Marine Jurassic Formations and Faunas in Southeast Asia and New Guinea

Contributions to the Geology and Palaeontology of Southeast Asia, CLII

Tadashi SATO

Although they exist in most countries, Jurassic rocks are sparsely distributed and the long-ranging continuous sequence with rich fossil assemblages are known only in a few places in Southeast Asia. As far as the information available to date is concerned, these are composed of sediments of various origin and are classifiable as follows:

1. Geosynclinal thick sequence, developed in Sumatra, Java, Timor and the central ranges of New Guinea. They are composed of predominantly thick pelitic rocks with subordinate volcanics and graywacke sandstones. In some places, these are metamorphosed and generally strongly folded.

2. Marine neritic calcareous facies, known largely in Moluccas, including East Sulawesi, and the Sula, Buru, Ceram and Misol island groups, where rich ammonite, belemnite, and pelecypod faunas are reported from the predominantly calcareous sediments.

3. Marine detritic sediments, scattered on the pre-Jurassic basement in West Thailand-East Burma, West Sarawak, Laos, Cambodia and Viet-Nam, west Philippines and Hong Kong. These are sediments of marine ingression, yielding sporadically molluscs of different ages.

4. Continental red beds, widely developed in Northeast Thailand and Southern Laos. These are called the Khorat group or Indosinias supérieures, and lie unconformably on the kratonic continental fragments. The ages of the beds are somewhat uncertain, in comparison to the marine strata, but plants and fresh water molluscs and other fossils enable us to correlate them with the Upper Triassic to the Cretaceous.

As will be easily realized, the Jurassic beds bear many different tectonic significances. ARKELL (1956) gave a very concise tectonic interpretation, but he devoted his book mainly to the description of the ammonite zonations and chronology. Although the general outlook of the Jurassic in these countries was already known by the 1950's, any precise biostratigraphical synthesis was not attempted. Since the beginning of the 1960's, governmental and university geologists in these countries began to engage in more advanced geological explorations; among them researchers from Japanese universities carried out stratigraphical works in Thailand, Malaysia, the

Philippines and also Borneo. APRSA members also participated largely in field studies, in close cooperation with the geologists of the host countries. Fossil specimens thus collected were partly submitted to Japanese specialists to study.

The Jurassic biostratigraphy, together with the paleontological works on fossils made great progress in less clarified areas since the 1960's. This chapter is devoted mostly to the recent advancement of the modern Jurassic zonal stratigraphy made during the last decade, especially by Japanese geologists.

I. Thailand

The marine Jurassic exposures in Thailand are confined into the major tectonic belt which constitutes the Thai-Burmese border mountains, while the flat-lying Khorat group, including the Jurassic part, is widely distributed in Eastern Thailand and also sporadically in the central lowland and Peninsular Thailand.

The Jurassic extends into the Shan States of Burma and farther to Yunnan. It is composed largely of non-marine red arenaceous sediments with coal measures, but intercalated by bands of marine sediments. The Namyau beds of the Northern Shan States overlie the Upper Triassic Napeng beds. The constituents are mostly red-purple sandstone but intercalated limestone bands yield famous Middle Jurassic brachiopod fauna.

The Loi-an Series were first described by COTTER (1924). It is composed of upper coal measures and lower flysch-like shaly parts; in the upper part is included the argillaceous limestone bands full of fragments of *Alectryonia* and crinoid stems, and in the lower part Jurassic ammonites are said to occur (THEIN, 1973). Therefore the Jurassic sea invaded at least partly in the narrow troughs formed on the land mass. This seems similar to the case of the Mae Sot Jurassic in Thailand, described later. The Loi-an series exposes along the synclinal axis in the Kalaw and Lashio basins which strikes NNW-SSE, then is likely to continue in the Thangyin River valley (according to the geological map by THEIN and HAQ, 1969), overlying the older beds of different ages.

As actually clarified by BAUM et al. (1970), the Triassic is widely developed along the northern part of Thailand, among which chert and limestone beds are frequently intercalated. The Kamawkala limestone of the Upper Triassic, known since the days of COTTER, is likely to correspond to one of these limestone beds.

Overlying the Kamawkala limestone, the Lower Jurassic marine beds are exposed in restricted area around Mae Sot, Tak province, in Thailand.

The relation to the substratum of these beds is unknown, but judging from the lithology and distribution, these might represent the sediments of temporary marine ingression, comparable to the Loi-an series.

Jurassic fossils discovered from the Chumphon River mouth, farther south, are collected probably from a similar marine band intercalated in the red beds.

Unlike THEIN's statement (1973) that the complete upheaval of the Shan-Tenessarim belt occurred after the Cretaceous, this tectonic belt tended to emerge above sea level even during the Jurassic, but temporary marine ingressions left the predominantly calcareous sediments on stable seashore of largely scattered synclinal depressions, as demonstrated by the Loi-an and Mae Sot Jurassic. In fact, to the east of this belt, continental influence becomes stronger as exemplified by intercalations of red beds among the Triassic sequence around Phayao (BAUM et al., 1970). As compared to the Triassic, the Jurassic continental sedimentation spread farther to the west, thus the marine Jurassic at the Chumphon River mouth might be intercalated in red sequence. This reveals the folding before the end of the Triassic but as stated already (KOMALARJUN and SATO, 1964), folding occurred even after the Lower Jurassic, keeping the fold axes parallel to that of the precedings.

In Eastern Thailand and the adjoining areas of Indochina, the consolidated basement rocks are covered by flat-lying red beds carrying rock salt and gypsum beds. These are the Khorat group (series) of Thai and Indosinias supérieures of FROMAGET (1941). LAMOREAUX et al. (1958) gave the more detailed stratigraphy of the group. On the basis of fresh water molluscs sporadically collected from the various formations of the group (KOBAYASHI, 1963; KOBAYASHI, TAKAI and HAYAMI, 1963; HAYAMI, 1968) and plants (KON'NO and ASAMA, 1973) the age of the Khorat group was clarified to range from Upper Triassic to the Cretaceous.

The details of the stratigraphy of this group are discussed in the article by IWAI and his collegues in this volume.

Mae Sot Jurassic

A small marine Jurassic outcrop in the Mae Sot basin in Tak province was described briefly and incorporated in the Khorat group by BROWN et al. (1953), who dated the beds as Middle Jurassic by IMLAY's identification of ammonites. Recently ammonites and bivalves have been described more systematically by HAYAMI (1960) and SATO (1961a).

The locality was visited by HASHIMOTO and SATO with KOMALARJUN in 1962, where they studied the stratigraphy accompanying fossil hunting on the zonal scheme. The results are as follows: (KOMALARJUN and SATO, 1964)

Ban Yang Puteh bed: composed of dark brownish grey cryptocrystal-

line marly limestone, and carrying
Tmetoceras regleyi DUMORTIER
Graphoceras concavum (SOWERBY)

Ban Hui Hin Fon bed: composed of dark impure marly limestone, stratigraphically divisible into two horizons.

Horizon 2: *Tmetoceras dhanarajatai* SATO
Erycites like ammonite whorls
Erycites sp. juv.
Posidonia sp. ex gr. *ornati* QUENSTEDT

Horizon 1: *Erycites* sp.

These two beds are exposed in separate localities, so that the mutual relationship remains uncertain. The fossil content of both beds indicate unquestionably Aalenian (Lower Jurassic, but Middle Jurassic in English sense).

The beds are judged to be covered by oil-shale bearing Tertiary named the Mae Sot Series which are gently folded. Though the base of the beds is not exposed, the substratum might be the Permo-Triassic formation including the Kamawkala limestone of the Upper Triassic. To the east of the Mae Sot village, the beds overlie directly the Upper Paleozoic including the Rat Buri limestones.

The Jurassic beds, rather thin, are lithologically indicative of the quiet water sediments, deposited in an intermontane depression. The beds are steeply folded, with the fold axis parallel to that of the Permo-Triassic substratum and of the crystalline schists which constitute the western cordillera of Thailand (KOMALARJUN and SATO, 1964). It is possible that the folding occurred before and after the Lower Jurassic.

Chumphon River mouth area

A marine Jurassic bivalve, *Eomiodon chumphonensis* HAYAMI (HAYAMI, 1960), was collected from the mouth of the Chumphon River, in the east coast of Peninsular Thailand. This is said to have been collected from argillaceous sandstone exposed at that locality. HASHIMOTO, TORIYAMA, KANMERA and SATO visited Chumphon in 1963, but they failed to discover the bed; red beds similar to the Khorat group are developed at the said locality (small island off Chumphon, called Fang Dang). The *Eomiodon* bed, if it exists, might be intercalated within the Khorat group.

Sri Sawat Region

Recently KOCH (1973) reported the occurrences of possibly Jurassic microfauna from the upper reaches of the Kwae Yai around Sri Sawat and Thong Pha Phun in Western Thailand. The fossils are not described yet, as well as the details of the stratigraphy of the presumed Jurassic. According to KOCH's note, the beds are composed of bedded limestone 300 m thick, overlying unconformably the conglomerate bed of presumably Triassic age. The beds, if really Jurassic, might represent the southern extension of the Mae Sot Jurassic, although KOCH compared it to the Namyau bed in Burma.

Table 1. Fossil list of the Marine Jurassic in Thailand.

			*	
Aalenian	*Tmetoceras dhanarajatai* SATO *Erycites*-like Ammonite	Ban Hui Hin Fon Bed 2	T1	KOMALARJUN & SATO, 1964
	Posidonia sp. ex gr. *ornati* QUENSTEDT			HAYAMI, 1960
	Erycites sp.	Ban Hui Hin Fon Bed 1	T1	KOMALARJUN & SATO, 1964
	Tmetoceras regleyi DUMORTIER *Graphoceras concavum* (SOWERBY)	Ban Yang Puteh Bed	T1	
	Eomiodon chumphonensis HAYAMI	Mouth of Chumphon River	T2	HAYAMI, 1960
Lower Juras.	Microforaminifera (KEMPER det.)	S and SW of Thong Pha Phun, N of Sri Sawat	T3	KOCH, 1973

* Numbers indicate the location on the accompanied map (Fig. 1).

II. Malay Peninsula

In the Malay Peninsula, no marine Jurassic has been so far found, except a bed containing marine molluscs of presumably Middle Jurassic age in Singapore (NEWTON, 1906). Instead, the non-marine coarse clastics dominantly red in color, exposed widely along the axial belt of West Malaysia, east of the Central Range, are mostly attributable to the Upper Triassic to the Jurassic. This is SCRIVENOR's Tembeling Series (SCRIVENOR, 1907), later formalized by KOOPMANS as the Tembeling Formation (KOOPMANS, 1968).

The main outcrop of the Formation develops in Kelantan and Pahang, of which the type section was chosen in the Sungai Tekai upstream in Jerantut. The Formation is composed of conglomerate, feldspathic and quartzitic sandstone and shale, likely to overlie the Upper Triassic conformably but elsewhere unconformably on the beds of various ages ranging from the Carboniferous to the Triassic.

As indicated by a gradual transition from the Triassic near the type locality, these beds of non-marine origin are sediments deposited on the remnant of BURTON's eugeosynclinal furrow (BURTON, 1973). This indicates the general upheaval of land in the late Triassic.

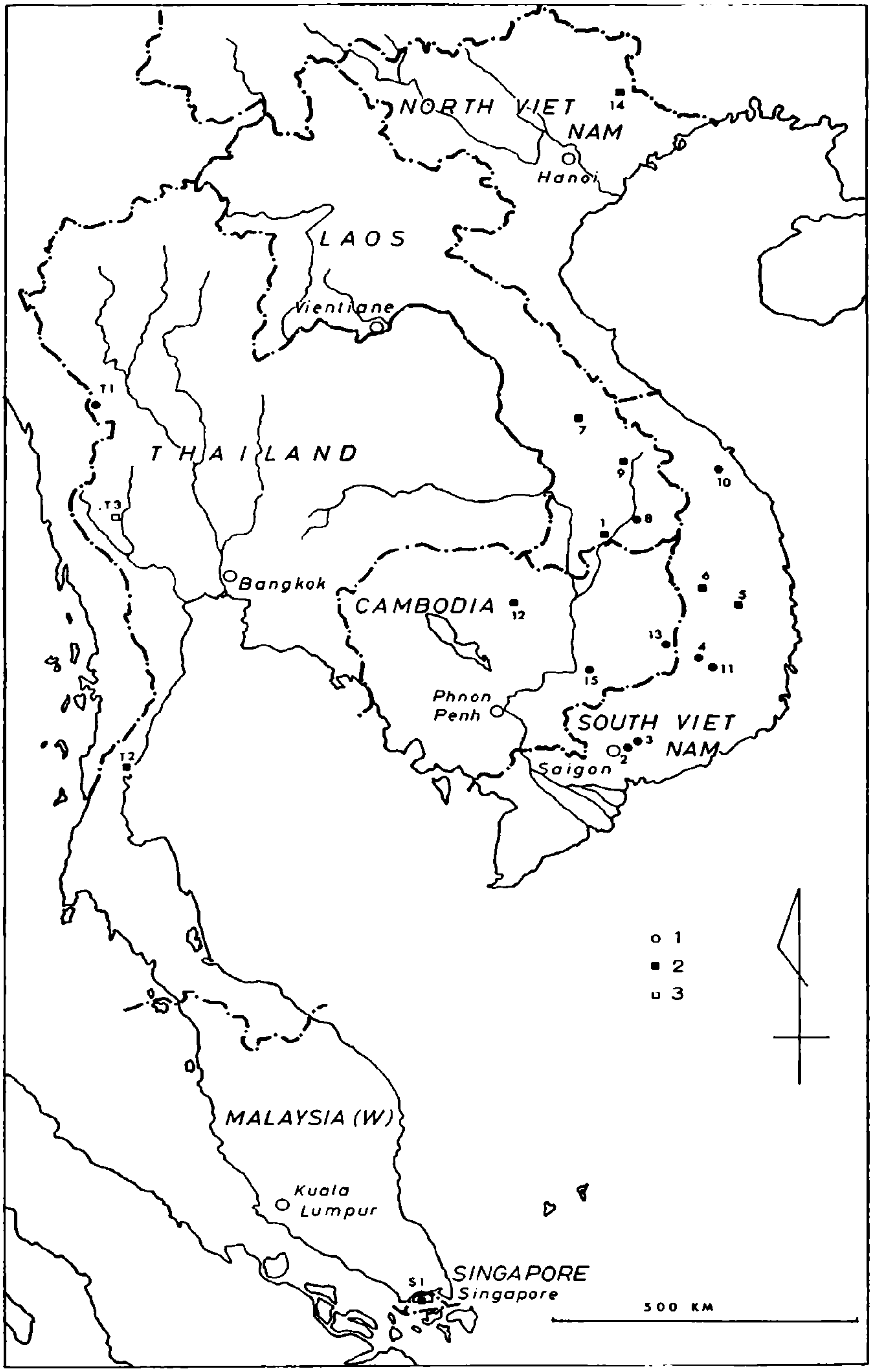


Fig. 1. Fossil localities of the marine Jurassic fauna in Thailand, Singapore and Indochina. Numbers of the localities are the same as in Fossil List; Tl—3 refer to the localities in Thailand, Sl refers to that in Singapore. Symbols: 1, Fauna including Ammonoids; 2, Fauna predominantly of Bivalves; 3, Other fauna.

Similar beds are known to the west, around Bukit Pakir Terbang in Northeast Kedah, and are called Saiong Beds (Foo, in BURTON, 1973). The lithology is similar to the typical Tembeling Formation (ONG, 1968 MS), and represents the late to post-orogenic sediments in BURTON's miogeosynclinal furrow.

Red-purple polymict conglomerate exposed at Tanjong Murau to Tanjong Tenggaroh, south of Mersing, overlies unconformably Carboniferous metasediments. KOOPMANS (1968) differentiated this as the Murau Conglomerate Member, and correlated it to the basal member of the Tembeling Formation in other areas.

In South Johore and Singapore, extending to the Riouw archipelago in Indonesia, a similar non-marine sequence with coal seams was described by CHIN FATT (1965 MS). He differentiated this as the Pasir Panjong Member, and placed it as an upper member of the Triassic Jurong Formation. The beds which are said to carry the classical Mount Guthrie fauna of probably Middle Jurassic age (NEWTON, 1906) are lithologically correlatable to that member. Therefore, the Jurong Formation ranges at least up to the Jurassic. The gradual succession from the Triassic to the Jurassic in this formation is also worthy of note.

The top of the Tembeling Formation is generally lost, but at G. Penumpa the Formation is covered by the Gagau Formation. Because of the scattered outcrops throughout the Malay Peninsula, the stratigraphy of the Tembeling Formation leaves some unsettled problems. The reader is requested also to refer to BURTON's synthesis (1973) and IWAI's article in this volume.

The age of these beds is important. Lithologically, the Tembeling Formation is similar to the Khorat group or Indosinias supérieures. Probably equivalent sediments are developed as far north as in the region of Chiang Rai in North Thailand. In Tembeling and corresponding rocks, the reliable marine fauna, capable of indicating the age, is known only in the Mount Guthrie bed.

The Mount Guthrie fauna has a different composition from those of the Triassic faunas known in the whole Malay Peninsula. NEWTON originally assigned the Middle Jurassic to the fauna on the basis of *Podozamites* cf. *lanceolatus*, but this plant does not warrant this dating (KOBAYASHI and TAMURA, 1968). KOBAYASHI and TAMURA pointed out that a *Goniomya* similarly ornamented like that of the Mount Guthrie fauna occurs also in Indochina, where *Goniomya* in association with *Astarte* like the Mount Guthrie fauna is considered to be Lower Jurassic. They reserved, however, a similar dating for the Mount Guthrie fauna. BURTON (1973) correlated the bed in question to the Lower Jurassic, emphasizing the above authors' suggestion. Anyhow, precise dating is impossible unless better index fossils are available.

If the age assignment of the Tembeling Formation to the Upper Triassic – Jurassic is accepted, it can be concluded that the geosyncline began to convert to land in the late Triassic. Depression seemed to have persisted until the Early or Middle Jurassic, which was rapidly filled up by deltaic deposits derived from nearby rising mountain ranges.

Table 2. Fossil list of the Marine Jurassic in Singapore.

			*	
Jurassic?	*Cucullaea scrivenori* NEWTON *Arca* sp. *Gervillia hanitschi* NEWTON *Volsella* cf. *compressa* GOLDFUSS *Nuculana* (?) sp. Nuculoid, gen. et sp. indet. *Lucina* (?) sp. *Astarte scrivenori* NEWTON *Astarte guthriensis* NEWTON *Astarte guthriensis* var. NEWTON *Goniomya scrivenori* NEWTON *Goniomya singaporensis* NEWTON *Thracia* (?) sp. *Podozamites* cf. *lanceolatus* LINDLEY & HUTTON *Carpolithus* sp.	Mount Guthrie	S1	NEWTON, 1906

*Number indicates the location on the map (Fig. 1).

III. Borneo

Jurassic rocks are known only in West Sarawak and Northwest Kalimantan in Borneo. Lower Jurassic is known in very limited areas in Northwest Kalimantan and the Middle-Upper Jurassic-Cretaceous sequence unconformably overlies the Triassic in Southwest Sarawak. These Jurassic rocks are incorporated into the basement constituting the "Continental Core" (LIECHTI et al., 1960) or an eugeanticlinal ridge (HAILE, 1969) of Cretaceous-Tertiary Northwest Borneo Geosyncline, which passes through the West Kalimantan-Sarawak border and Semitau, and are composed of folded Triassic and Palaeozoic sediments.

The Danau Formation of MOLENGRAAFF (1900), characteristically composed of diabase tuff, sandstone, slate and chert, was once dated as Jurassic (HINDE, *in* MOLENGRAAFF, 1900), on the basis of radiolarians preserved in chert and schalstein beds. The age of these chert and tuff beds has long been a matter of dispute. Generally the Jurassic age based on radiolarians can be discarded, and thus the Formation was attributed to the Permian-Carboniferous (e.g. ZEIJLMANS VAN EMMICHOVEN, 1939), to the Permo-Triassic (SIBINGA, 1940; KOBAYASHI and KIMURA, 1944a, b), to the Triassic (e.g. VAN ES, 1918; WANNER, 1922), or even to the Upper Cretaceous (e.g.

LIECHTI et al., 1960). Probably beds of entirely different ages but of similar lithology were bundled into one formation.

The Alino Formation and Paniungan beds, distributed in the southern part of the Meratus range, Kalimantan Selatan, intruded by a serpentinite mass, were correlated to the Jurassic to the Upper Cretaceous by KOOLHOVEN (1935). The correlation was based on the lithological similarity with the Danau Formation. Though the original author reserved the uncertainty of this correlation, this is adopted in the stratigraphical lexicon of Indonesia (MARKS, 1957).

HASHIMOTO and KOIKE (1973) made the field observations of the type localities of the Formations, profiting before the outcrops were submerged under the water of the reservoir at the Riam Kanan river. Unfortunately, they failed to discover any reliable time indicators, so that the Alino and Paliungan formations still remain undated. It is clear that the lithological similarity cannot afford any correlation between two remote areas.

The Lower Jurassic proved by index fossils was known from two localities in Northwest Kalimantan. One is at the tributary of the Sungai Teberan, near Ban Pin San, from where '*Aegoceras borneense*' (KRAUSE, 1911) was discovered. This ammonite might be *Xipheroceras* sp. (ARKELL, 1956), of the Sinemurian. The lithological and sequential characters of the beds which carry this ammonite are not clarified. The other is north of the Bawang Mountains, northeast of Pontianak, where KRAUSE (1896) described *Harpoceras radians* REINECKE, and later EASTON (1904) reported *Harpoceras* sp. The ammonites are thought to be a species of *Dumortieria* (ARKELL, 1956); thus the beds, even if the details are unknown, are of the Upper Toarcian.

These beds of two different ages are assumed solely by the occurrences of ammonites but their stratigraphical relation with other beds is obscure. This is also the case for a small fauna discovered from the tuffaceous sandstone of the Sungai Semoenti in the Lake District in central Borneo by TER BRUGGEN (TER BRUGGEN, 1935); it comprises

Protocardia multiformis VOGEL
Protocardia crassicostata VOGEL
Corbula borneensis VOGEL;

the Jurassic age is attributed to this faunule but this dating is uncertain.

Stratigraphy is much more clear as regards the Jurassic-Cretaceous in the southwestern part of West Sarawak. The Jurassic rocks there are represented by Kedadom, Bau Limestone, and Pedawan (Lower Member) Formations. The area was studied and mapped in detail by WILFORD (1955), WOLFENDEN (1965), WILFORD and KHO (1965). Rich fossil assemblages contained in these formations are cited in EASTON (1904), WILFORD and KHO (1965), HASHIMOTO and TAMURA (1969), TAMURA (1973) and described by

COX and HOWARTH (1960). Besides, some spotty occurrences of a few number of fossils were reported by NEWTON (1897), SCRIVENOR (1905), WILFORD (1955), WOLFENDEN (1961), TAMURA (1973) and HASHIMOTO (1973).

The lowest Kedadom Formation, composed of sandstone and some beds of conglomerate, thin beds of shale, limestone and dacitic radiolarian tuff, overlies unconformably the Sadong-Serian Formations of Triassic and earlier age. The Formation is exposed around Piching, Sarawak, but disappears toward the north and south, apparently interfingering with the lower part of the Bau Limestone Formation. Many molluscan fossils are cited in WILFORD and KHO (1965). Among these, *Lithacoceras* or *Subplanites* sp. with aptychii denotes the Kimmeridgian, but there is no evidence of Lower-Middle Jurassic. The other molluscs, mostly bivalves, are cited in EASTON (1904) and WILFORD and KHO (1965), but they can be no definite time indicator.

The Bau Limestone Formation, much more extensively developed in West Sarawak and possibly in Northwest Kalimantan, is characterized by micritic and calcarenite limestone. The limestone carries abundant fossils including foraminifers, calcareous algae, coelentrates and stromatorpores, from the Upper Jurassic to the Lower Cretaceous. It overlies unconformably various horizons of the Upper Triassic Serian Formation, but locally gradually passes into the Kedadom Formation. Contained fauna shows the time ranging from the Upper Jurassic to the Lower Cretaceous. Taking the interfingering relation into consideration, as stated above, at least a part of the present formation can be interpreted as synchronous but of different facies as the Kedadom Formation.

Overlying the Bau Limestone is the Pedawan Formation, composed of mostly argillaceous rocks, accompanying thick sandstone and conglomerate beds. Thin *Orbitolina* limestone lenses and tuff layers are also intercalated. It rests on the Bau Limestone Formation, but elsewhere directly on the Sadong and Serian Formations.

It is divided biostratigraphically into three divisions; characteristic fossils are foraminifers and pollens. Middle and upper members are proved to be Cretaceous, but the age of the lower member is somewhat uncertain. Ammonite fragments are reported from several localities (SCRIVENOR, 1905; HASHIMOTO and TAMURA, 1969; TAMURA, 1973). However, all the specimens are poorly preserved. The citation of these ammonites as *Perisphinctes* or Perisphinctid is not easily acceptable, because the determination of Perisphinctid genera requires well preserved specimens, especially adult whorls. Of these, that from a locality along the Pedawan Road, 25 miles from Kuching (TAMURA, 1973), might belong to the genus *Berriasella* or *Micracanthoceras*, and indicates the age from Upper Tithonian to Lower Neocomian. Other fossils are incapable to differentiate the Jurassic age.

In short, the lower division of the Pedawan Formation is of the Tithonian-Neocomian; therefore it is probable that this formation is partly synchronous with the Bau Limestone Formation.

The individualization of these three formations should be tested by further detailed biostratigraphical studies.

The Jurassic-Cretaceous in West Sarawak represents the sediments deposited on the shore which developed on the southern slope of the Cretaceous-Tertiary Northwest Borneo Geosyncline (Haile, 1969), in other words, on the northern slope of the then emergent geanticline. This announces the beginning of the geosynclinal downwarping in the north of this belt. Very restricted Jurassic exposures suggest, however, that the Jurassic sea invaded in narrow belts of depressions, on the previously emerged land mass, as in the case of southern Indochinese Lower Jurassic. The firmly dated Jurassic has never been discovered in central and north Borneo or in the Palawan and Sulu island areas.

Table 3. Fossil list of the Marine Jurassic in Borneo.

Pedawan Formation, Lower Member

			*	
Berriasian – Up. Tithon.	*Berriasella* or *Micracanthoceras* sp. *Nuculana*	25 miles, Pedawan Rd.	1	Tamura, 1973;
	Perisphinctid	231/3–2/3 miles Pedawan Rd.	1	
	Ammonites *Palaeoneilo*	Kpg. Pesang	1	Hashimoto & Tamura, 1969
	Parvamussium sp. cf. *hinagense* Tamura	Kpg. Begu	1	
Age unknown	*Perisphinctes* sp.	Bidi	1	Scrivenor, 1905
	'*Trigonia*' '*Myophoria*'	G. Akud, 21.5 miles Simangan Rd.	1 1	Wilford, 1955
	Ammonite fragment Coral Stromatopora *Lopha* sp.	G. Akud	1	Hashimoto & Tamura, 1969

Bau Limestone Formation

Up. Jurassic	*Nautiloculina oolithica* Möhler *Nautiloculina oolithica* var. *N.* sp. indet. *Pseudocyclammina* sp. (aff. *P. jaccardi* Schrodt) *P. lituus* (Yokoyama) *Torinosuella peneropliformis* (Yabe & Hanzawa) *Trocholina* spp.	Bau	1	Wilford & Kho, 1965

Table 3. Fossil list of the Marine Jurassic in Borneo.

	Ammobaculites spp. *Haplophragomoides* spp. *Clypeina marteli* EMBERGER *Lithocodium aggregatum* ELLIOT *Permocalculus inopinatus* ELLIOT *Clypeina* sp. nov. *Cylindroporella arabica* ELLIOT *Lithocodium* cf. *japonicum* ENDO *Nipponophycus ramosus* YABE & TOYAMA *Pianella tosaensis* (YABE & TOYAMA) *Salpingoporella nulata* CARROZI & other 43 spp. after ELLIOT *Burgundia semiclathrata* (HAYASAKA) & other 12 spp. after THOMAS *Actinostromaria* sp. & other 6 spp. after ELLIOT			
	Sarawakia ellipsactinoides HASHIMOTO	Kpg. Semadang, Bau	1	HASHIMOTO, 1973
	Alectryonia amor D'ORBIGNY	Loc. unknown	1	NEWTON, 1897

Kedadom Formation

Low. – Mid. Kimmeri-dgian	*Lithacoceras* or *Subplanites* sp. *Lamellaptychus* sp. (after HOWARTH)	Tebedu Rd. 3 miles NW of Piching	2	WILFORD & KHO, 1965
	Nuculana (Dacryomya) spp. *Cucullaea* spp. *Nucula* sp. *Plicatula* sp.? *Astarte* cf. *defecta* TAMURA *Astarte* cf. *sakamotoensis* TAMURA *Opis* cf. *chamcourtensis* DE LORIOL *Corbula* spp. *Goniospira* spp. *Terebrella?* (after COX)			
	Cucullaea? sp. *Gervillia* cf. *solenoids* DEFRANCE *Astarte* spp. *Venericardia* cf. *cuneata* (J. de C. SOWERBY) *Pholadomya*? sp. *Protocardia* cf. *hillana* (J. SOWERBY) *Natica* sp. (after COX)			
	Astarte? sp. nov. ? *Camptochlamys* sp. *Pteroperna* sp. ? *Gervillella* sp.	Sungai Kedadom	2	

	Bozitra (Posidonia) ornati (QUENSTEDT) *Opis (Trigonopis?)* sp. nov. *Protocardium* sp. *Neoburmesia iwakiensis* YABE & SATO ? *Cirsochilus* sp. nov. ? *Ampullospira* sp. nov. *Eunerinea* sp. indet. ? *Procerithium* sp. Apporhaidae, *Cuphosolenus* or *Pietteia* sp. *Trochacteonina*? sp. nov. (after MORRIS)			EASTON, 1904
Low. Cret.	*Protocardia* *Pholadomya* sp. *Exelissa*? *Perisphinctes* MARTIN, 1895 [= *Perisphinctes martinsi* NEWTON] Radiolaria Coral	Kpg. Tengoewai (Sungai Pade), Kalimantan	3	
Up. Jura. ?	*Pecten* sp. *Ostrea* sp. cf. *Cardium* *Astarte borneense* VOGEL	Nh. Taman	3	
	Mytilus sp. *Astarte borneense* VOGEL *Exelissa septemcostata* VOGEL	Nh. Teman, upper bed	3	
Age unknown	*Myophorella (Haidaia) molengraffi* (NEWTON)	Buduk		KOBAYASHI, 1957
Toarcian	*Harpoceras radians* [= *Dumortieria* sp. (ex gr. *radians*)]	N of Bawang Mts. Sambas District, Kalimantan	4	KRAUSE, 1896
Sinemurian	*Aegoceras borneense* KRAUSE [= *Xipheroceras* sp.]	Sungai Teberan, Kalimantan	4	KRAUSE, 1911

*Numbers indicate the location on the map (Fig. 2).

IV. Indochina

The sea began to retreat in the Norian from most of present Indochina. The newly upraised land received, since then, deposition of continental or lacustrine sediments, with workable coal seams from place to place. The non-marine sediments in Indochina are generally called Indosinias, of which the upper part (Indosinias supérieures, FROMAGET, 1934), or Terrain Rouge supérieur, LANTENOIS, 1907) is correlated to the Jurassic and Cretaceous.

Temporary marine ingression occurred in the early Jurassic along the narrow zone meridionally running along the Sékong River, which corre-

Fig. 2. Fossil localities of the marine Jurassic fauna in Borneo.
For legend, refer to the Fig. 1.

sponds to a line of disjunction between the Khorat-Cambodia mass and the "massif du Kontum" (FROMAGET, 1952). In fact, mainly pelitic sediments yielding rich and well preserved marine molluscs, are noted in South Viet-Nam, southern Laos and eastern Cambodia. Nearly all the stages of the Lower Jurassic are represented there, but these are not continuous to make up one single sequence, but largely scattered in different places. In most cases, the stratigraphy is rather vaguely reported; marine beds are, in general, likely to be intercalated within the non-marine Indosinias sequence, which lies unconformably on the older substratum. From the Middle Jurassic, the whole of Indochina emerged definitely above sea level, and no marine strata younger than the Lower Jurassic have ever been discovered.

The Lower Jurassic marine fauna, mostly molluscs, are rather abundantly reported. Since the International Stratigraphical Lexicon was published in 1956, biostratigraphical or paleontological contributions on the Jurassic were made by HAYAMI (1964, 1972), SAURIN (1965), FONTAINE (1962, 1966), NGUYEN (1966), Ta Tran TAN (1968), and SATO (1972). SATO and HAYAMI's identifications of the specimens are quoted in some of the above mentioned papers.

Important paleoxylological monographs on fossil plants have also been published (SERRA, 1966a,b, 1967, 1968). A review paper on the geology of the southern part of Indochina and eastern Thailand is also present (WORKMAN, 1972).

Hettangian was believed to exist in the Quang Nam coal field by the discovery of *Psiloceras longipontinum* OPPEL by COUNILLON (1908). The sequence and structure of the beds distributed in this region was studied in detail by COUNILLON (1908), FONTAINE (1962), and NGUYEN (1966); according to NGUYEN (1966);

Top	Red beds	Tho Lam Series
	Sandstone-shale	
	Conglomerate with thin limestone beds	
	Sandy beds with shale intercalations	
	Coal measures	

The beds are ubiquitously rich in fossil plants of which a part is cited in FONTAINE (1962). Marine molluscan faunas are discovered from calcareous bands and immediately underlying shale layers. The fossils were first described by COUNILLON (1908), and later collections were studied by HAYAMI (1964) and SATO (in NGUYEN, 1966).

The beds unconformably overly the crystalline schists and are gently folded to form a syncline of which axis runs approximately in a NE-SW direction. COUNILLON's locality of *Psiloceras* and numerous bivalves is situated on the NW wing of the syncline as well as FONTAINE's Khe Ren locality (HAYAMI, 1964).

Controversy is raised by the occurrence of Polymorphitid of the Pliensbachian in the latter locality (NGUYEN, 1966) which was quoted frequently in later papers. The determination was made by SATO, but the specimen is poorly preserved so that the decisive determination is impossible. ARKELL (1956) suggested that the *Psiloceras* described and figured by COUNILLON might be *Waehneroceras*, but it seems that this determination was based only on COUNILLON's figure. From the bivalvian faunas, no definite dating in the order of stage is possible. Therefore, the correlation will rest unsettled until a better specimen becomes available, unless the horizons of the two specimens in question are different from each other, though that is very unlikely.

The true Hettangian *Psiloceras* ex gr. *planorbis* SOWERBY was described by SAURIN (1965) from around Kratié, eastern Cambodia, but the bed from which the present specimen was found is not precisely known.

The Sinemurian in South Viet-Nam is confirmed by the discovery of *Coroniceras* and *Vermiceras* in the Darlac area (SAURIN, 1956b, 1965; FON-

TAINE, 1966) and *Asteroceras, Coroniceras,* and *Oxynoticeras* in the Bien Hoa area north of Saigon (Ta Tran TAN, 1968). All the beds yielding ammonites are pelitic-psammitic sediments, often covered by Terrain Rouge with basaltic flows intercalated.

Farther to the west, in North Cambodia, east of Rovieng, bivalves and brachiopods were discovered by SAURIN (1943) who correlated the beds to the Sinemurian. The beds overlie the Nor-Rhaetian coal measures conformably.

In North Viet-Nam, DEPRAT (1915) and MANSUY (1919) noted the fossil bearing calcareous shale in Na Cham, about 30 km northwest of Lang Son, with a small faunule characterized by *Cardinia.* This *Cardinia* bed was considered to be Hettangian and early Sinemurian. However, no definitive Hettangian or Sinemurian indicator is present in their fossil lists, and this age determination is open to question, although the Jurassic age can be accepted.

The Sinemurian has a wider extension in Cambodia and South Viet-Nam, than other Lower Jurassic stages. Compiling the occurrences of the Sinemurian together with other stages, FROMAGET (1941) and SAURIN (1956) presumed the "Sillon cochinchinois" or "Golfe du Cambodge" in the Lower Jurassic which is the result of marine invasion along the fracture of the pre-Jurassic basement complex.

Pliensbachian (Charmouthien) was proved only in upper reaches of the Srepok River, southern Laos. Since HOFFET's (1933) reports on bivalvian faunas, with a *Polymorphites* from Sakamane Valley near Attopeu, no new discovery of this stage was made, except SATO's suggestion of the occurrence of Polymorphitid from the Huu Nien area hitherto considered as Hettangian, as discussed above.

Argillaceous marls yielding brachiopods in Luang Prabang in North Laos, attributed to the Pliensbachian by MANSUY, is now placed in the Norian.

The Toarcian is developed in the southern part of South Viet-Nam. A Classical locality at Trian, north of Saigon, yielded a rich fauna of pelecypods, including some Upper Toarcian ammonites (MANSUY, 1914; LANTENOIS, 1915). *Dumortieria* (originally described as *Hildoceras*) indicates definitely an Upper Toarcian *Lytoceras jurense* Zone. A similar but better preserved fauna was discovered from Lo Duc 2 near Bien Hoa, to the south of Trian. Stratigraphy of the locality according to FONTAINE (1969) is as follows:

Top 4. Grey to brown fine grained micaceous sandstone
3. Bluish or greenish shale and mudstone (20 m+)
2. Yellowish green fine grained slightly micaceous sandstone (10m)

1. Grcy-blue mudstone and shale (30 m +).

The fossils were found from ferrugineous or siliceous concretions judged to be comprised in bed 3. The bivalve fauna was described by HAYAMI (1972), accompanying revisions of Trian and other faunas. The newly described ammonite faunule is composed of *Dumortieria, Pseudogrammoceras*?, and *Hammatoceras*; the Upper Toarcian is therefore confirmed. Because the directions of both the Trian and Lo Duc beds are the same, it is highly probable that the beds of both localities represent a single horizon.

FONTAINE's Lo Duc 1 locality contains similar fauna (HAYAMI, 1972), but its relation with Lo Duc 2 is uncertain. Beds of nearly the same age are known in the Darlac region (SAURIN, 1956), intercalated in "grès supérieur".

In the valley of the Middle Sékong River, from various beds of shale, sandstone and sandy limestone, SAURIN (1944) reported a bivalvian fauna, barren of ammonites, and attributed to the Aalenian, by the judgement that the composition of the fauna is different from the Toarcian one of Trian. This is said to continue gradually to "grès supérieur" (SAURIN, 1953), therefore this marine bed is intercalated within the continental Terrain Rouge. The Toarcian marine ingression spread as widely as the Sinemurian. After the Toarcian, no marine sediments have so far been discovered from any part of Indochina.

Table 4. Fossil list of the Marine Jurassic in Indochina.

			*	
Aalenian	*Ostrea knorri* *Ostrea* cf. *marshi* *Pecten lens* SOWERBY *Gervilleia* aff. *subtortuosa* *Gervilleia* aff. *ferruginea* *Trigonia* aff. *similis* AGASSIZ *Protocardia striatula* SOWERBY *Protocardia subtruncata* *Astarte* sp. *Perna isognomoides* *Leda claviformis* SOWERBY	Valley of Middle Sekong (S. Laos)	1	SAURIN, 1944a
	Dumortieria lantenoisi (MANSUY) *Dumortieria* cf. *metita* BUCKMAN *Pseudogrammoceras*? *loducensis* SATO *Pseudammatoceras molukkanum* (CLOOS) *Hammatoceras* sp. *Hammatoceras* sp. juv.	Lo Duc 2, Bien Hoa	2	SATO, 1972
	Palaeonucula saigonensis HAYAMI *Grammatodon tenuis* HAYAMI *Nanonavis*? *(Indogrammatodon)*? sp. *Modiolus sestinae* HAYAMI *Pinna* sp. indet.			

Table 4. Fossil list of the Marine Jurassic in Indochina.

Toarcian	*Pseudomytiloides* sp cf. *dubius* (SOWERBY) *Camptonectes (Camptonectes) fromageti* HAYAMI *Entolium* sp. aff. *E. partitum* (SOWERBY) *Parvamussium (Parvamussium) donaiense* (MANSUY) *Plagiostoma* sp. aff *P. eipybolus* (WHIDBORNE) *Myophorella saurini* HAYAMI *Integricardium (Yokoyamaia) globosum* HAYAMI *Isocyprina* sp. indet. *Tancredia (Paratancredia) latoniformis* HAYAMI *Osteomya* sp. cf. *O. dilata* (PHILLIPS) *Goniomya (Goniomya) knorri* AGASSIZ *Pholadomya (Bucardiomya) fontainei* HAYAMI *Myopholas minor* HAYAMI *Ceratomya* sp. cf. *C. aalensis* (QUENSTEDT) *Ceratomya* sp. cf. *C. tanganycensis* COX *Thracia loducensis* HAYAMI	Lo Duc 2, Bien Hoa	2	HAYAMI, 1972
	Hildoceras lantenoisi MANSUY [= *Dumortieria lantenoisi*] *Pecten (Amussium) donaiensis* [= *Parvamussium (p.) donaiensis*]	Trian, N of Saigon	3	MANSUY, 1914
	Cucullaea aff. *inaequivalvis* GOLDFUSS [= *Myopholas minor* HAYAMI] *Modiola* cf. *cuneata* SOWERBY [= ?*Modiolus saurini* HAYAMI] *Modiola* aff. *modiolata* QUENSTEDT *Inoceramus dubius* SOWERBY [= ? *Pseudomytiloides* sp. cf. *P. dubius* (SOWERBY)] *Posidonomya (Steinmannia) bronni* VOLZ *Pecten (Camptonectes) aalensis* PARIS-RICHARDSON [= *Camptonectes* (*C.*) *fromageti* HAYAMI] *Pecten (Entolium) demissus* PHILLIPS *Pecten (Amussium) pumilus* var. *donaiensis* MANSUY [= *Parvamussium (P.) donaiense* (MANSUY)] *Trigonia similis* AGASSIZ	Donnai River (Trian and neighborings)	3	SAURIN, 1935

Toarcian	*Trigonia striata* MILLER [= *Myophorella saurini* HAYAMI] *Pleuromya unioides* GOLDFUSS *Nucula jurensis* QUENSTEDT *Nucula hammeri* DEFRANCE *Leda* cf. *claviformis* SOWERBY *Cucullaea* aff. *münsteri* ZIETEN *Astarte voltzii* GOLDFUSS *Gryphaea* sp. *Natica* cf. *pelops* D'ORBIGNY *Cerithium* cf. *armatum* GOLDFUSS *C.* sp. *Pleuromya* sp. *Lucina* sp. *Pleurotomaria* sp. *Taeniopteris* sp. ? *Zamites* sp.			
	Hildoceras cf. *quadratum* HAUG *Nucula jurensis* QUENSTEDT *Modiola* aff. *striatula* GOLDFUSS *Inoceramus dubius* SOWERBY [= ?*Pseudomytiloides* sp. cf. *P. dubius* (SOWERBY)] *Pecten (Camptonectes) aalensis* PARIS-RICHARDSON [= *Camptonectes (C.) fromageti* HAYAMI] *Pecten (Entolium) demissus* PHILLIPS *Pecten (Amussium) pumilus* var. *donaiensis* MANSUY [= *Parvamussium (P.) donaiense*] *Plicatula* cf. *catinus* DESLONGCHAMPS *Plicatula spinosa* SOWERBY *Lima (Plagiostoma) semicircularis* GOLDFUSS cf. *Exogyra auricularis* MÜNSTER *Trigonia similis* AGASSIZ *Trigonia striata* MILLER [= *Myophorella saurini* HAYAMI] *Astarte voltzii* GOLDFUSS *Astarte* aff. *cincta* GOLDFUSS *Pholadomya idea* D'ORBIGNY [= ? *Pholadomya (Cucardiomya) fontainei* HAYAMI] *Cucullaea* sp. Gastropoda sp. *Serpula* sp.	Darlac-Pleiku (Ban Don and Na Bich) in Southern S. Viet Nam	4	SAURIN, 1935, 1944
	Pecten (Amussium) pumilus LAMARCK var. *donaiensis* MANSUY *Trigonia striata* MILLER Gastropods	Valley of Song Ca Lui	5	SAURIN, 1944b
	Gryphaea aff. *sublobata* DESCHAYES *Plicatula spinosa* SOWERBY			

Table 4. Fossil list of the Marine Jurassic in Indochina.

			*	
Toarcian ~ Aalenian	*Pecten (Amussium) pumilius* Lamarck var. *donaiensis* Mansuy *Pecten (Camptonectes) lens* Sowerby *Cucullaea* aff. *oblonga* Sowerby *Trigonia striata* Miller *Trigonia similis* Agassiz *Astarte* cf. *opalina* Quenstedt *Protocardia* cf. *striatula* Sowerby *Araucarioxylon* sp.	Ea-Tréa stream bed (Plateau de Darlac)	5	
	Astarte aff. *opalina* Quenstedt *Pecten lens* Sowerby *Trigonia striata* Miller *Gervilleia* sp. *Gervilleia* cf. *oblonga* Moore *Astarte* sp.	Between Ea Kmok and Ea Hlée (SE of Plateau du Pleiku)	6	
Up. Lias	*Lepidotus* *Pleisiosaurus* *Gervillia* sp. *Alectryonia vallata* Spongiomorphides	Muong Phalanc, Bas Laos	7	Hoffet, 1937
Low. Pliens-bachian	*Polymorphites* cf. *jamesoni* (J. de C. Sowerby) *Goniomya engelhardtii* *Pecten* cf. *philis* *Mytilus variabilis* *Gervilleia* sp. *Pholadomya* sp. *Gryphaea* sp.	Region of Attopeu, Sakamane Valley (Brao) (Bas Laos)	8	Hoffet, 1933
	Avicula sp. *Goniomya engelhardtii*	Saravane Region (Bas Laos)	9	
	? Polymorphitidae gen. et sp. indet.	Khe Ren (Huu Nien)	10	Sato, in Nguyen, 1966
Sinemurian	*Coroniceras* cf. *multicostatum* (Sowerby) ?*Paracoroniceras gmündensis* Oppel	Chute de Drayling sur la Srepok (Darlac)	11	Fontaine, 1966
	Coroniceras cf. *multicostatum* (Sowerby)	Chu Ebur, Ban Me Thuot (Darlac)	11	Saurin, 1956b
	Gryphaea arcuata *Oxytoma inaequivalve* *Chlamys textoria* *Pecten hehlii* *Spiriferina walcotti* *Spiriferina tumida* *Zeilleria*	E of Rovieng (O Khley, O Kombor) (N Cambodia)	12	Saurin, 1943
	Asteroceras stellare (Sowerby) *Coroniceras rotiforme* (Sowerby) *Oxynoticeras* cf. *oxynotum* (Quenstedt) *Arnioceras* sp. *Arietites* sp.	Cote 20, Binh-An,		

	Corals Sponges Brachiopoda Lamellibranches Gastropoda	Bien Hoa	2	Ta Tran TAN, 1968
	Vermiceras spiratissimum (QUENSTEDT)	Near Bon Dak Der, Ban Don	13	SAURIN, 1965
Hettangian ?—Low. Sinemurian	*Cardinia nachamensis* MANSUY *Cardinia latitruncata* MANSUY *Cardinia* sp. ? aff. *C. crassissima* SOWERBY *Cardinia* sp. ? aff. *C. plana* AGASSIZ *Zygopleura cossmanni* MANSUY	Na Cham, NW of Lang-son (N. Viet Nam)	14	DEPRAT, 1915; MANSUY, 1919
Hettangian ?	*Psiloceras longipontinum* OPPEL [=*Waehneroceras* sp.] *Turritella rhodana* MARTIN *Cerithium dumortieri* MARTIN *Actaeon sinemuriense* MARTIN *Monotis substriata* ZIETEN *Nucula subovalis* GOLDFUSS *Nucula ovum* SOWERBY *Astarte subcarinata* MÜNSTER [=?*Astarte (Nicaniella)* sp. indet] *Astarte voltzi* GOLDFUSS *Tancredia marcignyana* MARTIN *Protocardia philippianum* DUNKER *Gervillia* cf. *lanceolata* (SOWERBY) [=*Gervillia (Cultriopsis) counilloni* HAYAMI] *Pecten* sp. *Goniomya* sp [=*Goniomya fontainei* HAYAMI] *Chemnitzia polita* MARTIN	Huu Nien Area (Khe Ren, Khe Du, Ho Bui, Ho Nuoc)	10	COUNILLON, 1908; em. HAYAMI, 1972
	Grammatodon khensis HAYAMI *Modiolus saurini* HAYAMI *Parainoceramus* sp. *Chlamys* sp.ex gr. *C. textoria* (SCHLOTHEIM) "*Exogyra*" *vietnamensis* HAYAMI *Cardinia indochinensis* HAYAMI *Entolium* sp. indet.	Khe Ren, Ho Bui, Ho Nuoc (Huu Nien)	10	HAYAMI, 1964
	Psiloceras ex gr. *planorbis* (SOWERBY)	Kratié (Mondol Kiri Province)	15	SAURIN, 1965
Low. Jurassic?	*Modiolus* sp. aff. *M. sestinae* HAYAMI *Camptonectes (Camptonectes) fromageti* HAYAMI	Lo Duc 1, Bien Hoa	2	HAYAMI, 1972

*Numbers indicate the location on the map (fig. 1).

V. Philippines

The Philippine archipelago is a composite island arc, constituted of orogenic belts of different ages. It is now largely covered by Cenozoic sedimentaries and volcanics, of which the "basement complex" is exposed in several restricted areas. The Jurassic takes part of this complex, but as will be stated later, it has its own historical significance.

On the compiled geological map of the Philippines published in 1963 by the Bureau of Mines at Manila, the Jurassic is indicated not only in the classical Mansalay area in South Mindoro but also in the North Palawan and the neighboring Calamian insular group. The latter was, in fact, dated as Permian and Triassic (HASHIMOTO and SATO, 1973) by conodonts and fusulines. The erroneous attribution to the Jurassic seems to be based on the lithological similarities to the Danau Formation in central Borneo, of which the Jurassic age can not be sustained.

Jurassic molluscs, including ammonites, were first reported by DEVILLA (1941) from the Mansalay area in Oriental Mindoro province. Rather rich molluscan fauna was repeatedly described and figured (HAYASAKA, 1943; RIVERA, 1954; KOBAYASHI, 1957; SATO, 1961b). Unfortunately, no stratigraphy accompanied these reports, so that the biostratigraphy of the Formation was never clarified. It was first established by HASHIMOTO and SATO in 1965 together with Messrs ANDAL, ESGUERRA, and REYES, then staff of the Bureau of Mines (ANDAL et al., 1968).

The Mansalay Formation, the name proposed by DEVILLA (1944), is exposed in the mountain range northwest of Mansalay. It has an unexpectedly wide distribution, and the whole surface has not been mapped yet.

Presumed Jurassic west of the Bongabon River area, together with presumed Triassic in the Baroc River area (Wasig Formation by DEVILLA, 1944; TEVES, 1957), was corrected to be of the Eocene (HASHIMOTO and SATO, 1973).

The sequence established in the Amaga-Mansalay-Cagancan Rivers in the southern part of Oriental Mindoro is as follows (ANDAL et al. 1968):

Top 10. Black sandy shale, 150m.

9. Granule conglomerate and coarse grained arkose sandstone

——— Fault contact ———

8. Lithic medium to coarse grained sandstone
7. Black shale, 250–300 m
6. Alternation of black shale and tuff, 20–30m.
5. Black sandy shale (Amaga River Horizon), 350m.
4. Bluish grey, medium grained sandstone with shaly intercalations, 1,200 m.
3. Black sandy shale with calcareous concretion (Parucpoc Hill Horizon), 200 m.
2. Grey, fine to medium grained quartzose sandstone, with black shale intercalation, 700–1,000 m.

1. Black shale with carbonaceous medium-grained sandstone (Caromata Hill Horizon).

Bottom

The ammonites were described by SATO (in ANDAL et al., 1968) and bivalves by HAYAMI (1968).

The age of the formation can be established by these fossils it contains. The Amaga River Horizon is characterized by the main stock of Perisphinctidae in association with *Euaspidoceras* and *Taramelliceras*, therefore of the *Gregoryceras transversarium* Zone to the Lower *Epipeltoceras bimmamatum* Zone in age (Upper Oxfordian).

The `Parucpoc Hill Horizon assemblage comprises *Parawedekindia, Perisphinctes* (*Kranaosphinctes*), *Euaspidoceras* and *Campylites*, known also in the Dhosa Oolite group of Cutch. The assemblage is of the *Cardioceras cordatum* Zone to the *Gregoryceras transversarium* Zone in age (Lower and early Upper Oxfordian).

The lowest horizon with ammonites is the Caromata Hill Horizon; its constituents are *Hecticoceras* (*Zieteniceras*) and generically indeterminable Perisphinctid. *Hecticoceras* is a genus suggestive of the Lower-Middle Callovian.

In short, the Mansalay Formation ranges, as far as concerns the ammonite-bearing parts, from the Lower Callovian to the Upper Oxfordian. The Formation is generally correlated to the classic Wai Galo beds in Indonesia, the Kantecote Sandstone and Dhosa Oolite in Cutch, or the Kaizara and the Yambarazaka Formations in central Japan.

Beside the ammonites in the established sequence in the Amaga-Mansalay-Cagancan River area, *Hecticoceras* (*Lunuloceras*) was discovered from a bed stratigraphically difficult to correlate to any of the Amaga section. This indicates also the Callovian. No indicator other than the age of the Mansalay Formation has been discovered by recent field investigations. There are, in fact, some other specimens collected from the river floats, but the biochrons of all these fall in the above time span.

Most of the previously known ammonites are not chronologically contradictory with this age determination, except for some few doubtfull genera cited by the previous authors. For example, HAYASAKA cited *Arietites* sp. of the Sinemurian (HAYASAKA, 1943), DeVilla *Arietites* and *Hammatoceras* of the Lower Jurassic (DEVILLA, 1941, 1944). However these determinations are open to question, because no such genera are known, not only in recent collections, but also in some private collections owned by natives, which the present writer had a chance to study.

Bivalves such as trigonians and inocerami are distributed throughout the sequence, often preserved in the same slab with the ammonites. No chronological discrepancies were raised from the studies on these bivalve faunas (KOBAYASHI, 1957; HAYAMI, 1968).

In the Sipatag River area, the conglomerate bed is intercalated in an unclassified horizon, and carries limestone pebbles containing fusulines (ANDAL, P.P., 1966).

The Mansalay Formation is unconformably covered by flat-lying limestone beds of the Eocene in the southern part of the area, but to the north and west it is in contact with the Eocene clastics by faults. The very base of the formation has not been observed.

The crystalline schists, presumed to be the substratum of the Formation, and cropping out near the area of distribution of the Mansalay, namely in the Bongabon River valley, are very tightly folded; the structure is complex and awaits elucidation. The more extensive outcrop is known in Northern Mindoro, where the general fold axes of the 1st generation are judged to be in a NE-SW direction (HASHIMOTO and SATO, 1968; 1973).

Meanwhile, the beds constituting the Mansalay Formation are homoclinally inclined in the Amaga-Mansalay-Cagancan River area, striking nearly in a NW-SE direction. However the NE-SW running folds are also observable in the Caguray River area, west to the preceding section. Therefore, the Formation is judged to have been folded at least two times in different directions.

The fold is, however, of the gentle flexure type. The contrast between this nature of deformation and tightly folded, strongly metamorphosed crystalline schists which may underlie the Jurassic, suggests that the unconformity exists between two rock units.

In North Palawan, recent investigation has clarified that the metamorphic terrain, annexed to the Mindoro Metamorphics, merges gradually into weakly metamorphosed Permo-Triassic (HASHIMOTO and SATO, 1973). Therefore, it is possible that the Lower and Middle Jurassic are lacking in the Mindoro-Palawan arc. It is comprehensible that the marked contrast between the deformation features of the basement and the covering Jurassic, and also the post-orogenic nature of the Jurassic, are the results of an orogenic disturbance which occurred after the Triassic and before the Upper Jurassic.

While the Eocene limestone beds lie flatly on the eroded surface of the Jurassic in the southern part, the Eocene clastics north of Mansalay are folded, cleaved and faulted. The deformation recurred at least twice, as in the case of the Jurassic. Therefore, it must be considered that the deformation continued to recur intermittently after the Jurassic, intervened by the partial erosion of the Jurassic in Cretaceous-early Tertiary time.

From the facts described briefly here, it is concluded that the Palawan-Mindoro arc is basically composed of Paleozoic-Triassic folded and metamorphic terrain. It was eroded and covered by Jurassic of the post-orogenic nature. This situation is closely similar to the basement metamorphic terrain and covering Middle-Upper Jurassic in the northern part of central Japan.

Table 5. Fossil list of the Marine Jurassic in the Philippines.

			*	
Upper Oxfordian	*Perisphinctes (Kranaosphinctes) bullingdonensis* ARKELL *Perisphinctes* subg. & sp.indet. *Euaspidoceras* cf. *hypselum* (OPPEL) *Paraspidoceras* cf. *knechti* (JEANNET) *Taramelliceras* cf. *trachinotum* (OPPEL) *Myophorella (Promyophorella) orientalis* KOBAYASHI & TAMURA *Inoceramus* sp. Pectinids	Amaga River (Amaga River Horizon, bed 5)	1	ANDAL et al., 1968; HAYAMI, 1968
	Euaspidoceras sp. *Dichotomosphinctes* like sp. *Myophorella* sp.	Habang Sapa (Amaga River Horizon, bed 5)	2	
	Peltoceras sp.juv. *Phylloceras* sp. *Perisphinctes* spp. *Myophorella (Promyophorella) orientalis* KOBAYASHI & TAMURA *Plagiostoma (Plagiostoma)* sp. *Astarte (Astarte) mindoroensis* (HAYASAKA) *Astarte (Astarte) satoi* HAYAMI	Amaga River (bed 4)	1	
Low. & early Upp. Oxfordian	*Parawedekindia arduennensis* (D'ORBIGNY) *Parawedekindia* sp. *Peltoceratoides* sp. *Perisphinctes (Kranaosphinctes)* cf. *bullingdonesis* ARKELL *Peripshinctes (Kranaosphinctes)* sp. *Euaspidoceras* ? sp. *Campyllites* sp. *Lissoceratoides* sp. *Vaugonia (Vaugonia) mindoroensis* (HAYASAKA) *Myophorella* sp. *Astarte (Astarte) satoi* HAYAMI	Parucpoc Hill (Parucpoc Hill Horizon, bed 3), Colasi Point	1	
	Calliphylloceras sp. *Proscaphites* sp. Perisphinctid Peltoceratid *Myophorella* sp. *Belemnites* sp.	Amaga River (bed 2)	1	
Low.-Mid. Callovian	*Hecticoceras (Zieteniceras)* sp. Perisphinctid *Belemnites* sp. *Cladophlebis* like plant impression	Caromata Hill (Caromata Hill Horizon, bed 1)	1	

Table 5. Fossil list of Marine Jurassic in the Philippines.

	Hecticoceras (Lunuloceras) cf. *lunula* (REINECKE) *Hecticoceras (Lunuloceras)* sp. *Aulacomyella* sp. aff. *A. neogeae* IMLAY	Kipalaye River	1	HAYAMI, 1968
Callovian	*Hecticoceras (Sublunuloceras) guthei* (NOETLING)	Amaga River Float	1	ANDAL et al., 1968
	Phylloceras sp. *Lytoceras* sp.ex gr.*L.fimbriatus* (J.de C.Sowerby) *Hecticoceras (Lunuloceras)* sp.	Sipatag River	1	ANDAL et al., 1968
	Inoceramus cf.*I.galoi* BOEHM *Aulacomyella* sp.			HAYAMI, 1968
Oxfordian –Callovian	*Rutitrigonia yeharai* KOBAYASHI *Rutitrigonia amagensis* KOBAYASHI *Latitrigonia multicostata* KOBAYASHI *Nipponitrigonia* (?) sp. indet. *Myophorella (Promyophorella) orientalis* KOBAYASHI & TAMURA *Myophorella (Promyophorella)* sp.nov. *Chlamys (Radulopecten?) villai* KOBAYASHI *Chlamys* sp. indet.	Amaga River Float	1	KOBAYASHI, 1957
	Astarte (Astarte) mindorensis HAYAMI			HAYAMI, 1968

*Numbers indicate the location on the map (Fig. 3).

VI. Indonesia and New Guinea

Although the detailed stratigraphy is scarcely known except for some particular cases, the Jurassic in Indonesia has a potentially wide distribution. The fossils are also abundantly reported from Moluccas. The outline of the Jurassic in Indonesia was summarized early in 1931 by WANNER and later by Van BEMMELEN (1949). The complete list of fossils up to 1931 was given in Feestbundel for K. MARTIN published in Leidsche Geologische Mededeelingen in 1931 (e.g. KRUIZINGA, 1931 on fossil cephalopods, and by KRIJNEN, 1931 on other molluscs). A Stratigraphical Lexicon was edited by P. MARKS (1959), which summarizes the information before this date and useful for reference. ARKELL gave the discussions mainly on zonations based on ammonites and correlation of the Jurassic (ARKELL, 1956).

Modern stratigraphical and paleontological studies in Indonesia on the Jurassic are, however, quite few since the 1960's. Our knowledge on the Jurassic is still based essentially on the publications which appeared in the days of MARTIN and WANNER.

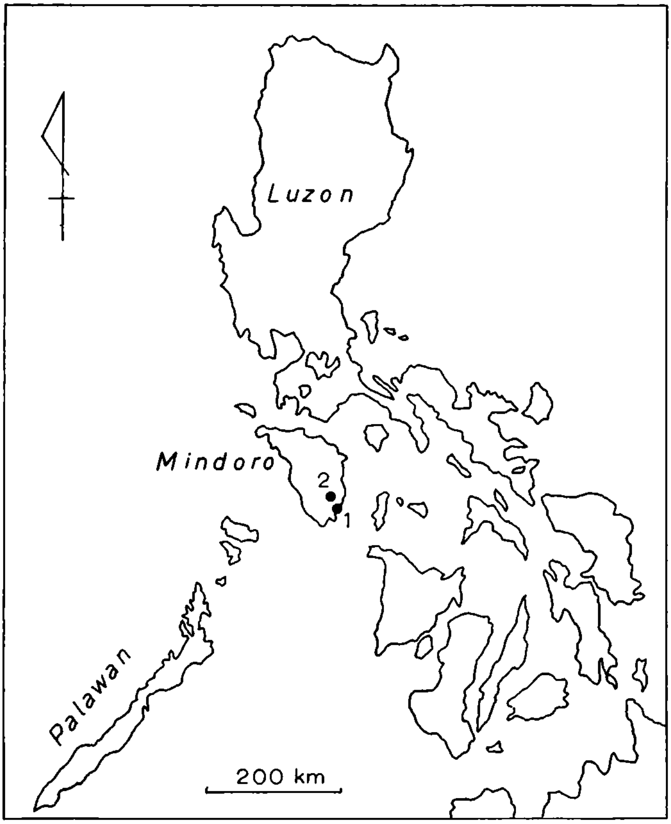


Fig. 3. Fossil localities of the marine Jurassic fauna in the Philippines. For legend, refer to the Fig. 1.

The most complete sequence of the Jurassic is known in the Sula islands. A number of well preserved ammonites, belemnites and inocerami were collected from the river beds, described by BOEHM (1904, 1907, 1912). The detailed stratigraphical elucidation is awaited, because a standard column of the Indonesian Jurassic might be established there.

Meanwhile, New Guinea has become rather well documented with regard to the Jurassic these days (see fossil list). Here the Jurassic is grouped under the name of the Kembelangan Formation. The type locality is in the Kembelangan Peninsula at the mouth of Etna Bay, but the lowest part is poorly developed there. The Wandamen Range, in the Geelvink Bay coast of the Vogelkop was chosen to be a type locality of the lowest member. The general account of the formation is well summarized in VISSER and HERMES (1962), with a detailed note on the fossils contained. Correlation is also discussed in this paper.

Along the Central Range of West Irian and Papua-New Guinea, the

Kembelangan equivalent is widely developed, from which the rich ammonite faunas were collected (GERTH, 1965; WESTERMANN and GETTY, 1970). The Formation is characterised by generally argillaceous sediments, containing calcareous concretions. The magnificiently preserved fossils are comprised in the concretions. From Bajocian, almost all the stages of the Middle and Upper Jurassic are thought to exist, and pass gradually into the Lower Cretaceous. BURTON, studying the area of the upper reaches of the Sobger River, a tributary of the Mamberamo River which flows into the Pacific Ocean, and near the West Irian-Papua-New Guinea border. He collected a small number of ammonites, belemnites and inocerami from Kembelangan like-rock in Ok Atem and Ok Bon, beside Ordovician Ellesmeroceroid cephalopod in the pebbles (KOBAYASHI and BURTON, 1971). BURTON's collection of Jurassic ammonites comprises such Callovian genera as *Dolikephalites, Eucycloceras,* and *Idoceras,* while some doubtfull Pseudoperisphinctid of the Bathonian? and Perisphinctid of the Tithonian(?).

From the Kemaboe valley, east of Zanepa, H. SUZUKI then of Kyoto University, collected the well preserved ammonites of mostly Bajocian age. The locality is in close proximity to WESTERMANN and GETTY's, and the fauna in question is nearly identical, except some new forms yet unknown in New Guinea. The specimens are now being studied.

Table 6. Fossil list of the Marine Jurassic in New Guinea.

			*	
Up. Tithonian –Valanginian	*Blanfordiceras wallichi novanguinense* GERTH *Blanfordiceras* sp.indet. *Himalayites* aff. *H. nederburghi* BOEHM *Olcostephanus ('Rogersites')* sp. indet.	Iwaboe River, Kemaboe	1	WESTERMANN & GETTY, 1970
Berriasian	*Berriasella* sp. *Blanfordiceras novaguinense* GERTH *Blanfordiceras* sp. *Spiticeras (Kilianiceras)* sp.	Aramarai, tributary of Toli	2	GERTH, 1965
Tithonian	*Kossmatia* sp.	Striclkand River	4	ETHERIDGE, 1890
	Haplophylloceras strigile BOEHM *Haplophylloceras* ? sp.	N of Jameor Lake	5	DONOVAN, in VISSER & HERMES, 1962
	Paraboliceras cf. *polysphinctum* UHLIG *Kossmatia desmidoptycha* UHLIG	Upper Sepik River, River Float	6	SCHLÜTER, 1928
	Perisphinctid	Upper Fly River	7	OSBORNE, 1945
	Perisphinctes (Pachyplanulites) novaguinense GERTH *Pseudoparaboliceras aramaraii* GERTH	Aramarai, tributary of Toli	2	GERTH, 1965

Oxfordian	*Inoceramus galoi* Boehm ?*Pseudomonotis* sp. *Posidonomya* sp. *Belemnopsis gerardi* Oppel	Itebere River, Vogelkop	8	Broili, 1924
	Perisphinctes burui Boehm *Perisphinctes taliabuticus* Boehm *Perisphinctes molluccanum* Boehm *Inoceramus* cf. *galoi* Boehm	Upper Sepik	6	Schlüter, 1928
	Peltoceras sp. [= *Peltoceratoides* sp.]	Wairori, Vogelkop	9	Gerth, 1927
	Belemnopsis gerardi (Oppel) *Buchia malayomaorica* *Inoceramus*	Upper Fly River	7	Osborne, 1945
	Mayaites cf. *maya* (Sowerby) *Inoceramus galoi* Oppel	Aramarai, tributary of Toli	2	Gerth, 1965
Mid. Callovian	*Baculatoceras* sp. [= *Blanfordiceras wallichi novaguinense* Gerth] ? *Labyrinthoceras* sp. [=*Subkossmatia obscura boehmi* Westermann & Getty]	Lenggoeroe area (Wati)	3	Donovan, in Visser & Hermes, 1962
	Macrocephalites keeuwensis Boehm, pl. 2, fig. 4 [=*Idiocycloceras* ? sp.] *Macrocephalites keeuwensis gamma* var. *bifurcata* Boehm [=? *Eucycloceras* sp.indet.] *Macrocephalites keeuwensis beta-gamma* Boehm, pl.5, fig.2; pl.3, fig.4 [=*Subkossmatia obscura boehmi* Westermann & Getty]	Windesi, N. Lenggoeroe	3	Boehm, 1913
	Subkossmatia obscura boehmi Westermann & Getty (?) *Eucycloceras intermedium* Spath	Iwaboe River, Kemaboe	1	Westermann & Getty, 1970
Low. Callovian	*Stephanoceras* sp.indet.ex aff. *lamellosi* (Sowerby) [=*Kamptokephalites etheridgei* Spath] *Stephanoceras* sp.indet.ex aff. *calloviensis* (d'Orb.) [= *Dolikephalites flexuosus* Spath	Strickland River	4	Etheridge, 1890
	Macrocephalites [= *Bullatimorphites* ? sp.] ?*Quenstedtoceras* [= *Macrocephalites* sp.] *Coeloceras* ? [= *Irianites* ? sp.] *Inoceramus* cf.*galoi* Boehm *Belemnites*	S. slope of Central Range (Setakwa, Digoel, B-Rivers)	10	Martin, 1911
	Phylloceras mamapiricum Boehm [= *Holcophylloceras mamapiricum* (Boehm)] *Phylloceras* sp. *Oppelia* sp. *Macrocephalites* (*'Dolikephalites'*) cf.	Lenggoeroe	3	Boehm, 1913

Table 6. Fossil list of Marine Jurassic in New Guinea.

M.keeuwensis BOEHM			
Coeloderoceras aff.*moermanni* (KRUIZINGA) [= *Irianites moermanni* (KRUIZINGA)]	Wairori, Vogelkop	9	GERTH, 1927
Idiocycloceras cf. *I. bifurcatum* (BOEHM) *Macrocephalites (Dolikephalites) keeuwensis* BOEHM *Macrocephalites (Dolikephalites)* cf. *keeuwensis* BOEHM *Macrocephalites (Dolikephalites)* aff. *subcompressus* (WAAGEN) ? *Macrocephalites (Kamptokephalites) terebratus* (PHILLIPS) [=? *Macrocephalites (Kamptokephalites)* sp.] *Macrocephalites (Kamptokephalites) beta-gamma* BOEHM *Macrocephalites (Kamptokephalites)* sp. *Macrocephalites (? Pleurocephalites)* sp. juv. *Macrocephalites* ? sp. *Normannites* cf. *moermanni* (KRUIZINGA) [= *Irianites moermanni* (KRUIZINGA)] *Stemmatoceras brodiaei* (SOWERBY) [= *Stephanoceras (Stemmatoceras?) etheridgei* GERTH] *Stemmatoceras* aff. *indicum* (KRUIZINGA) [= *Stephanoceras (Stemmatoceras)* cf. *etheridgei* GERTH]	Lenggoeroe area (N of Jamoer River, WSW of Windesi, Waro River, Head-water of Wati)	3	DONOVAN, in VISSER & HERMES, 1962
Pelecypods	Upper Fly River	7	OSBORNE, 1945
Macrocephalites sp. ? *Lytoceras* Belemnite *Homomya* *Inoceramus*	Woesi River, Tributary of Lorentz River	11	TERPSTRA, 1939
Macrocephalites keeuwensis BOEHM *Idoceras* cf. *mihanum* BOEHM	Upper Sepik River Float	6	SCHLÜTER, 1928
Macrocephalites keeuwensis BOEHM ? *Macrocephalites ('Kamptokephalites')* sp.	Jakati River, Vogelkop	12	VISSER & HERMES, 1962
Macrocephalites like Ammonite Belemnite	Area around Wissel lakes	5	VISSER & HERMES, 1962
Macrocephalites keeuwensis alpha BOEHM *Macrocephalites keeuwensis beta*	Sinak River, Jamo	13	GERTH, 1965

BOEHM

Bathonian -Low. & Mid. Callovian	*Inianites moermanni* (KRUIZINGA) *Bullatimorphites (Treptoceras)* aff. *B. uhligi* (POPOVIC-HAZEG) *Bullatimorphites* (?) *(Treptoceras ?)* aff. *B. microstoma* (D'ORBIGNY) *Bullatimorphites ? (Treptoceras ?) costidensus* WESTERMANN & GETTY *Bullatimorphites* ? n.sp. (*Treptoceras* ?) *Bullatimorphites* ? sp. nov.	Iwaboe River, Kemaboe	1	WESTERMANN & GETTY, 1970
Bathonian	*Stephanoceras* sp. [= *Cadomites* ? ex gr. *C. rectelobatus* (HAUER) *Tulites (Rugiferites) ? godohensis* (BOEHM)	Windesi, N. Lenggoeroe	3	BOEHM, 1913
	Bullatimorphites (Treptoceras) aff. *B. uhligi* (POPOIVIC-HAZEG)	Wairori, Vogelkop	9	GERTH, 1927
	(?) *Cobbanites* aff. *C. engleri* (FREBOLD)	Iwaboe, Kemaboe	1	WESTERMANN & GETTY, 1970
Up. Bajocian	? *Cadomites daubenyi* (GEMMELLARO) *Sphaeroceras* cf. *submicrostoma* GOTTSCHE [= *Chondroceras ? (Praetulites) kruizingai* WESTERMANN]	Windesi	3	BOEHM, 1913
Mid. Bajocian	*Normannites* cf. *itinsae* (MCLEARN) [= *"Itinsaites" itinsae*] *Stephanoceras (Stemmatoceras)* cf. *S. frechi* (RENZ) *Stephanoceras (Stephanoceras)* sp. *Stemmatoceras* cf. *coronatum* QUENSTEDT [= *Stephanoceras (Teloceras)* cf. *S. itinsae* (MCLEARN)]	Lenggoeroe area, (Headwater of Wati)	3	DONOVAN, in VISSER & HERMES, 1962
	Lamellibranchiata Brachiopoda *(Rhynchonella ?)* Echinoid Stephanoceratidae Ammonite	Toeaba & Kamora Rivers (S slope of central range)	14	VISSER & HERMES, 1962
	? *Stephanoceras (Stemmatoceras ?) etheridgei* (GERTH) *Stephanoceras* s.l. (probably *Itinsaites*) *Itinsaites* aff. *mackenzii* MCLEARN	Wairori	9	GERTH, 1927
	Chondroceras (Defonticeras ?) boehmi WESTERMANN *Stephanoceras* of *S. humphriesianum* group	Windesi	3	BOEHM, 1913
	Stephanoceras (Stephanoceras) aff. *humphriesianum* (SOWERBY) (?) *Stephanoceras (Stemmatoceras) etheridgei* (GERTH) *"Itinsaites"*	Iwaboe, (Kemaboe)	1	WESTERMANN & GETTY, 1970
Low. Bajocian	*Otoites antipodus* ARKELL [= *Pseudotoites (Latotoites)* cf. *P. woodwardi* (CRICK)]	Roemberpon Isl.	15	ARKELL, in VISSER

Table 6. Fossil list of the Marine Jurassic in New Guinea.

	Pseudotoites cf. *spitiformis* ARKELL [= *Pseudotoites* sp.]			& HERMES, 1962
	Docidoceras (Docidoceras) longalvum cf. *limatum* (POMPECKJ) *Fontanesia* aff. *F. clarkei* (CRICK) (subsp. *kiliani* (KRUIZINGA))	Iwaboe, Kemaboe	1	WESTERMANN & GETTY, 1970
Age unknown	*Ctenostreon* cf. *terquemi*	Setakwa River	16	NEWTON, 1916
	Grammatodon (Indogrammatodon) virgatus (SOWERBY)	Kembelangan Well 1	17	VISSER & HERMES, 1962
Mostly Callovian & Bathonian, Tithonian forms present	*Idoceras molengraffi* (KRUIZINGA) (WI0004) New form of Ammonite (WI0004) Belemnite (WI0004)	Ok Japi	18	KOBAYASHI & BURTON, 1971 (determination SATO)
	Pseudoperisphinctid (cf. *Cobbanites*? sp. (503B, 504A) Perisphinctid (cf. *'Kossmatia' indica* KRUIZINGA) (504) *Lytoceras* sp. (504) *Eucycloceras* sp. (509) *Dolikephalites* ? sp. (510)	Ok Atem, Ok Bon. 25 & 45 km W of the border of Papua-New Guinea		

*Numbers indicate the location on the map (Fig. 4).

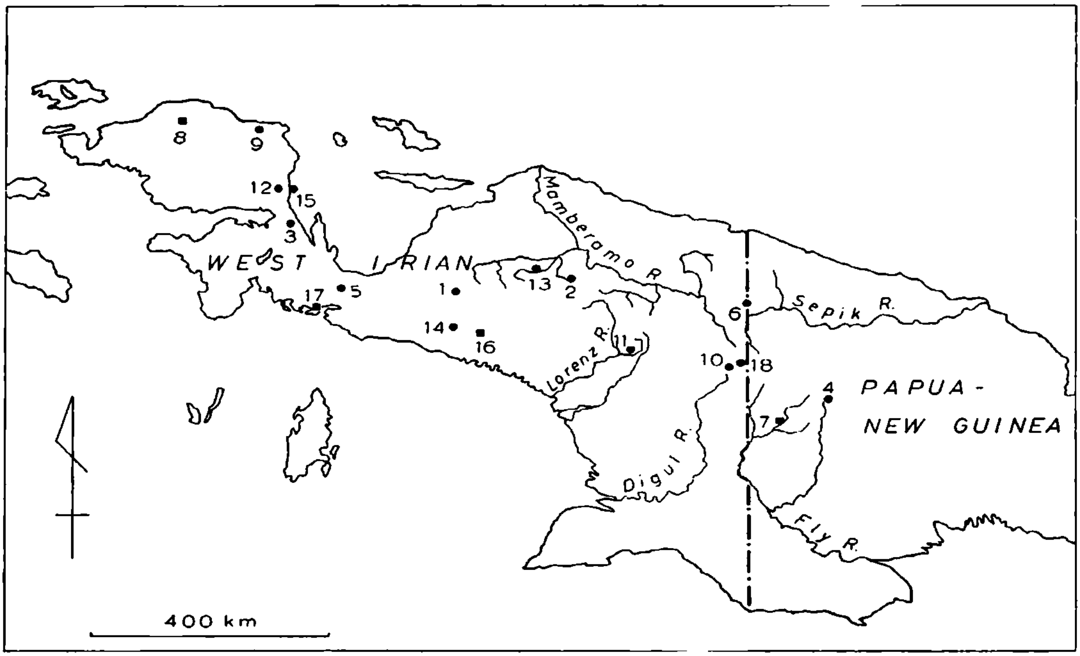
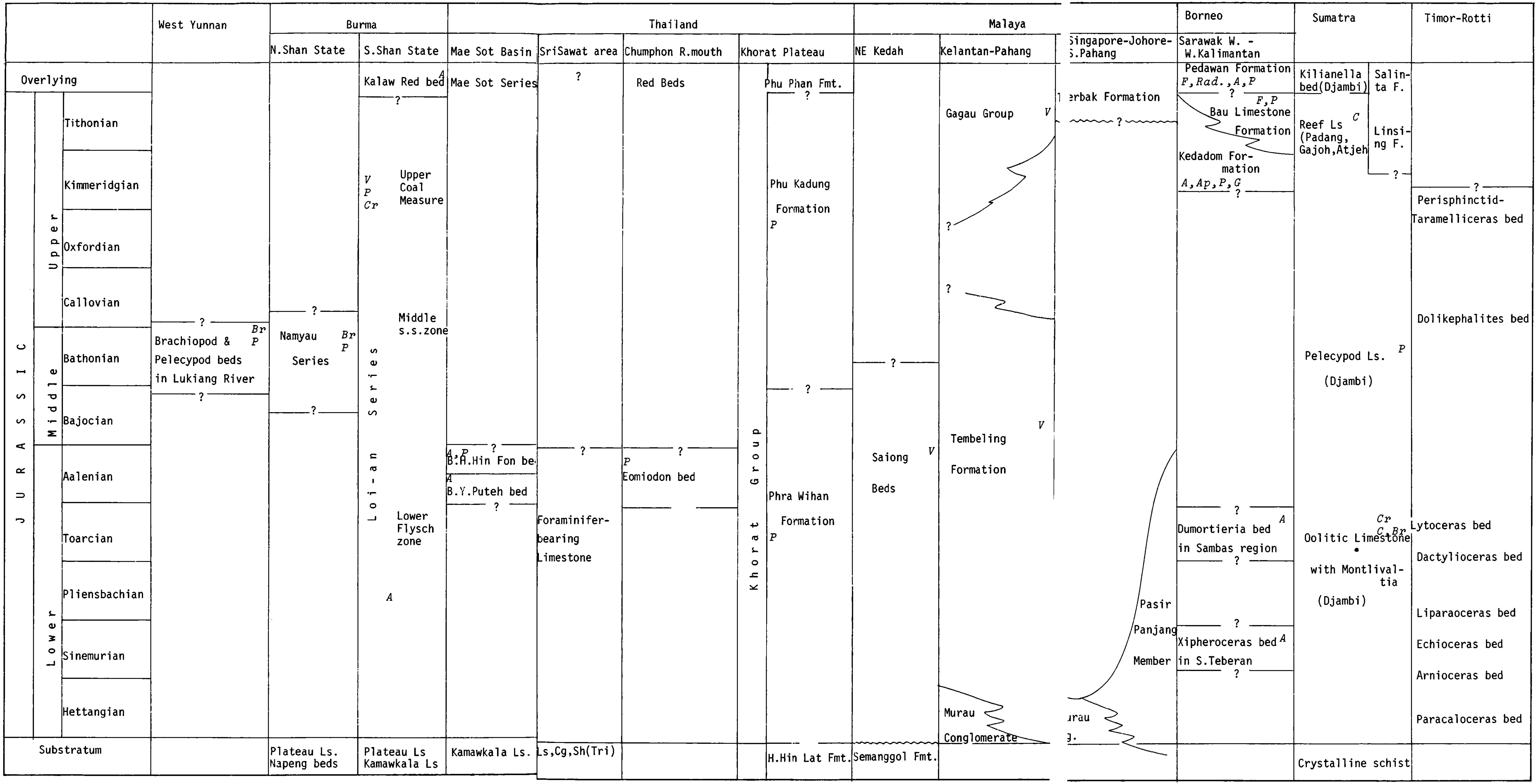
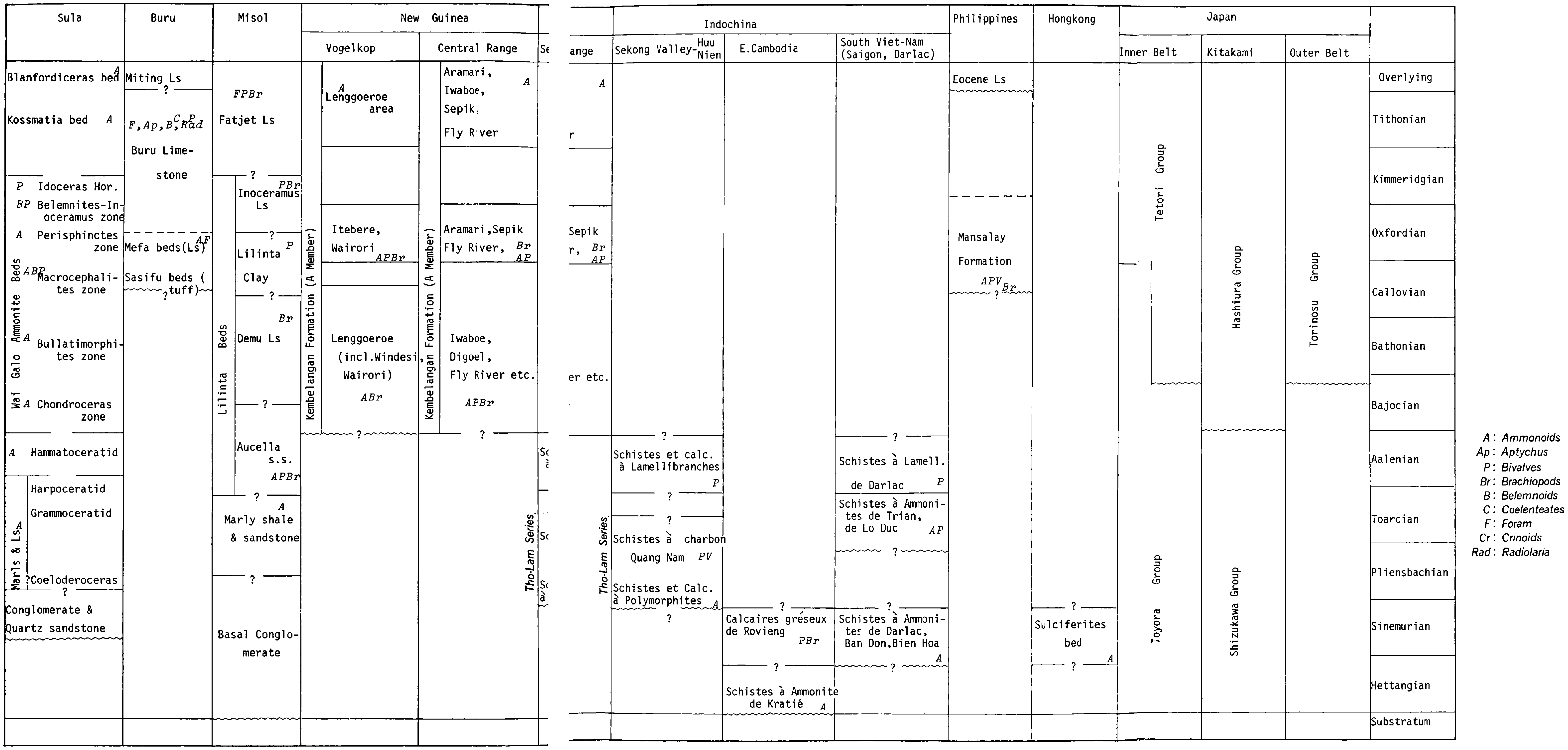


Fig. 4. Fossil localities of the marine Jurassic fauna in New Guinea. For legend, refer to the Fig. 1



West Yunnan
Burma
N.Shan State
S.Shan State
Thailand
Mae Sot Basin
SriSawat area
Chumphon R.mouth
Khorat Plateau
Malaya
NE Kedah
Kelantan-Pahang
Singapore-Johore-S.Pahang
Borneo
Sarawak W. - W.Kalimantan
Sumatra
Timor-Rotti
Overlying
JURASSIC
Upper
Middle
Lower
Tithonian
Kimmeridgian
Oxfordian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Substratum
Brachiopod & Pelecypod beds in Lukiang River
Br P
Namyau Series
Br P
Plateau Ls. Napeng beds
Kalaw Red bed
A
V P Cr
Upper Coal Measure
Middle s.s.zone
Loi-an Series
Lower Flysch zone
A
Plateau Ls Kamawkala Ls
Mae Sot Series
A,P
B.H.Hin Fon bed
A
B.Y.Puteh bed
Kamawkala Ls.
Foraminifer-bearing Limestone
Ls,Cg,Sh(Tri)
Red Beds
P
Eomiodon bed
Phu Phan Fmt.
Phu Kadung Formation
P
Khorat Group
Phra Wihan Formation
P
H.Hin Lat Fmt.
Saiong Beds
V
Semanggol Fmt.
Gagau Group
V
Tembeling Formation
V
Murau Conglomerate
Kerbak Formation
Pasir Panjang Member
Murau Cg.
Pedawan Formation
F, Rad., A, P
F, P
Bau Limestone Formation
Kedadom Formation
A, Ap, P, G
Dumortieria bed in Sambas region
A
Xipheroceras bed in S.Teberan
A
Kilianella bed(Djambi)
Salinta F.
Reef Ls (Padang, Gajoh, Atjeh)
C
Linsing F.
Pelecypod Ls. (Djambi)
P
Cr C Br
Oolitic Limestone with Montlivaltia (Djambi)
Crystalline schist
Perisphinctid-Taramelliceras bed
Dolikephalites bed
Lytoceras bed
Dactylioceras bed
Liparaoceras bed
Echioceras bed
Arnioceras bed
Paracaloceras bed



Sula
Buru
Misol
New Guinea
Vogelkop
Central Range
Se
ange
Indochina
Sekong Valley-Huu Nien
E.Cambodia
South Viet-Nam (Saigon, Darlac)
Philippines
Hongkong
Japan
Inner Belt
Kitakami
Outer Belt
Blanfordiceras bed A
Kossmatia bed A
P Idoceras Hor.
BP Belemnites-Inoceramus zone
A Perisphinctes zone
ABP Macrocephalites zone
A Bullatimorphites zone
A Chondroceras zone
Wai Galo Ammonite Beds
A Hammatoceratid
Harpoceratid
Grammoceratid
?Coeloderoceras
Marls & Ls. A
Conglomerate & Quartz sandstone
Miting Ls
F, Ap, B, C, P, Rad
Buru Limestone
Mefa beds(Ls) AF
Sasifu beds (tuff)
FPBr
Fatjet Ls
Inoceramus Ls PBr
Lilinta Clay P
Demu Ls Br
Lilinta Beds
Aucella s.s. APBr
Marly shale & sandstone A
Basal Conglomerate
Lenggoeroe area A
Itebere, Wairori APBr
Lenggoeroe (incl.Windesi, Wairori) ABr
Kembelangan Formation (A Member)
Aramari, Iwaboe, Sepik, Fly River A
Aramari, Sepik Fly River, Br AP
Iwaboe, Digoel, Fly River etc. APBr
Sepik
r, Br AP
er etc.
Tho-Lam Series
Schistes et calc. à Lamellibranches P
Schistes à charbon Quang Nam PV
Schistes et Calc. à Polymorphites A
Calcaires gréseux de Rovieng PBr
Schistes à Ammonite de Kratié A
Schistes à Lamell. de Darlac P
Schistes à Ammonites de Trian, de Lo Duc AP
Schistes à Ammonites de Darlac, Ban Don, Bien Hoa A
Eocene Ls
Mansalay Formation APV Br
Sulciferites bed A
Tetori Group
Toyora Group
Hashiura Group
Shizukawa Group
Torinosu Group
Overlying
Tithonian
Kimmeridgian
Oxfordian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Substratum
A: Ammonoids
Ap: Aptychus
P: Bivalves
Br: Brachiopods
B: Belemnoids
C: Coelenteates
F: Foram
Cr: Crinoids
Rad: Radiolaria

VII. Faunistic Considerations

Ammonoids:——

A great number of Jurassic ammonites were already known from Southeast Asia. Generally ammonites are distributed in discontinuous sequence, and the successions of assemblages are scarcely known except for some cases such as the Sula Island Jurassic.

Faunistically, these ammonites show a strong Pacific and Tethyan affinity, but in some stages endemic forms are prolific.

Lower Jurassic ammonites are reported in Thailand, Indochina, Western Borneo and Indonesia (especially Moluccas). These are represented by genera of generally cosmopolitan distribution. Hettangian Psiloceratids, Sinemurian Arietitids and Echioceratids, and Toarcian Harpoceratids and Grammoceratids are abundantly known in this region, as well as in the northern Pacific and also in the Tethyan belt. These offer a very firm basis for international correlation.

In Indochina, recently discovered Upper Toarcian ammonite fauna from Lo Duc near Bien Hoa, north of Saigon, shows stronger affinity with the Tethyan fauna than the northwestern Pacific one. This is composed of *Dumortieria* and *Pseudogrammoceras* ? in addition to the world wide *Hammatoceras*. Both generically and specifically, they are more closely allied to the northern Iranian and Caucasian faunas, than nearby Japanese fauna. It is suggested that, at least in Toarcian time, the sea in Indochina was more intimately connected to the Himalayan-Tethyan seas, unlike the suggestion by SAURIN (1956) or by FROMAGET (1941) that the Jurassic sea in Indochina was invaded from the south. West Kalimantan genera, though quite few, show evidently close affinity to Indochinese ones, as well as the Tethyan one. This is also true for bivalves as reported by HAYAMI (1972).

Aalenian ammonite fauna is known from northwestern Thailand. Its generic composition is similar to that of Northeast Japan (Hosoura Formation, Zone of *Planammatoceras hosourense* and Zone of *Hosoureites ikianus*) and also that of the corresponding formation in South Alaska and Western Canada (SATO, 1962). The fauna of similar composition is, however, widely developed in the Tethyan realm. The free seaway connecting Tethys and the Pacific is suggested in this stage.

According to ARKELL (1956), a Pacific realm began to individualize in the Bajocian (Middle Bajocian in English sense). This is represented by the occurrence of an endemic genus, such as *Pseudotoites* of Otoitidae, in Moluccas and New Guinea, along the present east coast of the Pacific as far north as South Alaska. However, associated genera are mostly Tethyan or cosmopolitan.

In the Bathonian, globally poorly developed stage, except in Tethys, is represented partly in Southeast Asia, namely in Moluccas and New Guinea. *Irianites* are endemic in Moluccas and New Guinea and are Bathonian. The Namyau beds in the North Shan States of Burma are dated by brachiopods but not by ammonites.

Callovian ammonites show again characteristically Tethyan affinity in Southeast Asia. The great proliferation of true Macrocephalitidae (*Macrocephalites, Dolikephalites, Kamptokephalites*) are noted everywhere in Moluccas and New Guinea, accompanying introduction of essentially Indian genera, such as *Eucycloceras, Idiocycloceras* and *Subkossmatia.* This is a great contrast to the northern Pacific faunas, exemplified by Alaskan and Canadian predominantly arctic faunas. Japan stood between two realms, and was inhabited by only cosmopolitan genera with temporary introduction of a boreal genus (*Seymourites*). The lowest member of the Mansalay Formation in Mindoro, Philippines, is dated at Callovian by the occurrence of Hecticoceratinae genera. Because the Hecticoceratinae are widely distributed in the Tethyan realm, exclusion of characteristic Tethyan Macrocephalitids in the Philippines might signify that the Hecticoceratinae spread over the northern limit of the Macrocephalitidae, reaching as far as Japan.

A similar case is recognized in the Oxfordian. The Indonesian-New Guinean province is characterized by the Tethys-Pacific assemblage, composed of Perisphinctid, Aspidoceratids and some Oppeliids, in addition to Indian genera such as *Mayaites* and its allied genera. The Middle and Uper members of the Mansalay Formation in the Philippines are devoid of Mayaitids, but comprise many common elements as in the Japanese equivalents. *Kranaosphinctes* and *Dichotomosphinctes*, rather cosmopolitan, reveal the close affinity not only to Tethys but also to Japan.

Kimmeridgian and Tithonian are generally meagerly documented and if present, confined to Moluccas and New Guinea. The contemporaneous sediments are mostly continental in Thailand and Malay Peninsula. Where marine strata are deposited and preserved, Indo-Paicfic faunas represented by *Aulacosphinctoides-Kossmatia-Blanfordiceras* assemblage are distributed (ENAY, 1973).

Bivalves:——

Because bivalves are strongly influenced by environments, their fossil assemblages are difficult to compare biogeographically between different areas. However, on a global scale, Jurassic bivalvian faunas have some provincialities, as shown by HALLAM (1971). In Indonesia and its neighborhood, *Inoceramus galoi* or *Malayomaorica* are rather indigeneous genera, and show somewhat clearly demarcated provinciality. There are some other examples of belemnites of the Southeast Asian province (e.g. STEVENS, 1963).

Recent studies on Jurassic bivalves found in Southeast Asia demonstrated similar facts. Toarcian bivalves collected from South Viet-Nam were directly identified to European species, and it was considered that Indochina was very closely related to the Tethyan province (COUNILLON, 1909; SAURIN, 1935). HAYAMI (1972) studied Toarcian bivalves collected by FONTAINE at Lo Duc, north of Saigon, and clarified that, though some elements constituting the said fauna are, in fact, very closely related to Indian or Tethyan faunas, certain number of species are indigeneous to Indochina. He gave a list of bivalves of the same age described and reported from South Viet-Nam, of which a part was systematically revised. His list shows that the Lo Duc fauna is the most prolific assemblage of Lower Jurassic bivalvian faunas in Southeast Asia, and can be considered to be a standard.

However, there are some other bivalvian faunas of different ages in Indochina. The famous Huu Nien fauna of presumably the lower Lower Jurassic has no common characteristic with the Lo Duc fauna. It comprises also many indigeneous elements. But both show no linkage between Japan and Indochina.

Upper Jurassic bivalvian faunule collected from the Mansalay Formation shows, in turn, some affinity with the Japanese contemporaneous ones. Especially its Trigonian constituents (*Myophorella* and others) contain identical species with the Japanese, beside *Inoceramus galoi* which is confined to the Indonesian-3 N arc province (KOBAYASHI, 1957; HAYAMI, 1968).

Therefore, bivalves in Southeast Asia show definitely the Tethyan aspect in some stages of the Jurassic, but links western Pacific and Tethyan realms in other stages. From the faunistic viewpoint, much awaits to be elucidated at present.

References

ANDAL, D. R., ESGUERRA, J. S., HASHIMOTO, W., REYES, B. P. and SATO, T. (1968): The Jurassic Mansalay Formation, Southern Mindoro, Philippines. *G.P.S.E.A.*, **4,** 179–197.

ANDAL, P. P. (1966): A Report on the Discovery of Fusulinids in the Philippines. *Phil. Geol.*, **20**(1), 14–22.

ARKELL, W. J. (1956): Jurassic Geology of the World. 806 p., 46 pls. *Oliver & Boyd*, Edinbourgh.

BAUM, F., VON BRAUN, E., HAHN, L., HESS, A., KOCH, K. E., KRUSE, G., QUARCH, H. and SIEBENHÜNER, M. (1970): On the Geology of Northern Thailand. *Beih. Geol. Jahrb.*, **102,** 23p., 1 map.

BEMMELEN, R. W. van (1949): The Geology of Indonesia, 732 p. *Government Printing Office,* The Hague.

BOEHM, G. (1913): Unteres Callovien und Coronaten Schichten zwischen MacCluer-Golf und Geelvink-Bai. *Nova Guinea,* **6**(1).

——— (1904, 1907, 1912): Beiträge zur Geologie von Niederlandisch-Indien. *Palaeontogr. Suppl.* **4,** 1–46, 47–58, 59–120, 121–179.

BOURRET, R. (1925): La Chaine Annamitique et le plateau du Bas-Laos à l'Ouest de Hué. *Bull. Serv. géol. Indochine,* **14,** 50–56.

BROILI, F. (1924): Zur Geologie des Vogelkop (N. W. Neu-Guinea). *Dienst. Mijnb. in Ned. Ind. Wetensch. Meded.* **1.**

BROWN, G. F., BURAVAS, S., JAVANAPHET, J. C., JALICHANDRA, N., JOHNSTON, W. D. Jr., SRE-

STHAPUTRA, V. and TAYLOR, G. C. Jr. (1953): Geologic Reconnaissance of the Mineral Resources of Thailand. *Roy. Dept. Mines, Mem.* **1**, Bangkok.

Bureau of Mines (1963): Geological Map of the Philippines, Manila.

BURTON, C. K. (1973): Mesozoic. *in* D. J. GOBBETT & C. S. HUTCHISON eds. Geology of the Malay Peninsula, p. 97–141, Wiley.

CHHIBBER, H. L. (1934): Geology of Burma. McMillan, 538 p., London.

COTTER, G. de P. (1924): The Oil Shales of Eastern Amherst, Burma, with a Sketch of the Geology of the Neighbourhood. *Rec. Geol. Surv. India,* **55**, 282–286.

COUNILLON, H. (1908): Sur le Gisement liasique de Huu-Nien, province de Quang-Nam (Annam). *Bull. Soc. géol. France,* (4), **8**, 524–532.

——— (1913): Flore fossile des Gîtes de Charbon de l'Annam. *Bull. Serv. géol. Indochine,* **1**(2).

COX, L. R. and HOWARTH, M. K. (1960): Molluscs from the Bau Limestone Formation of the Teberkang arca, First Division. *Brit. Borneo Geol. Surv. Annual Rept.* 1960, 47–49.

Department of Mineral Resources (1969): Geological Map of Thailand, 1/1,000,000. Bangkok.

——— (1971): Geology of Thailand (mimeographed explanatory notes on Geological Map of Thailand), 16 p., Bangkok.

DEPRAT, J. (1915): Le Trias et le Lias sur la Feuille de Phu-Nho-Quan. *Bull. Serv. géol. Indochine,* **2**(2).

DEVILLA, E. M. (1941): New Discovery of Mesozoic fossils made on Island of Mindoro. *Phil. Min. News,* **9**(7), 70–71.

——— (1944): A Contribution to the Geology of Mindoro and Palawan. *Rept. 21st committee on Geol. & Geogr. of SE Asia. Japan. Soc. Sci. Promotion,* Tokyo.

EASTON, N. W. (1904): Geologie eines Teiles von West-Borneo. *Jaarb. Mijnwez. in Ned. Oost-Indie, Wet. Ged.*

ENAY, R. (1973): Upper Jurassic (Tithonian) Ammonites. *in* HALLAM ed. Atlas of Paleobiogeography. 297–307.

ETHERIDGE, R. (1890): Our Present state of knowledge of the Paleontology of New Guinea. *Proc. Geol. Surv. New South Wales.* **1**, 172–179.

FONTAINE, H. (1962): Gîsements fossilifères du Bassin houiller du Quang-Nam (centre du Viet-Nam). *Trav. Géol. Univ. Hué., Lab. Géol.,* **1**, 33–52.

——— (1966): Nouveau gîsement d'ammonites sinémuriennes au Darlac (Viet-Nam méridional). *Arch. Géol. Viet-Nam,* **8**, 5–7.

——— (1969): Découverte de gîsements fossilifères dans la Région de Bien-Hoa (Viet-Nam). *C.R. somm. Séance Soc. géol. France,* 1969 (3), 68–69.

FROMAGET, J. (1934): Observations et Réflexions sur la Géologie de l'Indochine. *Bull. Soc. géol. France,* (5), 4.

——— (1941): L'Indochine française. Sa structure géologique, ses roches, ses mines et leurs relations possibles avec la Tectonique. *Bull. Serv. géol. Indochine,* **26**(2), 1–140.

——— (1952): Aperçu de nos Connaissance sur la Géologie de l'Indochine en 1948. *Intern. Geol. Congr., Rept. 8th Session Great Britain,* 1948, pt. 13, 63–77.

GERTH, H. (1927): Ein neues Vorkommen der bathyalen Cephalopoden-Facies des mittleren Jura in Niederländisch Neu Guinea. *Leid. Geol. Meded.* **2**(3), 225–228.

——— (1965): Ammoniten des mittleren und oberen Jura und der ältesten Kreide von Nordabhang des Schneegebirge in Neu Guinea. *N. Jb. Geol. Palaeont. Abh.,* **121** (2), 209–218.

HAILE, N. S. (1969): Geosynclinal Theory and Organizational Pattern of the Northwest Borneo Geosyncline. *Quart. J. Geol. Soc.,* **124**, 171–195.

HALLAM, A. (1971): Provinciality in Jurassic Faunas in relation to Facies and Paleogeography. *in* MIDDLEMISS et al. eds. Faunal Provinces in Space and Time., 129–152.

HASHIMOTO, W. and SATO, T. (1968): Contribution to the Geology of Mindoro and Neighboring Islands, the Philippines. *G.P.S.E.A.,* **5**, 192–210.

——— (1973): *Sarawakia ellipsactionoides,* gen. et sp. nov. an *Ellipsactinia*-like Fossil from the Bau Limestone Formation, Sarawak, Malaysia. *G.P.S.E.A.,* **12**, 207–215.

——— and SATO, T. (1973): Geological Structure of North Palawan and its Bearing on the Geological History of the Philippines. *G.P.S.E.A.,* **13**, 145–161.

——— and TAMURA, M. (1969): Report of Geological and Palaeontological Reconnaissance of Malaysia. *Mem. Fac. Educ. Kumamoto Univ.*, **17**(1), 34–50.

HAYAMI, I. (1960): Two Jurassic Pelecypods from West Thailand. *Trans. Proc. Palaeont. Soc. Japan., N. S.*, **38**, 284.

——— (1964): Some Lower Jurassic Pelecypods from South Viet-Nam, collected by Dr. H. FONTAINE. *Japan.J. Geol. Geogr.*, **35** (2–4), 163–174.

——— (1968): Some Non-Marine Bivalves from the Mesozoic Khorat group of Thailand. *G.P.S.E.A.*, **4**, 100–108.

——— (1968b): Some Jurassic Bivalves from Mindoro. *G.P.S.E.A.*, **5**, 173–185.

——— (1972): Lower Jurassic Bivalvia from the Environs of Saigon. *G.P.S.E.A.*, **10**, 179–230.

HAYASAKA, I. (1943): On the Jurassic Formations of the Philippine Islands. *Taiwan Chigaku Kiji*, **14** (1–2).

HOFFET, J. H. (1933): Etude géologique sur le Centre de l'Indochine entre Tourane et le Mékong (Annam central et Bas Laos). *Bull. Serv. géol. Indochine*, **20** (2).

——— (1937): Les Lamellibranches saumâtres de Senonien de Muong Phalane (Bas-Laos). *Bull. Serv. géol. Indochine*, **24**(1), 3–25.

KOBAYASHI, T. (1957): A Trigonian Faunule from Mindoro in the Philippine Islands. *J. Fac. Sci. Univ. Tokyo*, **10**(3), 251–265.

——— (1963): On the Cretaceous Ban Na Yo Fauna of East Thailand with a Note on the Description of *Nippononaia, Trigonioides* and *Plicatounio*. *Japan. J. Geol. Geogr.*, **34**, 35–43.

——— and KIMURA, T. (1944a): The Permo-Triassic Breaks in the History of Radiolaria supplemented with the Sambosan-Higashigawa Suite. *Proc. Imp. Acad. Tokyo*, **20.**

——— and ——— (1944b): A Study on the Radiolarian Rocks. *Jour. Fac. Sci, Imp. Univ. Tokyo*, sect. II, **7**(2).

———, TAKAI, F. and HAYAMI, I. (1963): On some Mesozoic Fossils from the Khorat Series of East Thailand and a Note on the Khorat Series. *Japan. J. Geol. Geogr.*, **34**, 181–192.

——— and TAMURA, M. (1968): Upper Triassic Pelecypods from Singapore. *G.P.S.E.A.*, **5**, 138–150.

——— and BURTON, C. K. (1971): Discovery of Ellesmeroceroid Cephalopods in West Irian, New Guinea. *Proc. Japan. Acad.* **47**, 625–630.

KOCH, K. E. (1973): Geology of the Region Sri-Sawat-Thong Pha Phum-Sangkhlaburi (Kanchanaburi Province/Thailand). *Geol. Soc. Malaysia, Bull.* **6**, 177–185.

KOMALARJUN, P. and SATO, T. (1964): Aalenian (Jurassic) Ammonites from Mae Sot, Northwestern Thailand. *Japan. J. Geol. Geogr.*, **35** (2–4), 149–161.

KOOLHOVEN, W. C. B. (1935): Het primaire voorkomen van den Zuid-Borneo diamant. *Verh. Geol. Mijnb. Gen. v. Nederl. & Kol., Geol. Ser.*, **11** (1935), 189–232.

KOOPMANS, B. N. (1968): The Tembeling Formation–a Lithostratigraphic description (West Malaysia). *Bull. Geol. Soc. Malaysia*, **1**, 23–43.

KRAUSE, P. (1896): Ueber Lias von Borneo. *Samml. d. Geol. Reichs. Mus. in Leiden*, Ser. 1, 5, 154–168.

——— (1911): Ueber unteren Lias von Borneo. *Samml. d. Geol. Reichs. Mus. in Leiden*, Ser. 1, 9, 77–83.

KRIJNEN, W. F. (1931): Palaeozoic and Mesozoic Gastropoda, Lamellibranchiata and Scaphopoda. *Leid. Geol. Meded. Deel* **5**, 164–205.

KRUIZINGA, P. (1926): Ammonieten en eenige andere fossielen uit de jurassische Afzettingen der Soela-eilanden. *Jaarb. Mijnw. in Ned. Oost-Indie (1925), Verh.* **I**, 11–85.

——— (1931): Cephalopoda. *Leid. Geol. Meded.* Deel **5**, 297–389.

LAMOREAUX, P. E., JAVANAPHET, J. C., JALICHAN, N., CHIANGMAI, P. N., BUNNAG, D., THAVISRI, A. and PAKPRATHUM, C. (1958): Reconnaissance of the Geology and Ground Water of the Khorat Plateau, Thailand. *Geol. Surv. Water Supply Paper*, **1429**, 1–62.

LANTENOIS, H. (1907): Notes sur la Géologie de l'Indochine. *Mém. Soc. géol. France* (4), **1** (4).

——— (1915): Note sommaire sur la Géologie du Sud Annam, de la Cochinchine et du Cambodge. *Bull. Serv. géol. Indochine*, **2**(3).

LEICHTI, P., ROE, F. W. and HAILE, N. S. (1960): The Geology of Sarawak, Brunei, and the western part of North Borneo. *Bull. Brit. Borneo Geol. Surv.*, **3.**

MANSUY, H. (1914): Gîsement liasique des Schistes de Trian (Cochinchine). *Mém. Serv. géol. Indochine,* **3**(2), 37–39.

——— (1919): Faunes triasiques et liasiques de Na Cham, Tonkin. *Mém. Serv. géol. Indochine,* **6**(1).

MARKS, P. (1957): Stratigraphic Lexicon of Indonesia. *Publikasi Keilmuan,* **31,** *Seri Geologi.*

MARTIN, K. (1911): Palaeozoische, Mesozoische und Kaenozoische Sedimente aus dem Suedwestlichen Neu Guinea. *Samml. Geol. Reichsamt. Leiden, Ser.* 1, **9,** 84–107.

NEWTON, R. B. (1897): A Jurassic Lamellibranch from Sarawak, Borneo. *Geol. Mag.*, **4,** 407.

——— (1906): Notice of some Fossils from Singapore discovered by John B. SCRIVENOR, geologist to the Federated Malay States. *Geol. Mag., N. S. Dec. 5,* **3.**

NGUYEN, Van Vinh (1966): Etude géologique de la Concession minière de Nong-Son (Province de Quang-Nam). *Arch. Géol. Viêt-Nam,* **8,** 17–57.

OSBORNE, N. (1945): Mesozoic stratigraphy of the Fly River Headwater, Papua. *Proc. Roy. Soc. Victoria (n.s.),* **56,** 131.

REED, F. R. C. (1924): Provisional list of Palaeozoic and Mesozoic fossils collected by Dr. Coggin BROWN in Yunnan. *Rec. Geol. Surv. India.,* **55,** 314.

RIVERA, R. (1954): Report on fossils from Mindoro, Philippine Islands. *Phil. Geol.,* **8**(2), 63–64.

SATO, T. (1961a): Une Ammonite aalénienne de la Région de Mae Sot, Thailande. *Japan. J. Geol. Geogr.,* **32**(1), 137–139.

——— (1961b): Les Ammonites oxfordiennes de l'Ile de Mindoro, Philippines. *Japan. J. Geol. Geogr.,* **32** (1), 141–143.

——— (1962): Etudes biostratigraphiques des Ammonites du Jurassique du Japon. *Mém. Soc. géol. France,* Mém. **94,** 122p.

——— (1962b): Le Jurassique du Japon-Zone d'Ammonites. *Colloque Jurassique Luxembourg, C. R. et Mém.,* 885–896.

——— (1972): Ammonites du Toarcien au Nord de Saigon (Sud Viet-Nam). *G.P.S.E.A.,* **10,** 231–242.

SAURIN, E. (1935): Etudes géologiques sur l'Indochine du Sud-Est (Sud Annam, Cochinchine, Cambodge oriental). *Bull. Serv. géol. Indochine,* **22**(1), 419 p.

——— (1943): Sur la Présence du Sinémurien au Cambodge. *Bull. Cons. Rech. Sci. Indochine,* Hannoi.

——— (1944a): Sur le Lias de la Moyenne Sékong et les Grès des Bolovens (Bas-Laos). *Bull. Cons. Rech. Sci. Indochine,* 13–19, Hannoi.

——— (1944b): Etudes géologiques sur le Centre-Annam méridional. *Bull. Serv. géol. Indochine,* **27**(1), 210 p.

——— (1956a): La Géologie de l'Indochine. *8th Pacific Sci. Congr. Proc.* **2,** 313–323.

——— (1956b): Extension du Sinémurien au Darlac (Sud Viêt-Nam). *C. R. somm. Soc. géol. France,* **5,** 67–69.

——— (1965): Deux Ammonites du Lias inférieur du Cambodge oriental. *Arch. Géol. Viêt-Nam,* **7,** 52–58.

SCHLUETER, H. (1928): Jurafossilen von Obern Sepik auf Neu-Guinea. *Nova Guinea,* **6**(3), 53.

SCRIVENOR, J. B. (1905): On the Geology of the Residency of Sarawak and the Sadong District, Borneo with special Reference of Gold and Coal. *Governm. Gazette Fed. Malay States. Suppl.* **24.**

——— (1907): Geologists reports of progress, Federated Malay States, Sept. 1903–Jan. 1907, 44p. Kuala Lumpur, Government press.

SERRA, C. (1966a): Etude anatomique et paléogéographique de quelques espèces homoxylées du sud Viêt-Nam et du Cambodge. *Arch. Géol. Viêt-Nam,* **8,** 59–131.

——— (1966b): Nouvelle Contribution à l'étude paléoxylologique du Cambodge, du Laos et du Viet-Nam. *Arch. Géol. Viêt-Nam,* **9,** 17–40.

——— (1967): Sur un nouveau Bois de Gingkoales récolté dans le Hoa-Gia. *Arch. Géol. Viêt-Nam.,* **10,** 93–103.

——— (1968a): Sur quelques végétaux mésozoiques de la Région de Vung-Rua (Province de Quang-Nam). *Arch. Géol. Viêt-Nam,* **11**, 1–19.

——— (1968b): Sur quelques Empreintes mésozoiques de Malaisie. *Arch. Géol. Viêt-Nam,* **11**, 43–51.

SIBINGA, S. F. L. (1940): Der Malaysche Archepel. *Geol. Jahresb. B. Reg. Geol.* **1.**

STEVENS, G. R. (1963): Faunal Realms in Jurassic and Cretaceous Belemnites. *Geol. Mag.,* **100** (6), 481–497.

TAMURA, M. (1973): Two Species of Lower Cretaceous *Parvamussium* from Kyushu, Japan, and Sarawak, Borneo. *G.P.S.E.A.,* **11**, 119–124.

Ta Tran TAN (1968): Ammonites sinémuriennes à Chau-Thoi (province de Bien-Hoa). *Arch. Géol. Viêt-Nam,* **11**, 103–112.

TER BRUGGEN, G. (1935): De Eocene Fyllietformatie in Centraal-Borneo. Diss. Delft.

TERPSTRA, H. (1939): Resultaten van een goud exploratie in het stroomgebied van de Lorentz en de Eilanden rivier in Ned. Nieuw Guinea. *Ingenieur in Ned. Indië.,* **4**, 1–6.

TEVES, J. S. (1957): Philippines. *Lex. Strat. Intern.* **3**, Asie (5).

THEIN, M. and HAQ, B. T. (1970): The Pre-Palaeozoic and Palaeozoic Stratigraphy of Burma. A Brief Review. *Union of Burma Jour. Sci. Tech.,* **2**(2), 275–287.

——— (1973): A Preliminary Synthesis of the Geological Evolution of Burma with Reference to the Tectonic Development of Southeast Asia. *Geol. Soc. Malaysia, Bull.* **6**, 87–116.

VANES, L. J. C. (1918): Es Geologische Kaart van Nederlandsch Indië: Schaal 1/1,000,000, Toelichting bij Blad IX (West-Borneo en Billiton). *Jaarb. Mijnw. Ned. Ind., Verh.* **2**, 1–35.

VISSER, W. A. and HERMES, J. J. (1962): Geological Results of the Exploration for Oil in Netherlands New Guinea. *Konink. Nederlands geol. Mijnb. genoots. Geol. Serie.* deel 20, spec. Nummber.

WANNER, J. (1922): Beiträge zur Geologie und Geographie von Nordost-Borneo. Ergebn. einer von Dr. K. STAMM in den Jaheren 1913 u. 1914 ausgeführten Reise. *Neues. J. Geol. Pal. B. B.,* **45**, 149–213.

——— (1931): Mesozoikum-II Der Juras. *Leid. Geol. Meded.* Deel V.

WESTERMANN, G. E. G. and GETTY, T. A. (1970): New Middle Jurassic Ammonitina from New Guinea. *Bull. Amer. Paleont.,* **57**(256), 231–301.

WILFORD, G. E. (1955): The Geology and Mineral Resources of the Kuching-Lundu area, West Sarawak, including Bau Mining District. *Geol. Surv. Dept. Brit. Terr. in Borneo,* Mem. **3**.

——— and KHO, C. H. (1965): Penrissen area, West Sarawak, Malaysia. Expl. sheets 1–110–2, 1–110–13, and 1–110–14. *Geol. Surv. Borneo Region, Malaysia, Report* **2**.

WOLFENDEN, E. B. (1961): Molluscs from the Bau Limestone Formation of the Tebakang area, First Division. *Brit. Borneo Geol. Surv. Ann. Rept. for 1960,* 47–49.

——— (1965): The Bau Mining District (Bau), West Sarawak, Malaysia. *Bull. Malaysia Geol. Surv. Borneo Region,* **7**(1), 147 p.

WORKMAN, D. R. (1972): Geology of Laos, Cambodia, South Viet-Nam and the Eastern part of Thailand. A Riview. *Inst. Geol. Sci., Rep. (Overseas Div),* **19**, 1–49.

ZEYLMANS VAN EMMICHOVEN, C. P. A. (1939): De geologie van het Centrale en Oostelijke deel van de Westerafdeeling van Borneo. *Jaarb. v. h. Mijnw. Ned. Indie,* **68** (1939), 7–186.