the AY domain is certainly a key element to understand the geodynamic setting of the local basement. This work is focused on the dolerites dyke swarms from Bérem (Fig. 1B). It aims to provide new contributions to the geological evolution of Adamawa-Yadé domain in central Cameroon.

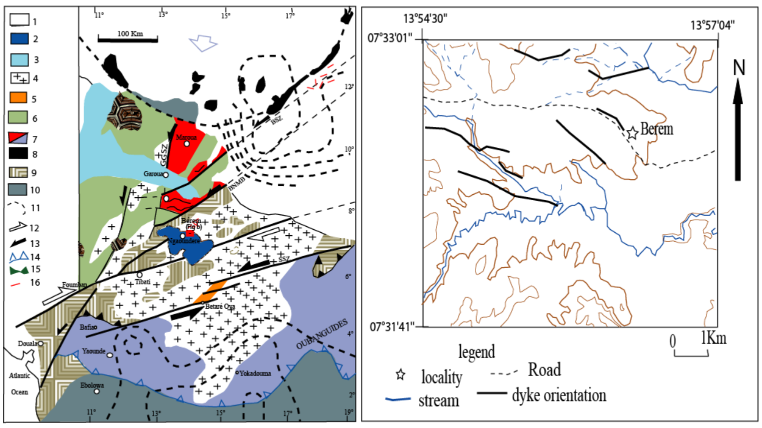

Fig. 1: Study Area Location: A Structural Map of the Central Africa Fold Belt (Coastal Region, Modified From Toteu Et Al. (2001): 1 Quaternary Sediments, 2 Neogen Volcanics, 3 Mesozoic Sediments (Benue Trough), 4 Late Syntectonic Subalkaline Granitoids, 5 Lom Syntectonic Basin (Meta-Sediments, Conglomerates, Volcanic Ash and Lavas), 6 Western Cameroon Domain (WCD; Early Syntectonic Basic to Intermediate Calc–Alkaline Intrusions, 660–600 Ma), 7a Poli Group (Active Margin Neoproterozoic Supracrustal And Juvenile Intrusions), 7b Yaoundé Group (Intracratonic Deposits), 8

Massenya–Ounianga Gravity Highs (10–30 Mgal), 9 Adamawa–Yadé and Nyong Paleoproterozoic Remnants, 10 Craton And Inferred Craton, 11 Effective Elastic Thickness Curves (Km), After Poudjom-Djomani Et Al. (1995), 12– 17=Structural Elements, 12 Foliation And Lineation Trends, 13 Upright and Overturned Antiforms, 14 Main Frontal Thrust Zone (Exhumation), 15 Main Thrust Zone Likely Associated to Crust Redoubling Zone, 16 Right Lateral Sense of Wrench Movement, 17 Left Lateral Sense of Wrench Movement, Large Grey Arrow Represents Regional Main Stress Direction Controlling Crust Thickening and Sinistral Wrench Movement, Respectively, B Topographic Map of Studied Area.

2. Geological setting

Bérem basement belongs to the Adamawa-Yade Domain (AYD), the Paleoproterozoic formation that was dismembered during the Pan-African orogeny (Toteu *et al.* 1990). In central Cameroon (Adamawa region), the AYD is characterized (Fig. 1) by Pan-African granitoids intruding Paleo- to Neoproterozoic gneisses which are intensively overprinted by regional-scale transcurrent shear zones (Toteu *et al.* 2004, Tchameni *et al.* 2006, Ganwa *et al.* 2008). The AYD basement rocks are composed of syn to post tectonic type and are Pan African in age (600-500 Ma, Tchameni *et al.* 2006). The chronology of tectono-magmatic and sedimentary events which have affected the Adamawa basement during pan-African orogeny has been outlined by Toteu *et al.* (2004): (1) a pre-collisional stage that is still to be better constrained and that includes the emplacement of pre-tectonic calc-alkaline granitoids (e.g., at 660–670 Ma); (2) a syn-collisional stage inducing crustal thickening and delamination of the subcrustal lithospheric mantle and comprising D1 and D2 deformations, MP to HP metamorphism with granulitic facies rocks, migmatization, and emplacement of syn-tectonic calc-alkaline and S-type granitoids (640–610 Ma); (3) a post-collisional stage associated with D3 deformation (nappe and wrench) concomitant with exhumation of granulites, development of D4 shear zones, and emplacement of late-tectonic calc-alkaline to sub-alkaline granitoids (600–570 Ma). The evolution ends with the development of molassic basins and emplacement of high-level alkaline granitoids (age at 545 Ma) in an extensional context. The AYD is dominated by four main deformation phases. D1 and D2 deformation phases that are the result of East–West regional shortening direction (Toteu *et al.* 2004) are consisting with isoclinal folds, N110°–N140° stretching lineation (Ferré *et al.* 1996) and tight and upright folds with vertical axial plane foliations, respectively. D3 is consistent with NNE–SSW shortening direction, while D4 is marked by WSW–ENE to SW–NE dextral shortening direction.

3. Methods

Eight thin polished sections have been made from representative samples at the 'Laboratoire de Pétrography de Nkolbisson', Cameroon. Whole-rock analyses were made by ICP–MS and ICP–AES methods to determine major, trace, and rare earth elements at ACMEL geological Analytical Laboratories Vancouver, Canada. 0.2 g of rock powder was fused with 1.5 g LiBO2 and then dissolved with 4 acid digestions. Analytical precisions vary from 0.04 to 0.1% for major elements; from 0.1 to 0.5 ppm for trace elements; and from 0.01 to 0.5 ppm for rare earth elements. Loss On Ignition (LOI) has been determined by weight difference after ignition at 1000°C.

4. Results

4.1. Fieldwork and petrography

Bérem dolerites crosscut the local granitoıds of the basement as dykes (Fig. 2A). They form a suite of N140-160E trending directions. Individual dyke may have 5 to 50 m wide and extend along strike at 200 to 300 m before disappearing and reappearing not so far away. When plotting on Google Earth, it appears that they may rich up to 3 km long (Fig. 1b). As the contact with the basement is concealed by altered products, the dip of each dyke is assumed to be sub-vertical or vertical. Dykes are exposed as an arena of angular blocks of 20 cm to 1.2 m in size (Fig. 2A), coated by 0.5 to 1 cm-thick brown patina. Hand specimen display aphanitic to phaneritic structures. Some representative samples exhibit coarse greenish matrix containing whitish feldspar and plagioclase (2 mm to 1.0 cm size) phenocrysts. Many rectangular or square shaped golden phenocrysts (5 to 7%) of pyrite are scattered in the matrix where they are associated with 1 to 1.5 mm black clinopyroxene and oxides dispersed in dark groundmass (Fig. 2B). Rare 2–6 cm crustal enclaves of granitoid composition have been found in some outcrops (Fig. 2C).

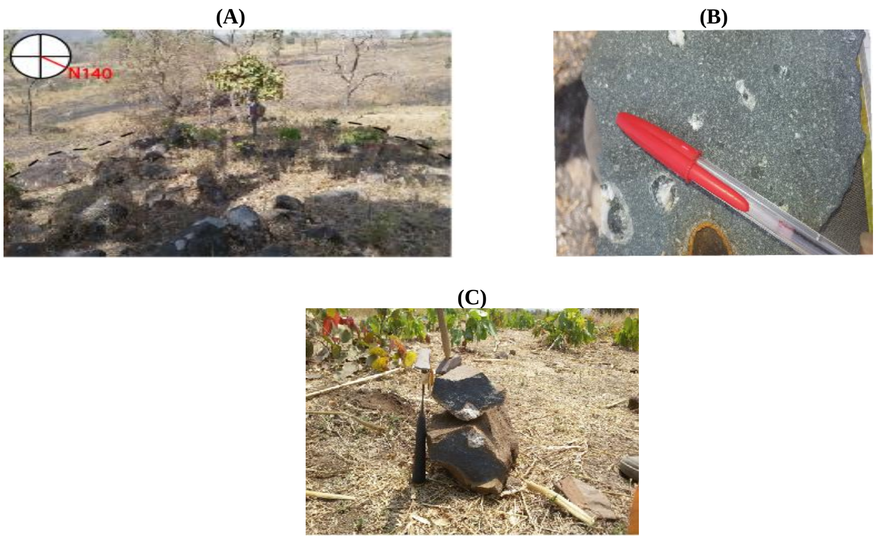

Fig. 2: Representative Bérem Dyke: A: Arena of Angular Blocks of Dolerites, B: Coarse Greenish Matrix Containing Whitish Feldspar and Plagioclase C: Crustal Enclaves of Granitic Composition.

Under the microscope, Bérem dolerits exhibit various textures of ophitic and subophitic doleritic types (Fig. 3). All samples are composed of phenocrysts, microlites and microcrysts of clinopyroxene, plagioclase, calcite, alkali feldspar and oxides (Fig. 3). Plagioclase crystals (20 vol. % of up to 1.3 to 2.0 mm) are euhedral and show sieve texture. Some plagioclases contain oxides inclusion. Clinopyroxene phenocrysts constitute the main oikocryst phases (15 vol. %) containing late crystalized minerals. They are euhedral (Fig. 3a) in shape and frequent contain inclusions of oxides and some crystals are altered into oxides phenocrysts (Fig. 3b). 10 vol.% of feldspar phenocrysts (Fig. 3c) and 5 vol.% and 0.7-1 to 1.2 - 2.1 mm calcite phenocrysts containing oxides inclusions are partially destabilized into oxides showing resorbed rims (Fig. 3d). Abundant crystals of alkali feldspar constitute the groundmass so as plagioclase and clinopyroxene microlites and oxides microcrysts.

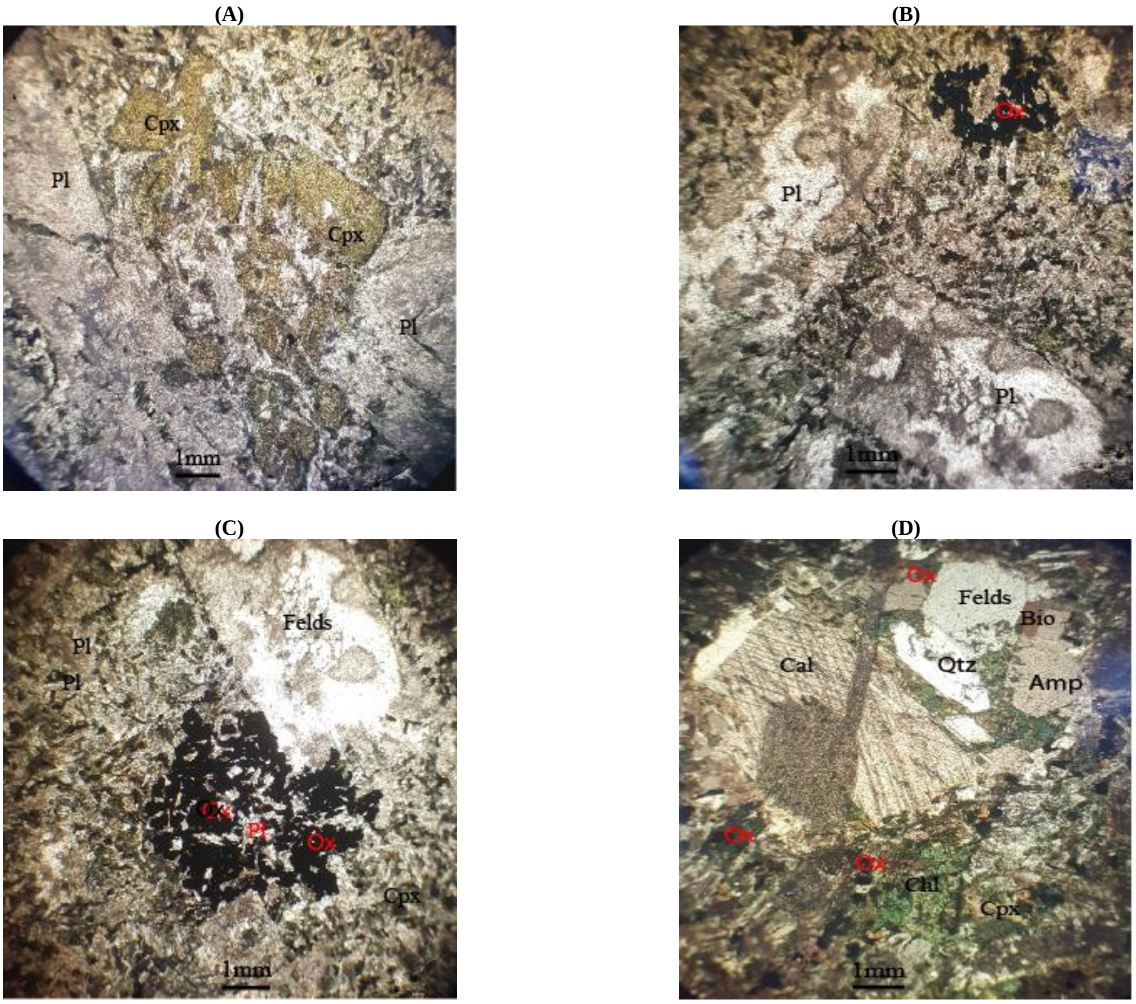

Fig. 3: Photomicrographs Showing Main Characteristic Intersertal Textures of Bérem Dolerites: Cpx = Clinopyroxene, Ox = Oxides, Pl = Plagioclase, Amp = Amphibole, Qtz= Quartz, Felds = Feldspar, Cal = Calcite. A: Clinopyroxene Phenocrysts in A Matrix Of Feldspar, Oxides and Plagioclase, B: Skeletal Plagioclase Phenocryst, C: Altered Feldspar Phenocrysts, D Calcite Phenocrysts Associate to Amphibole.

4.2. Geochemical outline

Geochemical analyses have been carried out on three dolerites samples from Bérem (Table 1). It appears that studied dolerites are characterized by relatively constant values of major elements: SiO_2 contents are between 51 and 53 wt. %, TiO_2 between 2.28 and 2.48 wt. %, constant Al_2O_3 (14.24-14.2 wt. %), Fe_2O_3 (11.70-12.78 wt. %), MgO (3.29.70-3.72 wt. %), CaO (5.47-5.88 wt. %). Alkali contents are relatively constant (Na_2O+K_2O=5.22-5.77wt. %). P_2O_5 are low and also constant (0.50-0.55 wt. %). Mg number ($Mg\#=100*(MgO/40.32)/(MgO/40.32+Fe_2O_3/71.85)$) are constant and relatively low (33.0-34.2). Classification of studied dolerites using IUGS scheme (after Le Maitre 2002) distinguishes the lavas of basaltic trachyandesite composition (Fig. 4). Norm calculations show that the studied dolerites are quartz and hypersthene normative lavas.

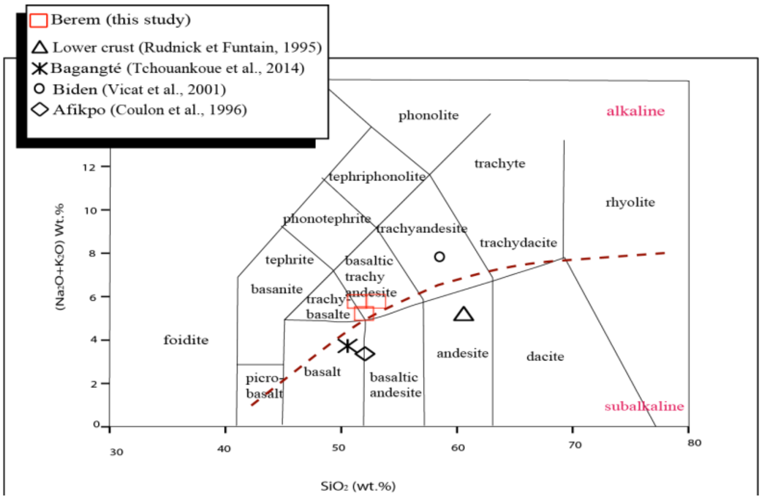

Fig. 4: Total Alkalis (Na_2O+K_2O) vs. Sio_2 (Wt % Volatile-Free Recalculated Compositions (After Le Maitre 2002) Diagram of Berém. Dolerites of Biden (Vicat Et Al. 2001), Afikpo (Coulon Et Al. 1996), Bangangté (Tchouankoue Et Al. 2014). Dashed Curve Separates Alkaline from Subalkaline Fields According To Miyashiro (1978).

Transitional trace elements vary widely between dolerite B1 and others samples. This sample shows the relatively high contents of Ni (1960 ppm), Co (105 ppm), Cr (2625 ppm) but low V contents (82 ppm). Inversely, dolerites B2 and B3 show very low and constant values of Ni (20-24ppm), Co (29.2-29.9 ppm), Cr (27.37 ppm) but relatively high V contents (199-201 ppm). Incompatible trace elements exhibit high contents in dolerites B2 and B3 than dolerite B1. Contents in Ba (946-1049 ppm), Rb (85.2-138 ppm) and Sr (614.1-765.4 ppm) are very high in B2 and B3, respectively compared to dolerite B1 where Ba (6.6 ppm), Rb (0.6 ppm) and Sr (19.9 ppm) are extremely low. Contents of incompatible elements Zr (10.5 ppm), Hf (0.28 ppm), Ta (0.04 ppm), Nb (0.66 ppm) ad Y (4.3 ppm) are low compared to those of the same elements analysed respectively in samples B2 and B3 where they are relatively constant : Zr (352.9-367.9 ppm), Hf (8.1-8.4 ppm), Ta (1.2-1.1 ppm), Nb (28.1-28.9ppm) ad Y (49.2-49.0 ppm). Th vary in the same rage with very low contents in B1 (0.08 ppm) relative to B2 (4.0ppm) and B3 (5.0 ppm). Zr/Hf (43.6-43.8) and Nb/Ta (16.8-19.0) ratios are relatively constant in dolerites B2 and B3. Zr/Hf (37.10) value is low in dolerite B1 but Nb/Ta (17.78) is in the same range as those of B2 and B3. Y/Nb is high in dolerite B1 (Y/Nb: 6.5) compared to the constant values of the same ratios in B2 and B3 (Y/Nb: 2.4). Spider diagram (Fig. 5) shows continuous decreasing values of normalized incompatible elements toward compatible ones. Negative anomalies are noticed Th, Nb, Ta, P and Ti. REE normalized patterns (Fig. 5) show high contents of LREE relative to HREE with weaken negative anomaly in Eu (Figure not shown). Regular decreasing values is noticed from LREE to HREE. Ce_N/Yb_N ratios of studied lavas are low (5.4-6.1).

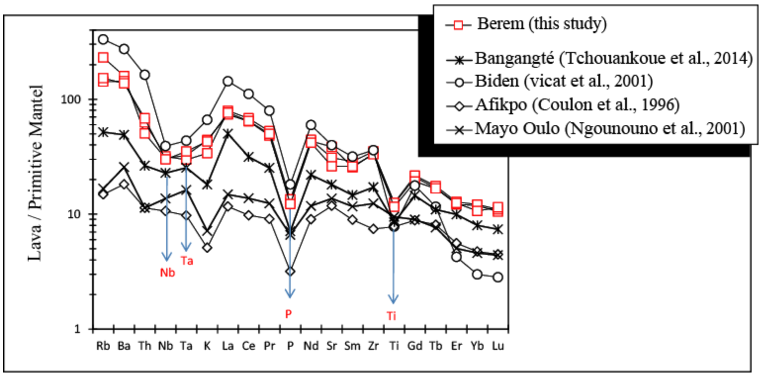

Fig. 5: Primitive Mantle-Normalized (Sun & Mc Donought, 1995) Multi-Element Patterns of Bérem Dolerites. Data of Biden (Vicat Et Al. 2001), Afikpo (Coulon Et Al. 1996) and Mayo Oulo (Ngounouno Et Al. 2001) are added for Comparison.

Table 1: ICP-AES Ad ICP-MS Geochemical Analyses of Bérem Dolerites. Baganté (Tchouankoue Et Al 2014), Biden (Vicat Et Al. 2001), Afikpo (Coulo Et Al. 1996) Ad Oulo-Léré (Ngounouno Et Al. 2001) are Added for Comparison

lava	Berem	Berem	Berem	Bagante	Biden	Afikpo	Mayo Oulo-Léré
sample	B1	B2	B3	DMA1	IN31	86B	dolerite
SiO2 wt. %	51.39	51.98	53.01	50.56	58.56	52.06	51.72
TiO2	2.43	2.48	2.28	1.68	1.54	1.54	1.87
Al2O3	14.64	14.24	14.72	15.82	14.95	15.18	14.10
Fe2O3	12.78	12.78	11.70	10.54	6.80	3.25	11.09
MnO	0.18	0.18	0.17	0.17	0.08	0.16	0.13
MgO	3.72	3.53	3.29	8.31	2.62	5.72	6.12
CaO	5.47	5.88	5.74	8.93	4.14	8.21	8.77
Na2O	2.75	2.90	2.83	2.47	3.30	3.00	3.46
K2O	3.02	2.32	2.94	1.24	4.53	0.35	0.49
P2O5	0.52	0.55	0.50	0.29	0.74	0.13	0.27
LOI	2.7	2.8	2.5		1.68	1.49	1.84
Sum	99.60	99.64	99.68	100.01	98.94	98.90	99.38
Norm CIPW							
quartz	2.90	5.15	5.22				
Orthoclase	17.85	13.71	17.37				
Albite	23.27	24.54	23.95				

Anorthite	18.68	18.99	18.78				
Diopside	4.24	5.54	5.40				
Hypersthene	20.81	19.60	17.92				
Magnetite	2.20	2.20	2.02				
Ilmenite	4.62	4.71	4.33				
Apatite	1.20	1.27	1.16				
D.I.	44.01	43.40	46.54				
Mg#	34.15	32.99	33.38				
Co (ppm)	105	29.9	29.2	25	53	34	33
Cr	2625	27.37	27.37	83.00		285.00	228
Ni	1960	20	24	33.00	146.00	53.00	109.00
V	82	199	201	118.00	206.00	200.00	170.00
Sc		25	25	22		22.1	
Ba	6.6	1049	946	402	323	120	169
Be	0.068	2	4				
Cs	0.021	0.4	0.3	2.4			
Ga		20.6	19.4				
Hf	0.283	8.1	8.4	4		2.2	3.4
Nb	0.658	20.1	20.9	8	15	7	9
Rb	0.6	138.0	85.2	62	31	8.9	10
Sn		3	3				
Sr	19.9	765.4	614.1	281	359	235	272
Ta	0.037	1.2	1.1	0.6	0.94	0.36	0.60
Th	0.0795	4.0	5.0	6.1	2.1	0.9	0.9
U	0.0203	0.6	0.8	1.60	0.40	0.21	0.20
W		<0.5	0.5				
Zr	10.5	352.9	367.9	125.00	180.00	78.00	130.00
Y	4.3	49.2	49.0	22.00	48.60	20.00	23.00
Cr							
Pb	0.15	0.0	0.0	15.3		1.70	0.90
La	45.1	48.6	46.8	30.70	87.93	7.15	9.10
Ce	102.7	108.8	103.2	50.33	177.80	15.66	22.00
Pr	11.65	12.72	12.04	6.10	19.18	2.20	3.00
Nd	51.3	52.5	49.6	26.10	70.73	10.74	14.00
Sm	9.86	11.12	10.05	5.66	12.21	3.45	4.50
Eu	2.91	2.84	2.90	1.70		1.38	1.70
Gd	10.72	11.09	9.84	7.43	9.09	4.53	4.60
Tb	1.59	1.65	1.57	1.03	1.09	0.76	0.72
Dy	8.82	9.25	8.54	6.87		4.44	4.40
Ho	1.89	1.90	1.81	1.40		0.86	0.96
Er	5.07	5.32	5.19	4.14	1.77	2.33	2.10
Tm	0.75	0.77	0.72	0.53		0.31	0.29
Yb	4.91	5.02	4.41	3.31	1.24	1.96	1.90
Lu	0.67	0.70	0.73	0.47	0.18	0.29	0.28
Zr/Hf	37.10	43.57	43.80				
Nb/Ta	17.78	16.75	19.00				
Y/Nb	6.53	2.45	2.34				
CeN/YbN	5.41	5.61	6.06				

5. Discussions

The occurrence of dolerite dyke swarms of more than 3 m width and extending beyond 1 km suggests the regional extension of the continental crust of Adamawa plateau. The studied dykes swarm occur as intrusive rocks into the pan African basement, mostly in E-W N100-120 and N120-160E directions which are parallel to the main Pan-African orientation suggested by Moreau et al. (1987). In this view, Bérem dyke swarms may be related to the Pan-African tectonic events which cracks might have served as magma conduits during the extension of the basement (Guiraud et al. 2005). The width of the dykes range from 7 to 50 meter with varying lengths thus belong to giant dyke swarms (Bryan & Ernst 2008). Fluids circulation is shown by green epidote crystals and pockets of carbonate. Centimetre-large xenoliths of basement granite occur in some dykes (Fig.2) suggest their possible contamination by the wall rocks.

Geochemical analyses of studied dolerited reveal the constants values of major elements contents and the occurrence of quartz and hypersthene in normative calculations of all samples attests their quartz tholeiite affinity. Low Mg# ratios of all samples lead to the evolved character of studied lavas. This suggestion is enhanced by low contents of transitional elements especially for dolerite B2 and B3. Dolerite B1 is particular as it shows the high contents of transitional elements. The fluid circulation is stand as the best process to explain the high values of Ni, Co and Cr of dolerite B1. This sample is also characterized by the very low contents of incompatible elements relative to samples B2 and B3. Fluids circulation could have carried away incompatible elements vis-à-vis to the transitional elements leading to the high contents of these elements in dolerite B1. All studied dolerites should belong the same magma series as attest the constants values of Zr/Hf, Nb/Ta ad Y/Nb ratios for dolerites B2 and B3. Once more dolerite B1 is characterized by high Y/Nb, low Zr/Hf and the same Nb/Ta ratios compared to dolerites B2 and B3. This fact is due to fluids circulation or crustal contamination. Studied dolerites exhibit the continental tholeiite affinity as shown I Fig. 6 and according to negatives anomaly in Nb, Ta and Ti (Dupuy & Dostal 1988) and Th/Ta ratios (2.0—5.0) (Cabanis & Thieblemont 1988).

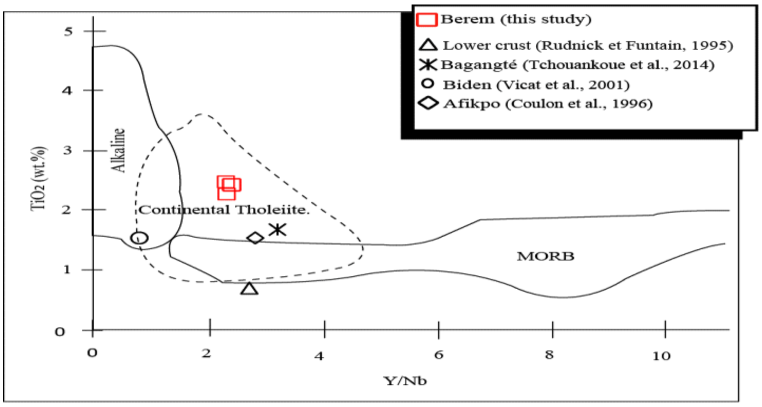

Fig. 6: Bérem Dolerite Compositions Plot in the Continental Tholeiitic Field in Tio₂ vs. Y/Nb Discrimination Diagram (After Floyd &Winchester, 1975). Same Symbols as in Fig. 4. Dolerites of Biden (Vicat Et Al. 2001), Afikpo (Coulon Et Al. 1996) and Bangangté (Tchouankoue Et Al. 2014) are added for Comparison.

The weak Eu anomalies in REE patterns should indicate the contribution of plagioclase to the magma differentiation and low value of Ce_N/Yb_N ratios (6.1-6.4) of Bérem dolerites suggest a high partial melting rate of their mantle source. The Bérem whole-rock analyses have been plotted in Y/15-La/10-Nb/8 diagram (Fig. 7, after Cabanis & Lecolle 1988) and Hf/3-Th–Ta diagram (Fig. 8, after Wood 1980). In these geotectonic diagrams, all studied samples fall within the Arc-related orogenic series or Volcanic Arcs Basalts (Fig. 8) of Wood (1980). Accordingly, the occurrence of Bérem dolerites is undoubtedly linked to the pan African orogeny probably at late Pan African or to its relaxation phase.

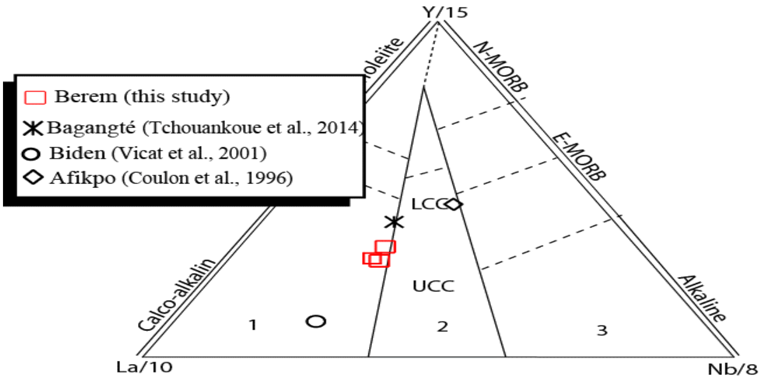

Fig. 7: Y/15-La/10-Nb/8 Diagram (Cabanis & Lecolle 1988) : CC: Continental Crust (Mean Value), LCC: Low Continantal Crust, UCC: Upper Continantal Crust, 1. Arc-Related Orogenic Series, 2. Intermediate Domain of Continental Tholeiite, 3. Anorogenic Series of Oceanic Ridges and Intraplate Alkaline Basalts. Dolerites of Biden (Vicat Et Al. 2001), Afikpo (Coulon Et Al. 1996) and Bangangté (Tchouankoue Et Al. 2014) are added for Comparison.

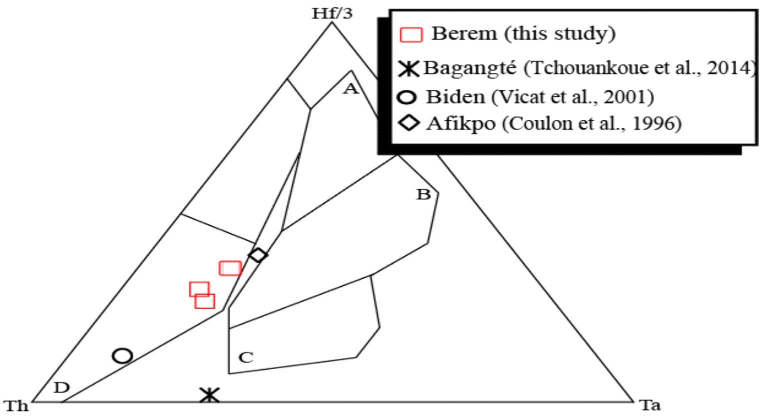

Fig. 8: Hf/3-Th–Ta Diagram (Wood 1980): A N-Type MORB, B E-Type MORB and within Plate Tholéiites, C Alkaline within Plate Basalts, D Volcanic Arc Basalts Where Hf/Th>3.0 and Calc-Alkali Basalts where Hf/Th < 3.0. Dolerites of Biden (Vicat Et Al. 2001), Afikpo (Coulon Et Al. 1996) and Bangangté (Tchouankoue Et Al. 2014) are added for Comparison.

The source of the magma should be the E-MORB mantle component if one considers the spider diagram where Bérem dolerites are characterized by very high ratios of incompatible elements of studied relative to the low ratios of the same elements in magma of N-MORB magma source as those of Afikpo and Mayo-Oulo (Coulon et al., 1996; Ngounouno et al., 2001).

6. Conclusion

Petrography and geochemistry carried out on Bérem dolerites dyke have shown that they are oriented toward N100-120, EW and N160E directions. Individual dyke may have 5 to 50 m wide and extend along strike on 200 to 3 km. They exhibit the doleritic textures of ophitic to sub-ophitic types. Studied dolerites are quartz hypersthene normative continental tholeiites of basaltic trachyandesite composition.

They are considered as imprints of late Pan African relaxation phase. Bérem dolerites mantle source is E-MORB mantle component which have undergone the relatively high partial melting rate. Resulted magma have experienced fluids circulation and crustal contamination processes.

Acknowledgments

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References

[1] Abdelsalam MG, Liégeois JP & Stern RJ (2002) The Saharan Metacraton. Journal of African Earth Sciences 34, 119-136. PII: S08 9 9- 5 3 62 (02) 0 00 1 3- 1 https://doi.org/10.1016/S0899-5362(02)00013-1.

[2] Bryan SE & Ernst RE (2008) Revised definition of Large Igneous Provinces (LIPs). Earth-Science Reviews 86, 175–202. https://doi.org/10.1016/j.earscirev.2007.08.008.

[3] Cabanis B & Lecolle M (1988) Le diagramme La/10—Y/15—Nb/8 : un outil pour la discrimination des séries volcaniques et la mise en évidence des processus de mélange et/ou de contamination crustale. Les comptes rendus de l'académie des sciences de Paris, 309 (2), 2023–2029. .

[4] Cabanis B & Thiéblemont D (1988) La discrimination des tholéiites continentales et des basaltes arrière-arc. Proposition d'un nouveau diagramme Th–Tbx3–Tax2. Bulletin de la Société géologique de France 8 6 (4), 927–935. https://doi.org/10.2113/gssgfbull.IV.6.927.

[5] Castaing C, Feybesse JL, Thieblemont D, Triboulet C & Chevremont P (1994) Paleogeographical reconstructions of the Pan-African/Brasiliano orogen: closure of an oceanic domain or intracontinental convergence between major blocks? Precambrian Research 69, 327-344. SSD10301-9268 (94) 00030-U. https://doi.org/10.1016/0301-9268(94)90095-7.

[6] Coulon C, Vidal P, Dupuy C, Baudin P, Popoff M, Maluski H & Hermitte D (1996) The Mesozoic to Early Cenozoic magmatism of the Benue rough (Nigeria); geochemical evidence for the involvement of the St Helena plume. Journal of Petrology 37 (6), 1341–1358. http://petrology.oxfordjournals.org/. https://doi.org/10.1093/petrology/37.6.1341.

[7] Dupuy C & Dostal J (1984) Trace element geochemistry of some continental tholeiites. Earth and Planetary Science Letters 67(1), 61-69. https://doi.org/10.1016/0012-821X(84)90038-4.

[8] Ferré EC, Déléris J, Bouchez JL, Lar AU & Peucat JJ (1996) The Pan-African reactivation of Eburnean and Archean provinces in Nigeria: structural and isotopic data. Journal of Geological Society of London 153, 719-728. https://doi.org/10.1144/gsjgs.153.5.0719.

[9] Ganwa AA, Frisch W, Siebel W, Ekodeck GE, Shang CK, Ondoa JM, Satir M & Numbem JT (2008) "Zircon 207Pb/206Pb Evaporation Ages of Panafrican Meta- sedimentary Rocks in the Kombé-II Area (Bafia Group, Cameroon): Constraints on Protolith Age and Provenance". Journal of African Earth Sciences, Vol. 51, No. 2 pp. 77-88. https://doi.org/10.1016/j.jafrearsci.2007.12.003.

[10] Guiraud R, Bosworth W, Thierry J & Delplanque A (2005) Phanerozoic geological evolution of Northern and Central Africa: An overview. Journal of African Earth Science 43, 83–143. https://doi.org/10.1016/j.jafrearsci.2005.07.017.

[11] Le Maître RW (2002) Igneous rocks. A classification and glossary ofterms. Recommendations of the International Union of Geological Sciences Subcommission on the systematics of IgneousRocks, Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511535581.

[12] Liégeois JP, Abdelsalam MG, Ennih N & Ouabadi A (2013) Metacraton: Nature, genesis and behavior. Gondwana Research 23, 220-237. https://doi.org/10.1016/j.gr.2012.02.016.

[13] Miyashiro A (1974) Volcanic rock series in Island area and active continental margin. American Journal of Sciences 274, 321–355. https://doi.org/10.1016/j.gr.2012.02.016.

[14] Moreau C, Regnoult JM, Déruelle B & Robineau B (1987) A new tectonic model for the Cameroon Line, central Africa. Tectonophysics 139, 317-334. https://doi.org/10.1016/0040-1951(87)90206-X.

[15] Ngako V, Affaton P & Njonfang E (2008) Pan-African tectonics in northwestern Cameroon: implication for the history of western Gondwana. Gondwana Research 14, 509-522. https://doi.org/10.1016/j.gr.2008.02.002.

[16] Ngounouno I, Deruelle B, Guiraud R & Vicat JP (2001) Magmatismes tholéiitique et alcalin des demi-grabens crétacés de Mayo Oulo-Léré et de Babouri-Figuil (Nord du Cameroun-Sud du Tchad) en domaine d'extension continentale. Comptes Rendu Académie Des Sciences Paris, Sciences de la Terre et des planètes / Earth and Planetary Sciences 333, 201-207. https://doi.org/10.1016/S1251-8050(01)01626-3.

[17] Oliveira EP, Toteu SF, Araújo MNC, Carvalho MJ, Nascimento RS, Bueno JF, McNaughton N & Basilici G (2006) Geologic correlation between the Neoproterozoic Sergipano belt (NE Brazil) and the Yaoundé belt (Cameroon, Africa). Journal of African Earth Sciences 44, 470-478. https://doi.org/10.1016/j.jog.2004.10.003.

[18] Poudjom Djomani YH, Nnange JM, Diament M, Ebinger CJ & Fairhead JD (1995) Effective elastic thickness and crustal thickness variations in westcentral Africa inferred from gravity data. Journal of Geophysic Research 100, 22047–22070. https://doi.org/10.1029/95JB01149.

[19] Rudnick RL & Funtain DM (1995) Nature and composition of the continantal crust: a lower crustal perspective. Reviews of geophysics 33 (3), 267-309. https://doi.org/10.1029/95RG01302.

[20] Srivastava RK (2011) Dyke Swarms: Keys for Geodynamic Interpretation. Springer-Verlag: Berlin. https://doi.org/10.1007/978-3-642-12496-9.

[21] Tchakounté J, Eglinger A, Toteu SF, Zeh A, Nkoumbou C, Mvondo-Ondoa J, Penaye J, De Wit M & Barbey P (2017) The Adamawa-Yadé domain, a piece of Archaean crust in the Neoproterozoic Central African Orogenic Belt (Bafia area, Cameroon). Precambrian Research 299, 210-229. https://doi.org/10.1016/j.precamres.2017.07.001.

[22] Tchameni R, Pouclet A, Penaye J, Ganwa AA & Toteu SF (2006) Petrography and geochemistry of the Ngaoundéré Pan-African granitoids in central north Cameroon: implications for their sources and geological setting. Journal of African Earth Sciences 44, 511–529. https://doi.org/10.1016/j.jafrearsci.2005.11.017.

[23] Tchouankoue JP, Simeni Wambo NA, Dongmo AK & Xian-Hua Li (2014) 40Ar/39Ar dating of Basaltic dykes swarm in western Cameroon: Evidence of late Paléozoic and Mesozoic magmatism in the corridor of the Cameroon line. Journal of African Earth Sciences 93, 14-22. https://doi.org/10.1016/j.jafrearsci.2014.01.006.

[24] Toteu SF, Van Schmus WR, Penaye J & Michard A (2001) New U-Pb and Sm-Nd data from north-central Cameroon and its bearing on pre-Pan-African history of central Africa. Precambrian Research 108, 45-73. https://doi.org/10.1016/S0301-9268(00)00149-2.

[25] Toteu SF, Penaye J & Poudjom Djomani Y (2004) Geodynamic evolution of the pan-African belt in central Africa with special reference to Cameroon. Canadian Journal of Earth Sciences 41, 73–85. https://doi.org/10.1139/e03-079.

[26] Vicat J-P, Ngounouno I & Pouclet A (2001) Existence of old dolerites dykes of continental tholeiites composition in the alkaline province of the Cameroon Line. Implication to the geodynamic context. Compte Rendu de l'Académie des Sciences Paris, Sciences de la Terre et des planètes / Earth and Planetary Sciences 332, 243-249. S1251-8050(01)01526-9/FLA. https://doi.org/10.1016/S1251-8050(01)01526-9.

[27] Wood DA (1980) The application of the Th–Hf–Ta diagram to problems of tectonomagmatic classification and to establishing the nature of crustal contamination of basaltic lava of the British Tertiary volcanic province. Earth and Planetary Science Letters 50, 11–30. 0012-821X/80/0000-0000. https://doi.org/10.1016/0012-821X(80)90116-8.