General Geology and Granite Geochemistry of the Kenaboi and Adjacent Area, Jelebu, Negeri Sembilan, Malaysia

Ghani A.A.1, Sofian-Azirun, M.2, Ramli, R.2, Hashim, R.2, Nur Islam1, and Zainuddin, Z.A.1

1Department of Geology, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia. azmangeo@um.edu.my
2Institute of Biological Sciences, Faculty of Science, University of Malaya.

ABSTRACT The Kenaboi and surrounding area consist of two main rock types; they are the metamorphic of Palaeozoic age and the Triassic igneous rock (including Sempah porphyry). The older (early Paleozoic) metamorphic rocks straddle the Triassic Main Range granite as large roof pendants. The metamorphic rock from the study area (Jelebu schist) consists of four rock types; they are schist, phyllite (green schist facies), amphibolite schist and serpentinite. The Triassic igneous rock consists mainly of granitic composition and can be divided into four different plutons consisting of Sempah porphyry, Beroga granite, Semenyih granite and Telemong granite.

INTRODUCTION

The Kenaboi area is located at the north of the Negeri Sembilan state in the Jelebu district. This area is part of the 1 inch to 1 mile series L7010 topographic sheet 95 (Kuala Kelawang). This project is part of the integrated study on flora, fauna and physical aspect of Hutan Simpan Kenaboi, Jelebu, Negeri Sembilan. It was funded by the Jabatan Perhutanan & Negeri Sembilan State Government. The area surrounding of the Kenaboi valley has a hundred years history of tin and wolfram mining centered around the placer deposits of the Kongkoi, Lemis, Teriang and Tinggi rivers. Small quantities of gold, monazite, zircon, and xenotime occur as by products of tin mining.

Tectonic Setting and General Geology

The Peninsular Malaysian granites are distributed into three parallel belts, i.e., Western, Central and Eastern belts. The Western and Eastern Belt province of the Peninsular Malaysia is separated by a line known as the Bentong-Raub suture [2]. The age of the Eastern Belt granites ranging from 200 to 264 Ma whereas the Western Belt granite confined to an age ranging from 190 to 210 Ma. The Western Belt province of Peninsular Malaysia consists of the granites with ‘S’ type characteristic [3, 4] and have more restricted composition (SiO2 > 65%). 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 [1, 5]. The Western Belt granite together with the southern Peninsular Thailand and central Thailand granite is associated with the tin deposits and has contributed 55% of the historic tin production of Southeast Asia.
The Kenaboi and surrounding area are located at the central part of the Western Belt Granite of Peninsular Malaysia. Rock formations within the area ranging in age from lower Palaeozoic to Quaternary. The area is dominated by two rocks types that is Pre-Silurian Jelebu schist and Late Triassic granite. The granitic rock in this area is a southern extension of the Kuala Lumpur and Bukit Tinggi granites. The granite consists of four different units that are Telemong granite, Semenyih granite, Beroga granite and Sempah porphyry [6]. The Telemong, Semenyih and Beroga granites are part of the Main Range Granite consisting of mainly S-type biotite bearing granite. The Jelebu schist consists of four rock types; they are schist, phyllite (greenschist facies), amphibolite schist and serpentinise. In Kenaboi area, the Jelebu Schist forms a roof pendant of oblong in shape, roughly about 5 km x 9.5 km. It is intruded by the Sempah volcanic to the northwest and the Semenyih granite to the west and south. Schist is found along the Sengai Kenaboi from Kampung Esok upstream to sungai Enjin (Fig. 1). The metamorphic rock in this part of the study area is quartz mica graphitic schist and minor amphibolite schist [6]. The amphibolite schist generally occur as lenses intercalated with the quartz mica schist, or as massive and thick lenses or as narrow bands 0.3 to 3 m wide running concordant to the schistociticy. Shu [6] estimated the possible stratigraphic thickness of the schist unit as 3000 m.

Alluvium deposit is generally limited in depth and spatially related to the present day drainage system. The alluvium rarely exceeds 7.5 m in depth and consists of well graded, fining upwards of stratified gravel, sand, silt, clay and peat. River sand and cobbles deposited (Fig. 2) along the river are also important sources of alluvial cassiterite.

**STRUCTURAL GEOLOGY**

The main structural elements in the study area are the series of subparallel NW-SE trending fault system (Map 1). This fault system is part of the Bukit Tinggi fault zone. It has been traced from Kuala Kubu Selangor through Bukit Tinggi down to the Kenaboi valley. In Kenaboi area, the sheared granite resulted from the fault can be found along the Kuala Kelawang – Hulu Langat road cut south of the Bukit Gelanggang. This area has been cut by the Kongkoi fault along the Kongkoi valley which forms an 8 km linear surface expression of brecciated granite and contorted schist. The Kenaboi valley has been cut by NW-SE Bukit Tinggi fault and N-S Karak fault which can be traced up to 32 km in length. The former is characterised by brecciated granite and 15 to 45 m wide quartz vein injected along the fault zone. Apart from the fault, the metasediments in the study area also have been folded into a series of anticlinoria and synclinoria along the NNW trending axes; this is the major structural trend of the Main Range batholiths.

**GRANITIC AND RELATED ROCKS**

Four main types of igneous rock occur in the study area [6]. They are (a) Sempah porphyry, (b) Beroga Granite, (c) Semenyih granite, and (d) Telemong granite (Map 2).

**Hulu Langat porphyry**

The Hulu Langat porphyry in the study area is the continuation of the Sempah volcanic complex. The Sempah volcanic complex is related, both temporally and spatially, to the Western Belt granite. The complex comprises units of tuff lavas, lavas and a distinctive porphyry sub volcanic unit which contains orthopyroxene phenocrysts [3, 7].

In Kenaboi area, part of this porphyry unit has been intruded by the younger Semenyih granite. The contact is characterised by aplite, pegmatite veins and dykes up to 1 m across [6]. Apart from the granites contact and the quartz vein associated with the fault zone, the porphyry as a whole is devoid of any other types of granites differentiates. Shu [6] found that in upper reaches of the Kenaboi area the porphyry is intruded by two small granites body which give rise to minor cassiterite mineralization. At Bukit Cincang Sebarau, a narrow band of intrusive breccia was found along the contact between the sempah volcanic and the quartz mica schist of Kenaboi area. In term of petrographic characteristic, the porphyry is mesocratic with the groundmass making up to 65% of the rock volume. Phenocrysts of twinned plagioclase, biotite, hypersthene and quartz, all averaging between 1 – 4 mm in diameter, are present in an aphanitic grey groundmass. Accessory minerals include magnetite, apatite and zircon. Most phenocryst phases are commonly fragmented with resorption features. Quartz occurs as phenocrysts and as an essential constituent of the groundmass. Two kinds of quartz phenocrysts are identified: large (~ 4 mm) grains and smaller (0.3 – 0.5 mm) rounded grains. Quartz sometimes occurs in quartz–plagioclase aggregates. Many of the phenocrysts are deeply and intricately embayed.
Figure 1. Metasediment consisting of interbedded sequence of quartzite and phyllite found as boulder at Kampung Esok, Kenaboi.

Figure 2. Gravels and pebbles deposited by the Kenaboi river.

Map 1. Fault system in the Kenaboi and surrounding area.
Plagioclase occurs as individual euhedral to subhedral laths, as glomeroporphyritic aggregates, and very commonly as angular fragments. Anorthite contents in cores and rims of zoned plagioclase range from An$_{38}$ – An$_{50}$. It is inferred that plagioclase was an early liquidus phase having a reaction relationship with evolving melts. This is based on the fact that plagioclase exists both as discrete phenocrysts, and also as glomeroporphyritic aggregates. Biotite occurs as euhedral to subhedral phenocrysts up to 3 mm in diameter. It is relatively rare as a groundmass constituent where it occurs as small shreds which have probably been dislodged from phenocrysts. Although euhedral biotite may be fairly common, the bulk of the biotite is present as ragged elongate shreds. The presence of subhedral hypersthene in the rock is characterized by high relief, low birefringence in sections of normal thickness and parallel extinction. Liew [3] presented the range as En$_{60}$Fs$_{40}$ for the hypersthene found in the Sempah area. Microperthite phenocrysts are often ornamented by internal zones and blebs of groundmass materials, indicative that the grains had continued to grow in optical continuity beyond its original outline [3].

**Beroga granite**

The Beroga granite forms an irregular body along the southern part of the study area from Titi Kerawang to Kuala Kelawang (Map 2). It is one of the most basic granite in the Western Belt. The granite is easy to map as it altered to reddish soil and can easily differentiate from other rock type in the study area.

The main granite type is biotite rich granite to granodiorite with distinct euhedral to subhedral K-feldspar megacryst. It also characterised by abundant xenoliths and other microgranular enclaves (Fig. 3). The rock is made up of K-feldspar, biotite, quartz, plagioclase, biotite, amphibole (cummingtonite?), apatite and zircon. Biotite forms interconnecting clots ranging from 2 mm to 1 cm across. The mineral can be up to 15% in a single hand specimen whereas for the other Western Belt granites the average biotite content ranges from 5 to 10%. The biotite may have resulted from dispersion of the mafic and metasediment enclaves in the magma. The main granite type is megacrystic coarse (Fig. 4) to medium grained biotite granodiorite.

**Semenyih granite**

The Semenyih Granite (Map 2) forms the Kongkoi hill with the highest point at Bukit Kongkoi (950 m). The outcrop of this granite was found at the Kongkoi – Chennah road cut. Shu [6] showed that the eastern part of the Semenyih granite in the Kongkoi area is faulted. The sharply angular outlines of this pluton are due mainly to the faulted contact. The Semenyih granite is coarse to medium grained equigranular to megacrystic (Fig. 5) biotite granite. The granite commonly intruded by microgranite, coarse grained leucogranite, aplite and pegmatites.

The phenocrysts usually make up less than 10% of the rock and consist of euhedral K-feldspars ranging in size from 2.5 to 3.8 cm. Mineralogy of the granite is quartz, K-feldspar, plagioclase, biotite, apatite and zircon. Main K-feldspar type is orthoclase with prominent perthite texture. Biotite only about 8% of the total mode.

**Telemong granite**

The Telemong granite forms an elongated body 24 km long and 11 km wide, trending southeast. It is the main granite body in the northeastern part of the Hutan simpan Kenaboi. The granite forms the most mountainous terrain of the study area, the highest peak is Gunung Besar Hantu (1460 m). It consists of coarse grained porphyritic biotite granite with medium to fine grained core.

**GEOCHEMISTRY**

Eleven granitic samples from the study area have been analysed for major and trace element contents. They are 6 samples from Beroga granite and 5 samples from Semenyih granite. Six major elements of the Hulu Langat Porphyry (equivalent to the Sempah volcanic) are taken from [6]. Twelve major and trace element analyses of the Sempah volcanic in previous studies were used for comparison [1, 3].

The samples weighing about 0.5 to 1 kg were firstly trimmed in order to remove any altered/weathered material. The clean and freshest samples were split into 1 cm cubes using a hydraulic jaw-splitter and an automatic jaw-
Figure 3. Field occurrence of the Beroga granite with 2 types of mafic enclave. Note the abundance of biotite clot compared to the Semeyih granite (Fig 5). Photograph taken from Ghani et al. (2008).

Figure 4. Photograph showing the Beroga porphyritic types with prominent euhedral to subhedral K-feldspar phenocrysts. Photograph taken from Ghani et al. (2008).

Figure 5. Semenyih granite from Kampung Lesung, Kenaboi. The granite is characterised by porphyritic coarse grained texture and slightly pinkish colour. Photograph taken from Ghani et al. (2008).

crusher, washed to remove dust, and dried (at room temperature) overnight. The chips were then reduced to powder by grinding in a “Tema” laboratory disc mill using a tungsten-carbide barrel. Substances W, Co and Ta are known contaminants that could be introduced at this stage. Milling time was 30 seconds (150 micron) and another 15 seconds to reduce the size to 53 microns.

The major and trace element concentrations were determined by using ThermoARL Advant’XP+ XRF at GeoAnalytical Lab, Geology Department, Washington State University. Three and a half grams (3.5 g) of the sample powder was weighed into a plastic mixing jar with 7.0 g of spec pure dilithium tetraborate (Li₂B₄O₇), assisted by an enclosed plastic ball, mixed for ten minutes. The mixed powders were emptied into graphite crucibles with internal measurements of 34.9 mm diameter by 31.8 mm deep. Twenty four filled crucibles were placed on a silica tray and loaded into a muffle furnace only large enough to contain the tray. Fusion takes 5 minutes from the time the preheated furnace returns to its normal 1000°C after loading. The silica plate and graphite crucibles were then removed from the oven and allowed to cool. Each bead is reground in the
swing mill for 35 seconds, the glass powder then replaced in the graphite crucibles and refused for 5 minutes. The beads were measures for 28 major and trace elements (Si, Al, Ti, Fe, Mn, Ca, Mg, K, Na, P, Sc, V, Ni, Cr, Ba, Sr, Zr, Y, Rb, Nb, Ga, Cu, Zn, Pb, La, Ce, Th, Nd)

RESULTS AND DISCUSSION

The Beroga granite has the lowest SiO₂ (67.22 – 68.02%) contents compared to the Semenyih granite and Hulu Langat Porphyry. This shows that the Beroga granite lies on the mafic end of the Western Belt granite. The Semenyih granite, on the other hand, contains 70.36 to 73.48% SiO₂. Selected Harker diagram (Fig. 6) shows clear trends of decreasing TiO₂, Al₂O₃, Fe₉₂, Na₂O, MgO, CaO and P₂O₅ with increasing SiO₂. K₂O and MnO increase with increasing SiO₂. All units have high alkali contents, with the following Na₂O+ K₂O ranges: Beroga granite (7.0-7.9%), Semenyih granite (7.60-9.38%) and Hulu Langat Porphyry (7.70 - 9.29%). On a K₂O vs. SiO₂ plot all sample fall in the high-K calc alkali field. On a Na₂O vs. K₂O diagram (Fig. 7), all samples plot in the S-type field suggesting that all the three magmas originated from a sedimentary source. The most probable candidates of the source rock is pelitic and greywacke. This findings contrast to the Eastern Belt granite which most of them can be classified as I-type.

The Beroga granite also has high Fe total, CaO, MgO, TiO₂, P₂O₅, Ba, Sr, Sc, Ni, Nd, V and Zn low Rb contents and Rb/Sr ratios compared to the Semenyih granite. This is evident from petrographic study as the Beroga granite contains up to 25% biotite and this suggests that it is more mafic compared to the Semenyih granite. The faulted Semenyih granite has low MgO, Ni, Y and Rb compared to the Semenyih granite proper. On the Sr vs. Ba diagram, both Beroga and Semenyih granites show a good positive correlation. This trend suggests that K-feldspar, biotite and plagioclase were being removed in differentiation sequence. The trend is in contrast to the Hulu Langat porphyry, where all the samples are scattered. Participation of plagioclase in the Semenyih magma is also evidence from Rb/Sr vs. SiO₂ (Fig. 8). The plot shows semi J-shaped trend which suggests the importance of fractional crystallisation with plagioclase as a major precipitating phase. The Rb/Sr ratio for the Semenyih granite (Rb/Sr: 2.8 to 7) is higher compared to Rb/Sr ratio of both Beroga granite samples (Rb/Sr: 1.6 to 1.9) and Langat Porphyry (Rb/Sr: 0.6 to 2.8). The low value of the Beroga and Langat rocks suggests that the magma is less evolved compared to the Semenyih magma.

The Beroga granite

Among the three studied granite, the Beroga granite is the most different compare to other Western Belt granite especially their petrographic characteristic. The granite is characterised by biotite contents up to 25% and forming interconnecting clots with the size ranging up to 2 cm across. It is also characterised by abundant xenoliths and other enclaves. Common enclave types are pelitic and various modifications of fine to medium grained biotite rich enclaves. It is interpreted that the biotite clots resulted from dispersion of the enclaves in the Beroga magma. Field observations showed that xenolith assimilation is widespread process in the Beroga magma and that different stages of assimilation can be observed.

The Hulu Langat porphyry

The Hulu Langat porphyry exposed at the northeastern part of the study area is the continuation of the Sempah volanic complex [10, 11]. It is closely related both temporally and spatially to the Western Belt granite [3]. The Sempah complex generally comprises unit of tuff lavas, lavas and a distinctive porphyritic subvolcanic unit which contain orthopyroxene phenocrysts [3, 12]. Ghani & Singh [10] showed that the multi elements profile of the Sempah Complex rocks is comparable and the Western Belt granites. The similar profile may suggest the common origin of both Western Granite and Sempah volcanic magmas. They are notably depleted in Ba, Sr, P and Ti which is probably related to fractionation of feldspars, apatite, sphene and Fe-titanium minerals. This is supported by the ACNK value of the Sempah complex ranging from 0.95 to 1.36 similar to the Western belt granite.
Figure 6. TiO$_2$ and Na$_2$O vs. SiO$_2$ plots for the granitic rock from the study area.

Figure 7. Na$_2$O vs. K$_2$O plot for the granitic rock from the study area. Symbols as in Figure 8.

Figure 8. Sr vs. Ba and Rb/Sr vs. SiO$_2$ for the granitic rock from Kenaboi area.

REFERENCES


