

- 赵裕亭, 1984: 从胞管口缘的退缩谈单笔石的演化. 地质学报, **58**(2): 95—105.
- Bjerreskov, M., 1975: Llandoveryan and Wenlockian graptolites from Bornholm. *Fossils and Strata*, 8: 1—93.
- Bulman, O. M. B., 1932: On the graptolites prepared by Holm, *Arkiv. For. Zoologi*, **24a**(8): 1—46.
- Bulman, O. M. B. 1970: *Graptolithina. Treatise on Invertebrate Paleontology*, Pt. V, (2nd edition). Geol. Soc. Amer. and Univ. Kansas Press.
- Elles, G. L., 1922: The graptolite fauna of the British Isles. *Geol. Assoc. Proc.*, **33**: 168—200.
- Li Ji-jin, 1981: The sequence of Lower Silurian graptolites in S. Anhui, In Rickards, R. B. (ed.): *Abstr. second Int. Grapt. Conf. Cambridge*, 1981.
- Li Ji-jin, 1984: Graptolites across the Ordovician-Silurian boundary from Jingxian, Anhui. *Stratigraphy and Palaeontology of Systemic Boundaries in China, Ordovician-Silurian Boundary (1)*, pp. 287—309. Anhui Sci. and Techn. Publ. House.
- Lin Yao-kun and Chen Xu, 1984: *Glyptograptus persculptus* Zone—the Earliest Silurian graptolite zone from Yanzi Gorges, China *Stratigraphy and Palaeontology of Systemic Boundaries in China, Ordovician-Silurian Boundary (1)*, pp. 203—222. Anhui Sci. and Techn. Publ. House.
- Mu En-zhi and Ni Yu-nan, 1983: Uppermost Ordovician and lowermost Silurian graptolites from the Xianza area of Xizang (Tibet) with discussion on the Ordovician-Silurian boundary. *Palaeontologia Cathayana*, **1**: 155—171.
- Rickards, R. B., 1974: A new monograptid genus and the origins of the main monograptids genera. *Graptolite studies in honour of O. M. B. Bulman (Special Paper in Palaeontology*, **13**, 141—147.
- Rickards, R. B. and Hutt, J. E., 1970: The earliest monograptid. *Proc. Geol. Soc. Lond.*, **1663**: 115—119.
- Rickards, R. B., Hutt, J. E. and Berry, W. B. N., 1977: Evolution of the Silurian and Devonian graptoloids. *Bull. Brit. Mus. nat. Hist. (Geol.)*, **29**(1): 1—21.
- Strachan, J., 1954: The structure and development of *Peiragraptus jalllex* gen. et sp. a new graptolite from the Ordovician of Canada. *Geol. Mag.*, **91**(6): 509—513.
- Williams, S. H., 1983: The Ordovician-Silurian boundary graptolite fauna of Dob's Linn. southern Scotland. *Palaeontology*, **26** (3): 605—639.
- Обут А. М. 1965: Граптолиты силура Омuleвских гор (бассейн реки Колымы). Стратиграфия и палеонтология Азиатской части СССР. Изд-во «Иаука». Москва.
- и Соболевская, Р. Ф., 1966: Граптолиты раннег силура в Казахстане. Изд-во «Наука». Москва.

[1988年2月10日收到]

DISCOVERY OF MONOGRAPTIDS IN BASAL PART OF LOWER SILURIAN FROM S. ANHUI WITH SPECIAL REFERENCE TO THEIR ORIGIN

Li Ji-jin

(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

Summary

For a long time, the evolutionary series of a didoraptids-dimorphograptids-monograptids has been generally recognized by graptolite researchers. In the past years, the akidograptids were found to appear in the Lower Silurian *Parakidograptus acuminatus* Zone, while the dimorphograptids in the *P. acuminatus* and *Orthograptus vesiculosus* Zones, but the monograptids appeared as late as in the *O. vesiculosus* Zone; this evolutionary series can be easily accepted by other people. Chen Xu and Lin Yao-kun (1978) put forward that the graptolites with uniserial portion composed of only one theca should represent the primitive species of the various genera of the Dimorphograptidae; these are just the species directly evolving from the *Akidograptus* after the loss of its first theca (th_1^1) in the second row. Later, since the second row thecae in the rhabdosome began to be lost one after

another, the uniserial portion became gradually longer and finally evolved itself to the *Monograptus* (Chen Xu and Lin Yao-kun, 1978. p. 15). Recently, monograptid graptolites have been successively found from the *Glyptograptus persculptus* Zone and its equivalent horizons at the base of the Silurian in Britain, Denmark and such areas as Qingyang of Anhui, Qijiang of Sichuan in China. Stratigraphically, the dimorphograptid species appeared much later than the earliest monograptids. Therefore, it is rather questionable whether the evolutionary series which was generally recognized in the past really exists. Bulman (1970) pointed out: "Regarded from the viewpoint of adult rhabdosome, the dimorphograptids occupy morphologically an intermediate portion between Diplograptidae and Monograptidae (and between Diplograptina and Monograptina), but as with the dicranograptids they were probably not phyletically intermediate." Then, after all, what kind of graptolites did the monograptids evolve from? The present paper will make a further probation into this problem. The *Pristiograptus antiquatus* sp. nov. appearing in the *Parakidograptus primarius* Zone at the basal part of the Kaochiapien Formation at Zhangcunxu of Qingyang, Anhui and the *Atavograptus primitivus* (Li) in the *Parakidograptus acuminatus* Zone of the same formation at Helixi of Ningguo, Anhui are the earliest monograptids in China, providing significant evidence for researches on the origin of monograptids. In these two species, the rhabdosome is extremely slender and slightly curving towards the dorsum, the sicula can be clearly observed, and the first theca (th₁) grows directly upwards after being produced from the upper or middle part of the sicula; some of the thecae are slightly depressed along the basal part of the ventral margin to the shallow apertural excavation, appearing more or less like those of the *Leptograptus*. In the developmental type of the proximal end and the thecal characters of the rhabdosome, the *Pristiograptus antiquatus* sp. nov. yielded from the upper part of the *Parakidograptus primarius* Zone in the Kaochiapien Formation at Zhangcunxu of Qingyang is very much similar to the *Parakidograptus primarius* sp. nov. produced from the lower and upper parts of the same formation at the same locality, while *Atavograptus primitivus* (Li) yielded from the *Parakidograptus acuminatus* Zone in the Kaochiapien Formation at Helixi of Ningguo is very close to the *Parakidograptus angustitubus* Li produced from the lower part of the *Parakidograptus primarius* Zone in the same formation at Zhangcunxu of Qingyang. The first row branch of the rhabdosome in the above-mentioned *Parakidograptus primarius* can hardly be distinguished from the rhabdosome of *Pristiograptus antiquatus*. Similarly, the first row branch of the rhabdosome in the *Parakidograptus angustitubus* is almost entirely the same as the rhabdosome of *Atavograptus primitivus* (text-fig. 1). *parakidograptus primarius* and *P. angustitubus* appeared some that earlier, while *Pristiograptus antiquatus* and *Atavograptus primitivus* somewhat later. Therefore, the writer believes that the latter probably evolved right from the former respectively which had lost all of their thecae in the second row, without any intermediate forms existing in between. their relation to each other can be shown in the Chinese diagram.

While describing the *Monograptus ceryx* Rickards et Hutt from the Llandovery *G. persculptus* Zone in the English Lake District of Britain, Rickards and Hutt (1970) considered that this kind of graptolites were particularly similar to certain glyptograptids from the *G. persculptus* Zone. Later, Rickards (1974) established a new genus under the name of *Atavograptus* with *Monograptus atavus* Jones as the type species, and placed *Monograptus ceryx* in it, taking into consideration that the earliest atavograptid *A. ceryx* is a nice intermediate in horizon and morphology between the *Glyptograptus* and *A. atavus*. In order to prove the derivation of *A. ceryx* from the *Glyptograptus*, Richards, Hutt and Berry (1977) plotted an idealized illustration showing the basically similar thecae of *G. persculptus* s. l. to those of *A. ceryx*. In morphology, the thecae in this kind of *Glyptograptus* are practically very similar to those in *A. ceryx*, but in the former, the first theca (th₁)

at the proximal end grows downwards along the sicula wall after being produced from the lower part of the sicula, and then grows upwards after reaching the sicula aperture, instead of growing directly upwards; this is quite different from the monograptid type development in which the first theca (th_1^1) at the initial end grows straight upwards after being produced from the sicula. Therefore, it seems impossible for the glyptograptid to evolve itself directly into the monograptid, unless rapid changes have taken place in the growing direction of their first theca (th_1^1). In recent years, some species of glyptograptids with a biserial portion at the proximal end and a uniserial portion at the distal end have been successively found from the top of Ordovician and the base of Silurian, such as *Glyptograptus regularis* Li (Li Ji-jin, 1984; pl. 1, fig. 13) from the *Diplograptus bohemicus* Zone of the Wufeng Formation (Upper Ordovician) in Jingxian, Anhui; *Glyptograptus lungmaensis* Sun (Lin Yao-kun and Chen Xu, 1984; pl. 1, fig. 6) from the *G. persculpius* Zone at the basal part of the Lungmachi Formation in Yichang, Hubei; *Glyptograptus? venustus* cf. *venustus*' (Legrend, 1976) (Williams, 1983; text-figs. 7d, 8h) from the *G. persculpius* Zone in the basal part of Birkhill Shale in Dob's Linn, Britain, and *Glyptograptus deadatus* Mu et Ni and *Glyptograptus elegantulus* Mu et Ni (Mu En-zhi and Ni Yu-nan, 1983; pl. 2, fig. 6 and pl. 4, figs. 11, 12; text-figs. 3b, 3d) from the *D. bohemicus* Zone of the Xianza Formation in Xianza, Xizang (Tibet). In particular, the two specimens of *G. elegantulus* with only 2—3 thecae remaining at the proximal end of the first row of the rhabdosome respectively, look very much like the monograptid graptolites at a sudden glance. Mu En-zhi and Ni Yu-nan (1983) considered that *G. elegantulus* probably represented the ancestor of *Atavograptus*. In some species of the above-mentioned glyptograptids, the uniserial portion is on the second row of the rhabdosome, such as *G. regularis* and *G. elegantulus*. At any rate, such kind of glyptograptids can never evolve themselves into the monograptids. In some other ones the uniserial portion is on the first row of the rhabdosome such as *G. venustus* cf. *venustus*', *G. deadatus*; these glyptograptids can never evolve themselves into the monograptids, either, unless rapid changes have taken place in the first theca (th_1^1) of the first row, i.e., growing immediately upwards in the beginning. In the *Peiragraptus fallax* Strachan yielded from the Upper Ordovician on the Anticosti Island, only one residual theca (th_1^1) of the second row exists in the rhabdosome; this species can never evolve itself into the monograptids, either, even though the theca has been lost. Just as Strachan pointed out (1954, p. 513): "Although occurring at a suitable horizon, *Peiragraptus* cannot be regarded in any way as ancestral to the monograptids since, even with the elimination of th_1^1 , the development of th_1^1 would require drastic modification to reach the monograptid type." What are the causes for the astogeny of these unusually developed graptolites? While discussing the two abnormal specimens of *Dicaulograptus hystrax* and *Glyptograptus denatus*, Bulman (1932) was of the opinion that the abnormality of these forms was pathological. Later, while discussing *D. hystrix*, Bulman (1970) pointed out: "It is not clear whether the example illustrated in Figure 47, 1 is truly pathological or follows damage to th_1^1 , but the normal biserial rhabdosome has been converted to an exceptional uniserial colony." (v. 71 and fig. 47, 1). Williams (1983) interpreted an abnormally developed specimen of *G.? venustus* cf. *venustus*', as caused by breakage. At the same time, Mu En-zhi and Ni Yu-nan (1983) also put forward that the suppression of one series of thecae in these abnormal species is most probably caused by damage rather than by pathology. In the writer's opinion, the genesis in the uniserial portion of these graptolites was not caused by the transformation of the normal biserial rhabdosome into a colony of rare uniserial rhabdosome, but by damage or pathological factors. For this reason, these graptolites cannot be taken as the intermediate type which evolved themselves into monograptids. Based on this recognition, the British *Atavograptus ceryx* can be considered as pro-

bably derived from *Parakidograptus*. The *Monograptus* sp.* (Bjerreskov, 1975) yielded in the *G. persculptus* Zone at the base of Llandovery in Bornholm, Denmark, probably evolved directly from *Akidograptus*. As for the *Monograptus* sp. occurring in the *G. persculptus* Zone at the base of the Lungmachi Formation in Qijiang, Sichuan (Jin Chun-tai and others, 1982), its source still remains unknown so far. Judging from the above statement, the writer considers the Diplograptid type—Akidograptid type—Monograptid type to be an evolutionary series (see text-fig. 5). The monograptid graptolites probably have evolved directly from the akidograptid graptolites. *Pristiograptus*, *Atavograptus*, *Monoclimacis* and *Monograptus* appearing at the base of Silurian serve as the foundation of monograptid evolution, and the subsequently developed monograptid graptolites are the derivatives from these genera.

The discovery of the earliest monograptids at the base of Silurian is of vital importance to the study of monograptid origin sequence of the Silurian graptolite fauna, and the Ordovician-Silurian boundary as well. In the past, the monograptids of Silurian were found to make their earliest appearance in the *O. vesiculosus* Zone; hence Elles (1922) placed this zone at the base of Silurian, and the *acuminatus* and *persculptus* Zones belonging to Ashgillian of Ordovician in the Diplograptid fauna. She pointed out: "The really striking faunal change, so far as the graptolites are concerned, comes with the advent of *Monograptus*". (Elles, 1922, p. 195). For the division of the evolutionary sequence of the Silurian graptolite fauna, Bulman (1958) adopted Elles' opinion (1922), but put the *G. persculptus* Zone at the base of Silurian. Mu En-zhi (1963) suggested for the first time to place the *G. persculptus* and *P. acuminatus* Zones in the Monograptid fauna. He considered that Since *Akidograptus* and *Dimorphograptus* were well-developed in the two zones, it is suitable to place these two zones in the Monograptid fauna. According to the present materials, monograptid graptolites have been successively found from the *G. persculptus* Zone and its equivalent horizons at the base of Silurian in Britain, Denmark and in Qingyang of Anhui, Qijiang of Sichuan in China, providing reliable evidences for placing the *G. persculptus* and *P. acuminatus* Zones in the Monograptid fauna.

The present writer agrees with Elles's viewpoint that the really striking faunal change, so far as the graptolites are concerned, comes with the advent of *Monograptus*. Therefore, from the viewpoint of graptolites evolution, the *G. persculptus* Zone and its equivalent horizons at the base of Silurian indicate a qualitative leap in the developmental history of graptolites, and the beginning of a new stage in the evolution of graptolites. The appearance of monograptids is a significant mark for the Silurian System, and the basal boundary of Silurian still remains to be drawn at the base of the *G. persculptus* Zone and its equivalent horizons.

Description of new species

Parakidograptus prinarius sp. nov.

(Pl. I, figs. 4—6; text-fig. 1a—c)

Rhabdosome small, less than 10 mm in length, with protracted proximal end, 0.4 mm in width across the apertures of the first thecal pair, then widening gradually to a maximum width of 1 mm at the distal end. Sicular 1.2 mm long, with a thin virgella, extending downward for a short distance before bifurcation (pl. I, figs. 5, 6; text-fig. 1b). Thecae in the form of straight tubes, 1.5 mm in length and 0.2—0.25 mm in width; apertural margins straight or slightly concave, right to the axis of the rhabdosome or inclining slightly outwards; holotype specimen with shallow thecal

* Here *Monograptus* sp. should be *Monoclimacis* sp.

excavation in the last theca of the second row; thecal inclining to axis at a low angle, overlapping one-third of their length and numbering 5 in 5 mm. Virgula extending beyond the distal extremity.

Comparison

In general characters of the rhabdosome, the new species resembles *Parakidograptus zhejiangensis* (Yang), but in the latter, the first theca (th_1^1) originates from the sicula at a lower position, with greater thecal overlapping.

Horizon and Locality

Parakidograptus primarius Zone, Kaochiapien Formation; Zhangcunxu, Qingyang, Anhui.

Pristiograptus antiquatus sp. nov.

(Pl. I figs. 8—11; text-fig. 1e—f)

1983 *Pristiograptus primitivus* Li, in Yang *et al.*, pp. 499—500, pl. 173, fig. 13, non 12.

Rhabdosome small and short, with pronounced dorsal curvature, 10—11 mm in length and about 0.3 mm in width across the apertures of the first theca, then widening slightly to a maximum width of 0.35—0.40 mm. Sicula quite conspicuous, 1.5 mm long and 0.2 mm wide in the aperture; apex reaching to the level of the second theca's proximal portion; first theca (th_1^1) originating from the upper part of the sicula and then growing upwards immediately. Thecae long and thin, 1.8 mm long and 0.2 mm wide across their aperture; ventral margins straight, inclining outward; apertural margins even, right to the axis of the rhabdosome; some thecae of the holotype specimen with shallow excavation; thecae inclining to the axis at a low angle of less than 10° , overlapping one-third of their length, with 8 of them in 10 mm.

Comparison

The new species resembles *Atavograptus primitivus* (Li) in general features of the rhabdosome, but in the latter, the first theca (th_1^1) originates from the sicula at a lower position than the present species, and the thecae are of the sub-glyptograptid type.

Horizon and Locality

Parakidograptus primarius Zone, Kaochaipien Formation; Zhangcunxu, Qingyang; in association with *Glyptograptus tamariscus nikolayevi* Obut.

图 版 说 明

所有标本均采自安徽青阳张村徐高家边组 *Parakidograptus primarius* 带(注明产地的除外), 保存在中国科学院南京地质古生物研究所。

图 版 I

- 1, 2. *Glyptograptus tamariscus nikolayevi* Obut
一个标本及其反对面, $\times 10$ 。采集号: SA 218; 登记号: 67291。
3. *Akidograptus* sp.
 $\times 20$ 。安徽宁国河沥溪高家边组 *Parakidograptus acuminatus* 带。采集号: SA 610; 登记号: 54187。
- 4—6. *Parakidograptus primarius* sp. nov.
4. 正模标本 (Holotype), $\times 10$ 。采集号: SA 218; 登记号: 67279。5, 6. 副模标本 (Paratype), 5. $\times 10$, 6. $\times 20$ 。采集号: SA 216; 登记号: 67280。
7. *Parakidograptus angustitubus* Li
 $\times 6$ 。采集号: 54221 (据李积金、葛梅钰, 1981, 图版 1, 图 5)
- 8—11. *Pristiograptus antiquatus* sp. nov.
8, 9. 正模标本及其反对面, $\times 10$ 。采集号: SA 218; 登记号: 54188。10, 11. 副模标本及其反对面, 10. $\times 6$, 11. $\times 8$ 。采集号: SA 218; 登记号: 67315。
- 12, 13. *Atavograptus primitivus* (Li)
12. $\times 6$ 。安徽宁国河沥溪高家边组 *Parakidograptus acuminatus* 带。采集号: SA 610; 登记号: 54186 (据杨达铨等, 1983, 图版 173, 图 12)。13. 同一标本的放大($\times 12$)。

