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Cathaysia, Gondwanaland, and the Paleotethys in the evolution of continental Southeast Asia

YURI G. GATINSKY[1] AND CHARLES S. HUTCHISON[2]
[1]All-Union Institute of Geology of Foreign Countries, Dimitrova, 7 Moscow, 109180, U.S.S.R.
[2]Department of Geology, University of Malaya, 59100 Kuala Lumpur, Malaysia.

Abstract: Continental Southeast Asia is dominated by Precambrian continental blocks overlain by Late Proterozoic to Paleozoic platform successions, representing Atlantic-type rifted miogeoclinal margins. All the blocks appear to have rifted and drifted from the Australian part of Gondwanaland. The timing and extent of their separation is analysed by the distribution of Permian Cathaysian *Gigantopteris* and Gondwana *Glossopteris* floras, assisted by dated tectono-structural units, paleoclimate indicators, and good quality paleomagnetic data.

Between the blocks lie narrow intensely folded Phanerozoic mobile belts, which developed on the oceanic crust of the Paleotethys ocean, characterized by pelagic-turbidite flysch sequences which shallowed as the oceans narrowed. The narrowing was effected by subduction resulting in island arcs within the oceans, and cordilleran volcano-plutonic arcs along the block margins. Extinction of the basins resulted in collision zones containing S-type granites and suture zones containing dismembered ophiolites. Post-consolidation plate readjustments resulted in wrench and rift faulting in several places while convergence continued elsewhere.

The tectonic analysis has been carried out by recognizing tectonic elements (structural-formational units) for selected Phanerozoic time frames. We also present a Phanerozoic sequence of palinspatic reconstructions for the rifting and drifting of the blocks from northern Australia. These are consistent with the known ages and distributions of the tectono-structural units and the good quality paleomagnetic data. We also present an analysis of the first-order relationship between the distribution of mineral deposits and the igneous events which resulted from tectonic reactions between the Precambrian blocks and the mobile belts.

INTRODUCTION

Many attempts have been made to analyse the tectonic evolution of Southeast Asia. The following are considered to be the most significant: Hutchison (1973), Stauffer (1974), Acharyya (1978), Gatinsky *et al.* (1978), Bunopas (1981), Gatinsky (1981), Mitchell (1981), Audley-Charles (1983), Stauffer (1983) and Gatinsky *et al.* (1984). Throughout this series of papers, there has developed a growing awareness that Southeast Asia is composed of a number of rigid Precambrian continental blocks separated by highly deformed mobile belts. There is also a general consensus that all the continental blocks have rifted and drifted from the northern margins of Gondwanaland. Audley-Charles (1983) takes the extreme view that they have rifted in the Jurassic, wheras Gatinsky *et al.* (1984) argue for Paleozoic rifting and a building up of the East Asian and later the Eurasian Continent throughout Paleozoic to Earliest Mesozoic times. To resolve such discrepencies of interpretation, a pragmatic approach is necessary in the recognition of the tectonic elements and their ages of formation.

THE METHOD OF ANALYSIS

We have constructed a series of maps of Southeast Asia for different time intervals throughout the Phanerozoic, beginning with the Silurian. They show the present-day geographical distribution of rock formations and structural data which are critical for locating the various tectonic elements of that chosen time interval. The time intervals are somewhat arbitrary but have been chosen because they display important features and significant changes. We have called these structural-formational maps (e.g. see Fig. 1).

The formations, rock sequences or assemblages, which have been identified on the maps are tabulated in Table 1. From the geographical distribution of these, we can then deduce the positions of the structural-formational complexes, or tectonic elements. They are identified on Table 1, and shown on the maps (e.g. Fig. 1) as letter symbols. Letters A through D represent the transition from continent across the shelf to the ocean in an Atlantic-type miogeoclinal margin. Basins (categories G and H) complicate the picture and need to be recognized. Plate margins may then be drawn on the maps along the lines of bilateral symmetry, which could not otherwise be accounted for. Convergent margins are indicated by subduction complexes and associated volcano-plutonic arcs, which may be radiometrically dated. Dates are also shown on the maps, together with an indication whether they represent an igneous event, or a tectonic or thermal re-setting. The end product of subduction is a collision belt caused by the welding together of continental blocks along a suture zone. Such an event results in a linear fold-belt and the production of potassic "S-type' granite batholiths. Associated with collisions are depressions such as foredeeps and intermontaine troughs, which can receive great thicknesses of marine and continental sediments.

Extensional tectonics of the continental crust can be recognized in two phases: firstly the thermal reworking and uplift stage, identified by basaltic volcanism, subalkaline granites, and other features such as listed in Table 1. The second stage is the development of a continental rift in which continental and later marine strata accumulate. This stage is also accompanied by alkaline volcanism.

THE SOURCE OF INFORMATION

We have drawn on a literature too extensive to enumerate here, but regional and country reviews have provided an important source of our information. Our interpretations are also based on first-hand knowledge of certain regions of Indonesia, Malaysia, Philippines, Thailand, Laos, Vietnam, and South China.

Unfortunately many literature descriptions give no indications of conditions of sedimentation, and many contain misleading information. There is confusion over the usage of terms such as flysch and molasse. Some flysch deposits are turbidites, but many are shallow water sandstone-shale sequences which include coal beds. It is dangerous to over interpret the term flysch from the older literature. Thus, Mitchell (1984) has interpreted the Triassic flysch of Burma and Tibet as resulting from turbidite sedimentation along the continental slope of Asia, whereas S.K. Acharyya and J. Stöcklin (personal comm,) believe that the Triassic flysch should not be interpreted as turbidite deposits unless modern sedimentological studies have shown this to be the case. Molasse is another interpretative term open to abuse.

TABLE 1
ROCK ASSEMBLAGES AND THEIR TECTONIC SETTINGS
FORMATION, SEQUENCE, OR ASSEMBLAGE

Structural formational complex in which it may occur

	A	B	C	D	F	T	G	H	S	J	K	L	M	P	R
continental redbeds	X				X							X	X		X
continental grey deposits	X				X			X				X	X		X
clastic continental and littoral	X				X						X	X	X		X
continental bauxite weathering	X													X	X
neritic marine < 50% carbonate	X	X			X			X							X
neritic marine > 50% carbonate	X	X													
reef limestone		X								X					X
pelagic limestone			X	X											
siliciclastic and carbonate flyschoid			X	X			X								
deep water turbidite flysch			X			X	X								X
flysch with chert				X											
deep water euxinic mud				X			X								X
deep water mudstone and chert				X			X								
pyroclastic strata with acid tuffs											X				
calc-alkaline volcanics, mainly acid											X		X		
calc-alkaline volcanics, mainly intermediate										X	X				
sub-alkaline volcanics, acid-intermediate														X	
trap, tholeiitic basalt & diabase														X	
low potassium tholeiitic basalt				X			X			X					
alkaline & subalkaline olivine basalt														X	X
shoshonite (potassic) basalt															X
bimodal volcanic association															X
potassic (S) granite (with Li & F)											X	X			
subalkaline granitoid														X	
K-Na granite-granodiorite											X				
Na-gabbro-granodiorite-plagiogranite							X		X	X					
monzonite-diorite														X	
K-Na alkaline intrusives														X	
potassic intrusives														X	
differentiated mafic-ultramafic intrusives														X	X
gabbro-amphibolite (ophiolite)							X		X			X			
alpine-type ultramafites							X		X			X			
sedimentary melange			X		X	X									X
tectonic melange									X			X			
salt deposits	X														
linear folding												X			

X = occurs in this tectonic setting.
A = inner epicontinental basin
B = continental shelf of platform
C = continental slope and rise, with contourite deposits
D = oceanic basin, with turbidite fan
F = continental foredeep
T = oceanic trench
G = basins on oceanic or intermediate crust (marginal; fore-arc)
H = basins on continental crust (back-arc)
S = subduction complex or accretionary wedge
J = ensimatic volcano-plutonic island arc
K = ensialic volcano-plutonic cordilleran arc
L = collision orogenic zone
M = orgenic intermontaine trough
P = zone of pre-rift thermal working of continental crust
R = continental rifting.

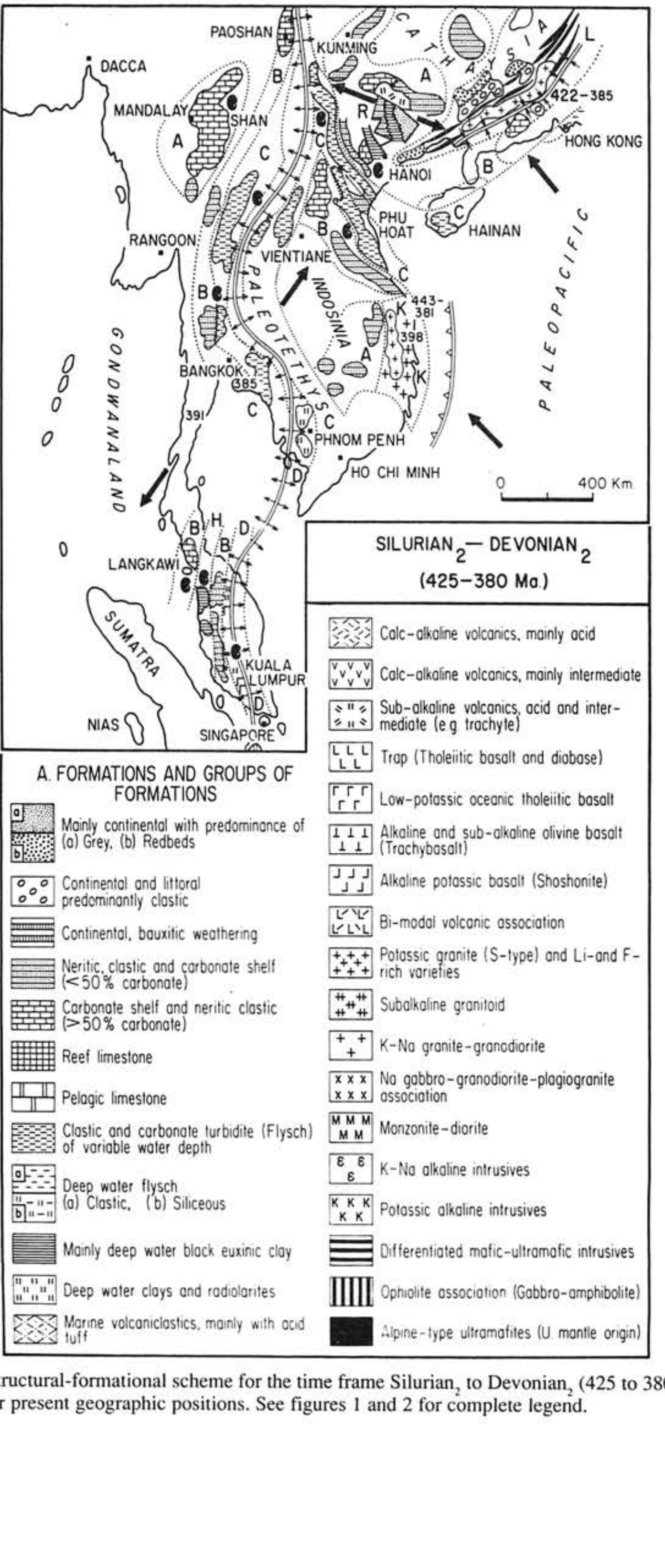

Fig. 1 Structural-formational scheme for the time frame Silurian$_2$ to Devonian$_2$ (425 to 380 Ma) showing the units in their present geographic positions. See figures 1 and 2 for complete legend.

Thus, Helmcke and Lindenberg (1983) have used it for what we believe to be miogeoclinal shelf successions in Thailand, thereby adding to the confusion that these terms have caused in the literature.

In addition to the older literature, and more recent publications on detailed areas, the following are the most important general references upon which we have based our interpretations: *Regional stratigraphy and tectonics*: Ray (1982), Hutchison (1982), Hutchison (in press), Gatinsky (in press): *Regional Paleontology*: Kobayashi *et al.* (1984); *Burma*: Bender (1983); *Thailand*: Bunopas (1981), Prinya Nutalya (1983); *South China and Tibet:* Chang and Pan (1984), Xiao and Gao (1984), Huang (1984); *Malaysia*: Gobbett and Hutchison (1973), Hutchison (in press), Haile (1974), Prinya Nutalaya (1983); *Indonesia*: Hamilton (1979), Hayes (1980, 1983); *Philippines*: Hayes (1980, 1983), Bureau of Mines (1981); *Indochina*: Fontaine and Workman (1978), Gatinsky (in press), Tri (1979), Trung *et al.* (1979).

CONTINENTAL BLOCKS OF CATHAYSIAN AFFINITY

The structural-formational maps for the Paleozoic (Figs. 1, 2, and 3) demonstrate the existence of a plate boundary extending southwards from China through Thailand and the Malay Peninsula, along sutures that Hutchison (1975) has named the Uttaradit-Luang Prabang and Bentong-Raub Lines. From the symmetry of facies distributions of Figures 1, 2, and 3, we conclude that this plate boundary was of major importance and represents all that is left of the Paleotethys Ocean. To the east of this lie the continental blocks of the West Borneo Basement, Eastern Malaya, Indosinia, and Cathaysia. The last two are sutured along the Song-Ma Line, which represents the Early Paleozoic Laos-Vietnam branch of the Paleotethys, which contains the Phu Hoat Precambrian microcontinent (Tri, 1979).

Although Indosinia and Eastern Malaya have been named separately, they are indeed the same continental terrain which continues beneath the Gulf of Thailand and the South China Sea, only slightly separated by Albian to Oligocene extensional tectonics in the back-arc-shear Malay Basin.

All terrains lying east of the Bentong-Raub and Uttaradit-Luang Prabang Lines were predominantly landmasses during the Permian, on which flourished Lower and Upper Permian *Gigantopteris* Cathaysian flora (Asama, 1984). Such a flora is thought to have evolved in equatorial latitudes, and McElhinny *et al.* (1981) have confirmed this by paleomagnetic data on the Permian O'Mei basalt of the western Yangtze Platform. In addition to the type localities on the Yangtze Platform, Cathaysian *Gigantopteris* flora has been confirmed in Indosinia (Fontaine and Workman, 1978), northern Thailand east of the Uttaradit-Luang Prabang Line, and Eastern Malaya (Asama, 1984), and in the Qantang-Tangula block of Tibet north of the Pangong-Nu Jiang Suture (Chang and Pan, 1984).

It seems appropriate to include the West Borneo Basement (Haile, 1974) within the Cathaysian realm, but no diagnostic Permian flora have been found. Sumatra presents an unresolved problem. *Gigantopteris* flora at Djambi in south Sumatra (Asama, 1984) indicates a Cathaysian attachment or proximity, but Carboniferous pebbly mudstones and Triassic formations indicate a strong similarity with the Phuket, Langkawi, Kedah areas of the western part of the Malay Peninsula (Cameron *et al.*, 1980). This problem may be resolved when more geological work has been done on central and south Sumatra, and this large island may turn out to be a composite of both Cathaysian and Gondwana parts.

THE EAST ASIAN CONTINENT

From Devonian to Early Carboniferous time, subduction of the lithosphere of the Laos-Vietnam branch of the Paleotethys beneath the Trungson and Phu Hoat areas resulted in narrowing of the ocean and an active volcano-plutonic arc (Fig. 2). The sequence portrayed in Figures 1 through 3 is illustrated by schematic plate tectonic cross sections in Figure 4, in which we can see the narrowing of this branch of the Paleotethys, and its final extinction in Mid Carboniferous times resulting in the Trungson foldbelt and Song-Ma Suture. Thus Indosinia and the Yangtze Platform coalesced to form the large East Asian Continent, which occupied equatorial latitudes in Permian times, and throughout which Cathaysian flora flourished.

A recent discovery of Devonian redbeds overlying the Trungson foldbelt may indicate that the suturing of Indosinia onto Cathaysia was a Late Caledonian event, related to the Caledonian foldbelt of southeast China. Detailed work will be necessary to refine the scenario, perhaps leading to a revision of the schemes of Figures 2, 3, and 4.

The Yangtze Platform may have been attached to northwest Australia during Cambrian time, as shown by paleomagnetic data (Lin *et al.*, 1983). The distinction between blocks of Cathaysian and Gondwana floral affinity therefore rests in the timing of their separation from Gondwanaland. Those that developed Cathaysian flora were separated by Permian times, and those that developed Gondwana flora still lay close to Gondwanaland in Permian times. The alternative hypothesis of Audley-Charles is flawed by his neglect of the Yangtze Platform and its Permian equatorial paleomagnetic position. We find it impossible to accept that our East Asian Continent had any attachment with Gondwanaland in Mid Carboniferous times.

CONTINENTAL BLOCKS OF GONDWANA AFFINITY

A. Sinoburmalaya

A narrow elongate continental block of unified Paleozoic predominantly shelf or platform stratigraphy extends southwards from S.W. China, through the Shan States of Burma, western Thailand, and into the western Malay Peninsula. Its Precambrian basement is exposed in the Shan States. A similar Carboniferous through Triassic stratigraphy in northern Sumatra (Cameron *et al.*, 1980) also requires that at least the northern part of Sumatra belongs to this block, which we herein call Sinoburmalaya. It has been called other names such as Shan-Thai (Bunopas and Vella, 1983), Sinoburmania (Gatinsky *et al.*, 1984), Main Range-Tenasserim-Shan (Hutchison, 1982), and Sibumasu (Metcalfe, 1984). Its eastern boundaries are defined by the Uttaradit-Luang Prabang and the Bentong-Raub Lines and its western margins lie close to the extensive outcrops of the Phuket Group of Thailand and its Malaysian equivalent the Singa Formation and the Sumatran equivalent the Bohorok Formation.

We interpret the pebbly mudstones of the Carbo-Permian Phukket-Singa-Bohorok Formations as marine tilloids shed off glaciated Gondwanaland into a rift system which developed along its miogeoclinal margin (Figs. 2, 4, 5). This interpretation is consistent with the descriptions of Stauffer and Mantajit (1981) and the paleomagnetic data of Bunopas

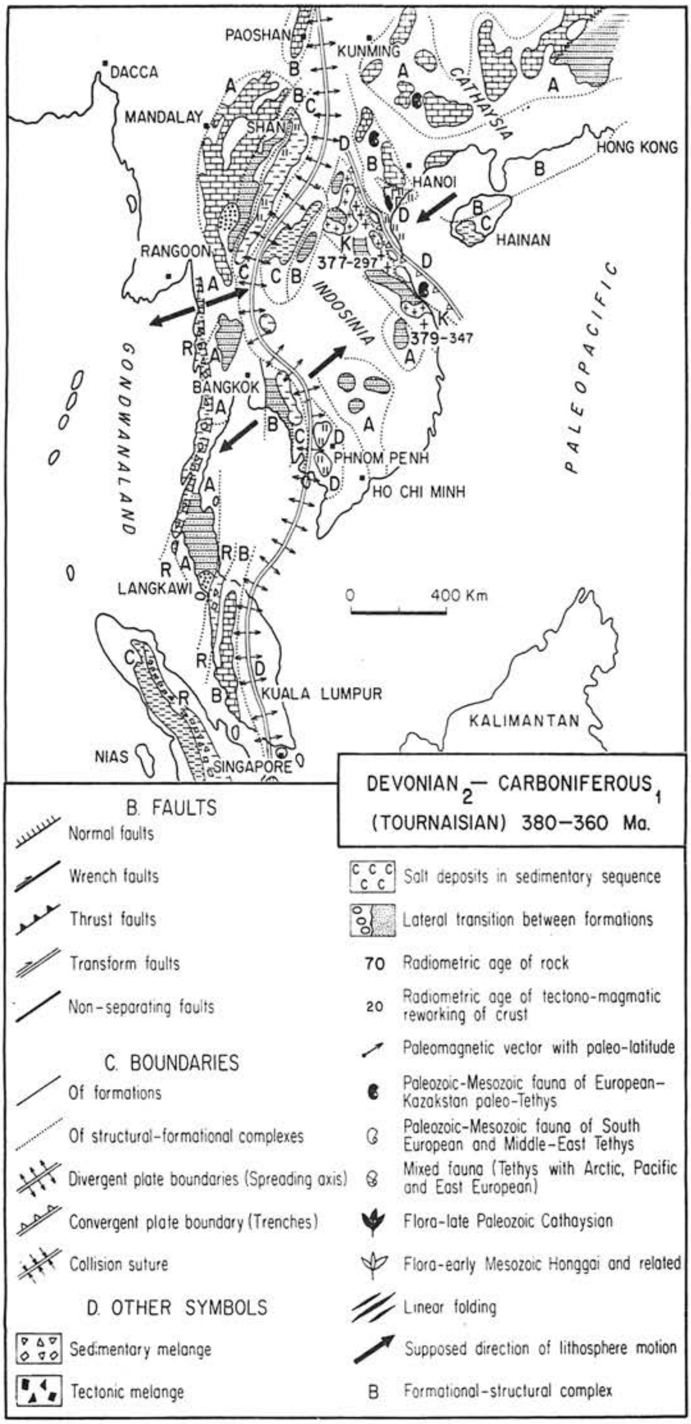

Fig. 2 Structural-formational scheme for the time frame Devonian$_2$ to Carboniferous$_1$ (Tournaisian) (380 to 360 Ma) showing the units in their present geographic positions. See figures 1 and 2 for complete legend.

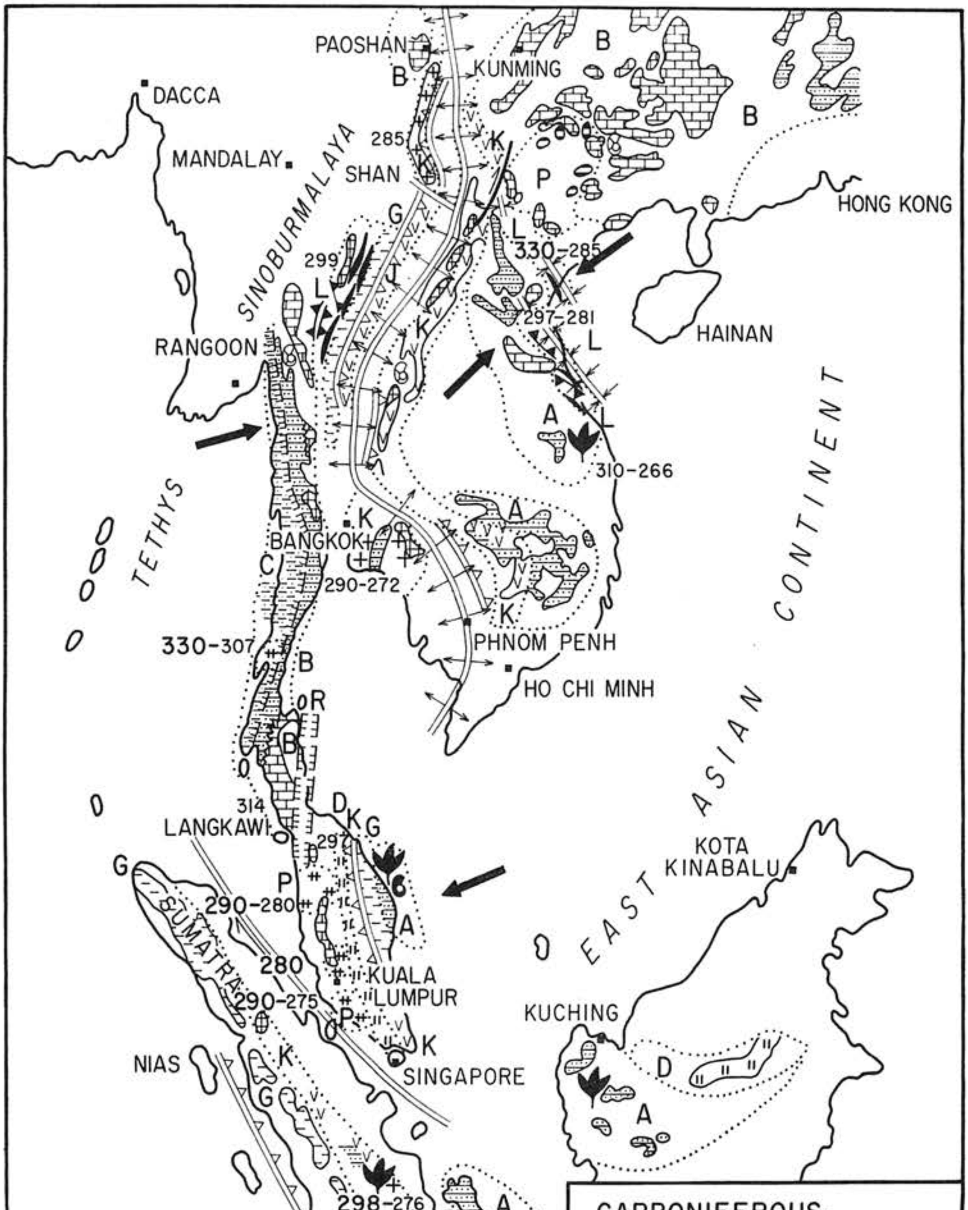

Fig. 3 Structural-formational scheme for the time frame Carboniferous$_1$ (Viséan) to Permian (340 to 265 Ma) showing the units in their present geographic positions. See figures 1 and 2 for the complete legend.

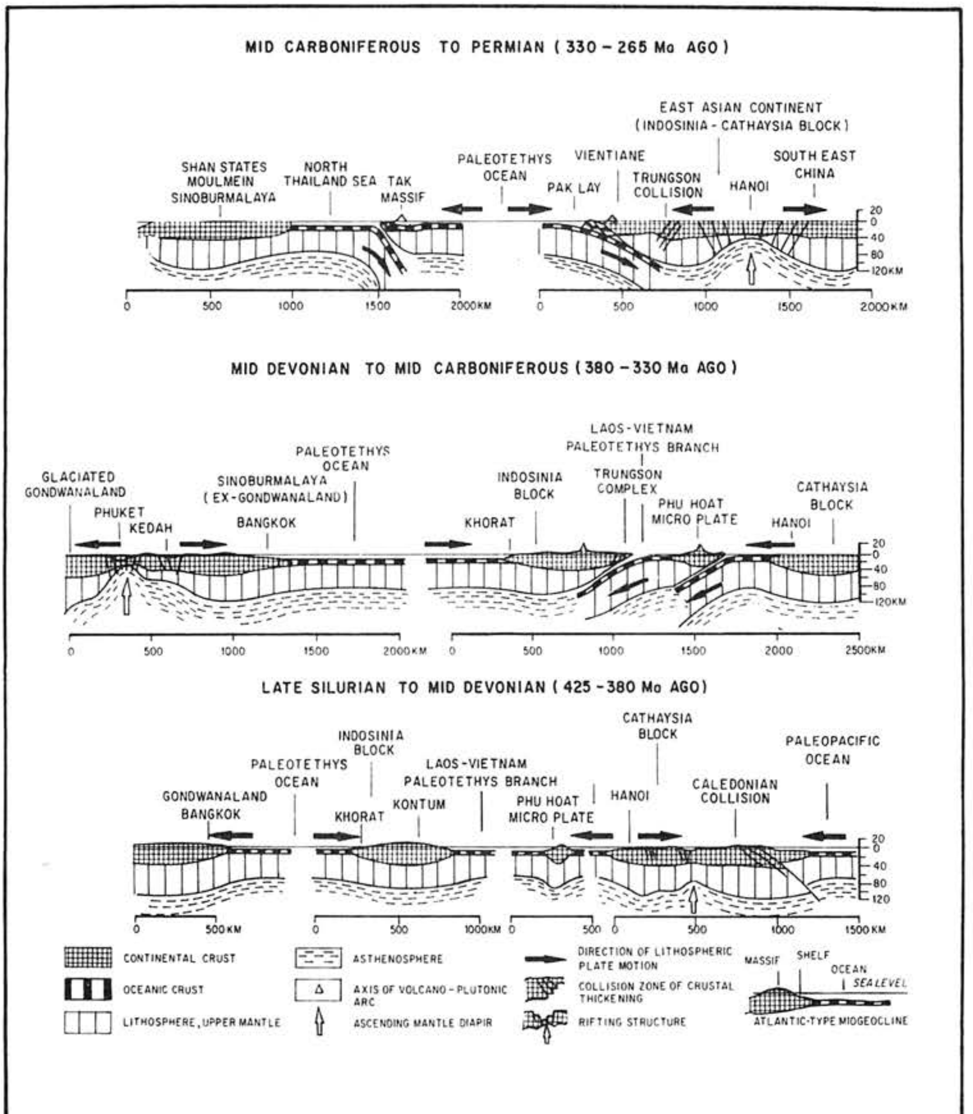

Fig. 4 Schematic plate-tectonic cross sections from Phuket to southeast China for the periods Silurian to Permian.

(1981). The interpretation is strongly supported by the paleontological data of Burrett and Stait (1984) and Waterhouse (1982) and the carbonate petrology of Rao (1984).

The Lower Paleozoic fossils of the Malay Peninsula are closely similar to those of the basins of N.W. Australia. The pebbly mudstones are associated with Early Permian cool water fauna. Permian limestones of the Malay Peninsula formed in cool waters, but Triassic limestones formed in tropical waters. These data support a Mid-Carboniferous rifting of

Sinoburmalaya from Australia (Figs. 2, 4, 5) and its northwards drift towards the East Asian Continent by Middle-Late Triassic (up to Carnian) times. Its collision with the East Asian Continent to form the Eurasian Plate (Fig. 5) is now precisely dated by Liew (1983) at 200 to 220 Ma for the Main Range S-type orogenic batholith. This Rhaetic-Liassic age is consistent with the rapid extinction of marine conditions over the new larger Eurasian Continent, upon which Jurassic-Cretaceous continental deposits are of wide occurrence.

B. Burma Plate

This is a separate block, named by Mitchell (1981) the Western Burma Block. Its eastern margin is defined by the major strike-slip Sagaing-Namyin Fault system, along which the Burma Plate has moved about 450 km northwards. There is also a line of serpentinites and pre-Eocene basalts, which Hutchison (1975) has called the Mandalay Line. The western margin is well defined as the Indo-Burman Ranges, a subduction complex which is a northwards continuation of the Nias-Mentawai system of western Sumatra.

The basement of the Burma Plate is not exposed, and the surface geology is predominantly of Tertiary sediments carried southwards by the proto Irrawaddy River. The stability of the Tertiary basins necessitates a continental infrastructure. A north-south medial volcanic arc bisects the basins, resulting from eastwards subduction of Indian Ocean lithosphere from a trench located in the Indo-Burman Ranges. This Plio-Pleistocene arc is composed of ignimbrite, latite, rhyodacite and high-potassium basalt (Stephenson and Marshall, 1984), demonstrating that the arc is built upon a continental basement.

Mitchell (1981) proposed that the Burma Plate collided with Sinoburmalaya in Jurassic times. In our palinspastic reconstructions (Figs. 7, 8, 9) we have shown it as a detached part of Sinoburmalaya, which later collided with its ancestor.

C. The Qantang-Tangla Block

This block of northern Tibet is outlined along its northern margin by the Litian-Jinsha Jiang suture zone and along its southern margin by the Pangong-Nu Jiang suture (Chang and Pan, 1984). The region north of the Litian-Jinsha Jiang suture is of Cathaysian floral affinity and belongs to the East Asian Continent (Xiao and Gao, 1984). By contrast, the blocks south of the Litian-Jinsha Jiang suture are all of Gondwana affinity. They contain distinct cold water faunas of Late Carboniferous to Early Permian age, and in addition they contain Carbo-Permian glacio-marine deposits, comparable to those bordering-Sinoburmalaya on its west.

The Qantang-Tangla block collided with the East Asian Continent in Late Triassic-Early Jurrasic times (Fig. 8). It is therefore possible to interpret this block as once an integral part of Sinoburmalaya. The continuity has been disrupted by the subsequent collisions of other Gondwana blocks behind it.

D. The Lhasa-Gandise Block

This block of Gondwana affinity extends southwards from the Pangong-Nu Jiang to the Yarlung-Zangbo suture in the south. The Lhasa-Gandise block was an integral part of Gondwanaland and is characterized by platform-type Paleozoic successions (Chang and Pan,

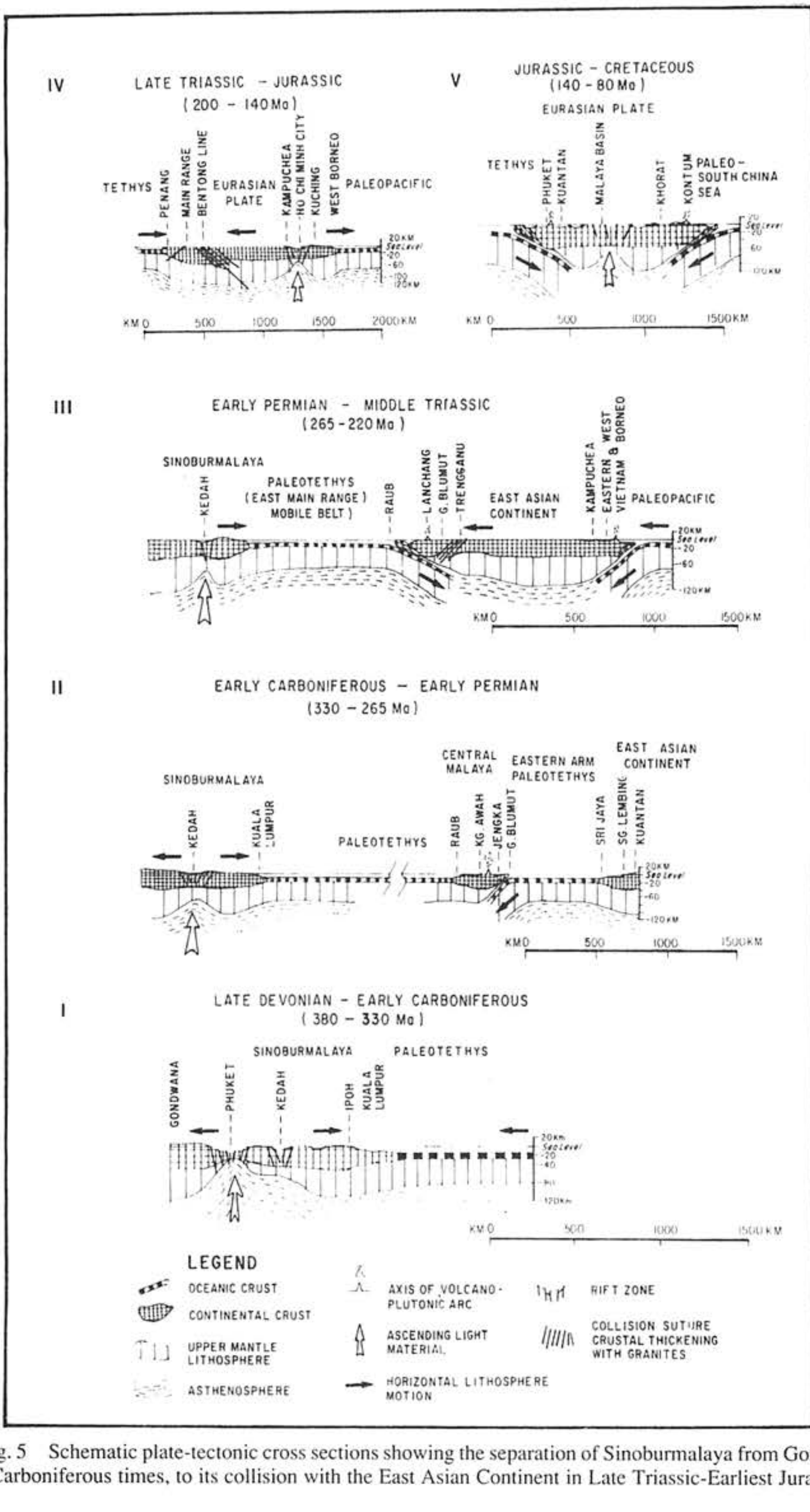

Fig. 5 Schematic plate-tectonic cross sections showing the separation of Sinoburmalaya from Gondwanaland in Carboniferous times, to its collision with the East Asian Continent in Late Triassic-Earliest Jurassic.

1984). Collision with the Qantang-Tangla block may be dated as Middle Cretaceous (Huang, 1984).

E. The Himalaya

The Himalayan Province is bordered on the north by the Indus-Yarlung-Zangbo suture, and on the south by the Main Boundary Thrust (Valdiya, 1984).

The Himalayan Province is split by intracrustal boundary thrusts into 3 subprovinces, from north to south: the Tethys Himalaya or Tibetan Zone, the Great Himalaya, and the Lesser Himalaya. The Tibetan Zone extends north from the Great Himalaya to.the Indus-Yarlung-Zangbo Suture. It is formed of a miogeoclinal sequence of over 10 km thickness ranging from Cambrian to Cretaceous and containing *Glossopteris* flora and glacial deposits of Carbo-Permian age (Stocklin, 1980), proving its Gondwana ancestry.

The Main Central Thrust between the Great and Lesser Himalayas is inclined 30 to 45° northwards and has uplifted by about 20 km the high grade Precambrian metamorphic basement. It served in Middle Miocene time as the plane of underthrusting of the Indian Plate (including the Lesser Himalayan Platform). The seismic slip along the Main Central Thrust is about 0.05 cm per year. Parts of the basement, containing 1800 Ma old granites, are thrust southwards over Paleozoic platform sediments of the Lesser Himalaya to form crystalline nappes and klippen (Valdiya, 1984).

The Himalaya may be considered as originally the miogeoclinal shelf forming the leading edge of continental India, which began subducting northwards beneath the Lhasa-Gandise block at the Indus-Yarlung-Zangbo suture in Early Eocene times. Underthrusting jumped progressively southwards to the Main Central Thrust, and later to the Main Boundary Fault, allowing the sections between the suture and the Main Boundary Fault to be overthrust upwards and southwards.

F. Indian-Shillong Platform

The Indian shield extends southwards from the Main Boundary Fault Zone. Down-dragging of the shield beneath the Himalaya led to the formation of the Cenozoic Siwalik foredeep. It appears likely that the Late Proterozoic Shillong Block has become detached from the Archean Indian shield along the Dauki Fault.

SUMMARY TECTONIC MAP

From our series of structural-formational maps, only the first three are shown here because of lack of space (Figs. 1, 2, 3). We have compiled from the complete set a summary tectonic map (Figure 6). The ornamentation has been designed to accentuate the difference between the continental blocks and the intervening mobile belts. The Precambrian massifs and platforms continue outwards into Atlantic-type miogeoclinal margins. The blocks of Cathaysian affinity, which formed the Permian equatorial East Asian Continent, are labelled 6, 7, 10, 11 and 12. All the other blocks arrived in the region in Mesozoic or Cenozoic times and they have Gondwana affinities. The blocks are sutured together by narrow highly deformed mobile belts, which always contain melange and ophiolite fragments. These mobile belts are the only remains of the former oceans. Subduction of the oceanic lithosphere beneath the continental block margins is shown by volcano-plutonic arcs. The type of ornamentation (Fig. 6) indicates when these arcs were active.

PALINSPASTIC SCENARIO

In Figures 7, 8, and 9 we show our scenario for the paleogeographic distributions of the continental blocks from the Late Devonian to the present. The continental blocks retain their size, shape and geological record, and may be compared with figure 6 for their present positions. The oceanic record is almost completely destroyed through subduction. The residual record is only the narrow mobile belts and bordering volcano-plutonic arcs (Fig. 6). Our latitudes are constrained by the paleomagnetic data.

However, we have found it necessary to reject the interpretation of McElhinny *et al.* (1974) for the Carbo-Permian position of the Malay Peninsula. We believe that the formations interpreted as Carbo-Permian (Bentong Group and Sempah Conglomerate) are indeed Mid Triassic. Their reported Carbo-Permian position between 10 and 20°N is in fact a Mid Triassic position, which is in agreement with the data of other workers. Some of the paleomagnetic problems are outlined by Bunopas and Vella (1983), and obviously much useful work remains to be done in this field to refine our picture.

In Figure 7 there is a suggestion that the blocks which are destined to form the East Asian Continent may have rifted from Gondwanaland in earliest Paleozoic times, but they all coalesced, or lay close together, in equatorial regions during Permian times.

The blocks of Gondwanaland affinity were rifting off glaciated Gondwanaland during Carboniferous times. Thus they all have a record of cool-water fauna and cold temperate flora as well as glacial deposits.

Figure 8 shows the collision of Sinoburmalaya and the Quantang-Tangla blocks with the East Asian Continent, enlarging the major continent to form the Eurasian Plate.

In Figure 9 we suggest that the West Borneo Basement detached from Indosinia and moved southwards along the straight fault margin of the Vietnamese shelf.

From Neogene to Quaternary it is possible to postulate independent movement of small blocks relative to each other along the S.E. directed older structurally weak zones. These independent motions cause compression ahead, and extension behind the blocks. Thus we find compression in the Indo-Burman Ranges, and extension in the South China Sea.

RELATIONSHIP TO MINERALIZATION

Following the tectonic analysis (Fig. 6) it becomes possible to rationalize the first-order distribution of mineral deposits (Fig. 10). The basis is that certain elements such as tin, tungsten and antimony, have been concentrated in the Precambrian continental crust. They may be mobilized into younger economic concentrations by magmatic-tectonic events which involve the Precambrian continental basement (Hutchison and Chakraborty, 1979). Such elements therefore are concentrated in Malayan-type collision belts characterized by S-type granite (Fig. 10). Localized rift-related igneous events, resulting in sub-alkaline anorogenic

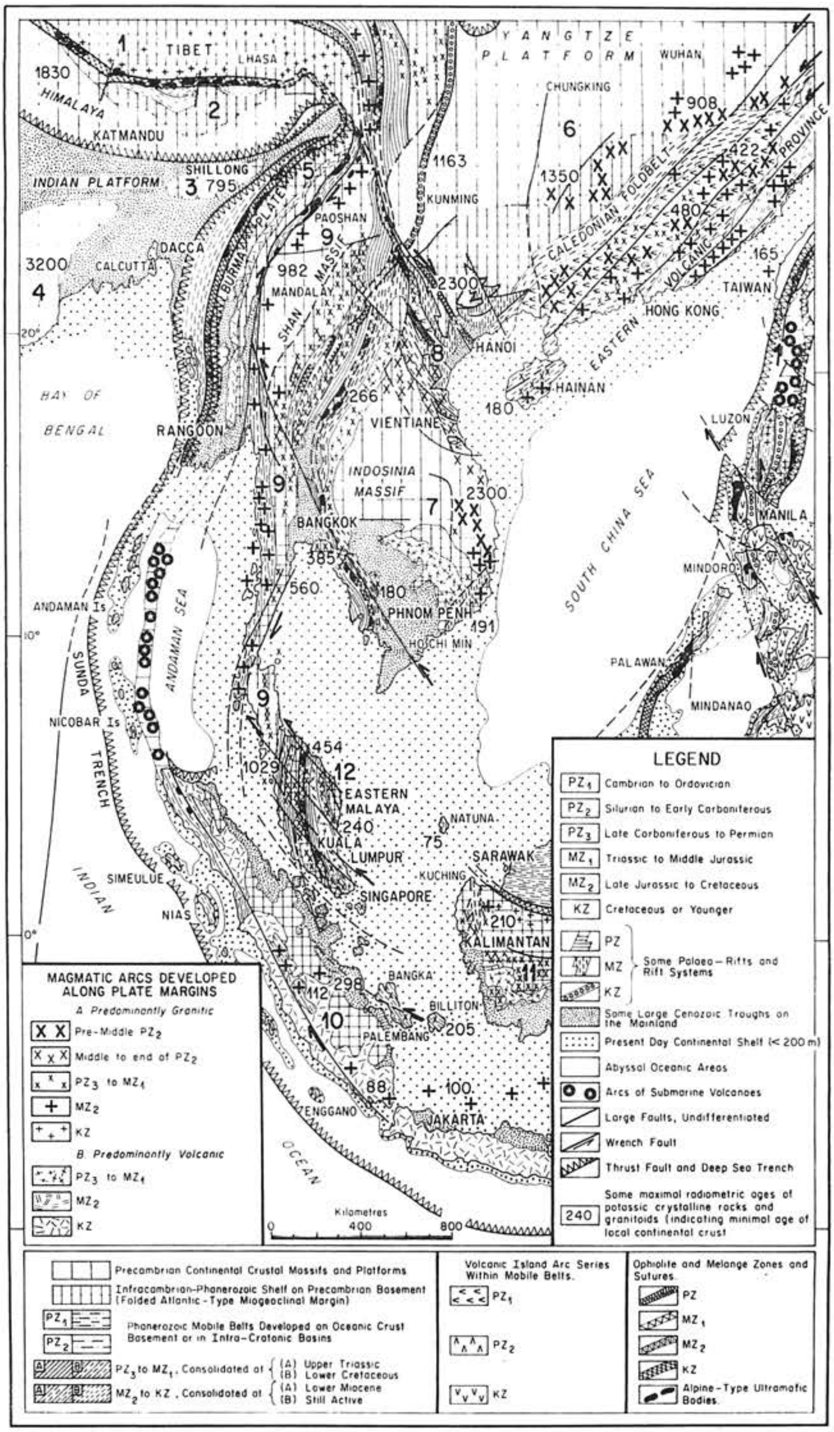

Fig. 6 Tectonic map of Southeast Asia, compiled from the series of structural-formational schemes, the first three of which are shown in figures 1 to 3. 1=Lhasa-Gandise Block; 2=The Himalaya; 3=Shillong Massif; 4=Indian Platform; 5=Burma Plate; 6=Yangtze Platform; 7=Indosinia; 8=Phu Hoat microcontinent; 9=Sinoburmalaya; 10=Sumatra; 11=West Borneo Basement; 12=Eastern Malaya.

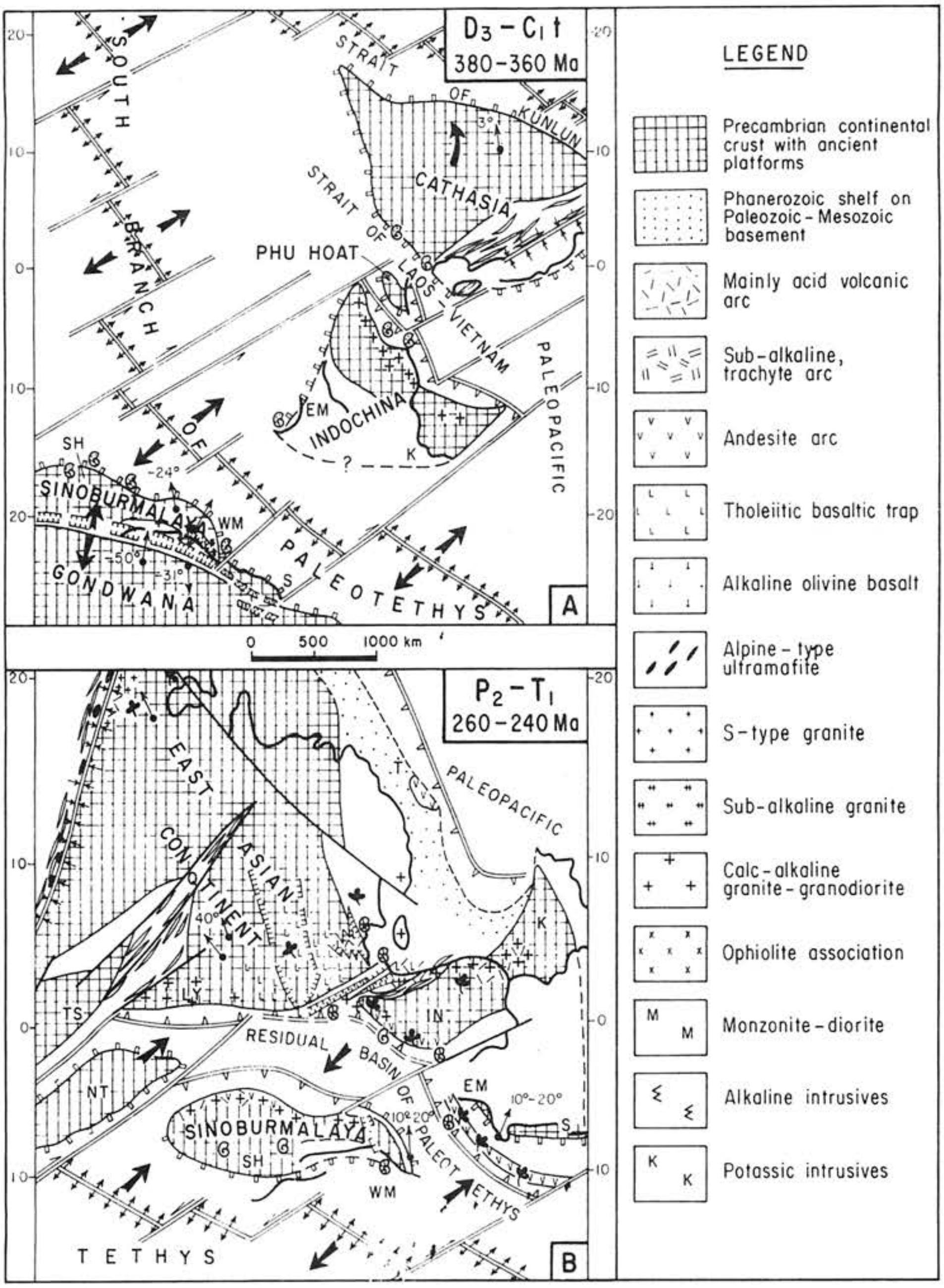

Fig. 7 Palinspastic map of Southeast Asia for the time period from Late Devonian to early Triassic. See figures 7, 8 and 9 for the complete legend.

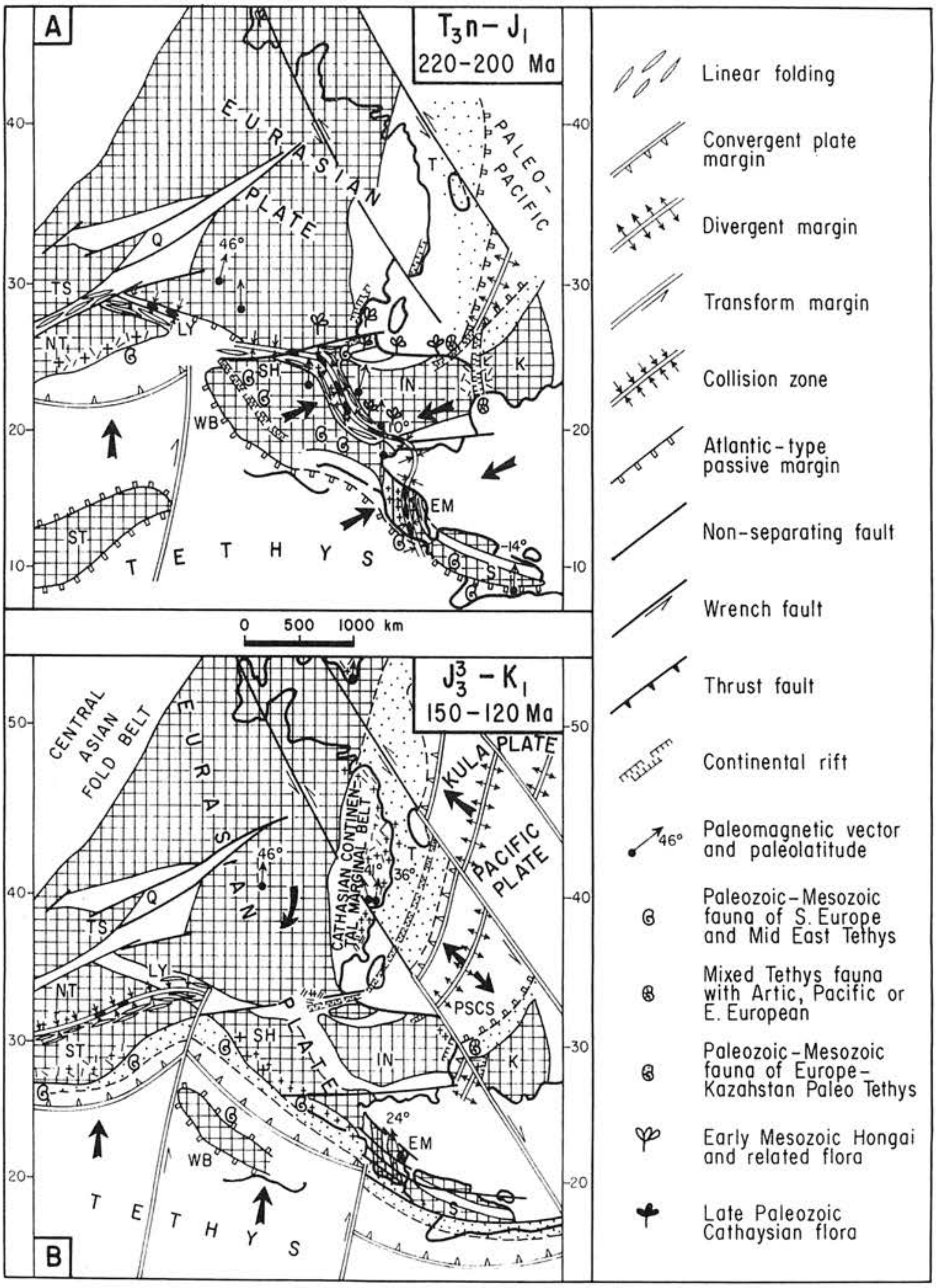

Fig. 8 Palinspastic map of Southeast Asia for the time period from Late Triassic to Early Cretaceous. See figures 7, 8 and 9 for the complete legend.

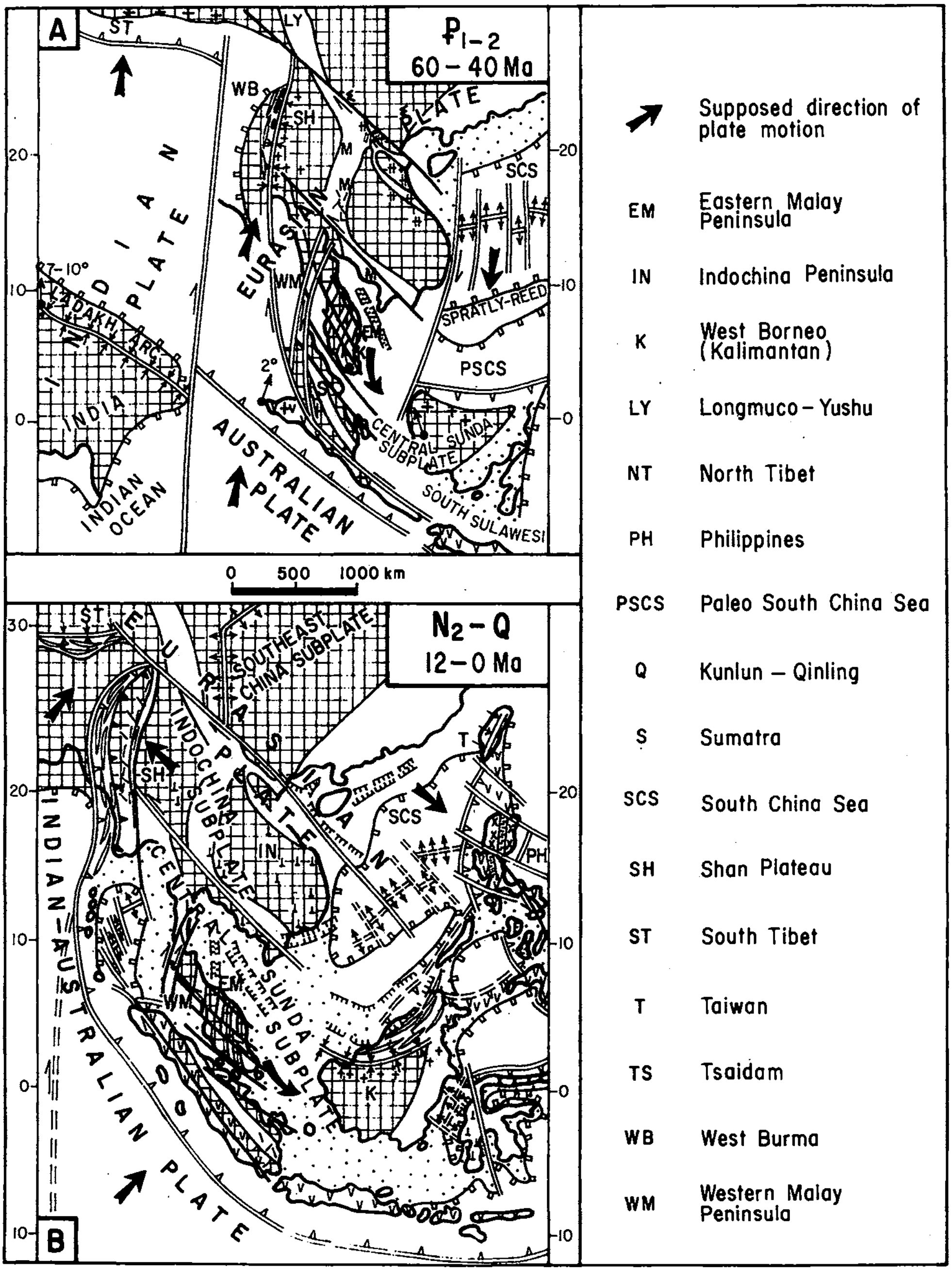

Fig. 9 Palinspastic map of Southeast Asia for the time period from Paleogene to the Present. See figures 7, 8 and 9 for the complete legend.

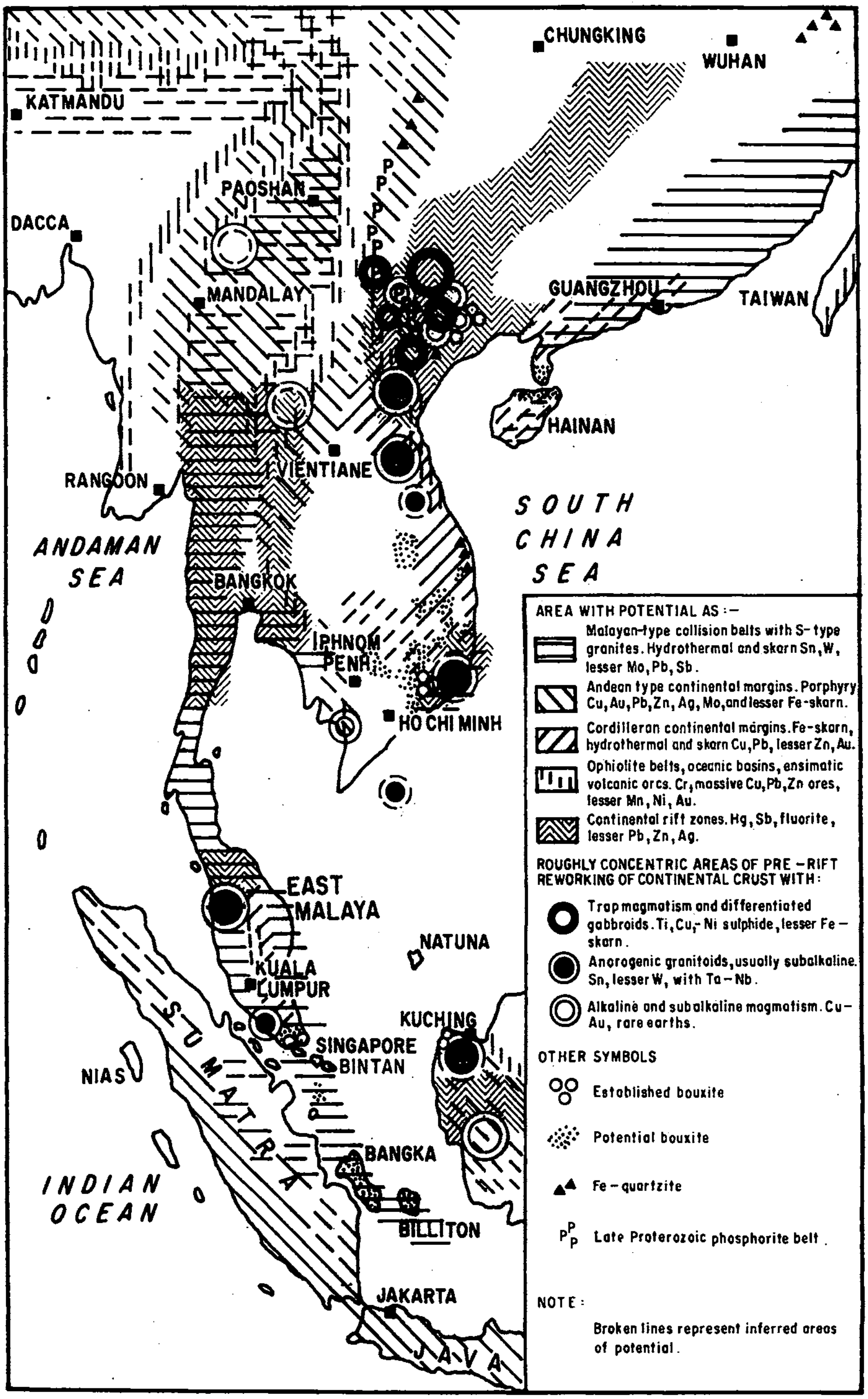

Fig. 10 Tectonic domains in which economic concentrations of elements may have been effected by igneous-tectonic events.

granites, will also cause mobilization from the continental basement, such as at Gejiu in south Yunnan, in north Vietnam, and in Kedah Peak and Bakri in Peninsular Malaysia.

Other elements, notably copper, gold, lead and zinc, may be directly introduced from the mantle in one igneous cycle in a volcano-plutonic arc (Hutchison, 1983).

Extensive areas of Southeast Asia have been affected by Late Mesozoic and Cenozoic continental rifting, which is likely to mobilize mercury, antimony and fluorite. Such mineralizations will be superimposed upon the older orogenic-related mineralizations (Fig. 10).

It is noteworthy that the bauxite deposits and prospects are confined to parts of the Cathaysian East Asian Continent. None is found in the Gondwana blocks. The fact that most of these terrains have been stable landmasses since the Permian, lying close to the equator, must be important in the bauxite genesis. However, the weathering of Cenozoic basalts in southeastern Indochina and in eastern Malaya has also given bauxite.

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