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The stong complex: A reassessment

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Abstract: Re-examination of the eastern and northern parts of the Stong Complex has shown that there are three plutonic components. The earliest two phases are in part highly deformed in a manner similar to that of the marginal country rocks. The third phase, a distinctive set of pink granites, is underformed. Around the granitic rocks a contact aureole is developed in which the highest grade rocks are of low amphibolite facies. The numerous metasedimentary and metavolcanic enclaves within the granites have upper amphibolite facies mineralogy. Available evidence suggests that the intense dynamothermal metamorphism and deformation recorded in both sedimentary and some plutonic rocks resulted from forces generated by emplacement of the granitic rocks. At least the last part of the intrusive history of the Stong Complex took place in Late Cretaceous times; the age of the earlier phases is uncertain but lies within the time-frame Triassic to Late Cretaceous.

INTRODUCTION

The Stong Complex consists of a variety of plutonic and metamorphic rocks which underlie Gunong Stong and its environs in the northwestern part of Kelantan State, Peninsular Malaysia. The eastern part of the Complex (that on Topographic Sheet 34) was geologically mapped at the scale of 1 inch to 1 mile (1:63,360) by Santokh Singh from 1960 to 1963 and his work, while in progress was reported briefly in Santokh Singh (1963). He recognised the essential character of the Stong Complex—a granitic core which was in part in migmatitic association with large enclaves of metasediments in which he recorded many metamorphic minerals, including garnet, sillimanite (apparently after andalusite), diopside and hornblende. In the surrounding sediments and volcaniclastics he noted (NW of Bertam) a passage from thermally indurated rocks, through mica schists and contact hornfelses of various grades to hybrid granite gneisses (lit-par-lit gneisses), gneissose granites and finally granites. He also recognised that the unmetamorphosed lithological equivalents of the strata in the enclaves within the granites could be traced to the east, south and north of the granite mass.

Santokh Singh (*op. cit.*, p. 14) considered that "The original granite magma advanced by conversion of its country rocks into granitic material and the incorporation of this into the main body of the moving magma. Granitization and feldspathization were established as a petrogenetic process. Coarse feldspar grains in gneisses are common in some localities and may well represent porphyroblasts resulting from feldspathization".

MacDonald (1967), having visited the eastern part of the Stong Complex with Santokh Singh, summarised the latter's work in his memoir on North Kelantan and

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North Trengganu. On the 1:250,000 map accompanying the memoir MacDonald distinguished between the sediments plus volcanics on the eastern margin of the Complex and the metamorphic rocks of the enclaves but accepted Santokh's view that the latter were probably mainly the metamorphosed equivalents of the former.

The granitic element of the Complex was regarded as an easterly protrusion from the Main Range Granite Batholith and it was described as an "Injection Complex" of great complexity.

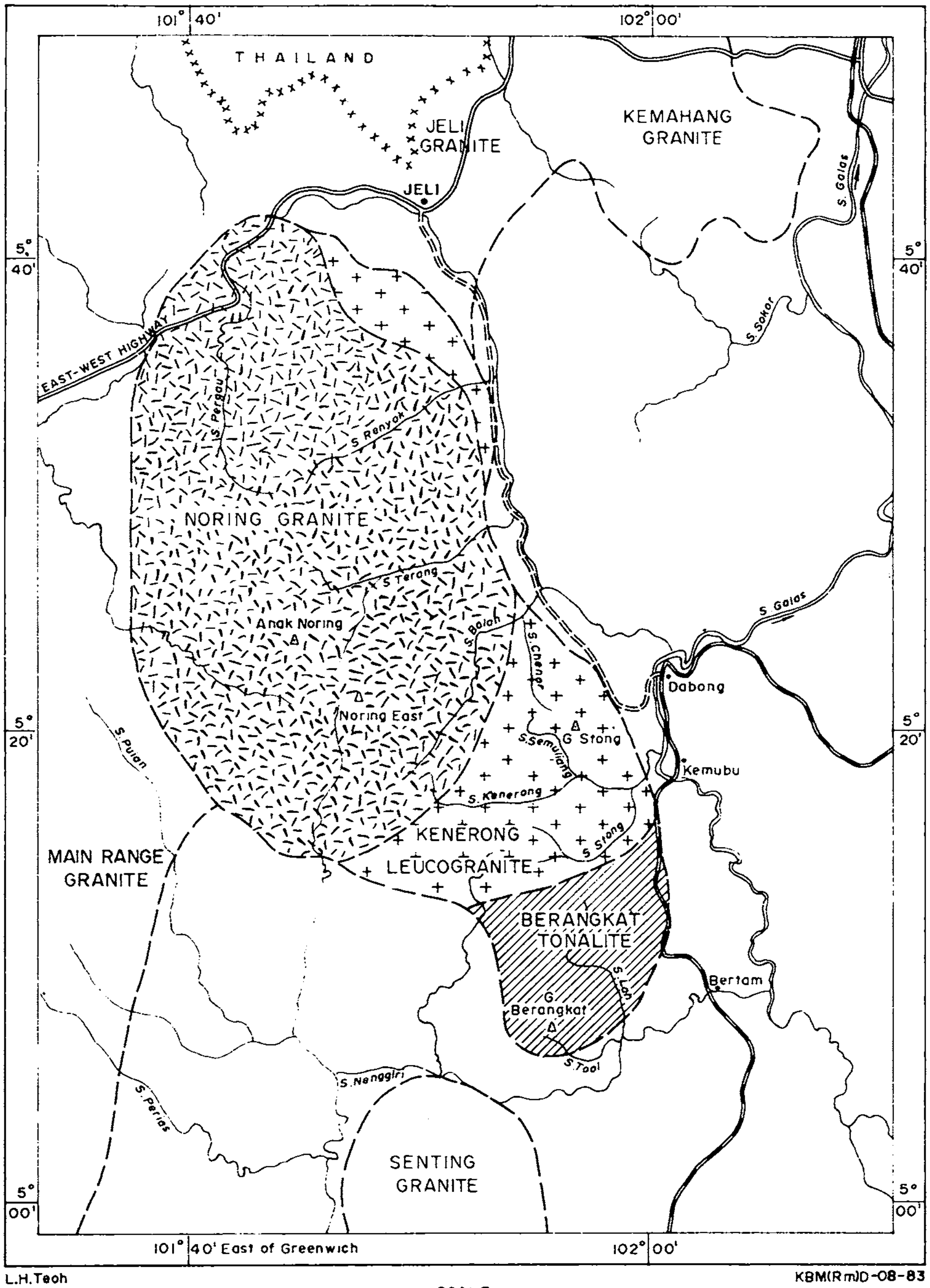
Hutchison (1969; 1973) later reported on the eastern side of the Complex and the coloured map of Malaysia compiled by Gobbett (1972) showed the Complex to consist of "Acid gneiss and other high grade metamorphic rock". Hutchison considered that the "general aspect of the Stong Complex is that it was derived from a sedimentary sequence that was predominantly arenaceous with lesser argillaceous and calcareous horizons. The general arenaceous nature has been favourable for large scale anatexis during the catazone metamorphism", i.e. in general agreement with Santokh Singh as to the nature of the Complex, although the latter considers the metasedimentary enclaves to be predominantly pelitic and calcareous with minor arenaceous and pyroclastic facies. The eastern margin of the Complex was stated by Hutchison to be faulted against the greenschist facies rocks of the Gua Musang Formation. No positive statement on the age of the Complex was made in the text but in the legend of his Fig. 9.1 (Hutchison, 1973) it was shown as consisting of "High grade metamorphic rocks of uncertain age; Lower Palaeozoic or older". In contrast to MacDonald (1967), Hutchison (1973) suggested that the granitic element of the Stong Complex was distinct from the granitic batholith of the Main Range.

The geological map of Malaysia published by the Geological Survey of Malaysia in 1973 shows the "roof pendants" and metamorphic aureole as being of Permian age, and the granitic rocks of the Complex as intruding formations of Permian and Triassic age.

In the light of these differences of interpretation, and in view of the clear possibility that the Complex might represent an inlier of Lower Palaeozoic, or even Precambrian, basement, which would have profound consequences for interpreting Malaysian geology, the collection of further information from the Complex was considered desirable. The account which follows is based on field observations made during a six-day visit in July 1982 and by study of thin sections and aeromagnetic and spectrometric data to supplement the data already accumulated by systematic surveys.

Accessibility to the eastern side of the Stong Complex is now good via the road under construction from Jeli to Kemubu and Bertam (Figure 1). Timber tracks branch off the road into the Complex and these substantially augment the natural access via the river courses. Traverses were made along all the most easily accessible routes and included a traverse of the newly-opened East–West Highway which joins Grik in Perak with northern Kelantan.

The western part of the Stong Complex, lying mainly in Topo Sheet 33, remains little known. A few traverses of major rivers were made by Chu (1973) for the 1:63,360



SCALE

Kilometre 10 5 10 10 20 Kilometres

Mile 10 5 0 10 Miles

The distubution of the various units is based upon aeromagnetic and spectrometric data and recent fieldwork.

LEGEND

Noring Granite	Berangkat Tonalite
Kenerong Leucogranite	Other rock types, undifferentiated

Fig. 1. Granitoid rocks of the Stong Complex.

scale Geological Survey mapping, but the area was closed for security reasons in 1974 and has remained closed until the present day.

SUMMARY ACCOUNT OF THE GEOLOGY OF THE STONG COMPLEX

The granitoids

Our observations have shown that the plutonic igneous component of the Stong Complex has three elements (Fig. 1) which we have named, in order of probable decreasing age, the Berangkat Tonalite, the Kenerong Leucogranite and the Noring Granite. The first two are, in part, highly deformed and strongly foliated whereas the pink megacrystic Noring Granite is unfoliated or only very weakly so.

The Berangkat Tonalite. Fresh outcrops occur in the road cuttings towards the southern end of the Complex and consist principally of a grey, rather mafic, in part highly foliated, megacrystic tonalite-granodiorite (Plate 1). The potash feldspar megacrysts range from 10 to 45 mm; they are grey-white in colour, generally euhedral but are commonly cataclastically deformed. Both hornblende and biotite are concentrated along foliae and usually constitute 10 to 20% of the rock. At other localities farther south medium-grained, less megacrystic diorites occur. Santokh Singh recorded large metasedimentary enclaves within the outcrops of the Berangkat pluton (MacDonald, 1967). In a tributary of Sungei Pinang (Topo Sheet 34, New Series, ref. 412716) and in Sungei Lah (ref. 429696) biotite-rich xenoliths of up to 12 cm by 5 cm were observed.

At grid ref. 412799 on Topo Sheet 34, the foliated tonalite is cut discordantly by unfoliated veins of pale leucogranite which have been assigned to the Kenerong Leucogranite (Plate 2). This relationship is also illustrated by Santokh Singh (1961, p. 561) and MacDonald (1967, Plate XII) who described the foliated Berangkat Tonalite as granitoid gneiss. The photograph was taken in the Sungei Kenerong (Topo Sheet 34, Old Series, ref. 949567), implying that elements of the Berangkat Tonalite extend for 8 to 10 km farther north than we recorded during our recent visit or have shown on Fig. 1.

The Kenerong Leucogranite. This granite was named after the Sungei Kenerong from where it was previously described by MacDonald (1967) and Hutchison (1969; 1973) as the granitic component of the "Injection Complex; Migmatite Complex". This granite body is made up of a sequence of veins of fine to medium-grained leucogranite and biotite granite, pegmatite and aplite. Leucogranite veins predominate and these display some lithological variation, particularly in the content of biotite. Nevertheless the overall impression is that the leucogranite veins are lithologically and texturally similar although compositional and textural differences have been recognised. Some of the pegmatities and aplites are garnetiferous.

The most striking feature of the leucogranite veins is their structure. The earliest veins are intensely foliated. These are cut by less foliated veins (which are in some cases boudinaged), whereas the youngest veins are unfoliated. This general sequence is

Plate 1. Berangkat Tonalite. Potash feldspar megacrysts sit in a coarse groundmass of feldspar and quartz and thick foliae of biotite and hornblende (SE Stong Complex; Grid Ref QZ 412799).

Plate 2. Highly foliated, biotite-rich facies of Berangkat Tonalite cut by medium-fine grained, unfoliated Kenerong Leucogranite. (SE Stong Complex; Grid Ref QZ 422811).

invariable but the number of generations of vein which may be recognised in any one place may range from as few as two to at least seven.

The earliest known veins are found as thin, foliated bands 5 cm to 2 m wide within the pelites, marbles and calc-silicate hornfelses which comprise the metasedimentary host. There is generally complete structural concordance between these early veins and the host rocks. Two of us (EJC and DIJM) consider that field evidence from the quarry in the Sungei Renyok (grid ref 316171, Sheet 21), which shows lithological banding in calc-silicate hornfels to be obliquely cut (Plate 3), suggests that these bands are intrusive veins. However, one of us (DSS) believes that some of these bands may represent granitized metasedimentary rock of different lithology to the calc-silicate hornfelses, e.g. meta-tuff or meta-arkose. The difference of opinion as to the origin of the earliest veins does not detract from the complete unanimity of all the authors as to the intrusive nature of the later veins. These are less intensely foliated, cut the earlier veins and also cut the metasedimentary host rocks. They are folded and deformed together with the enclaves and the resulting fabric is common to both (Plate 4). Subsequent veins which cut these, and which also cut the enclaves, are less deformed, but may also be foliated though less strongly so (Plate 5). More typically veins of this generation have been boudinaged (Plate 6). Many of the pegmatites seem to belong to this episode of intrusion. The final unfoliated leucogranites range in size from a few millimetres to several hundred metres in width; the smaller bodies are dykes but the precise form of the largest bodies is not known. No evidence of a central stock to the Kenerong Leucogranite has been found so far, but the question of the existence of such a stock could only be resolved by detailed mapping. At present the largest members of the body recognised are the late and unfoliated leucogranites.

The fragments of country rock which have been trapped between the veins and which now form the metasedimentary enclaves are essentially screens; contacts are usually, but not always, vertical which suggest that they have a deep vertical extent between the veins, though they are probably cut off at depth. Similarly their surface expression is very complex; they are most probably lozenge-shaped at outcrop. Topographically the Kenerong pluton is distinctive with cliffs which may mark the contacts between veins.

The pluton may be described as a vein complex, 'injection complex' MacDonald (1967), or 'migmatite complex' (Hutchison, 1969; 1973), since it reflects the complex relationship between the veins and the country rocks.

The Noring Granite. This seems to be of considerable size. The contacts of the Noring Granite have been drawn based on a combination of fieldwork data and the aeromagnetic and spectrometric data made available recently (Geological Survey of Malaysia, 1982). The spectrometric map shows the Stong Complex granitoids to be clearly defined by a change in radiometric topography and to extend continuously from south of Gunong Berangkat to the border with Thailand north of the East–West Highway. Apart from a narrow strip of Kenerong Leucogranite along the eastern margin the granites northwards from the Sungei Balah are generally pink, megacrystic Noring Granite. Most of the granitoids on the west side of the Stong Complex are also pink megacrystic biotite granite, including those on the flanks of

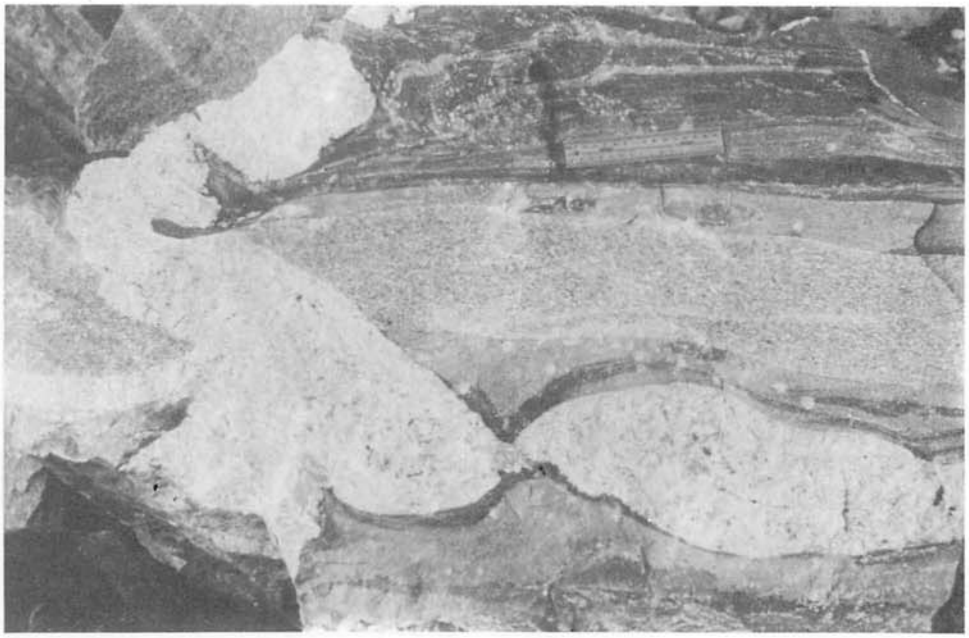


Plate 3. Banded calc-silicate hornfelses cut by sub-parallel vein of strongly foliated leucogranite which is itself cut by a boudinaged vein of granite pegmatite. (Sg Renyok Quarry; Grid Ref QU 316171).

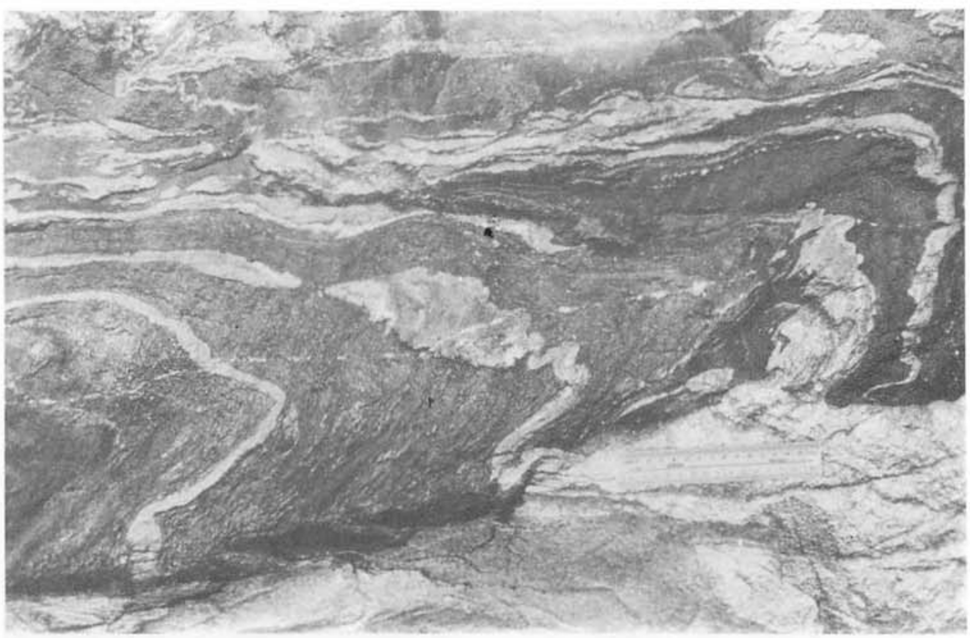


Plate 4. Veinlets from the margin of a thick body of Kenerong Leucogranite interfolded with the host semipelitic schists. (Sg. Renyok; Grid Ref QU 259146).

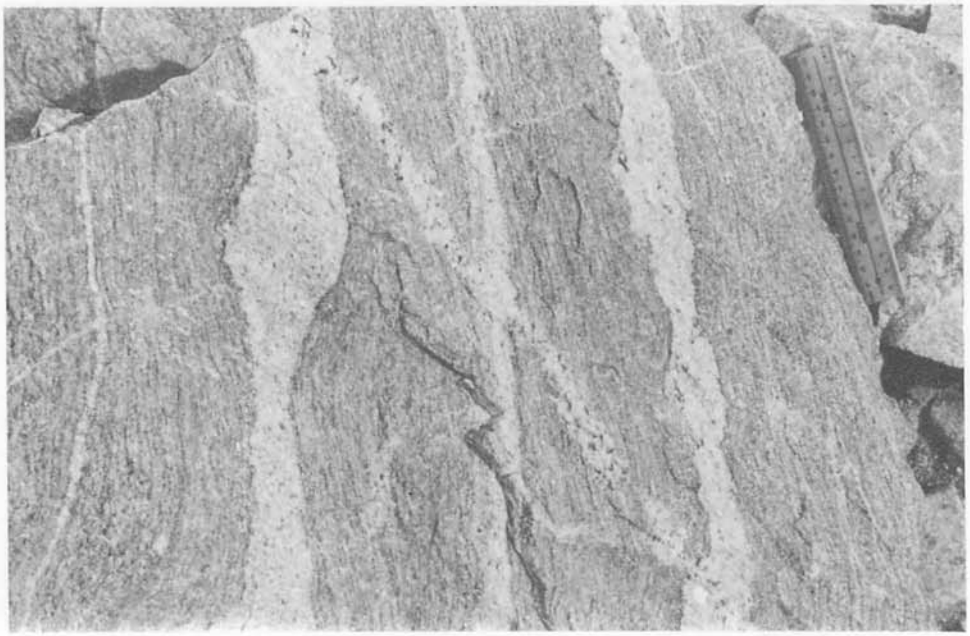


Plate 5. Three phases of Kenerong Leucogranite. Early, highly foliated granite cut by concordant veins showing incipient boudinage with late discordant vein of granite pegmatite. (Sg Renyok Quarry; Grid Ref QU 316171).

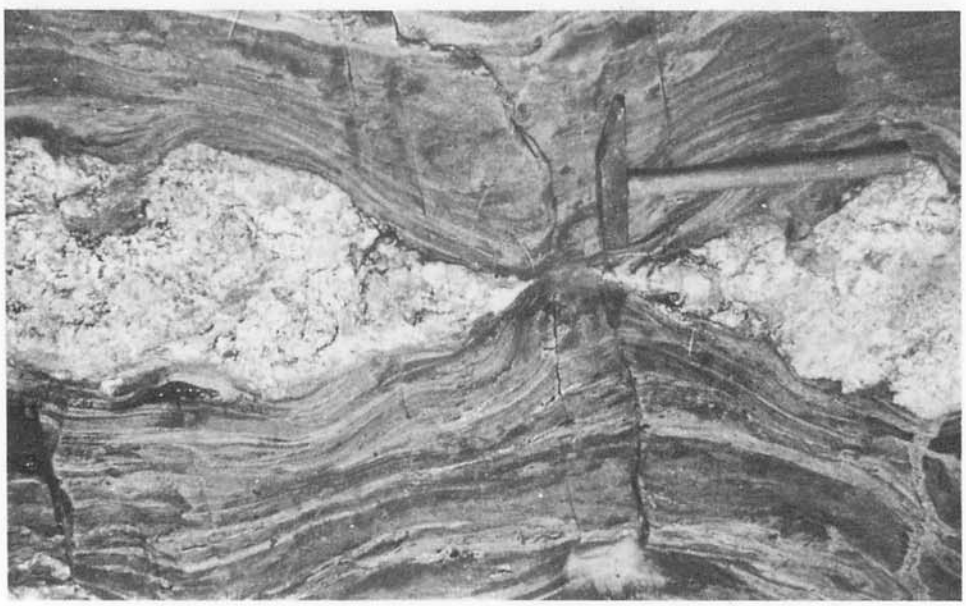


Plate 6. Boudinaged granite vein in calc-silicate and semi-pelitic hornfelses. (Sg Renyok; Grid Ref QU 316171).

Anak Noring and Noring East (Chu, 1973). These are cut by younger veins (Chu, *op. cit.*) a relationship also seen on boulders in Sg. Renyok and Sg. Terang. In the latter cases the microgranite veins contain pink fledspar (and in places large pink megacryststs) like the Noring Granite and unlike the Kenerong Leucogranite.

The Noring Granite is characterised by coarse texture and the almost invariable presence of euhedral potash fledspar megacrysts about 30 to 50 mm long (Plate 7). Milky-white plagioclase is present in the groundmass and locally mantles potash feldspar megacrysts. The more common *Terang facies* of the Noring Granite contain biotite as the only mafic mineral whereas the *Belimbing facies*, which occurs both in the East–West Highway and in the upper part of the Sungei Renyok, contains biotite and also hornblende in discrete euhedral prisms. Sphene is visible in both facies. Metasedimentary enclaves have also been observed within the outcrop of this pluton (Chu, *op. cit.*).

The Noring pluton cuts the foliated variety of the Kenerong Leucogranite in the lower reaches of the Sungei Sera (grid ref 318162, Sheet 21). Both here and in the Sungei Balah (grid ref. 318984, Sheet 33) a zone of regular schlieren banding (Plate 8) is developed over a width of several hundred metres parallel to the contact. The banding, which is on a scale of approximately 10 cm, consists of dense foliae of biotite separated by pegmatitic interbands and strikes approximately north with a steep eastward dip.

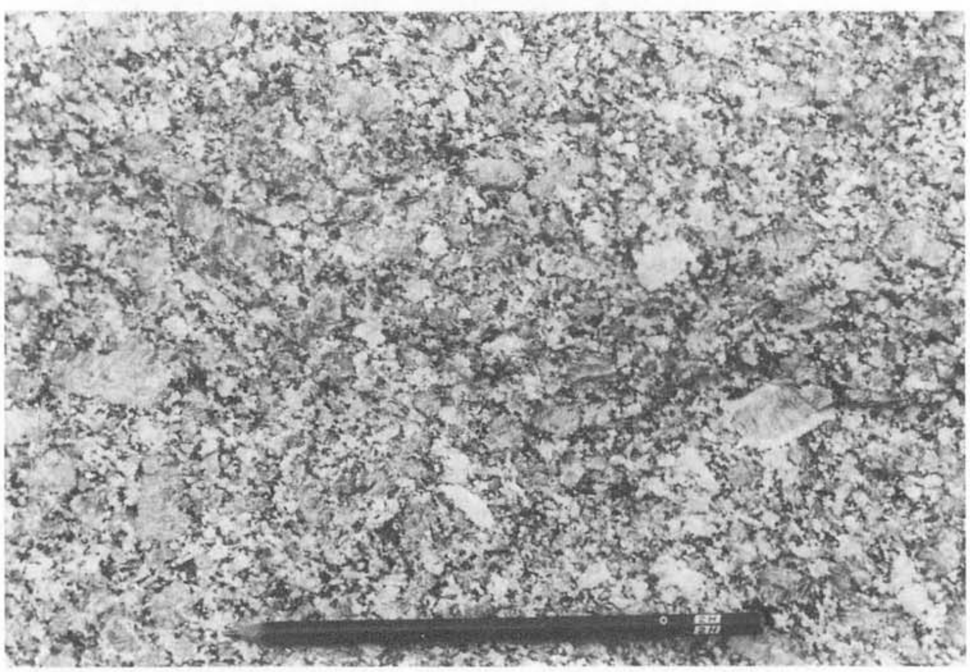


Plate 7. Noring Granite (Belimbing facies). Pink potash feldspar megacrysts, occasionally rimmed by plagioclase, in a coarse, unfoliated groundmass of quartz-plagioclase-biotite-hornblende. (East-West Highway; Grid Ref QU 135238).

Plate 8. Noring Granite (Terang facies). Differs from the Belimbing facies (Plate 7) principally in being hornblend-free. The dark layers are biotite-rich schlieren. (Sg. Sera; Grid Ref QU 318162).

The affinities of the granitoids. Both the Berangkat Tonalite and the Noring Granite have textural and mineralogical features (particularly the presence of hornblende) which are characteristic of the Eastern Belt granites and which distinguish them from the granites of the Main Range Batholith. The Kenerong Leucogranite, however, is not to be readily equated with either the Eastern Belt or the Main Range. This may be because of the small size and fine-grained nature of the individual veins which make up the Complex.

During 1981 and 1982 the following granite plutons in the Central Belt were also visited: Palong, Manchis, Kampong Teris, Benom, Senting and Kemahang. All of these are considered to have textural and mineralogical affinities with the granites of the eastern Belt and the fact that Berangkat Tonalite and Noring Granite also have similar features is consistent with their position in the same belt. Accordingly, both the Berangkat Tonalite and Noring Granite are considered to be normal Central Belt granites of Eastern Belt affinities. Since the Kenerong Leucogranite is bracketed in time tetween them it must also fall within the same group, at least in the chronological sense. These preliminary conclusions need to be investigated by geochemical and isotopic method.

METAMORPHISM AND STRUCTURE

Varying conditions of metamorphism have affected the metasediments of the enclaves, those of the aureole and also of the country rocks.

Country rocks: lithology and metamorphism

The country rocks are considered to be Permo-Carboniferous to Early Triassic age (Rajah and Yin, 1980). They consist mainly of dark carbonaceous shales with minor developments of pure and impure limestone, while volcanic and volcaniclastic material of andesitic to rhyolitic composition may be of significant local importance. The thickness of the sequence is not known but it is probably considerable. The sequence has been regionally metamorphosed in the lower green-schist facies and has been affected by intense penetrative slaty cleavage which is more pronounced in the pelitic shales, slates and phyllites than it is in the more competent volcanic and calcareous rocks. The structures of these rocks are not well understood but there are at least two closely-spaced penetrative cleavages present in most outcrops, and crenulation cleavages are also locally present, especially along the Sungei Galas between Kemubu and Bertam. The terrain into which the granites were emplaced was therefore characterized by low grade regional metamorphism and a complex structural history.

Metamorphism of the aureole. A traverse across the aureole along the Sungei Galas and Sungei Nenggiri was made by boat from the railway bridge at Kemubu to the Sungei Tool (Fig. 1). Near Kemubu the phyllites are of volcaniclastic origin and are highly folded. They grade into phyllitic pelites which are spotted with biotite porphyroblasts farther upstream; a thermal overprint. The first such spotting was noted at a distance of about 3 km from the granite contact, and is accompanied by a decrease in fissility along the main schistosity. Nearer to the granite fissility increases again as the rocks become slightly coarser, the dominant lithology being dark grey graphitic schist which, in Sungei Tool, contains a variety of porphyroblasts indicating moderate to high grade thermal metamorphism.

Good exposures of phyllites and fine-grained schists may be seen in new roadcuts on the eastern side of the Complex; and similar rocks are also present in stream sections at the southern margin, for example, in the Sungei Tool and Sungei Bertam. These rocks contain prominent porphyroblasts of garnet, staurolite and andalusite and in Sungei Bertam there is also wollastonite-bearing marble. Thin sections of these rocks show that all these porphyroblasts contain inclusion trains, chiefly of quartz, which define an earlier schistosity which has been overgrown by the porphyroblast (Plates 9 and 10). These inclusion trains are highly oblique to the main schistosity which is defined by foliae of muscovite and biotite. The presence of static growths of garnet, staurolite and andalusite in the aureole of the granites implies that recrystallisation of the country rocks took place under low confining pressure and moderately high temperature. (Higher confining pressure is implied by the presence of kyanite with staurolite in the contact zone of one of the granites of Johore recorded by Drummond (1963).) There is a strong contrast between the low amphibolite facies metamorphic grade of these marginal country rocks and the upper amphibolite facies of the enclaves, which in some cases outcrop within a distance of 1 km. (This distinction is analogous to that seen marginal to the Boundary Range Batholith of the Eastern Belt southeast of Kuala Krai where enclaves in the granodiorites are tough hornfelses, whereas the marginal metasediments are soft chiastolite slates).

Metamorphism of the enclaves. The rocks of the enclaves comprise metapelites, impure meta-arenites and impure to pure marble and, especially in the southern part of the Complex, amphibolites. These rocks have strongly planar metamorphic fabrics. Descriptions of them have been made by Santokh Singh (1963), MacDonald (1967) and Hutchison (1969; 1973). The index minerals garnet, sillimanite and cordierite have all been previously recorded from the pelitic rocks of the Complex, and diopside, scapolite, axinite, hornblende phlogopite, grossularite and sphene occur in the calc-silicate hornfelses. This assemblage is characteristic of the upper amphibolite facies of the Abukuma type of dynamothermal metamorphism (Hutchison, 1973).

Structure in the enclaves

It is impossible to separate the structures in the metasediments from those in the early granite veins, implying that they were both contemporaneously deformed. Nevertheless, in the more massive enclaves where there are few veins the structure there is essentially a planar schistosity and there are few suggestions of microfolds or intrafolial folds. No lineations were observed and the structures seen were compatible with a hypothesis of simple flattening. Near vein contacts, and especially near contacts of sequential vein emplacement, structures are very complex, the veins being commonly folded with the metasediments to give complex isoclinal fold patterns with steeply plunging fold axes (Plate 4). The geometry of these combined vein and metasediment folds also suggests simple flattening. Later veins which have not been folded but have been boudinaged indicate waning compression oriented in the same direction, approximately east-west along the eastern margin of the Complex.

Structures in the aureole and in the country rocks. The dominant structure in the

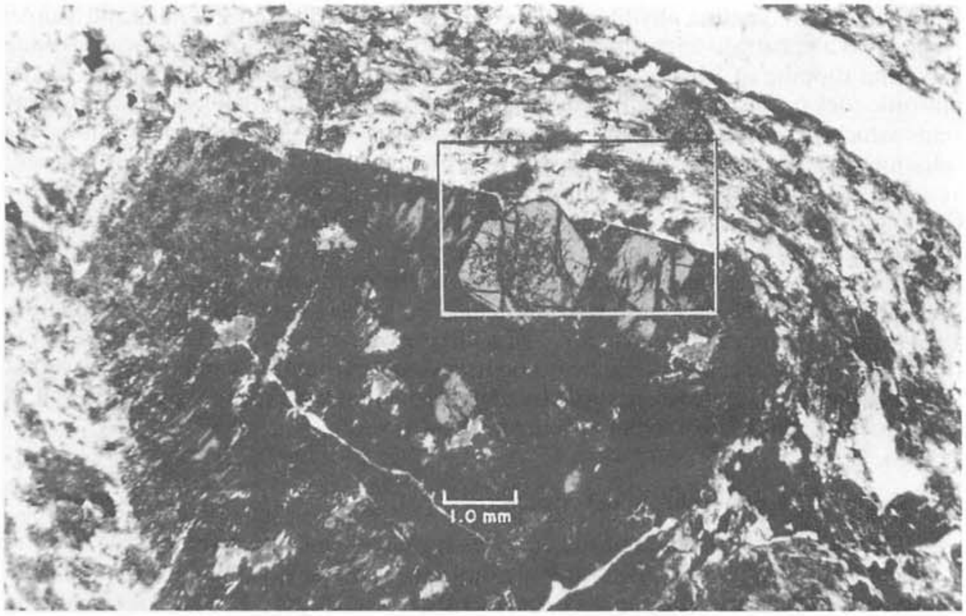


Plate 9. Staurolite-garnet-biotite schist. (Sg Tool; Grid Ref QZ 427648).

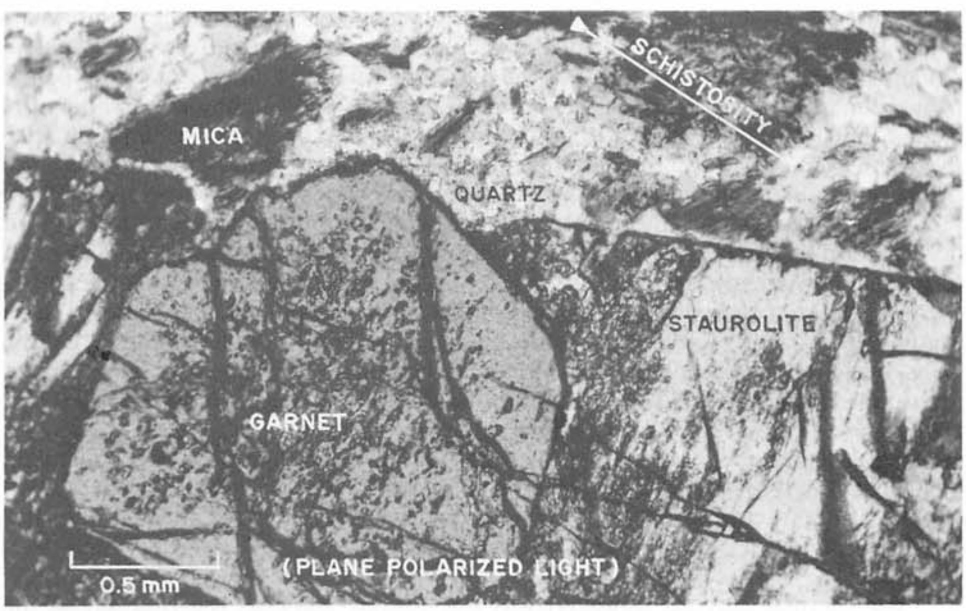


Plate 10. Enlargement of part of Plate 9.

volcaniclastic and pelitic phyllites of the country rocks in the Sungei Galas and Sungei Nenggiri is a penetrative schistosity which, at grid reference 485859, is vertical, striking 350° and dipping at 85° to the east, ie. approximately parallel to the margin of the plutonic rocks. Clasts of volcanic material are flattened but not elongated and quartz veins which traverse the schistosity are puckered by resurgent movement along the foliation planes. Crenulation cleavages striking at about 280° and 320° are also present at some localities. Within the aureole at Sungai Tool on the southern edge of the Complex the strike of the schistosity is 030°, again approximately concordant with the contact of the granite. The general concordance of schistosities within the aureole to the direction of the granite contact is a feature of the southern margin of the Complex, according to Hutchison (1973) and the 1 inch to 1 mile geological map compiled in 1963 (Santokh Singh, unpublished). The schistosity near the contacts is stronger than that in the country rocks farther away and the evidence from thin sections suggests that it was developed at least partly after the growth of the porphyroblasts and is consequently related to the emplacement of the granite.

Discussion of Metamorphism and Structure

The metamorphic grade of the enclaves is much higher than that of the country rocks and of the aureole (as is commonly the case with granite enclaves and aureoles). Moreover, the increase in grade in the aureole is very rapid. There is also a strong contrast between the static thermal overprint of much of the aureole and the highly deformed metasediments of the enclaves and contact country rocks. It is evident that the thermal metamorphism of the aureole was caused by an influx of heat from the nearby granite. The most salient problem of the Stong Complex, however, is the cause of the dynamothermal metamorphism which has affected the enclaves of the Complex and, to a lesser extent, the aureole. The metasedimentary enclaves and the granite veins which cut them are concordantly foliated and folded and are both affected by the same dynamothermal metamorphism. The sillimanite, garnet and cordierite of the pelitic metasediments crystallised within a fabric which was common to both the metasediments and the foliated granite veins, and which therefore was imposed after the granite veins had cut the metasediments. The disparity of grade within the enclaves compared to that in the aureole is consistent with a higher ambient temperature within the granite than within the aureole. Since the most intense metamorphism and deformation is within the granite plutons it is logical to suggest that the emplacement of the Kenerong Leucogranite veins induced a compressional system which, together with the heat, resulted in a dynamothermal metamorphism. By analogy these arguments also apply to the Berangkat Tonalite. They support the hypothesis that the veins, being introduced into an area already fully occupied by pre-existing material of approximately equal ductility, adapted to the situation by flattening. The pelites and calc-silicate hornfelses reacted in the same way; the degree of their flattening, deformation, and the complexity of their relationship with the veins being controlled by the ductility contrast between the veins and the metasediments. As the system cooled, brittle fractures were exploited to provide emplacement channels for the later cross-cutting veins.

The thermal aureole, however, was not entirely static as the rotation of the porphyroblasts indicates. The emplacement of the granite appears to have caused initial thermal overprinting expressed by growth of porphyroblasts which imply only fairly shallow, epizonal depths with low to moderate confining pressure. Later centrifugal directional stresses resulted in development of the new schistosity and porphyroblast rotation.

The continuous if irregular passage from the phyllites to the garnet-staurolite-andalusite schists of the aureole leaves little room for doubt that the phyllites and the aureole schists belong to the same stratigraphic formation. Similarly the lithologies in the enclaves can be recognised as having been derived from the same range of sedimentary and volcanic rocks as the lithologies in the envelope and, as it has been shown that the difference in their metamorphic grade was entirely due to the thermal influence of the Kenerong Leucogranite and the Berangkat Tonalite, the most reasonable hypothesis at present is that the rocks of the enclaves, the aureole and the country rock all belong to the same formation, as Santokh Singh (1963) had concluded.

CONCLUSIONS

The reconnaissance visit to the Stong Complex has established that the Complex comprises three granitoid plutons, the two earliests of which developed a thermal aureole in the country rock and are therefore later than the stratigraphic age of the envelope, and also of the regional metamorphism. The Noring Granite is the latest in the sequence, and it is undeformed. It is possible that it has not contributed to the development of the thermal aureole in the same measure as the two older plutons. The granites were emplaced in sequence, the Berangkat Tonalite first which was followed by the Kenerong Leucogranite vein complex which was in turn cut by the Noring Granite. The evidence for this sequence is that both the early foliated Kenerong Leucogranite and the Berangkat Tonalite are cut by the later unfoliated Kenerong Leucogranite. By implication, but so far unproven, the whole of the Kenerong Leucogranite post-dates the Berangkat Tonalite. The Noring Granite cuts the foliated Kenerong Leucogranite, and by application of a similar argument is implied to be later than the unfoliated leucogranite as well.

The lower age limit of the granites is set by the stratigraphic age of the envelope of Carboniferous to Triassic; the upper age limit is not well defined stratigraphically. Bignell and Snelling (1977) recorded a K-Ar age of 69 ± 2 Ma on micas from a 'biotite gneiss' from the Complex, and an Rb/Sr whole rock apparent age of 66 ± 1 Ma from the same sample. They considered that the regional context, in which most Rb/Sr age determination on granitoid rocks from the northern half of Malaysia were Triassic, suggested an older age for the Stong intrusions and that the younger ages reflected a Cretaceous resetting of mineral clocks. However, biotite from a megacrystic granite at Anak Noring (grid ref 184973) gave a K-Ar age of 64 Ma and an age of 67 Ma was obtained from biotite extracted from lithologically similar granite near Noring East (grid ref 227936). These results suggest a Cretaceous age of intrusion and metamorphism for at least some elements of the Complex.

On grounds of textural character and mineral composition the Berangkat and Noring granitoids are considered to be typical representatives of the granites of the

Eastern Belt. The Kenerong Leucogranite is not typical either of the Eastern Belt or of the Main Range but since it is temporarily bracketed between the Berangkat Tonalite and the Noring Granite it is chronologically grouped with the granites of the Eastern Belt.

The metasedimentary enclaves within the vein system of the Kenerong Leucogranite and those mapped by Santokh Singh (1963) within the Berangkat Tonalite are considered, on lithological grounds, to be correlative with the low grade metasedimentary and metavolcanic rocks of the envelope. The extreme degree of dynamothermal metamorphism and deformation which has affected the metasedimentary enclaves and the early granite veins of the Kenerong Leucogranite are believed to have resulted from forces generated by the emplacement of the granite, together with an influx of heat from the same source. The porphyroblasts in the aureole schists imply only shallow to moderate depths of intrusion and metamorphism. It is considered that the evidence available does not support the idea of an older metamorphic basement exposed through a tectonic window. The metamorphic features which are developed in this part of the Central Belt are entirely the result of geological processes involved in the development of the belt itself, which is probably not older than Permo-Carboniferous or Triassic. The metamorphism and structures developed within the Kenerong Leucogranite are in marked contrast to those found in other granites in Peninsular Malaysia (except perhaps those of southeast Johore (Drummond, 1963)).

It is hoped that this report will stimulate the detailed work which is now necessary to investigate the preliminary conclusions documented above. The eastern half of the Complex is now quite readily accessible by Malaysian standards.

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