Petrochemistry of Volcanic Rocks Exposed in the Chaung – Chaung Bya Area, Kawlin Township

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Abstract

The igneous rocks exposed in the The Chaung and Chaung Bya area are composed of volcanic rocks of Rhyolite, Andesite, Dacite and Basalt. Major– minor oxides and trace elements of volcanic rocks of The Chaung and Chaung Bya area are used to discuss the petrochemical characters. According to the chemical classification of various diagrams, the volcanic rocks of the study area belong to the acid to basic clan on total alkalis and silica content, with the (Na_2O+K_2O) vs SiO_2; within the field of high and low K– Series; subalkaline and calc–alkaline nature. The volcanic rocks of the study area show the calc–alkaline suit of AFM diagram, and with respect to the Fe^T + Ti–Al–Mg diagram of Jensen. According to the trace–element data, Ti–Zr–Sr and Zr/4–2×Nb–Y discrimination diagrams, all the basaltic rocks of the study area fall within the island–arc calc–alkaine basalt (CAB) and Volcanic–arc basalts field. Calc–alkaline nature of the volcanic of the study area is related to the subduction related plate tectonic process.

Keywords: trace–element, calc–alkaline, volcanic–arc basalts, subduction

Introduction

The study area, part of the Wuntho Massif, is situated within theKawlinTownship, Sagaing Division, and Northern Myanmar. It is located about 24 km north–west of Kawlin. This area is bounded by Latitude 23° 46´ N to 23° 54´ N, and Longitude 95° 27´ E to 95° 34´ E. It covers parts of 84 M/5 and 84 M/9 one inch topographic maps and UTM map sheet No.2395/05 to No.2395/09. It is about 17 km long in N–S direction and about 12.8 km wide in E–W direction covering approximately 218 square kilometers (see Fig. (1)).

Regional Geologic Setting

The Chaung – Chaung Byaarea lies in the southern part of the Wuntho Massif which is a part of central volcanic line. The Wuntho Massif is an elongated batholith trending NNE–SSW. It is about 40 km wide and 190 km long and consists of several types of igneous rocks. The Wuntho Massif includes the 75–km–long NNE trending Kanzachaung batholith in the south, the Pinhinga Plutonic Complex in the northeast, and the Taungthonlon extinct stratovolcano.Biotite and hornblende–biotite Granodiorites from the Kanzachaung batholith in theWuntho–Banmauk segment of the arc have given K/Ar biotite ages of 93.7 ± 3.4 Ma and 97.8 ± 3.6 Ma (UNDGSE, 1978a).Moreover, according to Mitchell (2017), isotope age on the Kanzachaung batholith is early Upper Cretaceous in age.

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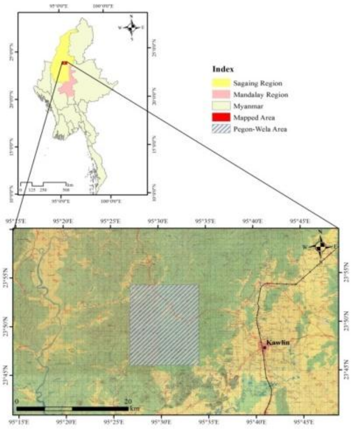


Figure (1) Location map of the study area (source: MIMU, 2010)

Materials and Methods

The present study includes field methods and laboratoryinvestigations and employs the three methods to achieve the objectives ofthe research. The three methods are (a) making landsat imageand aerialphotographic interpretation before doing the field trip, (b) detailedstudiesof outcrops and sampling applying the GPS method and (c)using the XRF analysis to discuss the major and trace element content.Systematic sample collection of rocks was done in some individual rock types. Rock samplings were made for petrological and geochemical analysis studies.

Chemical Analyses of Volcanic Rocks

General Statement

The study area consists of Rhyolite, Andesite, dacite and basaltic dykes which are studied. Samples were collected for the geochemical analysis and analyzed for both major and trace element behavior. Twenty seven representative samples of extrusive igneous rocks were investigated. These twenty seven samples are fresh, lack alteration and veining as much as possible. Analyzed samples and their locations are shown in Table (1) and Table (2). The results of the geochemical analysis of whole–rock major oxide data and trace elements of rhyolite, andesite, dacite and basalt are presented in Table (3), Table (4), Table (6) and Table (7). In the norm calculation, norms of the volcanic rocks are shown in Table (5) and Table (8).

Classification of Volcanic rocks

Volcanic rocks of the study area are plotted on total alkalis and silica content, (TAS) diagram of Le Bas et al. (1986) for the chemical classification of volcanic rocks. Major element data suggests that the study area belongs to rhyolite, dacite, basaltic andesite, andesite, basalt fields, fall in Sub–alkaline affinity and in acid to basic field, according to their position in the (Na_2O+K_2O) vs SiO_2 diagram (Fig.2).

TAS diagram (Na_2O+K_2O–SiO_2) after Middlemost, 1994 shows that the volcanic rocks of the study area are confined with rhyolite, dacite, basaltic andesite, andesite and basalt fields (Fig. 3). And also R_1–R_2 diagram of De la Roche et.alshows the classification of extrusive rocks of study area (Fig. 4).

Chemical Analysis Using Selected Major and Trace Element Diagrams

The AFM diagram (after Irvine and Barager, 1971) shows that all volcanic rocks fall in Sub–alkaline Series (Fig. 5). In SiO_2–K_2O diagram (Peccerillo and Taylor, 1976), most volcanic rocks of study area fall in low K (tholeiite series) to calc–alkaline series (Fig.6). The volcanic rock samples have a wide range in SiO_2, ranging from 51% to 78% and potassium content is high and low K series. The basaltic rocks are represented by SiO_2 (51.21–46.79 %), Al_2O_3 (21.60–11.12 %), CaO (16.92–9.34 %) and Fe_2O_3 (11.53–8.00 %), and low Na_2O (3.33–0.87 %), MgO (13.72–3.80 %) and K_2O (1.10–0.11 %) (Table.7). Total alkali content is between 1.00% and 4.44 %, showing the sub–alkaline nature of these basaltic rocks. Subalkaline series can be further subdivided into tholeiite and calc–alkaline type (Philpotts, 1990). Fe^T + Ti–Al–Mg diagram of Jensen shows calc–alkaline, subalkaline basalt and KOMATITE field. In this diagram, it can be seen that most basaltic rocks of study area are calc–alkaline (Fig. 7).

Table (1): Analyzed Samples and their Locations of the Study Area

No.	Sample	Symbol	Lithology	Location (Lat& Long)	Analysis epartment
1.	L3B5	▲	Rhyolite	N 23°49'430" E 95°33'129"	DSSTRC
2.	L12B18	▲	Rhyolite	N 23°49'20" E 95°33'154"	DSSTRC
3.	L5F4	▲	Rhyolite	N 23°47'437" E 95°29'589 "	DSSTRC
4.	L1F1	▲	Rhyolite	N 23°53'1042" E 95°30'0322 "	DSSTRC
5.	L6D7	▲	Rhyolite	N 23°51'0358" E 95°28'3579 "	DSSTRC
6.	L3S3	▲	Rhyolite	N 23°48'1386" E 95°32'5742"	DSSTRC
7.	L16 B26	▲	Rhyolite	N 23°5'2338 " E 95°27 '3128"	DSSTRC
8.	L5 C7	▲	Rhyolite	N 23°48 '2223" E 95°30'0982"	DSSTRC
9.	L9 E9	▲	Rhyolite	N 23°46'574 " E 95°31'074"	DSSTRC
10.	L5 S5	▲	Rhyolite	N 23°53'080 " E 95°32'166"	DSSTRC
11.	L7 C12	▲	Rhyolite	N 23°51'086 " E 95°32'451"	DSSTRC
12.	L1 B1+	▲	Rhyolite	N 23°51'3884" E 95°28'3275"	DSSTRC
13.	L1C1	▲	Dacite	N 23°51'019" E 95°32'376 "	DSSTRC
14.	L9 A13	▲	Dacite	N 23°48'125 " E 95°31'213 "	DSSTRC
15.	L6 S11	▲	Dacite	N 23°48'681" E 5°33'761"	DSSTRC

Table (2): Analyzed Samples and their Locations of the Study Area

No.	Sample	Symbol	Lithology	Location (Lat& Long)	Analysis epartment
16.	L14 S12	▲	Dacite	N 23°53'730 " E 95°32'704"	DSSTRC
17.	L10C15	▲	Andesite	N 23°51'396" E 95°33'034 "	DSSTRC
18.	L6E5	▲	Andesite	N 23°50'4034" E 95°30'1653"	DSSTRC
19.	L4F3	▲	Andesite	N 23°47'447 " E 95°29'595"	DSSTRC
20.	L5 A7	▲	Andesite	N 23°48'010" E 95°31'398"	DSSTRC
21.	L1 C2	▲	Andesite	N 23°48'3266" E 95°30'3432"	DSSTRC
22.	L10 F8	▲	Andesite	N 23°47'429 " E 95°29'380"	DSSTRC
23.	L13F9	▲	Basalt	N 23°47'286" E 95°29'301"	DSSTRC
24.	L10 A14	▲	Basalt	N 23°48'2408" E 95°29'022"	DSSTRC
25.	L8 S13	▲	Basalt	N 23°53'695 " E 95°32'624"	DSSTRC
26.	L11 S9	▲	Basalt	N 23°48'338 " E 95°33'929"	DSSTRC
27.	L15 D13	▲	Basalt	N 23°50'0807" E 95°28'3033"	DSSTRC

Most of the volcanic rocks have experienced various degrees and types of alteration. The TAS classification may not accurately classify the rocks because the TAS method depends upon Na and K concentrations which are relatively mobile elements. Therefore, selected minor and trace elements (e.g, Ti, Zr, Y and Nb) that are believed to be relatively immobile under conditions of metasomatism and low grade hydrothermal metamorphism are used to characterize the volcanic rocks with respect to original composition and possible tectonic environment of formation (e.g., Pearce and Cann, 1973; Winchester and Floyd, 1977).

These volcanic rocks are distinguished by TiO_2 (0.657– 0.918 %) and P_2O_5 (0.145 – 0.069 %). The Zr/TiO_2–SiO_2 discrimination diagram (Winchester and Floyd, 1977) has shown in the rhyolite, dacite, andesite, basalt field (Fig.8). This trace element classification generally agrees with the TAS classifications of (Fig. 2). The nature of the volcanic rocks of the study area is the calc–alkaline series affinity. So it can be considered that calc–alkaline nature of the volcanic of the study area is genetically related to the subduction related plate tectonic process.

Tectonic Discrimination of Basaltic Rocks

Trace element data can also provide a means to determine the tectonic setting. Trace element analyses have been used to investigate the tectonic environment of basalts from the study area. Y, Nb and Rb are utilized in tectonic discrimination diagrams as they are generally considered immobile under most geologic conditions.The analyses show mafic with SiO_2 contents lower than 53%. Most of these mafic lavas display rather low contents in compatible trace elements (Cr, Co, Ni). On the basis of the content

Table (3): Major and Minor Element Analyses (in Wt %) and Norms of the Volcanic Rocks from the Study Area

	Rhyolite												Dacite			
	L1 F1	L3 B5	L3 S3	L5 F4	L6D7	L12B18	L5 C7	L16B26	L1 B1+	L11 B17	L5 S5	L9 E9	L1 C1	L9 A13	L14S12	L6 S11
S	0	0	0	0	0	1	280	430	1241	5240	340	-	0	9660	711	7423
V	13	62	50	21	9	57	-	-	-	-	-	-	59	-	-	-
Cr	0	0	0	0	4	0	130	111	198	74	180	118	18	105	155	87
Co	22	32	33	27	33	27	-	-	-	-	-	-	18	-	6	-
Ni	13	7	6	7	8	6	-	-	-	-	-	-	24	-	-	-
Cu	0	0	0	0	0	0	-	-	60	0	-	-	0	-	-	306
Zn	0	0	0	0	0	0	-	-	20	27	20	27	0	47	-	369
Pb	0	0	0	0	0	0	-	-	-	-	-	-	0	61	-	-
As	10	2	3	1	1	8	-	-	-	-	-	-	7	-	-	-
Mo	4	3	4	4	4	3	-	-	-	-	-	-	13	-	-	-
Rb	120	1	6	16	4	8	-	-	-	-	44	-	0	-	-	-
Sr	19	120	157	64	216	107	66	264	161	-	88	183	231	103	205	161
Ba	58	0	137	37	170	24	-	-	-	-	-	-	91		-	
Y	31	26	60	48	112	35	-	-	-	-	284	519	20	-		-
Zr	90	164	226	193	233	184	133	229	30	-	44	185	151	155	207	163
Ta	0	0	0	0	0	0	-	-	-	-	-	-	0	-	-	-
Nb	11	3	5	5	12	3	-	-	-	-	-	-	0	-	-	-
Ti	503	0	3494	2002	935	2715	1597	1114	1397	1558	1450	1914	5939	2476	1809	3625

Table (4): Trace Element Analyses (in ppm) of the Volcanic Rocks from the Study Area

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Rhyolite												Dacite			
Sample ID	L1 F1	L3 B5	L3 S3	L5 F4	L6D7	L12B18	L5 C7	L16B26	L1 B1+	L11B17	L5 S5	L9 E9	L1 C1	L9 A13	L14S12	L6 S11
SiO_2	78.268	73.316	74.356	75.754	78.472	73.734	77.958	72.491	72.102	70.157	72.607	71.264	67.711	68.041	71.058	65.560
TiO_2	0.084	0.452	0.583	0.334	0.156	0.453	0.267	0.186	0.233	0.260	0.242	0.319	0.991	0.413	0.302	0.605
Al_2O_3	13.9	14.171	13.234	12.537	12.066	13.08	12.189	15.589	14.554	15.882	14.920	14.244	14.563	14.190	15.253	17.445
Fe_2O_3	0.888	2.485	2.958	2.498	1.37	2.639	1.401	1.811	1.282	1.660	1.920	2.616	6.019	4.244	2.475	5.104
MnO	0.008	0.064	0.102	0.1	0.011	0.08	0.028	0.020	0.028	0.049	0.043	0.054	0.11	0.088	0.038	0.041
MgO	0.4	1.674	1.329	2.166	0.415	1.807	0.864	0.291	1.554	2.243	0.636	1.295	1.657	1.899	0.930	3.013
CaO	0.193	1.273	1.136	0.5	2.925	0.681	0.639	3.635	3.053	0.775	2.004	3.475	4.655	1.468	4.239	0.601
Na_2O	0.433	4.724	4.388	2.798	3.588	3.963	4.473	5.577	6.555	7.219	5.499	4.759	3.384	6.344	5.260	5.232
K_2O	1.955	0.209	0.892	1.255	0.394	0.663	2.025	0.190	0.235	0.604	1.908	1.770	0.092	0.876	0.138	0.700
P_2O_5	0.001	0.068	0.102	0.035	0.009	0.046	0.055	0.039	0.083	0.086	0.062	0.066	0.299	0.061	0.084	0.055

Table (5): CIPW Norm or Wt % Norm of the Volcanic Rocks from the Study Area

	Rhyolite												Dacite			
	L1 F1	L3 B5	L3 S3	L5 F4	L6D7	L12B18	L5 C7	L16 B26	L1B1+	L11B17	L5 S5	L9 E9	L1 C1	L9A13	L14S12	L6 S11
Quartz	66.86	39.18	40.16	49.44	48.55	43.84	41.58	31.09	26.22	25.7	27.78	28.81	33.93	29.85	30.03	32.34
Plagioclase	4.58	45.81	42.2	25.94	44.93	36.58	40.31	63.87	64.28	57.5	55.64	67.28	49.84	47.93	61.66	37.2
Orthoclase	11.66	1.24	5.4	7.45	2.45	3.9	11.94	1.12	1.36	3.55	11.51	0.95	0.53	5.2	0.83	4.14
Corundum	10.71	4.03	3.17	5.75	0.38	4.72	1.67	-	-	3.49	0.35	-	1.12	2.73	-	9.01
Diopside	0	0	0	0	0	0	-	0.49	3.3	-	-	2.26	0	-	2.04	-
Hypersthene	1.75	6	5.44	7.53	2.16	5.12	2.96	1.76	2.92	5.89	2.93	-	8.75	6.47	3.01	9.99
Ilmenite	0.15	0.85	1.1	0.63	0.3	0.85	0.51	0.36	0.44	0.49	0.46	0.19	1.88	0.78	0.57	1.14
Magnetite	0.43	1.2	1.44	1.2	0.67	1.28	0.61	0.78	0.55	0.72	0.84	0.38	2.91	1.84	1.07	2.22
Apatite	0	0.16	0.23	0.09	0.02	0.12	0.12	0.09	0.19	0.21	0.14	-	0.7	0.14	0.19	0.14
Zircon	0.01	0.03	0.04	0.04	0.04	0.03	0.03	0.04	-	-	0.01	0.03	0.03	0.03	0.04	0.03
Chromite	0	0	0	0	0	0	0.03	0.03	0.04	0.01	0.04	0.03	0	0.03	0.03	0.01
Pyrite	0.02	0.04	0.08	0.04	0.02	1.51	0.04	0.06	0.21	0.89	0.06	-	0.02	1.63	0.13	1.25
Na_2SO_4	-	-	-	-	-	-	0.11	0.16	0.44	1.86	0.12	-	-	3.42	0.25	2.63
Total	96.17	98.54	99.26	98.11	99.52	97.95	99.91	99.85	99.95	100.1	99.88	99.94	99.71	100.5	99.85	100.1
DI	83.1	86.2	87.8	82.8	95.9	84.3	93.8	96.1	91.9	86.8	94.9	90.7	84.3	83	92.5	73.7

Table (6): Major and minor Element Analyses (in Wt %) and Norms of the Volcanic Rocks from the Study Area

No.	17	18	19	20	21	22	23	24	25	26	28
	Andesite						Basalt				
Sample ID	L4 F3	L6 E5	L10C15	L5 A7	L1 C2	L10 F8	L13 F9	L10 A14	L8 S13	L11 S9	L15 D13
SiO_2	54.242	53.682	51.954	51.705	56.307	55.842	48.032	47.097	47.102	46.790	51.210
TiO_2	0.813	0.752	1.026	0.918	0.619	0.672	0.906	0.764	0.918	0.657	0.689
Al_2O_3	14.794	14.774	9.966	17.102	17.560	18.906	15.821	21.069	21.602	14.784	17.036
Fe_2O_3	7.475	9.668	6.019	11.846	5.953	7.838	11.196	9.824	11.538	10.166	10.497
MnO	0.151	0.249	0.275	0.225	0.101	0.144	0.286	0.140	0.187	0.188	0.250
MgO	7.189	6.363	3.882	7.433	8.063	4.126	6.959	4.635	3.809	10.647	5.906
CaO	7.359	11.384	11.453	5.109	5.353	6.836	13.194	13.553	10.402	15.281	9.343
Na_2O	2.445	1.659	0.438	5.028	3.925	3.877	1.136	2.324	2.815	0.946	3.339
K_2O	1.391	0.267	0.05	0.428	1.745	1.278	0.533	0.298	0.765	0.112	1.108
P_2O_5	0.194	0.056	0.379	0.071	0.149	0.222	0.069	0.079	0.145	0.084	0.137

Table (7): Trace Element Analyses (in ppm) of the Volcanic Rocks from the Study Area

	Andesite						Basalt					
	L4 F3	L6 E5	L10C15	L5 A7	L1 C2	L10 F8	L13 F9	L10 A14	L8 S13	L11 S9	L7 E6	L15 D13
S	0	0	0	205	285	395	0	390	3088	556	440	335
V	224	334	91	369	-	-	403	307	-	356	276	-
Cr	399	194	0	-	192	-	234	105	142	650	1312	2154
Co	66	13	33	39	19	19	23	13	39	45	32	26
Ni	168	77	3	-	58	-	86	-	-	-	136	-
Cu	0	0	0	-	399	53	0	60	67	93	126	-
Zn	0	0	0	87	54	81	0	54	87	67	54	114
As	22	8	0	-	-	-	12	-	-	-	-	-
Mo	19	13	0	-	-	-	12	-	-	-	-	-
Rb	44	4	1	-	44	-	17	-	-	-	0	44
Sr	506	226	40	81	308	439	210	315	256	132	88	220
Ba	527	59	8	-	-	-	93					
Y	17	8	54	-	-	600	11	-	-	-	-	-
Zr	134	57	105	44	126	185	24	-	89	59	30	96
Nb	0	0	3	-	-	-	0	-	-	-	-	-
Ti	4873	4507	6149	5501	3708	4030	5208	4578	5503	3937	2171	4132

Table (8): CIPW Norm or Wt % Norm of the Volcanic Rocks from the Study Area

	Andesite						Basalt				
Weight % Norm	L4 F3	L6 E5	L10C15	L5 A7	L1 C2	L10 F8	L13 F9	L10 A14	L8 S13	L11 S9	L15 D13
Quartz	7.66	10.33	24.06	-	1.95	5.77	1.17	-	-	-	-
Plagioclase	45.77	46.06	28.8	65.25	58.2	62.73	47	65.58	65.92	43.44	56.27
Orthoclase	8.65	1.67	0.3	2.54	10.28	8.07	3.2	1.77	4.55	0.65	6.56
Diopside	8.35	19.6	23.67	1.6	0.26	1.8	23.95	16.62	3.71	31.38	13.85
Hypersthene	20.33	15.27	3.03	9.82	24.47	15.63	15.79	3.37	16.37	11.3	13.47
Olivine	-	-	-	12.71	-	-	-	5.78	0.06	6.14	2.21
Ilmenite	1.54	1.42	1.96	1.75	1.18	1.27	1.65	1.44	1.75	1.25	1.31
Magnetite	3.61	4.67	2.91	5.15	2.6	3.41	5.54	4.28	5.02	4.42	4.57
Apatite	0.44	0.14	0.88	0.16	0.35	0.51	0.16	0.19	0.35	0.19	0.32
Zircon	0.03	0.01	0.01	0.01	0.03	0.04	0	-	0.01	0.01	0.01
Chromite	0.09	0.03	0	-	0.04	-	0.04	0.03	0.03	0.13	0.46
Pyrite	0.04	0.04	0.06	0.04	0.04	0.06	0.21	0.06	0.53	0.08	0.06
Na_2SO_4	-	-	-	0.07	0.11	0.14	-	0.14	1.1	0.2	0.12
Total	96.51	99.24	85.68	99.1	99.51	99.43	98.71	99.26	99.4	99.19	99.21
DI	62.1	58.1	83.2	67.8	70.4	76.6	51.4	67.4	70.5	44.1	62.8

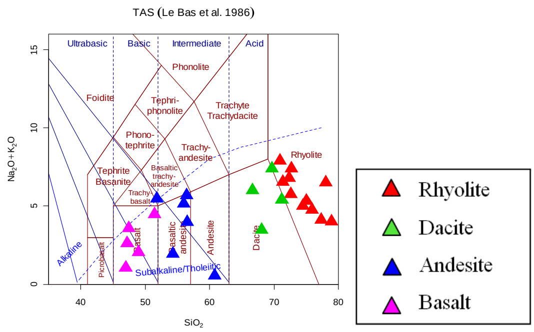


Figure (2): TAS diagram (after Le Bas et al, 1986) showing the volcanic rocks of the study area falling in subalkaline affinity and in acid to basic group

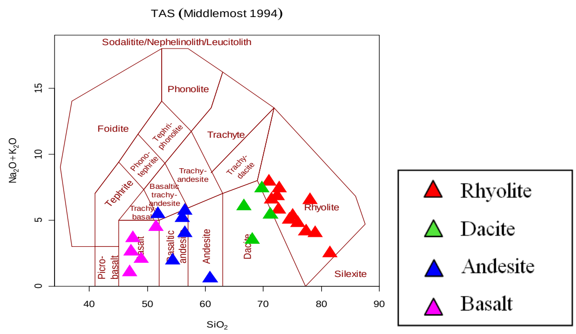
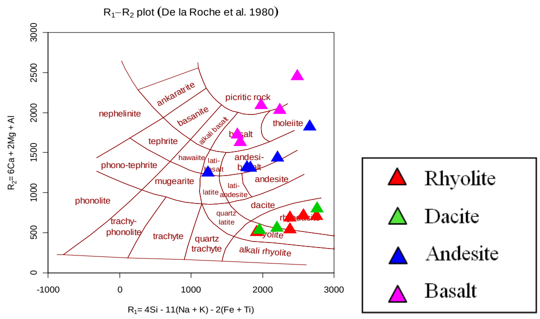


Figure (3): TAS diagram of study Middlemost that shows the classification of extrusive rocks of the area



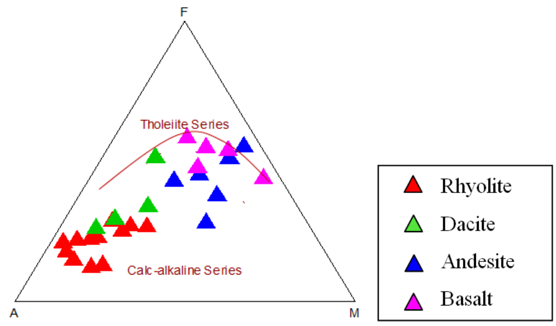
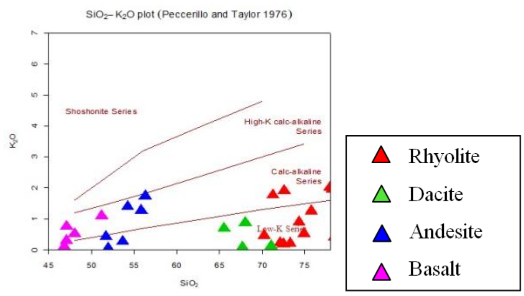


Figure (4): R1–R2 diagram of De la Roche et.alshowing the classification of extrusive rocks of study area

Figure (5): The AFM diagram (after Irvine and Barager, 1971) showing Tholeiite Series and Calc–alkaline Series



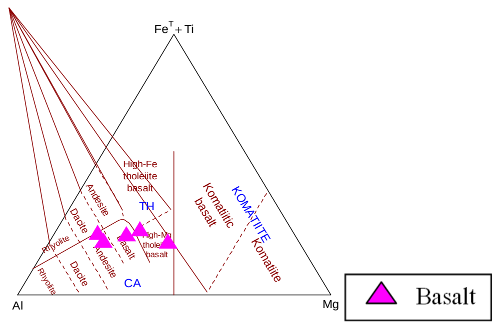


Figure (6): SiO_2–K_2O diagram of Peccerillo and Taylor showing Shoshonite Series, High K calc–alcaline series, Calc–alcaline series and Low K Series

Figure (7): Fe^T + Ti–Al–Mg diagram of Jensen showing TH (tholeiite), CA (calc–alcaline) and KOMATITE

of minor elements Zr and Sr, Pearce and Cann (1973) have divided basalts into different tectonic settings; island–arc tholeiites (IAT), calc–alkali basalts (CAB) and mid–ocean ridge basalt (MORB). In the Ti–Zr–Sr discrimination diagram, the basalts under present investigation area fall within the CAB field (Fig.9). This trace element analysis agrees with the Fe^T+Ti–Al–Mg diagram of Jensen (Figs.7).

Silica ranges 46.79 – 51.21 % SiO_2 of basalts are plotted in the MnO–TiO_2–P_2O_5 discrimination diagram (after Mullen, 1983); the fields are MORB; OIT–ocean–island tholeiite or seamount tholeiite; OIA–ocean–island alkali basalt or seamount alkali basalt; CAB–island–arc calc–alkaine basalt; IAT–island–arc tholeiite; Bon–boninite. The MnO – P_2O_5 values are multiplied by 10 in order to expand the plotted fields. The basaltic rocks of the study area fall in the IAT, CAB setting and one sample fall in Bon setting. The boninite field occupies the MnO–rich sector of the CAB field. On a triangular plot of Zr/4, 2×Nb and Y (Fig. 10), Meschede (1986) shows that four main basalt fields, can be identified. Within–plate alkali basalts plot in field AI; within–plate tholeiites plot in fields AII and C. E– type MORB plots in field B whilst N– type MORB plots in field D. Volcanic–arc basalts also plots in fields C and D. From this trace element discrimination diagram, it is clear that all the basaltic rocks of the study area fall in Volcanic–arc basalts (field D) (Fig. 11).

Conclusion

Therefore, Major element data suggests that the study area belongs to rhyolite, dacite, basaltic andesite, andesite, basalt fields, arefallen in Sub–alkaline affinity and in acid to basic group in TAS plot. The AFM diagram shows in Tholeiite Series and Calc–alkaline Series. Fe^T + Ti–Al–Mg diagram falls in calc–alcaline field. The basaltic rocks of the study area fall in the IAT, Bon and CAB setting. Ti–Zr–Sr discrimination diagram shows that basalts of study area falls within the calc–alkali basalts (CAB) field. The calc–alkaline nature of the volcanic of the study area is genetically related to the subduction related plate tectonic process.

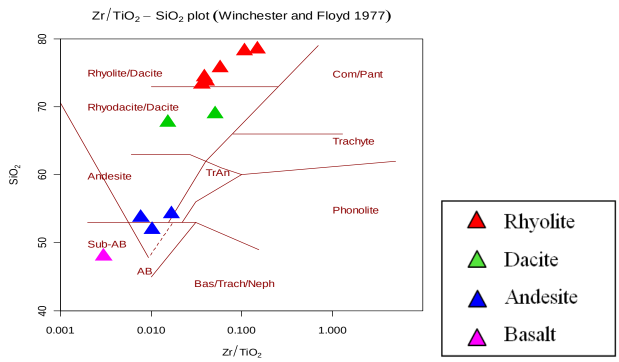


Figure (8): Trace element discrimination diagram showing classification of volcanic rocks of the study area (After Winchester and Floyd, 1977)

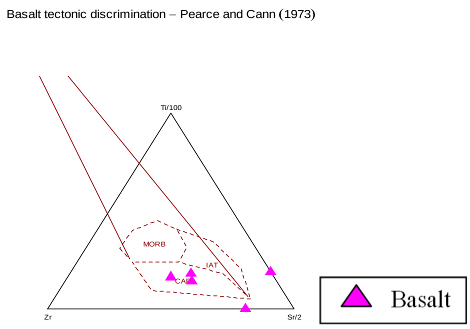


Figure (9): Ti–Zr–Sr discrimination diagram showing MORB, IAT and CAB field (after Pearce and Cann, 1973 in Rollinson, 1995)

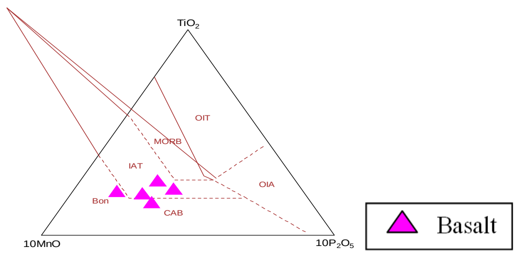


Figure (10): The $MnO–TiO_2–P_2O_5$ discrimination diagram for basalts of study area belongs to CAB–island–arc calc–alkaine basalt; IAT–island–arc tholeiite; Bon–boninite (after Mullen, 1983)

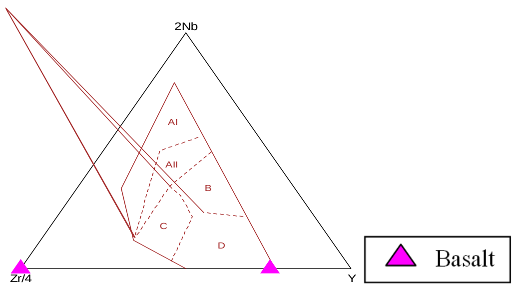


Figure (11): The 2Nb–Zr/4–Y discrimination diagram for basalts after Meschede (1986), the study area fall in Volcanic–arc basalts.

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