Rock Sequences and Petrography of the Popa – Kyauktaga Area, Kyaukpadaung Township, Mandalay Region

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Abstract

The present area is the northwestern part of Mt.Popa region which lies in the Central Volcanic Line of Late Cretaceous in Myanmar. The main four types of rock sequence are observed in the area: Kyauktaga-Legyi agglomerate (KL_A), basaltic lavas (V_5), black tuffs and andesitic lavas (V_3) and Popa andesite(P_A). The Irrawaddy Formation is well developed in the northwestern part of the area. The Popa andesite rocks are well exposed at the Popa village and found as irregular large boulders. They also capped the Irrawaddy sand rocks. The V_{3-} flow is well exposed on the western flank of Mt.Popa volcano. Sometimes, this lava flow shows slagg and ropy structure. Andesitic tuffs also have been associated with this unit. In the upper portion of this flow, the phenocrysts of hornblende, augite and plagioclase are relatively larger size than those of the lower portion. The V_5 flow is one of the last major flows on the northwestern slope of Mt. Popa cone and highly distributed near the Taungbaw village and found in the plantation area. At the northwestern end, this lava breaks up into partially cooled blocks which roll over one another and occur as blocks one upon the other. The phenocrysts of olivine have not been recognized in the middle portion of V_5 - flow basalt. Kyauktaga - Legyi agglomerate unit extends as far north as the legyi village about 10.4 km from the crater. They consist of volcanic ash, tuff, pumice, scoria and unsorted volcanic fragments.

Keywords: Mt. Popa Volcano, Central Volcanic Line (CVL), Petrography, Irrawaddy Formation

Introduction

Popa area lies in Kyaukpadaung Town-ship, Myingyan District, Mandalay Division and located about 10 miles NE of Kyaukpadaung where is readily accessible by car throughout the year. This area lies between North latitudes 20° 55' to 20° 58' and East longitudes 95° 11' 6" to 95° 15' 20" which is bounded by vertical grids 40 to 46 and horizontal grids 53 to 61 of the one-inch topographic maps 84 P/1 and 84 P/5. The areal coverage is about 14 square miles. The location of study area is shown in figure (1).

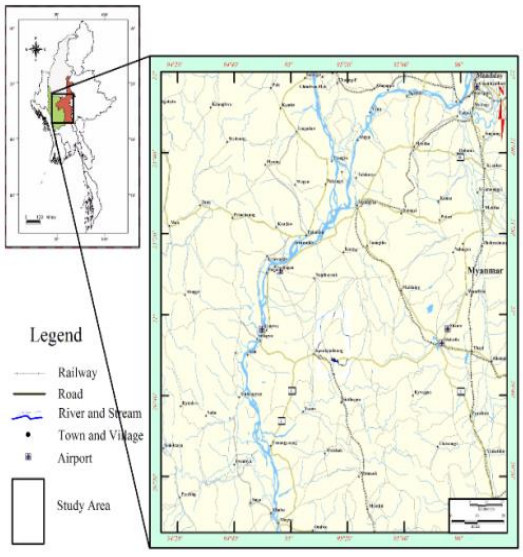


Figure. 1. Location map of the study area

Rock sequence

General statement

In Mt.Popa area, the volcano rocks have been observed overlying the Irrawaddy Formation. The most widely distributed rock types were basalts and andesites in this area. There are ten flows of lava and pyroclastics in the whole area of Mt. Popa volcanic terrain (Aung Moe, 1980). The four main rock flows were observed in the study in the study area. These are as followings;

4- KL_A, Kyauktaga-Legyi agglomerate
3- V_5, Basaltic lava [northwestern flow
2- V_3, Black tuff and andesite lavas
1- P_A, Popa Andestie

Popa plateau andesite

These rocks are well exposed at the Popa village. The plateau on which Popa village itself in situated is built up Irrawaddy sand rocks, black tuff, agglomerate and lava. This plateau is table landform and capped by agglomerate and lava. It is about 1900 feet above sea level. They are found as irregular large boulders shown in figure (2). These rocks are unconformably overlain on the Irrawaddy sand rocks (Fig. 3).

Popa andesite is generally a coarse-grained sandy ash that often passes into coarse tuff in which the fragments of andesitic rock have been cemented by finer ash. These rocks are light-grey in color and contain black phenocrysts of augite and hornblende and patches of feldspar laths. This lava flow is about 5-100 feet in thickness.

V_3-Andesitic lava flow

These rocks are well exposed on the western flank of Mt. Popa at some 500 feet above the plateau level, on the eastern and western sides of northern region and relicts of the part of the northern flank such as Taungbaw and Ngayangon flows of Chhibber (1934). Andesitic tuffs have also been observed .There is a slight westerly slope which is covered especially around its margin with numerous blocks. These blocks of various size and most of them make water warm and form a tumultuous assemblage lying upon an irregular of the Irrawaddy sand rock. The lava flow shows slaggy and ropy structures in figure (4).

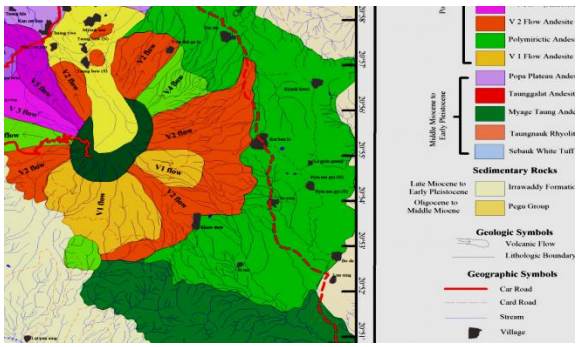


Figure. 2. Photograph showing the exposure of Popa Plateau Andesite. (Loc:568442)

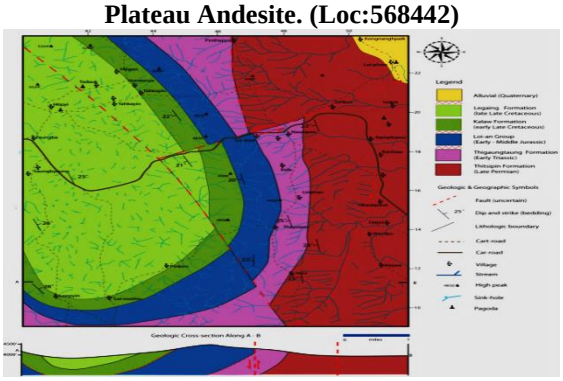


Figure. 3. Photograph showing the unconformable contact between Popa Plateau andesite and Irrawaddy Formation. (Loc:553407)

Figure. 4 Photograph showing the ropy structure of V_3- flow in the Kyauksitma Chaung. (Loc: 576443)

This rock is generally light grey in color, often with purplish grey color due to the weathering and is characterized by short rounded augite crystals which are densely distributed. The rock consists of smaller and more even grains of phenocrysts than the other igneous rocks present in the area. The exposure of black tuff occurred surrounding Taungbaw village is shown in figure (5). It occurs as a pile of marginal blocks with a about 15 m in thickness on the northern side of the crater which was blown apart.

Figure. 5. Photograph showing the ragged surface of scorinaceous black tuff in the V_3- unit at the Hnatmyatnar Taung (Loc:597435)

V_5-Basaltic lava flow

This is one of the last major flows north-western slope of Mt. Popa cone and well distributed near the Taungbaw and found in the plantation area in the vicinity of the Mt.Popa. These rocks are grouped in the north-western flow which is called hornblende-augite basalt by Chhibber (1934). They occur as blocky lava along the stream near the Kyauktaga village. At the northwestern end, the lava flow breaks up into partially cooled blocks which roll over one another. The evidence of such flow behavior is that the basalt occurs as blocks one upon the others (Fig. 6).

The rock is generally dark grey to black but often purplish in color. The phenocrysts of olivine, augite and hornblende can be observed.

Figure. 6. Photograph showing the basalt exposure of the V_5- flow. (Loc:572437)

Kyauktaga –Legyi Agglomerate

This rock unit is highly distributed between Kyauktaga and Legyi villages (Fig. 7). Mt. Popa originally would have a circular crater but the whole of northern side was blown away, probably by the final paroxysmal outburst. The outburst reached as far north as the Legyi village which marks the northern limit of the agglomerate. This unit covers about 6.5 miles from

crater to Legyi village. In the east of Gyaingywa, these roads are observed as bombs and blocks in the stream section. They are occurred as ash layers in the stream section (Fig. 8). The ash layers are also observed in the plantation area of Ngayangon and Taungbaw villages.

This rock unit is generally grey and light grey in color which consists of bomb, block, lapalli and ash. These blocks are the fragments of basalts and andesites. This rock type is agglomerate which consists of consolidated ash, various sizes of basalt and andestie fragments (Fig. 9). Aggregation of lamprobolites, pumices, and scorias are also observed in this unit. This unit is about 15 m in thickness in the stream sections.

Figure. 7. Photograph showing the massive, unsorted volcanic agglomerate with some blocks more than 0.7m across. Eastern side of Kyaukpadaung-Myingyan car road, 5.5km due north of Mt. Popa volcano (Loc: 599471)

Figure. 8. Photograph showing the massive, unsorted ash-flow tuff, exposed along the chaung section, just west of Taungbaw village. (Loc: 596405). (Exposure is about 15 m high)

Figure. 9. Massive, unsorted agglomerate studded with fragments of andesitic rock and minor amount of pumice. KLA Unit, at the mouth of opening crater of the Mt. Popa volcano. (Loc: 586439).

Sedimentary Rock

Irrawaddy Formation

This unit is well developed in the western part of the study area and overlain by the younger volcanic, in some places they are intercalated with older volcanics. The dip amount ranges from 20° to 30°. It is composed of medium to coarse grained buff colored sandstone, medium to thick bedded interbedded with mud stone and shale. The exposed thickness of this formation is different in places. Generally, it may be considered to be about 20000 feet in thickness.

Although fossils are not abundantly present, vertebrate bones, silicified fossil woods and burrow structures are found this formation. Referring to the eastern continuation of the study area, the Irrawaddy formation unconformably overlies the Khabo sandstone. According to this relationship age of the Irrawaddy Formation may be regarded as Upper Miocene to Pliocene. This formation may be considered to be deposited in a non-marine environment due to the presence of locally abundant wood fossils. The lithologic attributes and sedimentary structural assemblages also suggest that this formation is deposited under the fluvial environment.

Petrography

Popa Plateau Andesite (Augite andesite)

The rock has a holocrystalline groundmass in which phenocrysts of augite, olivine and plagioclase are present. Thus, it is shows the physic texture. Augite phenocrysts are euhedral to subhedral form and (0.6 - 4.0 mm) in size. Cognate crystals of olivine and augite also observed (Fig. 10).

Olivine is also noted as phenocrysts which is 0.9 mm maximum in diameter. They have often been altered to iddingsite especially around the margin and occasionally along the cracks. Plagioclase also occurs both as phenocrysts and microlites in the groundmass. The composition of phenocrysts is in the range from andesine to acid labradorite (An_{37}-An_{55}). Size of the phenocrsts is range from 0.5 mm to 1.5 mm in diameter. Zoning is dominant in most phenocrysts of plagioclase. Twinning is very well recognized as the albite, carlsbad and polysynthetic twins. Subophitic texture is noted in the phenocrysts of augite and feldspar laths in thin section. Subpilotaxitic texture is also observed by the sub-parallel alignment of feldspar laths (Fig. 11).

V_3 - flow andesite

The samples were collected from different levels along the V_3 flow to examine the variation or differentiation of crystallization between early phase and later phase.

Lower portion of the flow (Augite-hornblende andesite)

The rock contains phenocrysts of hornblende and augite in groundmass which is pertaining to the glassy matrix. The type of hornblende is lamprobolite.

Lamprobolite phenocrysts are bright yellowish brown colour, euhedral to subhedral form and it is more common than pyroxene in andesite as whole. Some hornblende is partically replaced by a mixture of augite, magnetite and feldspar. In thin section, they are heavily rimmed by titaniferous mangnetite. They are clearly and early crystallizing in primary phase. Corroded rim can also be observed (Fig. 12).

Augite phenocrysts are subhedral form and pale green in colour under P.P.L and zoning is present. It is partly replaced by hornblende that occur as poikilitic texture. The groundmass contain feldspar microlites, augite and magnetite granules in the glassy matrix. Plagioclase microlites are crudely aligned around the hornblende phenocryst and showing the pilotaxitic texture (Fig. 12).

Upper portion of the flow (Honblende-augite andesite)

In thin section, it is the same in mineralogically but texture is fairly different from those of the lower portion. The phenocryst of lamprobolite, augite and plagioclase are relatively larger size than its early phase and corroded border and zoing are present. Plagioclase occurs as both phenocryst and groundmass and composition is andesine. Small grain of anhedral augite, magnetite and feldspar microlaths are embedded in hyalocrystalline groundmass that has shown by felty texture.

V_5 - Lava flow basalt

The V_5 - Lava flow basalt has been studied in there portions such as lower, middle and upper portions.

The lower portion (Hypersthene basalt)

The phenocrysts of hornblende, augite, olivine, hypersthenes and plagioclase feldspar are embedded in the groundmass. Horblende pheno -crysts are bright yellowish brown color, subhedral to euhedral form and with decomposed rims which in opaque Fe-Ti oxides can be observed (Fig. 13).

Olivine is present as the phenocrysts with minor amount and subhedral to euhedral form with many fractures. They have been altered to iddingsite along the cracks. Augite phenocrysts are subhedral form and pale green in color under P.P.L and corroded nature is present.

The phenocrysts of plagioclase feldspar are most abundant and have the composition of labradorite to bytownite (An_{53}–An_{75}) range. Zoning is very predominant in most phenocrysts of the feldspar laths. Twinning is very well recongnized as the albite, carlsbad and penetration twins (Fig. 14). Subophitic texture and subpilo- taxitic texture are also observed. Hypersthene phenocrysts is rather developed (Fig. 15). The groundmass consists of fine-grained granules of augite, magnetites and feldspar microlites and appear as intersertal texture.

The middle portion (Olivine free basalt)

The rock has a microcrystalline groundmass in which the phenocrysts of hornblende, hypersthene, augite and plagioclase are present. Hornblende occurring as phenocrysts is a dark reddish brown lamprobolite. It has bright pleochroism of yellowish brown to reddish brown color with altered rims of an opaque are mineral. It occurs as phenocrysts up to 3.4 mm in length. In some section, it is decomposed to form aggregates of fine-grained magnetite (Fig. 16).

Augite phenocrysts occur subhedral crystals with corroded rims of magnetite and hematite. The minor amount of hypersthene phenocrysts are also observed. The phenocrysts of feldspar have zoning and twinning (Fig. 17). The orientation of feldspar laths showing the pilotaxitic texture (Fig. 17). The ophitic and subophitic textures are also observed where plagioclase laths are projecting into augite crystals. The groundmass is composed of fine-grained augite, plagioclase microlites and magnetite. The crystals of augite are partly enveloping some of the feldspar laths and partly interstitial between them.

The upper portion (Olivine augite basalt)

The phenocrysts of olivine, hyperstene, augite and plagioclass feldspar laths are observed in holocrystalline groundmass. Olivine is present as subhedral to euhedral phenocrst with many fractures (Fig. 18). Augite occurs as subhedral phenocryst up to 1.8 mm in length. Twinning is also observed (Fig. 19). Hypersthene is observed as phenocrysts with little amount. The phenocrysts of plagioclase feldspar are most abundant. Zoning is present in feldspar laths. The most feldspar laths are altered to sericite and geniculated twin also observed (Fig. 20). The groundmass is holocry- stalline and made up of plagioclase microlites, granules of augite and magnetite. The orientation of plagioclase crystals is subparalled and show pilotaxitic texture. The three portions are different in mineralogy. The lower portion has abundant plagioclase, less amount in olivine and presence of lamprobolite.

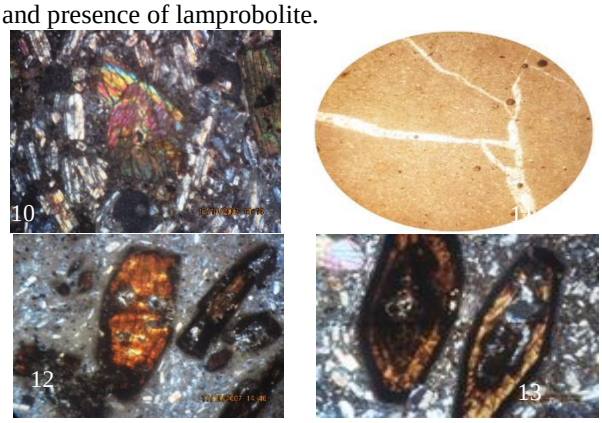


Figure.10. Cognate crystal of olivine and augite in Popa plateau andesite, 30X,X.N (Loc:56442)

Figure 11. Plagioclase phenoclasts showing the subpilota- xitic texture in Popa

The middle portion is absent in olivine and less amount in lamprobolite. The upper portion has less amount in olivine, abundant plagioclase and absence of lamprobolite. plateau andesite 30X,X.N (Loc:56442), 12.Hornblende with corroded border and pilotaxitic texture in felty groundmass; V_3 30X,X.N (Loc:58544) and 13.

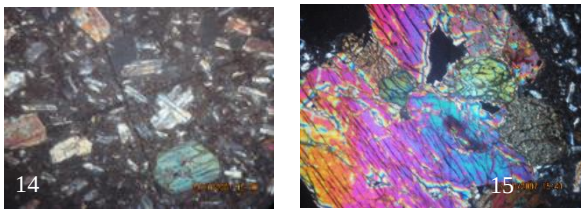
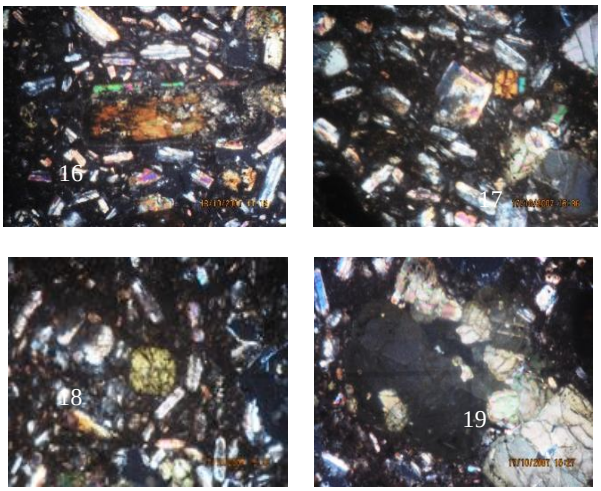


Figure 14. Plagioclase feldspar laths showing penetration twin in V_5 30X,X.N (Loc:575438) and 15. Larger phenocryst, cognate crystal of hypersthene and olivine in V_5 30X,X.N (Loc:575438)



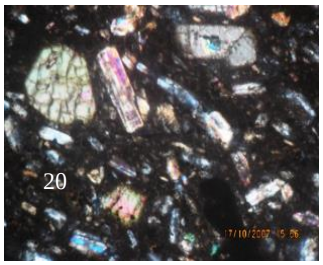


Figure 16. Decomposed hornblende remnant in core, surrounded by plagioclase laths showing pilotaxitic texture in V_5 flow basalt. 30X,X.N (Loc:585420), 17. Phenocrysts of feldspar show zoning, twinnign and pilotaxitic texturein hyalocrystalline matrix. 30X,X.N (Loc:585420), 18.Olivine phenocrysts, suborientation of plagioclase laths microphenocryst and numerous magnetite cluster in hyalocrystalline matrix in V_5 flow basalt. 30X,X.N (Loc:599411), 19. Large phenocryst of augite show twinnig in V_5 flow basalt. 30X,X.N (Loc:599411) and 20. Olivine phenocryst, micro-phenocrysts of geniculated plagioclase in hyalocrystalline matrix in V_5 flow basalt. 30X,X.N (Loc:599411).

Lamprobolite with corroded rim, showing alterration in the core of crystals, subpiloraxitic rexture groundmass in V_5 30X,X.N (Loc:575438).

Using the chemical analysis data of Chhibber (1934), Amose (1978), Stephenson and Marshall (1984) (Tables. 2 & 3), volcanic rocks of the study area are plotted in the TAS classification - diagram of Le Bas *et al*. (1986). TAS diagram indicated that most of them are in the basalt and basaltic andesite fields (Fig. 21).

Table 1. The modal composition of representative sample of the study area (in volume percent)

Rock Type	Popa plateau andesite	V_3-lava flow		V_5-lava flow		
		Lower	Upper	Lower	Middle	Upper
Locality	565442	585441	592422	575438	585420	599411
Plagioclase	20	10	7	14	10	15
Hamblende	-	20	19	6	5	-
Augite	16	5	10	7	6	8
Olivine	5	-	2	9	-	10
Hypersthene	-	-	-	5	2	2
Groundmass	59	65	62	59	77	65
Total	100	100	100	100	100	100

Table 2. XRF analyses of Pliocene and Pleistocene lavas from the study area. Source; from Chhibber (1934)

	V_3-flow	NW-flow	NW-flow	V_3-flow	P_A	NW-flow	V_3-flow	V_3- flow
SiO_2	49.4	47.4	51.83	54.21	51.21	55.42	54.98	52.56
L_2O_3	20.35	21.8	17.73	18.48	17.59	16.73	17.13	17.85
FeO	10.25	10.05	4.16	1.16	3.93	4.24	2.57	5.36
Fe_2O_3			3.82	6.06	6.09	3.00	5.85	4.51
CaO	12.10	12.25	10.44	8.08	2.60	2.00	1.82	2.18
MgO	4.78	5.68	5.70	4.02	12.15	11.82	9.95	11.33
TiO_2	-	-	0.83	0.58	0.33	0.25	0.17	0.25
P2O5	-	-	0.21	0.33	0.13	0.08	0.17	0.11
MnO	-	-	0.14	0.13	0.14	0.13	0.13	0.17
Na_2O	2.50	1.96	2.87	2.98	2.92	2.70	2.97	2.86
K_2O	1.06	1.08	1.21	2.44	1.61	1.36	1.97	1.28
BaO	-	-	0.08	0.14	-	-	-	-
CO_2	-	-	-	-	-	-	-	-
H_2O	-	-	± 0.78	± 1.66	-	-	-	-
Lol	-	-	-	-	1.12	0.86	1.20	0.52
Total	1002.24	100.22	99.8	100.26	99.65	98.64	98.91	98.98

Table 3. XRF analyses of Pliocene and Pleistocene lavas from the study area Source; from Stephenson & Marshall (1984)

		Ol-Cp-Bas		Cp-Am-Bas & BA		
	XRF	XRF	XRF	XRF	XRF	XRF
SiO_2	50.14	50.14	50.93	53.26	50.23	52.86
TiO_2	0.81	0.87	0.85	0.72	0.93	0.75
AL_2O_3	18.30	17.08	16.59	16.10	17.04	17.09
Fe_2O_3	2.99	4.03	4.69	2.86	6.09	5.27
FeO	5.43	5.36	3.93	4.29	2.43	2.57
MnO	0.14	0.14	0.13	0.11	0.13	0.12
MgO	4.02	6.22	6.09	6.56	5.72	4.79
CaO	10.66	10.87	10.79	10.01	10.22	9.44
Na_2O	2.59	2.56	2.52	2.43	2.40	2.88
K_2O	1.11	1.36	1.66	1.50	1.95	2.17

P_2O_5	0.17	0.22	0.21	0.18	0.22	0.28
Lol	1.48	0.52	1.12	0.86	4.58	1.20
Total	99.84	99.37	99.51	98.88	101.94	99.42
Q	0.17	0.28	2.34	4.99	3.24	5.13
Or	6.66	8.12	9.96	9.03	11.82	13.40
Áb	22.25	21.89	21.65	20.95	20.95	24.78
An	35.62	31.47	29.54	29.18	30.78	27.70
Di	13.69	17.32	18.51	10.16	15.40	14.00
Hy	15.18	12.77	8.91	13.59	7.50	5.66
Mt	4.41	5.91	6.91	4.23	5.71	6.61
Il	1.56	1.67	1.64	1.40	1.81	1.45
He	-	-	-	-	2.32	0.80
Ap	0.41	0.51	0.49	0.42	0.52	0.66
DI	29.09	30.29	33.94	34.97	34.90	42.95

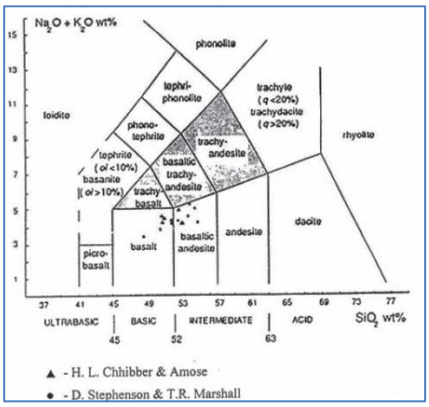


Figure. 21. Chemical classification and nomenclature of volcanic rocks using the total alkali versus silica (TAS) diagram (after La Bas *et al*, 1986)

Conclusion

The present area is the northwestern part of Mt. Popa region which lies in the Central Volcanic Line of Late Cretaceous in Myanmar. These rocks cover all the plain with the layer of agglomerate which is underlain by Popa andesite. The V_3, Andesitic Lava flows are well exposed on the western flank of Mt.Popa at some 500 feet above the plateau level, on the eastern and western sides of nothern region and relicts of the part of the northern flank such as Taungbaw and Ngayangon flows. The Basaltic lava flow occurs as blocky lava along the stream near the Kyauktaga village. At the northwestern end, the lava flow breaks up into partially cooled blocks which roll over one another. The final explosion, which mainly gave rise to tremendous amount of pyroclastic ejecta (i.e. Kyauktaga-Legyi Agglomerate Unit) is most responsible for the northern flank of the volcanic cone to be blown out.

It is distinctly investigated that most of the lava flows overlie the Irrawaddy Formation. Thus, it may be concluded that the volcanic activity of the study area started in Late Pliocene time. In Popa Plateau Andesite, augite phenocrysts are euhedral to subhedral form. Cognate crystals of olivine and augite also observed. The plagioclase phenocrysts showing the subpilotaxitic texture in Popa plateau andesite. The V_3 flow shows the variation or differentiation of crystallization between early phase and later phase. Lower portion of the flow is augite-hornblende andesite.

The type of hornblende is lamprobolite. Plagioclase microlites are crudely align around the hornblende phenocryst and showing the pilotaxitic texture. The phenocryst of lamprobolite, augite and plagioclase are relatively larger size than its early phase and corroded border and zoning are present in upper portion. The V_5 - Lava flow basalt have been studied in there portions such as lower, middle and upper portions. In the lower portion, it is composed of hypersthene basalt, olivine free basalt is occurred in middle and olivine augite basalt is found in upper portion. By using the chemical analysis data of Chhibber (1934), Stephenson and Marshall (1984) (Tables. 2 & 3), volcanic rocks of the study area are plotted in the TAS classification - diagram of Le Bas *et al.* (1986). TAS diagram indicated that most of them are in the basalt and basaltic andesite fields.

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References

Aung Moe (1980), Petrology and structures of the Rocks of Mount Popa Area, Kyaukpadaung Township: *M.Sc. Thesis, Unpub*, University of Rangoon.

Chhibber, H.L. (1934), Geology of Burma*:* London, Mac. Millan.

Le Bas M J, Le Maitre R W, Streckeisen, A Zanettin B, (1986). A Chemical Classification of Volcanic Roccks base in the total alkali-silica diagram. *Journal of petrology 27,* p.745-750

Stephenson, D. & T.R. Marshall (1984). The Petrology and mineralogy of Mt.Popa Volcano and the nature of the Late-Cenozoic Burma volcanic-Arc, *Geol. Soc.* London, Vol. 141.

Williams, H., F.J. Turner and C.M, Gilbert (1983). Petrography. 2nd edition, Freeman Co., San Francisco.