Zonation and correlation of the earliest Ordovician graptolites from Hunjiang, Jilin province, China

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On the basis of studies of the graptolite succession at the Xiaoyangqiao, Qinggouzi and Muxiantogou sections in the vicinity of Dayangcha village and near Hunjiang City in SW Jilin Province four graptolite zones can be recognized in the 'Yeli Formation': 1. *Rhabdinopora parabola* Zone, 2. *Anisograptus* Zone, 3. *Psigraptus* Zone and 4. *Adelograptus-Clonograptus* Zone. The correlation of each zone with the equivalent zone and the Cambrian-Ordovician boundary both in China and in other areas of the world are discussed.

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The Xiaoyangqiao section near Dayangcha village ca. 50 km E of Hunjiang, Jilin Province is considered to be of one of the best Cambrian-Ordovician boundary sections discovered in China in recent years. This section was first reported by Kuo et al. (1982). Chen et al. (1983, 1985) outlined a zonation scheme of this area when they discussed the faunal sequence across the Cambrian-Ordovician boundary in northern China. In the summer 1984 the senior author, accompanied by Mrs. Liang Zhongfa and Yan Hui, and in May 1985 also by the junior author investigated this section and the Qinggouzi and Muxiantougou sections near Hunjiang City. The authors believe that the earliest Ordovician graptolite sequence there is well represented with regard to the first occurrence of *Rhabdinopora* and probably documents the best Tremadoc graptolite sequence in China. These sections, therefore, are very important for study of earliest Ordovician graptolite zonation and for correlation of the Cambrian-Ordovician boundary both within China and to other areas of the world.

Graptolite sequence

The Xiaoyangqiao Cambrian-Ordovician boundary section lies near Xiaoyangqiao, north of the Dayangcha train station and the Qinggouzi section is in the south roadside of the exit of the Quinggouzi reservoir (Fig. 1). Based on the distribution of graptolites in these two and other nearby sections four graptolite zones can be recognized in the 'Yeli (Yehli) Formation' of the Hunjiang area, named as follows in descending order (Fig. 2):

(4) *Adelograptus-Clonograptus* Zone
(3) *Psigraptus* Zone
(2) *Anisograptus* Zone
(1) *Rhabdinopora parabola* Zone

The Hunjiang area is situated in the northern fringe of the North China Ordovician biofacies region and borders on the Tianshan-Xinan region (Wang, 1980; Lai et al., 1982), so that the uppermost Cambrian-lowermost Ordovician atrata here are not fully equivalent to those exposed in the Tangshan area, Hebei Province and in the Taizihe (Taizuho) Valley, Liaoning Province in their lithological characteristics. The Yeli Formation, used in the present area by Kuo et al. (1982) and Chen et al. (1983, 1985), in fact includes some equivalent strata to the Qiushugou (Chiushukou) Member of the Fengshan Formation from the Taizihe Valley, Liaoning, which was originally regarded as being of late Cambrian age (Mu, 1953, 1955; Zhao, 1983; Zhao et Chen, 1984). In advance of future revision at the litho-

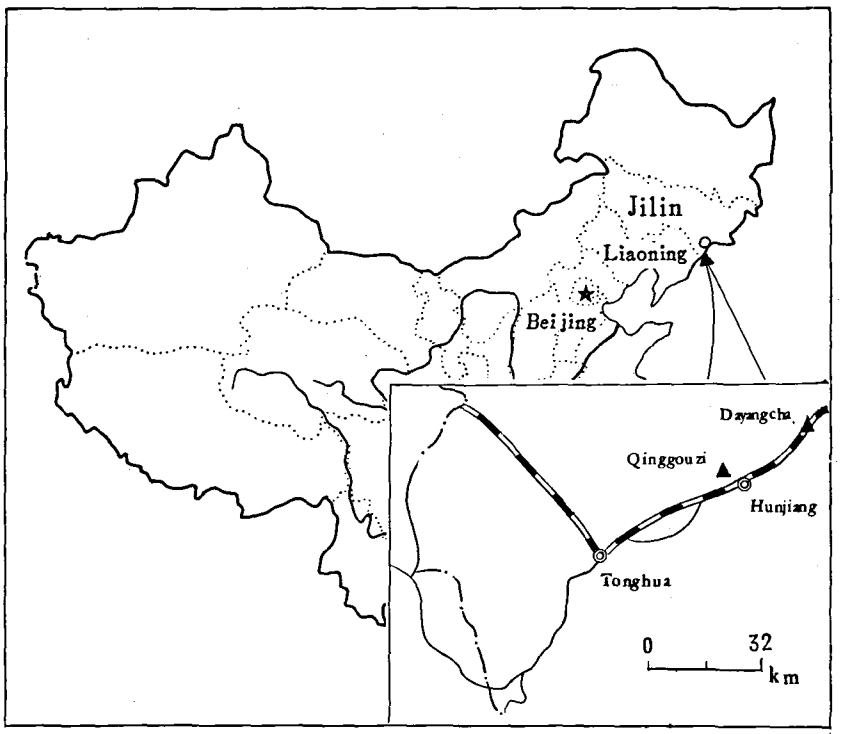


Fig. 1. Sketch map showing location of measured sections in the Hunjiang area.

stratigraphic units in the area and in order to avoid the confusion with the typical Fengshan and Yeli Formations these two names are used in present paper, in generalized sense indicated by applying single quotation marks to their names.

Correlation

1. *Rhabdinopora parabola* Zone

This zone, representing the lowermost Ordovician graptolite zone, is characterized by the appearance of *Rhabdinopora parabola* (Bulman) (see pl. 2, figs. 1, 3, 8–9; pl. 3, fig. 1) in association with *R. flabelliformis* s.l. (Eichwald) (see pl. 3, fig. 9), *R. socialis* (Salter) (see pl. 2, fig. 5) and the trilobite *Richardsonella,* cystoids *Echinosphaerites* sp. The above mentioned graptolites are found at the base of the yellow-greenish mudstone with bands of thin-bedded limestone, 1.5 m thick at the base of the 'Yeli Formation', which is probably equivalent to the lower part of Bed 14 at the Dayangcha section, measured by Kuo et al. (1982) or Bed 21 (of Chen et al., 1985). The first appearance of *R. flabelliforme* represented by *R. parabola* is thought to be an important mark for determining the base of the Tremadoc (Bulman, 1954; Erdtmann, 1982). The associated *R. socialis* is also an indicator defining the base of the Tremadoc, though it sometimes can range up to a slightly higher level (Bulman, 1954). *R. socialis* of the present paper provinsionally remains in the sense of *'Dictyonema' flabelliforme socìale* Salter of Bulman (1927, 1954), but the probability of synonym of *R. socialis* with *R. flabelliformis* can not be ruled out. This idea had already been pointed out by Salter himself (1858) and by Erdtmann (1982). Based on the graptolite assemblage the *R. parabola* Zone from the 'Yeli Formation' of the Hunjiang area is easy to correlate with the beds containing *R. parabola* and *R. socialis* near the base of the Cambrian-Ordovician boundary interval at the Naersnes section, Oslo, Norway (Bruton et al., 1982), and it also correlates with the *R. flabelliformis* Zone from Taimyr, USSR (Obut et Sobolevskaya, 1964) that includes *R. parabola* and *R. socialis*. In western Newfoundland, *R. flabelliformis* and *parabola* type and *R. socialis* were also reported to occur at the base of the Tremadoc at Broom Point South section (Fortey et al. 1982), but recent investigations by the junior author cast doubts upon the occurrence of

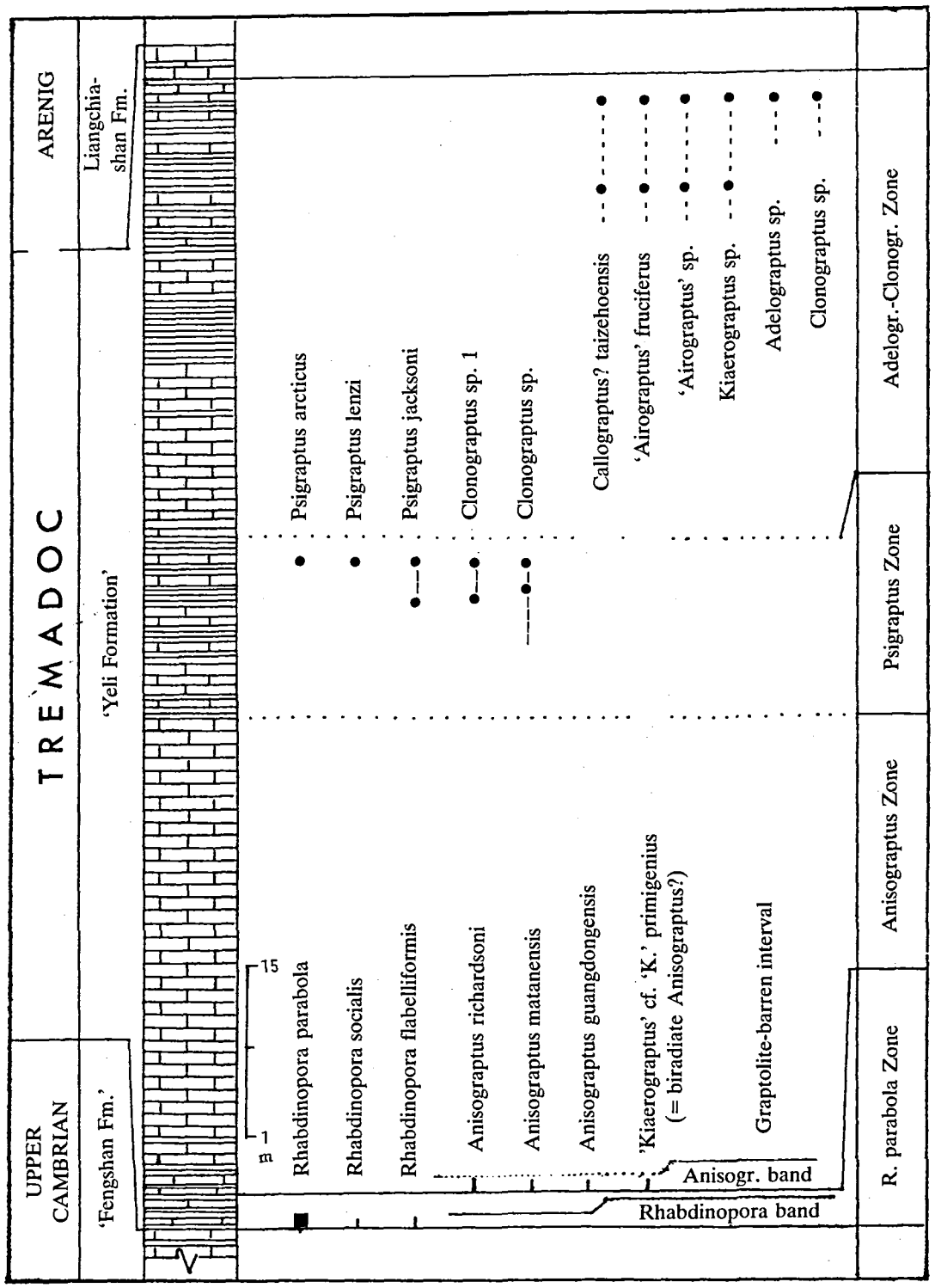


Fig. 2. Stratigraphic distribution of principal graptolites at the Xiaoyangqiao section near Dayangcha, Hunjiang, Jilin.

the forms in that section of the Cow Head Group. Rushton (1982) proposed to define the base of the type Tremadoc at or just below, the lowest beds with *R.* ex gr. *socialis* (Salter) at Brynllinfawr section in North Wales. This boundary is basically coeval with that between the 'Yeli' and 'Fengshan' Formations in the present area. The definition of the Cambrian-Ordovician boundary and the correlation between different fossil assemblages relevant to this interval are subjects of international discussion (Norford, 1982). It is imperative to define the base of the Tremadoc as the Cambrian-Ordovician boundary, since this boundary is not only advantageous to an internationally precise correlation, but also coincides with one of the most important events in graptolite evolution: the appearance of the nematophorous coni-siculate anisograptoids with the virtually synchronous first occurrence of the pendent *Rhabdinopora* group and the horizontal *Staurograptus* group. At the Xiaoyangqiao and Qinggouzi sections this boundary should be drawn at or just below the base of the *R. parabola* Zone.

It was reported by Lin (in Chen et al., 1983) that the following graptolites were found in the lowermost part of the 'Yeli Formation' at the Dayangcha section: *'Dictyonema' flabelliforme* Eichwald, *Staurograptus dichotomous* Emmons and *Anisograptus mirus* Lin, without appending illustrations and descriptions. The first full description and illustration of this graptolite fauna is given by Lin (in Chen et al., 1985). Researches of this section show that among the graptolites associated with *Rhabdinopora parabola, R. socialis*, and *R. flabelliformis* some forms possess some similar features to 'Staurograptus' (see pl. 2, fig. 1) and *'Anisograptus'* (see pl. 2, fig. 2) but they represent juvenile growth stages of *R. parabola* with 4 'primary' stipes (= 2 primary and 2 pseudoprimary stipes), and *Rhabdinopora* with 3 'primary' stipes (= 2 primary and 1 pseudo-primary stipes), respectively. The real *Anisograptus* appears in beds 2.5 m above the *R. parabola* band at the Xiaoyangqiao section near Dayangcha or in beds 4.1 m above the *R. parabola* band at the Quinggouzi section, where no graptolites belonging to the *Rhabdinopora* type are found (pl. 1, figs. 1–2), although at Muxiantougou, a parallel valley section ca. 1.5 km to the west, these occur 2.1 m below the *Anisograptus* beds. Also it has been reported that *Anisograptus* sp. A, *Staurograptus minutus* Mu?, *Triograptus osloensis minor* Ruedemann, *Aletograptus* sp., *Kiaerograptus spinicrispus* Yu, Lin et Fang and *Bryograptus jiangxiensis* Yu, Liu et Fang, along with *'Dictyograptus' parabola (= Rhabdinopora parabola)* were found in the base of the 'Tangpan Formation' (i.e. the upper part of the original Xiyangshan Formation) at Wuning, Jiangxi Province (Yu et al., 1982, 1985). Based on the researches of that section by senior author the above mentioned graptolites, associated with *R. parabola,* are likely to be juvenile stages of *Rhabdinopora* except for *K. spinicrispus,* which is probably identical to or related to *'Kiaerograptus' primigenius* (Bulman). The latter probably represents an imture biradiate 'morph' of the *Staurograptus-Anisograptus* plexus. The graptolites belonging to the *Staurograptus-Anisograptus* Zone occur in beds just 1.6 m above the *R. parabola* Zone at Wuning. If this is correct, the *R. parabola* Zone there is equivalent to the zone of the same name of the Hunjiang area, while the overlying *Staurograptus-Anisograptus* Zone should be correlated with the *Anisograptus* Zone at Hunjiang (table 1).

2. *Anisograptus* Zone

The base of this zone is provisionally drawn at the base of *Anisograptus* band, since a graptolite barren interval, 2.5 m thick, exists between the *Rhabdinopora* and *Anisograptus* bands. At the Xiaoyangqiao section, the *Anisograptus* band consists of yellow-greenish shale or grey thin bedded limestone intercalated with yellow-greenish or purplish shale, above the *R. parabola* Zone (pl. 1, fig. 1) and extends for ca. 1 m. The *Anisograptus* band is likely to belong to the upper part of Bed 14 and lower part of Bed 15 of the Xiaoyangqiao (Dayangcha) section as measured by Kuo et al. (1982) or Bed 23 and 24 of Chen et al. (1985). It is followed by approximately 4 m of graptolite-barren limestone before the appearance of elements showing the *Psigraptus* Zone. At the Qinggouzi section, the graptolites of the *Anisograptus* band is similar to that of the Xiaoyangqiao section, but the thickness between this band and the underlying *Rhabdinopora* band increases to 4.1 m. Common graptolites of the *Anisograptus* band are *Anisograptus richardsoni* Bulman, *A. matanensis* Ruedemann, *A. guang-*

Table 1. Correlation of the early Ordovician Hunjiangian graptolite zones of Hunjiang, Jilin with other places both in China and elsewhere.

Hunjiang, Jilin			Taishan, Guangdong	Taizehe Valley, Liaoning	Yichang, Hubei	Wuning, Jiangxi	Changshan, Zhejiang
Ordovician (Hunjiangian)	'Jeli Formation'	*Adelogr.-Clonogr.*	Xichang Formation *Adelogr.-Clonogr.*	*C. ?taizehoensis* *'D.' liaotungensis* *D. lotolazeensis*	*Adelogr.-Kiaerogr.*	*Adelogr. asiaticus* *-Clonogr. minutus*	*Adelogr.-Clonogr.*
		Psigraptus					
		Anisograptus	*(Aletogr.-Triogr.)* *Anisogr.-Staurogr.*	*R. flabelliformis*	*R. nanjinguanensis* *D. yichangense*	*(Aletogr. orientalis)* *S. dichotomous*	*S. dichotomus*
		Rhabdinopora parabola			*H. simplex* *-M. sevirensis* (conodonts)	*Rhabdinopora parabola*	*Hysterolenus*

Hunjiang, Jilin			Oslo, Norway	Victoria, Australia	Yukon, Canada	Newfoundland, Canada	G. Britain (N. Wales, Shropshire)
Ordovician (Hunjiangian)	'Jeli Formation'	*Adelogr.-Clonogr.*	*Ceratopyge* Lst. *K. kiaeri, B. kjerolfi* (3aβ-3aγ)	*A. victoriae-* *'D.' macgillivrayi*	*K. antiquus* (with *Psigraptus* near base)	*Clonogr. flexilis* *-Adelograptus*	? *Angelina sedgwickii* *Shumadia pusilla*
		Psigraptus	3a	*Psigraptus* *-Clonograptus*	*C. aureus*		*C. tenellus*
		Anisograptus	*Anisogr.* (2eδ) *R. flab.* (2eβ-r)	*'D.' scitulum* *-Anisograptus*	*A. richardsoni* *S. tenuis*	*A. richardsoni* *Psigr.? canadensis* *Radiograptus*	Tremadoc
		R. parabola	*R. parabola-socialis* *R. praeparabola*			R. cf. *parabola?* *Staurograptus?* *R. cf. praeparabola*	

dongensis Wang, Liu et Zhou, and rarer forms include *'Kiaerograptus' primigenius* (Bulman) and *?Staurograptus* sp. In Canada, *Anisograptus richardsoni* has been reported from the *Anisograptus* Zone above the *R. flabelliformis* s.l. Zone (Erdtmann, 1971) and regarded as an index fossil of the *Anisograptus richardsoni* Zone in the Yukon (Jackson, 1974, 1975). The latter zone overlies the *Staurograptus tenuis* Zone. The graptolite assemblage shows that the *Anisograptus* Zone of the present area may be correlated with the same name zone of Newfoundland and the *Staurograptus tenuis* and *Anisograptus richardsoni* Zone of Yukon. *Anisograptus richardsoni* with *Staurograptus, Radiograptus, 'Triograptus'* and *Rhabdinopora*, excluding *R. socialis,* were also found in the Matane Shale, Quebec, Canada (Bulman, 1950). The beds bearing these graptolites are roughly equivalent to the *Anisograptus* Zone of the present area in age and also could correspond to the beds containing *Anisograptus* above the *R. socialis* Zone in Argentina (Turner, 1960) and with the Unites 2–7, yielding *Anisograptus richardsoni, Rhabdinopora flabelliformis* s.l., *'Triograptus' canadensis* and *Aletograptus* from Taimyr, USSR. According to Cooper and Stewart (1979), in Australia the *'Dictyonema' scitulum – Anisograptus* Zone is characterized by the appearance of *'D.' scitulum, Anisograptus compactus* and *A. delicatulus. A. compactus* is closely related to *A. richardsoni* (Erdtmann and Botsford, in prep.), while *A. delicatulus* probably is identical with *A. guangdongensis* Wang, Liu et Zhou, but the latter was published a little earlier than the former. The *'D.' scitulum-Anisograptus* Zone is correlative in age of the *Anisograptus* Zone of

the present area. The *Dictyonema* Shale (2eβ–2eδ Subzone) at the Töyen and Hammersberg section in Oslo, Norway probably also correlates with the *Anisograptus* Zone from Hunjiang, or its top limit is is slightly lower.

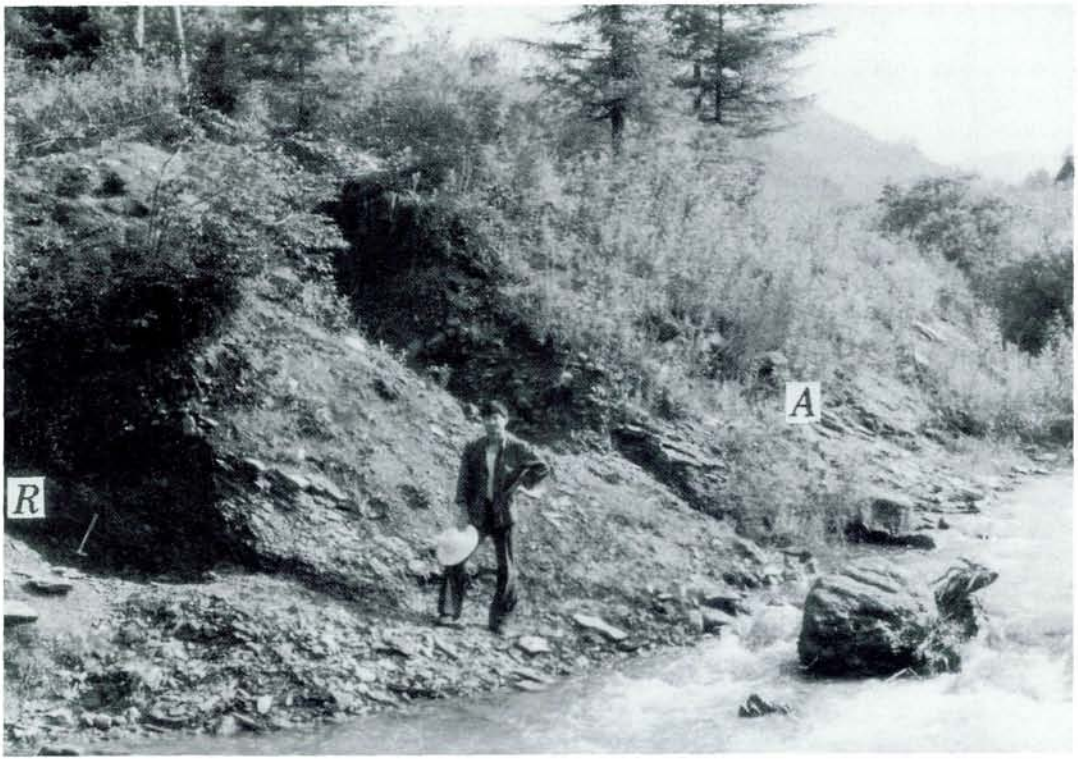
Since Mu (1974) divided the Xinchang Formation, Taishan, Guangdong Province into three graptolite zones, they have been widely quoted in Chinese literature (Mu et al., 1979, 1980; Yu et al., 1982, 1985). These authors considered that the lowest *Anisograptus-Staurograptus* Zone represents the lowest Tremadoc graptolite zone. There is, however, no evidence to show that the base of the *Anisograptus-Staurograptus* Zone at the Xinchang section coincides with that of the Tremadoc (Xu et al., 1983; Chen et Lenz, 1983) because no fossil has been found below this zone as yet (Wang et al., 1979). The earliest Ordovician graptolite sequence from the Hunjiang area shows that the *Anisograptus-Staurograptus* Zone (x1) there can only be compared with the *Anisograptus* Zone of the present area. *R. parabola* Zone graptolites are absent in Xinchang owing to an inhospitable ecostratigraphical environment. According to Lu et al. (1983) an interval with trilobites of the *Hysterolenus* Zone, at least 25 m thick, exists between the *S. dichotomus* Zone and the Cambrian-Ordovician boundary in the Jiangshan-Changshan area, Zhejiang Province. On the other hand, it is apparent that the base of the *S. dichotomus* Zone there can not be correlated with the base of the Tremadoc as marked by the first appearance of *R. flabelliformis* of *socialis* or *parabola* type. The Cambrian-Ordovician boundary in the Jiangshan-Changshon area should be defined at the base of the *Hysterolenus* Zone, but not at the base of the *S. dichotomus* Zone (Wang, 1980; Lai et al., 1983; Lu et al., 1983). In the Taojiang area, Hunan Province, the *R. flabelliformis-Staurograptus* Zone at the base of the Baishuxi Formation is characterized by yielding numerous *R. socialis* (Jin et Wang, 1977). Associated with *R. socialis* are *Rhabdinopora taojiangensis* and *'Staurograptus diffissus'*. The former is a small slender form virtually without dissepiments, which may, if a synonym could be proven, be identical with *R. praeparabola* Erdtmann (1982) and a senior synonym of the latter. *'Staurograptus diffissus'* was considered to be identical with *Staurograptus minutus* Mu (Mu, 1980). Since the specimens of this form are quite rare and very small, the present authors suspect that they represent juvenile growth stages of *Rhabdinopora*. The Analysis of the graptolite fauna from the Upper Qiushugou Member of the Fenshan Formation, Benxi, Liaoning Province as reported by Zhao (1983) and by Zhao and Chen (1984), suggest that the *R. flabelliformis-Staurograptus* Zone is likely to be a correlative of the middle *Dictyonema* Shale of Norway and slightly younger than the *R. parabola* Zone. The associated *'Staurograptus'* (Zhao, 1983, pl. 4, figs. 1–4, 6–8) is possibly not a true *Staurograptus,* but belongs either to *Anisograptus* or represent young astogenetic growth stages of *Rhabdinopora.*

3. *Psigraptus* Zone

This zone is found in the grey and dark grey shale with beds of thin bedded limestone in the middle part of the 'Yeli Formation' at Erdaopuzi village near Xiaoyangqiao, 4 km E of Dayangcha (see also Zhao & Zhang, 1985). Its position in the sequence is about 16 m above the underlying *Anisograptus* Zone. This zone is marked by yielding *Psigraptus arcticus* Jackson, *P. lenzi* Jackson and *P. jacksoni* Rickards et Stait as well as *Clonograptus* sp. 1 and *C.* sp. with small size and slender stipes (see pl. 2, figs. 6–7) which are similar to those described by Cooper and Stewart (1979). The first mentioned two species of *Psigraptus* occuring in the uppermost part of this zone were originally discovered by Zhao and Zhang (1986). In slightly lower interval of 1–3 m thick numerous *P. jacksoni* associated with *Clonograptus* were obtained by Zhao & Zhang (1985), and by the present authors. *Psigraptus lenzi* and *P. arcticus* were first reported from beds probably belonging to the lowest *Kiaerograptus*

Fig. 1. The Cambrian-Ordovician boundary at the Xiaoyangqiao section near Dayangcha village, Hunjiang, R: showing the locality of the *R. parabola* band occurring in the base of the *R. parabola* Zone; A; the locality of the *Anisograptus* band at the base of the *Anisograptus* Zone. The Cambrian-Ordovician boundary is drawn at or just below the base of the *R. parabola* band.

Fig. 2. The Qinggouzi Cambrian-Ordovician boundary section. R: the locality of the *R. parabola* band. The hammer indicates the boundary between the Ordovician and Cambrian systems.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antiquus Zone (Jackson, 1967, 1974, 1975). The former species is also known from a thin shale seam between the La 1 and La 2 intervals in Victoria, Australia, along with small and slender *Clonograptus*. The *Psigraptus-Clonograptus* Zone was proposed by Cooper and Stuart (1979) for this interval. *P. jacksoni* is known only from the Tremadoc of the Florentine Valley in Tasmania, Australia (Rickards and Stait, 1984). The level of which this species is occuring is likely to be equivalent to that of *P. lenzi* or a little lower. The discovery of *Psigraptus* in Hunjiang is important for the study of anisograptoid evolution, for worldwide stratigraphical correlation and for palaeoenvironmental reasons. Based on the graptolite assemblage the *Psigraptus* Zone of present area may be correlated with the *Psigraptus-Clonograptus* Zone of Lancefield in Victoria, Australia and with the lowest *Kiaerograptus antiquus* Zone in the Yukon, Canada, or it may be slightly older. As to the taxonomy of *Psigraptus,* we are inclined to agree with Rickards' and Stait's (1984) idea, that the genus *Yukonograptus* (with *Psigraptus lenzi* as type species) and the new family Psigraptidae erected by Lin Yao-kun (1981) should not be supported. It needs to be further pointed out that the recently reported four new genera *(Muenzhigraptus, Diphygraptus, Hunjiangograptus* and *Holopsigraptus)* and the eight new species from Hunjiang area by Zhao and Zhang (1985) appears to be identical with *Psigraptus jacksoni* Rickards et Strait. The new family they suggested Muenzhigraptidae, likewise can not be supported.

The upper two zones of Mu's division (1974) of the Xinchang Formation, Taishan, Guangdong Province are the *Aletograptus-'Triograptus'* Zone and the *Adelograptus-Clonograptus* Zone. In the 'Tangpai Formation' at Wuning, Jiangxi Province, *Aletograptus* and *'Triograptus'* are also present in the underlying *Staurograptus dichotomus* Zone (Yu et al. 1982). Chen and Lenz (1984) pointed out that the *'Triograptus'* at Wuning probably is a juvenile rhabdosome of *Anisograptus*.

4. *Adelograptus-Clonograptus* Zone

This zone, representing the uppermost graptolite zone of the 'Yeli Formation', was first found near the Dayangcha Village by Lin (in Chen et al., 1983). The following species are reported: *Clonograptus sinensis* (Mu), *C. uniformis* (Mu), *Adelograptus papillinaceus* Lin, *A. asiaticus* Mu, *A. victoriae* (T. S. Hall) and *Kiaerograptus heng-*

(All specimens shown on plate 2 occur in the Xiaoyangiao section except for Figs. 3,5.)

Fig. 1. *Rhabdinopora parabola* (Bulman)
×9, juvenile rhabdosome with pseudo-quadriradiate (two primary stipes and two pseudo-primary stipes) proximal development, which is similar to *Staurograptus* in shape preservation. HL-2, *R. parabola* Zone of the 'Yeli Formation'.

Fig. 2. *Rhabdinopora* sp.
Juvenile specimen with pseudo-triradiate (two primary stipes and one pseudo-primary stipe) proximal development, ×9, HL-2, horizon same above.

Fig. 3. *Rhabdinopora parabola* (Bulman)
An young rhabdosome, showing the sicula and fibrous nematic sheafs, ×3, Hj 1, the *R. parabola* Zone at the base of the 'Yeli Formation' of the Qinggouzi section, Hunjiang.

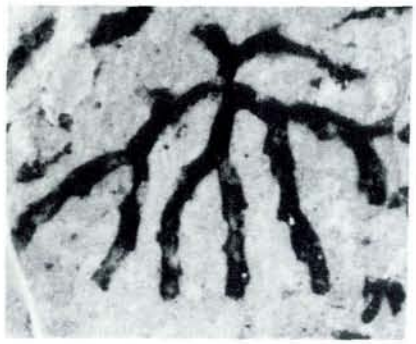
Fig. 4. *Kiaerograptus ? primigenius* (Bulman) (= probably a bi-radiate morph of *Anisograptus*) ×4.5, HL 3, *Anisograptus* Zone of the 'Yeli Formation'.

Fig. 5. *Rhabdinopora socialis* (Salter)
×3, Hj 1, locality and horizon same as Fig. 3.

Fig. 6–7. *Clonograptus* sp. 1 Cooper & Stewart
All ×3, HX 1, *Psigraptus* Zone of the of the 'Yeli Formation'.

Figs. 8–9. *Rhabdinopora parabola* (Bulman)
8. A juvenile specimen with pseudo-quadriradiate development and one dissepiment, which is similar to *Radiograptus* in shape preservation, ×4.5, *R. parabola* Zone of the 'Yeli Formation'; 9. A mature specimen with a juvenile specimen, ×3, same horizon.

Fig. 10. *Psigraptus jacksoni* Rickards & Stait
This specimen shows the pseudo-triradiate development formed by two reclined primary stipes and one reclined pseudo-primary stipe and secondary branches up to 3rd order, in the proximal part of the rhabdosome, the autothecae are curved, aperturally isolated, less to distally. ×10, HX 1, *Psigraptus* Zone of the 'Yeli Formation', Erdoupuzi near Xiaoyangqiao.



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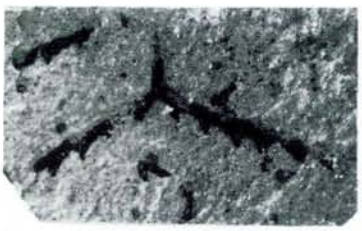

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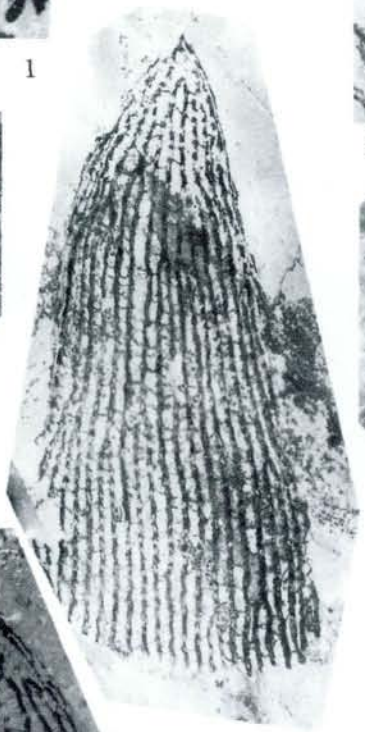

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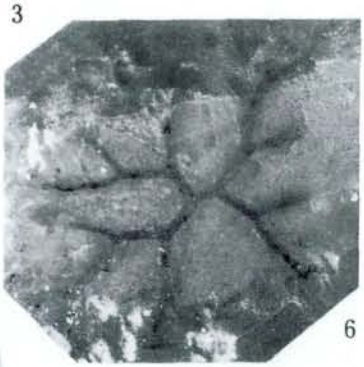

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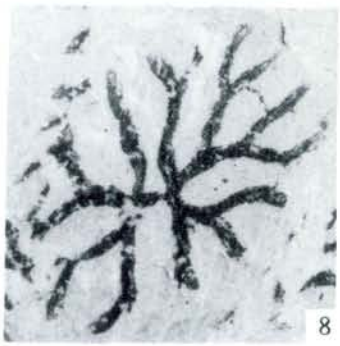

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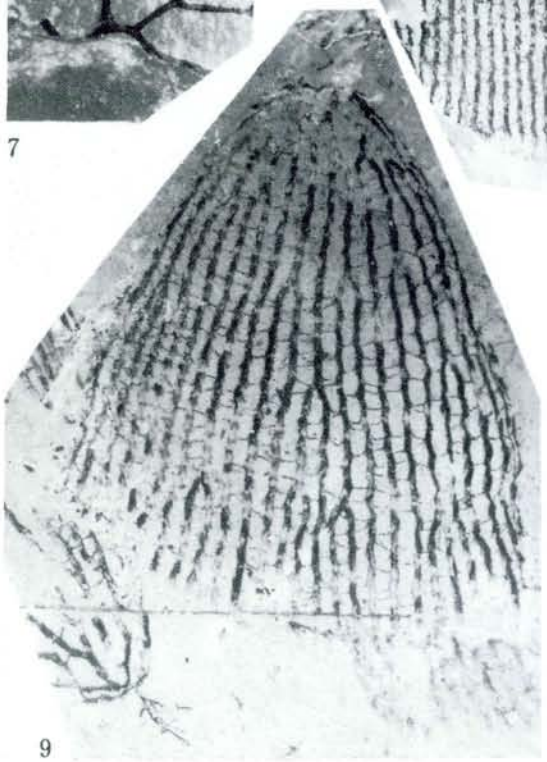

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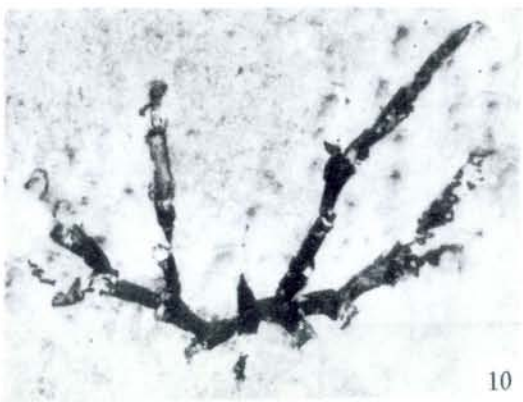

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shanensis Lin. At the Xiaoyangqiao section the following graptolites have been found in the yellow-greenish and grey-greenish shale intercalated with thin bedded limestone, about 15 m thick in the uppermost part of the 'Yeli Formation': *Callograptus ? taizehoensis* Mu (pl. 3, fig. 8), *'Airograptus'* sp. A, *'A.' furciferus* (Ruedemann) (pl. 3, figs. 3–4), *Dictyonema* sp. and *Adelograptus?* sp. The boundary between the 'Yeli' and Liangchiashan Formations is not exposed due to cover. In the same level *Kiaerograptus* and *Adelograptus* were also found by Zhao and Zhang (1985) and by the junior author. This shows that the *C. ? taizehoensis* Zone of the present area, which we proposed in the abstract of this paper submitted to the Graptolite conference of Copenhagen in 1985, has to be discarded. Based on these graptolites the *Adelograptus-Clonograptus* Zone of the present area is roughly equivalent to the same name zone of the Xinchang Formation, South China, to the *Adelograptus victoriae-'Dictyonema' magillivrayi* (La 2) Zone of Victoria, Australia and the upper *Kiaerograptus antiquus* Zone of Yukon, Canada (table 1).

A major hiatus, documented by an angular unconformity or at least an erosional disconformity exists between the 'type' – Tremadoc and Arenig in Great Britain. The graptolites being equivalent to the *Adelograptus-Clonograptus* Zone of the present area or to the La 2 and La 3 interval of Australia are absent there. The chronostratigraphic gap neccessitates a redefinition of the Tremadoc and Arenig Series or the establishment of a new series to fill this major gap. The Hunneberg Stage of Tjernvik (1956, 1980) would best satisfy this requirement but its inclusion with either the Tremadoc or the Arenig Series, or the insertion of Hunneberg as a new series would have to be defined and decided by the IUGS Subcommission on Ordovician Stratigraphy.

Conclusions

On the basis of the studies of graptolite succession from the Xiaoyangqiao near Dayangcha and Qinggouzi sections across the Cambrian-Ordovician boundary four Hunjiangian (or Tremadoc) graptolite zones can be recognized in the 'Yeli Formation' of Hunjiang area, Jilin Province: 1. *Rhabdinopora parabola* Zone, 2. *Anisograptus* Zone, 3. *Psigraptus* Zone and 4. *Adelograptus-Clonograptus* Zone. At present they comprise the best earliest Ordovician graptolite zonal sequence in China. In view of the graptolite assemblage of each zone the following ideas are proposed in the present paper:

1. The graptolite sequence of the Xinchang Formation, Guangdong Province, which is widely used in China and correlated with the Tremadoc Series in age, actually is not complete nor fully representative. The *Anisograptus-Staurograptus* Zone at the base of the Xinchang Formation is only equivalent to the *Anisograptus* Zone of the present area. Graptolites equivalent to the earliest Ordovician *R. parabola* Zone are absent in Xinchang, Guangdong. If the base of the Tremadoc Series were to be accepted for the base of the

(All specimens shown in plate 3 occur in the Xiaoyanggiao section near Dayangcha).

Fig. 1. *Rhabdinopora parabola* (Bulman)
A specimen with pseudo-quadriradiate development, ×4.5, HL 2, *R. parabola* Zone at the base of the 'Yeli Formation'.

Fig. 2,7. *Anisograptus matanensis* Ruedemann
All ×4.5, HL 3, *Anisograptus* Zone at the lower part of the 'Yeli Formation'.

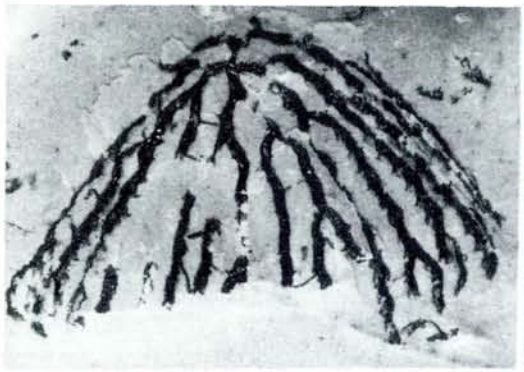
Fig. 3,4. *'Airograptus' furciferus* (Ruedemann)
3. ×3, 4. ×9, *Adelograptus-Clonograptus* Zone of the 'Yeli Formation'.

Fig. 5. *Anisograptus guangdongensis* Wang, Liu et Zhou
Probably a juvenile specimen, ×4.5, HL 3, same horizon as Figs. 2,7.

Fig. 6. *Anisograptus richardsoni* (Bulman)
×3, HL 3, same horizon as Figs. 2,7.

Fig. 8. *Callograptus ? taizehoensis* Mu
×4.5, HD, same horizon as Figs. 3,4.

Fig. 9. *Rhabdinopora flabelliformis* (Eichwald)
×3, HL 2, same horizon as Fig. 1.



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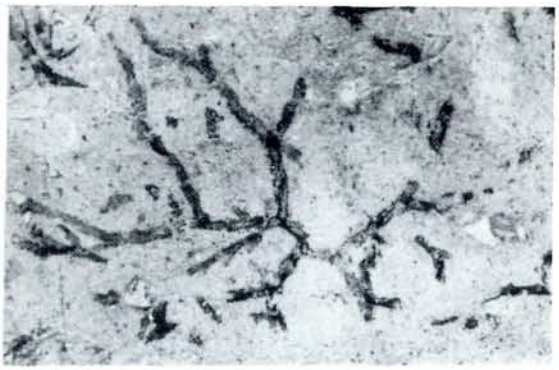

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Ordovician System, the base of the *R. parabola* Zone in the lowest 'Yeli Formation' of the Hunjiang area would coincide with it or very close to this horizon. Due to its incompleteness the Xinchangian Stage, in its chronostratigraphical sense, must be discarded and the 'Hunjiangian' Stage is proposed here in its place.

2. Recognition of a *Triograptus-Aletograptus* Zone within the Xinchang Formation is not supported. Data from the 'Tangpan Formation', Wuning, Jiangxi Province (Yu et al., 1982, 1984) indicate that *'Triograptus'* and *Aletograptus* are present in the *Staurograptus dichotomus* Zone. *'Triograptus'* probably represents merely a juvenile growth stage of *Anisograptus*.

3. The appearance of psigraptid graptolites characterized by proximally isolated the thecae and strongly reclined stipes is thought to represent a significant event for anisograptoid evolution. The *Psigraptus* Zone is easily correlated with the *Psigraptus-Clonograptus* Zone of Victoria, Australia. It probably is early Late Tremadoc age.

4. The *Adelograptus-Clonograptus* Zone is considered as the uppermost graptolite zone of the 'Yeli Formation' in the present area, being equivalent to the same name zone of the Xinchang Formation and to the La 2 Zone of Australia.

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Dansk sammendrag

Efter studier af graptolit successionerne i Xiaoyangqiao, Qinggouzi og Muxiantogou profilerne i nærheden af landsbyen Dayangcha og nær byen Hunjiang i den sydvestlige Jilin Provins kan fire graptolitzoner udskilles i 'Yeli Formationen': *Rhabdinopora parapola* Zonen, *Anisograptus* Zonen, *Psigraptus* Zonen og *Adelograptus-Clonograptus* Zonen.

Korrelationen af hver zone med tilsvarende zoner i andre områder af verden diskuteres i afhandlingen.

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