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Late Mesozoic-Early Tertiary faults of Peninsular Malaysia

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Abstract: Three samples of sheared granite were collected from two fault zones; the Bukit Berapit Fault and Bukit Tinggi Fault. The samples were dated by using the K/Ar method on the whole rock. Three isotope ages for the timing of fault movements were obtained i.e. 83.6 ± 4.2 Ma, 53.4 ± 2.7 Ma and 46.0 ± 2.3 Ma. The implication of the fault movements and the tectonic significance of resulting ages will be discussed.

Abstrak: Tiga sampel granit terricih diambil daripada dua zon sesar; Sesar Bukit Berapit dan Sesar Bukit Tinggi. Sampel-sampel tersebut telah ditentukan usia dengan menggunakan kaedah K/Ar bagi seluruh batuan. Tiga usia isotop masa pergerakan sesar yang didapati ialah 83.6 ± 4.2 Ma, 53.4 ± 2.7 Ma dan 46.0 ± 2.3 Ma. Implikasi pergerakan sesar dan kepentingan usia-usia tersebut dari kacamata tektonik akan dibincangkan.

INTRODUCTION

The anatomy of major faults in Peninsular Malaysia has been studied by Zaiton Harun (1992). The study of faults is not complete without information about the age of the faulting. The age of faulting is very important for interpreting the tectonic history. In Peninsular Malaysia, not many faults have been dated by isotope dating. This paper is to report several isotope datings for samples collected from the Bukit Tinggi Fault Zone and Bukit Berapit Fault Zone (Fig. 1). The implications of the faulting and tectonic events which may be related to the timing of the same fault movement will be discussed.

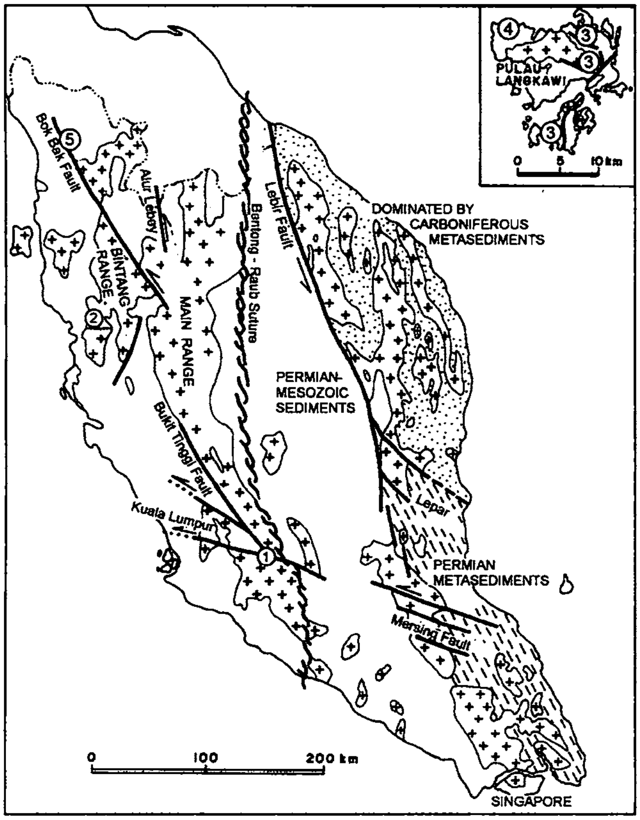

Figure 1. Map of several major faults in Peninsular Malaysia. 1, location of Bukit Tinggi Fault at Kajang- Kuala Kelawang road. 2, Bukit Berapit Fault. 3, Kisap Fault, 4, Susulan Datai Fault. 5, Pokok Sena town (modified after Tjia 1989a).

GEOLOGICAL SETTING

The study area is located at the Bukit Berapit area north Perak, the Bukit Tinggi area in Pahang and the Kuala Kelawang area in Negeri Sembilan (Fig. 1). The rock in the areas comprises granitic rock of late Triassic in age. The granite in the Bukit Berapit area including Bubu granite at the south of Kuala Kangsar is part of the Banjaran Bintang Granite (Bignell and Snelling, 1977). The age of the Bubu Granite is indicated as 210 Ma in the geological map of Peninsular Malaysia (Santokh Singh, 1985). The granite is cut and displaced by lateral faults.

The Bukit Berapit fault zone is exposed at a road-cut along the Kuala Kangsar-Changkat Jering highway and at the old road of Kuala Kangsar-Changkat Jering. The occurrence and description of the fault zone were reported by Zaiton Harun (1994). The fault zone consists of porphyritic megacryst biotite granite and mylonites. The mylonites consist of asymmetric and symmetric lenses of quartz and feldspar, and light greenish grey in colour (Fig. 2). Generally, the mylonite foliation strikes east-west. The fault planes of the same attitude cut the foliation in an anastomosing manner. Relationship between asymmetric lenses of quartz and feldspar, and shear band indicate dextral and the sinistral sense of movements (Fig. 3 and 4).

Alexander (1968) discovered a zone of mylonite in granite, along Ulu Tanglir –Ulu Benus and believed the existence of a northwest fault in the Bentong and Genting Sempah area. The fault zone trace runs from Kuala Kubu

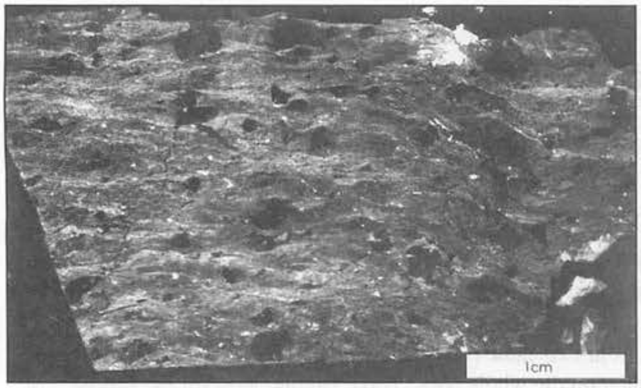

Figure 2. Thin section of granitic mylonite from Bukit Berapit Fault. Dark grains are quartz and feldspar. This is a direct print of negative of thin section onto photograph paper.

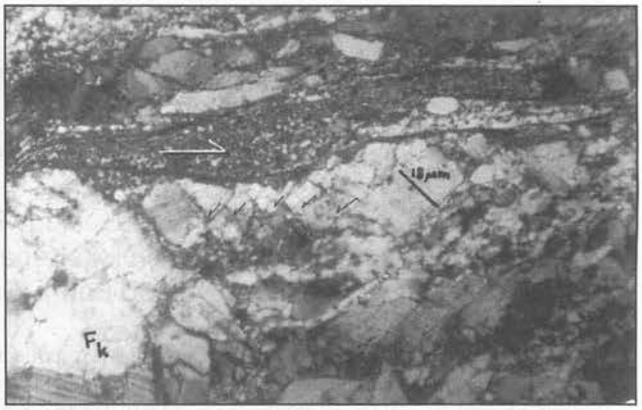

Figure 4. Photomicrograph of kinked feldspar (Fk) and displaced broken feldspar (shown by thin half arrow) due to dextral movement (thick half arrow) (after Zaiton Harun (1994).

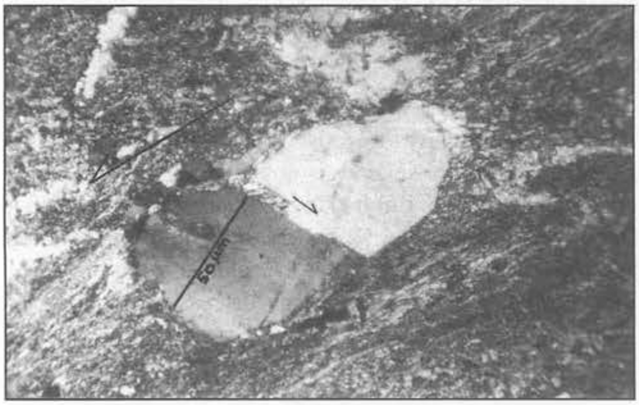

Figure 3. Photomicrograph of displaced broken quartz in mylonite due to sinistral movement (Thicker half arrow). After Zaiton Harun (1994).

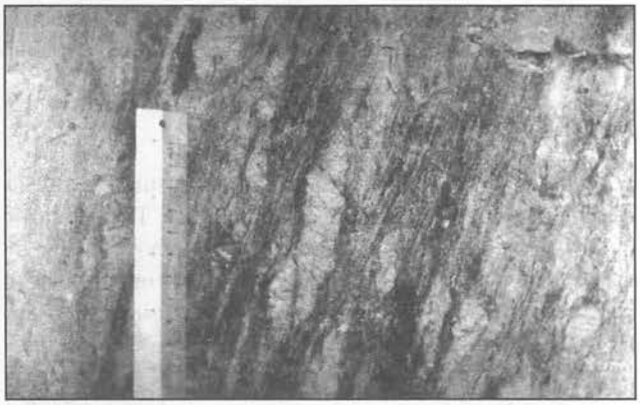

Figure 5. Flasered porphyritic megacrystic granite from Bukit Tinggi Fault Zone.

Bahru to north of Bahau. Later Shu (1969) named the 110 km shear zone as Bukit Tinggi Fault (Fig. 1). The fault cuts the Main Range granite and also forms a boundary between the granite and the lower Paleozoic rocks (Santokh Singh, 1985).

The Bukit Tinggi Fault Zone is exposed at three road-cuts along the Kuala Lumpur-Karak Highway and at one road-cut along Kajang-Kuala Kelawang road. The fault zone is defined as three bands of sheared granite cutting the biotite granite. The bands are exposed at km 45, km 46.5 and km 47.3 along the Kuala Lumpur-Karak Highway. Each band is 50 m, 150 m and 160 m wide respectively. The fault zone is characterised by light to dark grey porphyritic flasered granite (Fig. 5) and fault breccia. The flasered granite comprises medium to coarse grained symmetric to asymmetric lenses of feldspar. The foliation strikes northwest. Relationship between asymmetric lenses of feldspar and shear plane indicates left lateral movement along the general strike (Fig. 6). The outcrop at km 54 Kajang-Kuala Kelawang road exhibits 15m wide flasered granite striking northwest.

AGES OF FAULTS

Two samples of granitic mylonite were collected from the Bukit Berapit Fault and one sample of flasered granite from the Bukit Tinggi Fault Zone at km 54 Kajang-Kuala Kelawang road. The samples were sent to Teledyne Isotopes, U.S.A. for whole-rock isotope dating by using K/Ar method. The results are as follows:

Kajang-Kuala Kelawang	83.6 ± 4.2 Ma
Bukit Berapit-1	53.4 ± 2.7 Ma
Bukit Berapit-2	46.0 ± 2.3 Ma

Isotopic age 83.6 ± 4.2 Ma of flasered granite sample Kajang-Kuala Kelawang corresponds to the boundary Santonian-Campanian which is late Cretaceous. Isotopic age 53.4 ± 2.7 Ma and 46.0 ± 2.3 Ma of mylonite sample Bukit Berapit-1 and Bukit Berapit-2 correspond to Early Eocene and Middle Eocene, respectively.

Tjia (personal comm.) obtained the same age 83 Ma for the Bukit Tinggi Fault Zone. Rock from cataclastic zone in porphyritic granite from Pulau Pangkor, have ages of 70.2 ± 3.5 and 73.2 ± 4.6 (Syed Sheikh Almashoor and

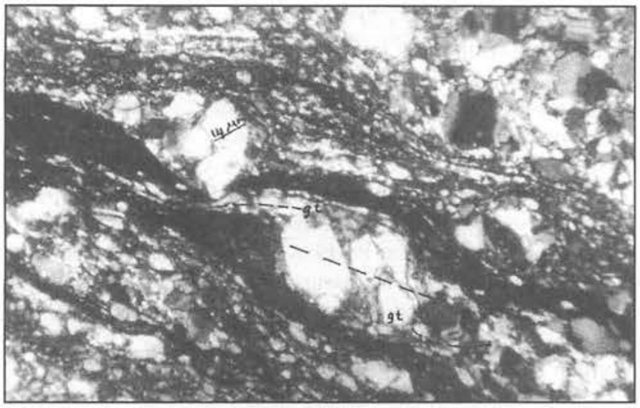

Figure 6. Book-shelf sliding to the right illustrated by broken porphyroclast due to the sinistral movement.

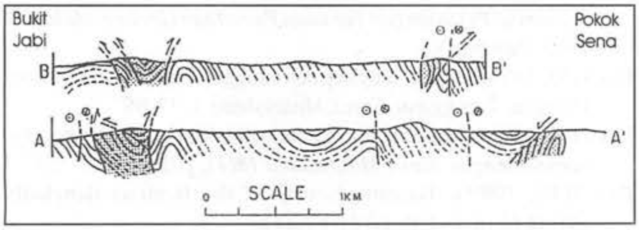

Figure 7. Two cross sections between Bukit Jabi and Pokok Sena showing the position of the Mahang Formation (grey and stippled) on top of the Kubang Pasu Formation. After Zaiton Harun and Basir Jasin (1998).

Zaiton Harun, 1995) whereas the age of Pangkor granite determined by Bignell & Snelling (1977) is late Triassic.

TECTONIC SIGNIFICANCE

It seems that the late Cretaceous includes one of the important faulting events in Peninsular Malaysia. The youngest granite intrusion also took place during this time. The ages may indicate reactivation of existing faults in relation to granite intrusion during Cretaceous. This is evidenced by the flasered granite that filled the narrow bands of the Bukit Tinggi Fault Zone within the Banjaran Titiwangsa (Main Range) batholith. Cobbing *et al.* (1986) believed that there is no indication of deformed granitic rocks. The deformation of the rock are found to be related to the fault movement. The reactivated fault zones may have controlled and facillitated the intrusion of the Cretaceous granites.

Major faults in Peninsular Malaysia strike north, north-northwest, northwest and west-northwest. Indications of recurrence movements along these faults have been proved by several workers e.g. sinistral and dextral sense of movements were observed in phyllonite of the Alur Lebey Fault (e.g. Zaiton Harun, 1996), the youngest dextral movement along the Raub-Bentong Suture was preceded by the west and east vergence along the thrust faults in the suture (Tjia, 1989b). Reactivation of the major faults may have caused the loss of argon that resulted the younger age of the isotope dating.

During this event the strike-slip faults that strike northwest, north-northwest and west-northwest moved sinistrally, e.g. the Bukit Tinggi Fault, Bok Bak Fault, Kuala Lumpur Fault, Lebir Fault and Alur Lebey Fault (e.g. Zaiton Harun, 1992). Thrust faults i.e. Kisap Fault, Dungun Fault (e.g. Tjia, 1974) are also affected by this tectonic event. The sinistral movement along the Bok Bak Fault is responsible to the formation of folding and reverse faulting adjacent to the fault. These structures characterised transpressive tectonic environment which is created at certain parts of the fault segments. Emergence of the Mahang Formation on top of the younger Kubang Pasu Formation are evidenced at several localities in north Kedah. Topographically they form as isolated small hills and ridges adjacent to the Bok Bak Fault traces for example Bukit Jabi, Bukit Kerangan, Bukit Tunjang. Reverse fault is commonly found at the boundary between the lower Paleozoic of the Mahang Formation and the upper Paleozoic of the Kubang Pasu Formation (Zaiton Harun & Basir Jasin, 1998, 1999, 2000). The fault strike is ranging from NW to N and dip gently to moderately steep either to east and/or west. Slickensides on fault surfaces indicate lateral oblique slip with reversal sense of movement. Combination movements of sinistral slip and thrusting form a positive flower structure (Zaiton Harun, 1992, Zaiton Harun & Basir Jasin, 1998, 2000) which is commonly found in transpressional zone of the strike slip region (Naylor *et al.*, 1986). These movements have brought up the Mahang Formation on top of the Kubang Pasu Formation (Fig. 6). Perhaps this may also explain the presence of the northerly striking folds and reverse faults in the Semanggol Formation, indicating vergence to the east and west (Ibrahim Abdullah *et al.*, 1990).

The movement of the Early and Middle Eocene may be related to the collision of India and south Asia. Peltzer & Tapponnier (1988), interpret the eastward extrusion of Indochina and China along major strike slip faults as the result of India-south Asia convergence. In this interpretation the extrusion movements created extension in Southeast Asia continental shelf and the opening of the South China Sea. The collision reactivated the movements of major faults and fractures in Southeast Asia. Dextral movements along the NW, N and WNW faults and fractures may have caused the opening of Tertiary basins inland and offshore of Peninsular Malaysia

The opening of the Tertiary basins in Peninsular Malaysia is due to the transtensional setting created at certain segments of the faults (Tjia, 2000, 2001). Recurring movements along the faults i.e. the Bok Bak Fault and the Bukit Tinggi Fault may have also occurred during this time. Even though sinistral is the major characteristic observed in the field and under microscopic study, the dextral sense of movements are sometimes discovered (Zaiton Harun, 1992). Burton (1970) also mentioned the occurrence of the dextral sense of movement in sinistral Bok Bak Fault. The occurrence of the dextral sense of movement is clearly described in the Bukit Berapit Fault and Alur Lebey Fault (Zaiton Harun, 1994, 1996).

CONCLUSION

Three isotope ages are obtained through whole-rock isotope dating using the K/Ar method on one sample from the Bukit Tinggi Fault Zone and two samples from the Bukit Berapit Fault Zone, respectively. The flasered granite sample from the Bukit Tinggi Fault Zone corresponds to late Cretaceous. The other two mylonite samples of Bukit Berapit Fault correspond to Early Eocene and Middle Eocene.

Late Cretaceous is the time of faulting that may be related to the late Cretaceous granite intrusion. During this event, the northwest, north-northwest and west-northwest strike-slip faults moved sinistrally. Transpressional zones were created at certain overlapping segments of the fault zones as a result of the sinistral movement along the Bok Bak Fault Zone. The movements during Early and Middle Eocene may be related to the convergence of India and south Asia. The convergence may have caused the opening of Tertiary basins in Peninsular Malaysia as the result of extrusion of China and Indochina to the east-southeast.

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