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论奥陶纪三叶虫属 *Reedocalymene* Kobayashi，1951*

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提要　由于建立 *Reedocalymene* 一属的模式种标本保存甚差，长期以来，这一属的概念一直不甚明了。研究了峡东地区庙坡组新发现的丰富且保存完好的 *Reedocalymene expansa* Yi 材料，其中完整背壳系首次发现。新材料揭示了以往 *Reedocalymene* 的一些鲜为人知的背面和腹面形态，从而有可能对该属进行全面的修订。讨论了 *R. expansa* 的某些重要特征，如面线、前坑、腹边缘板、前舌以及壳面装饰等。*R. expansa* 标本中的形态变异和保存差异表明，以往描记的所有产自峡东地区庙坡组的其他种都是它的晚出异名。目前归属于 *Reedocalymene* 的只有模式种 *R. unicornis* 和 *R. expansa* 两个种。

关键词　三叶虫　*Reedocalymene*　奥陶纪

NOTES ON THE GENUS *REEDOCALYMENE* KOBAYASHI，1951 (TRILOBITA，ORDOVICIAN)

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Abstract：　For a long time，the concept of *Reedocalymene* has been unclear because its type species was erected on poorly preserved specimens. The abundant，well preserved material of *Reedocalymene expansa* Yi from the Miaopo Formation of the eastern Yangtze Gorges area in western Hubei，including the first recorded complete exoskeleton，reveals some dorsal and ventral morphologies that were little known previously in *Reedocalymene*. This material allows us to revise the genus comprehensively. Some of important features of *R. expansa*，such as facial sutures，fossulae，rostral plate，anterior projection of cephalon，and exoskeletal sculpture，are discussed，providing a basis for understanding the genus until more is known about the type species. At present，only the type species，*R. unicornis*，and *R. expansa* can be assigned to *Reedocalymene*. The range of morphological variation and the observed differences in preservation in *R. expansa* suggest that all other previously described species assigned to *Reedocalymene* from the Miaopo Formation in the eastern Yangtze Gorges area should be suppressed as junior synonyms of *R. expansa*.

Key words：　*Reedocalymene*，trilobite，Ordovician

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INTRODUCTION

The genus *Reedocalymene* is one of the most distinctive calymenid trilobites, characterized by having an notably elongated anterior cranidial border. It appears to be endemic to the Yangtze Platform. It is known only from western Yunnan and western Hubei provinces. The genus was established by Kobayashi (1951, p. 45) with *Calymene unicornis* Reed (1917, p. 52—54, pl. 8, figs. 10—13) as its type species. At the time, *R. unicornis* was the only known species. The type species is based on three fragmented, highly deformed cranidia and one pygidium, all collected from the Shidian Formation near Pupiao, westerrn Yunnan. Because of the poor preservation of the type material, and the inaccuracy of both Reed's (1917) illustrations and Kobayashi's (1951) reconstruction for the type species, the generic concept of *Reedocalymene* has been more or less obscure. For this reason, Dean and Zhou (1988, p. 633) pointed out that a revision of the genus was needed. However, for nearly half a century since the genus was erected, no any attempt had been made to revise the partially erroneous generic diagnosis given by Kobayashi (1951).

According to Cowper Reed (1917, p. 1), the type material of the type species, *R. unicornis*, was collected in early years of the twentieth century (1908—1910). Since then no additional specimens have been obtained from the type locality or elsewhere in western Yunnan. In contrast to the rareness and poor preservation in Yunnan, *Reedocalymene* is commonly collected from the Miaopo Formation in the eastern Yangtze Gorges area, western Hubei(Yi, 1957; Lu, 1975; Xia, 1978; Sheng and Ji, 1986; Xiang and Zhou, 1987), and is usually found in a good state of preservation. So far as known, five other species were proposed based on specimens from western Hubei.

The material of *Reedocalymene expensa* dealt with in this paper is also from the Miaopo Formation in the eastern Yangtze Gorges area. In that region, the formation is 2.1—2.6m thick, and composed of greenish yellow to dark gray shales with several limestone intercalations. Specimens are mainly collected from the shales although a few specimens are from the limestone intercalations. Most specimens are well-preserved as external and internal molds, but some specimens expose the exoskeletal surface. For the first time, the new material reveals the entire dorsal morphology and some ventral characters for *Reedocalymene*, and makes it possible to emend the generic diagnosis. In addition, the variation in morphology and preservation in the present collection suggests that all specimens previously described under five other specific names from the eastern Yangtze Gorges area belong to one species, *R. expansa*. Therefore, *Reedocalymene* currently includes only two species, the type species and *R. expansa*. Although the type material of the type species is poorly preserved, the material from western Hubei provides a clear understanding of the characters of the genus *Reedocalymene*. Until more is known about the type species, it seems more practical to base the generic concept largely on features of *R. expansa*.

TERMINOLOGY

Terminology used in this paper follows the *Treatise of Invertebrate Paleontology, part O, Revised* (Whittington and Kelley, 1997, p. 313—329) with some exceptions. The term *anterior node* is used herein for the paired nodes that lie inside the fossulae, close to the anterolateral corner of *Reedocalymene expansa* and *Calymenesun tingi*. We adopt the term *unrolled spiral enrollment* from Bergström (1973, p. 14—15, text-fig. 8f) for the partly unrolled trilobite that has part of the pygidium visible even when fully enrolled.

DISCUSSION OF SOME FEATURES OF *REEDOCALYMENE*

Observation of the new material and examination of the *Reedocalymene* collection of Nanjing Institute of Geology and Palaeontology (NIGP) made it possible to reveal some features previously unknown or poorly known for *Reedocalymene*. These features are discussed below. Some specimens in the *Calymenesun* collection of the NIGP were also examined for the purpose of comparison.

Facial suture and genal spines: Kobayashi (1951, p. 45) regarded the facial suture of *Reedocalymene* as gonatoparian. As the facial sutures are hard to judge from the specimens of the type species (Reed, 1917, pl. 8, figs. 10—12), Kobayashi's conclusion seems to be based on the facial suture patterns of other calymenidids, most of which have gonatoparian sutures (Whittington, in Moore, 1959, p. 450—453). Our new material of *R. expansa* indicates that such a diagnostic character for the genus is dubious. The suture type for the type species remains unsettled, but *R. expansa*, the only other valid species, possesses proparian facial sutures. In *R. expansa*, the posterior section of the facial suture runs directly outward from the palpebral lobe, nearly parallel to

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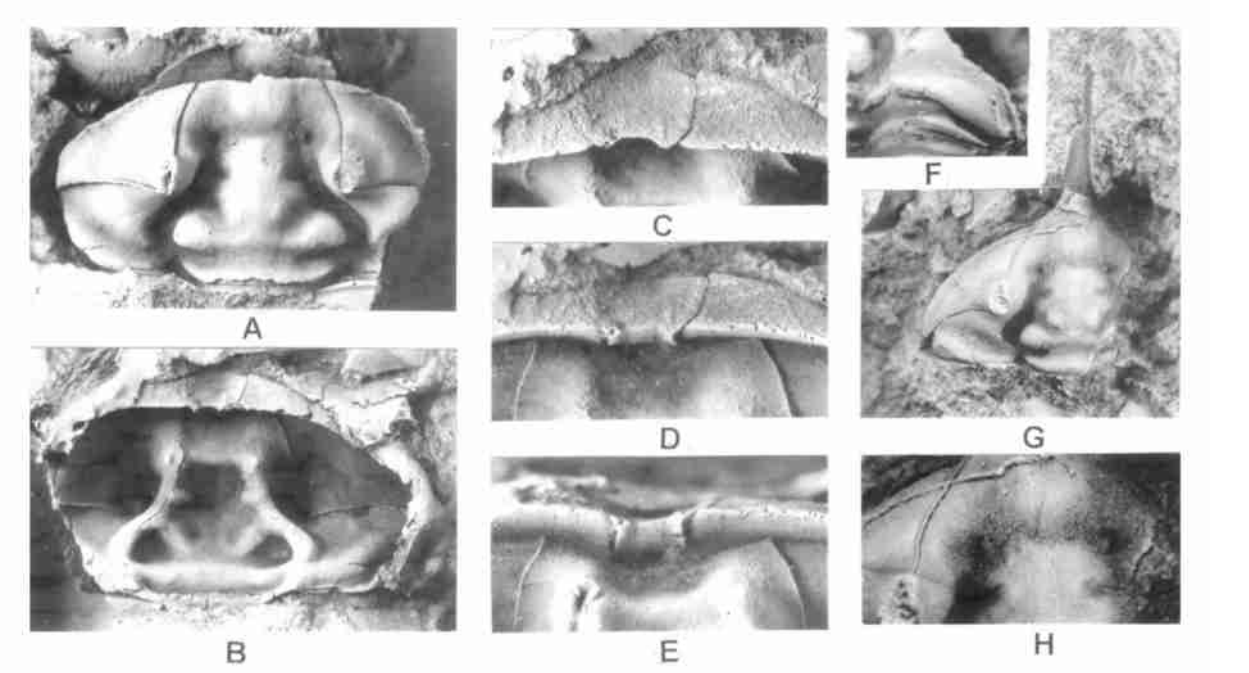

Text-fig. 1　*Calymenesun tingi* (Sun, 1931). A-E, internal mold of the syntype cephalon figured by Sun (1931, Pl. 3, fig. 9a) and Lu (1975, Pl. 46, fig. 13), showing cephalic doublure and rostral plate, A-B x 3, C-E x 5; F, part of the internal mold of exoskeleton figured by Zhou and others (1984, Fig. 7b), showing the base of the genal spine, x 6; G, H, the internal mold of incomplete cephalon figured by Zhou and others (1984, Fig. 7g), showing the anterior nodes and fossulae near anterolateral corner of the glabella, x 3, x 6.

the posterior cranidial margin with its outer end slightly curved rearward to cut the lateral margin slightly in front of the genal spine which is produced from the genal corner (Pl. Ⅰ, figs. 1, 3; Pl. Ⅱ, figs. 1—6, 9).

The course of the anterior section of the facial suture in *R. expansa* is more or less similar to that of other calymenidids. The facial sutures gently converge forward from the palpebral lobes and across the cephalic border to intersect the cephalic margin, then they turn sharply inward and slightly forward to run underneath the anterior projection of the cephalon. They contour the curvature of lateral margins of the cephalon and meet medially. The ventral part of the suture separates the cranidial doublure from the doublure of anterior projection.

The proparian suture and genal spine are known not only from *Reedocalymene* but also from *Calymenesun*, a genus referred also to the subfamily Reedocalymeninae. *Calymenesun* has proparian sutures similar to those of *R. expansa*. A fragmental exoskeleton and a cephalon (refigured herein as Text-fig. 1) assigned as *C. tingi* (Sun) from Guizhou (Zhou and others, 1984, p. 29, figs. 7b, g) are reported to have a short genal spine, which Zhou and others (1984, p. 29) regarded as an intergenal spine. Examination of their material shows that the spine was likely damaged previously, and only the base of spine can be observed at the tip of cephalic posterior border on the exoskeleton (Text-fig. 1F). If the genal spine does exist on both specimens, the posterior section of facial suture should meet the lateral cephalic margin in front of the genal corner. Therefore, we would consider such a spine as a genal spine.

In the Reedocalymeninae, the genal spine is also known in *Neseutetinus* Dean, which was originally regarded as a subgenus of *Neseuretus* (Dean, 1967). A cranidium assigned to *Naseutetinus turcicus* from Sardinia, Italy, bears tiny genal spines (Hammann and Leone, 1997, pl. 28. figs. 3a, c; text-fig. 28). *N. turcicus* may also have a proparian sutures. The distal part of the posterior section of the facial suture of *N. turcicus* remains ambiguous, but the lateral view of the Sardinian cranidium (Hammann and Leone, 1997, pl. 28, fig. 3c) shows that the posterior facial suture is likely to cut the lateral cephalic margin well in front of the genal corner.

Rostral plate and cephalic doublure: Although the rostral plate and cephalic doublure have been commonly recorded in the Calymenidae (Campbell, 1967; Siveter, 1967) and in some genera of the Reedocalymeninae (Lu, 1975; Hammann, 1985), the rostral plate and the ventral cephalic doublure had not been previously described in *Reedocalymene*. The rostral plate of *Neseuretus avus* (Hammann, 1983, p. 61, text-fig. 26; Pl. 4, fig. 39b) is closely similar to that of other calymenids, for example, *Flexicalymene*, which has a wide (tr.) border sector and a wide doublure sector. The same characters are present

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but very narrow in *Calymenesun* species such as *C. granulosa* (*Lu*, 1975, *Pl.* 47, *fig.* 3, 4). *Re-examination the cephalon of C. tingi*, figured by Sun (1931, Pl. 3, fig. 9a) and refigured by Lu (1975, Pl. 46, fig. 13), confirms the narrower nature of the rostral plate in that species (Text-fig. 1, B—E). It also shows that the cephalic doublure in *C. tingi* is, like the rostral plate, sharply flexed and barely narrows toward the genal angle (the lateral cephalic doublure looks to be narrowing in the Text-fig. 1C because it is strongly upturned and inward curved).

The first recorded rostral plate and cephalic doublure for *Reedocalymene* are closely similar to those of *Calymenesun*. The doublure in *R. expansa* is narrow (sag. and exsag.) and nearly uniform width. The rostral plate with its border and doublure sectors is very narrow (tr.). In the present collection of *R. expansa*, the border sector of the rostral plate is incomplete with only its posterior part being preserved. However the straight, diagonally directed connective sutures (Pl. Ⅲ, fig. 8) indicate that the border sector also is relatively narrow (tr.). The doublure sector is strongly flexed downward and forward and strongly bent forward. The curved surface of the doublure sector is more likely to accommodate the most posterior part of the pygidial axis during enrollment (Text-fig. 2F). If so, *R. expansa* had an unrolled spiral enrollemnt style (Bergström, 1973, p. 14—15, fig. 8f).

As discussed by Fortey (1990, p. 533), trilobites having natant and conterminant conditions of hypostomal attachment also have the outline of the anterior margin of the hypostome corresponding closely with that of glabella (actually the preglabellar furrow). So far as known, calymenid trilobites have a primitive conterminant condition of hypostomal attachment. Such a condition is well documented in the advanced calymenids (Whittington, 1998b; Fortey, 1990), and is known also in some primitive calymenids that have an extended preglabellar area. Also as shown and noted by Fortey (1990, text-fig. 3a; 541—542) those primitive calymenids retain a conterminent attachment by either extending forward the anterior margin of the hypostome (as in *Neseuretus*, see Henry, 1980) or by extending backward the rostral plate (as in *Pharostoma*, see Whittard, 1960) to 'cover' the distance between anterior border and preglabellar furrow.

As a primitive calymenid, *Calymenesun* was considered by Fortey (1990, p. 542, based on personal communication from D. J. Siveter) to be conterminant. He stated: '*Calymenesun* covers the extended area by growth of the rostral plate and the adjacent genal doublure. The hypostome remains in its usual position'. Fortey further concluded: 'So far as can be ascertained primitive calymeninaceans with preglabellar field were also conterminant'.

We think Fortey's viewpoint on the relationship of the hypostomal position to the glabella is reasonable, but, as our evidence shows, his view on the hypostomal condition of *Calymenesun* seems disputable. The hypostomal conditions of both *Calymenesun* and *Reedocalymene* remain uncertain at present.

As described above, the syntype cephalon of *C. tingi*, the type species of *Calmenesun*, has a cephalic doublure that is not extended backward to the preglabellar furrow (Text-fig. 1B) and a rostral plate that also seems normal for calymenids except in having an unusually narrow width (tr.). As the doublure sector is sharply flexed forward, there should be a great distance between the preglabellar furrow on the dorsal surface and the posterior margin of the doublure sector on the venter, which corresponds to the hypostomal suture in other conterminant calymenids. If the '*Calymenesun*' of Siveter does have an extended doublure and rostral plate, it should belong to a genus other than *Calymenesun*. Since the rostral plate has no backward extension in *Calymenesun*, and if the hypostome lies in a position corresponding to the front of glabella on dorsal surface, the only way for *Calymenesun* to effect a conterminant attachment would be by extending the anterior margin of the hypostome forward similar to *Neseuretus*. This, however, seems to be an unlikely possibility, as the extension of the anterior margin should be quite broad and long. Such a hypostome would seem unable to attach properly to the very narrow (tr.) doublure sector of *Calymenesun*.

As discussed above, the rostral plate and cephalic doublure of *Reedocalymene* are comparable with those of *Calymenesun* in having a great distance between the preglabellar furrow and the posterior margin of rostral plate. Judging from the morphology of the rostral plate and the considerable distance to be covered we would assume a natant, rather than conterminant, hypostomal condition for both *Reedocalymene* and *Calymenesun* (Text-fig. 2F).

Fossulae and anterior node: Whittington (1941, p. 494, 516) and Evitt and Whittington (1953, p. 50) discussed the relationship of the fossulae (anterior pits) in the axial furrow of cranidium to their corresponding anterior wings of the hypostome on the ventral surface of *Flexicalymene*. Evitt and Whittington interpreted those structures as a mechanism for support of the hypostome. Whittington (1988a, b) further described the connection of the anterior wings and the fossulae. As interpreted by

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him, in living *Calymene* the wing process of the hypostome would have rested against the fossular apodeme (anterior boss), which corresponds with a fossula on the internal surface of the exoskeleton. In Reedocalymeninae, the fossulae are also known in *Neseuretus*, as in *N. tristani* (Hammann, 1977, Pl. 1, fig. 3), *Neseuretinus*, as in *N. turcicus* (Dean, 1967, Pl. 9, figs. 1—3), and *Calymenesun*, as in *C. tingi* (Lu, 1975, Pl. 46, figs. 9—14). They are usually described as hypostomal pits (Whittard, 1960; Dean, 1967; Hammann and Leone, 1997). In *Reedocalymene*, whether the fossulae are present in *R. unicornis*, the type species, remains uncertain, but they do develop well in *R. expansa*. In this species, they are, however, placed not exactly in the axial furrows but slightly outward from the furrows. Lu (1975, p. 236, 447) noted that there is a pair of nodes, the anterior nodes, situated very close to the fossula. Our observations show that they are actually be situated inside the fossula, lying on the adaxial slope, so that the fossula in *R. expansa* is not rounded but becomes crescentic in shape. Usually the anterior node is more notably present on the internal mold than on the external mold (Pl. Ⅲ, figs. 14, 15). That means it is faintly defined on the dorsal surface but has a deep corresponding pit on the internal side of the integument. The node is a distinctive feature of *Reedocalymene* as it has never been found in any other calymenids except *Calymenesun* (Text-fig. 1, F—H). Lu (1975)interpreted the nodes as a pair of sockets in the internal exoskeletal surface for the attachment of antenna muscles, while fossulae were interpreted as antennary pits. As the anterior node occurs within the fossula, we follow Evitt and Whittington in regarding it, together with the fossular, as a device for support of the hypostome. So far, no hypostome of *R. expansa* has been found, so it is not possible to determine whether the anterior wing of a hypostome in *Reedocalymene* bears structures corresponding to the anterior node.

Dorsal and ventral features of the anterior projection: Yi (1957) and Lu(1975) figured some specimens of *R. expansa* that bear the doublure of the anterior projection. However, the doublure was mistakenly described as a dorsal feature, with the median furrow on the doublure erroneously interpreted as an axial ridge. The cephalic anterior projection is the most notable character of *Reedocalymene*. It is here regarded as an elongated anterior border of cranidium, defined posteriorly by a broad and faint crnidial anterior border furrow. The anterior border furrow continues abaxially as the lateral furrows on the librigenae, which are well defined. A pair of reniform bulges lie medially at the basal part of the anterior projection, immediately in front of the cranidial anterior border furrow, forming a longitudinally elliptical depression between them. The depression continues forward as a shallow and wide median furrow that becomes narrower and fainter anteriorly and obsolete at about half the length of the projection. On the internal exoskeletal surface, the bulges correspond with a pair of concavities. The anterior half of the concavities lie underneath the basal part of the doublure of the anterior projection, and the posterior half of the concavities underneath the cephalic doublure. Because it is strongly flexed downward and forward, the rostral plate, along its posterior margin of the doublure sector, extends to the mid-length of the concavities. The doublure of the anterior projection is moderately curved dwonward (dorsally), and has a rounded edge posteriorly (Pl. Ⅲ, fig. 16) where the doublure flexes sharply dorsally and forward to form a narrow ridge (Pl. Ⅲ, fig. 10). The doublure bears a thin but distinct median furrow that corresponds with the median furrow on the dorsal surface. When well preserved, the median furrow occupies about four-fifths the length of the anterior projection (Pl. Ⅲ, fig. 6). The furrow is often observed as an axial ridge on the internal mold of the doublure (Pl. Ⅲ, figs. 3, 6, 12). Both Reed (1917, p. 52) and Kobayashi (1951, p. 45) noted that the type species *R. unicornis* has an axial ridge on the projection. An examination of specimens referable to that species is needed to ascertain whether the ridge is actually formed from the median furrow on doublure.

Eye and eye socle: Lu(1975, p. 235, 446, Pl. 46, fig. 5) figured librigena of *R. expansa* with a small eye. However, because the illustrated specimen is an internal mold, neither morphology of the eye nor the eye socle are clearly presented. The external mold of an exoskeleton illustrated here (Pl. Ⅰ, fig. 1; Pl. Ⅱ, fig. 13)shows that the eye of *R. expansa* is reniform in shape, well elevated above the cephalic genae, surrounded on the inner and outer sides respectively by the palpebral lobe and the band-like eye socle. Both the palpebral lobe and the eye socle are moderately raised. Small subrounded lenses are densely placed on the right eye, indicating that the eye of *R. expansa* is holochroal.

Thorax: No thorax of *Reedocalymene* has been recorded previously. The specimen illustrated here shows that the thorax is similar in morphology to that of *Calymenesun* (Zhou and others, 1984, figs. 7a, c, f). One difference is that the posterior pleurae are more obliquely directed. The thorax consists of 13 segments with an axis that nearly as wide as the pleural region. Each pleura bears a thin, ridge-like anterior band, a wide and deep pleural furrow, a wide (exsag.) longitudinally convex

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posterior band, and an outwardly broadening articulating facet with an evenly rounded lateral margin. The axial ring bears a narrow (tr., sag.) articulating half-ring.

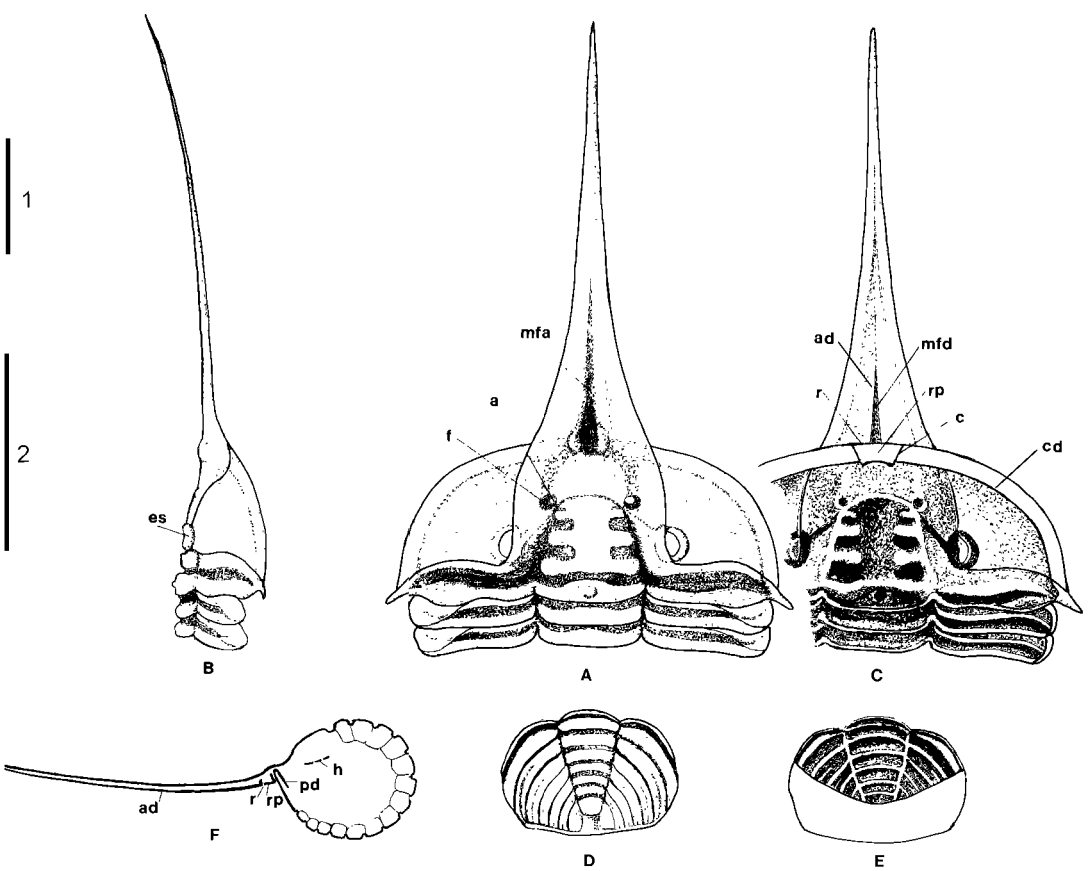
Surface sculpture: According to Reed (1917), the surface of the cephalon of type species *R. unicornis* is covered with fine granules. Sculptures had not been reported for the type material of *R. expansa* by Yi (1957), but Lu (1975, p.236, 446) noted that the surface of the cranidium and librigena of the species is "crowded with numerous granules, and with some few large tubercles between them on glabella and occipital ring". New material assigned to this species shows that not only the glabella and occipital ring have granules, but most of cephalon is ornamented with one or two differently sized granules. The granules become progressively less dense on the thorax, and become completely absent on the last several thoracic segments. They are also absent from the pygidium. Granules are also developed on some of ventral surfaces such as the doublure of the anterior projection, the cephalic doublure, and the border sector of the rostral plate.

SYSTEMATIC PALAEONTOLOGY

Family CALYMENIDAE Burmeister, 1843

Subfamily REEDOCALYMENINAE Hupé, 1955

Remarks: Hupé(1955) erected this subfamily to accommodate *Reedocalymene* Kobayashi, 1951 and *Calymenesun* Kobayashi, 1951. Whittington (1971, text-fig. 1) grouped both genera with *Vietnamia* Kobayashi, 1960, while Lu (1975) included them with *Neseuretus* Hicks, 1872 [=*Synhomalonotus* Pompeckj]. We follow Dean (1967), Dean and Zhou (1988), and Hammann and Leone (1997) in including *Reedocalymene*, *Neseuretus*, *Calymenella* Bergeron, 1890, *Calymenesun*, *Vietnamia*, *Neseuretinus* Dean, 1967, and *Sarrabesia* Hammann and Leone, 1997 in the subfamily. Dean and Zhou (1988, p. 633) expressed doubt about the position of



Text-fig. 2. Reconstruction of *Reedocalymene expansa* Yi. **A-C**, cephalon with two anterior thoracic segments, dorsal, lateral, and ventral views; **D, E**, pygidium, dorsal and ventral views; **F**. suggested unrolled spiral enrollment state. Abbreviations: **a**-anterior node, **ad**-doublure of anterior projection, **c**-connective suture, **cd**-cephalic doublure, **es**-eye socle, **f**-fossula, **h**-hypostome (suggested a natent attachment condition), **mfa**-median furrow on the external exoskeletonal surface of anterior projection; **mfd**-median furrow on the external exoskeletonal surface of the doublure of anterior projection, **pd**-pygidial doublure, **r**-rostral suture, **rp**-rostral plate. Scale bars equal 1cm. Bar 1 for A-C, bar 2 for D, E.

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Reedocalymene in the subfamily, but the close similarities, as discussed above and below, to *Calymenesun* confirm the classification of *Reedocalymene* within the Reedocalymeninae. Lu (1975, p.235,445) emended the subfamilial diagnosis and that diagnosis is followed here with minor changes relating to the facial suture and the genal spine. The facial suture is of gonatoparian or proparian type, and the genal angle may or may not have a genal spine. So far as known, all the genera in the subfamily have 13 thoracic segments.

As discussed above, the hypostomal attachment condition of *Reedocalymene* and *Calymenesun*, differs from that of *Neseuretus* and some other genera referred to the subfamily. These genera having other hypostomal conditions and originally assigned to the subfamily by Hupé need re-evaluation.

Genus *Reedocalymene* Kobayashi, 1951

Type species: *Calymene unicornis* Reed, 1917, from the Middle Ordovician Shidian Formation of Pupiao, Baoshan, western Yunnan, China.

Other species: *Reedocalymene expansa* Yi, 1957, from the Upper Ordovician Miaopo Formation of Yichang, western Hubei, China.

Emended diagnosis: Reedocalymeninid with spatulate frontal area comprising a gently bossed preglabellar field, a faint anterior cranidial border furrow, and an elongated, triangular cranidial anterior border with incomplete median furrow, extended into long frontal spine; glabella tapers forward with acutely rounded to evenly rounded front; and S1 and S2 deeply incised, directed inward or inward and slightly rearward, S3 short and faint to absent; eye small, raised and placed close to axial furrow opposite S1 or L2; facial suture proparian with subparallel anterior section and nearly transverse posterior section; genal angle bears short spine; pleural region in thorax narrower than or nearly as wide as the axis; pygidium elliptical in outline with narrow and long axis, with well developed interpleural furrows, and with equally but faintly divided pleurae.

Remarks: *Reedocalymene* most closely resembles *Calymenesun*. *Reedocalymene* differs from *Calymenesun* most noticeably in having a broad projection rather than a short cephalic spine on cranidium. Moreover, *Calymenesun* is differentiated by its glabellar morphology with strongly inward-curved flanks, by having larger, more tumid L1 lobes, and by having curved instead of straight, diagonally directed connective sutures on the cephalon. *Calymenesun* also has a proportionally wider axis on the thorax, and a shorter axis on pygidium (see Zhou and others, 1984, figs.7a—g), than *Reedocalymene*.

Reedocalymene expansa Yi, 1957

(Pl. Ⅰ—Ⅲ, Text-fig.2)

1957 *Reedocalymene expansus* Yi, p.531, Pl.1, figs.1a—e; Pl.2, figs. 1a—d.

1957 *Reedocalymene expansus* var. *brevica* Yi, p.532, Pl.1, figs. 2a—f.

1965 *Reedocalymene expansa* Yi, Lu, Zhang, Zhu and others, p.622—623, Pl.129, figs. 13—15.

1965 *Reedocalymene expansa* var *brevica* Yi, Lu, Zhang, Zhu, and others, p.623, Pl.129, fig.16.

1974 *Reedocalymene expansa* Yi, Lu, Zhang, Qian, and others, p.133, Pl.52, fig.15.

1975 *Reedocalymene expansa* Yi, Lu, p.235—236, 446—447, Pl.46, figs.4—6.

1975 *Reedocalymene expansa* var. *brevica* Yi, Lu, p.236, 447, Pl.46,fig.7.

1975 *Reedocalymene elongata* Lu, p.236, 447, Pl.46, fig.8.

1977 *Reedocalymene expansa* Yi, Zhou, Liu, Mong, and Sun, p.262, Pl.80, figs.5,6.

1977 *Reedocalymene expansa* var. *brevica* Yi, Zhou, Liu, Mong, and Sun, p.262—263, Pl.80, fig.4.

1977 *Reedocalymene elongata* Lu, Zhou, Liu, Mong, and Sun, p.63, Pl.78, fig.13.

1978 *Reedocalymene expansa* Yi, Xia, p.182, Pl.37, figs.1,2.

1978 *Reedocalymene expansa* var. *brevica* Yi, Xia, p.182, Pl.37. fig.3.

1978 *Reedocalymene biconcavus* Xia, p.182—183, Pl.37, figs.4,5.

1984 *Reedocalymene expansa* Yi, Sun, p.418, Pl.158, fig.11.

1986 *Reedocalymene expansa* Yi, Sheng and Ji, Pl.1, fig.8

1987 *Reedocalymene jielingensis* Xiang and Zhou, p.332, Pl.33, figs. 6,7.

Holotype: Internal mold of a nearly complete cranidium (Yi, 1957, Pl.1, fig.1a) from the Upper Ordovician Miaopo Formation, at Fenxiang, in Yichang County, China.

New Material: 3 exoskeletons, 4 cephala, more than 30 cranidia, and 3 pygidia, all from the Miaopo Formation at Chengjiahe, Fenxiang, and Huanghuachang in Yichang County; and at Xintan in Zigui County, China.

Diagnosis: Species of *Reedocalymene* with semielliptical cephalon, width twice length (except anterior projection), bearing faint anterior border furrow and clearly defined lateral border furrows; lateral margin of anterior projection varies from slightly concave to slightly convex; glabella rounded or acutely rounded anteriorly, S1 transverse or slightly oblique rearward, S2 transverse, S3 very short, weak; occipital ring with medial occipital node; ocular ridge diagonally directed; fossulae well defined, bearing pair of anterior nodes; genal spine short; cephalon and thorax covered with fine granules and scattered coarse granules; rostral plate narrow (tr.) with gently rounded edge between the border and doublure sectors, defined

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laterally by diagonal connective sutures.

Remarks: *Reedocalymene expansa* var. *brevica*, *R. elongata*, *R. biconcavus*, and *R. jielingensis* are considered to be conspecific with *R. expansa*. They are all from shales of the Miaopo Formation at or near the type locality of the latter species. The type specimens assigned as *R. expansa* and *R. expansa* var. *brevica* come from the same horizon at the same locality. According to Yi (1957), *R. expansa* var. *brevica* differs from *R. expansa* by having a shorter glabella and a shorter L1. From review of the type specimens, as well as study of a new population collected from single bed, we conclude that such differences are mainly caused by different preservation states. Specimens preserved as internal molds commonly have proportionally shorter glabellas, and broader S1 and S2 furrows. Having broader S1 and S2 causes L1 to have a shorter appearance.

R. elongata was based on a single specimen. The holotype cranidium is probably from the type locality of *R. expansa*. Examination shows that it is a testate specimen with poorly preserved surface sculpture. Differences from *R. expansa* listed by Lu (1975, p. 236, 447) are the proportional length of glabella, the nature of the preglabellar furrow, the slightly outward convex lateral margins of the anterior projection, the nature of the lateral glabellar and occipital furrows, and the degree of obliquity of the ocular ridge, all of which fall well within the range of the morphological variation observed in the new material.

R. biconcavus was based on two specimens, a crushed cranidium and a flattened pygidium. The types were found in association with *R. expansa* (Xia, 1978, p. 183). Xia stated that *R. biconcavus* differs from *R. expansa* in some cranidial characters. However, those characters fall within the range of morphological variation of *R. expansa*. The shape of glabella and the number of lateral glabellar furrows are viriable in *R. expansa*. Differences in preservation, such as the nature of the preglabellar field and the proportion of the anterior projection are also variable in this species. *R. biconcavus* shows no significant difference from *R. expansa*, and we regard it as a junior synonym of *R. expansa*.

R. jielingensis from Jieling, Yichang was based on an incomplete cranidium and two pygidia, all of which are preserved on one slab of shale. According to Xiang and Zhou (1987, p. 332), '*R. jielingensis* resembles *R. expansa* in having similar deep and broad glabellar lateral furrows and similary directed S1, but the latter differs in having a shorter glabella with more rounded front, shorter lateral furrows, and without an occipital node, and in having transverse anterior margin in the pygidium'. However, specimens in our collection show that supposed differences in the glabella fall well within the range of variation observed in *R. expansa*. Our specimens also show that *R. expansa* does have an occipifal node, but it is better preserved on the testate specimens than on the external molds. We found no difference in pygidial margin between *R. jielingensis* and *R. expansa*. Because there is no reliable means of distinguishing the *R. jielingensis* from *R. expansa*, we suppress it as a junior synonym of *R. expansa*.

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EXPLANATION OF PLATES

The figured specimens are all from the Miaopo Formation in the eastern Yangtze Gorges area, western Hubei, China. They were collected at Chengjiahe (FC) and Huanghuachang (FH), both in Fenxiang, Yichang, and at Xintan, Miaohe, Zigui (XM). The specimens are deposited in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, and are prefixed with NIGP.

Plate Ⅰ

1—8. *Reedocalymene expansa* Yi, 1957

1,3,7,8. Exoskeleton, all ×2, coll. no. FC1, cat. no. NIGP 124313. 1, 3. latex cast from external mold, dorsal view (stereo pair) and lateral view; 7,8. internal mold, oblique-frontal and dorsal views, the former shows the doublure sector of rostral plate.

2. Internal mold of exoskeleton, ×2, coll. no. FC1, cat no. NIGP 124314.

4,5. Testate pygidium, all ×4.5, posterior view and dorsal view (stereo pair), coll. no. MX2, cat. no. NIGP 124315.

6. Internal mold of pygidium, ×4, dorsal view, coll. no. FC2, cat. no. NIGP 124316.

Plate Ⅱ

1—13. *Reedocalymene expansa* Yi, 1957

1. Cranidium, dorsal view, coll. no. FC2, cat. no. NIGP 124317, ×2.4.

2. Cranidium, dorsal view, coll. no. FC2, cat. no. NIGP 124318, ×2.4.

3,12. Internal mold of cranidium with the anterior projection removed, and detail of the basal part of doublure of anterior projection to show surface sculpture of granules (as pits) and the midian furrow (as a ridge) on external mold the doublure, dorsal views, coll. no. FC2, cat. no. NIGP 124319, ×2.4, ×5.

4. Posterior area of fixigena of cranidium, showing posterior section of facial suture and genal spine, dorsal view, ×4, coll.

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no. FC2, cat. no. NIGP 124320.

5. Cranidium, internal mold, dorsal view, coll. no. FC2, cat. no. NIGP 124321.

6,7. Cranidium, internal mold, dorsal view, ×2.4, ×4, coll. no. FC2, cat. no. NIGP 124322, note the fossulae and the anterior nodes.

8. Latex cast from the exoskeleton internal mold of plate 1, fig.2, showing first 7 pleurae, ventral view, ×5.

9. Latex cast from external mold of cranidium, note the median furrow on the anterior projection, coll. no. FC2, cat no. NIGP 124323.

10. Part of the doublure of cranidial anterior projection figured on plate Ⅲ, fig. 16, showing the surface sculpture with almost evenly spaced granules and median furrow, ventral view, ×5.

11. Part of cranidium, showing surface ornament, consisting of two differently sized granules on the glabella and preglabellar area; and showing the paired reniform bulges lying close the sagittal line, immediately in front of the anterior border furrow on the anterior projection, with a longitudinally elliptical depression in between the bulges, latex cast, dorsal view, ×6.

13. Enlargement of the exoskeleton on plate Ⅰ, fig. 1 to show eye, eye socle, and palpebral lobe, latex cast, dorsal view, ×7.

Plate Ⅲ

1—16. *Reedocalymene expansa* Yi, 1957.

1—4. Latex cast from the internal mold of exoskeleton figured on plate Ⅰ, fig.8, ×2, ×2, ×6, ×6.1, 2, showing portion of cephalic doublure with rostral plate, ventral, oblique-ventral views; 3,4. close-up photos of the rostral plate (doublure sector) and the posterior part of the cephalic doublure.

5. Lateral view of the external mold of exoskeleton figured on plate Ⅰ, fig.2, ×2.

6,7. Internal mold of cephalon, and its latex cast. 7. showing the cephalic doublure with rostral plate (border sector), connective sutures, dorsal and ventral views, coll. no. FC2, cat. no. NIGP 124324, ×2.4, ×4.

8. Cranidium, internal mold, showing the doublure of anterior projection and part of displaced cephalic doublure (d) with straight connective suture (c), coll. no. FC2, cat. No. NIGP 124325, ×2.4.

9,15. Latex cast of cranidium from the internal mold, ventral view. 15. shows the internal exoskeletonal surface with the fossular apodeme (fa) and the clearly defined pits formed by corresponding anterior node on external exoskeletonal surface (ap), ventral views, coll. no. FH, cat. no. NIGP 124326, ×2.4, ×5.

10—12. Oblique-anterior, dorsal views, and closed-up dorsal view of incomplete cranidium, internal mold. 10. shows the up-turned (or dorsally-upturned) posterior edge of the anterior projection; and 12. shows the basal part of the doublure of anterior projection and the posterior parts of the paired reniform bulges, coll. no. FC2, cat. no. NIGP 124327, ×3, ×2.4, ×5.

13. Latex cast of cranidium, showing anterior projection, coll. no. FC2, cat. no. NIGP 124328, ×2.4

14. Left-middle part of external mold of cranidium, showing the counterpart morphology of the fossula (f) and the anterior node (a) on external mold, which is slightly different in notability from the fossular apodeme and the pit corresponding with the anterior node on the internal surface of dorsal interument (cf. fig.15), ventral view, coll. no. FC2, cat. no. NIGP124329, ×5.

16. Doublure of anterior projection of incomplete cranidium, latex cast, ventral view, note the median furrow on the rear part of the doublure, coll. no. FC2, cat. no. NIGP 124330, ×2.4.

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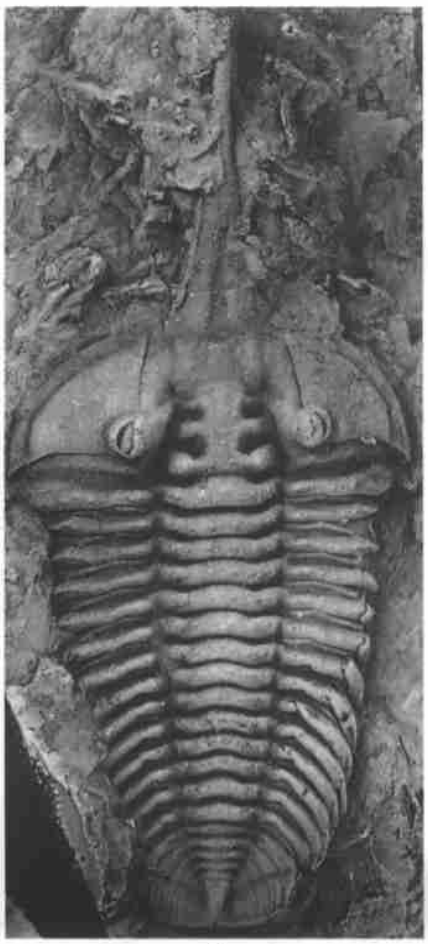

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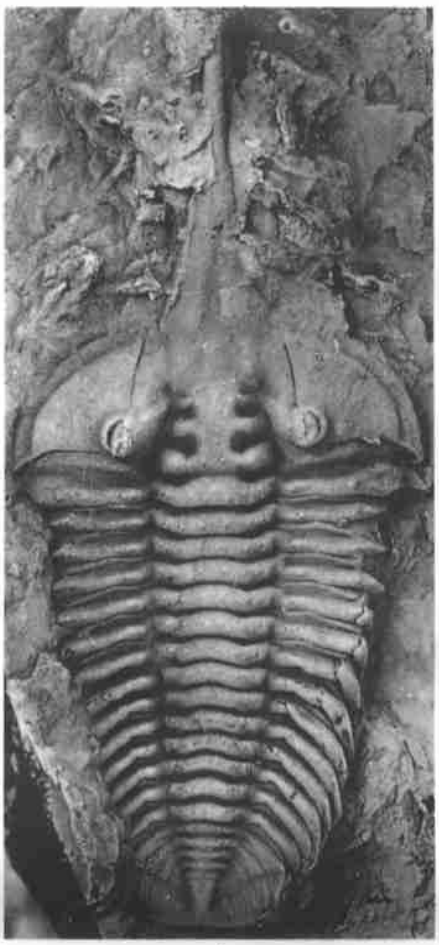

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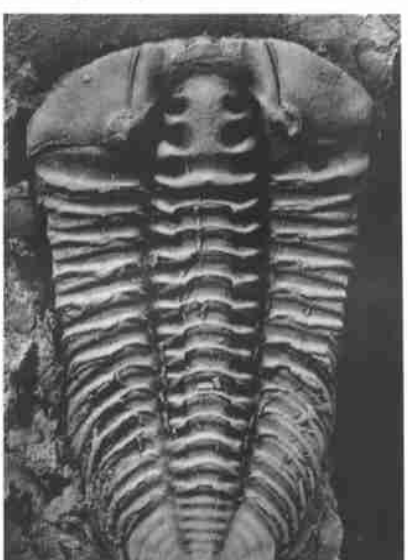

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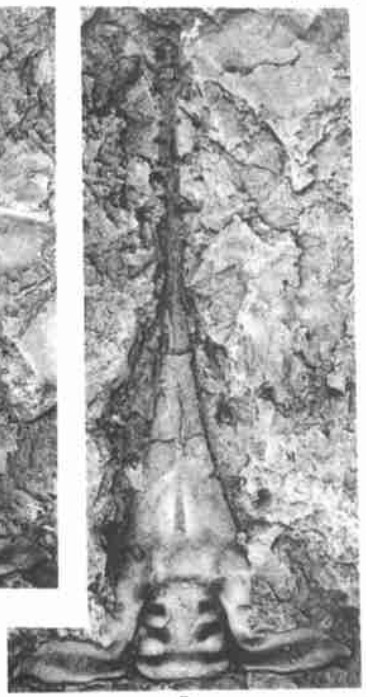
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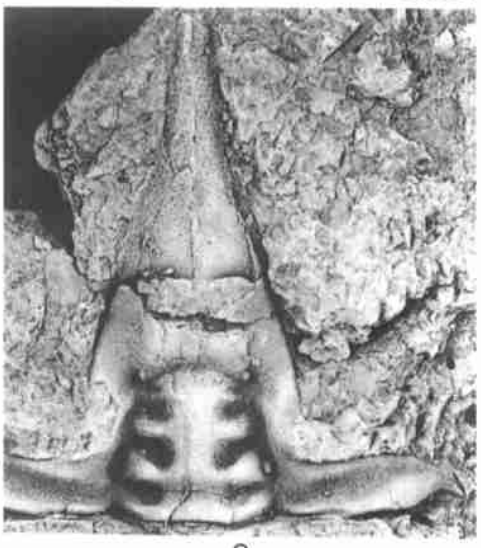
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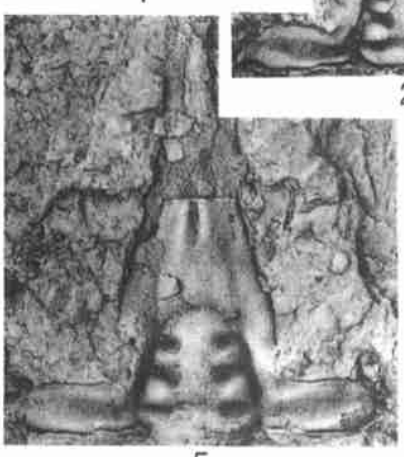
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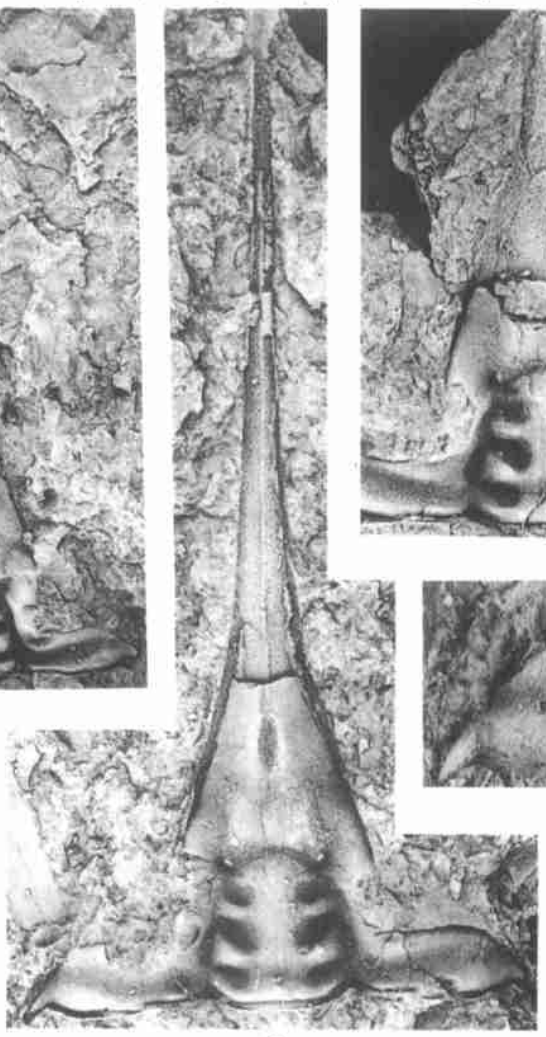
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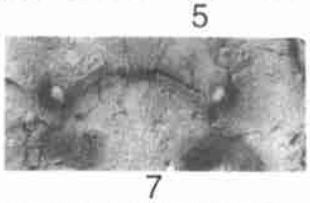
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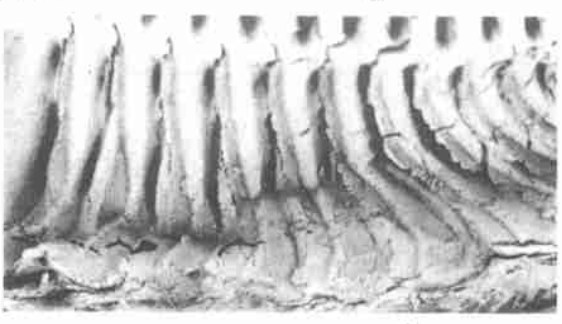
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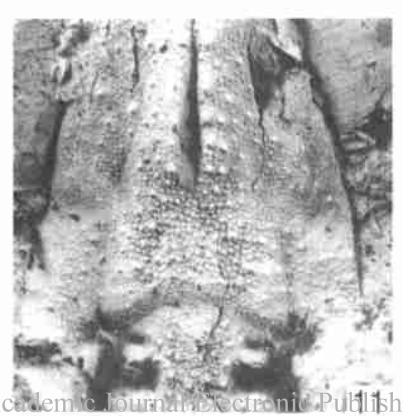
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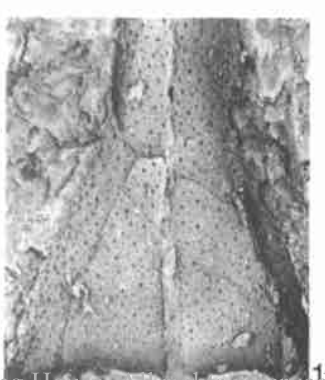
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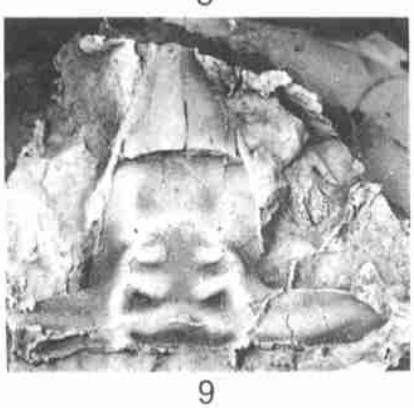
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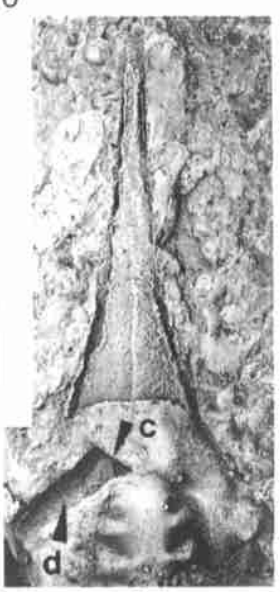

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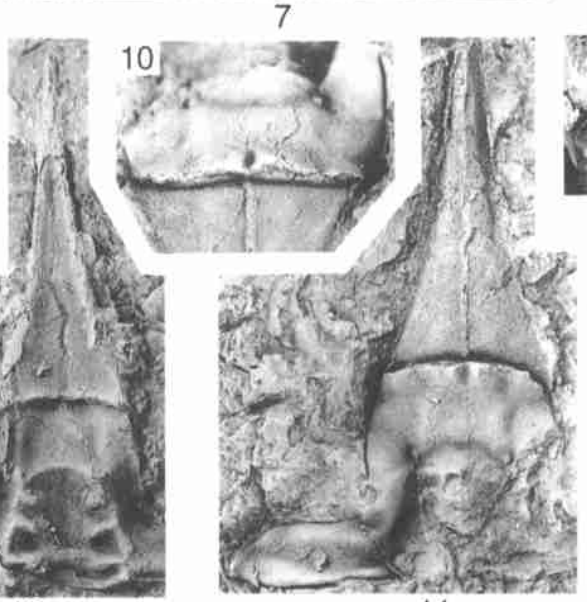

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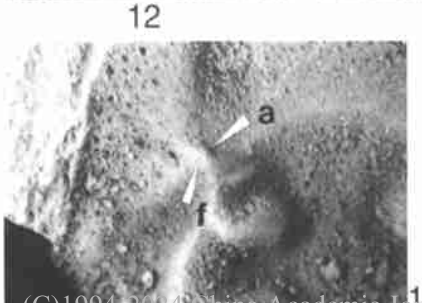

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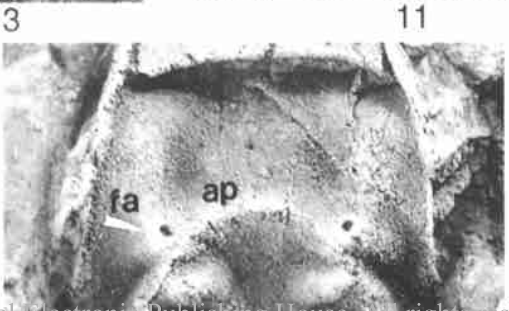

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