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The tectonic framework and evolution of the Central Belt and its margins Peninsular Malaysia

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Abstract: The parallelism of the mineral belts in Peninsular Malaysia with the regional structural trends has led to considerable speculation on the tectonic development of the different belts. The justification for the three-fold division of the peninsula is critically examined and while it is proposed to retain this scheme, the present basis for demarcating the boundaries of the different belts are found to be too arbitrary. The Central Belt is shown to be separated from its margin by major northerly fault zones. These faults are interpreted as essentially normal faults related to continental rifting and graben development during the late Paleozoic and Mesozoic. The downfaulted Central Belt graben, flanked by the uplifted Western and Eastern Belts, has undergone a different geological evolution characterised by well developed marine and non-marine sequences and active volcanism. A subduction related origin for the small bodies of serpentinite is not favoured and these rocks are interpreted as originating along geofractures close to the margins of the graben. Mineralization related to deep seated sources may be expected to have been facilitated during their upward migration and emplacement by these faults and the margins of the Central Belt are favourable locations for the presence of continental rift associated mineralization.

INTRODUCTION

The concept of a three fold division of the Malay Peninsula into the Eastern, Central and Western Belts was first suggested by Scrivenor (1928) on the basis of differences in mineralization styles. The Eastern and Western Tin Belts are separated by a region relatively less enriched in tin and noted at that time for the only known large in situ deposit of gold. This Central Gold Belt was later renamed the Central Gold and Base Metal Belt by Rajah & Yin (1980). Although this three fold division has been generally accepted and followed in nearly all geological reconstructions and regional consideration of the geology, the basis for demarcating the boundaries have never been clearly stated and the lines shown in published geological sketch maps representing the limits of the different belts are often drawn arbitrarily.

The earliest discussion on the tectonic implications of the different zones in the Malay Peninsula was by van Bemmelen (1949) and Klompe (1961). Both these authors incorporated the three fold division of the peninsula in their continental growth models for this region. The age of the orogenic events in these three belts were thought to be progressively younger to the west. More recently, considerable interest has been shown in the differences in the mineralogy and chemistry of the granites in these three belts, e.g. Hutchison (1977), Bignell and Snelling (1977) and Yeap (1980).

Several tectonic schemes based on the Plate Tectonic theory, e.g. Hutchison (1973, 1977), Tan (1976), Mitchell (1977) and Bignell and Snelling (1977) have been put

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forward to explain the zonal division of the Malay Peninsula and other features of Peninsular Malaysian geology. The limited geological data available over most of the dominantly forested terrain greatly hinder the reconstruction of the paleohistory of this area and often necessitate considerable assumptions and speculations on the part of the authors to fill large gaps in our knowledge of the geology of the peninsula. Unfortunately, many authors do not differentiate clearly between the known and substantiated facts from the inferred and unproven. The scarcity of undisputable geological evidence for or against any of the possible paleo-tectonic schemes for the evolution of the peninsula imposes very little constraints on anyone attempting a geological reconstruction of the region.

Although the Central Belt geology and mineralization has been described in several publications, e.g. Aw (1977) and Rajah & Yin (1980), there remains many aspects of the geology of this belt which have not been satisfactorily explained. One of the main problems with the three fold zonal scheme is that while it provides a very good and simple working model to highlight the main differences in the geology and mineralization in the three belts on a broad scale, these differences are not sufficiently pronounced to make it easy to assign all the different geological units occurring within the peninsula to one of the three belts and to demarcate the boundaries of the three belts. In this paper, the criteria for distinguishing the three belts will be examined and the problems associated with the demarcation of the limits of each of these belts will be discussed. As many of the possible criteria for differentiating the different belts are closely associated with its origin and tectonic setting, it will be necessarily also to incorporate some discussions on the tectonic evolution of these regions and the probable causes for the three-fold zonal arrangement of the peninsula.

THE POSSIBLE CRITERIA FOR DIFFERENTIATING THE EASTERN, CENTRAL AND WESTERN BELTS

Although there has not been any general agreement on the boundaries of the three belts, the most recent interpretation as shown in the map by Rajah et. al. (1978), serves as a convenient basis for discussing the possible differences between the different belts (Fig. 1).

Some of the major differences between the geology of the three belts which have been suggested by various authors as important criteria for distinguishing the different belts are listed below.

1. Mineralization. The base metals of the Central Belt are principally of copper, lead and zinc (Rajah & Yin, 1980). No large proven deposits are known but it is believed that this belt has a good potential for such deposits.

2. Cassiterite. The highly pleochroic cassiterite is confined to the Main Range Granite of the Western Belt while in the Eastern Belt the cassiterite is only weakly to non-pleochroic (Hosking, 1974).

3. Age of the Granites. The early ideas of a progressively younger orogeny on moving westwards based on the relief that the granites in the Eastern Belt are

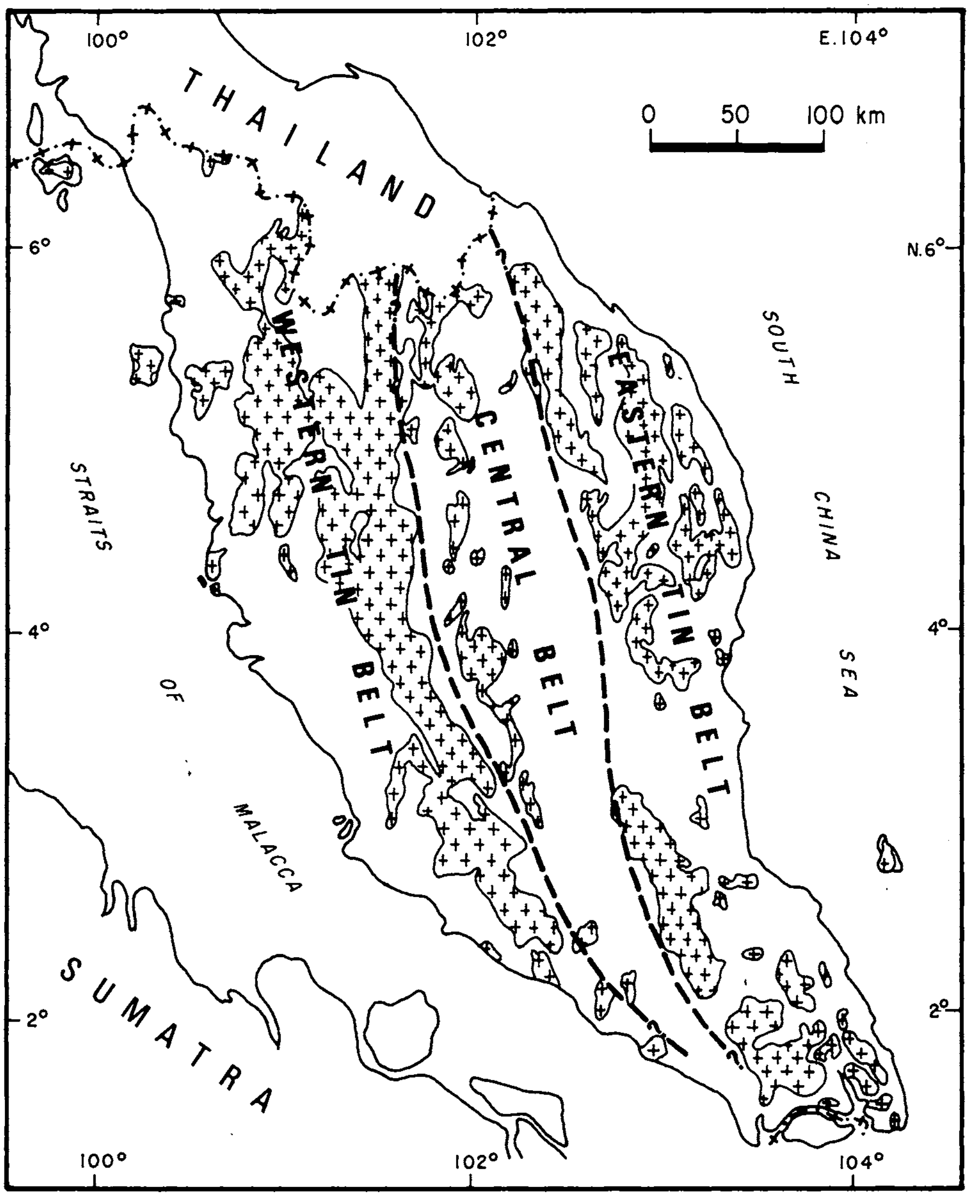

Fig. 1. The mineral belts of Peninsular Malaysia, after Rajah et. al. (1978).

older than those in the Western Belt has now been prove to be incorrect. Radiometric ages from Bignell and Snelling (1977) show that Triassic ages are predominant in both these these belts but the Western Belt Main Range Granite also gives older ages such as late Carboniferous.

4. ^{87}Sr:^{86}Sr and Rb: Sr ratios. Hutchison (1977) stated that the most outstanding difference between the main granitic belts is that the Eastern Belt granite are lower in Rb and higher in Sr than the Western Belt granite and suggests that the Eastern Belt granite were derived from a much less continental and sialic basement. The new data from Bignell and Snelling (1977) show that while the Rb:Sr ratios indicate that the west coast granites are more differentiated than the east coast granites, the initial ^{87}Sr:^{86} Sr ratios yielded by most Malaysian granites clearly preclude a simple mantle origin and necessitate the involvement of continental crustal material. The ^{87}Sr:^{86} Sr ratio for the late Permian/early Triassic granites of the Eastern Belt are also found to be comparable to the main body of the Western Belt granites.

5. Levels of granite emplacement. The Western Belt granite is mesozonal according to Hutchison (1973, 1977) while the Eastern Belt granite is epizonal. The most compelling evidence for the epizonal nature of the East Coast batholiths according to Hutchison (1973) is provided by the formerly believed Carboniferous age of the granite combined with the knowledge that they were emplaced into Lower Carboniferous sedimentary rocks. This conclusion now needs to be reappraised in view of the "revised" later Permian/Triassic age of these granites (Bignell & Snelling 1977). Rajah et. al. (1977) apparently do not subscribe to the epizonal nature of the Eastern Belt granites as they stated that compare to the Western Belt, the granitoid bodies in the Eastern Belt were probably emplaced at progressively lower levels and that remarkable little thermal metamorphism is impressed in the host country rocks.

6. Structure. The Central Belt rock sequences are popularly referred to as being isoclinally folded and faulted based mainly on the presence of widely separated stratigraphic horizons being repeated across the strike (Gobbett, 1973). The Mesozoic Tembeling Formation rocks in the Central Belt are also folded while the stratigraphically equivalent Gagau Formation rocks in the Eastern Belt are not folded (Yin and Aw, 1976).

7. Metamorphism. The best known large body of regionally metamorphosed sediments, the Taku Schists (MacDonald, 1967) is restricted to the Central Belt.

Taken individually, each of the criteria listed above cannot stand by itself as exceptions to the general rule can in all cases be found. It is now known that the granites in each of the belts are not all of the same age or having the same mineralogy and chemistry (Bignell and Snelling, 1977) and some of the differences between different bodies within the same belts can be greater than the differences postulated between granitoids of different belts. The mineral distribution maps of the Geological Survey e.g. Rajah & Chand (1976) do not show distinctly different mineral occurrences between the three belts to warrant anything more than the general statement listed above. Even tin is present though in relatively small quantities in the Central Belt and many of the mineral occurrences noted in the Central Belt are also found in the Eastern Belt e.g. gold. Given these limitations, it is perhaps not surprising that the limits of the three belts are invaribaly shown to be different in all published maps proposing to show the extension of the three zones.

Inspite of the non-exclusive nature of the various criteria which have been proposed for differentiating the three belts, the concept of a threefold division of the peninsula cannot be discarded. The predominance of granitoids and associated tin mineralization in both the Eastern and Western Belts contrasts markedly with the largely sedimentary and volcanic nature of the Central Belt rocks and it seems likely that there are some significant differences in the geological evolution of these three belts. It is clear however that these differences are less pronounced than had been speculated in the past and the causes for the threefold division of the peninsula is a subject which warrants further investigation.

THE BOUNDARIES OF THE CENTRAL BELT

It is interesting to note that while Scrivenor (1928) proposed the three-fold division of the Malay Peninsula, he did not elaborate on the probable causes for the differences in mineralization in the three belts. Scrivenor however did remark on the narrowness of this belt which only attained a maximum width of 70 km. The maps drawn since then based on this zonation are not accompanied by an explanation on the basis for drawing the boundaries of the different belts but it is clear that a number of factors have influenced the authors of such schemes. The main factors are (1) the distribution of the granitic rocks, (2) the so-called ophiolites and paleosuture to the east of the Main Range granites and (3) the Lebir fault zone to the east of the Central Belt.

From published accounts, there appear to be a strong resemblance on the western boundary of the Central Belt as shown in Rajah et. al. (1976), and Hutchison (1977). Hutchison interpreted this line as marking the site of a former suture with ophiolites and the later discovery of serpentinite from a drill core in Malacca by Khoo (1978) has caused him to redraw this tectonic line "to run out into the Straits of Malacca and not to continue southwards to Singapore as formerly believed." The locations of the ophiolites are not shown but from the locations of the known serpentinised ultrabasic rocks in the peninsula (Fig. 2) it is clear that the line shown in published maps as representing the Bentong-Raub suture is drawn arbitrarily and is in places more than 50 km away from the serpentinised rocks which forms the basis for the interpretation of the tectonic line. A line drawn passing through the known serpentinised body would not be gently curving but would be highly irregular with sharp bends to join for example the Kuala Pilah serpentinite (Khoo, 1975) with those in Malacca (Khoo, 1978). The line drawn representing the western-most limits of the Central Belt tends to follow close to the eastern edge of the Main Range granite but, especially in the north, all interpretations of this line will have to cut the granite. Hutchison (1977) showed the Bentong-Raub ophiolite line as neatly demarcating the eastern limits of the Main Range granite but this is achieved only be leaving out several granitic bodies in the

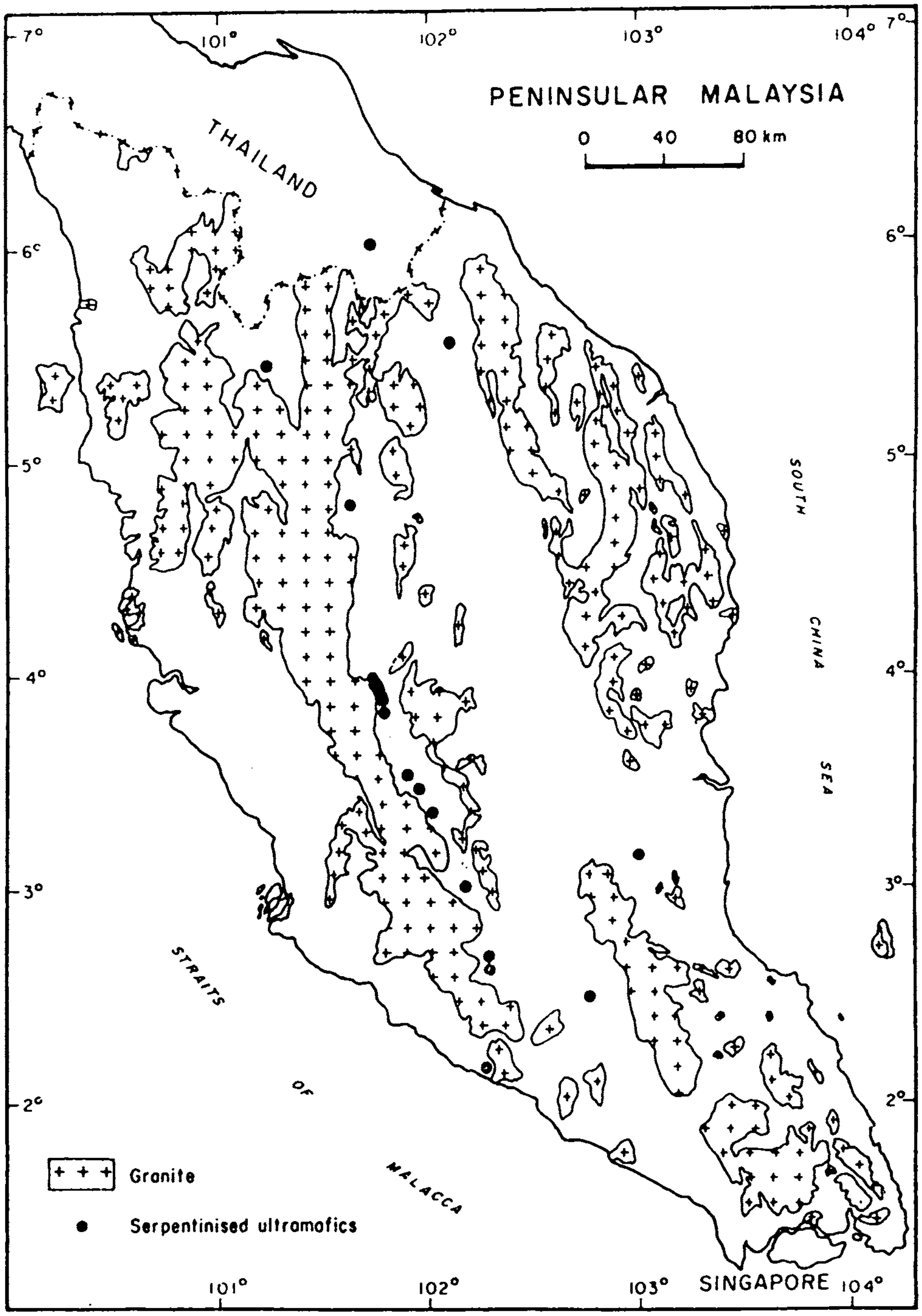

Fig. 2. Distribution of serpentinised ultramafics in Peninsula Malaysia after Tan & Khoo (1981).

north including the well known Kemahang granite (Khoo, 1980). The now redrawned tectonic line (Hutchison, 1978) running out into the Straits of Malacca will also have to cut the Main Range granite.

The eastern limits of the Central Belt follow closely to the Lebir fault trace (Tjia, 1972) which also appears to mark the western limits of the Eastern Belt granite in the north and central part of the Peninsular. The main problem with this boundary is in the south beyond the southern limits of the Lebir fault where different interpretations, e.g. Rajah et. al., (1976) and Rajah et. al., (1978) show this line either to be on the west or east of the large granite bodies in Johore. It is clear from petrological similarities that the large granitic body in central Johore would be more confortably placed in the Eastern Belt rather than in the Central Belt but this can only be achieved by curving the linear northwest southeast line westwards away from the Lebir fault in the south but in any case, the evidence available do not allow for anything more than an arbitrary positioning of this eastern limits of the Central Belt.

THE STRUCTURES OF THE ROCKS IN CENTRAL PENINSULAR MALAYSIA

Very little structural studies have been undertaken on the rocks in this area. The scattered rocks exposes do not show any good small scale structures or evidence of strong deformation. However, it is often stated in published work that isoclinal folding and thrusting are characteristic features in these rocks. Mitchell (1977) for example attributes his statement to C.S. Hutchison (personal communication). Hutchison (1977) has isoclinally folded metasediments in the country rocks of the Main Range granite of the Western Belt and strongly folded Permian rocks underlying gently folded Triassic and Mesozoic sequences in the Central Belt. (Hutchison, 1975 & 1978) show strongly isoclinal folding and thrusting in the Lower Paleozoic rocks along the western margin of the Central Belt. However the descriptions and localities for these structures are not provided. Rajah and Yin (1980) attributed their interpretation on isoclinal folding in Central Malaya to Gobbett (1973). Gobbett put forward this interpretation to account for the repetition of similar Permian—Triassic stratigraphic horizons across the strike. The area discussed by Gobbett is at some distance from the so-called Bentong–Raub suture described by Hutchison (1977), Mitchell (1977) and Bignell and Snelling (1977). Gobbett's suggestion of probable isoclinal folding and faulting to explain the stratigraphic repetition is highly speculative as the same results could be accomplished by faulting alone. No detailed mapping has been carried out to provide the geological map to support his interpretation of the geological structure in this area. Isoclinal folding of this relatively thickly bedded sequence as shown in Gobbett (1973) seem unlikely as the rocks do not show any sign of intense deformation or well developed cleavage and the fossils found are rarely deformed tectonically.

The Lebir fault was postulated by Tjia (1972) based mainly on the remarkably straight valley in the north. This fault is interpreted from fault plane markings as indicating sinistral offset but no evidence has been offered to give any indication of the magnitude of the horizontal displacement. The available geological maps do not show any geological features present on both sides of the faults which could be correlated to give the magnitude of the strike slip displacement. The fault is also interpreted as providing sufficient relief in the south to be responsible for thick sequences of conglomerate to be derived from the fault scarp. This morphological expression of a upthrown fault block to the east suggest that the main fault movements is down dip instead of strike slip. It is possible that strike slip movement could have been generated later along the existing fault plane to give rise to the fault plane markings but the morphology and the absence of horizontally displaced geological units which can be correlated across the fault trace indicates a high probability that normal faulting movement is dominant.

In view of the important role attributed to the major postulated faults separating the different belts in most of the tectonic schemes for the peninsula, the basis for the interpretation of these faults need to be carefully assessed. Neither of the major faults near the eastern or western margins of the Central Belt are shown in the published geological maps of the Malaysian Geological Survey. Some faults are shown in the vicinity of the proposed major fractures but these faults are of relatively very limited extent. The Bentong-Raub suture (Hutchison, 1975, 1977) was interpreted solely on the basis of the serpentinite exposure, but since the exposures known at that time are limited mainly to the Bentong, Raub and Kuala Lipis area, the extension of this suture to the north and south are purely speculative. To the east of the Central Belt, the Lebir fault trace (Tjia, 1972) can only be interpreted with some degree of confidence in Kelantan and north Pahang, mainly on its geomorphological expression. The southern extension of this fault across the peninsula is also highly speculative as the faultl trace appears to be truncated by the sedimentary units east of Gunung Tahan shown on the geological map as being of Permian age (Yin & Shu, 1973). In a heavily forested region the easiest way to detect the presence of major structural lineaments is either from aerial photographs or Satellite imageries. Although aerial photographs are available for most of the country, the most common scale 1:25000 is too large for studying megastructures. Satellite imageries with low percentage of cloud cover is only available for less than a quarter of the peninsula. Fortunately one of the best available imagery covers the critical area north of Bentong and includes the region where the boundaries between the Central and the Western Belts have been drawn and the critical area for the interpretation of the postulated paleosuture zone.

New data obtained from satellite imagery (Fig. 3) show that the area immediately east of the Main Range granite in central Peninsular Malaysia is characterised by several north-south trending faults. The Karak-Kelau fault (Tjia, 1972) is part of this parallel fault system but the most prominent lineament is displayed by the long fault trace running to the west of the Karak-Kelau fault. This fault can be seen on aerial photographs and topographic maps as a prominent lineament running into south Thailand where it has been called the Tomo fault (Muenlek & Meesook, 1981). South of Bentong, this fault becomes less prominent and is not topographically well exposed. This north-south major fracture is not the Bentong-Raub suture of Hutchison (1977). It does not join the serpentinite bodies and its fault trace is in places as much as 20 km west of the interpreted Bentong-Raub suture.The straightness of this lineament in the rugged terrain in this part of the peninsula indicates that the fault plane must be very steep or vertical. Several smaller faults are also present and some of these faults appear to have exerted an influence on the emplacement of the serpentinite and the smaller granitic bodies.

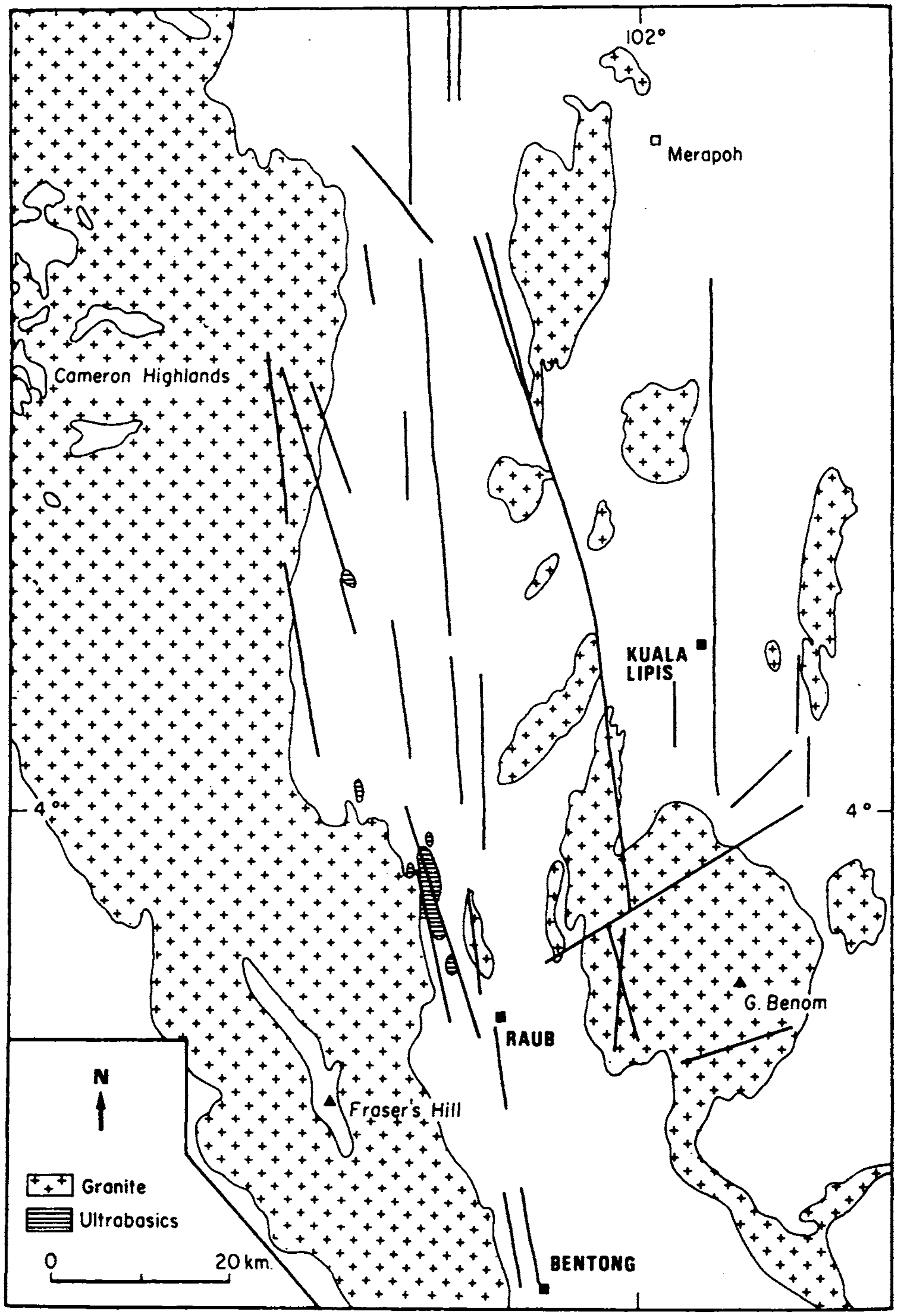

Fig. 3. Major faults in the Raub—Merapoh area as interpreted from LANDSAT imagery, Band 7, 5th January 1978.

THE GEOLOGY OF THE CENTRAL BELT

The geology of the Central Peninsular Malaysia has been described by Rajah and Yin (1980) and by Aw (1977).In general, the area is overlain to a large extent by Permian—Triassic clastic sequences. The oldest rocks comprising of schists and phyllite with Devonian fossils (Jaafar, 1976) are restricted to the western margin of this belt. The sedimentation is associated with acid to basic volcanics and interbedded tuffs and pyroclastics are common occurrences. Thick sequences of conglomeratic rocks are also abundant. The Triassic marks an important phase in the sedimentation history. The pre-Triassic sediments are largely marine and the post-Triassic rocks are characteristically non-marine while the Triassic sediments are in parts marine and non-marine. The Jurassic Cretaceous sequence has been described by Koopmans (1968) as belonging to the Tembeling Formation. This sequence is gently folded and Yin and Aw (1976) have suggested that the rocks here are identical in age to the almost flat lying Gagau Formation to the east and the difference in folding style is attributed to difference in tectonism in the different belts.

THE TECTONIC DEVELOPMENT OF THE MALAY PENINSULA

In Peninsular Malaysia, the general popularity of the Plate Tectonic theory in the past ten years has led to a profusion of tectonic schemes to account for the evolution of the region. Most of these speculative models have adopted Htuchison's (1973) interpretation of a paleosubduction zone based largely on the evidence provided by some small serpentinised ultramafic bodies to the east of the Main Range granite. The evidence for the existence of a collision suture within the peninsula has been evaluated in a separate paper (Tan & Khoo, 1981). It is argued in this paper that the serpentinised ultramafics are not ophiolitic in origin and consequently are not remnants of oceanic lithospheres. The main evidence against the presence of a paleosuture in the peninsula is the fairly widespread and non linear distribution of the serpentinites and the absence of almost all the features commonly associated with ophiolitic belts such as tectonic melange, deep sea sediments, other members of the ophiolite suites, and calc-alkaline volcanism.

The difficulty in defining the boundaries of the Central Belt gives some indications of the high degree of similarity in the geology between the three belts especially in the southern part of the peninsula where whatever differences that may exist have a tendency to be reduced. Inspite of many exhaustive studies to show the differences between the granites of the various belts, it has yet to be conclusively established that major differences which can be directly related to different crustal properties exist between the granites of the different belts. The similarities in the different granitoids are also important for any paleo-tectonic reconstruction. For example, both the Eastern and Western Belts' granites are rich in cassiterite, a mineral which is only rarely found in more than trace amounts in most granitic bodies elsewhere. The mineralization in the Eastern Belt also have a number of similarities with that of the Central Belt and many of the minerals occurring in the Central Belt can also be found in the Eastern Belt.

Any tectonic model to explain the evolution of the peninsula must take note of both the differences and the similarities in the geology of the three belts. The difficulty in delineating the margins of the different belts and the impossibility of drawing a line along the margins which does not cross-cut the outcrops of known geological units clearly indicate that the differences in the crust of the three belts are not very pronounced. If the crust of the Central Belt is asimatic as is suggested by plate tectonic models involving subduction of oceanic crusts one would expect the paleosuture to exert a more pronounced effect on the geology resulting in a more easily defined suture zone.

The evidence available do not support the existence of a paleosubduction zone and it seems more likely that boundaries of the Central Belt are defined by the broad zone of northerly striking faults. The margin with the Eastern Belt is generally accepted as coinciding with the Lebir fault zone and the serpentinites in Bukit Ibam been suggested as resulting from this deep geofractures (Hutchison, 1977). The presence of major north-south faults east of the main range granite makes it likely that the western margin of the graben is also fault bounded and the serpentinites occuring along this linear belt could also have resulted from intrusion along deep rooted fracture zones as in Bukit Ibam instead of having an ophiolitic origin. The postulation of a graben structure for the Central Belt seems to be most appropriate to explain the known geological evidence. Hutchison (1977) also includes a Central Graben but his graben structure is fault bounded only on one side with the other side being a paleo-subduction suture.

The geology of Peninsular Malaysia as we know it today does not warrant the need for the fusion of widely separated landmasses and widespread subduction of oceanic crust. The graben structure of the central part of the peninsula with its faulted margins gives a clear indication that an entirely different geotectonic interpretation should be sought. The aborted rift hypothesis proposed earlier by Tan (1976) can explain adequately the graben structure and the differences in the geology of the three belts. The deep fractures would not necessarily be restricted to a single line but could be made up of several parallel fractures and this can explain more satisfactorily the non-linear distribution of the small serpentinite bodies which are intruded along the different fractures on both the eastern and western margins of the Central Belt (Fig. 4).

The graben forming process was probably initiated during the late Paleozoic and the early formed fractures were reactivated during certain periods in the Upper Paleozoic—Mesozoic history. Granite intrusions follow the boundaries of these fractures but in places cross-cuts the fracture zones. This faulting hypothesis for the evolution of the Central Belt explains more readily the difficulty of drawing in the boundaries as the differences between different fault bounded slices are not so pronounced especially if they are old features which are covered mostly by younger geological units and crosscut by younger granitic intrusions with the exception of some of the fracture planes which have been reactivated. The stresses causing these reactivation during later periods in the geological history could be completely different from those causing the development of the graben and this could have given rise to features along the fault plane which suggests that the main movement is strike slip, e.g. the Lebir fault (Tjia, 1972). It is well known that surface markings along fault planes often only gives an indication of the latest movement and the difference in the geology on both sides of the Lebir fault and the graben structure suggest that the main

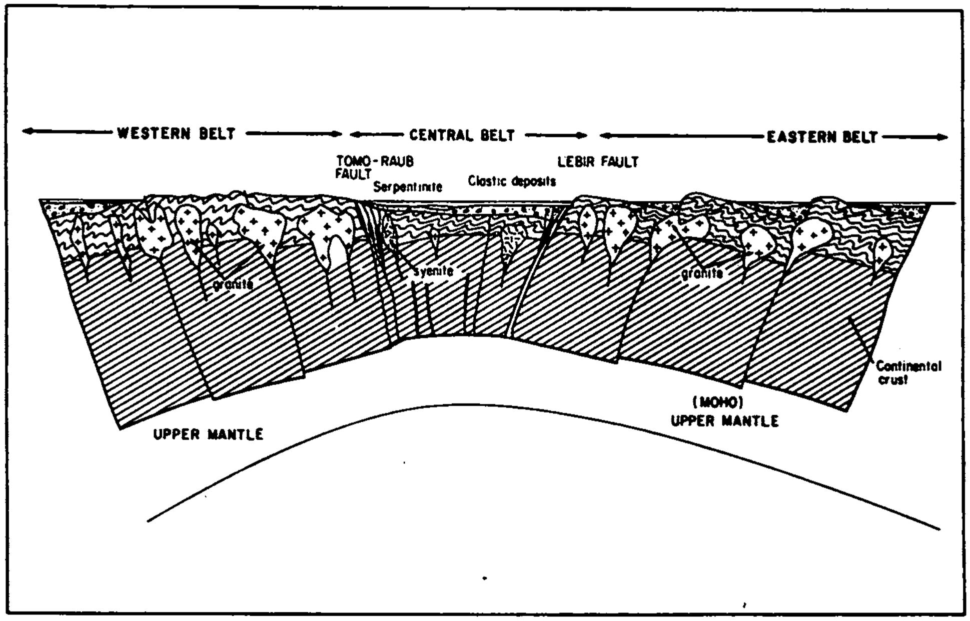

Fig. 4. Diagrammatic east-west profile across Peninsular Malaysia during the late Mesozoic.

movement is down dip instead of horizontal. The failure of attempts at correlating geological units which have been displaced by the postulated strike slip movement has always been the weak point of the large scale trancurrent movement hypothesis.

The approximately north-south block faulting postulated in the aborted rift model appears to agree with the north-south trending linear structures in the Gulf of Thailand and off the east coast of Peninsular Malaysia as reported in Ben-Avraham & Emery (1973) and Woodlands and Haw (1976). The main structure in these offshore areas involve basin development along elongated downfaulted blocks or grabens. The different tectonic regimes attributed to the Central Belt and its margins by the aborted rift model can explain the differences in the folding history of the clastic rocks of similar late Jurassic to early Cretaceous age in these two belts as noted by Yin & Aw (1976) as the release of the tensional forces at the termination of the rifting processes could result in compressional stresses acting on the rocks within the graben while the rocks on the more stable margins are left unfolded.

The major offshore structures to the north and east of the peninsula and the interpreted geofractures and zonal subdivision of the Peninsular Malaysia are shown in Figure 5. The north-south geofractures and the graben structure appear to be a continuation of the structures in the Gulf of Thailand. The offshore basin to the east of the peninsula has a similar orientation to the Lebir fault and suggest that its origin could be related to that of the Central Belt. Similar basement geofractures such as those in the Central Belt could possibly be present in the offshore area to the east and these deep seated faults could be reactivated in the Tertiary to give rise to the deep offshore

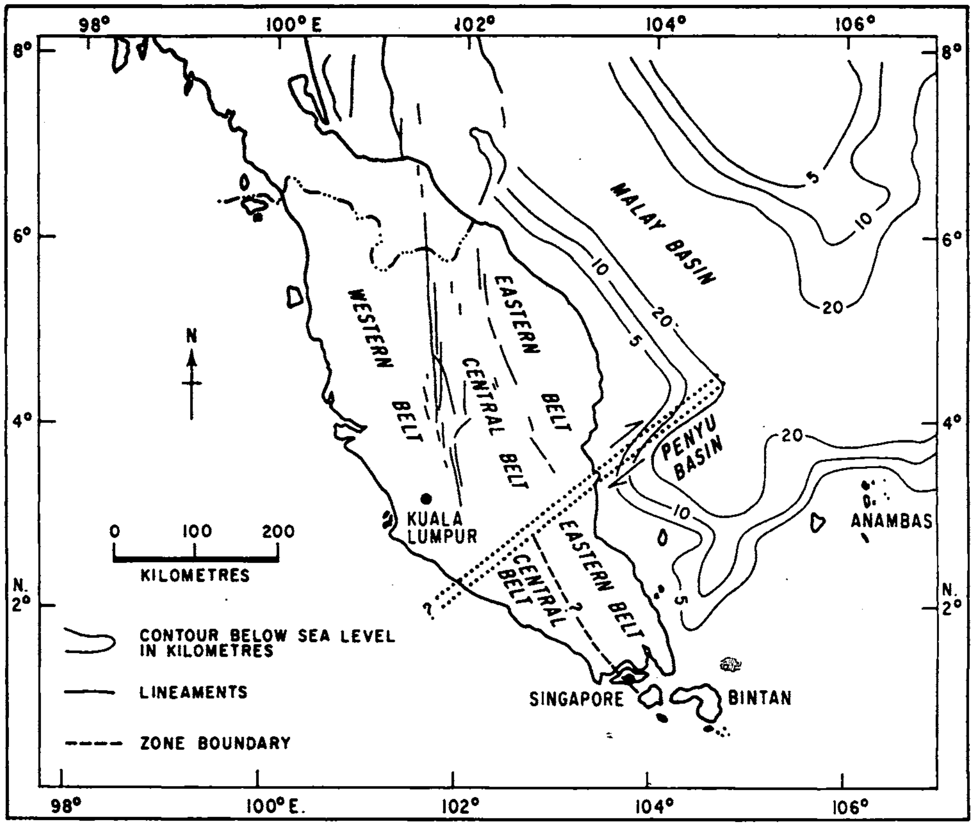

Fig. 5. Generalised basement structures in the Gulf of Thailand, Peninsular Malaysia and South China Sea. Offshore data after Woodlands & Haw (1976) and Ben Avraham & Emery (1973).

basin. It is interesting to note that the southern part of this basin has a prominent westward bulge which agrees with the westward shift of the southern part of the Central Belt boundary as shown by Rajah et. al. (1978) to accomodate the large granitoid bodies in Johore into the Eastern Belt. It is tempting to speculate on the tectonic origin of this feature, possibly involving the presence of a transform fault to account for the apparent westward shift of the zonal boundaries in the south, but at present the evidence available is very limited.

It has often been stated by many geologists working in this part of Malaysia e.g. Chung & Yin (1978) that the northerly faults are the oldest of the prominent sets of fault system in the peninsula and that these faults are normal faults. The present study supports the existence of these old faults along the margins of the Central Belt and assign a major role to these structures in the tectonic evolution of the peninsula.

MINERALIZATION

Since it is popular today to associate mineral deposit with tectonic setting, the tectonic model for the evolution of the Malay Peninsula is very important for the economic geologists. The Central Belt is now attracting considerable attention in the search for large base metal deposits. Although our knowledge of the style of mineralization in this region is not sufficiently complete, several suggestions have been made regarding the tectonic setting of the mineral deposits. Most of the speculations regarding the source and emplacements of the economic minerals involved closure of ocean basin and continental collision (e.g. Mitchell, 1977). Chand & Troup (1980) have also speculated on the occurrence of porphyry-molybdenum system associated with a Permo-Triassic calc-alkaline volcanogenic sequence interbedded with marine sediments within the Central Belt.

The close proximity of a number of potential mineral deposits within the Central Belt with the proposed system of geofractures along the eastern margin of the Central Belt indicates that we should seriously consider these deposits as originating along deep crustal zones and facilitated during their emplacement in the higher levels of the crust by the presence of these fracture zones. It is well known that deep fractures do facilitate the emplacement of economically important ore deposits and such deposits could include barite, zinc, lead, molydenum, fluorite, uranium, thorium, niobium, tin, beryllium or rare earth mineral as found in continental rift setting (Alstine, 1976).

On the basis of the current evidence, it is suggested that the Central Belt mineralization is largely fault controlled and that more attention should be given to the search of base metal deposits along the fault bounded margins of the Central Belt. At the moment, the search for base metal deposits is centred mainly along the eastern margin of the Central Belt but it seems probable that the western margin could also be potentially interesting as the tectonic setting of both these margins could be essentially similar.

CONCLUSION

It is perhaps too early at this present time to advocate only one tectonic scheme for the evolution of the Malay Peninsula and to discard all other possible models. It is possible that new geophysical data may be available in future to throw more light on our ideas on the crustal evolution of the Central Belt and necessitate a change in our geological thinking. However, base on our current knowledge, the author feels that the model of a fault bounded graben structure for the Central Belt offers a simpler and more satisfactory explanations for many of the features present than the more elaborate and speculative collision model involving subduction and closure of ocean basin.

There still remains many unresolved problems concerning the evolution of the Central Belt. The difficulty of finding supporting geologicall evidence to extend the Central Belt interpretation, with confidence, in the southern part of the peninsula poses a challenge for future field mapping and research. The apparent westward shift of southern Johore and Singapore which appear to be the southern extension of the Eastern Belt has yet to be satisfactorily accounted for. The postulated Kuala Lumpur—Mersing trancurrent fault (Stauffer, 1968) would give rise to an eastward displacement of the southern sector instead of a westward displacement as suggested by the correlation of the geological units. A major east-west fracture probably exist to account for this displacement in the south but the evidence for such a large fault zone have yet to be found. Perhaps, when earth satellite imagery become available for this part of the Peninsular, new evidence on this east-west fracturing will be forthcoming.

The recent interest shown in the mineralization in the Central Belt and the accompanying geological investigation in the search for new economically viable deposits could considerably increase our knowledge of this region and could clarify many of the uncertainties existing at present regarding the evolution of the Central Belt. The careful study of this mineralization style could also provide some clues as to their origin and could support or eliminate some of the speculative tectonic models suggested.

The north-south faults along the western margin of the Central Belt probably reflect deep crustal structures which have been activated at different times during the geologic history. Uplift along these geofractures to the east and west accompanied the development of the graben structure. These structures are pre-granite in origin and the later granitic intrusions could have been aided by other parallel fracture zones. Large batholiths emplaced in this way may obliviate any surface expressions of the fault plane unless the fault is later reactivated. Evidence of post granite movement along this north south fault can be found at several localities in the northern part of the Peninsula where the fault cuts the granite. The presence of granite on both sides of the fault contributes to the difficulty of previous attempts at defining the margins of the Central Belt. If the margins of the granites are used as the basis, then the margins will be irregular and non-linear. If as suggested in this paper, the fault zones along the margins of the Central Belt with step-like upthrow and downthrow blocks is part of the Central Belt graben structure, then this zone will provide a convenient margin for the Central Belt. Following this model, differences in the geology across the margin need not be sharp as the total block faulting movement is distributed among the different faults occurring within the fault zones. It is possible at present to define only two broad fault zones for the margins of the Central Belts. The continuation of the zones to the south remains problematical and must await the availability of additional geological information.

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