NONE OF THE MODELS FOR SOUTHEAST ASIAN CAINOZOIC FAULTING AND SUBSIDENCE IS SATISFACTORY

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Regional Compression Hypothesis

Wood (1985) related the Cainozoic fault and basin pattern to E-W compression. However Mohr-Coulomb theory does not apply in a direct way to the faulting of anisotropic and pre-fractured rocks because planar weaknesses, oriented at angles as high as 65° to σ_1, can be re-activated at relatively low critical stress levels. Therefore "it is unlikely that principal stress orientations responsible for the faulting can be deduced from the geometric facts available" - G.H. Davis (1984).

The flaws in the analysis of Wood (1985) are: a) No recognition was given to regional basement anisotropy, b) No change in stress pattern with time was entertained, c) His map is interpretative, and his fault extrapolations cannot be substantiated, d) There seems to be little case for a major Cainozoic E-W directed σ_1.

Escape Tectonics Hypothesis

The innovative plasticene experiment of Tapponier *et al.* (1982) gave new direction to analysis of the Eocene and younger tectonics. The primary motivator is no longer regional compression (σ_1), but wrench faults propagated through the region from the Yunnan Syntaxis. The strain ellipsoid can be used to analyse the relationship between the wrench faults, and induced extension and compression patterns localized above and contiguous with the faults.

Pre-existing suture zones and narrow deformed fold belts should be the first to suffer wrench tectonics. The notable examples, which by fortuitous (?) accident lay in the orientation required for extrusion tectonics, are the E-W Quinlin and the NW-SE Red River-Song Ma. Both were active in the Paleozoic and Mesozoic, and presently are earthquake zones.

Wrench motion can be documented on the Bentong-Raub and Nan-Uttaradit-Luang Prabang to Dien Bien Phu sutures. However they are not now seismically active. N-S right-lateral wrench motion in the Central Belt of Peninsular Malaysia is held responsible for *en-echelon* folding of the predominantly Jurassic Tembeling Formation. In the Eastern Block, which is devoid of wrench faults, the Jurassic-Cretaceous formations are not folded, but have been differentially uplifted and tilted along the margins of the Malay Basin.

Early rifting of the Penyu Basin is documented by Albian (110 Ma) basaltic dykes at Kuantan. However, like most pre-existing zones of weakness, it was probably re-activated in the Cainozoic.

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The N-S trending morphology of the Gulf of Thailand is controlled by Paleozoic and Mesozoic structures in Malaysia and Thailand. The E-W opening of Cainozoic basins in the Gulf and in North Thailand may have resulted from Cainozoic strike stip motion on the NW-SE Mae Ping and Three Pagodas Pass faults. The N-S striking elements are of older ancestry.

The Sibu Zone (Lupar and Mersing lines) continues towards the Natuna Arch as a Late Cretaceous through late Eocene active plate margin. Its accompanying volcano-plutonic arc should extend from the Schwaner Mountains towards the southern part of the Malay Basin. The Ketungau and Melawi fore-arc basins are related to this plate margin.

Essential towards an understanding of the fault systems and basins of Southeast Asia is a regional basement map, so that a **distinction** can be made between **older structures,** which may or may not have been re-activated, and the completely **new features imposed by Cainozoic escape tectonics.**

Triple Junction Rifting Hypothesis

The fractures and crustal attenuation patterns may have resulted from a high regional heat flux from the mantle, with little help from escape or compression tectonics. The S.E. Asian region seems to have been a very large mantle hot spot since the Late Mesozoic, resulting in triple junction rifting. There is one outstanding triple junction, which was active from the Palaeocene through the Miocene. The three arms are:

1. The Red River-Gulf of Bacbo (Tonkin); 2. The N.E. trend from south Hainan towards Taiwan; and 3. The N-S faulted margin of Vietnam. One arm of a triple junction will invariably be defined by a pre-existing zone of weakness (arm 1). The other two are new directions. Arm 2 caused the rifting of the Chinese continental shelf, and eventually developed sea-floor spreading as the South China Sea Basin. Arm 3 became a major strike slip fault, responsible for removing part of the Precambrian Kontum Massif to an unknown destination (West Borneo ?).

Complications From Plate Rotations

Other possible triple junctions have been so modified by plate rotations as to be difficult to decipher. The plate rotations are real. Schmidtke *et al.* (in press) proved that the whole of West Borneo has progressively rotated anti-clockwise, by 90° since Mid Cretaceous and by 45° since Eocene. There is support for an anti-clockwise rotation of S.E. Peninsular Malaysia. What drives this rotation is uncertain, but we also do not know what drives sea-floor spreading and subduction. The anti-clockwise rotation runs totally counter to the escape tectonics hypothesis.

Pessimistic Conclusion

Is there any possibility of evolving a satisfactory hypothesis for S.E. Asian Cainozoic tectonics?. Probably not, for tectonic processes are non-linear and non-linear processes usually defy analysis. No single process is allowed to continue long in S.E. Asia before being modified by other geological events, and plate rotations will result in continuously changing regional and local stress patterns.