Geomorphology of Mount Popa and its Environs, Kyaukpadaung Township, Mandalay Region

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Abstract

The studied area is located about 8-miles northeast of Kyaukpadaung Township, Mandalay Region. Mt. Popa is a volcanic mountain occupying the middle part of Central Volcanic Line of Myanmar. It is an ancient volcano. Originally, its crater may have assumed a circular shape. However, it now has a horse-shoe shape as its northern end was blown away, probably by a big volcanic eruption at a later time. This region is now fingered by numerous geological processes mainly fluvio-volcano and volcano-denudation. The most obvious landforms originated by those processes are volcanic cone, volcanic crater, lava plateau, volcanic neck, northern paroxysmal outburst flank, mesa, lava flows, volcanic foot slope and flat terrain.

Introduction

Location

The studied area located about 8-miles northeast of Kyaukpadaung Township, Mandalay Region. This area falls in one-inch topographic maps 84 P/1 and 84 P/5. Mt. Popa is a volcanic mountain with an area of about 50 square miles, occupying the middle part of Central Volcanic Line of Myanmar. Location map of the studied area is shown in (Figure 1).

Physiography

Mt. Popa is a greenish landmark arising out of the dry zone of Central Myanmar. Although the main mountain is only about 3000 feet high from its base, it appears as a great mountain as it dominates the surrounding flat plain. It is an ancient volcano. Originally, its crater may have assumed a circular shape. However, it now has a horse-shoe shape as its northern end was blown away, probably by a big volcainc explosion at a later time. The most prominent peaks in the crater rim are Hmanpya Taung (4981') at southeastern part, Sabapon Taung (4801') at southwestern rim and Saemon Taung (4502') at the western rim. On the southwestern slope Taunggalat (2417') is a precipitous peak which is the in filled neck of a subsidiary volcano.

Aims and Objectives

(1) To study the geomorphology of Mt. Popa and its environs

(2) To interpret the environmental hazards of the study area

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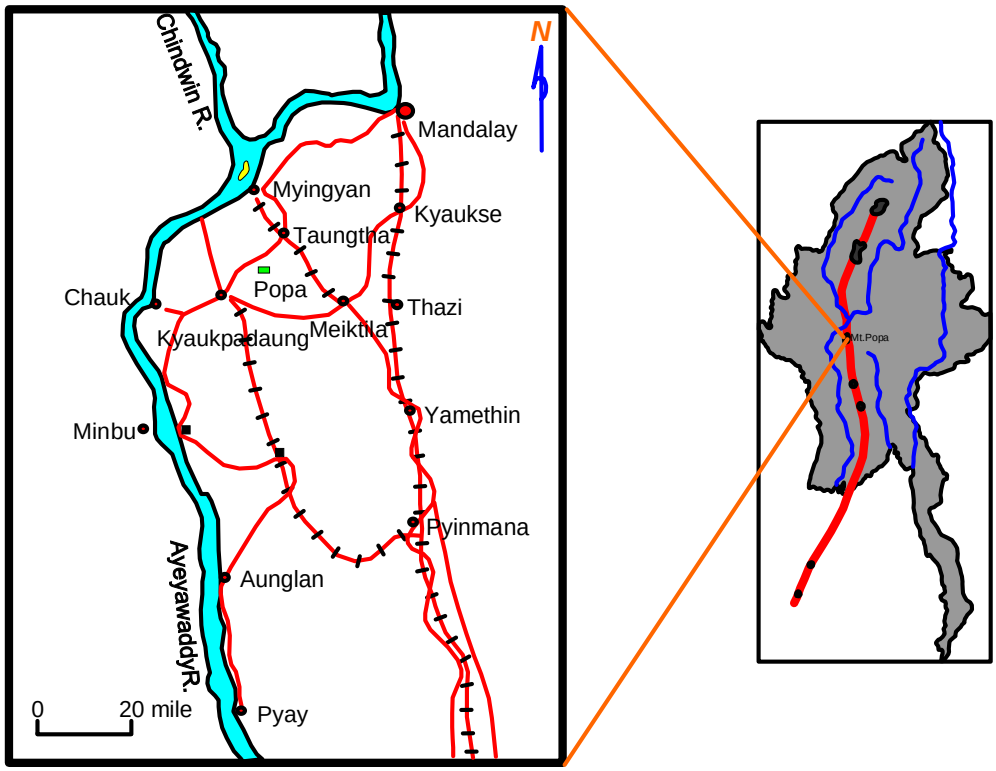

Figure 1. Location map of the study area

Methods of study

Detailed geomorphological data of Mt. Popa and its environs were studied on field investigation, satellite and air photo observation.

Geomorphology of Mount Popa and Its Environs

General Statement

The studied area situated in the central Myanmar attracts everybody for its fantastic and majestic landscape which is mainly originated by volcanogenic origin. The scenic Mt. Popa (locally called Taungmagyi) and lovely volcanic stock (Taunggalat) are prominent forms which evident the central eruption type. The most abundant rock types: basalt, olivine basalt and andesitic rocks of somewhat fluidal magma occupied the main volcanic crater. Stratocones (Central vents) and associated volcanic neck (secondary vents or veinlet) and stratified layers of lava with gentle slope generally indicate the vulcanian type (Zuidan, 1985). On the basis of satellite image and aerial photographic interpretation with the combination of field observation, some distinct geomorphological terrain units are roughly classified as follow: volcanic cone, volcanic crater, lava plateau, volcanic butte (volcanic neck), northern paroxysmal outburst flank, mesa (capped with lava), lava flows, volcanic foot slope and flat terrain (Table 1 and 2). The generalized terrain unit's map is illustrated in (Figure 2).

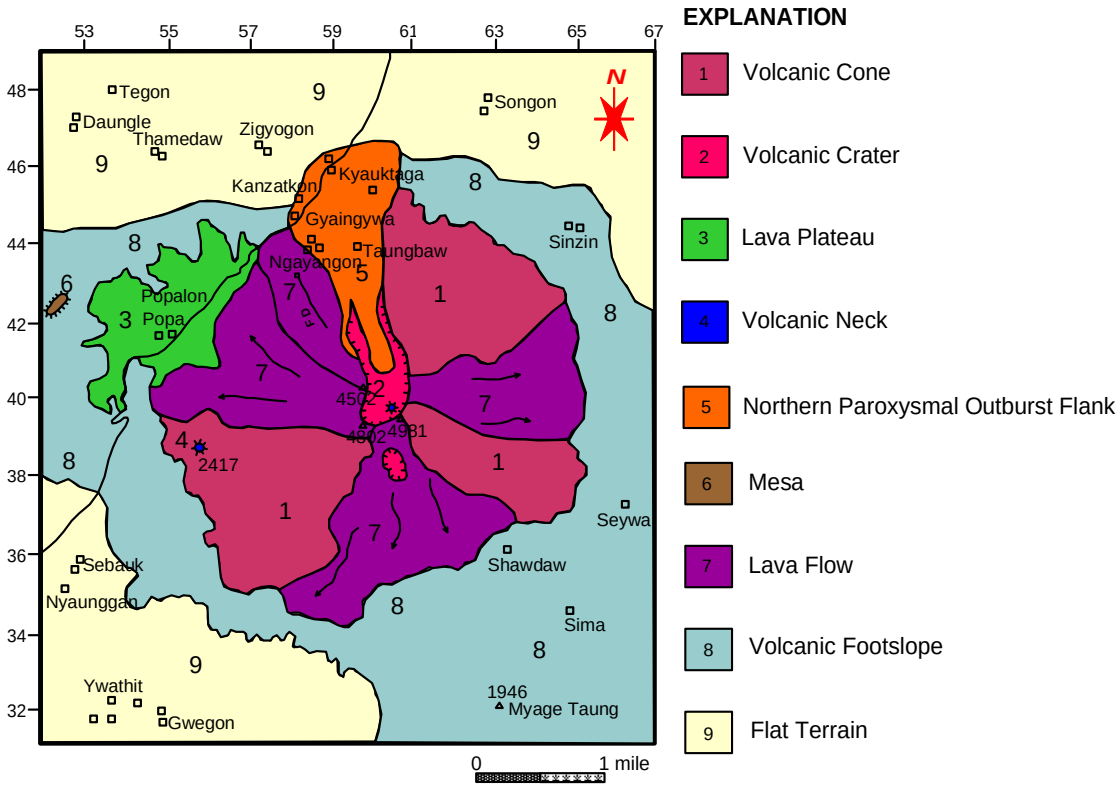

Figure 2. Geomorphological Terrain Units of Mount Popa Area and Its Environs

General Morphological Description

Volcanic Cone

The most obvious feature of the studied area, volcanic cone, is said to be composite cone built up by an alternative layers of lava, ash or tuffs and some agglomerative aggregates. The typical positive conical form is clearly seen from the southern side of the area (Figure. 3). The flanks are gently to moderately slop and the average slope angle is (15˚-20˚). Although the north-western part of the cone was thrown away by the last violent eruption, the other sides of cone are still retained as a remnant crater (eroded crater). The outer slopped area is now eroded by distinct radial drainage system excluded the north-western part. The outer slope is gentler than the inner slope (crater) (Figure 3).

Volcanic Crater

Initially, Popa volcano should be stratovolcano with circular crater. Because of final paroxysmal outburst (violent explosion), the northern flank of the older crater rim was blown away and retained as a northward opening crater forming a horse-shoe shape (Figure 4). On the basis of this extremely violent explosion and horse-shoe shaped crater, the final stage volcanism occurred in the Mount Popa could be "Vesuvian" type of volcanic eruption. Magma violently explored form the strato-cone and lava flowed outward in some distance. Ngayangon flow and Taungbaw flow indicated this explosion.

This eruption could be occurred after long interval of mild activity. Therefore, vent tends to be erupted to considerable depth. The present crater has 1-mile in diameter from west to east and average depth is 2000 feet. Inner slope of the crater is steeper than the outer slope. In this case, centripetal drainage on the inner slope and centrifugal drainage on the outer rimy flank are distinctly occurred on both airphotograph and satellite image.

At present, the older crater rim is eroded and forming as individual hillocks which are still retained as the rimmed crater. The most prominent peaks in the crater rim are Hmanpya Taung (4981') at southeastern part, Sabapon Taung (4801') at southwestern rim and Saemon Taung (4502') at western rim.

The erupted crater bottom is now filled with loose materials mainly volcanic rock fragments, ash and tuffaceous piles. Due to both chemical and physical weathering occurred in these materials, formed the fertile soil covers having considerable thickness. That is why; the northern side of the crater is now covered with agricultural lands.

Lava Plateau (Popa Plateau)

Fairly viscous and more resistant lava and tuff retained as a capping with flat top prior to the building up of the volcanic cone. In the studied area, this type of plateau is formed and observed. Popa village is situated on the just central part of this plateau, locally called Popa Plateau (Figure 5). This plateau is now located at the western proximal part of the main volcano. This plateau could be formerly large lava shield poured out from the major vent just near the present day Mt. Popa cone. Because of very fluid magma (low viscosity) and large volume of magma flowed, spread over the large aerial coverage on the sandstone unit of Irrawaddy Formation.

Table (1) Relationship between terrain units and various terrain characteristics (For unit 1, 2, 3, 4 and 5)

Terrain Unit		Terrain Characteristics					
Code	Name	Relief-morphology	Process	Rock Type	Soil	Hydrologic Situation	Vegetation land-use
1	Volcanic cone	steep slope, frequently convex top, concave lower slope, irregular surface: blocks, lava flows, rills and gullies	accumulation of volcaniclasts, ash and scoria, strong rill & gully erosion, mud flow	lava interbedded with soft material (ash, sand, lapilli, bombs & blocks)	thin soil cover (because of hot and dry climatic condition)	radial drainage, no surface water, spring exist at the foot	grass and natural vegetation on the top slope, cultivated land on the foot slope
2	Crater	very steep slope on the inner part, moderately steep on the outer side	at an active stage eruption occurred from this opening at present, subsidence of crater may occur	crater rim consists of hard igneous rocks, crater bottom consists of loose materials	absent, if the volcano is active now, covered with thick fertile soil	centripetal on the inner side, centrifugal on the outer flank	cultivated land on the crater bottom
3	Lava plateau	flat-broad surface covered with lava, steep slope on the outer end	accumulation of lava or lava flow, strongly gully erosion	mostly fluidal lava (andesitic rocks & tephra)	residual soil formed by chemical weathering	dendritic drainage, slightly parallel drains on the edge of the plateau	thick, fertile soil useful for cultivations, flatbroad plains are settlement areas
4	Volcanic neck	isolated, very steeply pinnacle, flat smooth topped surface	rapid surface runoff, limited speed of weathering and erosion	intrusive rocks mostly andesite	absent, debris on the foot slope	no surface of groundwater	lack of natural vegetation, studded with pagoda
5	Northern paroxysmal outburst flank	Moderate to gentle slope, more gentle on the slope edge	Violent eruption burst opened the old crater, gully erosion	Basalt and agglomerates (tephras)	Thick residual soil of basaltic composition	Well drained surface water	Natural vegetation and agricultural land

Table (2) Relationship between terrain units and various terrain characteristics (For unit 6, 7, 8 and 9)

Terrain Unit		Terrain Characteristics					
Code	Name	Relief-morphology	Process	Rock Type	Soil	Hydrologic Situation	Vegetation land-use
6	Mesa	Table land capped by hard and resist materials	Denudational-erosional (differential weathering), rill erosion	Igneous rocks on topped surface,sandstone underlines the hard cap	No soil, loose material on the top face	No dominant drainage, subparallel on the short steep slope	Lack of vegetation, no land-use
7	Lava flows	Gentle slope, more gentle away from the major vent	Outcoming of fluidal lava, mud flow, strong rill & gully erosion	Lava and tephras	Thin to moderately thick soil cover	Surface and groundwater available	Dense vegetation, good arable land
8	Volcanic footslope	Gentle to moderately steep slope, concave, smooth slope	Transition or accumulation zone of fluvio-volcanic activities	Fluvio-volcaniclastic materials	Good, deep soils with various texture	Surface and groundwater available, springs exist below the boundary between volcanic cone and footslope	Dense vegetation good arable land
9	Flat terrain	No relief, totally flat	Mainly fluvial-denudational	Clastic materials mostly sandstone	Moderate to thick soil	Surface or groundwater available	Sparse natural vegetation, good arable land

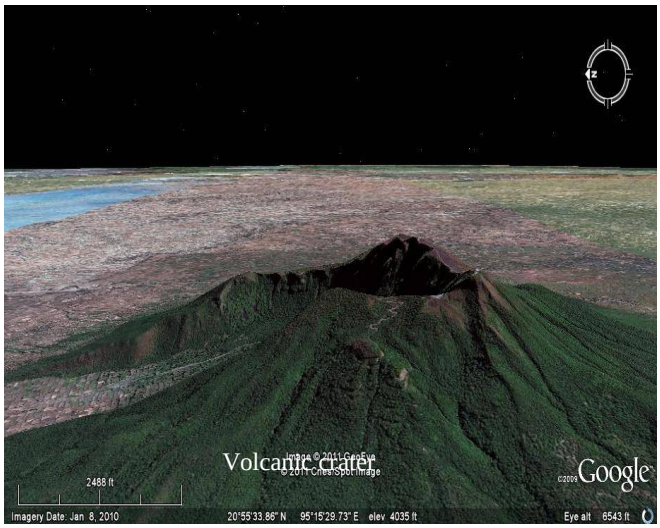

Figure 3. Satellite image showing positive conical form of volcanic cone of Mt. Popa

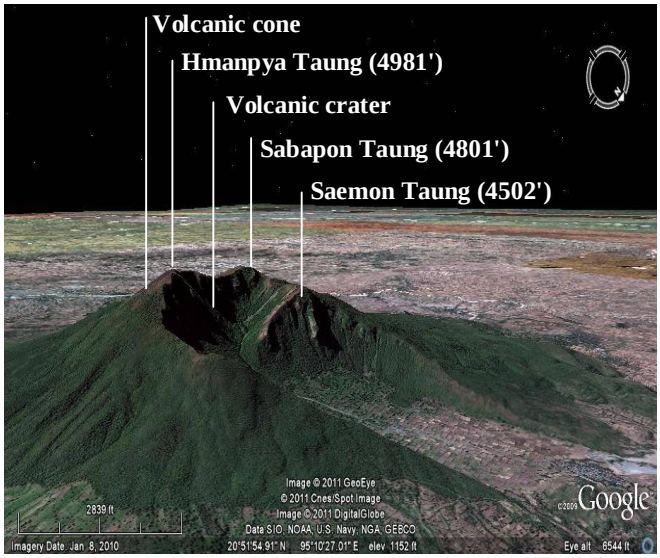

Figure 4. Satellite image showing a horse-shoe shaped volcanic crater of Mt. Popa

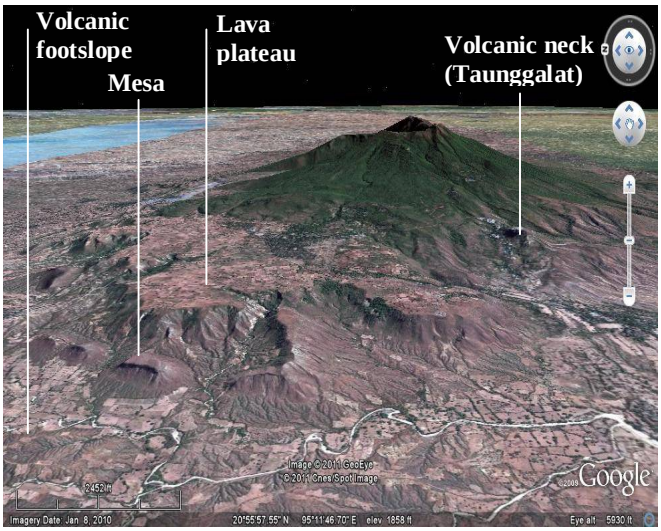

Figure 5. Satellite image showing Popa Plateau on the northwestern part

This interlocking nature of ash and sand layers is easily observed on the section near Sinzin village. Later denudation took place on these lava shield and outer edges were eroded away, especially on the western side. Eastern side was overlain by younger lava flow. This nature of contact relationship between older flow and younger flow is easily recognized on aerial photos. The western margin of plateau is marked by erosion-scarp which cropping out the underlying older sand layers belongs to Irrawaddy Formation. In conclusion, this lava plateau could be formed as a result of denudational process. No evidence enlighten the structural origin is occurred.

Volcanic Neck (Volcanic Butte)

It is another salient landform observed at the place about 300-400 m far from Mt. Popa. The grid locality is F-558387. The steeply sided slope capped with resistant rocks and its isolated nature could be designated as butte possible formed by eroded volcanic neck. It is situated on the south-western flank and its present elevation is about 2417'. It is a subsidiary volcano and due to intensive erosion, volcanic neck retained as a prominent feature (Figure 6). It is a cylindrical mass having 100 m in diameter and its top flat surface is now studded with pagodas and many other religious buildings. Now it is fame as Popa Taunggalat.

Field observation and aerial photo interpretation made an analysis of slope classes viz., class I steep slope, class II- moderate slope and class III- gentle slope (Figure 7). Steeply inclined walls are composed essentially of hard and compact volcanic igneous mass, andesitic rocks.

The moderately inclined slope is designated as the mid-slope. Foot slope is gently inclined away from the centre and composed materials are mainly talus debris (Figure 8). This slope could be unstable when the detritus mixed with water, soil and sand rocks. A small scale, but destructive land sliding occurred on the eastern side of Taunggalat. This type of land sliding is still going on and large cracks and fissures can easily be seen on the foot slope. Land sliding might have been triggered by slope gradient, permeability of loosely cemented massive sand which is overlain by red volcanic soil or pyroclasts and ground water percolation. Present land sliding in Popa Taunggalat because a large amount of damage on building but no human lost. Land conservation measure had being made already for the protection and prevention of further land sliding and associated natural hazards.

Northern Paroxysmal Outburst Flank

It is the opening of nearly flat terrain area formed by final eruption occurred on the major crater (Figure 9). Because of extremely violent eruption northern part of crater rim completely thrown away and formed the present land condition. Large volcanic bombs, blocks, tephra and large boulder sized andesitic fragments from older crater rim are widely spread over the terrain. Thick soil layers covered the whole terrain especially on the gently slopped area. Fluvio-volcanic processes predominate in this region. Very hot lava had been poured out from the opening caused by the horrible event which blustered the major crater rim. The widely spread lahars deposit from the northern part of the crater and around the environs of Myauktaw village were possible formed by the final violent eruption.

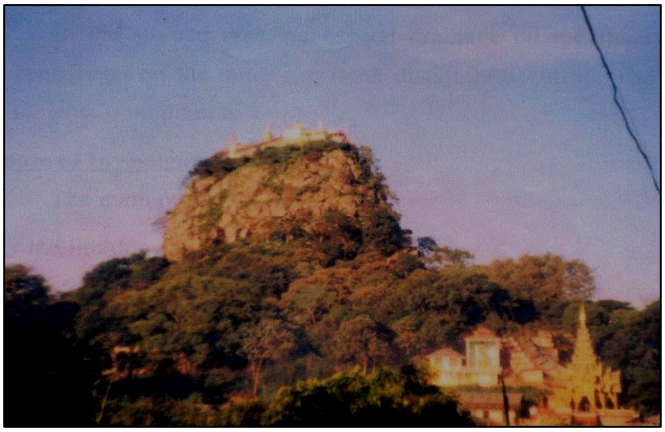

Figure 6. Photograph showing volcanic neck retained as a prominent feature at Mt. Popa

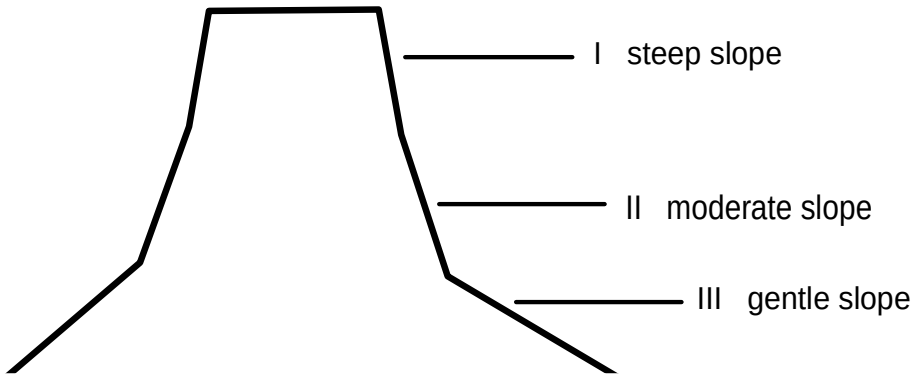

Figure 7. Schematic cross-section showing distinct slope classes (not in scale)

Figure 8. Satellite image showing foot slope of Taunggalat which is gently inclined away from the centre and talus debris materials

Mesa (capped with Lava)

This table land capped with hard volcanic materials is formed by denudation process (Figure 10). It has an isolated flat topped summit bounded by steep-sided, and its dimension is about 0.08 square miles. This table land is located about one mile WNW of Popa village. The underlying basement is sand layers of Irrawaddy Formation.

Lava Flows

On the basic of aerial photo interpretation, at least five phases of Lava eruption may have been occurred from the major crater (Mt. Popa). Although the clear contact relationship between these flows could not be found in the field, the boundaries of each flow can be seen on the aerial photographs. Aung Moe (1980) drew the boundaries of each flow with the aid of photo interpretation.

Distinct features found on the air photos and satellite image are sinks and rises formed by lava collapsion, flow structure, probable cinder cone and lava mound (Figure 11). Tonal contrast and nature of overlapping greatly enlighten the succession of lava flows. The more older the lava, the more prolong weathering may have occurred. So, the dense vegetation and soil on the older flow is formed than the younger one.

The stony rises formed by irregular collapse are observed on the eastern slope. The other rises built up by the compact igneous intrusion are found around the collapse lava which is broadly spread on the western slope. Because of lava collapsing these hard bodies retained as accordant heights. The flows on the southern slope show gently sloping nature especially at the higher level. But there occurred concave flow or spoon shaped flow at the lower lever of the highly weathered and denudated slopes. Cooling and contraction of lava are frequently found on the flow surfaces where vegetation is sparse.

Volcanic Foot slope

It is the terrain of gentling slopping area at the base of the major volcano (Figure 12). The outer boundaries of this terrain are in contact with the sandstone and tuffaceous sandstone of Irrawaddy Formation. Inter tonguing nature of lavas and sediments indicated the alternative episodes of lava eruption and sedimentation. Many accumulative materials which are transported by lahars, debris flows, land sliding and rock falling processes are found on the slope. This terrain is also term as an accumulation zone of the fluvio-volcanic activities. In some places thick black and red soils covered on a large aerial extent, whereas fragmented volcanic clasts widely spread over the slope in another places. This terrain is covered by dense forest or natural vegetation due to the presence of surface and ground water (spring) conditions.

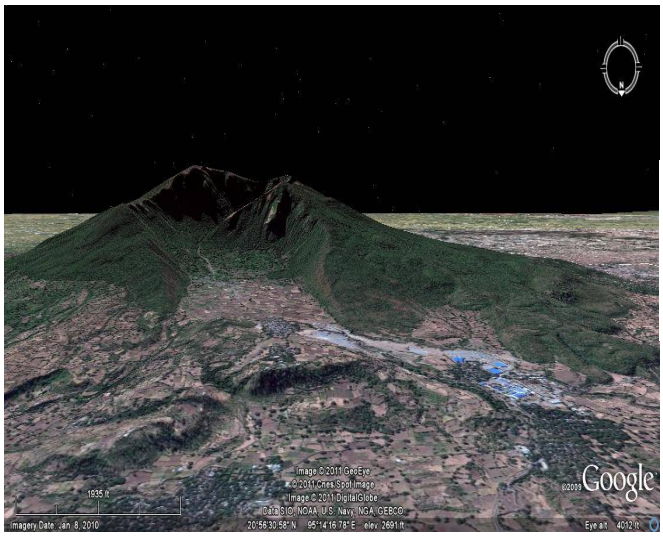

Figure 9. Satellite image showing northern Paroxysmal outburst flank which is composed of lahars deposit

Figure 10. Satellite image showing mesa

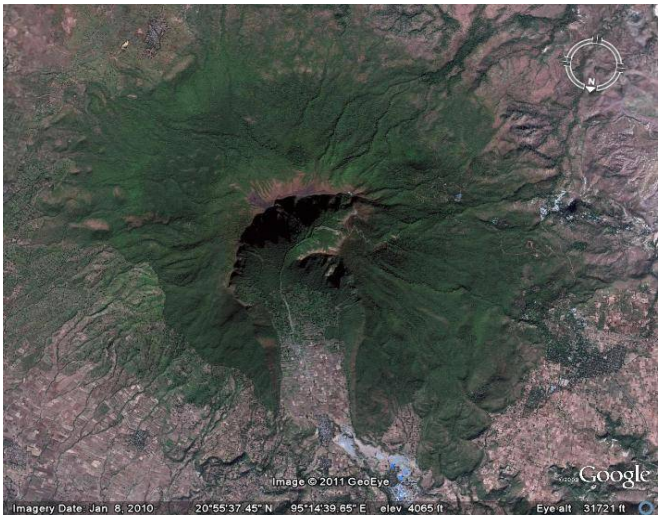

Figure 11. Satellite image showing sink and rise features of lava flows

Flat Terrain

The basement of the Mt. Popa is rather flat terrain composed essentially of sandy deposits belonging to Irrawaddy and Pegu Group (Figure 13). Prior to the volcanic eruption, these basement layers were slightly tectonized and giving rise to folded terrain. Irrawaddy Formation is exposed on the western side of volcano and Pegu Group is cropped out on the eastern foot hill of Taungmagyi strongly pointed to this tectonic episode before the initial pouring out of lava from a certain main opening.

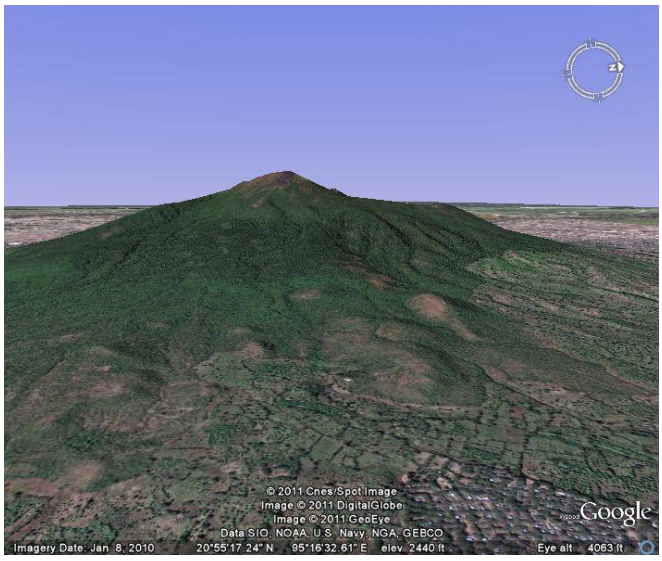

Figure 12. Satellite image showing volcanic foot slope

Figure 13. Satellite image showing flat terrain which is composed of sandy deposits of Irrawaddy and Pegu Group

Conclusion

The studied area situated in the Central Myanmar attracts everybody for its fantastic and majestic landscape which mainly originated by volcanogenic origin. Mt. Popa (locally called Taungmagyi) and volcanic neck (Taunggalat) is prominent forms which evident the central eruption type. Gullies erosion and distinct radial drainage pattern, horse-shoe shaped rim crater, eroded lava flow, thick soil and dense natural vegetation indicated that the stage in erosion of Mt. Popa could be said to have "Residual Volcano". Inter tonguing nature of ash and sand layers of the upper part of the Irrawaddy Formation are clearly seemed on the outcrops. Therefore, the age of Mt. Popa is estimated to be about 2 or 3 million years. On the basis of present investigation and its retained morphological terrain units, the most probable eruption type of Mt.Popa could be "Vulcanian type". The most probable processes that caused the present landscapes are fluvio-volcanic and volcano-denudation processes. It could be concluded that Mt.Popa and its environs are figured by endogenic and exogenic processes. Both major and minor land sliding events occasionally happened through Pleistocene to Recent.

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