

Petrology of granitic rocks along new Pos Selim to Kampung Raja highway (km 0 to km 22): identification of different granitic bodies, its field and petrographic characteristics

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Abstract: Four granitic bodies have been identified along the Pos Selim-Kampung Raja Highway (0 to km 18). They are Selim granite (km 0 to km 5), Suku granite (from km 6 to km 11), Semerengol aplopegmatite (occur as granitic dykes intruded the metamorphic rocks at km 14 to km 15) and Regul granite (km 17 to km 18). The Selim granite consists of outer coarse grained porphyritic biotite granite and medium to fine grained granite. The Suku granite is characterized by the presence of xenoliths and other enclaves. Among the enclaves are biotite rich, quartz tourmaline pods and various types of xenoliths (metamorphic). The Regul granite at km 17 and 18 contains primary muscovite. The Semerengol aplopegmatite consists of tourmaline muscovite garnet granite and their aplopegmatite dykes found at km 14 and 15. Geochemical evidence showed that three granitic bodies (Selim, Suku and Regul granites) are different in term of their TiO_2 , Fe_2O_3 and P_2O_5 contents. This supports our field observation and division of the granites along Pos Selim-Kampung Raja Highway.

Abstrak: Empat badan granitik telah dikenalpasti di sepanjang jalan Pos Selim-Kampung Raja (km 0 ke 18). Mereka adalah Granit Selim (km 0 ke km 5), Granit Suku (km 6 ke km 11), Semerengol aplopegmatite (wujud sebagai daik-daik granite yang menerobos batuan metamorfik di km 14 ke 15) dan Granit Regul (km 17 ke km 18). Granit Selim mengandungi granit biotit porfiritik berbutir kasar dan granite berbutir halus ke sederhana. Granit Suku di cirikan oleh kehadiran berbagai jenis xenolit dan 'enclave'. Di antara 'enclave' yang hadir ialah enclave kaya biotite, pod kuarza tourmaline dan berbagai jenis xenolit metamorf. Granite Regul dijumpai antara km 17 dan 18 mengandungi muskovit primer. Semerengol aplopegmatit pula mengandungi granite tourmaline muskovit garnet dan daik-daik aplopegmatit dijumpai di km 14 dan 15. Bukti geokimia menunjukkan ketiga-tiga badan granit (Granit Selim, Suku and Regul) adalah dari magma yang berlainan berdasarkan kandungan TiO_2 , Fe_2O_3 and P_2O_5 . Ini menyokong pemerhatian lapangan dan pembahagian granit di sepanjang Jalanraya Pos Selim-Kampung Raja.

INTRODUCTION

The Western Belt granite of the Peninsular Malaysia is characterized by a huge mountain range extending from Malacca in the south to Thailand in the north (Cobbing *et al.*, 1992). Two main batholith masses can be distinguished in the Western Belt Granite. These are the Main Range batholith on the eastern flank and the adjacent Bintang batholith immediately to the west. Small intrusive centres are found further to the west (Fig. 1). These are called Bukit Mertajam-Kulim, Penang, and Langkawi complexes. Each granitic batholith and complex consists of individual plutons (Liew, 1983). The main rock type is a coarse to very coarse grained megacrystic biotite muscovite granite. Two phase variants, however, developed almost everywhere and may be volumetrically important (Pitfield *et al.*, 1990; Cobbing *et al.*, 1992; Mursyidah and Azman, 1999). Aplopegmatite and mesogranites are commonly associated with the individual granitic body. Common features of the aplopegmatite and mesogranites complex is the development of mineral layering; good examples are found in the Kuala Lumpur granites (Pitfield *et al.*, 1990); Tanjung Jaga area (Jerai pluton) and south of Tuba island (contact granite with Setul Formation) in the Langkawi group and occurrence

of aplopegmatite dykes e.g. Kuala Lumpur Granite (Ng, 1997).

Construction of the Simpang Pulai-Pos Selim-Kampung Raja highway across the Main Range granite has exposed fresh outcrops of the Western Belt granite. In this paper geology of the granite from km 0 to km 22 of Pakej 2X of the highway is described. This paper concentrates on the field relation and petrology of the granites.

On the total, this study revealed four different granitic bodies from the area. All the four bodies will be described in different section namely, (1) Selim pluton (km 0 to km 5), (2) Suku granite (from km 6 to km 11) (3) Semerengol aplopegmatite (occur as granitic dykes intruded the metamorphic rocks at km 14 to km 15) and (4) Regul granite (km 17 to km 18).

GENERAL GEOLOGY

The study area is located along the Pos Selim highway, Perak-Pahang border. The highway is part of the East West Highway project which is currently under construction. It stretches from Pos Selim in Perak to Ladang Blue Valley at Cameron Highlands, Pahang. The length of the highway is approximately 35 kilometers and traverses over the

Titawangsa Main Range (Western Belt granite). The topography of the study area is mountainous with elevation up to 1,797 m. The area is generally underlain by granitic and metamorphic rocks (Fig. 2). The age of the granite ranges from 199 to 206 Ma (Gobbett and Hutchison, 1973) and consists mainly of coarse grained biotite granite.

FIELD RELATION AND PETROGRAPHY

Selim granite

The Selim pluton crops from km 0 to km 3.4 of the highway. The pluton consists of coarse grained porphyritic biotite granite (Fig. 3) and medium to fine grained granite (Fig. 4). The latter intruded by numerous tourmaline and aplite veins and dykes. The porphyritic biotite granite exposed from km 0 to km 1.1, usually weakly foliated with phenocrystic K-feldspar trending parallel to each other. The medium to fine grained granite varies gradationally from medium grained granite to fine grained granite, both

granites characterized by blue coloured quartz. Intensity of both aplite and tourmaline veins and dykes also increases towards the centre of the pluton. The medium to fine grained granite are more equigranular and contain less ferromagnesium minerals compared to the outer units

The porphyritic Selim granite is characterized by large phenocrysts with the size ranging from 5 to 8 cm and phenocryst-matrix ratio is about 50:50. Mineralogy of the granite in decreasing abundance is K-feldspar, quartz, plagioclase, biotite, muscovite, apatite, secondary epidote and tourmaline. Large K-feldspar phenocrysts up to 7 cm long are common. The phenocrysts usually consist of microcline microperthite.

Plagioclases ranging from 0.7 to 4 mm in size and may occur as discrete phenocrysts or as glomeroporphyritic aggregates showing resorbed outlines in the mafic members of the granites. Quartz in the porphyritic granite is mostly anhedral and sometimes occurs as subgrains with the size ranging from 1 to 3 mm. The colour of the mineral grades from grey to bluish from porphyritic granite to the medium to fine grained granite. Biotite occurs as discrete plates, as ragged shreds in mafic clots and as small flakes associated with granoblastic aggregates of quartz and plagioclase. The pleochroism scheme is typically pale brown to dark brown but the green varieties also occur. The biotite content (%) and size decreases from the coarse grained porphyritic biotite granite to inner medium to fine grained granite.

Suku Granite (from km 6 to km 11)

This granite is characterized by the presence of xenoliths and other enclaves the larger part of which are from the enveloping metasediments. The type of xenoliths in order of decreasing abundance includes semi-pelite, calc-silicate and quartzite. Other types of enclave are tourmaline quartz pods (Fig. 5) and biotite rich microgranitoid (Fig. 6). The enclave and xenoliths sometimes occur as small and thin plates lying parallel to the foliation of the rocks. Two types of granites can be identified in the pluton namely coarse (sometimes porphyritic) equigranular biotite granite (80%) (Fig. 7) and medium to fine grained granite (20%) (Fig. 8). The contact between these two granites can be seen at an abandoned quarry at km 11 of the new road (Fig. 8). The granites from this pluton can easily be differentiated from the Selim granite as their mafic mineral (biotite) content is higher (up to 10%) and thus the colour of the rock is darker.

Plagioclase is euhedral with the sizes up to 0.5 cm. Quartz in the granite is mostly anhedral and sometimes show embayed texture. The size of the mineral ranges from 0.1 to 2 mm. Biotite may occur as discrete plates, as ragged shreds in mafic clots and as small flakes associated with granoblastic aggregates of quartz and plagioclase. The pleochroism scheme is typically pale brown to dark brown but the red varieties also occur. Alteration of biotite to chlorite is rather common. Orthoclase and microcline are common K-feldspar type present in the rock.

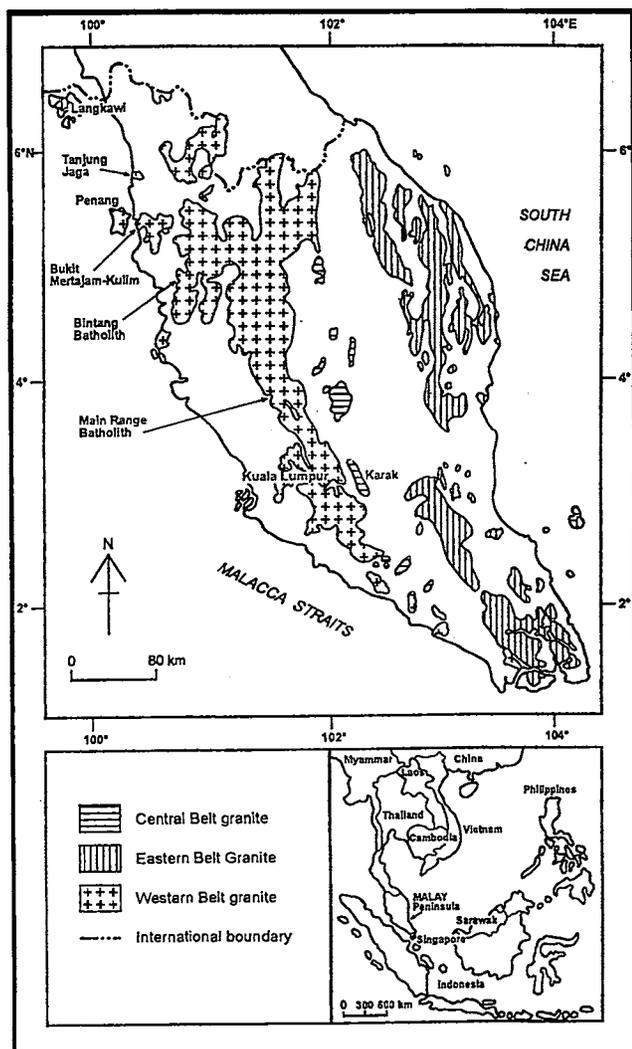


Figure 1. Map of the Peninsular Malaysia showing the Western Belt granite in relation to other granites batholith. Square inset map shows the location of Peninsular Malaysia.

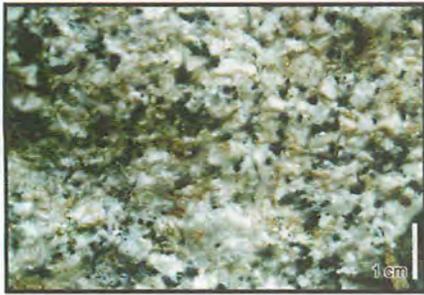


Figure 9. Coarse grained tourmaline muscovite garnet granite at km 15 (Semerengol granite). Note the occurrence of garnet and tourmaline.



Figure 10. Aplo-pegmatite dykes (and veins) intruded the country rock (Schist and Phyllite) at km 14 to km 15. The thickness of the dyke is about 1.5 m.



Figure 11. Zoned aplo-pegmatite dykes (and veins) intruded the country rock (Schist and Phyllite) at km 14 to km 15. Note the abundance of mafic mineral (biotite & Tourmaline) at the margin of the dyke.

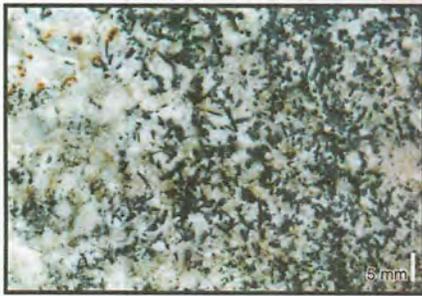


Figure 12. Tourmaline in some of the aplopegmatite dykes can reach up to 1 to 2 cm long.

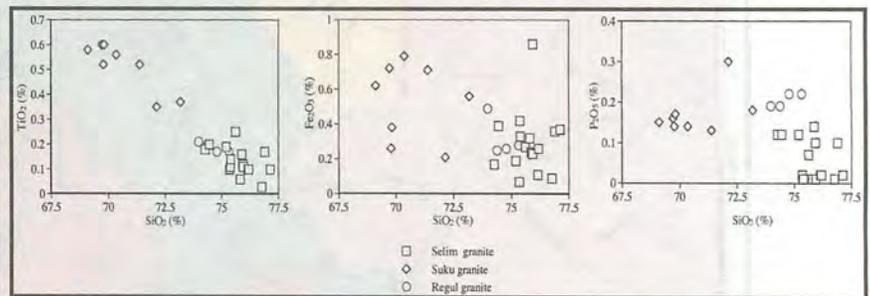


Figure 13. Major Harker diagram SiO_2 versus TiO_2 , Fe_2O_3 and P_2O_5 .

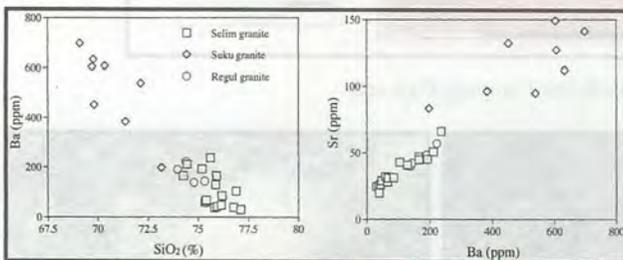


Figure 14. Ba vs SiO_2 and Sr vs Ba of the Selim granite.

in the metamorphic rock. The dykes sometime faulted and diverge into several smaller dykes. Zonation consists of fine grained marginal aplite bordered the tourmaline rich leuco-pegmatite is rather common. Tourmaline in the latter can reach up to 1 to 2 cm long (Fig. 12).

The tourmaline-muscovite-garnet granite is medium to coarse grained and is the only rock along this highway that contains garnet (Fig. 9). The size of the garnet can reach up to 0.5 cm. The muscovite also about the same size as the garnet which suggests that the mineral is primary. Tourmaline in the granite is slightly smaller compared to those occurring in the dykes. The size of quartz, plagioclase and K-feldspar ranging from 0.2 to 0.5 cm.

Regul granite (km 17 to km 18)

The outcrop of this granite can be found from km 16.8 to km 18.5. The granite contains muscovite ranging from

3 mm to 5 mm in size. Compared to the Suku Granite, the muscovite granite has no enclave and contain less biotite. The fairly uniform muscovite granite consists in order of abundance; quartz, plagioclase, alkali feldspar, biotite, muscovite, rutile, apatite and opaque phases. Alkali feldspar is anhedral microcline-micropertthite. It is larger (up to 1.5 cm) than quartz and plagioclase. Inclusions of small plagioclase, biotite and apatite crystals are common. Plagioclase is usually smaller than alkali feldspar. Two types of plagioclase crystals can be distinguished; (i) small (less than 0.5 mm) subhedral, unoriented, sericitized plagioclase enclosed poikilitically in perthitic alkali feldspar (ii) large, (up to 1 cm) anhedral to subhedral crystals usually occurring in clusters. Alteration of plagioclase to epidote, sericite and muscovite is common.

Quartz occurs as anhedral crystals or interstitially to plagioclase and alkali feldspar. The average size is from 0.5 to 1.2 mm. Biotite is subhedral to anhedral and usually occurs as individual small crystals (less 1 mm across) and rarely forms clots with epidote and muscovite. The pleochroic scheme is X = green to brown and Y = straw yellow. Alteration to chlorite is common.

Muscovite occurs in two modes. The first type is secondary muscovite, resulting from the alteration of plagioclase (20 to 30% of the total muscovite) and consists of very small crystals. The second type forms large muscovite grains (3 to 5 mm across) usually occurring as aggregates of four to six subhedral crystals but occasionally as individual crystals.

Table 1. Summary of the petrographic dan field data of the Selim granite at km 0 to 5, Pos Selim Kampung Raja Highway.

	CH 0000 - CH 1030	CH 1090 - CH 1300	CH 3270 - CH 3370
Rock types	Coarse-grained Porphyritic Granite	Medium to Fine grained equigranular Granite	Coarse-grained Porphyritic Granite
Colour	Bluish grey	Light grey	Grey
Groundmass size	Medium (0.1 cm - 0.4 cm)	Fine (< 0.1 cm)	Equigranular (0.5 cm - 2.5 cm)
Groundmass shape	Alloctriomorphic to Hypidiomorphic		
Phenocryt Characteristic			
Type	K-feldspar	Quartz	K-feldspar
Shape	Subhedral - anhedral	Rounded	Euhedral - subhedral
Size*	Nearly > 7 cm	0.3 cm - 0.5 cm	±5 cm
Abundance**	Medium (15%)	Low (< 10%)	High (25%)
Characteristic Similarity	+ Fine Muscovite (< 1%), medium percentage of opax mineral abundances (5% - 10%) intergrained.		
Others Characteristic	Largest phenocryt Occurrence at Selim Granite group	+ Tourmaline veins (1-2 mm), + medium-rounded blue quartz (1-7 mm)	Weathered K-feldspar minerals

Note : * phenocryt length ; ** groundmass and phenocryt ratio ; + Occurance

Table 2. Summary of the petrographic dan field data of the Suku granite at km 6 to 11, Pos Selim Kampung Raja Highway.

	CH 4480 - CH 14140	CH 11 200
Rock Types	Coarse grained Biotite Granite (± porphyritic texture)	Fine grained Biotite Microgranite
Colour	Light grey	Dark grey
Groundmass Size	(0.5 cm - 0.1 cm)	(< 0.1 cm)
Groundmass Shape	Alloctriomorphic to Hypidiomorphic	
Phenocryt Characteristic		
Type	K-feldspar	K-feldspar & Quartz
Shape	Euhedral - subhedral	
Size (length)	Nearly ≥ 5 cm	Max ± 0.3 cm
Abundances (Phenocryt / roundmass)	High (25% - 30%)	Low (< 5%)
Characteristic Similarity	Occurance of xenoliths	
Others Characteristic	+ xenolith metasediment. The groundmass are made of quartz, plagioclase, K-feldspar and mafic minerals.	Chloritisation, + biotite-rich enclave (± 30%), + tourmaline veins, + Milky quartz (± 2 mm)

Note: + Occurance

Table 3. Summary of the petrographic dan field data of the tourmaline muscovite garnet granite and aplopegmatite dykes (Semerengol aplopegmatite complex) at km 14 to 15, Pos Selim Kampung Raja Highway.

	CH 14 670 - CH 14 680 and CH 15180 - CH 16 280
Rock Types	Garnet Muscovite Tourmaline Granite Aplopegmatite dyke
Colour	Light white with black and red spots, leucocratic
Groundmass Size	Fine (< 0.1 cm)
Groundmass Shape	Alloctriomorphic to Hypidiomorphic
Features	Masive granite body Off shot dykes from Garnet Muscovite Tourmaline Granite
Characteristic Similarity	Showing minerals alignment likes schlieren texture, High occurrences of felsic minerals (> 65%),
Others Characteristic	Garnet (0.5 cm), primary muscovite (0.1 - 0.5 cm) and Tourmaline (0.1 - 0.5 cm) The sizes of tourmatine is much larger (> 5 cm) acicular shape

Table 4. Summary of the petrographic dan field data of the Muscovite granite at km 17 to 18, Pos Selim-Kampung Raja Highway.

	CH 16760 - CH 18450
Rock Types	Muscovite Granite
Colour	Light grey, leucocratic
Groundmass Size	Equigranular, 0.3 cm - 0.5 cm
Groundmass Shape	Alloctriomorphic to Hypidiomorphic
Mineral present and their abundances	K - feldspar 50% Quartz Plagioclase Muskovite Biotite + mafic ↓ 10% Mineral percentage decreases
Others Characteristic	Absence of enclave and phenocryt, Fresh rock with high occurance of muskovite (0.3 to 0.5 cm),

GEOCHEMICAL EVIDENCE OF DIFFERENT PLUTON

To support our field observations, we have examined the geochemical characteristics of three granitic bodies i.e. the Selim, Suku and Regul granites. Harker diagrams of SiO₂ versus TiO₂, Fe₂O₃ and P₂O₅ are shown in Figure 13. The plots show that the Suku granite is the most basic compare to both Selim and Regul granites. The range of SiO₂ for the three plutons are: Suku (68 to 73% SiO₂), Selim (73 to 77% SiO₂) and Regul (74 to 75% SiO₂). Thus between the Suku granite and the other two granites (Selim and Regul), they are separated by a gap of about 1% SiO₂. Although the later two granites overlap in their SiO₂ content, P₂O₅ behaves differently as they show a different trend in the content. P₂O₅ in the Selim pluton decrease whereas in Regul granite, P₂O₅ increase with increasing SiO₂. Furthermore the concentration of P₂O₅ content in the Selim pluton (0.02-0.14%) is lower compared to the muscovite granite pluton (0.18 -0.22%). In all three plots, the three granites can be discriminated in terms of their TiO₂, Fe₂O₃ and P₂O₅ content. This evidence supports the field classification of the granitic rocks from the newly built Pos Slim to Kampung Raja highway. However the evolution of all the granite magmas is controlled by the same mineral that is K-feldspar and plagioclase. This is evident from the Sr vs Ba diagram of the granites (Fig. 14).

DISCUSSIONS AND CONCLUSIONS

This study shows that along the Pos Selim-Kampung Raja Highway (0 to km 18) four granitic bodies have been identified, which are

- (1) Selim granite (km 0 to km 5),
- (2) Suku granite (from km 6 to km 11),
- (3) Semerengol aplopegmatite complex (occur as granitic dykes intruded the metamorphic rocks at km 14 to km 15) and
- (4) Regul granite (km 17 to km 18).

Summary of the petrographic and field data of the four granitic bodies are given in Tables 1, 2, 3 and 4.

The Selim granite consists of outer coarse grained porphyritic biotite granite to inner medium to fine grained granite. The Suku granite is characterized by the presence of xenoliths and other enclaves. Among the enclaves are biotite rich, quartz tourmaline pods and various types of xenoliths (metamorphic). Semerengol aplopegmatite complex (tourmaline muscovite garnet granite and aplopegmatite dykes at km 14 and 15) are closely related with the country rocks. The tourmaline muscovite garnet granite magmas differentiated and formed a highly evolved aplopegmatite magma which later intruded the country rocks. The presence of pegmatite pods and aplites provides strong evidence for the presence and exsolution of a vapour phase from the tourmaline-muscovite-garnet granite magma, probably at the final stages during solidification. During the late magmatic stage, pegmatite crystallised from a

hydrous silicate melt under high vapour pressure (Jahns and Burnham 1969), which had separated from the underlying granitic magma and collected under the roof of the magma chamber. The high vapour pressure may cause periodic sudden fracturing, resulting in the formation of aplites. This would have crystallised as aplopegmatite magmas which intruded as dykes and veins in the country rocks. Mahood *et al.* (1996) studied a peraluminous magma chamber, Panamint Mountain, California and showed that accumulation of water rich and more felsic magma toward the roof suppressed crystallisation there by lowering the liquidus temperature. Mahood *et al.* (1996) showed that at the highest levels, accumulation of differentiated liquids and crystallisation proceeded until water saturation was reached, resulting in the formation of the aplites and pegmatites of the roof zone.

ACKNOWLEDGEMENT

This study partly is sponsored by University of Malaya (Vot F 0727/2002A and 0739/2002A). The authors wish to acknowledge Prof. Chen Tingyu from National Research Centre of Geoanalyses, Institute of Geology, Chinese Academy of Geological Science, Beijing for major, trace and REE analyses.

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Manuscript received 25 February 2003