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Sha Jingeng, Shi Xiaoying, Zhou Zhonghe & Wang Yongdong

The Jurassic System of Thailand

Meesook A. & Sha Jingeng



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PREFACE

The Jurassic period (200~145 Ma) witnessed a number of important geological, geographical, climatological, biological and metallogenical events happened globally.

During the Jurassic, China and environs as a domain was bordered by the western palaeo-Pacific in east and by the Tethys in west, and it was connected to Russia in north and located at the junction between the western palaeo-Pacific and northeastern Tethys. The Jurassic rocks of China and environs are therefore the largest geological body which has recorded various geological events happened in the Tethyan, subboreal and palaeo-Pacific realms both in marine and non-marine systems.

The International Jurassic Congress is an international scientific forum on the Jurassic held once every four years sponsored by the International Subcommittee on the Jurassic System. The Jurassic experts and students from around the world gather together to present their recent work and research results on the topics of geology, stratigraphy, palaeontology, palaeobiology, palaeogeography, palaeoecology, palaeoclimatology, sedimentology, geochemistry, palaeomagnetism, tectonics, astronomic geology, and mineral and energy resources, as well as ideas on geosciences education and geoheritage protection, to predict the Earth's future, and to discuss the international collaborations focus on such issues as challenges of global change.

The 8th International Jurassic Congress will be held in China in August of 2010. To provide a better introduction for all the congress participants and colleagues worldwide about the current study on the Jurassic in China and environs, and to highlight the major progresses in global marine and non-marine Jurassic studies made by the Chinese and Asian Jurassic workers, we have compiled a series of books on the Jurassic stratigraphy, consisting of five books, including "The terrestrial Triassic and Jurassic Systems in the Sichuan Basin, China", "The Jurassic System of northern Xinjiang, China", "Outline of the Jurassic and Cretaceous Systems in western Liaoning, NE China", "The Tethyan Jurassic of southern Tibet, China", and "The Jurassic System of Thailand". The first two books mainly describe the non-marine Jurassic and part Triassic strata of the largest basins in Sichuan of southwestern China and northern Xinjiang of western China, the third one outlines the Jurassic and Cretaceous strata that yield the famous Jehol Biota and other lagerstätten in western Liaoning Province, northeastern China, the fourth one introduces the Tethyan marine Jurassic in southern Tibet, southwestern China (to be published after the congress), and the last one describes the marine and non-marine Jurassic strata, faunal associations, palaeoecology, palaeoenvironment, tectonics and palaeogeography of

Thailand.

This series of stratigraphic books are dedicated to the 8th International Congress on the Jurassic System and the UNESCO-IUGS International Geoscience Programme IGCP 506. This work is supported by the National Natural Science Foundation of China, the Ministry of Science and Technology, PRC, the Chinese Academy of Sciences and the Shehong County People's Government of Sichuan Province. We sincerely thank Professors Chen Peiji, Meng Fansong, Zhang Shibei, Zhang Sengui, Lu Huinan and Zhang Yunbai for critically reading the manuscript and providing helpful discussions and comments for the authors. Special thanks are due to Prof. Zhang Sengui, the executive editor, for enormous assistance in editing.

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ABSTRACT

Jurassic rocks of Thailand consist of marine, brackish and non-marine aspects distributed throughout the country. Marine Jurassic rocks are well exposed in the Mae Sot, Umphang, and Phop Phra areas, less extensively near Mae Hong Son, Kanchanaburi, Chumphon, Nakhon Si Thammarat and Krabi. Generally, these rocks are unconformably underlain by Permian and Triassic rocks, and are overlain by Quaternary strata. Fourteen lithostratigraphic units are, in ascending order, defined: Pa Lan, Mai Hung, Kong Mu formations of the Huai Pong Group in the Mae Hong Son area; Khun Huai, Doi Yot, Pha De formations of the Hua Fai Group, Mae Sot area; Klo Tho, Ta Sue Kho, Pu Khloe Khi, Lu Kloc Tu formations of the Umphang Group, Umphang area; and Khlong Min Formation in the Chumphon, Nakhon Si Thammarat, and Krabi areas. Mudstones, siltstones, sandstones, and limestones are dominant lithologies in the Mae Sot, Phob Phra, Umphang, Kanchanaburi and Mae Hong Son areas; marls are found only in Mae Sot. Sequences are approximately 900 m thick (Mae Sot), 450 m thick (Umphang) and thinner elsewhere, especially the south. Based on ammonites, brackish to marine bivalves, and foraminifera, the beds are dated mainly as Toarcian-early Bajocian.

A paleoecological analysis and depositional history of the marine Jurassic strata cropping out in the western part of Thailand are reported, based on bivalve assemblages with additional data from ammonites, brachiopods and microfossils. Generally, the benthic bivalve facies in most outcrops is rich in infaunal, semi-infaunal and epifaunal suspension-feeders. Of these, infaunal forms dominate. The diversity of this benthic assemblage was influenced by energy level, substrate, sedimentation rate and salinity. Low to intermediate energy levels and rather soft fine-grained siliciclastic substrate are proposed as factors governing faunal distribution and explaining the greater abundance and diversity of infaunal than epifaunal suspension-feeders. There were paleoenvironmental change both in space and time, i. e. from north to south (Mae Sot to Umphang) and from Toarcian to early Bajocian. In the Toarcian, most outcrops in Umphang are dominated by benthic bivalve facies (infaunal, semi-infaunal and epifaunal associations) implying warm, shallow water (inner neritic, ? 50~100 m) and oxygenated conditions except for the Mae Sot area where a deeper setting (outer neritic to possibly upper continental slope, 50~200 m) with restricted basinal anoxic conditions is favoured as indicated by the presence of *Bositra*. After higher energy conditions in the Toarcian, lower energy conditions with low sediment supplies prevail in the Aalenian, and the Mae Sot area was

still a restricted basin. As a result of higher sea levels, the oxygen content in the basin is increased, resulting in the presence of the ammonites. By the end of the Alenian-early Bajocian, An ammonite-bivalve association (Mixed Facies A) and the presence of corals and microfauna (Mixed Facies B) are dominant but pass upwards to near-shore higher energy conditions in most areas except for restricted basin in Mae Sot. By the middle Bajocian the environment in all areas had changed from marine to non-marine

Based mainly on 5 measured sections in the Mae Sot area, marine Jurassic rocks of the Khun Huai, Doi Yot, and Pha De formations have been selected for detailed study with the total thickness varying from 200~832 m. The sedimentary sequences of the group are analyzed in terms of lithofacies association representing the shoreface, fan-deltas, protected lagoon, intertidal, subtidal and inner to outer ramp environments with occasional carbonate platform and reef flat. The Toarcian rocks were represented by transgressive-regressive (T-R) cycles and gradually changed to the highest sea level and water depth in the Aalenian. During late Aalenian to early Bajocian, sea level was still changing to transgressive phase. After early Bajocian, the sea level was retreated from this area. The eustatic curves in this study during Toarcian-early Bajocian correspond to the global curves, but differ significantly in the Late Jurassic-Cretaceous. In Late Jurassic-Cretaceous, T-R phases were conversely and probably caused by local tectonic movements.

The non-marine Jurassic rocks are widespread in the northeastern part (the Khorat Plateau), and partly in the northern, eastern, and southern portions of Thailand. In the Khorat Plateau, the rocks, more than 1,000 m thick, are represented by the Phu Kradung and Phra Wihan formations of the Khorat Group. The rocks are less extensive in the north, east, and south, respectively. Reddish brown to greyish purple sandstones, siltstones, claystones, conglomeratic sandstones and conglomerates are the main lithologies; calcrete nodules are also present in claystones only in the Phu Kradung Formation. The non-marine Jurassic rocks are interpreted as having been deposited mostly by the meandering and braided rivers in semi-arid and slightly humid conditions for the Phu Kradung and Phra Wihan formations, respectively, except for the south where lacustrine deposits dominate. Age determinations are based mainly on vertebrates, bivalves and palynomorphs indicating that the rocks are reassigned to the Jurassic-possibly Early Cretaceous.

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Chapter 1

INTRODUCTION

I. General information

Generally, Jurassic sedimentary rocks of Thailand consist of marine, brackish, and non-marine facies. Marine Jurassic strata are widely distributed in northern, western and peninsular Thailand, whilst non-marine and brackish rocks are widespread in northeastern and southern peninsular Thailand, respectively. These Jurassic rocks are regionally described herein which have been divided as the north-western, northeastern, southeastern, and peninsular regions. Although numerous investigations have been conducted over the last sixth decades in these regions, detailed stratigraphy of the marine Jurassic rocks has been carried out recently by Meesook and Grant-Mackie (1996), Meesook et al. (2006), and recently by Saengsrichan (2007) and Saengsrichan et al. (2009).

In the following account, geographic place names are given in Latin script and include prefixes meaning village (Ban), secondary administrative centre (Amphoe), provincial administrative centre (Changwat), Mountain (Doi), and stream (Huai).

II. Marine Jurassic rocks of Thailand

Brackish to marine Jurassic strata are found in north-western and peninsular Thailand with many lithostratigraphic units and faunal aspects. Based on the physical continuity of lithologic units supported by data from ammonites, bivalves, vertebrates, and some microfossils, new correlations are given. The results provided contribute to correlation within the country and to an improved understanding of the sedimentary and tectonic evolution of the Jurassic rocks of Thailand.

The stratigraphic units described below have already been introduced informally (Meesook & Grant-Mackie, 1994) and the formal definition and description provided later (Meesook & Grant-Mackie, 1996). The correlations given here make use of their data and a further study will document full details of the marine molluscan fauna, including the erection of a number of new species. Additional units are described from peninsular

Thailand where brackish to marine rocks have recently been found. Distribution of marine Jurassic units in Thailand is shown in Figure 1.1.

Mainland Southeast Asia is divided into three major tectonic terranes: Western Burma, Shan-Thai, and Indochina (Burrett, 1974; Stauffer, 1974; Hutchison, 1975; Gatin-sky et al., 1978; Ridd, 1980; Mitchell, 1981; Bunopas, 1982; Burrett et al., 1990). Thailand is made up of both the Shan-Thai terrane in the west and the Indochina terrane in the east. The Jurassic areas are located in the Shan-Thai terrane west of the Nan Suture Zone, which was created during Late Triassic by continent-continent collision with the Indochina terrane to the east (Bunopas, 1982; Hahn et al., 1986). The main area investigated is a long narrow N-S trending strip running along the Thailand-Myanmar border that occupies more than 7,000 km² of the Mae Hong Son, Tak and Kanchanaburi areas, with three isolated areas, the Chumphon, Nakhon Si Thammarat, and Krabi Provinces in southern peninsular Thailand (see Figure 1.1).

Geologically, strata in western and peninsular Thailand range from Precambrian to Quaternary in age. Regional stratigraphic correlations in Thailand have recently been summarized (Bunopas, 1992).

As mentioned earlier, Mesozoic sequences in Thailand can be lithologically subdivided into three main facies: marine, brackish, and the younger continental. Jurassic marine to brackish facies have been reported in the west and south. These sediments are distributed in three basins: the Mae Hong Son-Kanchanaburi Basin in the northwest and west; the Chumphon Basin in the northern part of the peninsula; and the Nakhon Si Thammarat and Krabi in the south. The location and extent, orientation of Jurassic strata in each basin and present relationship between basins resulting from both strike-slip and normal faulting are shown in Figure 1.2. Of these basins, the Mae Hong Son-Kanchanaburi Basin has the most fully developed and widely distributed marine Jurassic. Fossils cited here have been collected during fieldwork by the senior author and colleagues.

III. Jurassic Locality

Six localities of marine Jurassic rocks are distributed in the north-western and southern parts of Thailand i.e., the Khun Yuam-Mae Hong Son, Mae Sot-Umphang and Phop Phra, Chumphon, Thung Song-Khlong Thom, and Ao Luk-Plai Phraya areas, situated in Mae Hong Son, Tak, Chumphon, Nakhon Si Thammarat and Krabi Provinces, respectively (Figure 1.3).

The Khun Yuam-Mae Hong Son area was previously thought to be covered only by marine Triassic rocks trending north-south along the Thailand-Myanmar border. In 1985, Charoenprawat et al. discovered marine Jurassic rocks at Ban Pa Lan and its vicinity, the Muang and Khun Yuam Districts of Mae Hong Son Province. Since then, Mee-

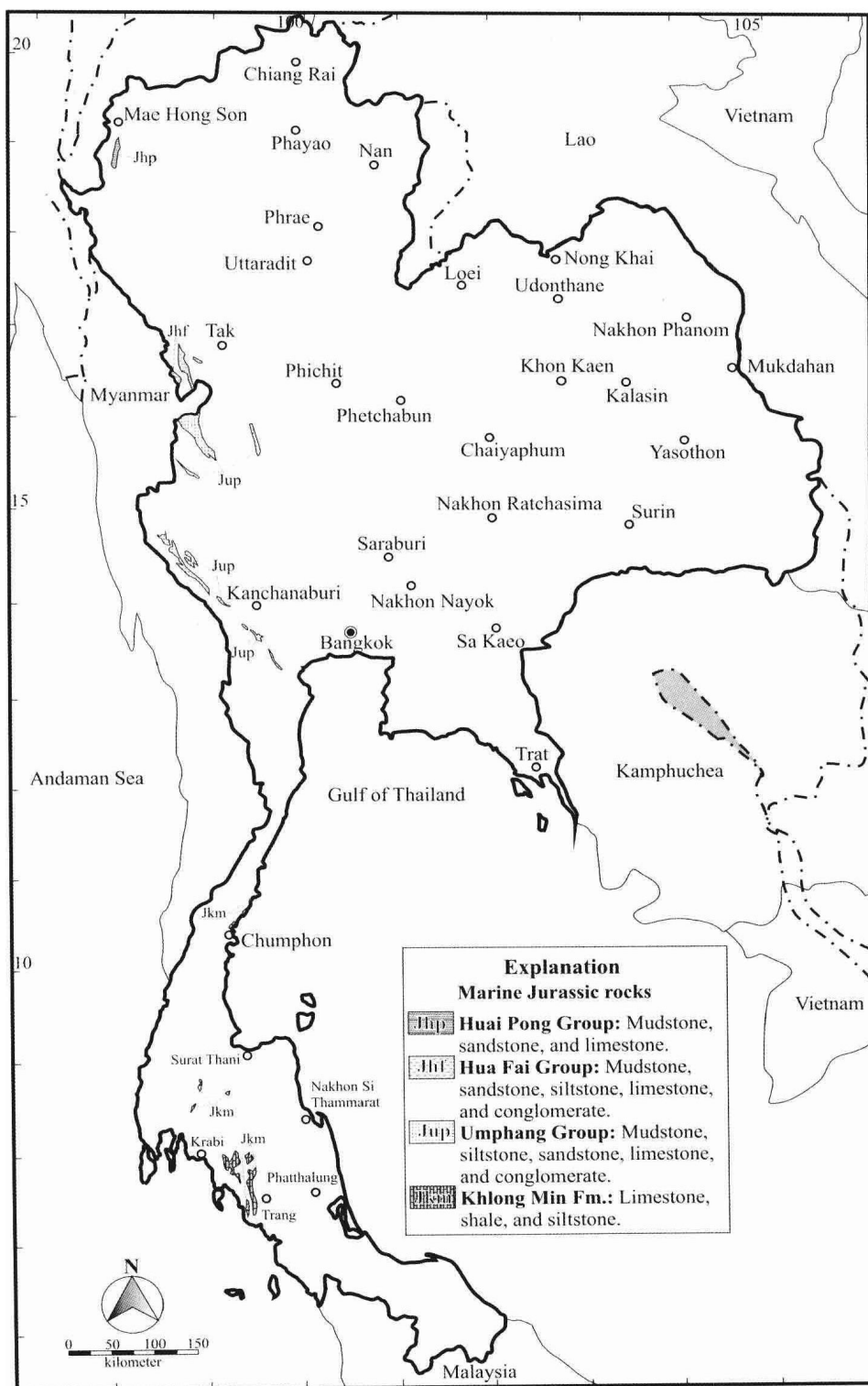


Figure 1.1 Marine Jurassic distribution of Thailand including rock units
(modified after Meesook & Grant-Mackie, 1996)

sook et al. (1985), and Meesook and Grant-Mackie (1994, 1996) have studied the rocks in terms of stratigraphy and paleontology. As a result, many Jurassic bivalves, ammonites and microfossils have been found and can be correlated with those of the Mae Sot-Umphang, and Phop Phra areas. The Mae Sot-Umphang and Phop Phra areas of Tak Province, northwestern Thailand, approximately 2,500 km², are selected to be the first two pilot areas of the country for studying marine Jurassic faunas because of their abundance and diversity. The areas have been investigated by many geologists and paleontologists both Thai and overseas for many years. In the Mae Sot area, marine Jurassic rocks in the eastern and western parts of the Mae Sot Basin, are rich in fossils previously living in very shallow-marine environments, including bivalves, ammonites, corals, gastropods, foraminifera etc. The rocks are also well exposed in the northwest and southeast portions of Phop Phra District covering an area approximately 700 km² and extending into Myanmar. Jurassic rocks are confined to the western part along the Thailand-Myanmar border in the Umphang area.

The sedimentary rocks in these areas consist mainly of marine to brackish clastic facies. The name “Umphang Group” was proposed (Meesook, 1994) for the rocks in this area and this group can be subdivided lithostratigraphically into four formations, in ascending order: Klo Tho, Ta Sue Kho, Pu Khloe Khi, and Lu Kloc Tu formations. In the Mae Sot area, the Hua Fai Group represents a Jurassic sequence, consisting of marine clastic rocks. The group can be divided into three: Khun Huai, Doi Yot, and Pha De formations, in ascending order (Meesook, 1994). In Chumphon Province of Peninsular Thailand, marine to non-marine Cretaceous rocks (the Thung Yai Group) are composed mainly of continental red beds with occasional brackish-marine mudstones, siltstones and limestones. The Jurassic areas are located in Pathiu and Tha Sae Districts, Chumphon Province of approximately 700 km². The marine Jurassic rocks in the Chumphon Basin are also recognised as containing one of the richest faunal assemblages for the non-marine to marine in Thailand. However, these faunal assemblages are undetermined, especially in the area under the present investigation of Chumphon, Nakhon Si Thammarat and Krabi Provinces.

The non-marine (brackish-freshwater-continental) Jurassic rocks in peninsular Thailand have been long known as “continental red beds”, most of which are distributed from Chumphon Province to the north, Nakhon Si Thammarat, and Krabi Provinces to the south, with particular emphasis on the Thung Song-Klong Thom area of Nakhon Si Thammarat and Krabi Provinces, and the Ao Luk-Plai Phraya area of Krabi and Surat Thani Provinces. The Krabi-Khlong Thom sequences consist mainly of marine to brackish and continental red beds. Lithostratigraphically, the Thung Yai Group (Raksaskulwong, 2002) is proposed for the mentioned rocks and this can be subdivided into four formations: Khlong Min, Lam Thap, Sam Chom and Phun Phin formations, in ascending order. Of these, the Khlong Min Formation of Jurassic age is thought to have been

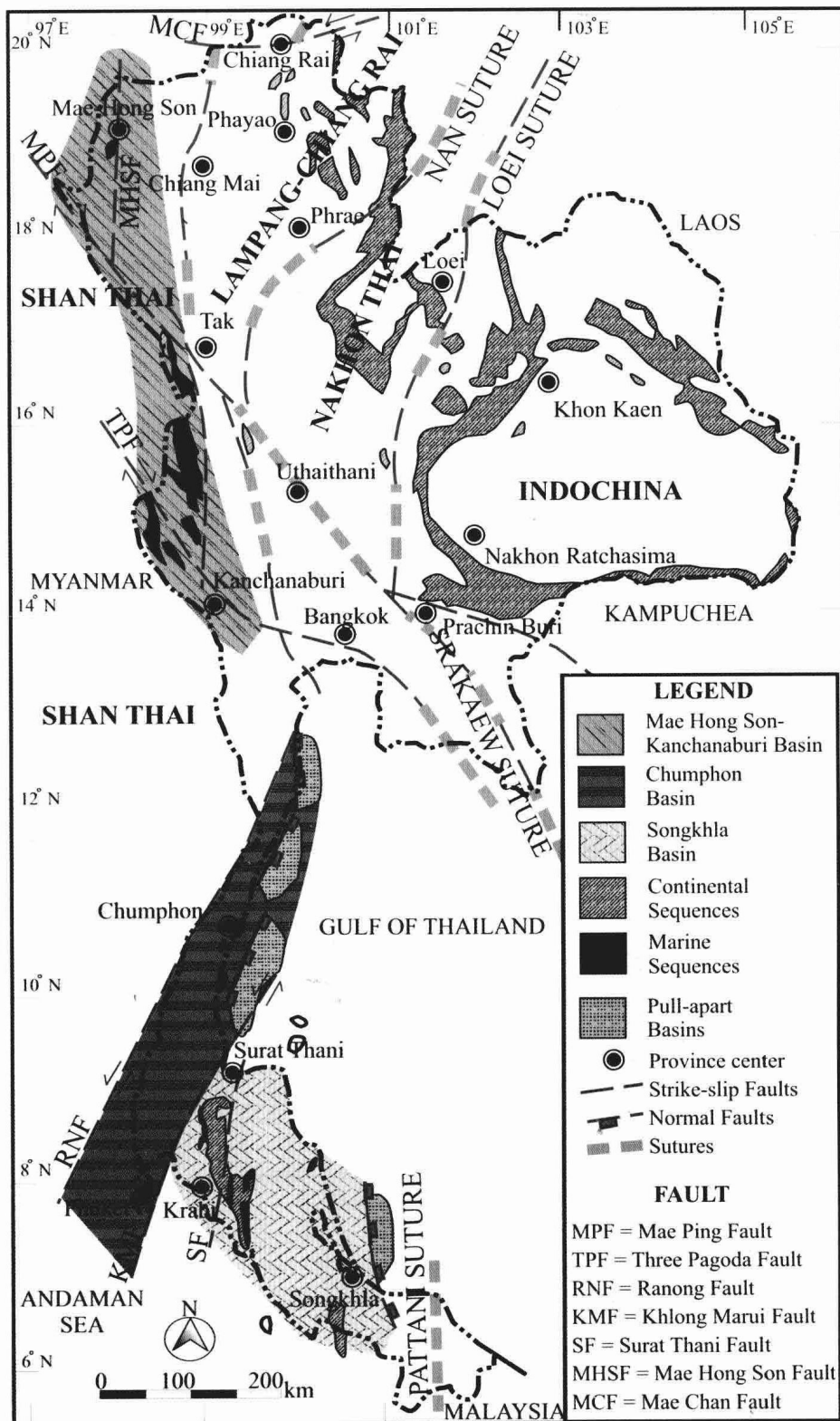


Figure 1.2 Major tectonic units and distribution of the Jurassic-Cretaceous rocks and basins with some major geological structures (modified after Meesook, 1994; Charusiri et al., 2002)

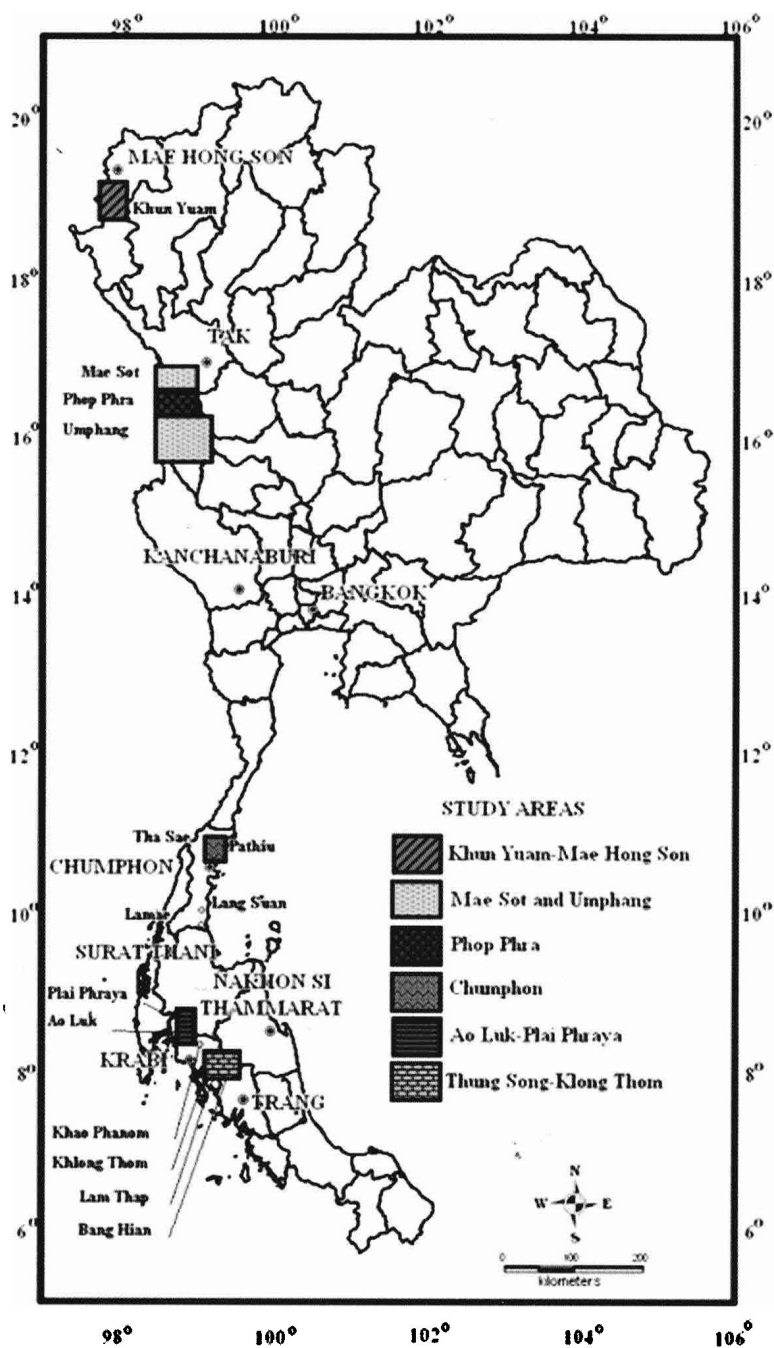


Figure 1.3 The study areas of marine Jurassic rocks of Thailand mentioned in text
(after Meesook et al., 2006)