Lower Silurian graptolite zonation in the eastern Yangzi (Yangtze) Gorges, China

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The Silurian in the eastern Yangzi Gorges is divided into the Longmaxi, Loreiping and Shamao Formations. Eleven graptolite zones, namely, the *persculptus* Zone, *acuminatus* Zone, *vesiculosus* Zone, *acinaces* Zone, *cyphus* Zone, *triangulatus* Zone, *magnus-thuringiacus* Zone, *argenteus* Zone, *convolutus* Zone, *sedgwickii* Zone and *arcuatus* Zone, are recognized from the Longmaxi Formation and the Lower Member of the Loreiping Formation at Wangjiawan section, near Yichang. The 'late Silurian' graptolites reported from the lower part of the Shamao Formation are revised. In the equivalent level *C. nebula, M.* cf. *drepanoformis, Pr. variabilis* and *M. marri* etc. have been found. The graptolite sequence across the Ordovician-Silurian boundary and its international correlation is further discussed.

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Introduction

The Silurian System of the eastern Yangzi (Yangtze) Gorges has remained the focus for studying the Silurian biostratigraphy of China since the pioneering works given by Lee C. C. and Chao Y. T. (1924) and Hsich C. Y. and Chao Y. T. (1925). Numerous workers mentioned or discussed the Silurian divisions and various fossils in it. The first studies on graptolites were made by Sun (1933) and Hsü (1934), and later by Mu (1959, 1962). More systematical descriptions and discussions of both stratigraphy and fossils were carried out by Nanjing Institute of Geology and Palaeontology (1974), Ni (1978) and Ge et al. (1979) in nearby Loreiping, Yichang and by Wang (1978) at Fenxiang, Yichang. The Silurian strata of present area are widespread around the Huanglin anticline (Fig. 1). They are divided into the Longmaxi, Loreiping and Shamao Formations in ascending order. The most representive section lies at Wangjiawan, near Loreiping, the second at Fenxiang. They are 42 km and 31 km NNE of Yichang City, respectively, and rich in various fossils, such as graptolites, brachiopods, trilobites, corals, conodonts, cephalopods and bivalves. The graptolites mainly occur in the Longmaxi Formation. The Loreiping and Shamao Formations, characterized by yielding a number of shelly fossils, yielded only a few graptolites. Based on the researches of the Wangjiawan, Fenxiang and neighboring sections, the latest Ordovician to Silurian graptolite zonation of present area and their correlation are discussed in this paper.

Longmaxi Formation

The Longmaxi Formation is composed of 622.9 m of black and yellowish-green graptolitic shale. Its base is coincident with the first occurrence of the *G. persculptus* zone, which is attributed to the latest Ordovician according to a decision on the Ordovician and Silurian boundary, ratified by the international Commission of Stratigraphy and IUGS. Its top which is the lower part of the Loreiping Formation is drawn at the appearance of abundant shelly fossil-bearing silty mudstone with nodules. The Longmaxi Formation is further divided into a lower Black Shale Member, and an upper Yellowish-green Shale Member (Yan and Wang, 1978).

Black Shale Member

This member is a set of black shale, about 51.9 m thick, the upper part of which gradually weathers into grey black shale, and contains abundant graptolites. Eight graptolite zones can be recognized at Wangjiawan section in descending order:

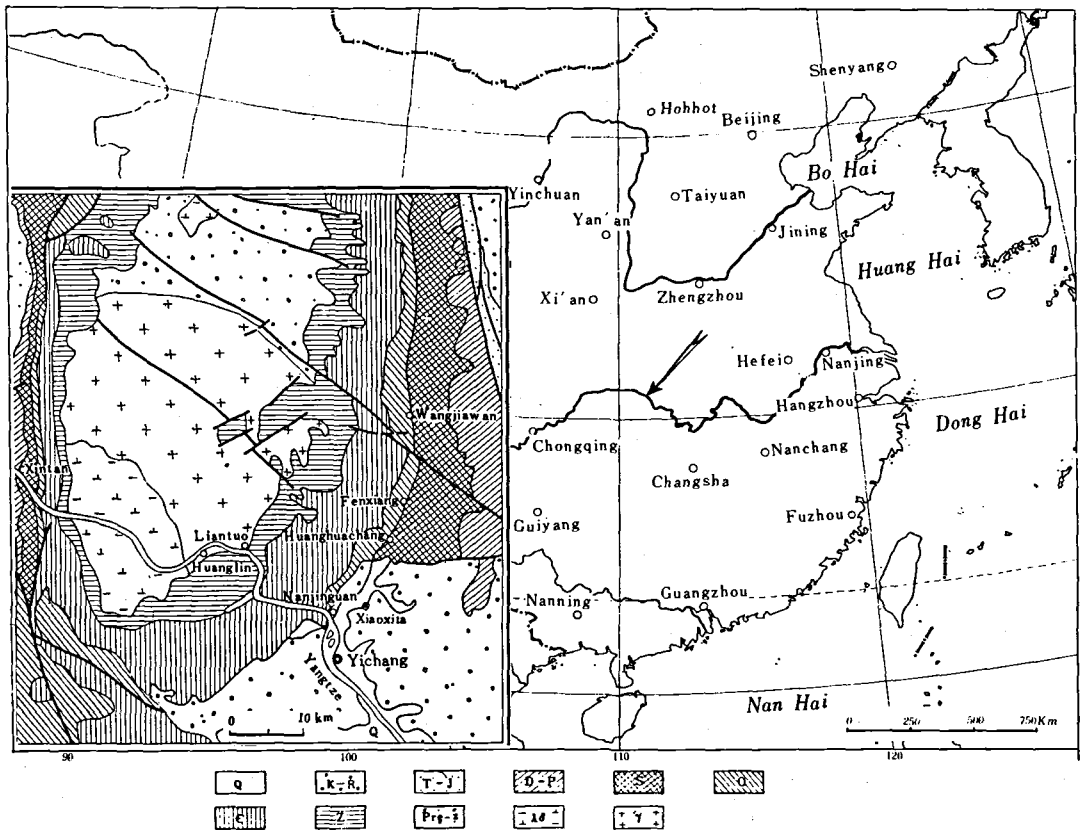


Fig. 1a – b : Geographical and geological position of the sections in the eastern Yangtze Gorges.
a – Geographical outlines ; b – geological map.

Pernerograptus argenteus Zone
Diplograptus magnus-D. thuringiacus Zone
Demirastrites triangulatus Zone
Coronograptus cyphus Zone
Logarograptus acinaces Zone
Orthograptus vesiculosus Zone
Parakidograptus acuminatus Zone
Glyptograptus persculptus Zone

The *Glyptograptus persculptus* Zone

This zone is 0.32 m thick and is characterized by the appearance of *G. persculptus* Salter, associated with *G. gracilis* Ge, *G. maderni* Koren et Mikhaylova, and *Climacograptus angustus* Perner at Wangjiawan section. *Akidograptus ascensus* occurs rarely in the upper part. In addition, *Paraorthograptus* cf. *typicus* (= *P.* cf. *pacificus* Ruedemann), *Climacograptus innotatus* (Nicholson), *C. acanthodus* (Ni) (= *C. multispinus* Wang 1983 and ?*Paraclimacograptus sinitzini* Chaletzkaja), *Diplograptus fusus* Wang have been recorded from this zone of Fenxiang and Huanghuachang sections (Wang et *al.*, 1983a,b). The *G. persculptus* identified by Lin et Chen (1984. pl. 1, figs. 1–3) are generally poorly preserved and some are thought to be similar to those of Bornholm, Denmark (Bjerreskov, 1975), which have a fairly narrow rhabdosome and a low thecal count. In comparison with Williams (1983), it is unclear whether the latter may be assigned to *G. persculptus* s.s. The *G. persculptus* Zone of the present area may with the exception of the underlying 0.7 m thick black shale intercalated with thin-beded metabentonite containing *G. ?'venustus* cf. *venustus*', be correlated with the well-known uppermost Ordovician same name zone of English Lake District (Hutt, 1975), and of Dob's Linn, Scotland (Williams, 1983).

The *Parakidograptus acuminatus* Zone
This zone characterized by the presence of *P. acuminatus* is represented by the greyish-black thin bedded siliceous rock with shale. At Wangjiawan section its thickness is 0.63 m. The following graptolites have been obtained from the exposures: *Akidograptus ascensus, Climacograptus acanthodus* (Ni), *C. rectangularis* M'Coy, *C. medius* Törnquist, *C. innotatus* (Nicholson), *Diplograptus modestus* Lapworth. It is easily correlated with the corresponding *acuminatus* Zone from Bornholm, Denmark and northern Canadian Cordillera (Lenz, 1982) as well as from Britain, and from Mirny Creek and Kazakhstan, USSR (Koren et al., 1979; Apollonov et al., 1980).

The *Orthograptus vesiculosus* Zone
P. acuminatus Zone passes into the *O. vesiculosus* Zone without obvious lithological change. This zone is indicated by the disappearance of *P. acuminatus* and the appearance of abundant *O. vesiculosus,* along with *Diplograptus modestus* Lapworth, *D. longiformis* Wang, *D. thuringiacus* (= *D. elongatus* Churkin et Carterr), *Climacograptus rectangularis* M'Coy, and *C. normalis* Lapworth. Its thickness is 2.6 m. In the Fenxiang section the zone yields *Atavograptus atavus* (Jones). This graptolite assemblage and its stratigraphic position show that the *O. vesiculosus*-Zone of China is equivalent to the *vesiculosus* Zone redifined by Toghill (1968) at Dob's Linn with a 'acme-zone' character and may be correlated with the homonymous zone from Tongzi, Guizhou (Chen et Lin, 1978) and Guanyinqiao, Jijiang, Sichuan (Jin et al., 1982), and Alaska, N. American (Churkin et al., 1971) and with the *A. atavus* Zone of Britain (Rickards, 1976) and northern Cordilera (Lenz, 1982).

The *Lagarograptus acinaces* Zone
No marked lithological change is seen between this zone and the *O. vesiculosus* Zone. The *L. acinaces* Zone is characterized by the appearance of *L. acinaces* (Törnquist) and *Coronograptus leei* (Hsü) in association with *Monograptus? changyagensis* Sun, *Diplograptus mucroterminatus* Churkin et Carter (= *D. acuminatus* Wang, 1977), *D. diminatus* E. et W., and *D. bifurcus* Mu et al. (? = *D. coremus* Chen et Lin, 1978). *L. acinaces* is chosen as zonal designation in place of the original *C. leei* Zone since *C. leei* ranges through the *L. acinaces, C. cyphus* Zones and even higher levels. The *L. acinaces* Zone here is likely correlative to the same name zone of Britain, northern Canada and USSR (Koren, 1973).

The *Coronograptus cyphus* Zone
This zone of the Longmaxi Formation near Loreiping Village was first reported by Mu (1959). This species is quite frequent in the equivalent level on Lipeng, Yidu County (Wang, 1984), but has not been found at the Wangjiawan section. The zone is characterized by the appearance of *Monograptus? revolutus* (Kurck), *Pernerograptus* cf. *austerus* (Törnquist) and *Monoclimacis luncta* Chen et Lin at the Wangjiawan section. The appearance of *Demirastrites triangulatus* marks the end of this zone. Both *M. ?revolutus* and *P. austerus* are representive elements of the *C. cyphus* Zone elsewhere in the world. *M. luncta* is also disignated as an equivalent zonal fossil to *C. cyphus* in Guizhou (Chen et Lin, 1978). The graptolites associated with them, *Diplograptus microterminatus* Churkin et Carter, *D. thuringiacus* Eisel, *Coronograptus* cf. *gregarius* (Lapworth), *Logarograptus* cf. *acinaces* (Törnquist), *Glyptograptus enodus* Packham, are all common elements of the *C. cyphus* Zone. The *C. cyphus* Zone of present area, therefore, is regarded as equivalent to the homonymous zone from Britain, Alaska of North American and USSR, as well as to the *C. gregarius* Zone of northern Cordillera (Lenz, 1982) and the upper part of the *M. ?revolutus* Zone from Bornholm, Denmark (Bjerreskov, 1975).

The *Demirastrites triangulatus* Zone
This zone is about 12.6 m thick at the Wangjiawan section. Its lithological characteristic is similar to that of the underlying *C. cyphus* Zone. The greyish black shale is rich in graptolites. The zone is defined by the disappearance of *C. cyphus* and *M. ?revolutus* and the appearance of *D. triangulatus.* Associated graptolites are *Diplograptus mucroterminatus* Churkin et Carter, *D. thuringiacus* Eisel, *Glyptograptus* cf. *sinuatus* (Nicholson), *Pseudoglyptograptus retroversus* (Bulman et Rickards), *Oktavites communis* (Lapworth), *Petalolithus* cf. *folius* (Hisinger). This graptolite assemblage indicated that the zone here probably correlates with the same name zone of Britain

(Hutt, 1974; Rickards, 1976) and northern Canadian Cordillera (Lenz, 1982) and the lower *C. gregarius* Zone of Bornholm, Denmark (Bjerreskov, 1975).

The *Diplograptus magnus- D. thuringiacus* Zone
This zone, which is 15.2 m thick in the Wangjiawan section, is marked by the appearance of *Diplograptus thurinjiacus.* Other common graptolites comprise *Pribylograptus leptotheca* (Lapworth), *P.* cf. *argutus* (Lapworth) and *Pseudoglyptograptus retroversus* (Bulman et Rickards). *Diplograptus* cf. *magnus* was obtained from the more or less identical level of Gaolou, Ensi City. It is similar to *D. thuringiacus* in the characteristics of rhabdosome and thecae, and differs only in that the latter is bigger. Whether the two species are synonymous is worth considering. Since this assemblage is situated between the *D. triangulatus* and *P. argenteus* Zones, it is likely equivalent to the *D. magnus* Zone of Britain.

The *Pernerograptus argenteus* Zone
This zone, which is situated in the toppest Black Shale Member of Wangjiawan section, is about 5.6 m thick. It is characterized by incoming of *Pernerograptus cygneus* (Törnquist). *P.* cf. *argenteus* was only found at the neighboring Fenxiang section. The common graptolites are *Pernerograptus difformis* (Törnquist), *P. austerus bicornis* (Hutt), *P.* cf. *austerus sequence* (Hutt), *Paramonoclimacis sinicus* (Geh), *Rastrites phleoides* (Törnquist), *Orthograptus* cf. *cyperoides* (Törnquist), *Diplograptus thuringiacus* Eisel, *Pseudoglyptograptus retroversus* (Bulman et Rickards), *Climacograptus scalaris* (Hisinger). *argenteus* and *cygneus* are typical elements for the *P. argentues* Zone of Britain, moreover, Hutt (1975) has shown that *cygneus* is a junior synonym of *argenteus. P. difformis, P. austerus bicornis, P.* cf. *austerus sequence,* on the other hand, are mainly recorded from the *D. triangulatus* and *D. magnus* Zones of Britain (Hutt, 1974). Accordingly, whether the *P. argenteus* Zone of the study area can be correlated with the same zone elsewhere in the world and whether its boundary coincides with the underlying *D. magnus- D. thuringiacus* Zone is worth further study. It is suggested that the Black Shale Member at the Wangjiawan section is correlative with the Rhuddanian to lower Idwian (B1-B2).

Yellowish-green Shale Member
This member consists of yellowish-green shale, and sandy shale with a few sandstone bands, and contains graptolites and few shelly fossils. Its thickness is 571.4 m. The following three graptolite zones, *Demirastrites convolutus, Monograptus sedgwickii* and *Coronograptus ?arcuatus* (= *Monoclimacis arcuata*) zones can be recognized. The uppermost zone can, however, range up to the Loreiping Formation.

The *Demirastrites convolutus* Zone
This zone, which is 51.9 m thick, readly correlates with the same name zone all over the world since the graptolite assemblages are similar. The *D. convolutus* Zone at Wangjiawan section is marked by the incoming of *D. convolutus* (Hisinger), *D. decipiens* (Törnquist), *Streptograptus*

Explanation of Plate 1
Fig. 1. *Glyptograptus persculptus* Salter X9, the *G. pesculptus* Zone, Fenxiang section, Yichang, Hubei.

Fig. 2. *Parakidograptus acuminatus* (Nicholson) X6, the *P. acuminatus* Zone, Wangjiawan section, Yichang, Hubei.

Fig. 3 *Akidograptus ascensus* Davies X3, the *P. acuminatus* Zone, Huanghuachang section, Yichang, Hubei.

Fig. 4. *Diplograptus thuringiacus* Eisel X5, the *D. convolutus* Zone, Wangjiawan section, Yichang, Hubei.

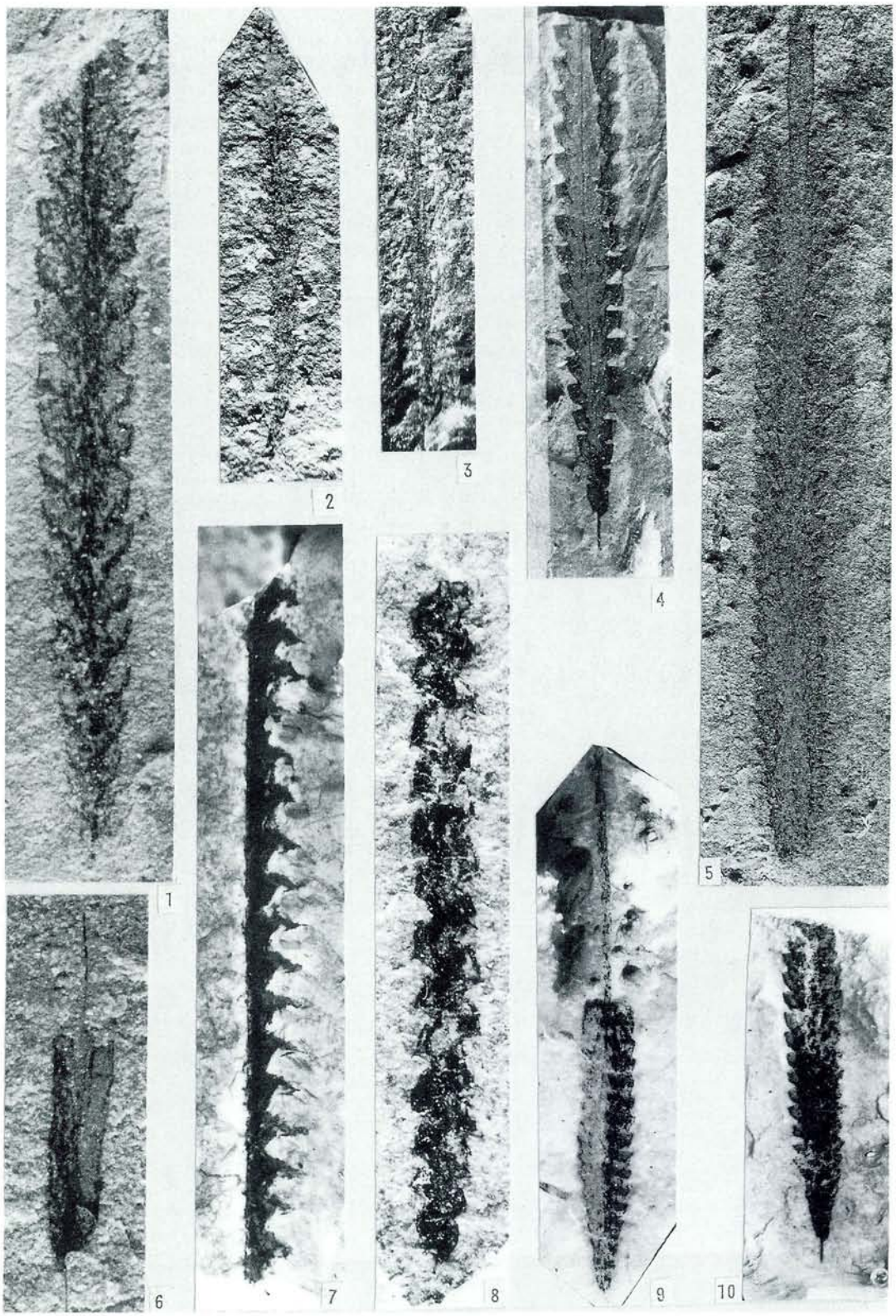
Fig. 5. *Orthograptus vesiculosus* (Nicholson) (= *Cystograptus vesiculosus*) X3, the *O. vesiculosus* Zone, Fenxiang section, Yichang, Hubei.

Fig. 6. *Climacograptus nebula* (Toghill et Strachan) X10, the Member 1 of the Shamao Formation, Wangjiawan section, Yichang.

Fig. 7. *Monograptus sedgwickii* (Portlock) X5, the *M. sedgwickii* Zone, Wangjiawan section, Yichang, Hubei.

Fig. 8. *Pseudoglyptograptus retroversus* (Bulman et Rickards) X10, the *D. convolutus* Zone, Wangjiawan section, Yichang, Hubei.

Figs. 9–10. *Diplograptus* cf. *magnus* H. Lapworth X3, the *D. magnus- D. thuringiacus* Zone, Gaoluo section, Xuanen, Hubei.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?lobiferus (M'Coy), *S. lobiferus harpago* (Törnquist), *Diversograptus ramosus* Manck, *Glyptograptus elegans* Packham, *Oktavites communis* (Lapworth), and *Petalolithus ovato-elongatus* (Kurch).

The *Monograptus sedgwickii* Zone

This zone is 138.9 m in thickness. It is characterized by the presence of *M. sedgwickii* (Portlock) at the Wangjiawan section. Other graptolites comprise *Glyptogratus incertus* Elles et Wood, *Demirastrites decipiens* (Törnquist) and *Pernerograptus cygneus* (Törnquist). This graptolite assemblage is very close to that of corresponding *M. sedgwickii* Zone from Britain, Northern Canadian, USSR and Alaska of North American.

The *Coronograptus ?arcuatus* Zone

This zone ranges from the uppermost part of the Yellowish-green Shale Member into the lower part of the overlying Loreiping Formation. The *C. ?arcuatus* Zone is divisible into Lower and Upper units. The Lower *C. ?arcuatus* Zone is difined by the appearance of the nominal species, the absence of *M. sedgwickii* at the Wangjiawan section. Associated graptolites are *Pseudoglyptograptus retroversus* (Bulman et Rickards), *Glyptograptus incertus* Elles et Wood, *Climacograptus simplex* Rickards, and *Oktavites communis obtusus* (Rickards). These graptolites all are of common elements of the *M. sedgwickii* Zone and the last two species are usually recorded in the middle part of the *M. sedgwickii* Zone of Britain (Rickards, 1976). The Lower *C. ?arcuatus* Zone is, therefore, probably coeval with the middle part of Britain *M. sedgwickii* Zone, while underlying *Monograptus sedgwickii* Zone of the present area is correlative with only the lower part of British *sedgwickii* Zone. The thickness of the lower *C. ?arcuatus* Zone is 303.5 m.

Loreiping Formation

Lower Member : Upper *C. ?arcuatus* Zone

This member is composed of yellowish-green calcareous silty mudstone with nodular biogenic marl, containing abundant brachipods, trilobites, corals, conodonts and a few cephalopods and graptolites. Its thickness is 103 m. The dominant graptolites are *Coronograptus ?arcuatus* (Mu et al.), *Glyptograptus elegans* Packham, *G. serratus* Elles et Wood, *Climacograptus simplex* Rickards, *Pseudoglyptograptus retroversus* (Bulman et Rickards), and *Pristiograptus regularis* (Törnquist). This assemblage suggests that the Upper *C. ?arcuatus* Zone probably corresponds to the upper part of British *M. sedgwickii* Zone. In view of this, the boundary between the Longmaxi and Loreiping Formations roughly coincide with the boundary between the middle and upper parts of British *M. sedgwickii* Zone.

Upper Member

The member is composed of yellowish-green thin-bedded siltstone, silty mudstone, with 45.9 m thick, containing various shelly fossils. Its top and bottom are marked by the presence of bio-

Explanation of Plate 2

Fig. 1. *Monograptus* cf. *drepanoformis* Toghill et Strachan X5, the Member 2 of the Shamao Formation, Wangjiawan section, Yichang.

Fig. 2 *Demirastrites* cf. *triangulatus* (Harkness) X10, the *D. triangulatus* Zone, Wangjiawan section Yichang, Hubei.

Fig. 3. *Demirastrites triangulatus* (Harkness) X3, the *D. triangulatus* Zone, Fenxiang section, Yichang, Hubei.

Fig. 4. *Lagarograptus* cf. *acinaces* (Törnquist) X5, the *L. acinaces* Zone, Wangjiawan section, Yichang, Hubei.

Fig. 5. *Demirastrites convolutus* (Hisinger) X5, the *D. convolutus* Zone, Wangjiawan section, Yichang, Hubei.

Figs. 6,8. *Climacograptus nebula* (Toghill et Strachan) X10, the Member 1 of the Shamao Formation, Wangjiawan section, Yichang.

Figs. 7,10. *Monograptus marri* Perner X3, Fig. 7 is a part of the opposite aspect of the Fig. 10, the Member 2 of the Shamao Formation, Wangjiawan section, Yichang, Hubei.

Fig. 9. *Pernerograptus* cf. *argenteus* (Nicholson) X5, the *P. argenteus* Zone, Fenxiang section, Yichang, Hubei.

Fig. 11. *Monograptus ?revolutus* (Kurck) X5, the *C. cyphus* Zone, Fenxiang section, Yichang, Hubei.


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genic limestone containing *Pentamerus* and is easily distinguished from the overlying and underlying strata. The Upper Member of the Loreiping Formation lies between the Upper *C. ?arcuatus* Zone of the Lower Member and the Member 1 of the Shamao Formation with *Climacograptus nebula* (Toghill et Strachan) (= *Retioclimacis typica* Mu). Although no graptolite have been found, the interval is likely to be equivalent to the most part of the *S. turriculatus* Zone, of the upper Fronian (C2–3) stage.

Shamao Formation

The age of the Shamao Formation has been a controversial and unresolved problem for a long time. The Shamao Formation of this paper is same as the original Shamaoshan beds proposed by Xie and Chao (1925) except that the upper unit of the original definition is now proven to be the Middle Devonian Yuantaiguan Formation. Lithologically, four members can be recognized. Member 1 and 3 consist of mudstone and siltstone, while member 2 and 4 are characterized by sandstone and siltstone.

Member 1

This member is characterized by yellowish-green silty mudstone intercalated with siltstone and is 77.4 m in thickness. It contains shelly fossils and graptolites, the latter is represented by *Climacograptus nebula* (Toghill et Strachan) (= *Retioclimacis typica* Mu et al.), *Pristiograptus variabilis* (Perner), *Monograptus* cf. *drepanoformis* Toghill et Strachan, and *Oktavites planus* (Barrande)?. *C. nebula* was first discovered from the *M. griestoniensis* Zone of Grieston Quarry, near Innerleithen, Peebleshire, Britain (Toghill and Strachan, 1970), and subsequently was reported from the *turriculatus-griestoniensis* Zone of English Lake District and Howgill Fells (Hutt, 1974), and from the corresponding level on Bornholm, Denmark (Bjerreskov, 1975). These graptolites indicate that Member 1 of the Wangjiawan section may be equivalent to the upper *turriculatus* and lower *crispus* Zones.

Member 2

Member 2 comprises a set of yellowish-green and greyish-green thin bedded siltstone, and fine sandstone, intercalated with sandy shale and shale. Its thickness is 118 m. The base is marked by the incoming of very red mudstone bands. Its top is readily drawn at the appearance of a thin (0.93 m) band of brown ferruginous calcareous sandstone, containing conodonts and fragments of trilobites. The following graptolites are found in the lower and middle parts of this member at the Wangjiawan section: *Monograptus* cf. *drepanoformis* Toghill et Strachan, *M. marri* Perner, *Monoclimacis* sp., *Pristiograptus variabilis* (Perner), *Pr. wulongguanensis* Wang sp.n., and *Petalolithus* cf. *minor* Elles. *M. drepanoformis* is a principal element of the *M. griestoniensis* Zone of the Grieston Quarry, Britain (Toghill et Strachan, 1970). *M. marri* is a common element in the *turriculatus* to *crispus* Zones of Britain. *Pr. regularis* and *Pe.* cf. *minor* usually appear in a lower stratigraphic level elsewhere in the world. The graptolite fauna suggests that Member 2 is equivalent to the upper *crispus* to *griestoniensis* Zones of Britain. Hun (1958) reported that a late Silurian graptolite fauna had been discovered from the Wulongguan near Loreiping, Yichang. A reexamination of Hun's collections and the acquisition of new material suggests that the fauna is typical of Member 2 of the Wangjiawan section. Specimens identified as *Monograptus bohemicus,* and *M. nilssoni* are, in fact, *Pr. regularis* and *Pr. variabilis,* respectively, while *Monograptus uncinatus* cf. var. *micropoma, M. dubius* and *M. colonus* are thought to identical with *Pr. wulongguanensis* Wang sp.n.

Member 3

Overlying Member 2 is a 284 m thick sequence of yellowish or greyish-green shale, and sandy shale

Explanation of Plate 3

Figs. 1,4. *Coronograptus ?arcuatus* (Mu et al.) X20, the C. *?arcuatus* Zone, Fenxiang section, Yichang, Hubei.

Fig. 2. *Coronograptus cyphus praematures* (Toghill) X10, the *?vesiculosus* Zone, Liping, Yidu, Hubei.

Fig. 3. *Demirastrites convolutus* (Hisinger) X3, the *D. convolutus* Zone, Gaoluo section, Xuanen, Hubei.

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with a few bands of argillaceous siltstone, designated Member 3. Its fauna includes a few brachiopods, bivalves, trilobites and the graptolite *Dictyonema wangjiawanensis* Wang sp.n. Since the shelly fossils found here are similar to those of the upper Xiushan Formation which contains *Stomatograptus sinensis* Wang (Ge et al., 1979), the age of Member 3 is likely to be of the latest early Silurian or earliest middle Silurian.

Member 4

The highest member of the Shamao Formation is composed of greyish-green and very red barren medium bedded fine-grained quartz sandstone and siltstone intercalated with sandy shale. Its thickness is 185.3 m at the Wangjiawan section. This member is readily distinguished from the yellowish-green sandy mudstone at the top of the Member 3 by greyish-green medium bedded sandstone in the lower part of this member. Its top lies unconformably beneath the grey quartzite with gravels which characterizes the base of the Middle Devonian Yuantaiguan Formation. Based on the lithology and stratigraphic position, the age of Member 4 may be equivalent to the Huixinshao Formation in Rongxi and Xiushan of Sichuan and Shiqian of Guizhou, that is early middle Silurian. The correlation of the graptolite sequence from the Longmaxi Formation to the Shamao Formation of the eastern Yangzi Gorges with other regions of the world is shown in table 1.

The graptolite sequence across the Ordovician-Silurian boundary

There are three Ordovician-Silurian boundary sections, near Yichang, as reported by Wang et al. (1980, 1983a,b): (1) Huanghuachang section,

Table 1. Correlation of the graptolite sequence from the Longmaxi to the Shamao Formation in the eastern Yangzi Gorges, China with other regions of the world.

E. Yangzi Gorges, China			G. Britain Rickards, 1976			N. Canadian Cordillera (Lenz, 1982)	Alaska, U.S. 1970 (Churkin & Carter)	Bornholm, Denmark (Bjerreskov, 1975)
Shamao Fm.	M. 3		Llandovery	Telychian	crenulata	sakmaricus-laqueus	grandis	lapworthi
	M. 2	cf. drepano-formis			griestoniensis	spiralis	spiralis	spiralis griestoniensis
	M. 1	nebula			crispus			crispus
Loreiping Fm.	U.M.			Fronian	turriculatus maximus subzine	turriculatus	turriculatus/ maximus	turriculatus
	L.M.	arcuatus			sedgwickii	sedgwickii	sedgwickii	
	Yell.-green Shale Mem.	sedgwickii						
Longmaxi Fm.		convolutus			convolutus	convolutus	convolutus	cometa band ? convolutus
	Black Shale Member	argentus		Idwian	leptotheca	argenteus	gregarius	gregarius ?
		magnus-thuringiacus			magnus	magnus?		pectinatus
		triangulatus			triangulatus	triangulatus		triangulatus
		cyphus		Rhuddanian	cyphus	gregarius	cyphus	revolutus
		acinaces			acinaces	acinaces	acinaces	
		vesiculosus			atavus	atavus	vesiculosus/atavus	vesiculosus band/acinaces
		acuminatus			acuminatus	acuminatus	acuminatus	acuminatus
		persculptus			persculptus	persculptus?	persculptus	persculptus?

Table 2. The correlation of the latest Ordovician-earliest Silurian biostratigraphic succession from the eastern Yangsi Gorges with other places of the world.

E. Yangzi Gorges		Dob's Linn, Scotland (Williams, 1982, 1983)		Darraweit Guim Australia (VandenBerg et al., 1984)	Kolyma, Siberia & Kazakhstan, USSR (Koren et al.) 1977, 1980	N. Cordillera, Canada (Lenz et McCracken, 1982)	Barrandian, Bohemia (Storch, 1982)
Longmaxian	*P. acuminatus*	Birkhill Shale	*P. acuminatus*	*P. acuminatus*	*P. acuminatus*	*P. acuminatus*	*P. acuminatus*
	G. persculptus		*G. persculptus*	*G. persculptus*	?	*G. persculptus*	*A. ascensus* ?
Wufengian	*Hirnantia-Kinnella*		*G.?'venustus'*	*C.?extraordinarius*	*D. bohemicus* (= *G. persculptus* forma B) *C.?extraordinarius*	Conodont fauna 12	(*D.* aff. *bohemicus*) *Hirnantia* fauna *D. bohemicus*
	D. bohemicus	Upper Hartfell Shale	Interval 1.17 m *C.?extraordinarius*				
	Paraorthograptus-D. mirus		Barren mudstone 0.96 m	?	?		no fossils
	T. typicus	*D. anceps*	*P. pacificus* (Anceps Band E)	*D. ornatus-*	*C. l. supernus* *P. pacificus*	*P. pacificus*	
	D. szechuanensis (= *D. complexus*)		*D. complexus* (Anceps Band A-D)	*C. latus*	*Upper C. longispinus*	*D. ornatus* ?	

(2) Fenxiang section, and, especially (3) Wangjiawan section, which are the best potential candidates for the choice of an international Ordovician-Silurian boundary stratotype. In these sections the following eight zones can be recognized in the Wufeng Formation and basal Longmaxi Formation: *D. szechuanensis* (= *D. complexus*), *T. typicus, Paraorthograptus- D. mirus, D. bohemicus, Hirnantia-Kinnella, G. persculptus, P. acuminatus* and *O. vesiculosus* Zones.

The suggestion that *D. szechuanensis* is conspecific with *D. complexus* Davies and that *Paraorthograptus typicus* Mu and other species of *Paraorthograptus* are conspecific with *P. pacificus* Ruedemann (Williams, 1982) are being serious consideraton by Chinese graptolite students. Ongoing studies the *Paraorthograptus uniformis* Zone (proposed by Mu 1974 and Mu et al. 1984) show that it is difficult to recognize and that even the index species is probably synonymous with *P. pacificus* even though present author previously recogzized it (Wang et al., 1983b). It should be noted, however, that *Paraorthograptus pacificus* is long ranging and is difficult to use for worldwide correlation as done by Williams (1983). The fact that *Dicellograptus anceps* has been found at the base and top of the *D. szechuanensis* Zone, and that *D. szechuanensis* may be conspecific to *D. complexus* suggests that the *D. complexus* Subzone as well as the basal *P. pacificus* Subzone with *D.* aff. *complexus* (Anceps Band D at Dob's Linn section, Scotland is correlative with the *D. szechuanensis* Zone of the eastern Yangzi Gorges. The fission track date of a bentonite layer near the top of the *D. szechuanensis* Zone is 447 ± 10 m.y. (Wang et al., 1980; Ross et Naeser, 1984). Most graptolites reported from the upper part of the *P. pacificus* Subzone (Anceps Band E) at Dob's Linn section by Williams (1982), such as *Dicellograptus graciliramosus* (= *D. minor*), *Climacograptus longispinus supernus, Orthograptus abbreviatus, Paraplegmatograptus uniformis* (= *Plegmatograptus ?craticulus*), *Paraorthograptus pacificus, Pleurograptus lui* and *Pararetiograptus regularis* (= *Orthoretiograptus denticulatus* Wang et al. of Williams, 1982), have been recorded from the *T. typicus* Zone of the eastern Yangzi Gorges. Furthermore, *P. lui* is found only in the *D. szechuanensis* and *T. typicus* Zones. It is suggested, therefore, that the upper part of the *P. pacificus* Subzone (Anceps Band E) at Dob's Linn section is possibly correlative with all or part of the *T. typicus* Zone. It should not overlooked that an interval of unfossiliferous

pale grey mudstone, 0.96 m thick is sandwiched between the Anceps Band E (i.e. the top of the *P. pacificus* Subzone) and a thin brown Extraordinarius Band at Dob's Linn section. An similar nonfossiliferous gap also exists between the *P. pacificus* and *C. ?extraordinarius* (= *G. ?persculptus* forma A) Zones at Mirny Creek and Kazakhstan sections, USSR (Koren et al., 1979; Apollonov et al., 1980) and at Darraweit Guim, central Victoria (Vandenberg et al., 1984). It is this interval which may be equivalent to the *Paraorthograptus – D. mirus* Zone and possibly the top of the *T. typicus* Zone in the present area. The occurrence of *C. ?extraordinarius* and related species in the *D. bohemicus* Zone suggests that the *D. bohemicus* Zone and the overlying *Hirnantia-Kinnella* Zone of the eastern Yangzi Gorges may correlate with the *C. ?extraordinarius* Zone at Dob's Linn section, Scotland and possibly with the overlying pale grey mudstone of 1.17 m thick and even the 0.56 m thick black shale with *G. ?'venustus venustus'* at the base of Birkhill Shale. They are also probable correlatives of the *C. ?extraordinarius* and *D. bohemicus* (= *G. ?persculptus* forma B) Zones of USSR.

The correlation of the Ordovician-Silurian biostratigraphic succession between the Wangjiawan section and other places of the world is shown in table 2.

The researches on the Ordovician-Silurian boundary in the eastern Yangzi Gorges suggest it more reasonable to fix the boundary at the base of the *G. persculptus* Zone, i.e. between the *G. persculptus* and *Hirnantia-Kinnella* Zones. In order to respect the decision ratified by the Commission of Stratigraphy and IUGS, however, the Ordovician-Silurian boundary is, unfortunately, drawn at the base of the *Parakidograptus acuminatus* Zone.

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Dansk sammendrag

De silure aflejringer, der er blottet i flodbrinkerne ved Yangzi opdeles i tre formationer: Longmaxi, Loreiping og Shamao. I Longmaxi Formationen samt det nederste led i Loreiping Formationen kan følgende graptolitzoner udskilles: *persculptus, acuminatus, vesiculosus, acinaces, cyphys, triangulatus, magnus-thuringiacus, argenteus, convolutus, sedgwickii* og *arcuatus*. De »sene silure« graptolitter, der har været rapporteret fra den nedre del af Shamao Formationen, revideres i dette arbejde. På et tilsvarende stratigrafisk niveau er der fundet *C. nebula, M.* cf. *drepanoformis, P. variabilis* og *M. marri*. Graptolit sekvensen hen over ordivicium-silur grænsen og dens internationale korrelation diskuteres.

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