

中国三叠纪海生爬行类综述¹⁾

李锦玲

(中国科学院古脊椎动物与古人类研究所 北京 100044)

摘要:三叠纪海生爬行类化石广泛分布于中国南方的安徽、湖北、贵州、云南、广西和西藏。它们不仅包括有世界性分布的鱼龙类、鳍龙类、海龙类、原龙类等,而且还有仅出现于扬子海区的湖北鳄类。简单回顾了我国三叠纪海生爬行类的研究历史。根据化石的地史分布确认了自早三叠世晚期至晚三叠世早期的7个海生爬行类组合带。它们是奥伦尼克期的 *Chaohusaurus-Keichousaurus-Hupehsuchus* 组合带,安尼期的 *Chinchenia-Sanchiaosaurus* 组合带和 *Dinocephalosaurus-Mixosaurus* 组合带,拉丁期的 *Dingxiaosaurus* 带和 *Keichousaurus-Nothosaurus* 组合带,卡尼期的 *Anshunsaurus-Qianichthyosaurus-Sinocyamodus* 组合带和诺利期的 *Himalayasaurus* 带。对化石的古地理环境分析表明,我国早三叠世晚期的海生爬行类主要分布于扬子海区东部(安徽、湖北)的浅海开阔台地和局限海台地。中三叠世由于东部地区的抬升,鱼龙类和鳍龙类向西扩散,在扬子区西部(贵州、云南)辐射发展,在拉丁期达到个体数量和种类的高峰。晚三叠世卡尼期动物的数量依然很多,个体有增大的趋向,但高级分类阶元的数量减少,它们埋藏于海水相对较深的浊积岩相中。晚三叠世诺利期的化石发现于西藏的定日和聂拉木,这是中国惟一属于冈瓦那特提斯区的三叠纪海生爬行类组合带,仅含大型的鱼龙类。受动物的生存环境和埋藏条件的影响,我国三叠纪海生爬行类化石记录并不完整。目前尚有相当数量的化石未经研究,已记述的化石也需要在研究程度上进一步深化。

关键词:中国南方,三叠纪,鱼龙类,鳍龙类,海龙类,原龙类,湖北鳄类

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A BRIEF SUMMARY OF THE TRIASSIC MARINE REPTILES OF CHINA

LI Jin-Ling

(Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences Beijing 100044)

Abstract This paper presents a brief review of the Chinese Triassic marine reptiles. Seven biozonations from the upper Lower Triassic to the lower Upper Triassic are recognized. Discussions on the biogeographic and palaeoenvironmental implications of these reptiles are provided.

Key words South China, Triassic, Ichthyosauria, Saurpterygia, Thalattosauria, Protosauria, Hupehsuchia

1 Introduction

Triassic marine reptiles are widespread in the Eastern Tethys Realm of China. In addition

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to an endemic group, hupehsuchids, they include all other forms known from the Western Tethys Province and the East Pacific Region, such as ichthyosaurs, eosauroptrygians, placodonts, thalattosaurs and protosaurs. Up to now, 33 species belonging to 28 genera have been described from this region, although some of their taxonomic status remains disputable on generic or species level, which will be discussed below. The marine reptiles occur in the deposits ranging from the upper Lower Triassic to the lower Upper Triassic in this region, and are distributed in Anhui, Hubei, Guizhou, Yunnan provinces, Guangxi Zhuang Autonomous Region and Xizang (Tibet) Autonomous Region (Fig. 1).

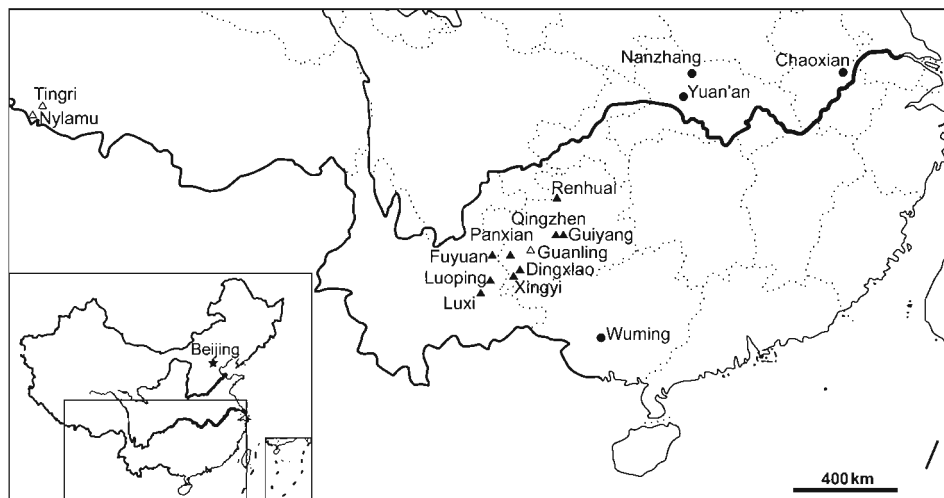


Fig. 1 Map of the South China showing the localities bearing Triassic marine reptiles
 ● Early Triassic; ▲ Middle Triassic; △ Late Triassic

2 Early research history

Study of the Triassic marine reptiles in China can be dated back to the fifties of last century, when *Keichousaurus hui* was discovered and described by C. C. Young in 1958. As a pioneer Chinese vertebrate paleontologist, mainly engaged in lower tetrapods, Young continued his research on marine reptiles since then. Subsequently, he further recognized 5 genera and 6 species of sauropterygians (*Keichousaurus yuananensis* Young, 1965a, *Shingyisaurus unexpectus* Young, 1965a, *Chinchenia suni* Young, 1965a, *Sanchiaosaurus dengi* Young, 1965a, *Kwangsisaurus orientalis* Young, 1959, *Kwangsisaurus lusiensis* Young, 1978), 3 genera 3 species of ichthyosaurs (*Mixosaurus maotaiensis* Young, 1965b, *Chaohusaurus geishanensis* Young et al., 1972, *Tibetosaurus tingjiensis* Young et al., 1982), one questionable thalattosaur (*Hanosaurus hupehensis* Young, 1972a), and one enigmatic aquatic reptile (*Hupehsuchus nanchangensis* Young, 1972b). In addition, 2 genera and 3 species of ichthyosaurs (*Himalayasaurus tibetensis* Dong, 1972, *Chensaurus chaoxianensis* (Chen, 1985), *Chensaurus faciles* (Chen, 1985)) and a genus (*Nanchangosaurus suni* Wang, 1959) closely related to *Hupehsuchus* were described by other students during the same period. All these important discoveries led to a preliminary division of biostratigraphic zonations and interpretation of the Triassic palaeoenvironments in South China.

It is worthy to mention that significant revisions had been made on Chinese sauropterygians, hupehsuchids and ichthyosaurs by both Chinese and foreign paleontologists in the nineties of last century. Carroll and Dong (1991) redescribed the type specimens of *Hupehsuchus nanchangensis* and *Nanchangosaurus suni*, and considered the two genera as representing a previously unrecog-

nized assemblage of Triassic aquatic reptiles, probably sharing a common ancestor with ichthyosaurs. Motani and You (1998) restudied three ichthyosaurs from the Lower Triassic of Chaohu, Anhui, and considered both *Chensaurus chaoxianensis* and *Chensaurus faciles* as synonyms of *Chaohusaurus geishanensis*. Rieppel (1998a, b, 1999) restudied several taxa of sauropterygian erected by Young. He assigned *Shingyisaurus unexpectus* to *Nothosaurus* sp., referred *Hanosaurus hupehensis* to the Pachypleurosauridae, *Chinchenia suni* and *Kwangsisaurus orientalis* to Pistosauroida, and considered *Kwangsisaurus lusiensis* as a taxon close to *Lariosaurus*.

3 Progress in recent years

3.1 New record of marine reptiles including the first placodont, thalattosaur and protosaurus found in South China

Since the end of the last century, study of Triassic marine reptiles in China has entered into a new era along with many discoveries of perfectly preserved skeletons. Fossils of these reptiles include new genera of not only ichthyosaurs and sauropterygians, but also thalattosaurs, placodonts and protosaurs, which are new records in China. They include 2 genera and 2 species of nothosaurs (*Lariosaurus xingyiensis* Li et al., 2002, *Nothosaurus youngi* Li et Rieppel, 2004); 3 genera and 3 species of placodont (*Sinocyamodus xinpuensis* Li, 2000, *Psephochelys polyosteoderma* Li et Rieppel, 2002, *Plachochelys ? minutus* Yin et Luo, 2000 (in Yin et al., 2000)); 2 genera and 4 species of thalattosaurs (*Anshunsaurus huangguoshuensis* Liu, 1999, *Xinpusaurus suni* Yin, 2000 (in Yin et al., 2000), *X. bamaolinensis* Cheng, 2003 and *X. kohi* Jiang et al., 2004); 8 genera 8 species of ichthyosaurs (*Qianichthyosaurus zhoui* Li, 1999, *Cymbospondylus asiaticus* Li et You, 2002, *Panjiangsaurus epicharis* Chen et Cheng, 2003, *Guanlingsaurus liangae* Yin, 2000 (in Yin et al., 2000), *Guizhouichthyosaurus tangae* Cao et Luo, 2000 (in Yin et al., 2000), *Typicusichthyosaurus tsaihuae* Yu, 2000 (in Yin et al., 2000), *Mixosaurus guanlingensis* Cao, 2000 (in Yin et al., 2000) and *Phalarodon* sp. (Jiang et al., 2003)); one genus and species of protosaurus (*Dinocephalosaurus orientalis* Li, 2003). The new discoveries are characterized by both abundant specimens and a significant taxonomic diversity, showing that all the major groups of the Triassic marine reptiles known from the West Tethys Province and the East Pacific Region, including Eosauropterygia, Placodontia, Ichthyosauria, Thalattosauria and Protosauria, are also present in the Triassic of the South China. The discovery of many marine reptiles in the Triassic of South China is also important for biostratigraphic zonation and correlation, and the interpretation of their palaeoenvironments.

3.2 The biozones of marine reptile fossils in South China

Marine deposits of the Triassic age are extensively distributed in South China. Up to now, 7 biozonations of marine reptiles have been recognized from upper Lower Triassic to lower Upper Triassic (Fig. 2). A brief introduction to their geological and stratigraphical distribution, composition of reptile assemblages and links with other marine reptile faunas of the same age will be given as follows.

3.2.1 The assemblage of *Chaohusaurus-Keichousaurus-Hupehsuchus*

Horizon and age

Jialingjiang Formation (Hubei Prov.), Nanlinghu Formation (Anhui Prov.) and Beisi Formation (Guangxi Autonomous Region)

Olenekian, Early Triassic

List of fossils

Ichthyosauria

Grippiidae

Chaohusaurus geishanensis Young et Dong, 1972

Sauropterygia

Pachypleurosauridae

Keichousaurus yuananensis Young, 1965*Hanosaurus hupehensis* Young, 1972

Pistosauroidae

Kwangsisaurus orientalis Young, 1959

Hupehsuchia

Nanchangosauridae

Hupehsuchus nanchangensis Young, 1972*Nanchangosaurus suni* Wang, 1959**Geographical distribution**

Chaoxian, Anhui Province

Yuan'an and Nanzhang, Hubei Province

Wuming, Guangxi Zhuang Autonomous Region

3.2.2 The assemblage of *Chinchenia*-*Sanchiaosaurus***Horizon and age**

Member I of Guanling Formation

Early Anician, Middle Triassic

List of fossils¹⁾

Sauropterygia

Pistosauroidae *incertae sedis**Chinchenia suni* Young, 1965Nothosauria *incertae sedis**Sanchiaosaurus dengi* Young, 1965**Geographical distribution**

Qingzhen and Guiyang, Guizhou Province

3.2.3 The assemblage of *Dinocephalosaurus*-*Mixosaurus***Horizon and age**

Member II of Guanling Formation

Late Anician, Middle Triassic

List of fossils

Protosauria

Family *incertae sedis**Dinocephalosaurus orientalis* Li, 2003

Ichthyosauria

Mixosauridae

(Mixosaurus maotaiensis Young, 1965—a *nomen dubium* (see Motani, 1999))*Phalarodon* sp. (see Jiang et al., 2003)

Sauropterygia

Nothosauridae

Nothosaurus sp. (undescribed specimens)**Geographical distribution**

Panxian and Renhuai, Guizhou Province

3.2.4 The biozonation of *Dingxiaosaurus***Horizon and age**

Yangliujing Formation

1) Including a footprint of *Chirotherium* from Zhenfeng, Guizhou Province (see Wang and Ma, 1989; Zhen et al., 1996).

Early Ladinian, Middle Triassic

List of fossils

Sauropterygia

Pistosauridae

Dingxiaosaurus luyinensis Liu et al. , 2002

Geographical distribution

Dingxiao, Guizhou Province

3.2.5 The assemblage zone of *Keichousaurus-Notosaurus*

Horizon and age

Zhuganpo Member of Falang Formation

Late Ladinian, Middle Triassic

List of fossils

Sauropterygia

Pachypleurosauridae

Keichousaurus hui Young, 1958

Nothosauridae

Lariosaurus xingyiensis Li et al. , 2002

Nothosaurus youngi Li et Rieppel, 2004

(*Shingyisaurus unexpectus* Young, 1965

= *Nothosaurus* sp. (see Rieppel, 1998a))

(“*Kwangsisaurosus*” *lusiensis* Young, 1978

—might represent a taxon close to *Lariosaurus* (Rieppel, 1998c))

Placodontia

Undescribed specimens

Thalattosauria

Undescribed specimens

Ichthyosauria

Undescribed specimens

Protosauria

Undescribed specimens

Geographical distribution

Xingyi, Dingxiao and Anlong, Guizhou Province

Luoping and Fuyuan, Yunnan Province

Luxi, Guangxi Zhuang Autonomous Region

3.2.6 The assemblage zone of *Anshunsaurus-Qianichthyosaurus-Sinocyamodus*

Horizon and age

Wayao Member of Falang Formation¹⁾

Carnian, Late Triassic

List of fossils

Thalattosauria

Askeptosauridae

Anshunsaurus huangguoshuensis Liu, 1999

Thalattosauridae

Xinpusaurus suni Yin, 2000 (in Yin et al. , 2000)

X. bamaolinensis Cheng, 2003

(*X. kohi* Jiang et al. , 2004

—a synonym of *X. bamaolinensis* (Rieppel and Liu, in press))

1) “Wayao Member of Falang Formation” was newly named as “Xiaowa Formation” by Wang et al. (2003).

Ichthyosauria

Shastosauridae

Panjiangsaurus epicharis Chen et Cheng, 2003

Cymbospondylidae

Cymbospondylus asiaticus Li et You, 2002

Guanlingsuridae

Guanlingsaurus liangae Yin, 2000 (in Yin et al., 2000)

Family *incertae sedis*

Qianichthysaurus zhoui Li, 1999

(*Mixosaurus guanlingensis* Cao, 2000 (in Yin et al., 2000)

—a synonym of *Qianichthysaurus zhoui* (Jiang and Li, in press))

(*Guizhouichthysaurus tangae* Cao et Luo, 2000 (in Yin et al., 2000) and

Typicusichthysaurus tsaihuae Yu, 2000 (in Yin et al., 2000), both are *species inquirendae* according to McGowan and Motani (2003))

Placodontia

Family *incertae sedis*

Sinocyamodus xinpuensis Li, 2000

Placochelyidae

Psephochelys polyosteoderma Li et Rieppel, 2002

(*Plachochelys ? minutus* Yin et Luo, 2000 (in Yin et al., 2000)

—a *nomen dubium*)

Geographical distribution

Guanling, Guizhou Province

Probably Qinglong and Xingyi, Guizhou Province

3.2.7 The biozonation of *Himalayasaurus***Horizon and age**

Qulonggongba Formation¹⁾

Norian, Late Triassic

List of fossils

Ichthyosauria

Shastosauridae

Himalayasaurus tibetensis Dong, 1972

(*Tibetosaurus tingjiensis* Young et al., 1982

—a *nomen nudum* for poorly preserved specimens)

Geographical distribution

Nyalam and Tingri, Xizang (Tibet) Autonomous Region

4 The analysis of palaeobiogeography

Early Triassic It is considered that the Early Triassic is the earliest interval that reptiles invaded into marine environment on a global scale. A shallow-water marine environment prevailed in the Yangtze Sea Region of South China during the Early Triassic. Although marine reptiles found in upper Lower Triassic occur sporadically and in very small number, the assemblage of *Chaohusaurus-Keichousaurus-Hupehsuchus* is important for biostratigraphic zonation, correlation and the interpretation of palaeoenvironments. Fossils of this assemblage were mainly discovered in the east part of the Yangtze Region, i. e., *Chaohusaurus* from the Nanlinghu Formation

1) See "Regional Geology of Xizang (Tibet) Autonomous Region" edited by Bureau of Geology and Mineral Resources of Xizang Autonomous Region (1993), Beijing: Geological Publishing House.

Age		Stratigraphical and Geographical distribution						Biozonation	pachypleurosaurs	eusauroptrygians	placodonts	thalattosaurs	ichthyosaurs	hupehsuchus	protosauurs	archosaurs
		Guangxi	Anhui	Hubei	Guizhou	Yunnan	Xizang									
Late Triassic	Norian						Qulong-gongba	<i>Himalayasaurus</i>								
	Carmanian							<i>Anshunsaurus- Qianichthysaurus- Sinocvamodus</i>								
Middle Triassic	Ladinian	Late						<i>Keichousaurus- Nothosaurus</i>								
								Early						<i>Dingxiaosaurus</i>		
	Anisian	Late							<i>Dinocephalosaurus- Mixosaurus</i>							
		Early							<i>Chichenia- Sanchiaosaurus</i>							
Early Triassic	Olenekian							<i>Chaohusaurus- Keichousaurus- Hupehsuchus</i>								

Fig. 2 Stratigraphy of the Triassic in the South China and the temporal distribution of marine reptiles
 — described fossils; == fossils discovered but undescribed

of Chaoxian, approximately 30 km from the Huaiyang Block Mass in the Lower Yangtze Region, and the other 4 genera, *Keichousaurus*, *Hanosaurus*, *Hupehsuchus* and *Nanchangosaurus* from the Jialingjiang Formation of Yuan'an and Nanzhang in east part of the Upper Yangtze Region. There are minor differences in sedimentation environment between the two regions. The Nanlinghu Formation of Chaoxian represents deposition of open platform¹⁾, but the Jialingjiang Formation of Yuan'an and Nanzhang comprises sediments of restricted platform²⁾. *Kwangsisaurus* is the only exception that was found in restricted or semi-restricted platform sediments of the Beisi Formation in the southern Yangtze Region. It is worthy of notice that, so far, there is no marine reptile known in the west part of the Yangtze Region—Yongningzhen Formation, which is also Olenekian in age and deposited in restricted platform³⁾.

Middle Triassic The east part of the Yangtze Region seemed to start an intermittent uplift and subsidence at the beginning of the middle Triassic age, and the deposits of the Badong Formation consist alternatively of marine and terrestrial beds, which contain some terrestrial archosaurs (Zhang, 1975) and amphibians (Liu and Wang, 2005). The appearance of abundant marine reptile fossils in the Middle Triassic of Guizhou and Yunnan provinces along with the occurrence of marine regression in the eastern Yangtze Sea, probably suggests that early marine

1) See "Regional Geology of Anhui Province" edited by Bureau of Geology and Mineral Resources of Anhui Province (1987), Beijing: Geological Publishing House.
 2) See "Regional Geology of Hubei Province" edited by Bureau of Geology and Mineral Resources of Hubei Province (1987), Beijing: Geological Publishing House.
 3) See "Regional Geology of Guizhou Province" edited by Bureau of Geology and Mineral Resources of Guizhou Province (1987), Beijing: Geological Publishing House.

reptiles, ichthyosaurs and pachypleurosaurs migrated westwards, settled down and flourished in the west part of the Yangtze region. As listed above, four assemblage zones are recognized in Members I and II of the Guanling Formation, Yangliujing Formation and the Zhuganpo Member of Falang Formation, respectively.

Member I of the Guanling Formation, Early Anician in age, yielded no ichthyosaurs, but two sauropterygians—*Chinchenia* and *Sanchiaosaurus*. The footprint of *Chirotherium* found also in this horizon indicates a near shore shallow-water sedimentary environment.

Up to now, one protosaurus, *Dinocephalosaurus*, and two ichthyosaurs, *Mixosaurus* and *Phalarodon* have been recorded from Member II of the Guanling Formation, which comprises deposition of partially enclosed shallow sea¹⁾ at the Late Anician age. Some undescribed specimens indicate that nothosaurs, pistosaurs, and even archosaurs may also be members of the fauna.

The Yangliujing Formation, Early Ladinian in age, is represented by a series of gray thin-bedded to massive or brecciated dolomite and a small amount of limestone, which indicate an evaporate sedimentation in semi-restricted platform¹⁾. Such an environment seems to be unfavourable to the marine reptiles, and only one taxon, *Dingxiaosaurus* was reported.

Late Ladinian of the Middle Triassic is a period of great prosperity for marine reptiles. Almost all groups of marine reptiles at the period left their trace in the Upper Yangtze Region. The Zhuganpo Member of the Falang Formation comprise a thick sequence of micritic limestone and verrucose limestone, a deposition of open platform that contains the most abundant and diversified fauna of fossil reptiles. Although only one pachypleurosaurs, *Keichousaurus*, and two nothosaurs, *Lariosaurus* and *Nothosaurus* have been reported, a considerable number of undescribed fossils of placodonts, thalattosaurs, ichthyosaurs and protosaurs have also been collected in the Zhuganpo Member.

Late Triassic A marine regression started at the beginning of Carnian age in the Yangtze Sea, but in some areas, such as Guanling, Xingren, Zhenfeng etc. marine water deepened. In Guanling the Wayao Member of Falang Formation comprises a series of turbidite rocks composed of marl, calcareous and sandy claystone, bioclastic limestone and micritic limestone, which represent a deposition of deep-water shelf facies¹⁾. The fauna of marine reptiles in the Wayao Member is abundant in individual number as that of underlying Zhuganpo Member, but less diverse in high rank taxon. It contains no pachypleurosaurs, nothosaurs or protosaurs that usually lived in shallow-water environment, but contains some large-sized ichthyosaurs, thalattosaurs and placodonts. It is easy to understand that large-sized ichthyosaurs being pelagic reptiles left their bodies in deposition of deep water, but the appearance of thalattosaurs and placodonts in the Wayao Member suggest that *Anshunsaurus* and *Xinpusaurus* might also be living in open sea, and *Sinocyamodus* and *Psephochelys* as benthonic placodonts can tolerant an environment of comparative deep sea.

The stratigraphical and geographical distribution of *Himalayasaurus*, a large ichthyosaur represented by a broken skull and some postcranial bones, has some important implications. It was collected from the Qulonggongba Formation (Norian in age) of Xizang (Tibet), and represents the latest member of Triassic marine reptiles ever found in China and the only occurrence in Gondwanan Tethyan region, rather than East Tethyan region.

5 Conclusion

Despite the remarkable discoveries in recent years the record of the Triassic marine reptiles

1) See "Regional Geology of Guizhou Province" edited by Bureau of Geology and Mineral Resources of Guizhou Province (1987), Beijing: Geological Publishing House.

of China is far from complete due to their unique palaeoenvironment, taphofacies and the insufficient study of the collected fossils. Based on the fact that the earliest ichthyosaur (*Chaohusaurus*) and sauropterygians (*Keichousaurus* and *Hanosaurus*) appeared in the east part of the Yangtze Sea, a westwards spread of marine reptiles is suggested.

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