



宽网叶肢介属重要分类特征的发现*

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提要 通过扫描电镜重新研究产自俄罗斯维特奴河流域下三叠统维特奴宽网叶肢介(*Loxomegalypta wetlugiana* Novojilov, 1958)的正模标本。电镜照相揭示了光学照相无法分辨的重要分类学新特征, 其中包括: 生长带饰有圆形、角状或椭圆形小筛坑状装饰(直径 15–25 μm), 筛坑被不同形状的隆起包围。均匀分布的针孔(直径 4–6 μm)不但出现在筛坑里, 而且布满了筛坑周围的隆起。这种装饰与该属建立时描述的多角状大网格装饰区别较大。从而修订了宽网叶肢介属生长带的装饰特征。

关键词 化石叶肢介 宽网叶肢介属 分类学 早三叠世 俄罗斯

中文引用 李 罡, 2020. 宽网叶肢介属重要分类特征的发现. 古生物学报, 59(4): x-x. DOI: 10.19800/j.cnki.aps.2020.043

英文引用 Li Gang, 2020. Discovery of important taxonomic features in fossil clam shrimp genus *Loxomegalypta* (Crustacea: Spinicaudata). Acta Paleontologica Sinica, 59(4): x-x. DOI: 10.19800/j.cnki.aps.2020.043

Discovery of important taxonomic features in fossil clam shrimp genus *Loxomegalypta* (Crustacea: Spinicaudata)

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Abstract Re-examination of the holotype specimen of the clam shrimp type species *Loxomegalypta wetlugiana* Novojilov, 1958 using a scanning electron microscope (SEM) has revealed details of carapace features with important taxonomic value, which have never been described hitherto. The new features include: growth bands in the middle and ventral part of the carapace are ornamented with circular, angular or elliptical sieve-like fine pits (15 to 25 μm in diameter), which are surrounded by variously shaped, wide swellings. Puncta (4 to 6 μm in diameter) occur not only in the pits, but also on the surrounding swellings. This ornamentation pattern is different from the originally described angular reticulation, and the diagnosis of *Loxomegalypta* is emended.

收稿日期: 2020-07-16, 改回日期: 2020-09-27; 录用日期: 2020-10-07; 责任副主编: 王 博

* 中国科学院战略性先导科技专项(B类)(XDB26000000)、国家自然科学基金项目(41688103, 41972007, 41572006)、烟台市科学技术局(2020MSGY070)和国际地球科学计划 IGCP 679 项目联合资助。

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Key words Fossil clam shrimp, *Loxomegalypta*, taxonomy, Early Triassic, Russia

1 INTRODUCTION

Clam shrimps are large branchiopod crustaceans, and they are widely distributed nowadays on all continents except for Antarctica (Brendonck *et al.*, 2008; Rogers *et al.*, 2012; Shu *et al.*, 2019; Sigvardt *et al.*, 2020). Clam shrimp have bivalved chitinous or complex chitin-mineral carapaces (Astrop and Hegna, 2015; Li, 2017a, 2017b, 2020), which were commonly preserved as abundant fossil records in lacustrine deposits since the Devonian (Tasch, 1969). As a result, they can be useful for biostratigraphic subdivision and correlation of non-marine fossil bearing strata (Chen *et al.*, 2007; Kozur and Weems, 2010; Li and Matsuoka, 2012, 2015; Boukhalfa *et al.*, 2015; Scholze *et al.*, 2015; Schneider and Scholze, 2016; Teng and Li, 2017, 2018, 2019, 2020; Liao *et al.*, 2019; Gallego *et al.*, 2020).

Loxomegalypta Novojilov, 1958 was described based on the material from the Lower Triassic along the Vetluga River in the Volga region of Russia. Then it was reported in the Upper Triassic to Lower Cretaceous in China (Zhang *et al.*, 1976; Duan, 1978; Chen and Shen, 1985; Li *et al.*, 1997; Gao, 2017). But there was only a reconstructed carapace figure published, no ornamentation image was available to show the details in the original description (Novojilov, 1958). In this paper, the author re-examined the holotype specimen by SEM microscopy and revealed important taxonomic features that were not mentioned hitherto.

2 MATERIAL AND METHODS

The figured specimen is the holotype, a right valve, broken in its dorsal part, PIN No. 986/8 of the collection of the Palaeontological Institute of Russian Academy of Sciences. The specimen was collected from the Lower Triassic (Vetluga stage) along the Vetluga River in the Volga region.

The original description of the type species *Loxomegalypta wetlugiana* Novojilov, 1958 was based on light microscopy. The author only provided a reconstructed figure (Novojilov, 1958, fig. 4) of the type specimen. No photo was available for showing the detailed ornamentation pattern or the carapace outline. In this study, a Leica M165 C light microscope was used to document general morphology of the studied specimen (Fig. 2A, 2B); a Tescan Vega II scanning electron microscope (SEM) of the Palaeontological Institute of Russian Academy of Sciences was used for the detailed observation and imaging of the delicate ornamentation of the type specimen. Nowadays SEMs are widely available, and necessary for the taxonomy of fossil clam shrimp, because the delicate carapace ornamentation could only be clearly observed and imaged under an SEM (Li and Batten, 2004a, 2004b, 2005).

3 SYSTEMATIC PALAEOLOGY

The author follows the recent classification of spinicaudatans by Martin and Davis (2001). The carapace size of the fossil clam shrimp was described as small (carapace length <5 mm), medium (carapace length between 5 mm and 15 mm) or large (carapace length >15 mm) (Chen and Shen, 1985). Recently, Scholze and Schneider (2015, table 1) proposed another terminology to describe the size of clam shrimp. The author finds that the tripartite category of Chen and Shen (1985) is easy to follow for describing the carapace size.

Order Diplostraca Gerstaecker, 1866

Suborder Spinicaudata Linder, 1945

Superfamily Eosestherioidea Zhang and Chen in Zhang *et al.*, 1976

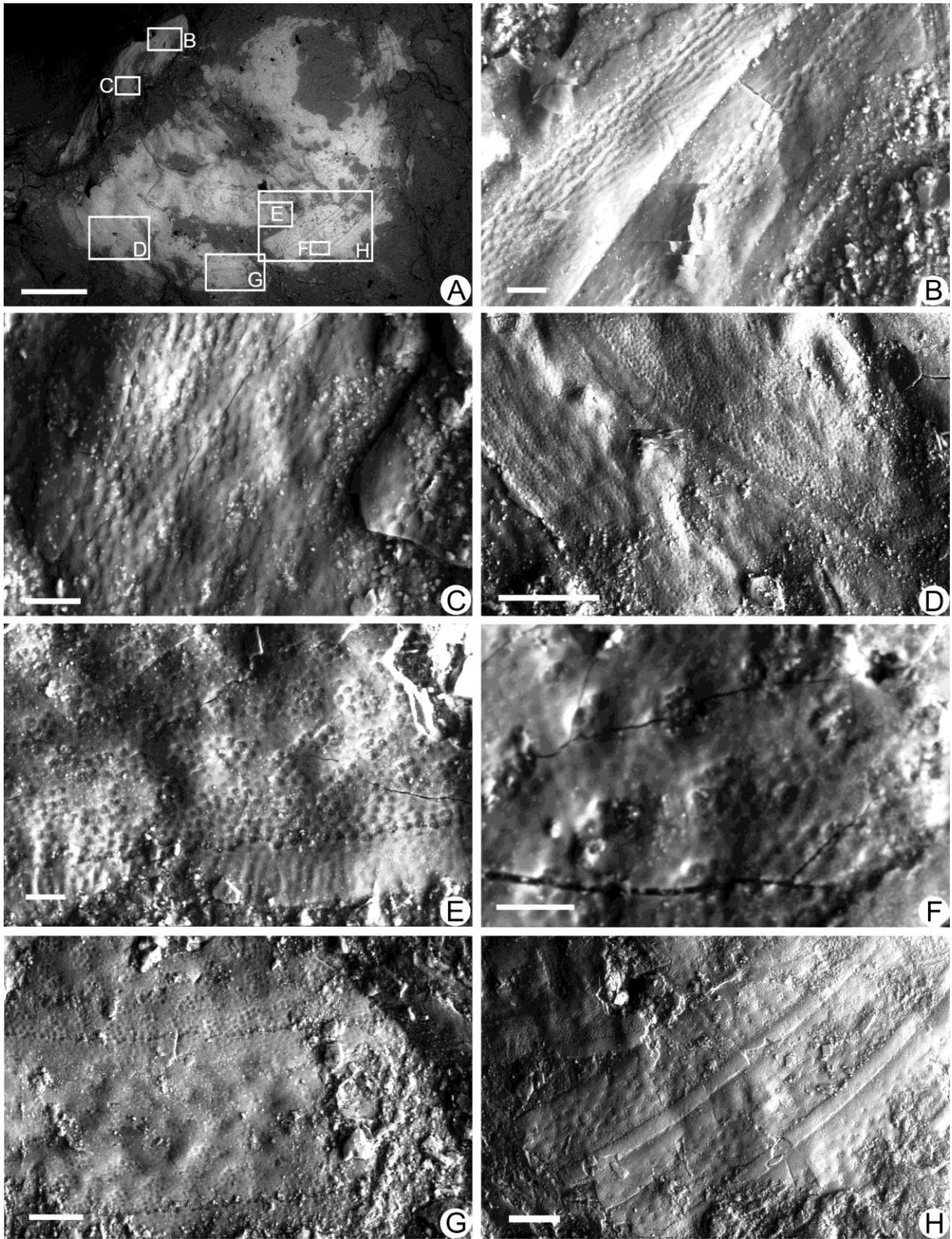


图 1 维特奴宽网叶肢介

Fig. 1 *Loxomegalypta wetlugiana* Novojilov, 1958 emend.

All are SEM images of the holotype specimen PIN No. 986/8 deposited in the collection of Palaeontological Institute of Russian Academy of Sciences, which was collected from the Lower Triassic along the Vetluga River in the Volga region, Russia. **A**, a right valve, scale bar = 0.5 mm. **B**, fine ridges on growth bands in the postero-dorsal part of the carapace, scale bar = 20 μ m. **C**, elliptical sieve-like pits and surrounding swellings with puncta on a growth bands in the posterior marginal area of the carapace, scale bar = 20 μ m. **D**, elliptical sieve-like pits and surrounding swellings on growth bands in the postero-ventral part of the carapace, scale bar = 100 μ m. **E, F, H**, ornament on growth bands in the antero-ventral part of the carapace, showing the circular, angular sieve-like pits surrounded by swellings, puncta occur in the pits and on the swellings. Fine and dense ridges can be seen on a growth band in **E**. Scale bars = 20 μ m in **E** and **F**; scale bar = 100 μ m in **H**. **G**, circular or angular sieve-like fine pits surrounded by swellings on growth bands in the ventral part of the carapace. Puncta occur in pits and on the swellings. Scale bar = 50 μ m.

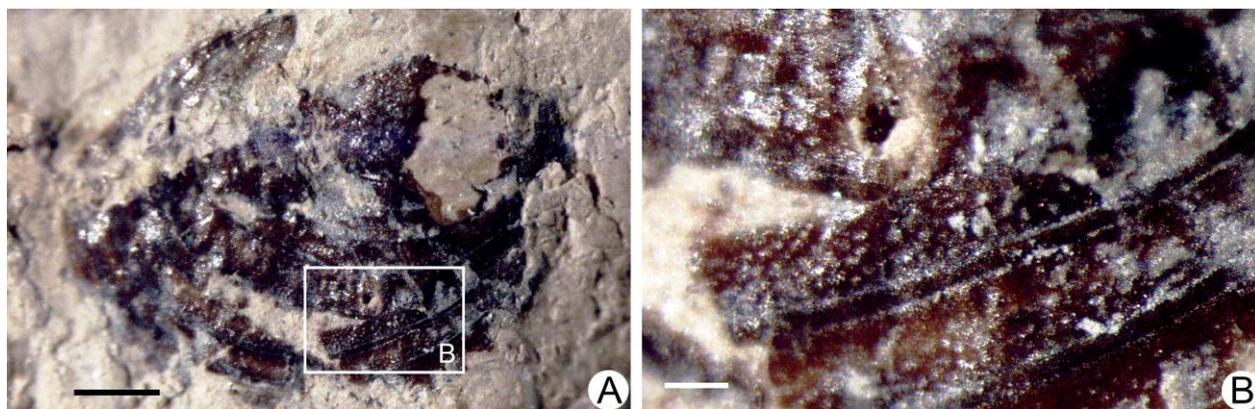


图 2 维特奴宽网叶肢介

Fig. 2 *Loxomegalypta wetlugiana* Novojilov, 1958 emend.

All are light microscopy images of the holotype specimen PIN No. 986/8 deposited in the collection of Paleontological Institute of Russian Academy of Sciences, which was collected from the Lower Triassic along the Vetluga River in the Volga region, Russia. **A**, a right valve, scale bar = 0.5 mm. **B**, circular or angular sieve-like fine pits on growth bands in the antero-ventral part of the carapace, scale bar = 100 μ m.

Family Loxomegalyptidae Novojilov, 1958

Remarks Novojilov (1958) erected the subfamily Loxomegalyptinae to include taxa with clear anterior and posterior dorsal angles and irregularly angular reticulations on growth bands. Later, it was elevated to a family rank (Zhang *et al.*, 1976) to include taxa with medium- to large-sized reticulations (mesh diameter between 0.02 and 0.2 mm). And the type genus *Loxomegalypta* Novojilov, 1958 was considered possessing large-sized, hexagonal reticulations (mesh diameter between 0.05 and 0.1 mm). But the re-examination of the type specimen demonstrates a circular or angular sieve-like fine pit ornamentation in *Loxomegalypta* (mesh diameter between 0.015 and 0.025 mm), which is much smaller than originally considered. And it is necessary to make an SEM re-examination on other taxa before the emendation of the diagnosis of the family could be carried out.

Genus *Loxomegalypta* Novojilov, 1958 emend.

Type species *Loxomegalypta wetlugiana* Novojilov, 1958 from Lower Triassic (Vetluga stage) along Vetluga River of Volga region, Russia.

Emended diagnosis Carapace small or medium in size, elliptical or oblique oval in outline. Dorsal margin straight, small umbo located at its middle or anterior part. Growth bands a few in number, flat and wide in the middle part of the carapace, but become narrow near the carapace distal margin. The punctate growth bands are ornamented with circular, elliptical or angular sieve-like fine pits (or depressions) surrounded by wide swellings forming irregular meshwork in the middle and ventral part of the carapace.

Remarks In the original description of the genus *Loxomegalypta*, Novojilov (1958, fig. 4) stressed the carapace oblique outline and the angular and irregular reticulations, which have been shown in the only reconstruction figure. Later, *Loxomegalypta* has been described as having a large-sized, regularly hexagonal

reticulation with flat mesh bottom and thin mesh wall (Zhang *et al.*, 1976; Duan, 1978; Chen and Shen, 1985). The present examination of the holotype of the type species under an SEM has revealed important taxonomic features previously not seen, namely: 1) punctuate sculptures on growth bands; 2) circular, elliptical or angular sieve-like pits surrounded by wide swellings forming irregular meshwork.

The Late Jurassic *Beipiaoestheria* Wang, 1980, considered as a synonym of *Loxomegaglypta* by Chen and Shen (1985), is characterized by large-sized reticulations on growth bands, which differs from the punctate, sieve-like fine pit ornamentation in *Loxomegaglypta*.

***Loxomegaglypta wetlugiana* Novojilov, 1958 emend.**

(Figs. 1, 2)

1958 *Loxomegaglypta wetlugiana* sp. nov. Novojilov, p. 10, fig. 4.

1985 *Loxomegaglypta wetlugiana* Novojilov, 1958. Chen and Shen, p. 104, fig. 63.

Emended diagnosis Carapace small in size, oblique ovate or rhombic in outline. Growth bands flat and wide in the middle part, and narrow in the distal margin area, ornamented with circular, angular or elliptical sieve-like fine pits (or depressions) surrounded by variously shaped, wide swellings, densely spaced puncta occur in the pits and on the swellings.

Dimensions of figured specimen Carapace length 2.68 mm, carapace height 2.18 mm, dorsal margin 1.68 mm, height/length ratio 0.81.

Description Carapace small in size, oblique ovate or rhombic in outline (Figs. 1-A, 2-A). Umbo small, located at the middle part of the straight dorsal margin, which represents about 63% of the carapace length. Antero-dorsal angle 120°, postero-dorsal angle 150°. Anterior margin widely rounded, posterior margin truncated, ventral margin widely arched. Growth bands wide in the middle part of the carapace, and become narrow near the ventral margin. Growth bands ornamented with circular, angular sieve-like fine pits (diameter between 15–25 µm) in the middle and antero-ventral part of the carapace (Figs. 1-E–1-H, 2-B), or transversely elliptical fine pits in postero-ventral or posterior part of the carapace (Figs. 1-C, 1-D). Pits are surrounded by variously shaped, wide swellings. Puncta occur in pits and on swellings, lumina of puncta about 4 to 6 µm (Figs. 1-E, 1-G). Growth line ornamented with densely spaced puncta or fine ridges (Fig. 1-E). Growth bands in the postero-dorsal angle area ornamented with transversely directed fine ridges (Fig. 1-B).

Remarks Novojilov (1958, fig. 4) described that the holotype was 4 mm long, which can be measured in his published reconstructed carapace figure. But the new measurement shows that the carapace is smaller, only 2.68 mm long. The growth band ornamentations were initially described as large-sized reticulations. But the SEM imaging has clearly demonstrated that growth bands in the middle and ventral part of the carapace are ornamented with circular or elliptical sieve-like fine pits (with a diameter between 15–25 µm) surrounded by variously shaped wide swellings. Puncta occur within the pits and on the surrounding swellings.

Two species *Loxomegaglypta luchangensis* (Chen, 1974) and *Loxomegaglypta tanbaensis* Chen in Zhang *et al.*, 1976 were reported from the Upper Triassic of southwestern China. They differ from the type species by different carapace outline: i.e. the former is ovate with the umbo located in the anterior part of the dorsal margin; the latter has an elliptical outline (Zhang *et al.*, 1976). Other species of *Loxomegaglypta* were also described from Russia and China: i.e. Early Triassic *L. tschalyschevi* Molin, 1965 and *L. jiaochengensis* Liu, 1982; Middle Triassic *L. subrotunda* Bi and Xie, 1982; Early Cretaceous *L.? wanquanensis* Niu in Wang *et al.*, 1984, *L.? subcircularis* Niu in Wang *et al.*, 1982. The growth bands of these species were described to be ornamented by large-sized reticulations, but the blurred images hamper further detailed comparison.

Locality and horizon Vetluga River of the Volga region, Russia; the Lower Triassic (Vetluga stage).

4 DISCUSSION

The pitted or cavernous sieve-like ornamentation has been reported in several fossil clam shrimp taxa, such as *Antronestheria* Chen and Hudson, 1991 (Middle Jurassic, Scotland), *Ethmosestheria* Stigall and Hartman, 2008 (Upper Cretaceous, Madagascar), *Martinsesetheria* Gallego *et al.*, 2013 (Lower Cretaceous, Brazil), *Neodiesteria* Chen in Zhang *et al.*, 1976 emend. Li *et al.*, 2016 (Lower Cretaceous, China). In *Antronestheria*, there is a row of deeply impressed fossae crowded along the upper margin of each growth line. *Ethmosestheria* differs from *Loxomegaglypta* in possessing puncta that only occur in the pits, not on the surrounded swellings. In *Martinsesetheria* the medium-ventral growth bands with scarce shallow ovate cavities (45–90 μm in diameter) are filled with minute puncta (2–3 μm in diameter), while the dorsal growth bands are ornamented with polygonal ornamentations, and its growth lines possessing distinct serrated structures.

Neodiesteria has more complicated growth band ornamentations. Its growth bands in antero-ventral, ventral and postero-ventral parts of the carapace are also ornamented with transversely elongate large pits (depressions) surrounded by swellings, appearing as a coarse reticulum superimposed over fine reticulation and radial lirae, but its growth bands near the umbo ornamented with evenly distributed sparse puncta; and its growth bands in the lower-middle and antero-ventral parts of the carapace ornamented with irregular, polygonal, fine reticulation with puncta present within each lumina; on growth bands in the ventral and postero-ventral parts, the fine reticulations gradually change to dense, fine radial lirae and crossbars (Li *et al.*, 2016).

The holotype specimen is not well preserved in the dorsal part of the carapace. Thus, it is necessary to search for better preserved specimens in the type locality in the future to clarify the full ornamentation pattern of *Loxomegaglypta*.

5 CONCLUSION

The previous studies on the taxonomy of fossil clam shrimp were mainly based on light microscopy. This led to the low resolution in imaging of growth band ornamentation, and important valuable taxonomic features were sometimes overlooked. In the present study the author re-examined the Early Triassic Russian type specimen of *Loxomegaglypta* Novojilov, 1958 under an SEM to carry out a morphological study. New important features are revealed and the diagnosis of the genus is emended: i.e. the carapace is ornamented by sieve-like pits surrounded by variously shaped wide swellings, and puncta occur within the pits and on the swellings. This ornament is different from the originally described polygonal reticulation.

Acknowledgements The study was supported by the Strategic Priority Research Program of the Chinese Academy of Sciences (XDB26000000), by the National Natural Science Foundation of China (41688103, 41972007, 41572006), and by Science and Technology Bureau of Yantai City (2020MS GY070). This is a contribution to UNESCO-IUGS IGCP Project 679. Great thanks go to Dr. M. Boiko, Mrs Irina and Dr. Roman Rakitov of Palaeontological Institute of Russian Academy of Sciences for their very kind help during my study in Moscow. Many thanks go to Hegna T A (SUNY Fredonia) and Shen Yan-bin (Nanjing Institute of Geology and Palaeontology, Chinese Academy of Science) for their very kind help to share the important literatures. Thanks go to the reviewers for their constructive comments.

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