Stress Field Interpretation of the West Bago Yoma Fault System, Myanmar

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Abstract

The study area is located at the western part of Bago. The Bago Yoma is nearly north south trending anticlinorium related with major Sagaing Fault. Upper Pegu Group and Irrawaddy Formation are mainly exposed along the ridge. Regional stress orientation of the area is NE-SW and it is related with subduction of India Plate beneath the Eurasia plate. The Bago Yoma anticlinorium is also located between Kabaw Fault at the west and Sagaing Fault at the east. Stress field analysis of the area indicated that there are two or more structural events.

Keywords: anticlinorium, ridge, stress, subduction, events

Introduction

Myanmar is located on the active plate boundary zone between Indian and Eurasian Plates. Neogene active thrust faulting and large regional scale strike slip faulting in the Southeast Asia regions are the most obvious examples of India-Asia collision (Tun Naing Zaw, 2006). The strike slip faulting and crustal thickening are also caused by this collision (Peltzer and Tapponier, 1988, Le Dain et.al, 1984, Molnar and Tapponnier, 1975).

The Bago Yoma, anticlinorium, is the one of the dominant uplift of the central lowland. The ridge was uplifted during the Late Miocene (GIAC, 2000). The ridge bounded by West Bago Yoma Fault at the west and dextral Sagaing Fault at the east. The West Bago Yoma thrust system is believed to be activated during the Pliocene tectonic inversion period related is oblique movement of India and dextral motion of Sundaland active margin or Sagaing fault (Lin Thu Aung, 2014).

Sandstone, shale, clay and mudstone are the major rocks of the Pegu Yoma. Upper Pegu Group of Pyawbwe Formation (Early Miocene), Kyaukkok Formation (Early Miocene) and middle Miocene Obogon Formation are well exposed along the Bago Yoma. Late Miocene to Pliocene Irrawaddy Formation is exposed at the western and eastern flank of ridge.

Methodology

Regional geological map, regional structures and other topographic features were investigated during desk study. Morphotectonic evidences, lineaments map and major structural trends are analyzed by using Google Earth Pro, arcMap, Goldern Surfer and Global Mapper software. Satellite image interpretation enable to trace regional structural trends of the study area. Lineaments, fault trace and joint features were analyses base on the satellite images. Digital elevation map (DEM), STRM and Landsat images are used to interpret tectonic morphology of the study area. Field investigation also carried out for collection of structural data such as dipping, fault plane, fold and others.

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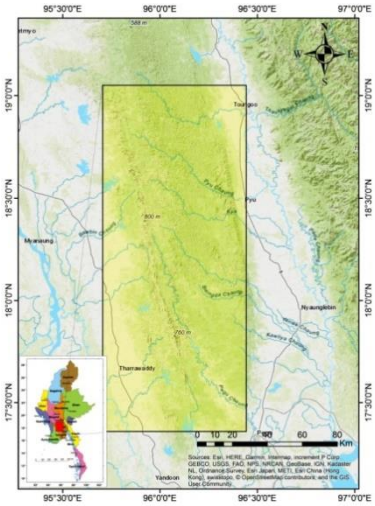

Figure 1. Location map the Bago Yoma area

Regional Geologic Setting

The Bago Yoma uplift is including in the fore-arc basin, which divided by the Mount Popa volcanic center into two parts (fore-arc and back-arc basin) (Bender, 1983). Burma Plate moved northward relative to Asia Plate (Tankard et.al 1994) in the early Eocene caused series of pull-apart basins such as Hukawng, Chindwin, Shwebo, Salin, Prome, Irrawaddy Delta basins. The unconformities in the Irrawaddy Formation and Miocene Formation controlled the timing of uplift of the basin-center thrust sheets. Regional uplift related with emplacement of the Mount Popa volcanics indicated by the angular unconformity at the base of Irrawaddy Formation (Khin and Win, 1969).

The Bago Yoma is structurally complex related with inversion of the older extensional faults and en-echelon folds associated to the strike slip faults. These folds are trending NNW-SSE direction related with right lateral Sagaing Fault and separated by the normal cross faults. During the Pliocene, these normal cross faults have been reactivated with oblique slip and occurred as a result of associated folds (Seehapol Utitsan et.al, 2014).

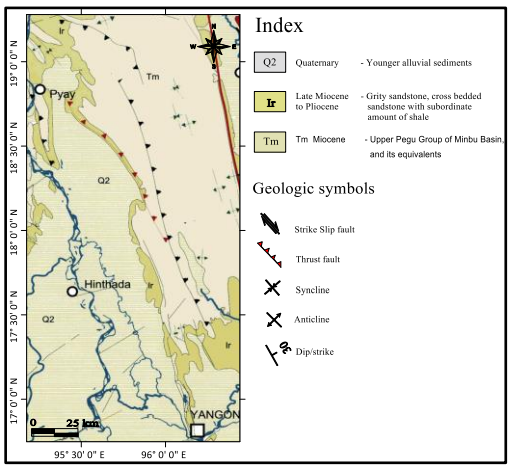

Figure 2. Regional geological map of the Pegu Yoma and surrounding region (MGS, 2014)

Bedding Nature

The Bago Yoma Range is mainly composed of sedimentary rocks such as sandstone, shale, clay and alluvium deposits. Most of the rock units are dipping east and west with low to moderate inclination. Thick bedded sandstone with cross bedding and gritty sandstone unit of Irrawaddy Formation was exposed at the eastern and western flank of anticline with low dip. Sandstone and shale alteration unit of Obogon Formation (Middle Miocene) is widely exposed along the range. The unit is mainly distributed in the middle part of study area and dipping toward east and west. Most of the dip are low to moderate and indicated the NNW-SSE trending fold axis.

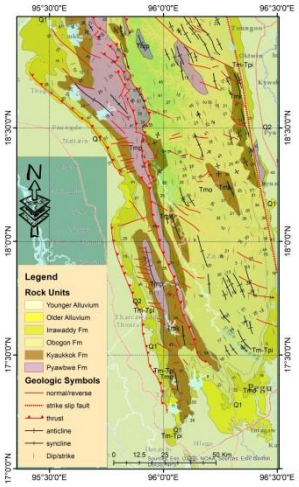

Figure 3. Geological map of the West Bago Roma Range (Modified after DGSE, 1979)

The sandstone unit of Early Miocene Kyaukkok Formation is well exposed along the eastern and western limbs of Thegon anticline, Gwedaukdsan anticline and Gyophyu syncline. The unit is well jointed nature and beds are also dipping east and west. The oldest unit of the study area is Pyawbwe Formation. The unit is mainly composed of shale unit and Early Miocene age. The bedding nature of this unit also indicated that the regional fold axis is NNW-SSE direction. According to the contour diagram of the bedding nature of all units, the regional fold axis of the Bago Yoma anticlinorium is trending NNW-SSE.

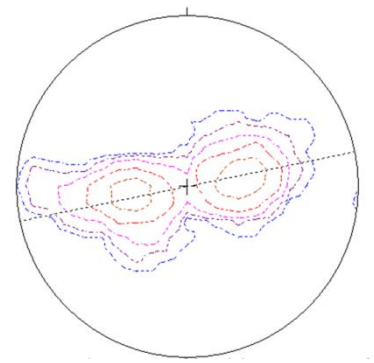

Figure 4. Contour diagram of the dip of all units exposed along the Bago Yoma and indicated that the dip of the beds are nearly east and west dipping and axis of regional fold is NNW-SSE direction

Joints

The soft sedimentary units of the study area are low jointed nature. However, the hard and massive sandstone unit of Kyaukkok Formation and other units are moderate to well jointed features. Most of the joint are nearly vertical inclination.

Most of the joints are striking NNW-SSE and nearly E-W. The first one is more dominant and related with ENE-WSW extension. The second one is perpendicular to the first one and it is related with NNW-SSE extension. According to the joint strike rose diagram, there are two or more events but NNW-SSE and nearly E-W are more dominant.

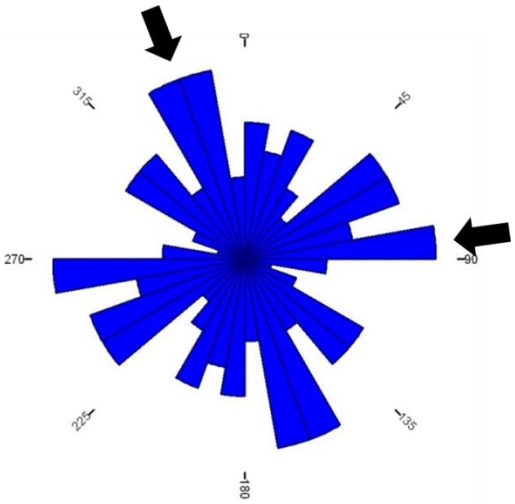

Figure 5. Joint strike rose diagram of the study area showing two structural events; NNW-SSE and nearly E-W extension (black arrow are possible stress regime)

Lineaments

Lineament mapping was made by using remote sensing and GIS software. The lineaments were extracted from satellite images, DEM (30 m resolution) and landsat 8 images. There are two major lineament trend occurred along the Bago Yoma in that NNW-SSE trending lineament are parallel to the west Bago Yoma Fault and WNW-ESE is parallel to the minor cross faults.

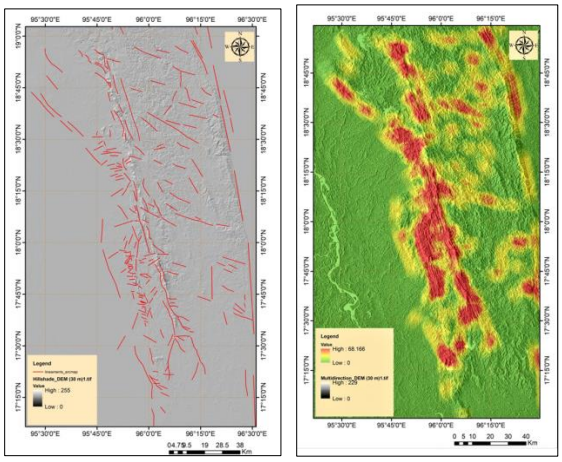

Figure 6. (a) Lineament map of the study area (base map – DEM 30 m), (b) lineament density map of the Bago Yoma Range. There are two lineament density trend; NNW-SSE and WNW-ESE. Bago Yoma Fault, Gwedauksan anticline and Thegon fault are weaker zone of the area

According to the lineament strike diagram, there are two prominent lineament strike occurred in this area. Nearly E-W or WNW-ESE trend is more dominant and related with Thegon fault and other minor cross fault. The second strike is related with nearly E-W extensional deformation. This one is parallel to the inactive splay of West Bago Yoma Fault system.

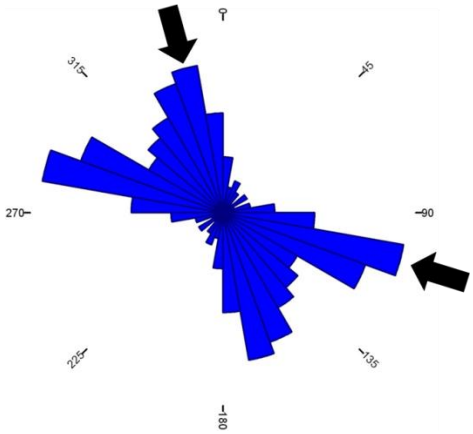

Figure 7. Lineament strike rose diagram of the Bago Yoma anticlinorium. The frequency of the WNW-ESE strike is more dominant than NNW-SSE strike (black arrow – possible stress field)

Folds

The Bago Yoma Range is highly folded and telted region. There are series of folding formed anticlinorium. There are three major fold and a lot of minor fold. Thagangaing anticline is located at the northwestern part of study area. The fold axis is NW-SE trending and bounded by thrust fault at the western limb. Another major fold is Gwedauksan anticline. This anticline is located near the Letpandan, western flank of Bago Yoma Range. The fold is trending NNW-SSE and parallel to the range. The last one is Gyophyu syncline. The fold axis is nearly N-S and also parallel to the range.

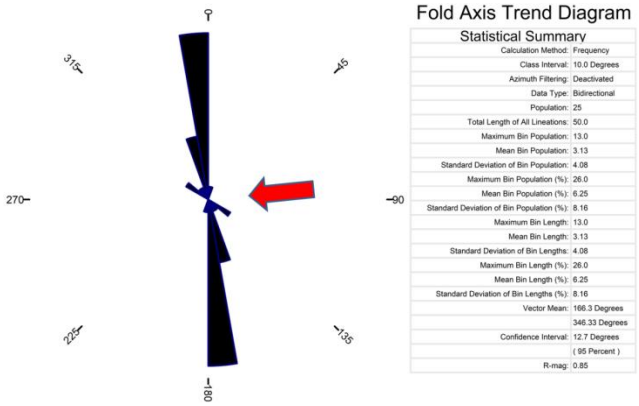

Figure 8. Trend of the fold axes diagram shown most of the folds are trending NNW-SSE and related with nearly E-W compression (red arrow – possible stress direction)

The strike of the fold axes plot in RockWork software. According to the fold axes diagram, there are two event of fold system. The most prominent fold axes are trending NNW-SSE and related with nearly E-W compression. The second one is not well dominant but different from first one. The trend of this event is NW-SE and caused by NE-SW stress regime.

Faults

The eastern and western splay of the West Bago Yoma Fault system are dominant structural feature of the area. Structural trend (NNW-SSE) of these are splay are same except Thegon Fault (NW-SE). There are also a lot of minor cross fault occurred across the NNW-SSE trends.

Figure 9. NE-SW extensional normal fault occurred in Kyaukkok formation (facing 75°)

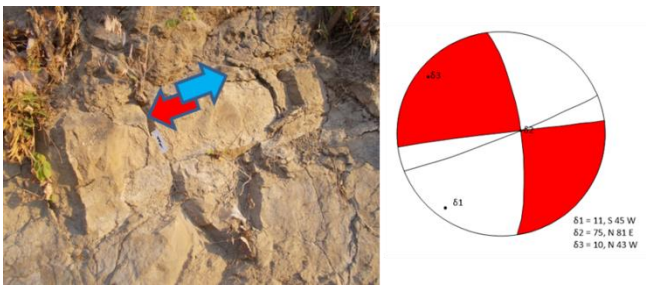

Figure 10. NE-SW trending sinistral fault and compressional stress is NE-SW direction (facing 342°)

Most of the local faults indicated that the stress field orientation is various directions. However, NE-SW and NNW-SSE compression is more dominant stress regime. Other minor fault deformed by nearly E-W and NW-SE compression.

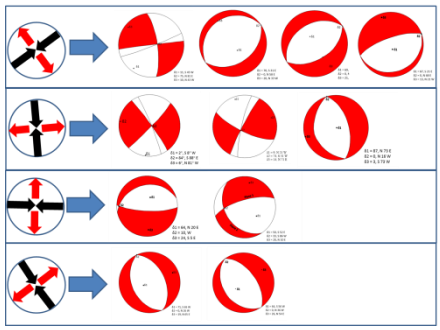

Figure 11. Stress field analysis of local minor fault with Smidth's net (lower hemisphere) (black arrow – stress direction, red color – extensional field)

Stress Field Orientation

Regional stress field of the Myanmar region is related with India-Asia subduction. Most of the tectonic activities of Myanmar is also deal with subduction mechanism. The study area, Bago Yoma, push up ridge formed by ENE-WSW compression. Most of the structural features are also related with dextral motion of Sagaing Fault.

Stress field analysis of local fault data shown in table (2). According to this table, there is two or more stress regime. Bedding characters indicated that the regional stress of area is nearly E-W direction.

Table 1. Stress field orientation of all minor structures by stereonet (lower hemisphere)

No.	Structures	Stress Field	Smidth's net	
1	Bedding	ENE-WSW		
2	Joint	NNW-SSE and Nearly E-W		
3	Lineament	NNW-SSE and Nearly E-W		
4	Fold	Nearly E-W		
5	Fault	NW-SE and Nearly N-S		

NNW-SSE and nearly E-W compression regime designated by joint strike rose diagram. There are also two regional stress field was indicated by lineament analysis. These are NNW-SSE and nearly E-W compression. Regional trend of the Bago Yoma anticlinorium is NNW-SSE. The anticlinorium composed a lot of minor folds. The stress field direction of these fold clearly indicated the nearly E-W. However, stress field analysis of minor fault shown various stress regimes. But NE-SW and NNW-SSE compression is more dominant in the area. Therefore, possible stress field regimes of the Bago Yoma are NE-SW, nearly E-W and NNW-SSE direction.

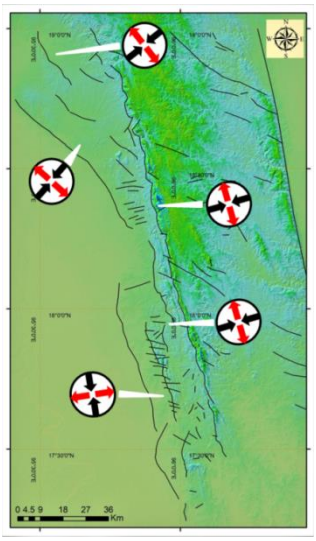

Figure 12. Possible stress orientation of the some major structures indicated the NE-SW, nearly E-W and NNW-SSE direction (red arrow - extension, black arrow – compression)

Conclusion

The Bago Yoma anticlinorium is formed by transpressional push-up and basin inversion in Late Tertiary. Bago basin was forming the Bago Yoma and related with Sagaing Fault during Late Miocene. Reverse fault occurred after the pull-apart basin had formed (Barnes et.al, 2005). The study area is mainly covered with Upper Pegu Group of Pyawbwe Formation, Kyaukkok Formation and Obogon Formation. Most of the beds are dipping toward east and west. The rock units are moderate to well jointed nature with NNW-SSE and nearly E-W extensional direction. The lineament of the research area also indicated the NNW-SSE and nearly E-W extension. The axes of the trend of fold are nearly N-S and related with E-W compression. However, the faults are deformed by various stress regimes. NE-SW, NNW-SSE and E-W compressional stress is more dominant. The stress field analysis of regional structural data sets indicated that the stress field orientation the area is NNW-SSE, nearly E-W and NE-SW direction.

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References

Barnes et.al, (2005). Strike-slip structure and sedimentary basins of the southern Alpine Fault, Fiordland, New Zealand.. Bull. Geol. Soc. Am. 117, 411-35, doi: 10.1130/B25458.1.

Bender, (1983). *Geology of Burma*. 1st edn. Gebruder Borntraeger, Berlin.

DGSE, (1979). *Geology of Burma*, Ministry of Mine, Unpublished Geological Map GIAC, 2000, Report of Geodynamics of India and Asia Collision, GIAC Project.

Khin and Win, (1969). Geology and hydrocarbon prospects of the Burma Tertiary Geosyncline. Union Burma Jour.Sci. Tech., V.2, P.53-81

Le Dain et.al, (1984). Active Faulting and tectonics of Burma and surrounding regions. J. Geophys. Res. V. 69, no. (B1), P 453-472

Lin Thu Aung, (2014). Active tectonics of Central Myanmar Belt between latitude 17◦ to 22˚N. Ph.D. Thesis, Department of Geology, University of Yangon (unpublished), Myanmar, 155.

Molnar and Tapponnier, (1975). Cenozoic tectonics of Asia: effects of a continental collision. Sceience, 189, p. 419-425

Peltzer and Tapponier, (1988). Formation and evolution of Strike slip faults, rifts and basins during the India-Asia collision, An experimental approach.J.Geophys.Res., Vol. 93, No. B 12, p. 15

Seehapol Utitsan et.al, (2014). Geological evolution of Bago-Yoma Basin, Onshore Myanmar, AAPG/MGS conference

Tankard et.al, (1994). Tertiary Wrench tectonics and sedimentation in the Central Basin of Myanmar, AAPC Bulletin, V. 78.

Tun Naing Zaw, (2006). Structures and tectonics of the eastern Bago Yoma between Phyu and Pyinmana. Unpublished Ph.D thesis