# On the origin of dimorphograptids

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Previous authors usually considered the *Diplograptus* stage → *Akidograptus* stage → *Rhaphidograptus* stage → *Dimorphograptus* stage to be an evolutionary series. After research on material of dimorphograptids from the Lower Silurian Kaochiapien Formation, southern Anhui in China, and taking into account the results from analyses on dimorphograptids in general, the writer considers that *Dimorphograptus* of the *elongatus* group and *Bulmanograptus* of the *confertus* group probably evolved from *Parakidograptus*, while *Dimorphograptus* of the *hubeiensis* group and *Bulmanograptus* of the *deminutus* group probably evolved from *Glyptograptus* and *Rectograptus* respectively. *Rhaphidograptus* probably evolved from *Climacograptus*.

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The dimorphograptids mentioned here include three genera, namely, *Dimorphograptus* (with glyptograptid thecae), *Bulmanograptus* (with rectograptid thecae) and *Rhaphidograptus* (with climacograptid thecae). *Akidograptus* and *Parakidograptus* are not dimorphograptids because in these two genera the first theca ($th_1^2$) in the second series of the rhabdosome is normal and is neither reduced nor lost (Li & Ge 1981).

Previous authors (Bulman, 1938; Mu & Li, 1960; Chen & Lin, 1978; etc.) considered the *Diplograptus* stage → *Akidograptus* stage (belonging to the diplograptid type) → *Rhaphidograptus* stage → *Dimorphograptus* stage (belonging to the monograptid type) to be an evolutionary series. Moreover, Chen & Lin (1978) further considered that the dimorphograptids with only one theca in the uniserial part represented the primitive group in different genera of the Dimorphograptidae; they directly evolved from the *Akidograptus* after the loss of the first theca in the second series. Later, due to the loss of the thecae one by one in the second series of the rhabdosome, and the uniserial part gradually becoming longer, they became the monograptids. Based on the present material, the paper presents a preliminary discussion on the origin of Dimorphograptids.

While making a study on the Lower Silurian Kaochiapien Formation graptolites from southern Anhui in China (Li, 1983), the writer discovered that in the dimorphograptids occurring in the *vesiculosus* Zone, such as *Dimorphograptus erectus* Elles et Wood, *Dimorphograptus maximus* Li, *Dimorphograptus minor* (Li), *Dimorphograptus elongatus* Lapworth, *Bulmanograptus confertus acuminatus* Li, *Bulmanograptus similis* Li, *Bulmanograptus ningguoensis* Li, the uniserial part of the rhabdosome is composed of 3–19 thecae; whereas in the dimorphograptids occurring in the *cyphus* and *gregarius* zones, such as *Dimorphograptus brevis* Li, *Bulmanograptus alternis* Li, *Bulmanograptus anhuiensis* sp. nov., there is only one theca in the uniserial part of the rhabdosome. Similar results can also be obtained from analyses of dimorphograptids material (Elles & Wood, 1901–1918; Manck, 1923; Münch, 1952; Obut, Sobolevskaya & Bondarev, 1965; Obut & Sobolevskaya 1966; Obut, Sobolevskaya & Nikolaev, 1967; Obut, Sobolevskaya & Merkureva, 1968; Churkin & Carter, 1970; Rickards, 1970; Schauer, 1971; Hutt, 1974; Bjerreskov, 1975; Lenz, 1982). It is helpful to list the stratigraphic range and the number of thecae in the uniserial part of the rhabdosome in the species assigned to the three genera (see tables 1–3).

From these 3 tables, it can be seen that amongst the dimorphograptids, the species with more thecae in the uniserial part of the rhabdosome made their appearence earlier stratigraphically, such as *D. elongatus* Lapworth, *Bulmanograptus confertus* (Lapworth), and *Rhaphidograptus extenuatus* (Elles & Wood); whereas

Table 1. Stratigraphic range of species in *Dimorphograptus*.

| Species \ Zones | *acuminiatus* | *vesiculosus* | *cyphus* | *gregarius* | *convolutus* | Number of thecae in the uniserial part |
|---|---|---|---|---|---|---|
| *D. elongatus* Lapworth | + | + | | | | 10–19 |
| *D. e. flexuosus* Schauer | | + | | | | 10-12 |
| *D. erectus* Elles et Wood | | + | | | | 3-4 |
| *D. hunanensis* Wang | | + | | | | 6 |
| *D. minor* (Li) | | + | | | | 5 |
| *D. maximus* Li | | + | | | | 3 |
| *D. guanyinqiaoensis* Ye | | + | | | | 2 |
| *D. urvantzevi* Obut et Sob. | | + | + | | | 6 |
| *D. procerus* Manck | | + | + | | | 5 |
| *D. ciliatus* Manck | | + | + | | | 3–4 |
| *D. incisus* Manck | | + | + | | | 3 |
| *D. erectus nicholsoni* Rickards | | + | + | | | 2–3 |
| *D. guichiensis* Li | | + | | | | 1 |
| *D. sichuanensis* Ye | | + | | | | 1 |
| *D. alternis* Li | | | + | | | 1 |
| *D. longicaudatus* Chen et Lin | | | + | + | | 1 |
| *D. brevis* Li | | | + | + | | 1 |
| *D. zintchenkoae* (Obut et Sob.) | | | | + | | 1 |
| *D. tenuilongissimus* (Obut et Sob.) | | | | + | | 1 |
| *D. longicaudatus fusiformis* Chen et Lin | | | | | + | 1 |
| *D. hubeiensis* Ni | | | | | + | 1 |

Table 2. Stratigraphic range of species in *Bulmanograptus*.

| Species \ Zones | *acuminiatus* | *vesiculosus* | *cyphus* | *gregarius* | *convolutus* | Number of thecae in the uniserial part |
|---|---|---|---|---|---|---|
| *B. confertus* (Nicholson) | + | + | + | | | 3–4 |
| *B. c. swanstoni* (Lapworth) | + | + | + | | | 4–6 |
| *B. c. acuminatus* Li | | + | | | | 5 |
| *B. nankingensis* (Sun) | | + | | | | 2–3 |
| *B. similis* Li | | + | | | | 2 |
| *B. ningguoensis* Li | | + | | | | 4 |
| *B. decussatus* (Elles et Wood) | | + | | | | 2 |
| *B. d. partiliter* (Elles et Wood) | | + | | | | 3 |
| *B. longissimus* (Kurck) | | + | + | | | 2–3 |
| *B. epilongissimus* (Rickards) | | + | + | | | 3–4 |
| *B. physophora* (Nicholson) | | + | + | + | | 1 |
| *B. macilentus aculeus* Chen et Lin | | | + | | | 1 |
| *B. deminutus* Ni | | | + | | | 1 |
| *B. alaskensis* (Churkin et Carter) | | | + | + | | 1 |
| *B. macilentus* Mu et al. | | | + | + | | 1 |
| *B. primus* (Obut et Sobolevskaya) | | | | + | | 1 |
| *B. anhuiensis* sp. nov. | | | | + | | 1 |
| *B. spiniferus* (Obot et Sobolevskaya) | | | | + | | 1 |
| *B. secundus* (Obut et Sobolevskaya) | | | | + | + | 1 |

those species with only one theca in the uniserial part of the rhabdosome appeared later, such as *Dimorphograptus hubeiensis* Ni, *B. anhuiensis* sp. nov. and *Rhaphidograptus sinicus* Mu et al. This evidence demonstrates that the species with more thecae in the uniserial part did not evolved from those species fewer thecae in the uniseral part.

Judging from the type of development at the proximal end, the thecal features and the shape

Table 3. Stratigraphic range of species in *Rhaphidograptus*.

| Species \ Zones | *vesiculosus* | *cyphus* | *gregarius* | *convolutus* | *sedgwickii* | Number of thecae in the uniserial part |
|---|---|---|---|---|---|---|
| *Rhaphidograptus extenuatus* (Elles et Wood) | + | | | | | 2–5 |
| *Rhaphidograptus sichuanensis* Ye | + | | | | | 1 |
| *Rhaphidograptus minutus* Chen et Lin | + | + | | | | 1 |
| *Rhaphidograptus toernquisti* (Elles et Wood) | + | + | + | + | + | 1 |
| *Rhaphidograptus maslov* Obut et Sobolevskaya | | | + | | | 1 |
| *Rhaphidograptus sinicus* Mu et al. | | | + | | | 1 |

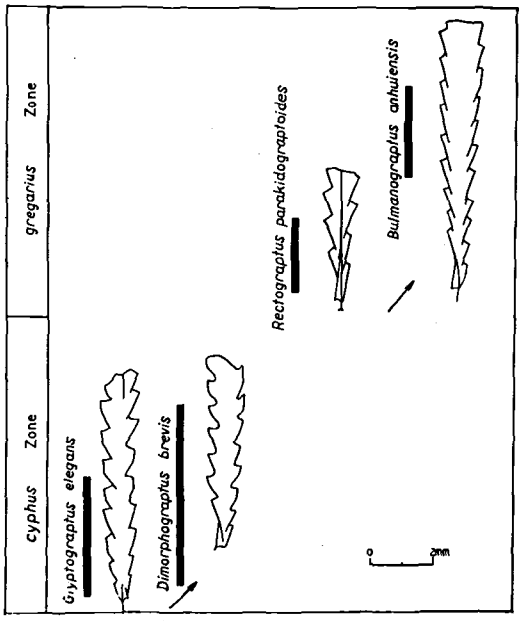


Fig. 1. Evolution of *Dimorphograptus* and *Bulmanograptus* in the Lower Silurian of Guichi, Anhui.

of the rhabdosome, the species *D. brevis* occurring in the *cyphus* Zone of the Lower Silurian Kaochiapien Formation in southern Anhui, is quite similar to *Glyptograptus elegans* Packham from the lower part of the same zone, or the same horizon; likewise, the species *B. anhuiensis* occurring in the upper part of the *gregarius* Zone is also quite similar to *Rectograptus parakidograptoides* Li from the lower part of the same zone. The writer believes that the above-mentioned *D. brevis* and *B. anhuiensis* probably have evolved from *G. elegans* and *R. parakidograptoides* respectively due to loss of the first theca in the second series of the rhabdosome. (see Fig. 1).

The species *D. hubeiensis* occurring in the *convolutus* Zone of the Lower Silurian Lungmachi Formation in Yichang, Hubei (Ni, 1978) resembles *Glyptograptus tamariscus* (Nicholson) from the lower part of the same zone; likewise, the species *Bulmanograptus deminutus* Ni appearing in the *cyphus* Zone, resembles *Rectograptus bellulus* (Törnquist) from the same horizon. Therefore, it seems that the above-mentioned *D. hubeiensis* and *B. deminutus* very probably have evolved from *G. tamariscus* and *R. bellulus* respectively as a result of loss of the first thecae in the second series of the rhabdosome (see Fig. 2).

At the same time, the species *D. elongatus* Lapworth appearing in the *vesiculosus* Zone of the Lower Silurian in eastern Thuringen, D. D.

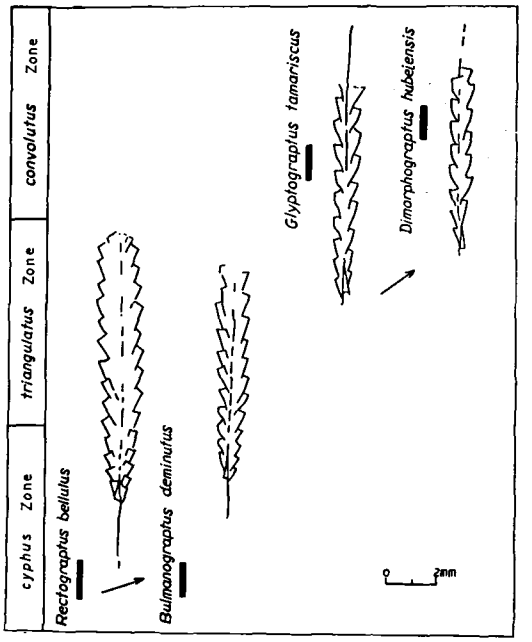


Fig. 2. Evolution of *Bulmanograptus* and *Dimorphograptus* in the Lower Silurian of Yichang, Hubei.

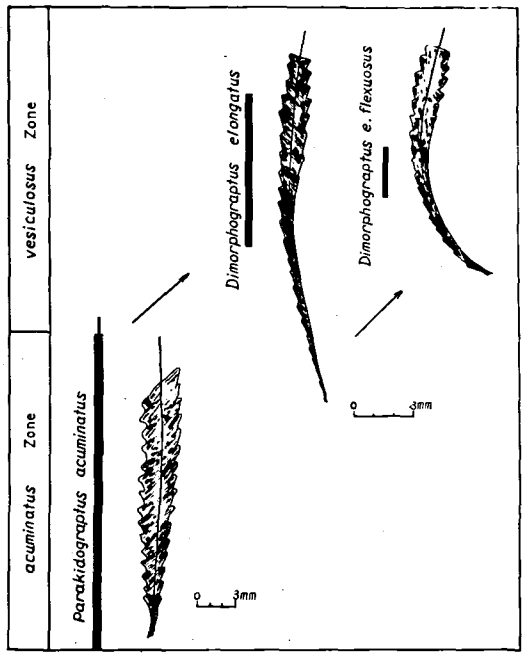


Fig. 3. Evolution of *Dimorphograptus* in the Lower Silurian of Eastern Thuringen, D.D.R.

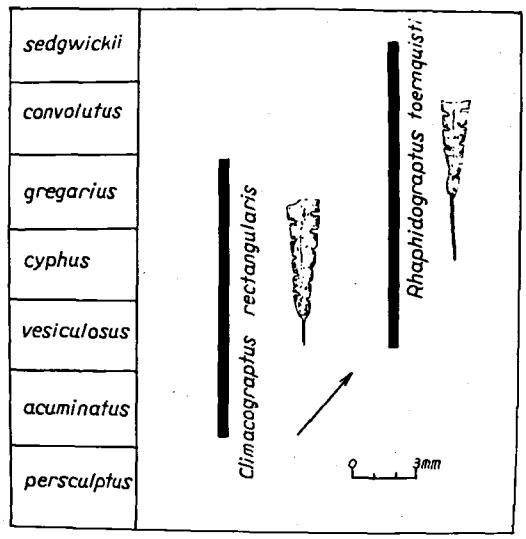


Fig. 4. Evolution of *Rhaphidograptus*.

R. (Schauer, 1971), is very similar to *Parakidograptus acuminatus* (Nicholson) appearing in the *acuminatus* Zone. The former probably has evolved from the latter with loss of most of the thecae in the second series of the rhabdosome. In *D. elongatus* the rhabdosome became further curved dorsally, and might have given rise to *Dimorphograptus elongatus flexuosus* Schauer (see Fig. 3).

The species *Rhaphidograptus toernquisti* (Elles & Wood) ranging from the *vesiculosus* Zone to the *sedgwickii* Zone of the Lower Silurian in Britain (Elles & Wood, 1901–1918; Rickards, 1970) is very similar to, and can be hardly distinguished from *Climacograptus rectangularis* M'Coy occurring from the *acuminatus* Zone to the *gregarius* Zone (Elles & Wood, 1901–1918). The former very probably has evolved from the latter due to the loss of the first theca ($th_1^2$) in the second series (See Fig. 4).

In Rickards, Hutt & Berry (1977)'s consideration, *R. toernquisti* evolved from a slender form of *Glyptograptus persculptus* Salter. However, the latter occurred at the *persculptus* Zone and disappeared at its apex of the zone, while the former didn't occur until the *vesiculosus* Zone came into being. Therefore, *G. persculptus* seem by no means to be evolved into *R. toernquisti*.

In species of dimorphograptids with more than two thecae in the uniserial part (exclusive of the *Rhaphidograptus*), the first theca ($th_1^1$) in the first series of the rhabdosome are generally sent forth from the sicula at a higher position, and the initial bud begins growing directly upwards, representing a relatively advanced stage in the development of the dimorphograptids (i.e. the monograptid type of development); *Parakidograptus* is quite near to this type of development because in this genus the first theca ($th_1^1$) was sent forth from the sicula at a higher position, the initial bud at first grew downwards, but very soon turning upwards. Thus it further evolved to *Dimorphograp-*

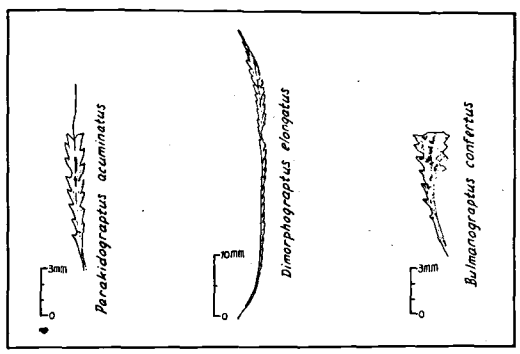


Fig. 5. Comparson of *Parakidograptus acuminatus* with *Dimorphograptus elongatus* and *Bulmanograptus confertus*.

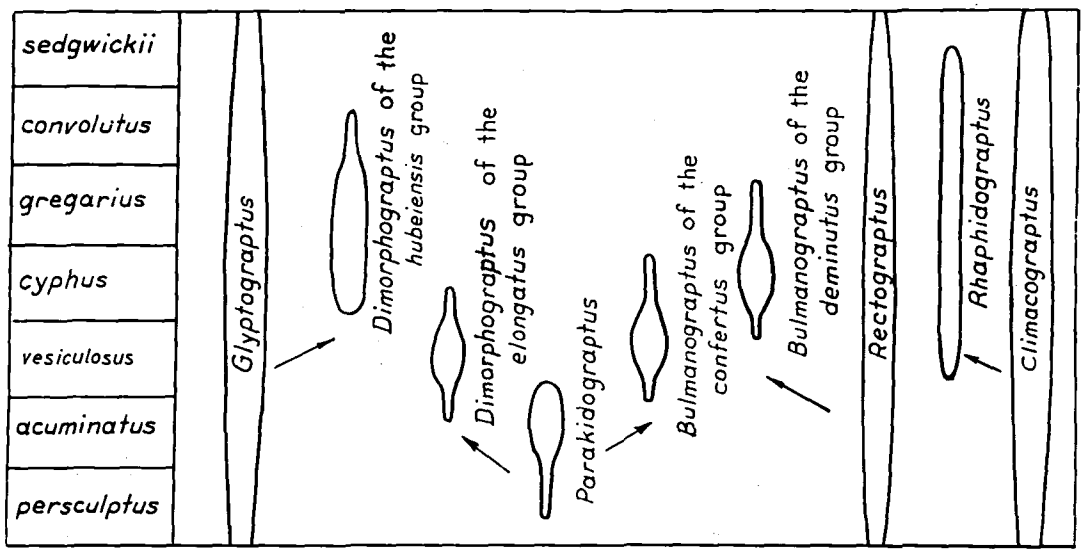


Fig. 6. Showing the probable evolutionary origin of *Dimorphograptus, Bulmanograptus* and *Rhaphidograptus.*

*tus* of the *elongatus* group and *Bulmanograptus* of the *confertus* group (see Fig. 5), whilst in the species with only one theca in the uniserial part of the rhabdosome, the first theca ($th_1^1$) generally sent forth from the sicula at a lower position, and the initial bud begins to grow first downwards and then upwards, representing a relatively primitive stage in the development of the dimorphograptids (i.e. the diplograptid type of development). This reflects their different origins in evolution.

The writer came to the conclusion that *Dimorphograptus* of the *elongatus* group and *Bulmanograptus* of the *confertus* group probably evolved from *Parakidograptus,* while *Dimorphograptus* of the *hubeiensis* group and *Bulmanograptus* of the *deminutus* group probably evolved from *Glyptograptus* and *Rectograptus* respectively. *Rhaphidograptus* probably evolved from *Climacograptus.* Their evolutionary relationship is shown in Fig. 6.

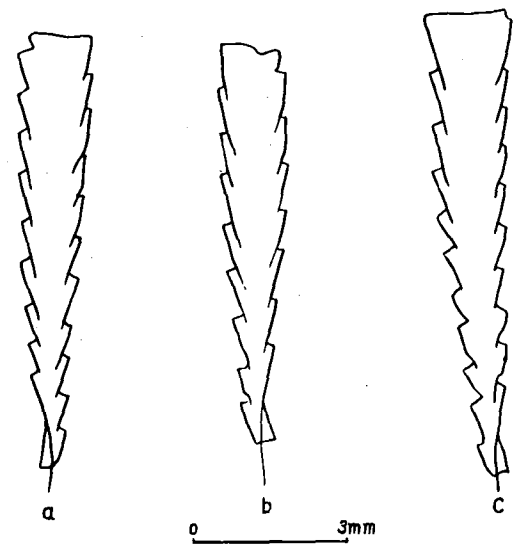


Fig. 7. a-c. *Bulmanograptus anhuiensis* sp. nov. a. Cat. no. 67285 (Holotype). b-c. Cat. nos. 67286–67287 (Paratype).

## Description of new species
## *Bulmanograptus anhuiensis* sp. nov.
## (Fig. 7a-c and 8a-c)

Material: Three well-preserved specimens in low relief.

Description: Rhabdosome small, 7.5–9 mm long with a tapering proximal end, widening gradually to a maximum breath of 1.3–1.4 mm at the distal end of the rhabdosome. Uniserial part very short and straight, and composed of only one theca, 0.7–1.1 mm long and 0.4–0.45 mm wide. Biserial part straight, 6.6–8.3 mm long and 0.65–0.7 mm wide at its proximal part and increasing to 1.3–1.4 mm at the distal end. Sicula short, 0.7–0.9 mm long and 0.20–0.25 mm wide across its aperture. Thecae being nearly simple

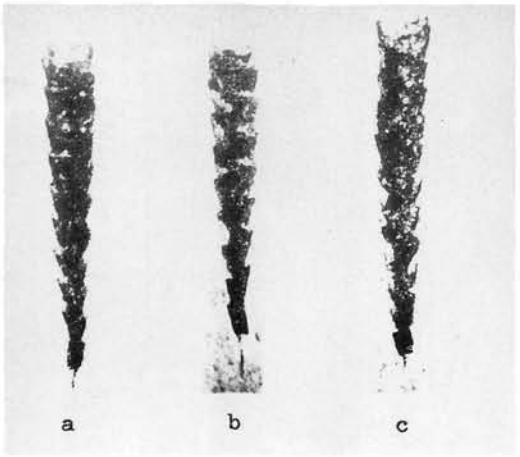


Fig. 8. *Bulmanograptus anhuiensis* sp. nov. a. Holotype, b-c. Paratypes, enlarged (X6). Cat. nos. 67285–67287.

tubes, 1.5 mm long and 0.15–0.2 mm wide across its aperture, alternate in arrangement, apertural margins everted, inclined to axis at a low angle of 10–20° and overlapping one half the thecal length.

Comparison: In the general features of the rhabdosome, the new species resembles *Bulmanograptus macilentus* Mu et al., but in the latter, the rhabdosome is greater in size, the thecae are gently curvature at the distal part of the rhabdosome.

Locality and Horizon: *Gregarius* Zone of the Kaochiapien Formation, Guichi county, Anhui, China, in association with *D. brevis* Li and *Atavograptus atavus* (Jones). Coll. nos. Dh 78–2, 79–1; Cat. nos. 67285 (Holotype), 67286–67287 (Paratype).

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## Dansk sammendrag

Tidligere forfattere har sædvanligvis regnet rækken af former: *Diplograptus – Akidograptus – Rhaphidograptus – Dimorphograptus* som en evolutionær serie. Som et resultat af studier af graptolitter fra den nedre silure Kaochiapien Formation i det sydlige Anhui i Kina, og efter overvejelser afstedkommet af studier af dimorphograptider kommer forfatteren til den konklusion at *Dimorphograptus* fra *elongatus*-gruppen og *Bulmanograptus* fra *confertus*-gruppen sandsynligvis udviklede sig fra *Parakidograptus; Dimorphograptus* fra *hubeiensis*-gruppen og *Bulmanograptus* fra *deminutus*-gruppen har sandsynligvis udviklet sig fra *Glyptograptus* og *Rectograptus* respektive; endelig er *Rhaphidograptus* nok udviklet fra *Climacograptus*.

## References

Bjerreskov, M. 1975: Llandoverian and Wenlockian graptolites from Bornholm. *Fossils and Strata* 8, 94 pp.

Bulman, O. M. B. 1936: *Rhaphidograptus*, a new graptolire genus. *Geol. Mag.*, 73, 19–26.

Bulman, O. M. B. 1938: Graptolithina. *In* Schindewolf, O. H. (*ed.*): *Handb. der Palaozool.*, Band 2D, Lief. 2, 1–92. Borntraeger (Berlin).

Bulman, O. M. B. 1970: Graptolithina. *In:* Moore, R. C. (*ed.*): *Treatise on Invertebrate Paleontology*, 5 (revised). Geol. Soc. Amer. and Univ. Kansas Press XXXII. 163 pp. Kansas.

Chen Xu. & Lin Yao-kun. 1978: Lower Silurian graptolites from Tongzi, northern Guizhou. *Memoirs of Nanjing Institute of Geology and Palaeontology*, Academia Sinica, 12, 1–76.

Churkin, M. Jr. & Carter, C. 1970: Early Silurian graptolites from southeastern Alaska and their correlation with graptolite sequences in North America and the Arctic. *Prof. Pap. U.S. Geol. Surv.* 653, 1–51.

Elles, G. L. & Wood, E. M. R. 1901–1918: A monograph of British graptolites. Pts. 1-XI, *Palaeont. Soc. Lond. Monogr.*, 539 pp.

Hutt, J. E. 1974: The Llandovery graptolites of the English Lake District. *Palaeontographical Society, Monog.*, Pt. 1, 1–56.

Lenz, A. C. 1982: Llandoverian graptolites of the northern Canadian Cordillera: *Petalograptus, Cephalograptus Rhaphidograptus, Dimorphograptus*, Retiolitidae and Monograptidae. *Life Science Contribution Royal Ontario Museum* 130, 1–154.

Li Ji-jin, 1983: Graptolithina. *In. Palaeontological Atlas of East China* (1). Volume of Early Paleozoic, Chiefly edited by Nanjing Institute of Geology and Mineral Resources. Geological Publishing House, Beijing, China, 493–396. (In Chinese).

Li Ji-jin (in press): *Lower Silurian graptolites from southern Anhui with special reference to the origin of Monograptids.*

Li Ji-jin & Ge Mei-yu, 1981: Development and systematic position of Akidograptids. *Acta Palaeontologica Sinica*, 20 (3), 225–234.

Manck, E. 1923: Untersilurische Graptolithenarten der Zone 10 des Obersilurs, ferner *Diversograptus* n. gen. nov. *Natur*, Lpz. 14, 284–289.

Mu En-zhi & Li Ji-jin, 1960: *Graptolite.* Science Press (In Chinese).

Münch, A. 1952: De Graptolithen aus dem Anstehenden Gotlandium Deutschlands und der Tschechoslowakei. *Geologica*, 7, 1–157.

Ni Yu-nan, 1978: Lower Silurian graptolites from Yichang, western Hubei. *Acta Palaeontologica Sinica*, 17 (4), 387–416.

Obut, A. M., Sobolevskaya, R. F. & Bondarev, V. I. 1965: Graptolites of the Silurian of Taymyr. *Trudy geol. Inst. Kazan. Filial*, 1–120. (In Russian.)

Obut, A. M. & Sobolevskaya, R. F. 1966: Lover Silurian graptolites in Kazakhstan. *Akad. Nauk SSSR, Sibirsk Otdel., Inst. Geol. Geoiz., Minist. Geol. SSSR, Nauchno-issledov. Inst. Geol. Arktiki*, 1–56. (In Russian.)

Obut, A. M., Sobolevskaya, R. F. & Nikoleav, A. A. 1967: Lower Silurian graptolites and stratigraphy of the uplifted margin of the Kolyma Massif (northeastern USSR). *Akad.*

*Nauk. SSSR, Nauchno-issledov. Inst. Geol. Arktiki,* 1–162. (In Russian.)

Obut, A. M., Sobolevskaya, R. F. & Merkureva, A. P. 1968: Llandovery graptolites from a borehole core in the Norilsk Region. *Akad. Nauk SSSR, Otdel. Inst. Geol. Geofiz., Minist. Geol. SSSR, Nauchno-issledov. Inst. Geol. Arktiki,* 1–136. (In Russian.)

Rickards, R. B. 1970: The Llandovery (Silurian) graptolites of the Howgill Fells, northern England. *Palaeontolographical Society Monograph,* 1–108.

Rickards, R. B., Hutt, J. E. & Berry, W. B. N. 1977: Evolution of Silurian and Devonian graptoloids. *Bulletin of the British Museum (Natural History), Geology,* 28, 1–120.

Schauer, M. 1971: Biostratigraphie und Taxionomie der Graptolithen der tieferen Silurs unter besonderer Berücksichtigung der tektonischen Deformation. *Freiberger Forsch. Hft. C 273,* Paläontologie 185 pp.