

## **On the supposed existence of the Kisap thrust in the Langkawi Islands, Northwest Peninsular Malaysia**

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**Abstract:** The Kisap thrust in Langkawi is the only large thrust fault described in Peninsular Malaysia. Its existence has been accepted by several authors and it has frequently been cited as evidence in support of plate collision hypothesis. A re-examination of the evidence shows that there are many aspects of the proposed thrust fault that cannot be substantiated and that the existence of large scale thrusting in the area has yet to be proven. All the structures attributed to the proposed thrust movement occur either within rocks of the same formation or between conformable sequences. The strikes of the proposed fault planes and the adjacent beds are markedly different and the dips of the known fracture planes are too steep to be associated with low angle over-thrusting. Present knowledge of the geology of these islands indicates that the geological boundaries shown in published geological maps need to be revised. Correspondingly, the location of the proposed fault plane, if it is present, will be at some distance from the fault trace drawn in the maps. The nature of the contact between the Lower and Upper Palaeozoic rocks interpreted as a thrust in the eastern part of the Langkawi islands cannot be satisfactorily resolved at present.

### **INTRODUCTION**

The Kisap thrust in the Langkawi Islands has, since its postulation by Koopmans (1965), been frequently cited in papers on Malaysian geology. Its implications on the geology and tectonic history of Northwest Peninsular Malaysia are fairly considerable as it has also been generally regarded as one of the major faults in the peninsula. Being the only well documented example of large scale thrusting in the country, it has often been referred to as evidence in support of the paleo-plate collision hypothesis for the peninsula, currently advocated by some writers. The trace of the thrust plane and its geometry has been the subject of some discussion and various modified versions of this thrust have been proposed but the existence of the Kisap fault has yet to be questioned. A critical analysis of the field evidence put forward in favour of this thrust revealed that several aspects of the proposed thrust fault cannot be substantiated and that the existence of large thrusting in the area has yet to be proven.

In his geological map of the Langkawi Islands, Jones (1966) introduced several large faults based mainly on the presence of slickensides and brecciated rocks and the contact relationship of rocks of widely differing ages. Most of these faults are shown to follow the geological boundaries on the eastern part of the island group. The faults separating the sedimentary formations were attributed to an east-west regional stress giving rise to thrust planes with a general strike of  $300^{\circ}$  and dipping eastwards and counter thrust striking  $020^{\circ}$  and dipping westwards (Kimura and Jones, 1967). Koopmans (1965), Foo (1964) and Miskin (1964) agreed essentially with Jones mapping of the fault traces. However, Koopmans differ from Jones by interpreting the fault on Pulau Dayang Bunting and the eastern part of the main island as one large

continuous fault extending for more than 40 kilometres which he named the Kisap thrust fault. The opposing dip directions were attributed to inversion of the thrust planes as a result of subsequent granite intrusion. Gobbett and Tjia (1973) modified Koopmans (1965) and Kimura and Jones (1967) interpretations and their diagrammatic representations of these earlier workers' views contain some important new implications regarding the tectonics of this region. Koopmans' (1965, Fig. 6) model for the development of the overthrust shows the thrust plane originating at the contact between the Setul and the Machinchang Formations while Gobbett and Tjia shows the same plane having been formed further down within the Machinchang Formation. The granite intrusion causing the inversion of the thrust plane surprisingly does not change the orientations of the beds of the underlying Chuping Formation. The diagram after Kimura and Jones extends their interpretation of thrust and counter thrust to a large thrust nappe. Hutchison (1973) extends the Kisap thrust beneath the Malay Peninsula giving it an origin in the rising axial zone of the Main Range granite. More recently Hutchison (1978a) shows the thrust to be part of a series of giant nappes stretching east-west for a distance of more than 150 km resulting from late Triassic plate collision of the eastern and western parts of the peninsula.

#### GEOLOGICAL SETTING

The Langkawi Islands with their extensive coastlines and often with good rock exposures displaying an almost continuous sedimentary succession from the Cambrian to the Permian, are often regarded as the classical area for Malaysian stratigraphy. Although the outcrops are good by Malaysian standard, accessibility is restricted by the inability to land, even with a small boat, on many of the rocky coasts and the rugged and thickly forested terrain in the interior. Only a few good geological contacts have been found and many of the current ideas on the geology are still speculative. A full account of the Palaeozoic stratigraphy may be found in Jones (1973) and Gobbett (1973). The sedimentary sequences belong essentially to four major stratigraphic units. These are a) the Machinchang Formation, mainly of quartzite of Upper Cambrian age, b) the Setul Formation of Lower Palaeozoic-Devonian limestone and minor detrital bands, c) the Singa Formation mainly of mudstones with age ranging from uppermost Devonian to Lower Permian and d) the Chuping Formation of Middle to Upper Permian limestone. Granites of Triassic age intrude these sequences. The well known stratigraphic and tectonic controversy centred around the existence of a Devonian folding phase proposed by Koopmans (1965, 1966) to account for the major differences in structural styles between the Lower Palaeozoic and the Upper Palaeozoic formations but disputed by Burton (1966) and Yancey (1975).

The Kisap thrust fault as proposed by Koopmans (1965) runs from the southern tip of Pulau Dayang Bunting through the main island and its northern-most trace is found in Pulau Dangli (Fig. 1). The fault trace is shown to separate the limestone with detrital bands of the Setul Formation in the east from the rocks of the Singa and Chuping Formations. It is interrupted by granite intrusions in the south and forms, in part, the contact between the sedimentary rocks and the granite in the main island. The field evidence put forward to support the proposed fault were collected from four localities indicated by A, B, C and D in Fig. 1.

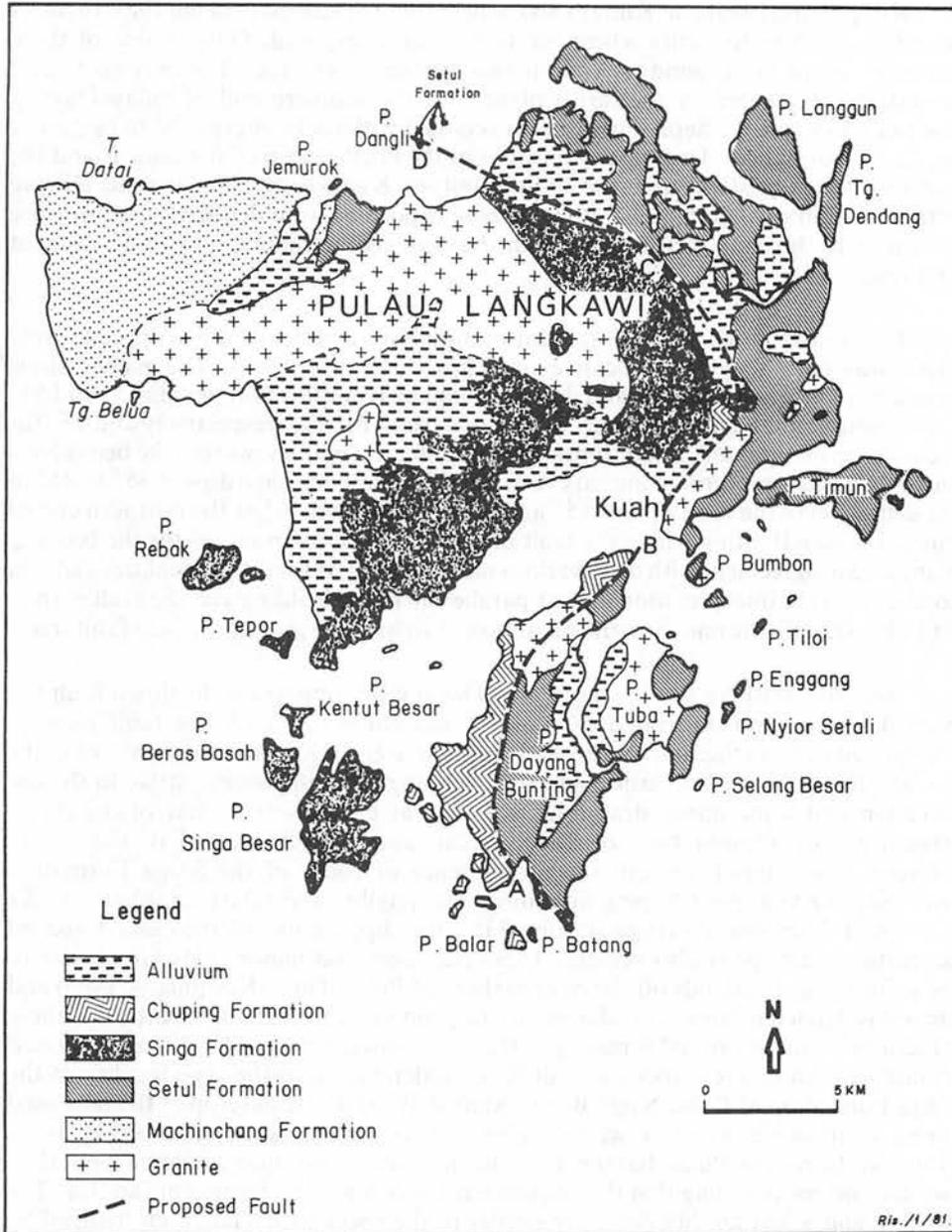


Fig. 1. Geological map of the Langkawi Islands (modified after Jones 1966) showing the Kisap fault trace proposed by Koopmans (1965).

## THE FIELD EVIDENCE

Koopmans (1965) and Kimura and Jones (1967) described in detail the structures found in the four localities where the fault trace is exposed. Only in one of these exposures is the fault found to separate two different rock units. The only geological boundary represented by the thrust plane is at the southern end of Pulau Dayang Bunting (A) where the Setul limestone is in contact with rocks interpreted to be part of the Singa Formation. Two other exposures at the northern tip of the same island (B) and on the main island near the sixth milestone Kuah-Ayer Hangat road (C) are entirely within the Chuping limestone. These exposures were deduced to be in close proximity to the main thrust plane on the basis of geological mapping undertaken at that time.

The similar strike and low amount of dip above and below the proposed thrust plane was considered as indicative of a low angle overthrust. The planes show striations or intense fracturing and dips measured by Kimura and Jones are  $15^\circ$  and  $50^\circ$  for the southern and northern part of Pulau Dayang Bunting respectively and  $35^\circ$  for the outcrop on the main island. Jones' (1966) geological map shows that the beds above and below this structural plane vary considerably. The beds have dips of  $35^\circ$  to  $45^\circ$  in the south where the fault dips at  $15^\circ$  and between  $10^\circ$  and  $40^\circ$  at the northern end of Pulau Dayang Bunting where the fault dips at  $50^\circ$ . These dip values for the bedding planes are in agreement with observations made recently at these two localities and is in conflict with the interpretation of near parallelism of the bedding and the fault planes. At Pulau Dangli, the regional strike is almost at right angle to the proposed fault trace.

Near the southern headland of Pulau Dayang Bunting where the thrust fault has been described and illustrated by Kimura and Jones (*op. cit.*), the fault plane is interpreted to form the contact between the phyllite and schistose subgreywacke of the Carboniferous Singa Formation and the overlying Setul limestone. Striae in the dip direction and some minor drag folds are cited as evidence in favour of the thrust structure. An examination of this critical outcrop revealed that the above interpretation cannot account for the presence of rocks of the Singa Formation overlying the younger Chuping limestone. The phyllite and schistose subgreywacke has a well developed cleavage striking  $335^\circ$  and dipping  $64^\circ$  to the east. A second generation cleavage is also present. These cleavages and minor folds are similar to those found in the islands off the eastern shore of Pulau Tuba (Koopmans, 1965) and are not restricted to the rocks adjacent to the proposed thrust fault. To attribute these structures to the proposed thrusting is therefore unwarranted. The petrography and metamorphism of these rocks also differ considerably from the type locality of the Singa Formation at Pulau Singa Besar (Ahmad 1973). If the outcrop at the proposed thrust location is continuous with the clastic rocks which has been mapped by Jones (1966) at the nearby Pulau Batang, then the thickness of this unit would be more than two kilometres assuming that this sequence is not repeated by folding or faulting. The phyllite and schist are lithologically similar to the rocks which has been mapped by Jones (1966) as belonging to the detrital bands in the Setul limestone and outcropping on the eastern part of Pulau Tuba and the small islands to the east. If this is true, then the proposed thrust could possibly be the conformable contact between the two units in the same formation. The stratigraphic discontinuity between the Lower Palaeozoic

rocks in the east and the Permian Chuping limestone would then be to the west of its present boundary and if this is a tectonic contact, then the fault would separate the phyllite and schist from the Chuping limestone on the west instead of the Setul limestone on the east. The striae on bedding planes could be due to minor movements along bedding planes of different competency similar to those found in beds folded by flexural slip (Ramsay, 1967, p. 392).

The inlier of the clastic layers of the Singa Formation in the Setul Formation near Sungai T. Apau on the main island described by Koopmans (*op. cit.*), has yet to be substantiated by careful geological mapping of this area. The geological boundary between the Setul limestone and the younger formations in the eastern part of the main island and correspondingly the Kisap fault trace has not been delineated with certainty due to the relatively poor exposures and the rugged terrain. Mapping undertaken by Jones (1966) and Wong (1974) shows the margin of the Setul limestone in this area to be one to two kilometres east of the line shown on Koopmans' map and the clastic layers of the Singa Formation would then be wholly within the Singa and not an inlier in the Setul as earlier interpreted. Mapping carried out to date in this area is generally on a reconnaissance scale and the geological boundaries over the entire group of islands is only approximately shown on geological maps. If the Setul Formation is indeed in fault contact with the younger formations then the locations and geometry of the fault trace or traces must remain largely speculative until more data becomes available.

## DISCUSSION

Current plate tectonic collision models for the evolution of the Malay Peninsula (Mitchell, 1977 and Hutchison, 1977 and 1978b), were developed partly on the basis of the supposed existence of large thrust and overthrust on the western part of the peninsula. Hutchison's (1978a) model showed a zone of large nappes and overthrusts extending laterally for more than 150 km. The Kisap thrust is shown to be part of this zone which extends from north Kelantan to the Langkawi island. Such a large zone of overthrusting would make the tectonic setting of this region comparable to or even exceeding the magnitude of the major nappes and overthrust zones elsewhere in the world such as the Alpine nappe zone. No supporting geological evidence was offered for this highly speculative postulation.

A re-examination of the evidence cited in favour of the presence of a major thrust fault in the Langkawi islands indicates that the basis for postulating this large scale faulting is not supported by the data available. Structures indicative of faulting, such as fault breccia, slickensides, jointing and limonitization all occur entirely within the same rock units. It is clear that the rocks in these islands have suffered some fault movements as with the other rocks of similar age elsewhere in the Malay Peninsula but the limited evidence from four exposures over a 40 km length of the proposed structure does not warrant the interpretations put forward to date. In any case, the dips of the faults as indicated by structural features present are steeper than the very low angle of the fault plane shown in most tectonic sections. The inconsistent dip directions of the fault plane cannot be so easily explained by inversion due to the granite intrusion as one would expect, in this case, the same inversion in dips of the beds adjacent to the fault plane. No marked change of dips or strikes in these beds have been noted. Minor folds such as

those described near the proposed fault zone are present over almost the entire outcrop of Lower Paleozoic rocks but they are only well displayed in outcrops near the sea where the weathering action of the sea has accentuated the differences in colour of the different layers in the seemingly massive limestone.

The geology of the Langkawi islands has probably been more intensely studied than other parts of Malaysia. However, in spite of the considerable work that has been done, a number of problems regarding the structural and stratigraphic history of this area have yet to be satisfactorily explained. The nature, geometry and the timing of the deformational events and the correlation and ages of the different rock units are important considerations for any structural interpretations. The well publicised controversy regarding the existence of a Lower Palaeozoic folding phase illustrates the difficulty of reconciling the available structural and stratigraphic evidence. On structural grounds, it is clear from the differences in folding styles that a major tectonic event occurs within the time span of the succession exposed in these islands. However, the presence of an unconformity in the Devonian separating the Setul Formation from the Singa Formation has been disputed on stratigraphic and paleontological grounds. If it is true that the Devonian succession is continuous, then the question remains as to the timing of this tectonic event. Could this unconformity be within the rocks presently mapped as the Singa Formation ranging in age from the uppermost Devonian to Lower Permian or as Tuah (1973) and Yancey (1975) suggested, after reassigning part of the previously mapped Setul Formation to the Singa Formation, be post Early Permian? In any case, no evidence for a Carboniferous or Permian unconformity has been put forward and the very limited occurrences of fossiliferous horizons and limited knowledge of the geology makes it difficult to correlate the often widely scattered rock exposures with certainty. Until these stratigraphic and structural problems can be resolved, the nature of the contact on the eastern part of the Langkawi islands along which the proposed Kisap fault trace was drawn must remain highly speculative. Even if it is a faulted contact, it could be along normal or high angle reverse faults.

One of the purposes of writing this paper is to show the highly speculative basis for the interpretation of a widely accepted geological feature, the Kisap thrust. Interpretations of other Malaysian structures especially the very large structures, are sometimes even more speculative and the uncritical acceptance of such interpretations can lead to the propagation of tectonic models which bear very little resemblance to the actual geology.

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