Malaysian Journal of Science **27** (3): 1 - 6 (2008)

The Geology and Geomorphology of Pulau Jarak, Pulau Sembilan and Pulau Perak

Azhar Hussin[1*], Azman Abdul Ghani[3], Khaira Ismail[3], Rosmadi Fauzi[2], Richard Dorall[2] and S. Gokilan[2]

[1] Institute of Ocean and Earth Sciences
University of Malaya
50603 Kuala Lumpur

[2] Department of Geography
University of Malaya
50603 Kuala Lumpur

[3] Department of Geology
University of Malaya
50603 Kuala Lumpur

* hhazhar@yahoo.co.uk (Corresponding author)

ABSTRACT Pulau Jarak and Pulau Perak in the northern part of the Straits of Malacca constitute the outermost islands of Peninsular Malaysia. Pulau Jarak is a granitic island with a well-developed soil cover on the upper slope which falls straight into the sea with almost no coastal plain. Hence the coastline is dominated by boulders and granitic outcrop. It is fringed by an asymmetrical subsea platform which supports luxuriant coral reef development. Pulau Perak is underlain by a metamorphosed sequence of predominantly thick bedded, low-dipping arenaceous sedimentary rocks which form a broad anticline. Poor soil development is seen in Pulau Perak, being limited to areas of thick guano from ocean birds. Its subaerial morphology of steep precipitous cliffs continue into the sea to a depth of 85 meters. Luxuriant growth of corals and algae plastered the walls of these subsea cliffs.

ABSTRAK Pulau Jarak dan Pulau Perak di bahagian utara Selat Melaka merupakan pulau pulau yang terjauh dari Semenanjong Malaysia. Pulau Jarak merupakan sebuat pulau granit yang mempunyai lapisan tanah yang tebal di bahagian atas cerun yang menjunam terus ke laut tanpa kawasan pamah. Oleh itu, garisan pantainya di hadiri oleh bungkah bungkah dan singkapan granit. Ianya di kelilingi oleh pelantar marin yang taksimetri yang menyokong pertumbahan pesat terumbu karang. Pulau Perak dialasi oleh satu jujukan batuan sediment berpasir yang mempunyai lapisan yang tebal dengan kemiringan yang rendah dan membentuk satu antiklin yang terbuka. Pembentukkan tanih adalah terhad kepada kawasan yang mempunyai lapisan guano (tahi burung) dari burung burung lautan. Morfologinya yang menunjukkan cerun yang sangat tinggi berterusan ke kedalaman laut sehingga 85 meter. Petumbuhan karang dan alga meliputi dinding struktur ini.

(geology, geomorphology)

INTRODUCTION

Pulau Perak and Pulau Jarak (Figure 1) are Malaysia's most westerly islands in the Straits of Malacca and are used as baseline points in the northern part of the Straits of Malacca for the Continental Shelf Boundaries of Malaysia. The Pulau Sembilan archipelago represent an important fishing area in the State of Perak. To date little geological work has been conducted on these islands, hence little is known about them.

Pulau Jarak and Pulau Sembilan

Pulau Jarak is located about 30 miles southwest of Pulau Pangkor. It is a granitic island surrounded by waters of 25 to 40 meters deep. The seas around the

Figure 1. Map of the Nothern Straits of Malacca showing the location of Pulau Jarak and Pulau Perak. The route of SESMA1 is shown in drawn lines.

Figure 2. The view of the eastern side of Pulau Jarak. Note the thick forest cover and the boulders at the coast.

island has several interesting diving sites, especially current drift diving. There is a little beach and small coral reefs nearby. Pulau Sembilan archipelago which consists of a cluster of 9 islands is about 10 nautical miles from the mouth of Sungai Perak.

The Bedrock Lithology of Pulau Jarak and Pulau Sembilan

The islands of Pulau Jarak (Figure 2) and Pulau Sembilan archipelago in the Straits of Malacca are situated between 20 and 40 nautical miles from the

mainland of Peninsular Malaysia and are underlain by granites. In Pulau Jarak, porphyritic to coarse-grained biotite granite dominates and is characterised by bluish rounded to sub rounded quartz. The main feature of the granite is accumulation of the large pegmatitic K-feldspar associated with various types of enclave. Main enclave type is metasedimentary, fine grained surmicaceous enclave and medium grained biotite-rich enclave. Pegmatitic K-feldspar pods/irregular bodies can be up to 1 m in length. Occasionally, the flow texture forms by alignment of K-feldspar megacryst. The granite underlying the Pulau Sembilan is similar to that of Pulau Jarak but is more homogeneous.

The Geomorphology of Pulau Jarak and Pulau Sembilan

Morphologically, all these islands have steep slopes and limited coastal plains. The shorelines are either bare granite outcrops or accumulation of granite boulders. Good long beaches are only found in isolated coves of Pulau Rumbia and on the eastern side of Pulau Lalang.

The coastline of Pulau Jarak is oval shape with two headlands protruding to the NE and SW. The seawards extension of these headlands forms two submarine ridges with several pinnacles which are partly exposed at low tides and pose navigational hazards. Several elevations data will be made at different points on the islands and their coasts using GPS technologies. Using the published topographic map and satellite images, the corrected position of these islands were remapped with GIS. This position is tested against the marine transects around these islands and rocks.

The Marine geomorphology of Pulau Jarak and Pulau Sembilan

Seafloor mapping of the surrounding sea of these islands were made. Of interest were the width and morphology of the platform surrounding these islands (Figure 3). The sediment cover was also interpreted from the sonar images and groundtruthed by snorkelling and scuba-diving. Coral reefs cover most of the surrounding platform of Pulau Jarak and breaks in the slope of the platform are interpreted to be elevation differences of the surface of the

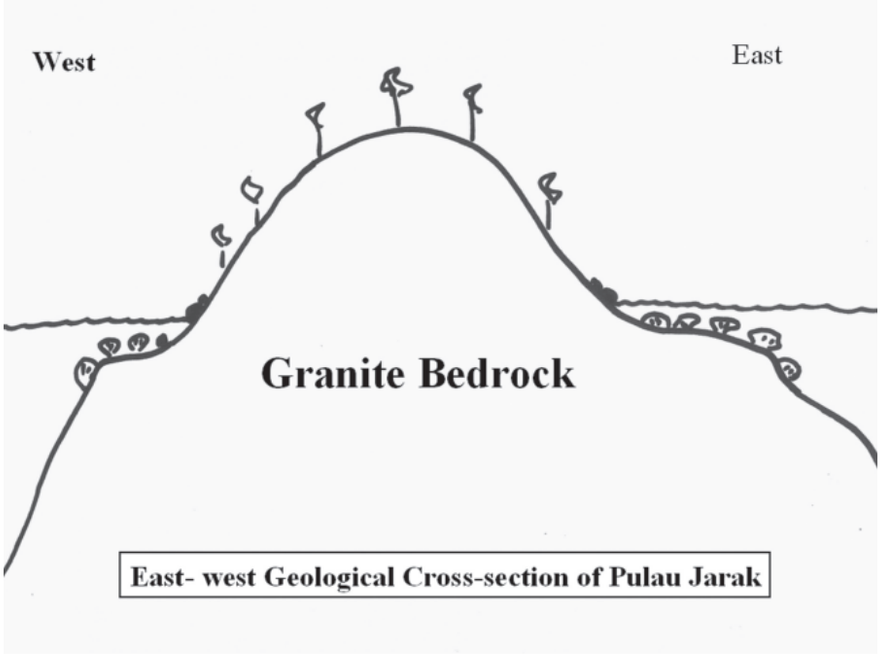

Figure 3. The east- west geological cross-section of Pulau Jarak showing the asymmetrical shape of the platform across the island.

underlying granites. To the east of Pulau Jarak a deep (200 feet) trough-like depression was mapped.

The seafloor to the east of Pulau Lalang is found to be of irregular depth forming a dissected basin topography. This appears to be the submarine extension of the southern Pulau Sembilan morphology. The horsts are dominated by granite bedrocks and boulders while most of the "graben" is covered by fine clastics. Green branching corals and a plethora of soft corals, red algae, and wisp corals are found coating the rock substrate. This surprising discovery warrants more detailed research in the future.

PULAU PERAK

Pulau Perak (Figure 4) with coordinates of 5d 40m 59.0s N, 98d 56m 17.2s E, Datum WGS84 is located almost in the center of the Straits of Malacca and is Malaysia's westernmost island. It is the closest island to south of the Andaman Sea Basin, and is 170km west of Sungai (Sg.) Petani in Kedah. Pulau Perak is located about 90km south-west of Pulau Langkawi. It is the northwestern most island in the Straits of Malacca. This 600m long and 400m wide island is surrounded by deep blue water of 85 meters depth. Along the summit, slopes and ledges, the rock surface is covered by a pearly grey deposit of guano formed from the droppings of countless numbers of sea birds which inhabit the island.

Previous work

Jones [1] visited the island in 1955 and reported that it was an isolated stack of 1800 feet by 750 feet that rised steeply to a height of 350 feet. He reported in his memoirs published in 1965 that the bedrock of Pulau Perak was indurated quartz tourmaline hornfels which was intensely veined with quartz tringers. The bedding appeared to be subhorizontal. No fossils has yet to be found in this rocks. Hence its age and stratigraphic affinity are unresolved. Jointing is common, forming a series of well defined joint planes whose erosional products produced deep gullies running from sea level to the summit. Jones also reported that was home to countless oceanic birds whose droppings especially at the summit formed a mantle 2-3 mm thick. There are no other geological report of this island. Due to its high degree of induration and the essentially arenaceous character of its lithology, Jones suggested it could possibly be correlated with the Machinchang Formation.

Figure 4. The view of the east side of Pulau Perak. Note the thin vegetation cover on the crest of the island and the barren precipituous slope.

Lithology and structure of Pulau Perak

Cliffs of close-bedded, grey and yellow, banded hornfels profusely veined by minute stringers of quartz rise steeply from the waters edge and only in a few places is a landing possible. Elsewhere, the rock shows a well-bedded character with the strata dipping at a low angle to the north-northwest in the west and easterly in the east. Jointing is common and a series of 4 well-defined joint-planes have been eroded into gullies running

from sea-level to the summit on the northeast side of the island.

The rock is fine grained and banded with layers rich in silty quartz interlaminated with ones in which tourmaline is the dominant constituent. The quartz is angular and intergrown closely with minute tourmaline crystals and minor iron oxides. The whole rock is impregnated by veins of quartz varying from hairlike stringers to veins of up to 1 inch of thickness.

The geomorphology of Pulau Perak

Pulau Perak forms a broad north-south trending anticlinal structure that is reflected by its outline. Its slopes form steep cliffs plunging almost vertically into the sea. Below the sea level, this unique morphological feature is covered with encrusting corals and algae from the sea level to depths of beyond 40 meters (Figure 5). Luxuriant marine life abound around this wall reef (Figure 6). Visibility is very good for up to more than 30 meters. Several caves formed by the intersections of bedding and joint systems are found at different elevation in Pulau Perak. One such cave occurs at sea level in the southeastern part of the island (Figure 7).

Impact of thin-soil cover on vegetation and ocean bird population

Soil formation is very limited in these arenaceous rocks of Pulau Perak. Only the presence of the guano supports sparse vegetation on Pulau Perak. Vegetation cover on Pulau Perak is about 25% of the land area and shows a maturing ecosystem compared to earlier reports that this island was a barren rock outcrop some 50 years ago. It is a breeding site to seabirds, especially the brown boobies and brown noddies. However, the population of these birds have dwindled and any future development will threaten them further.

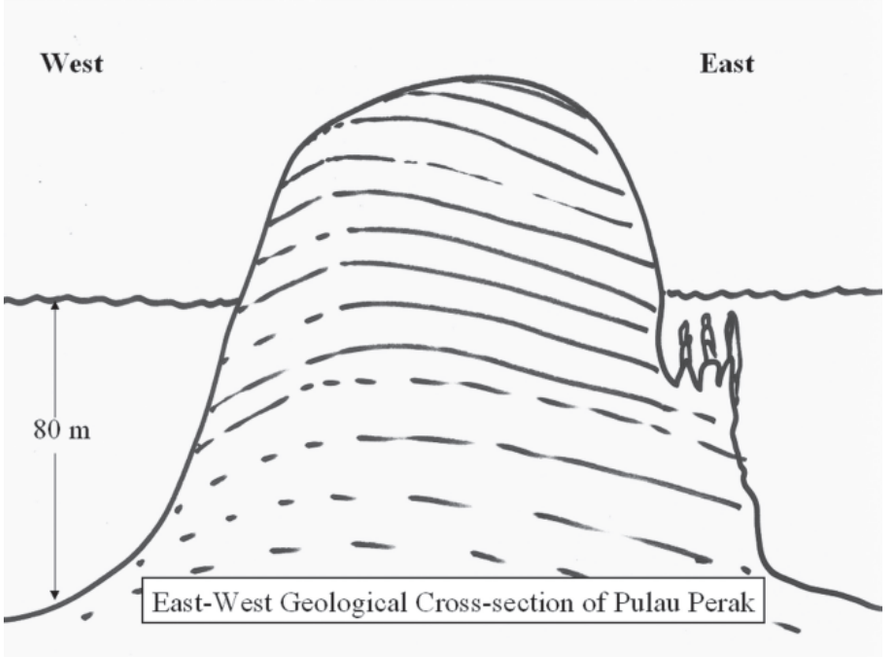

Figure 5. The NW-SE geological section of Pulau Perak showing its broad anticlinal structure and the slope that extends beneath the sea.

The scientific significance of Pulau Perak

Due to its unique morphology, luxuriant marine life, maturing ecosystem and its importance as a breeding site for the diminishing seabirds, brown boobies and brown noddies, it is proposed that Pulau Perak is gazetted as a protected area as it is a *site of scientific interest*. The only other site in Malaysia where these oceanic birds are found in Malaysia is Pulau Layang Layang, offshore Sabah.

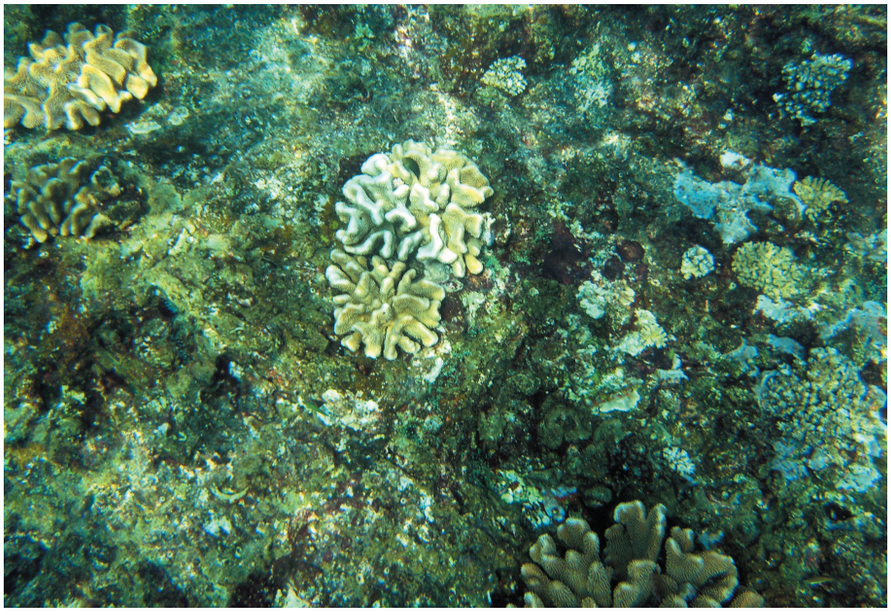

Figure 6. Coral and algae covering the wall of Pulau Perak.

Figure 7. A cave at sea level which is formed by the intersection of bedding and joint planes.

REFERENCE

1. Jones C.R., 1965. The Geology and Mineralisation of Langkawi and North Kedah. Geological Survey of Malaysia Memoir.

Malaysian Journal of Science **27** (3): 7 - 11 (2008)

Field and Petrographic studies of Granite from Pulau Jarak and Pulau Sembilan, Peninsular Malaysia

Azman A. Ghani

Department of Geology, Faculty of Science, University of Malaya 50603 Kuala Lumpur
azmangeo@um.edu.my

ABSTRACT Jarak and Sembilan islands are the westernmost islands off the mainland of Peninsular Malaysia. Both islands are underlain by granitic rock. Field and textural characteristics of the granites are similar to the tin bearing Main Range granite of Peninsular Malaysia. Structural features such as occurrence of tourmaline pods, accumulation of the large pegmatitic K-feldspar and occurrence of aplopegmatite complex suggest that the granite magma is highly evolved. Both islands are made up of porphyritic to coarse grained biotite granite. The grain size of K-feldspar phenocryst can be up to 4 cm across. The granite is made up of quartz (35%), plagioclase (19%), K-feldspar (43%), biotite (4.5%) and can be classified as monzogranite to syenogranite. Subhedral to anhedral biotite is the main mafic phase. The granitic rocks from Jarak and Sembilan occupy a central area of the QAP diagram. Granites plotting in this area have been regarded as crustal melts and this suggests the importance of crustal material in the source rocks of those plutons. The importance of crustal material in the source rock is supported by the occurrence of metasedimentary enclave. This may suggest that the Jarak and Sembilan magmas are derived from partial melting of the sedimentary rock e.g. pelitic rocks.

ABSTRAK Pulau Jarak dan Pulau Sembilan adalah pulau Semenanjung Malaysia yang paling ke-barat. Kedua-dua pulau ini dilapisi oleh batuan granit. Ciri-ciri lapangan dan tekstur menunjukkan batuan granit di kedua-dua pulau ini adalah sama dengan batuan granit kaya timah Granit Banjaran Utama. Struktur seperti pod tourmalin, pengumpulan K-feldspar dan aplopegmatit mencadangkan bahawa magma untuk batuan granit Jarak dan Sembilan adalah sangar terevolusi. Kedua dua pulau ini dibentuk oleh batuan granit biotit berbutir kasar ke porfiritik. Saiz butiran fenokris K-fedlspar boleh mencapai sehingga 4 sm. Mineralogi batuan granit ini terdiri dari kuartz (35%), plagioclase (19%), K-feldspar (43%), biotit (4.5%) dan boleh dikelaskan sebagai monzogranit dan syenogranit. Biotit subhedral ke anhedral merupakan fasa mafik yang utama. Batuan granit dari Pulau Jarak dan Sembilan diplotkan dibahagian tengah dalam gambarajah QAP yang mencadangkan magma batuan granit ini berasal dari leburan kerak. Kepentingan bahan kerak di dalam batuan punca disokong oleh kewujudan enklaf metasedimen. Ini mencadangkan magma batuan granit Pulau Jarak dan Sembilan berasal dari leburan separa batuan sediment contohnya batuan pelit.

(petrographic, granitic rocks, metasedimentary enclaves)

INTRODUCTION

The study area included the Jarak and Sembilan islands which are located off the west coast of Peninsular Malaysia. Jarak Island, located about 32 km southwest of Pangkor Island, is a tiny island that rises 50 m above sea level and is covered with lush green vegetation. On the other hand, Pulau Sembilan is a group of islands situated about 20 km off the southwest coast of the Pangkor Island. Among the islands in the Sembilan group are Rumbia, Lalang, Saga, Buluh, Black Rock and White Rock. This paper outlines the geology of both Jarak and Sembilan islands and classifies the islands' tectonic setting in term of Southeast Asia granite provinces.

REGIONAL SETTING

The Jarak and Sembilan islands are underlain by granitic rock similar to those found in the Western Belt of Peninsular Malaysia. The intrusion is the westernmost igneous bodies of the Main Range granite.

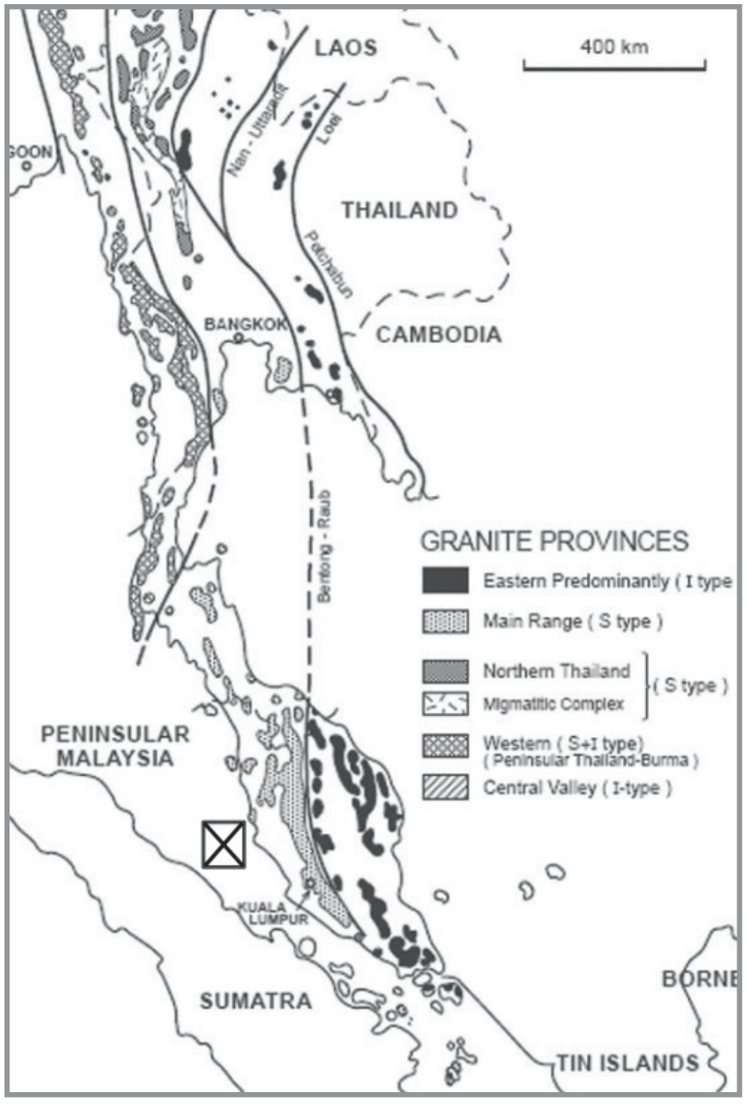

Figure 1. Location of Jarak and Sembilan granite (X) in relation to the granite province in Southeast Asia. Blue box is the location of both Jarak and Sembilan granites. Modified from Cobbing et. al. 1992.

The granitoids of Malaysia, Thailand and Myanmar have petrographical and geochronological features which permit them to be put into belts (Figure 1) [1]. The Peninsular Malaysia granites have been divided into two belts i.e the Western province and the Eastern Province. The Main Range Granite forms a main batholith in the Western Belt granite. The batholith extends through Peninsular Thailand as far as the latitude of Bangkok. In the mainland of Peninsula Malaysia, the westernmost granitic body that belongs to the Main Range Granite can be found along the coastal area of Perak, Penang and Selangor. Examples of the coastal granitic body are Dinding [2] and Mertajam–Kulim granites [3]. Less than 10 km off the mainland, the Pangkor and Penang island granites are the best examples. Although both Jarak and Sembilan islands are located more than 10 km off Peninsular Malaysia coast, clearly, the granitic rocks from these islands represent part of the Main Range Granite. The Main Range granites have a more restricted composition (SiO_2 > 65%). The granites that are responsible for the tin mineralization are exclusively of the S–type formed by continental collision. The

'S' type features [4] in the granites have: (a) high initial $87_{Sr}/86_{Sr}$ isotope ratio of > 0.710, (b) low Na_2O content of < 3.2% in rocks with ~ 5% K_2O, (c) narrow range of felsic rock (65.95 to 77.4% SiO_2), (d) high K_2O/Na_2O ratio of 1.4 - 2.8 ('S' type: 0.9 - 3.2), (e) usually ilmenite bearing and (f) pelitic or quartzose metasedimentary xenoliths.

FIELD CHARACTERISTICS

Both Jarak and Sembilan granites consist of homogeneous to porphyritic rocks. The Jarak granite grades from equigranular to porphyritic coarse grained granite (Figure 2) whereas the Sembilan granite is dominated by equigranular medium to coarse grained granite (Figure 3). Various types of enclaves occur on the southwest of Jarak island. Among the enclave types are metasedimentary, surmicaceous (Figure 4) and mafic microgranular enclaves. The occurrence of metasedimentary enclaves may suggest that the Jarak granite magma is closely associated with the metasedimentary source. Surmicaceous enclaves are spherical and are not spatially restricted to any particular granite variety. The enclave is less than a meter in length and melanocratic containing quartz, K-feldspar and biotite. Flow foliation defined by alternating bands of quartzo-feldspathic and micaceous minerals are also observed in this rock (Figure 5). Pegmatitic K-feldspar pods/irregular bodies can be up to 1 m in length. K-feldspar and tourmaline aplopegmatite vein, both zoned and unzoned, is also common (Figure 6).

PETROGRAPHY

Both Jarak and Sembilan granites consist of primary textured granite [1]. The only difference between these two granites is that the Jarak granite tends to be coarser grained compared to the Sembilan granite. They also share the same mineralogy content. The mineral composition of both Jarak and Sembilan granites in decreasing abundance are K-feldspar, quartz, plagioclase, biotite, zircon and apatite. In terms of Quartz–Plagioclase–K-feldspar classification [5] the granites can be classified as biotite monzo to syenogranite. The granitic rocks from Jarak and Sembilan granites occupy a central area of the QAP diagram. Granites plotting in this area have been regarded as crustal melts [6] and this suggests the importance of crustal material in the source rocks of these plutons.

Large K-feldspar phenocrysts up to 3 cm long are common in the Jarak granite. The K-feldspar in the Sembilan granite is more equigranular with other mineral phases. The main K-feldspar type of both Jarak and Sembilan granites is orthoclase. Plagioclases usually occur as discrete phenocrysts or as glomeroporphyritic aggregates showing resorbed outlines in the mafic members of the granites. The most common plagioclase type is oligoclase. Thin late albitic rim sometimes can be found surrounding the plagioclase crystal. Quartz is mostly anhedral and sometimes occurs as subgrains. In some places the quartz crystals in the Jarak granite are bluish in colour. Quartz is generally interstitial to all the other minerals, especially plagioclase and to a lesser extent to the orthoclase. It also occurs as small round crystals at the margins of the plagioclases. The only primary mafic rock-forming mineral is biotite, which occurs as plates up to 1 cm in diameter. In hand specimen, fresh biotite crystals are black and glossy. Chloritized biotites are dark green and have a dull luster. It 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. Tourmaline commonly occurs as large crystals in the leucogranitic either as tourmaline rossette or as tourmaline pods. Zircon and apatite are ubiquitous accessory phases.

CONCLUSION

Both the Jarak and Sembilan granites have textural and mineralogical features which are characteristic of the Main Range granite and which distinguish them from the granite of the Eastern Belt granite. Their location suggested that they may represent the westernmost granitic bodies of the Main Range granite. The mineralogical character of the Jarak and Sembilan granites are similar to the Penang and Pangkor granites which is also part of the Main Range granite. These preliminary conclusions need to be investigated by geochemical and isotopic method. A detailed study of geochemistry and mineralogy of the individual Jarak and Sembilan plutons with more careful, controlled sampling using a greater number of samples has to be done in order to understand fully the petrochemistry of each of the plutons. Detailed study of radiogenic isotope especially Sr, Nd, Sm and Pb should be undertaken to determine the source region and other processes such as mixing and high level interaction.

Figure 2. Coarse to medium grained equigranular biotite granite of the Jarak island. Note the bluish colour of the quartz crystal.

Figure 3. Granitc rock from Lalang island (Sembilan group). The main rock type is coarse to medium-grained equigranular biotite granite. Note that the granitic rock from Lalang island is leucocratic compared to the Jarak granite.

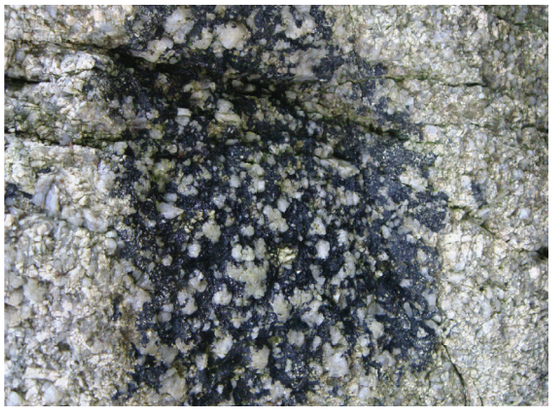

Figure 4. Surmicaceous enclave formed by accumulation of biotite. Location: Jarak Island.

Figure 5. Sclieren structure formed by alignment of biotite crystals in the Jarak granite.

Figure 6. Feldspar-tourmaline pegmatite cut through the Jarak granite.

The various types of enclaves that occur in the Jarak granites should be studied in more detail because they may provide information on the mode of emplacement, the origin of the granitic magma and the dynamics of magma chambers including magma interaction.

REFERENCES

1. Cobbing, E.J., Pitfield, P. E. J., Darbyshire, D.P.F., Mallick, D. I. J. (1992). *The granites of the South-East Asian tin belt.* Overseas Memoir 10, British Geological Survey.
2. Pitfield, P. E. J., Teoh, L. H. and Cobbing, E. J. (1990). Textural variation and tin mineralization in granites from the Main Range province of the Southeast Asia tin belt. *Geological Journal* **25**: 419 - 430.
3. Azman A. Ghani, Borhan M. Doya and G. H. Teh (2000). Age, petrochemistry and modelling of the Bukit Mertajam-Kulim granite, Northwest Peninsular Malaysia. *Bull. Geol. Soc. Malaysia* **44**: 129 - 150
4. Chappell, B.W. and White, A.J.R. (1974). Two contrasting granite types. *Pacific Geology* **8**: 173 - 174
5. Streckeisen, A. L. (1976). To each plutonic rock its proper name. *Earth Sci. Rev.* **12**: 1 - 33.
6. Bowden, P., Batchelor, R. A., Chappell, B. W., Didier, J. and Lameyre, J. (1984). Petrological, geochemical and source criteria for the classification of granitic rocks: a discussion. *Phy. Earth Planet. Int.* **35**: 1 - 11.