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STRUCTURAL CHARACTERISTICS OF THE SEMANGGOL FORMATION ALONG THE EAST-WEST HIGHWAY ROUTE 67 BALING AREA, KEDAH, MALAYSIA

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ABSTRACT

STRUCTURAL CHARACTERISTICS OF THE SEMANGGOL FORMATION ONGTHE EAST-WEST HIGHWAY ROUTE 67 BALING AREA, KEDAH, MALAYSIA. The amounts of structural data available from the East-West Highway Route 67 of Baling Area have been used to unravel the structural characteristics of the Semanggol Formation, which comprises black mudstone, sandstone, tuffaceous sandstone, tuff, paraconglomerate, siliceous shale and chert. The area was cut by two sets of faults trending NW-SE and NE-SW. The main fault in this area is known as Bok Bak fault that is trending NW-SE and have moderately to steeply dips (40^o-88^o) as compared to the conjugate faults. Two sets of folds trending NE-SW and NW-SE were also identified in this area, where most of them are symmetrical fold with gentle to open fold varies from non-plunging to nearly moderately plunging folds. Most of the faults have parallel orientation to the fold axis, indicated this pattern probably originated at the same period of deformation due to warping and uplifting.

Key words: Semanggol Formation, fault, fold, stereographic projection

ABSTRAK

KARAKTERISTIK STRUKTUR FORMASI SEMANGGOL DI SEPANJANG JALUR TOL TIMUR-BARAT RUTE 67 DAERAH BALING, KEDAH, MALAYSIA. Sejumlah data struktur geologi yang terdapat di sepanjang jalur tol Timur-Barat rute 67 daerah Baling telah digunakan untuk menguraikan karakteristik struktur dari Formasi Semanggol yang terdiri atas batu lempung hitam, batu pasir, batu pasir tufaan, tuf, para-konglomerat, batu serpih yang mengandungi silika dan batu rijang. Daerah ini dipotong oleh dua pasang patahan utama yang berarah NW-SE dan NE-SW. Sesar utama di kawasan ini dikenal sebagai Sesar Bok Bak dengan arah NW-SE dan kemiringan sedang hingga curam (40^o-88^o) sebanding dengan sesar konjugasinya. Dua pasang lipatan berarah NE-SW dan NW-SE juga dapat diidentifikasi di kawasan ini dimana sebagian besar dari lipatan tersebut merupakan lipatan simetri yang landai hingga terbuka dan bervariasi dari sudut penunjamannya dari tidak menunjam sama sekali hingga menunjam sedang. Kebanyakan dari sesar ini berorientasi sejajar dengan sumbu lipatan, mengindikasikan bahwa model ini kemungkinan terbentuk pada periode yang sama dengan proses terjadinya deformasi disebabkan oleh proses pelengkungan dan pengangkatan.

Kata kunci: Formasi Semanggol, sesar, lipatan, proyeksi stereonet

INTRODUCTION

There has been growing interest in understanding the geology of Baling area during the last few decades [1,2,3,5,7,8,9]. However, the earth works during latest urban development in this area resulted to the exposures of outcrops that may expose fresh structural and stratigraphy features. Detail observation and careful collection of field data are therefore crucial in order to capture new geological information of the area. Typical of thrust fault, strike slip fault, syncline, anticline, slump structure and normal and reverse graded bedding can be found in the study area. These geological features can be used to indicate complex structure and stratigraphy across the area.

The present work is a contribution from the Semanggol Formations that were exposed along the East-West Highway Route 67 Baling area, Kedah or approximately 70 kilometers away to the southeast of Kedah's capital, Alor Setar (Figure 1). About six outcrops have been observed and extensive structural data of more than 120 measurements were collected.

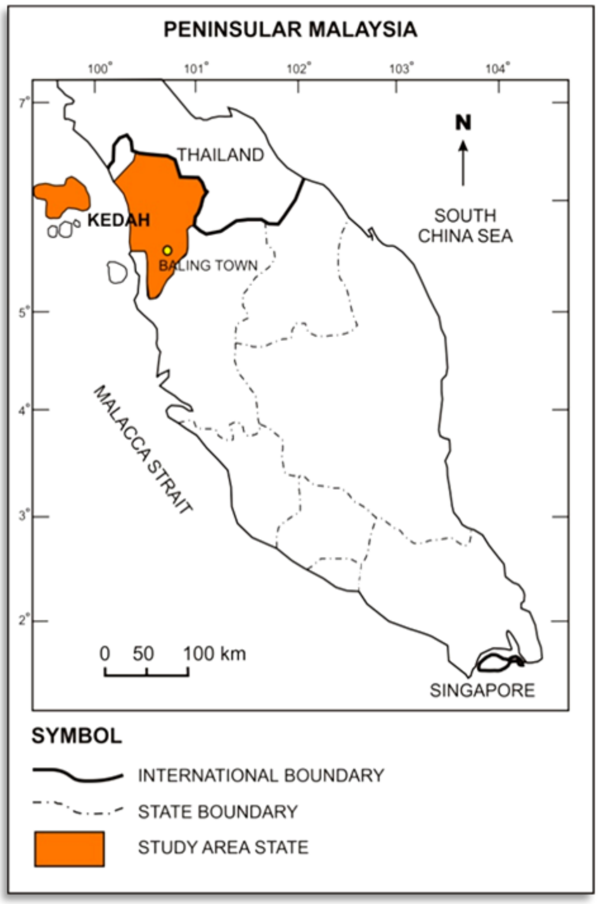


Figure 1**.** Index map of the Peninsular Malaysia. Shaded area represents the study area state of Kedah[8]

REGIONAL SETTING

The Baling area consists of typical rain forest and jungle with lowest relief is less than 30 meters (above the sea level) in the lower part of the Sungai Ketil valley to the highest part of over 1400 meters at a point on the south boundary high on the slopes of Gunung Inas. The lowest land, the floor of the trough is occupied by the Sungai Ketil and its tributaries. These have carved a broad deep valley in the western part of the area mainly in sedimentary rocks and parallel to the northeasterly regional strike[3]. Baling area covered complex geological structures of strike slip and thrust faults and folds, although most of the folds are minor in magnitude[8]. The stratigraphy for Baling area can be classified into three main formations, the

Baling Formation; Semanggol Formation and Bintang Granite Formation (Figure 2). However, this study focused only on the exposure of Semanggol Formation along the East-West Highway Route 67 Baling.

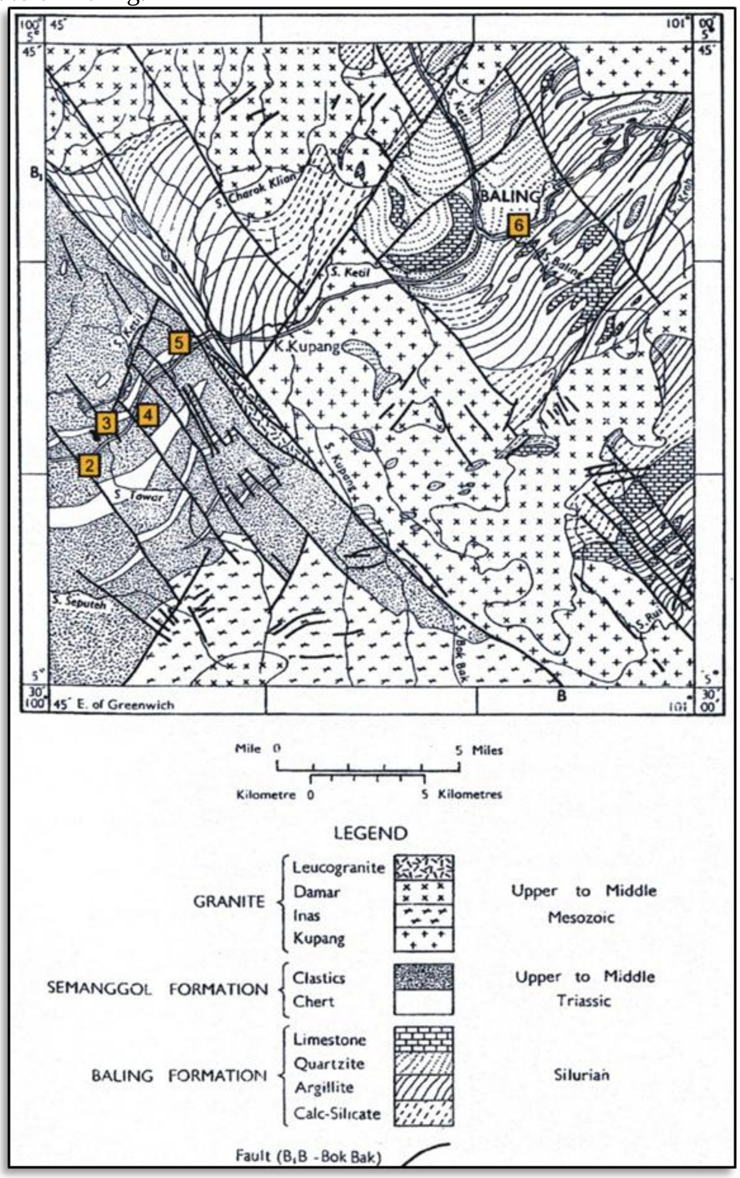


Figure 2. Geological map of Baling area with marked locations[3]

Semanggol Formation initially introduced for clastic rocks from the age of Lower Permian to Upper Triassic, located within the northwest of Peninsular Malaysia[3]. Semanggol Formation spread in three main areas, namely northern of Perak in the vicinity of Mount Semanggol, which Semanggol Formation had been first introduced, southern of Kedah at the vicinity of Kuala Ketil–Tawar, and north and central region of Kedah which is in the area of Kuala Nerang to Pedu[1]. The Semanggol Formation is divided into three members known as conglomerate member, rhythmite member, and chert member[3]. Three facies or members are same in age was studied[6]. However, the conglomerate member is still at the top unit and below it the rhythmite member, and finally the chert member.

Compared to Baling Formation, the strike and dip that were recorded in the Semanggol Formation is greatly varies. The pattern of dip sequences appears to indicate repeated folding[5]. Most of the faults in the Baling area are long and straight. Their horizontal traces continue almost without deflection through area of high relief, which indicates steep to vertical dips[3]. Burton proposed the occurrence of a major strike slip fault in Peninsular Malaysia, which cuts the rocks in the area of Baling and Kuala Ketil[2,3,4]. This fault is oriented northwest and named after the Bok Bak River, with which the lineament is partly aligned.

METHODS AND DATA PROCESSING

Six outcrops were examined in detail on structural geology. The choosing of these outcrops were based on the measurable orientation of structural elements in the outcrop is the main consideration. These six outcrops may illustrate the structural style along East-West Highway Route 67, Baling Area, Kedah. Structural characteristics of the area were analyzed by using stereographic projection software; *Stereonet 7 version 7.2.0* on the structural elements that are present within the outcrops shows the proof of geological setting of the studies area. Analysis from stereographic projection software especially data from bedding orientation, fault planes and joint planes confirmed the geological setting of the studies area that correlates with the Semanggol Formation.

The principal information that were recorded for structural studies are the strike, dip and dip direction (attitude) of the rock planar surfaces such as fault, joint, fold axis, fold limbs and sedimentary bed includes capturing in photos. The amount of data collected for structural analysis for a certain locations based on bedding, faults and folds is about 20 to 25 measurements, but for some locations which do not indicate any faults and/or folds element, bedding and joints were measured at those locations. Specifically for Kg. Charok Akar 2 outcrop, the total amount of data collected for structural analysis especially strike and dip is 47 measurements because it is the largest outcrop in this study as mentioned earlier. Once the data were collected, they are plotted in the topographic base map of Baling at the scale of 1: 50 000 during the fieldwork.

RESULT AND DISCUSSION

Summary of the stereonet analysis and structural characteristic of the Semanggol Formation along the East-West Highway Route 67 of Baling Area are discussed below, as indicated by Table 1 to Table 3.

Location 1

As shown in Table 1 (location 1), the two general trends of the bedding are one with striking north (0˚) with gently dipping around 4˚ towards east; the other orientation is striking NE (62˚) with gently dipping around 37˚ towards southeast. These two major bedding orientations represent two different attitude of bedding plane which are deformed due to the existence of faults in this location.

Table 3 (location 1) shows the well-defined bimodal pattern of preferred orientation of fault planes. Two general trends of faults are one striking NW-SE (344˚) with moderately dipping around 44˚ towards east; the other orientation is striking NW-SE (180˚) with moderately dipping around 43˚ towards west. Thus, it represents a conjugate pair of normal faults in this area. Figure 3 is a photograph shows the deformation of bedding planes by faults in location 1.

Table 1. Summary of the bedding and fold trend orientations analysis of the Baling area for location 1 to 4.

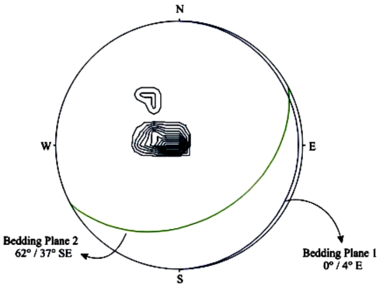
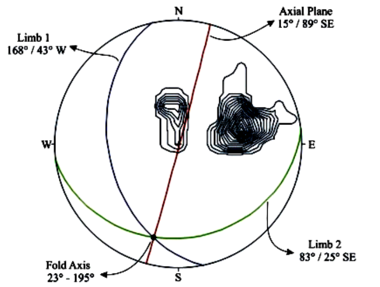
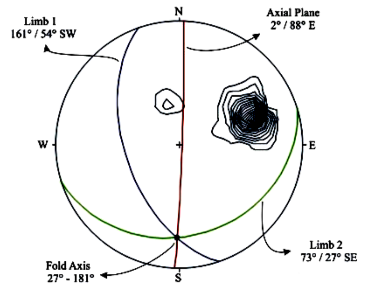
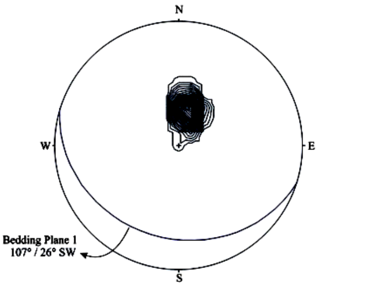
Area	Bedding and Fold Trend (Stereonet)	Bedding and Fold Trend (Strike/dip)
Kg. Batu Tujuh (location 1)		Bedding Plane 1 : 0° / 4° E Bedding Plane 2 : 62° / 37° E
Kg. Charok Akar 1 (location 2)		Limb 1 : 168° / 43° W Limb 2 : 83° / 25° SE Fold Axis : 23° - 195° Axial Plane : 15° / 89° SE
Kg. Charok Akar 2 (location 3)		Limb 1 : 161° / 54° SW Limb 2 : 73° / 27° SE Fold Axis : 27° - 181° Axial Plane : 2° / 88° E
Kg. Charok Akar 3 (location 4)		Bedding Plane 1 : 107° / 26° SW

Table 2. Summary of the bedding and fold trend orientations analysis of the Baling area for location 5 and 6.

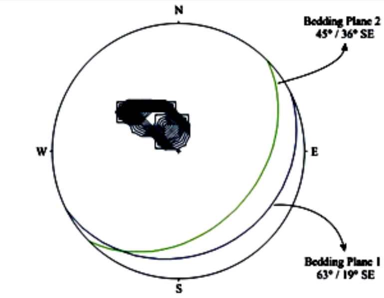
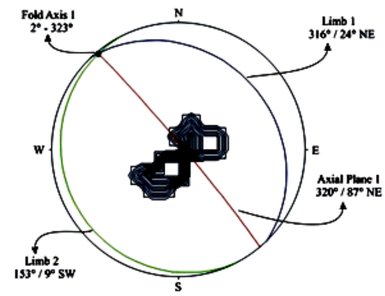
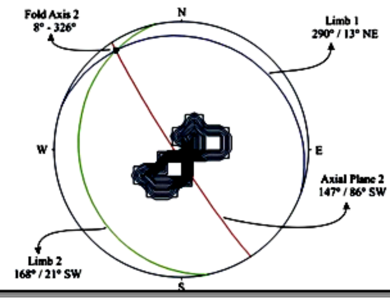
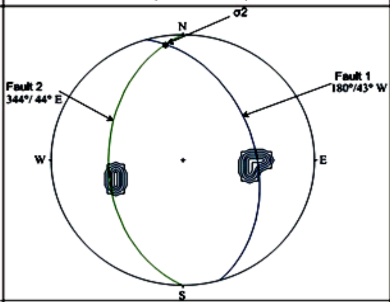
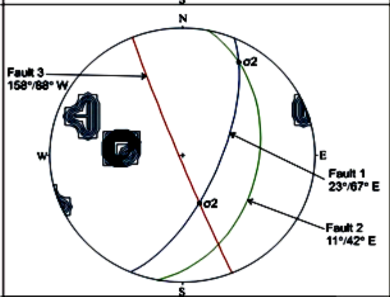
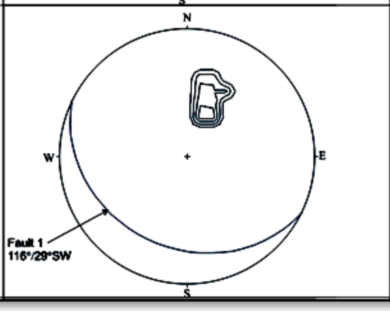
Area	Bedding and Fold Trend (Stereonet)	Bedding and Fold Trend (Strike/dip)
Kg. Tawar (location 5)		Bedding Plane 1 : 45° / 36° SE Bedding Plane 2 : 63° / 19° SE
Kg. Ketumbar Masjid (Location 6) Folding 1		Limb 1 : 316° / 24° NE Limb 2 : 153° / 9° SW Fold Axis : 2° - 323° Axial Plane : 320° / 87° NE
Kg. Ketumbar Masjid (location 6) Folding 2		Limb 1 : 290° / 13° NE Limb 2 : 168° / 21° SW Fold Axis : 8° - 326° Axial Plane : 147° / 86° SW

Table 3. Summary of the fault trend orientations analysis of the Baling area.

Area	Fault Trend (Stereonet)	Fault Trend (Strike/dip)
Kg. Batu Tujuh (location 1)		Fault 1 (Normal) : 180° / 43° W Fault 2 (Normal) : 344° / 44° E
Kg. Charok Akar 2 (location 3)		Fault 1 : 23° / 67° E Fault 2 : 11° / 42° E Fault 3 : 158° / 88° W
Kg. Ketumbar Masjid (Location 6)		Fault 1 : 116° / 29° SW

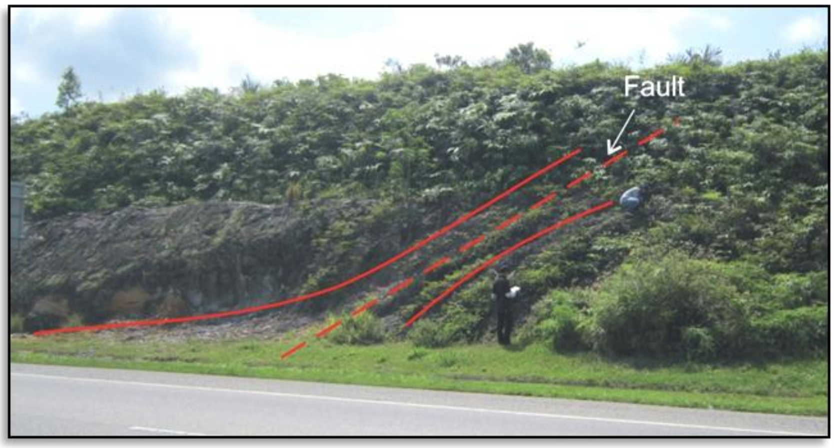


Figure 3. Photograph shows an evidence of bedding plane deformation by fault in location 1.

Location 2

The two general trends of the bedding are one with striking north (168˚) with gently dipping around 43˚ towards west; the other orientation is striking NE (83˚) with gently dipping around 25˚ towards SE as shown in Table 1 (location 2). These two major bedding orientations represent two limbs of a symmetrical fold plunging gently of around 23˚ towards SW at 195˚. The fold can be considered as gently-plunging fold (Figure 4). The swing in the bedding orientation suggests that the outcrops are mainly located near a gentle fold axis with interlimb angle around 112˚. Based on the calculation on the interlimb angle, the fold is therefore classified as open fold with moderately inclined (53˚) axial surface. Faults were not exposed in this outcrop.

Location 3

As shown in Table 1 (location 3), the two general trends of the bedding are one with striking NW (161˚) with gently dipping around 54˚ towards southwest; the other orientation is striking NE (73˚) with gently dipping around 27˚ towards southeast. These two major bedding orientations represent two limbs of a symmetrical fold plunging gently of around 28˚ towards SW at 181˚. The fold can be considered as nearly moderately-plunging fold. The swing in the bedding orientation suggests that the outcrops are mainly located near a gentle fold axis with interlimb angle around 99˚. Based on the calculation on the interlimb angle, the fold is therefore classified as open fold with moderately inclined (51˚) axial surface.

Table 3 (location 3) shows the well-defined three patterns of preferred orientation of fault planes. Three general trends of faults are one striking SE (23˚) with steeply dipping around 67˚ towards east; the other orientation is striking SE (11˚) with moderately dipping around 42˚ towards east. The third orientation is striking SW (158˚) with upright dipping around 88˚ towards west. Thus, it represents two conjugate pair of normal faults in this area. Above analysis are corresponds with the photograph of fold nose of moderately plunging fold (Figure 5) and photograph of Figure 6 which exhibit two preferred orientation of faults in location 3.

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Figure 4. A photograph shows an evidence of open – anticlinal – fold at location 2.

Figure 5. Photograph shows an evidence of anticline indicated by a fold nose at location 3.

Figure 6. Photograph shows two conjugate pair of faults at location 3.

Location 4

Outcrop in location 4 exposes one parallel bedding planes which is striking SE (107˚) with gently dipping around 26˚ towards southwest. Faults were not exposed in this outcrop (Figure 7).

Figure 7. Photograph shows one parallel bedding planes in location 4 which is striking SE (107˚) with gently dipping around 26˚ towards southwest

Location 5

Asshown in Table 2 (location 5), outcrop in location 5 also exposes two relatively parallel bedding planes which is striking NE (63˚) with gently dipping around 19˚ towards southeast and another bed striking NE (45˚) with gently dipping around 36˚ towards southeast (Figure 8). Faults were not exposed in this outcrop.

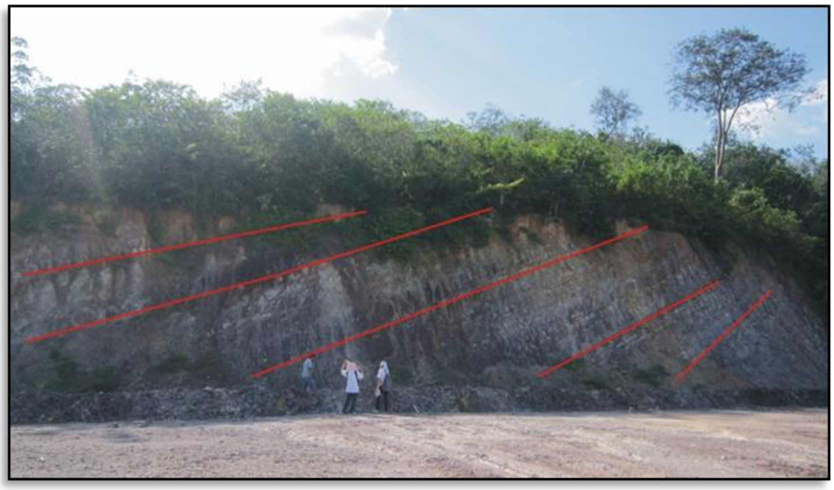

Figure 8. Photograph shows one parallel bedding planes in location 5 where gradual changes of dip to be more gentle in the southeast part may indicate this outcrop as a limb part of an open-folding structure.

Location 6

From the Table 2 (location 6), there are multiple folding but the general trend of these fold are only two. For the first trend of the bedding planes, the two general trends of the bedding are one with striking NW (290˚) with gently dipping around 13˚ towards northeast; the other orientation is striking SE (168˚) with gently dipping around 21˚ towards southwest. These two major bedding orientations represent two limbs of a symmetrical fold plunging gently of around 8˚ towards NW at 326˚. The fold can be considered as non-plunging fold. The swing in the bedding orientation suggests that the outcrops are mainly located near a gentle fold axis with interlimb angle around 147˚. Based on the calculation on the interlimb angle, the fold is therefore classified as gentle fold with upright (86˚) axial surface.

For the second trend of the bedding planes, the two general trends of the bedding are one with striking NW (316˚) with gently dipping around 24˚ towards northeast; the other orientation is striking SE (153˚) with gently dipping around 9˚ towards southwest. These two major bedding orientations represent two limbs of a symmetrical fold plunging gently of around 2˚ towards NW at 323˚. The fold can be considered as non-plunging fold. The swing in the bedding orientation suggests that the interlimb angle is around 147˚ which is same as the first bedding planes. Based on the calculation on the interlimb angle, the fold is therefore classified as gentle fold with upright (87˚) axial surface. Figure 9 is a photograph showing two different trend of folding in location 6 which are indicated by fold noses, while the Table 3 (location 6) shows the pattern of preferred orientation of a fault plane. The general trend of the fault is one striking SE (116˚) with gently dipping around 29˚ towards southwest. Thus, it represents the presence of a single fault.

Figure 9. Photograph shows an evidence of at least there are two anticlines exposed in location, as indicated by fold noses.

CONCLUSION

The six outcrops that were chosen for structural studies can illustrate the structural characteristics along East-West Highway Route 67. By using Stereonet 7 on the structural elements, which are present within the outcrops, the geological setting of the study area can be proven. Thus, the expected formations: Semanggol Formation is correlated with the geological setting of the study area from the bedding orientation and fault planes data.

Five folding have been observed in the study area and most of them are symmetrical fold with gentle to open fold and varies from non-plunging to nearly moderately plunging fold. Most folding that trending at Semanggol Formation were folded along NE-SW but there are also some folding that trending towards NW-SE.

The regional strike of the study area is northeasterly, and the majority of the dips are to the southeast. The angles of dip exhibited by the Semanggol Formation are relatively gentle. The major trend for the faulting at the study area is at NW-SE, thus it is in equal trending with the major fault at the study area, the Bok Bak fault. However, most faulting can not exposed clearly the movement of fault and or other indication of movement. Therefore, most faulting is typical of strike slip fault due to the regional geology of the area. This is the reason why most of the bedding planes showed in the study area has been deformed by the strike slip movement, which resulted in various trending of bedding planes. The bedding planes is striking NE-SW for location 1 and continues as indicated in location 2 which is also striking NE-SW. Then the folding is changing its trend striking at N-S in location 3 before striking NW-SE in location 4. The trend is then changing again with striking at NE-SW in location 5 and another change into NW-SE in location 6.

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