

The Occurrence of Thrusts in North Kedah and Perlis

ZAITON HARUN & BASIR JASIN

Program Geologi, Fakulti Sains dan Teknologi,
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Abstract

Several thrust faults were observed at Bukit Jabi, Bukit Kerangan, Bukit Tunjang and Kampung Binjai. The faults are high angle thrusts and dip towards the east. They exhibit more or less the same structural features. The faults displace the Lower Paleozoic Mahang and Setul Formations onto the Kubang Pasu Formation.

Kehadiran Sesar Sungkup di Utara Kedah dan Perlis

Abstrak

Beberapa sesar sungkup telah dikenalpasti di Bukit Jabi, Bukit Kerangan, Bukit Tunjang dan Kampung Binjai. Sesar ini mempunyai sudut sungkupan yang tinggi dan miring ke arah timur. Kebanyakan sesar sungkup ini menunjukkan ciri struktur yang lebih kurang sama. Sesar ini menyebabkan menggerakkan batuan Formasi Mahang dan Setul yang berusia Paleozoik Bawah ke atas Formasi Kubang Pasu.

INTRODUCTION

The Setul Limestone, Mahang, Singa and Kubang Pasu Formations are well exposed in the Langkawi Islands, Perlis and Kedah. Their lithostratigraphic relationships are well-established. Recently, the rocks of these formations became well exposed by earth quarrying activities. Many big quarries are located at Bukit Jabi, Bukit Kerangan, Bukit Tunjang and surrounding area in Kedah, and Kampung Binjai in Perlis (Figure 1). These exposures exhibit some geological features which were not previously reported. At least two fault systems were observed, the thrusts and the strike-slip faults. The aim of this paper is to highlight the occurrence of these faults.

GEOLOGICAL SETTING

The Mahang Formation is exposed in central and south Kedah. Burton (1967) divided the Mahang Formation into four lithofacies:

1. A dominant argillaceous facies
2. A subsidiary arenaceous facies
3. A minor siliceous facies that grades into the argillaceous
4. A restricted calcareous facies

In the Mahang area, Courtier (1974) divided the Mahang Formation into four members; dark grey shale or sandstone, dark graptolite-bearing shale, flagstone and chert, massive dark mudstone and red and grey laminated shale.

The Setul Formation forms the Setul Boundary Range in the west and extends to the north of Perlis. In Langkawi, the formation consists of the Ordovician limestone, the Lower Silurian Lower Detrital Member, the Silurian limestone and the Lower Devonian Upper Detrital Member. In Perlis the Detrital Member has not been reported yet and

the limestone passes conformably into the Kubang Pasu Formation.

The Kubang Pasu Formation crops out in central Kedah and extends into central and eastern Perlis. In central Perlis, the lower part of the Kubang Pasu Formation consists of mudstone interbedded with minor sandstone and the sandstone becomes dominant in the upper part.

The Kubang Pasu Formation in central and northwest Kedah conformably overlies the Mahang Formation. The lithology of the Kubang Pasu Formation consists of a chert sequence, mudstone interbedded with sandstone and a thick sandstone sequence representing the upper part of the formation. In Kedah the Kubang Pasu Formation is conformably overlain by the Semanggol Formation.

LOCATION AND DESCRIPTION OF THE OUTCROPS

Bukit Jabi

Bukit Jabi is a NNW-striking ridge. The Mahang Formation is exposed in the eastern part of the ridge and the western part is occupied by the Kubang Pasu Formation. The Mahang Formation consists of green to red colored slate. The slate of the Mahang Formation strikes NNW to north and the dip is moderately steep to steep to the east. The slate of the Mahang Formation is underlain by unmetamorphosed rocks of the middle and upper sequence of the Kubang Pasu Formation (Figure 2).

The middle sequence of the Kubang Pasu Formation consists of parallel and cross-laminated sandstone interbedded with mudstone. Thick sandstone, devoid of any primary structures and interbedded with thin mudstone, represents the upper part of the formation. Steeply dipping

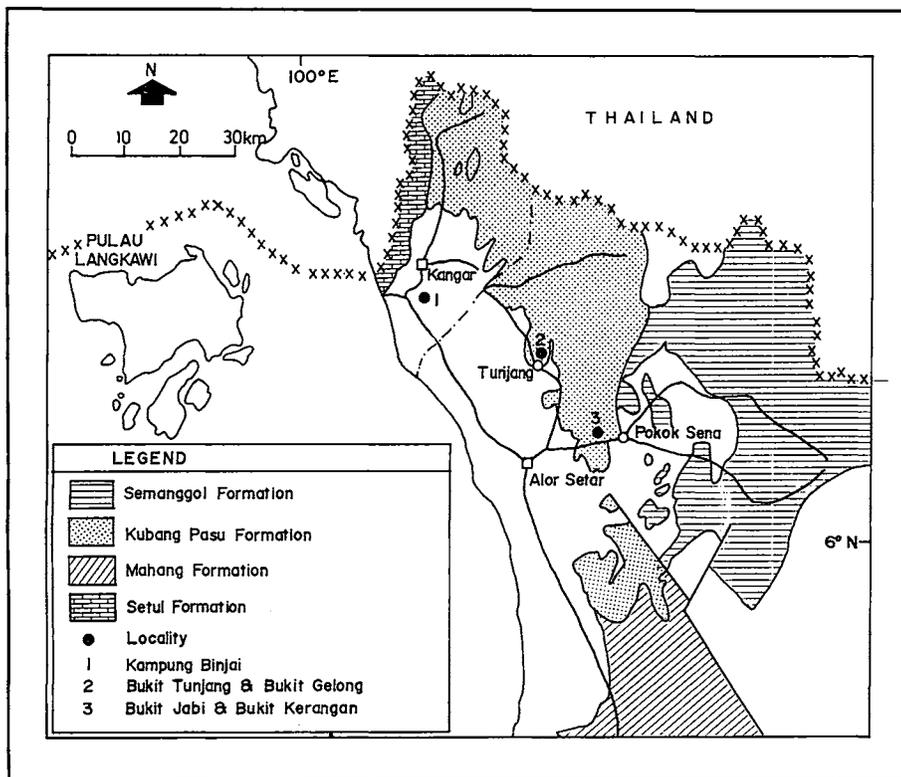


Figure 1: Simplified geological map of central and north Kedah, and Perlis. Locations of the thrust are marked on the map.

beds are younging towards the east with a general strike of NNW to NNE. The Mahang Formation and the Kubang Pasu Formation are separated by a mylonite zone. The boundary is a gentle to moderately steep-dipping fault with a strike ranging from NW to N.

Strike-slip faults and dip-slip faults were observed in both formations. The fault planes in the Mahang Formation are thinly mylonitised and the zones are highly fractured. The strike-slip and reverse faults in the Kubang Pasu Formation cut the beddings and often disappear into the bedding planes especially along thin shales. These shales exhibit foliated black shiny rocks that are easily broken and weathered. Merging of low angle and high angle fault planes are clearly observed in the field. These are oblique left lateral faults with reversal sense of movements. Generally the fault strikes range from NW to N. Slickensides on several fault surfaces plunge less than 10° to NW and to SE, and an almost pure strike slip is suggested. Oblique slip could also be suggested from the evidence of gentle to moderately ($24^\circ - 45^\circ$) plunging slickensides either to the SE or to the WNW. The left lateral faults were also observed cutting and displacing right lateral faults and the older left lateral faults.

Bukit Kerangan

The occurrence of another thrust fault at the northern extension of Bukit Jabi has been reported by Zaiton Harun (1998). The Mahang Formation consists of slate from various colours; greyish green, purple and red, and thin layers of chert. The Mahang Formation overlies the Kubang Pasu Formation and the boundary is a reverse fault (Figure 3). The reverse fault strikes NNE and dips gently towards ESE.

Bukit Tunjang

The southern part of Bukit Tunjang ridge is oriented NNW and the northern part is a northerly oriented ridge. The Tunjang Quarry is situated at the southern tip of Bukit Tunjang ridge. It is an abandoned earth quarry. The outcrop exhibits thickly bedded sandstone of the Kubang Pasu Formation. At the eastern part of the quarry there is a band of slate. The slate is dark and red in color. The dark colored slate is very hard, and weathered to form red slate. The slate strikes north and is steeply dipping towards the east. The slate is considered to be older than the Kubang Pasu Formation. At this outcrop the slate appears to be overlying the Kubang Pasu Formation (Figure 4).

At the Bukit Tunjang Quarry, the Kubang Pasu Formation comprises thickly bedded sandstone interbedded with thin shale. The slate is separated from the Kubang Pasu Formation by a vertical to subvertical black mylonite which strikes towards the north. The fault zone is extended about 20m from the boundary into the Kubang Pasu Formation. Mylonite zones along the bedding planes are indicative of fault movements along the planes. Reversal movements along the planes are indicated by the drag of the mylonite foliation. The faulting may have caused the tight folding formed within the fault zone. This fault seems to be cut by lateral faults; left and right lateral faults. Vertically to steeply dipping mylonites of lateral faults contain lenses of sandstone and slickensides indicating sense of movements along the faults. The N, NE and ENE striking faults with slickensides, moderately steep plunging toward the SSW, indicate oblique lateral with reversal sense of movements. The east striking faults exhibit gently plunging slickensides that are almost parallel to the strike

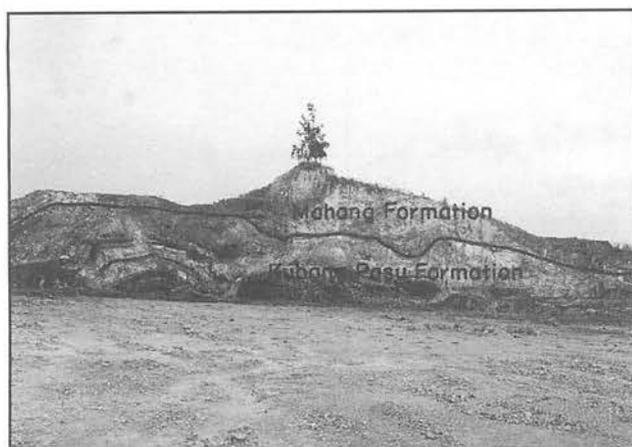


Figure 2: View looking west of Bukit Jabi showing the red slate of Mahang Formation on top of the Kubang Pasu Formation. The width of the photograph is about 130 m.

of the fault. Strike slip movements and dip slip movements are deduced from vertically plunging slickensides on the same planes. NW striking faults with moderately plunging slickensides towards the northwest are deduced to be oblique lateral faults. Both the NW and the east striking faults indicate a left lateral sense of movement. Recurring fault movements are indicated by highly fractured sandstones adjacent to the faults and overlapping of gently dipping and vertical slickensides on the same fault plane.

Bukit Gelong

Bukit Gelong is a small low hill situated at the east of Bukit Tunjang ridge. An abandoned earth quarry is on the west side of the hill facing the Muda Quarry. The Muda Quarry is still operating on the east side of Bukit Tunjang ridge. The slate of the Mahang formation is exposed at the western side of the hill. The color of the slate varies from dark red to whitish gray depending on the degree of weathering and leaching processes. The slates dip moderately steeply toward the east and strike from the north to NE.

A part of the Kubang Pasu sequence is overlying the slate of the older formation. The sequence of the Kubang Pasu Formation comprises channel sandstone within greyish white mudstone. Cross laminations within the sandstone show that the sequence is in normal position. The sequence dips moderately steeply towards the east and strikes from the north to the NE. The sequence is separated from the slate by a zone of mylonite striking to the NE and dips moderately steeply towards the east (Figure 5). Dip slip is indicated by slickensides moderately plunging to the ESE. The mylonite exposure is about 15 m in width and the slate exposure is about 180 m thick.

The Muda Quarry is situated about the northwest of the Bukit Gelong Quarry on the edge of the Bukit Tunjang ridge. The Kubang Pasu Formation is exposed in this quarry. Interbedded mudstone and sandstone overlies thick



Figure 3: The thrust fault separating the Mahang Formation on top of the Kubang Pasu Formation at Bukit Kerangan.

mudstone of the lower part of the formation. Interbedded thick sandstone and thin mudstone represents the upper sequence of the formation at this quarry. The sequence strikes NNW and dips steeply toward the east.

Kampung Binjai, Utan Aji

This is a temporarily abandoned earth quarry which exposed the Setul Formation within the Kubang Pasu Formation. The Setul Formation consists of dark gray limestone interbeds with bioturbated mudstone. The limestone is fossiliferous and contains thinly bedded siliceous materials. The sequence dips moderately steeply to the east and strikes to the NNW.

The Kubang Pasu Formation consists of thickly bedded mudstone and sandstone. The mudstone varies in color from grey, dark grey, greyish white and red. The red, massive mudstones are rich in the fossils *Cyrtosymbole (Waribole) perlisensis*, Cephalopoda, Brakiopoda, Moluska, Bivalvia and crinoids. Similar strata in Pulau Langgun have been recognised as the base of the Singa Formation (Hamada, 1969; Jones, 1981). The Kubang Pasu Formation in Kedah and Perlis is equivalent to the Singa Formation in Langkawi. Generally the sandstones are cross laminated, although some are devoid of any sedimentary structures. The primary structures within the sandstones indicate the sequence is still in normal position. General strike of the beds is NNW to NNE and dip is moderately steep towards the east. Orientation of the strata adjacent to the faults is normally deflected from the general strike due to the fault movements.

The Kubang Pasu Formation is stratigraphically on top but structurally underlines the Setul Formation; mylonite is the boundary between the two formation. The red colored mudstone occurs on the east of the limestone ridge and it is on top of the Setul Formation (Figure 6). This mylonite represents a thrust that could have brought up the upper part of the Lower Paleozoic limestone to overlies the Kubang



Figure 4: The fault zone separating the slate on the east and the Kubang Pasu Formation on the west of the Tunjang Quarry.

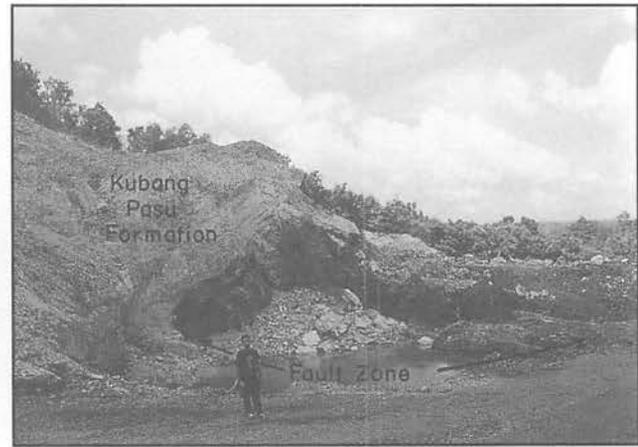


Figure 5: Part of the Tunjang thrust underneath part of the upper sequence of the Kubang Pasu Formation at Bukit Gelong.

Pasu Formation. Both formations were later cut again by vertical left lateral faults that strike WNW. The sense of left lateral slip is indicated by gently plunging slickensides to the WNW and meso-scale tension gashes on the fault surfaces.

CONCLUSIONS

In Bukit Jabi and Bukit Kerangan the slate and minor chert represent the Mahang Formation. The slate overlies the upper sequence of the Kubang Pasu Formation with the thrust fault as the boundary between them. Even though the sequence of the Kubang Pasu Formation is in normal position, the structural complication seems to be due to the fault movements. Merging of low and high angle faults and combination movements along the thrust and the strike slip faults form a flower structure which is common in transpressional zones.

The slate at the Bukit Tunjang Quarry and at the Bukit Gelong Quarry represent the older formation which may be equivalent to the Mahang Formation. The thickness of the slate is about 500 m and it is sandwiched within the upper sequence of the Kubang Pasu Formation. The sequence of the Kubang Pasu Formation at the Muda quarry, Bukit Tunjang Quarry and Bukit Gelong Quarry, exhibit coarsening and thickening upward sequences which seem to be typical of the Kubang Pasu Formation. The slate was thrust into the upper sequence of the Kubang Pasu Formation. The Kubang Pasu sequence is still in normal position.

It is believed that the sequence of interbedded mudstone and limestone at Utan Aji represents the upper part of the Setul Formation in Perlis. In Langkawi, the Upper Detrital Member represents the youngest part of the Setul Formation. It is pinching out in Perlis and replaced by the lenticular passage beds. The red fossiliferous mudstone representing the base of the Kubang Pasu Formation overlies the passage beds. The Setul Formation was thrust onto the Kubang Pasu Formation by the NNW thrust fault.



Figure 6: View looking of the ridge of the upper part of the Setul Formation on the west and the base of the Kubang Pasu Formation on the east at Kampong Binjai.

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