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SILURIAN *SPATHACALYMENE* TILLMAN, 1960 (TRILOBITA) FROM POLAND

Abstract. — Three new species of the genus *Spathacalymene* Tillman are described and figured on the basis of a rich material from the Gołdap, Mielnik and Terespol boreholes, situated in *Cucullograptus hemiaversus, C. aversus* and *Saetograptus leintwardinensis* zones of the platform area. Furthermore, *Calymene nodulosa* Shirley, 1933 and *Calymene pompeckji* Kummerow, 1928 are assigned by the present writer to the genus *Spathacalymene* Tillman, 1960. The relationships of *Spathacalymene* to other genera within the Calymeninae are discussed. The stratigraphic range of the trilobites described is very narrow and they are considered to be important index fossils of the uppermost part of the Lower Ludlovian.

INTRODUCTION

The genus *Spathacalymene* was erected by Tillman (1960) for the species *S. nasuta* (Ulrich, 1879) from Osgood Formation of the Middle Silurian in the south-eastern Indiana, U.S.A. The trilobites of this genus, similar to *Calymene*, differ from it in the presence of a spatulate process on the anterior part of their cranidium.

Many specimens of the genus *Spathacalymene* have recently been found in Mielnik Beds of the Mielnik, Gołdap and Terespol boreholes in north-eastern Poland. The material thus obtained (including incomplete specimens) consists of a complete enrolled specimen, about 100 cranidia, 20 free cheeks, 10 rostral plates, a fragmentary hypostoma, four fragments of thoraces, few single segments and 30 pygidia. On the whole, the specimens are well preserved, most of them having carapaces.

This material enabled the erection of three new species: *Spathacalymene linguata* n. sp., *S. flexuosa* n. sp. and *S. brevis* n. sp. which differ from each other in shape, size and position of the preglabellar process. In regard to stratigraphy, these species display a very small vertical range and may constitute a trilobite horizon with *Spathacalymene* characteristic of the top of the Lower Ludlovian.

All specimens of these trilobites were collected by the present writer and Dr. H. Tomczyk as they were studying boring cores from the Mielnik and Gołdap boreholes. In addition, Dr. H. Tomczyk found them also in the Ludlovian of the Terespol borehole.

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The trilobites described in the present paper are housed at the Museum of the Geological Institute (abbr. IG.).

CHARACTERISTICS OF THE LOWER LUDLOVIAN OF POLAND AND THE OCCURRENCE OF THE GENUS *SPATHACALYMENE*

In the Silurian of Poland, the occurrence of the genus *Spathacalymene* is limited to the uppermost part of the Lower Ludlovian. In the Mielnik borehole, the first species of *Spathacalymene* appear 20 m above the range of *Lobograptus scanicus parascanicus* and occur in sediments which comprise (Urbanek, 1966) the *Cucullograptus hemiaversus* and *C. aversus* zones, disappearing together with the upper range of the *Saetograptus leintwardinensis* zone. According to Tomczyk (1960, 1962, 1970), this zone makes up the top of Mielnik Beds.

The Lower Ludlovian deposits, called Prągowiec Beds in the Holy Cross Mountains (Góry Świętokrzyskie) and Mielnik Beds in the platform area, are developed in clayey lithofacies with graptolites. At the end of the Lower Ludlovian, in connection with the movements of what is known as Cracow phase (Łydka *et al.*, 1963), the marine basin became locally deeper or shallower, which caused a considerable differentiation of sediments. In the region of Cracow, Southern Poland, greywackes and conglomerates were formed during that period.

In the Holy Cross Mountains first the differences in thickness of the *Saetograptus leintwardinensis* zone and then the completion of the cycle of clayey sedimentation with graptolites were the evidence of the manifestation of Cracow phase (Tomczyk, 1962, 1970). In addition to the abundance of graptolites, a sporadical occurrence of pelecypods, cephalopods and remains of crinoids is recorded in the *Saetograptus leintwardinensis* zone. However, no trilobites have ever been found in it (Tomczykowa, 1960, 1962).

In the area of the Polish Lowland, the Lower Ludlovian deposits are widely distributed (Fig. 1). In the upper Mielnik Beds, a considerable

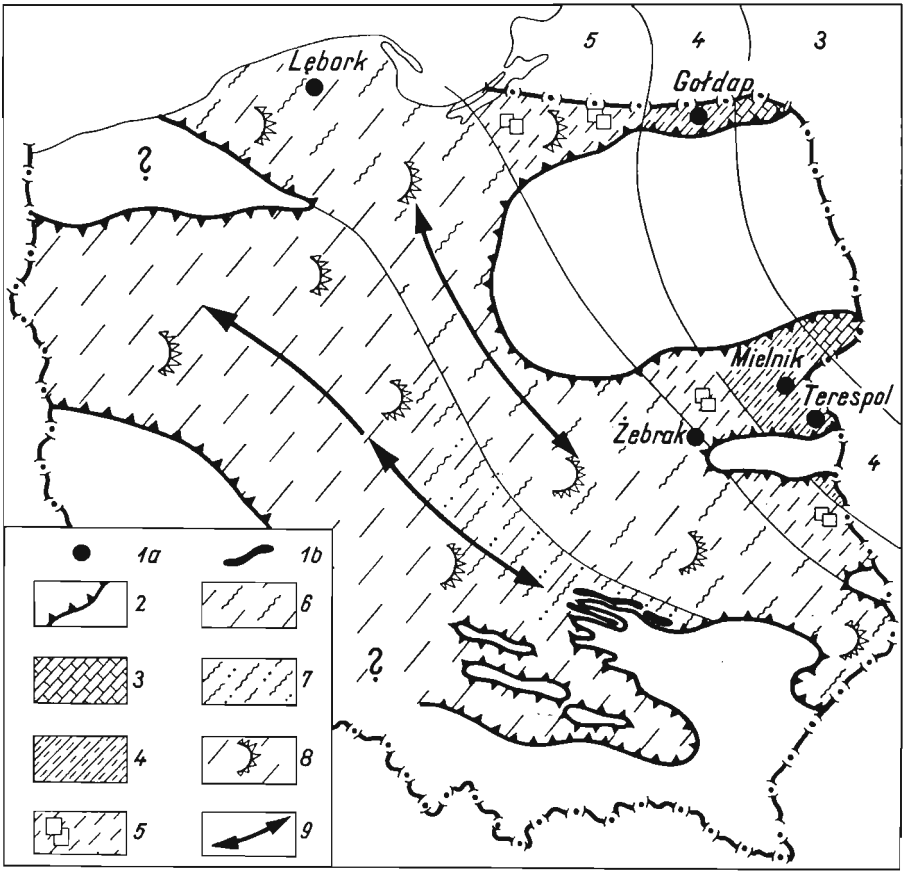
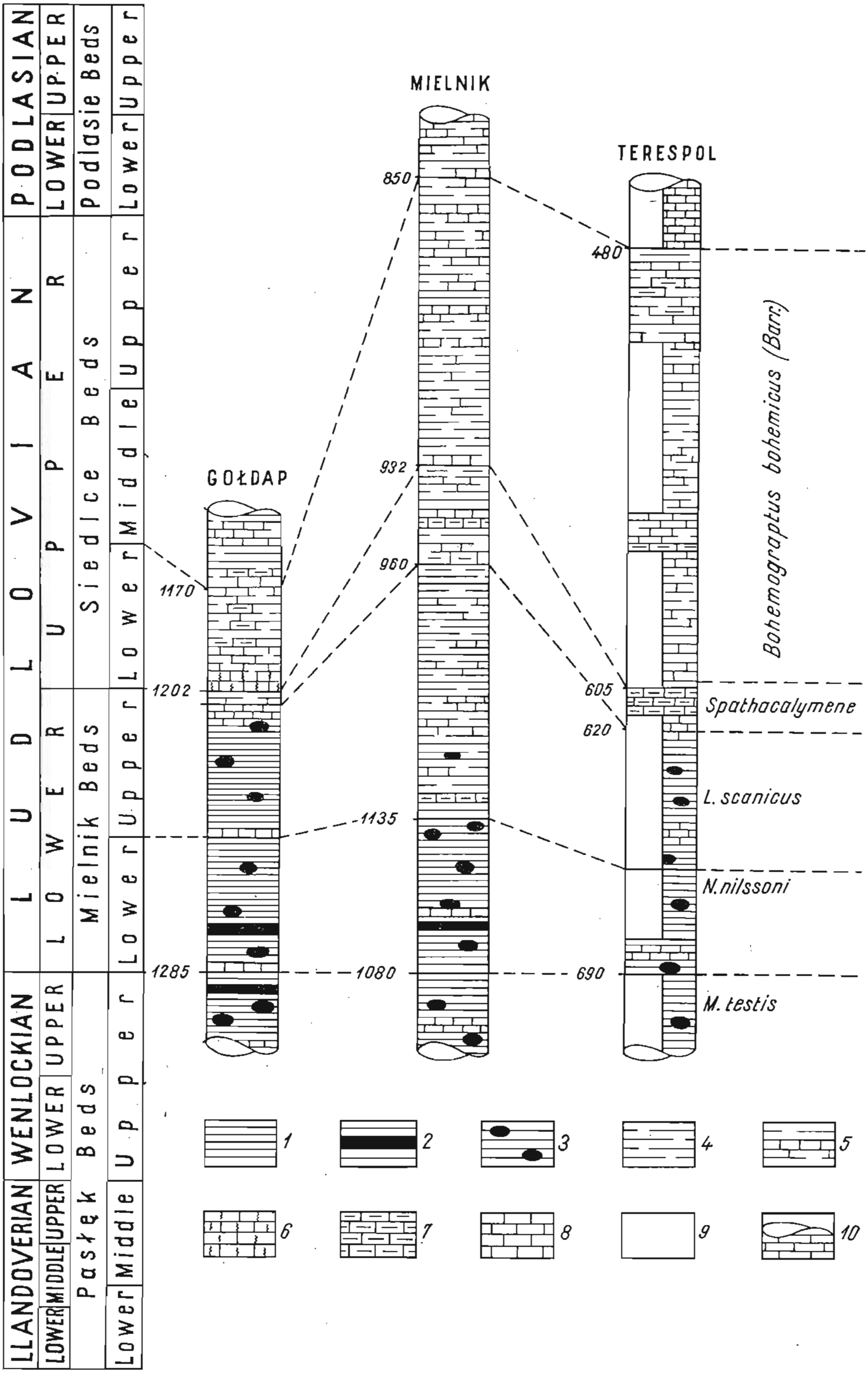


Fig. 1 —Sedimentary basin in Poland on the boundary between the Lower and Upper Ludlovian: *1a* main borings which reached the *Saetograptus leintwardinensis* zone, or a zone containing *Spathacalymene*, *1b* Silurian outcrops in the Holy Cross Mountains; *2* erosive boundary of the Silurian marine basin, *3* calcareous lithofacies; *4* marly-calcareous lithofacies with a mixed biofacies containing *Spathacalymene*; *5* clayey lithofacies with graptolites, sporadical concretions and lenses of limestones; *6* silty-clayey lithofacies with graptolites; *7* silty lithofacies with intercalations of greywackes and tuffogenic material from the Łysogóry area of the Holy Cross Mountains; *8* clayey lithofacies with graptolites (graptolitic facies; *9* main directions of the migration of fauna.



LLANDOVERIAN
WENLOCKIAN
LUDLOVIAN
PODLASIAN
LOWER
MIDDLE
UPPER
Paskęk Beds
Mielnik Beds
Siedlce Beds
Podlasie Beds
Lower
Middle
Upper
GOŁDAP
MIELNIK
TERESPOL
1170
1202
1285
850
932
960
1135
1080
480
605
620
690
Bohemograptus bohemicus (Barr.)
Spathacalymene
L. scanicus
N. nilssoni
M. testis
1
2
3
4
5
6
7
8
9
10

differentiation of deposits, probably due to the epeirogenic movements of Cracow phase, is observed above the *Lobograptus scanicus parascanicus* zone. The *Saetograptus leintwardinensis* zone is strongly developed in different lithofacies. The siltstone lithofacies stretches south-eastwards from the Baltic Sea (Darłowo-Żarnowiec), running through Lębork, Bytów, Pasłęk to the western part of the Podlasie depression (Okuniew-Żebrak) and probably joining the Łysogóry area of the Holy Cross Mountains (Fig. 1). In addition to abundant graptolites, sporadically occurring pelecypods, crinoids and cephalopods are also met within this horizon. A clayey lithofacies with graptolites, partly calcareous, runs east of this belt and parallel to it. Besides many pelecypods, cephalopods and crinoids, graptolites continue to dominate in it. Trilobites do not occur there.

It was only in the marly-calcareous lithofacies in the eastern part of the Peri-Baltic depression that the genus *Spathacalymene* was found by the writer in the profile of the Gołdap borehole. Its range is limited to light-gray marly claystones with intercalations of limestones about 2.6 m thick and at a depth between 1206.0 m and 1203.6 m. Calcareous claystones with graptolites occur lower in this profile (Fig. 2) down to the *Cucullograptus hemiaversus* zone, whereas compact limestones without fauna which pass into nodular limestones only 4 m thick occur above the range of *Spathacalymene*. The base of nodular limestones (Fig. 2) which may be evidence of epeirogenic movements falling in the top of the *Saetograptus leintwardinensis* zone has been asummed (Tomczyk, 1960, 1962, 1970) as a boundary between the Lower and Upper Ludlovian, i.e. between Mielnik and Siedlce beds. It seems that a decrease in thickness of sediments here took place was related with the formation of nodular limestones. This reduction may be confirmed by the occurrence of only two of the three species of *Spathacalymene*, i.e. *S. linguata* n. sp. and *S. brevis* n. sp. and the absence of *S. flexuosa* n. sp. which in the Mielnik profile occurs in higher layers than the former two (Table 1).

The marly-calcareous lithofacies probably continued over the area of the Mazury-Suwałki anteclise (Fig. 1) where it was subject to the pre-Permian denudation (Tomczyk, 1970). On the other hand, it was preserved in the eastern part of the Podlasie depression, where trilobites of the genus *Spathacalymene* were found in the Mielnik and Terespol boreholes. The same facies continued south-eastwards (Fig. 1). In the Mielnik borehole (Figs. 1 and 2), marly claystones and gray limestones with many graptolites (Urbanek, 1966) such as, *Cucullograptus hemia-*

Fig. 2. — Lithostratigraphic correlation of the *Spathacalymene* zone as an equivalent of the *Saetograptus leintwardinensis* zone in the Gołdap, Mielnik and Terespol boreholes: *1* claystones with graptolites, *2* claystones with graptolites and intercalations of benthonite, *3* claystones with graptolites and concretions and lenses of limestones, *4* marly claystones, *5* marly claystones with intercalations of limestones, *6* nodular limestones, *7* marly limestones, *8* compact clayey limestones, *9* core lacking, *10* drawing reduction of the profile.

TABLE 1

Correlation of graptolite and trilobite zones from the deposits of the Lower Ludlovian — Mielnik Beds

Stratigraphic subdivision			Graptolite zones	Trilobite zones
LOWER LUDLOVIAN	MIELNIK BEDS	Upper	*Saetograptus leintwardinensis*	*Spathacalymene flexuosa* n.sp.
			Cucullograptus aversus	*Spathacalymene brevis* n.sp.
			Cucullograptus hemiaversus	*Spathacalymene linguata* n.sp.
			**Cucullograptus pazdroi* *Lobograptus parascanicus*	
			Lobograptus progenitor	*Dalmanites vulgaris*
		Lower	*Neodiversograptus nilssoni*	
			Pristiograptus gotlandicus **Pristiograptus dubius*	*Raphiophorus rouaulti***
			Pristiograptus vulgaris	*Odontopleura ovata* **
			Gothograptus nassa	

* Subzones.

** Trilobites also known from the Upper Wenlockian.

Graptolite zones according to Tomczyk (1962, 1970) and Urbanek (1966).

versus Urbanek, *C. aversus* (Eisenack), *Saetograptus chimaera salveyi* (Hopkinson), *S. leintwardinensis* (Hopkinson), *S. fritschi* (Perner), *S. fritschi* cf. *linearis* (Bouček), etc., occur above the *Lobograptus scanicus* zone and *Cucullograptus pazdroi* subzone (Table 1) at depth ranging between 959.1 m and 936.0 m. In this series of deposits about 24 m thick, the writer found many representatives of the genus *Spathacalymene*. The stratigraphic ranges of particular species in this profile are as follows:

Spathacalymene flexuosa n.sp.	936.0—946.0 m
S. brevis n.sp.	937.5—948.0 m
S. linguata n.sp.	940.0—960.0 m

All the three species, as well as forms with characters transitional between them have been found within the bed — comprized between 940-946 m. The occurrence of these trilobites together with graptolites allowed the present writer to settle an exact stratigraphic correlation in the Mielnik profile. *Spathacalymene linguata* n. sp. appears in Mielnik in the *Cucullograptus hemiaversus* zone. According to Urbanek (1966), the first specimens of *Saetograptus* cf. *leintwardinensis* appear, however, in this borehole even at a depth of 960.9 m and, therefore, earlier than *Cucullograptus hemiaversus*. Thus, we may assume that the occurrence of trilobites *Spathacalymene* in the Polish Ludlovian is limited to the range of *Saetograptus leintwardinensis*.

Trilobites of the genus *Spathacalymene* associated with *Cucullograptus hemiaversus, Saetograptus chimaera salveyi* and *Bohemograptus bohemicus* were found by Tomczyk in cores sampled at depths ranging between 614.9 and 608.9 m in the Terespol borehole, situated somewhat southeast of Mielnik. Within this depth there occur marly-calcareous deposits similarly developed as those in Mielnik, and the association with graptolites referred to above gives evidence for a similar stratigraphic position of these deposits (Fig. 2). In that locality, the writer determined trilobites of the species *Spathacalymene flexuosa* n. sp. and *S. brevis* n. sp., as well as a pygidium *Encrinurus* sp. similar *E. tuberculatus* (Buckland) from Grinchuk Beds in Podolia (Arkhipova, 1968, Table 17, Fig. 32). Since no cores were sampled above and below the deposits, ranging between 614.8-608.8 meters (Fig. 2), it was impossible to trace a full stratigraphic range of *Spathacalymene* in the Terespol profile.

Saetograptus leintwardinensis and *Spathacalymene* do not pass higher in the Siedlce Beds and, therefore, they close the range of the Lower Ludlovian deposits. At the end of the Lower Ludlovian, great changes took place in the development of the marine basin in the area of almost entire Europe. In the area of Great Britain (Elles & Wood, 1901-1918; Holland *et all.*, 1963), classic for the European Silurian, the range of the graptolitic facies terminates in the *Saetograptus leintwardinensis* zone. In that area, there predominates the calcareous facies with a mixed fauna

of brachiopods and trilobites of which the subfamily Calymeninae is numerously represented.

In Southern Germany, Ockerkalk (Jaeger, 1962) occurs above the *Lobograptus scanicus* zone or, locally, above the range of *Saetograptus fritschi linearis.*

East of Poland, on Russian platform, in Latvia (Ulst, 1968) and in Volhynia (Krandijevsky, 1963), the graptolite facies of the Lower Ludlovian reaches at most the *Lobograptus scanicus* zone. Higher up calcareous sediments are deposited containing mixed fauna. The genus *Spathacalymene* has not so far been recorded in that area. It is only in Lithuania that the occurrence of "*Calymene* cf. *tuberculata* Dalm", in the series overlaying the *Lobograptus scanicus* zone is cited by Paškevičius (1959). In the coastbelt of Estonia (Kaljo & Sarv, 1966) and in Podolia (Kozłowski, 1929; Nikiforova, 1954), the Lower Ludlovian is developed in coral facies and contains very few trilobites. Of the subfamily Calymeninae only *Papillicalymene papillata* (Lindström), occurs in the upper part of Malinovtsy Horizon of Grinchuk Beds.

Trilobites *Papillicalymene papillata* and *P. excavata* (Lindström) are known in Silurian of the Island of Gotland. The species *S. pompeckji* (Kummerow), described from erratic boulders may be an indirect evidence of the possibility that *Spathacalymene* occur in that area.

A conspicuous shallowing of the marine basin observed at the end of the Lower Ludlovian caused a wider distribution of the calcareous facies corresponding to shallower parts of the basin. In those parts, there existed conditions favourable to the development of the benthonic fauna. The representatives of *Spathacalymene* are of particular importance to the stratigraphy of the sediments which were not reached by the graptolitic plankton.

DESCRIPTIONS

Family **Calymenidae** Burmeister, 1843
Subfamily **Calymeninae** Burmeister, 1843
Genus *Spathacalymene* Tillman, 1960

Type species: Calymene nasuta Ulrich, 1879.

Species assigned: Calymene pompeckji Kummerow, 1928, *C. nodulosa* Shirley, 1933, *Spathacalymene brevis* n.sp., *S. flexuosa* n.sp., *S. linguata* n.sp.

Geographic and stratigraphic range: USA: South-eastern Indiana; Middle Silurian, Osgood formation. England: Wenlockian-Lower Ludlovian. Gotland(?) — erratic boulders. North-eastern Poland: boreholes Mielnik, Terespol, Gołdap; Lower Ludlovian, Mielnik Beds, *Cucullograptus hemiaversus-Saetograptus leintwardinensis* zones.

Revised diagnosis. — Glabella bell-shaped, variably developed, U-shaped, spatulate process projects from the frontal part of the cranidium.

Ocular cheeks high. Rostrum large. Thirteen thoracic segments. Pygidium with 5-7 axial rings, 4 pleural furrows, interpleural furrows very faint or obsolete, border anteriorly wide.

Remarks. — The genus *Spathacalymene* has been known so far as a single species from the American Silurian. Now, five species from the European Silurian including three new ones from Poland are assigned to it by the present writer. The type species considerably differs from the remaining ones. It this connection, the diagnosis of the genus *Spathacalymene* Tillman, 1960 has been revised by the writer. In future, if a larger amount of the material would be found, the necessity might even arise of separating the European species and erecting a new genus.

The evolutional development of the subfamily Calymeninae is marked by the appearance of very characteristic but short-lived genera with a strongly developed anterior part of the cranidium. In the phylogenetic development this part of cephalon was subject to the greatest changes. The outline of the preglabellar area in Calymeninae was discussed in detail by Shirley (1936) who, however, did not attach a great importance to it. But such characteristic genera as the Middle Ordovician *Reedocalymene* Kobayashi, 1951 and *Calymenesun* Kobayashi, 1951 or the Middle Silurian *Spathacalymene* Tillman, 1960 were not yet known in those times.

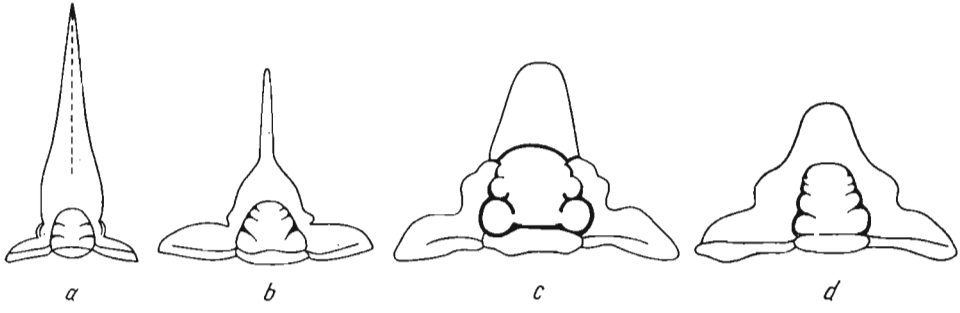


Fig. 3. — Comparison of four representatives of the subfamily Calymeninae having characteristic processes on cranidium: *a Reedocalymene expansa* (Yi, 1957), after Kobayashi, 1960, p. 44, Fig. 2c; *b Calymenesun tingi* (Sun, 1931), after Treatise, 1959, p. 453, Fig. 354,5; *c Spathacalymene nasuta* (Ulrich, 1879), after Tillman, 1960, Pl. 116, Fig. 8; *d Spathacalymene linguata* n. sp.

In these three genera, the processes on the anterior part of cranidium reach an uncommon size and shape (Fig. 3), whereas the preglabellar area in other genera of Calymeninae is mostly in the form of a more or less roll-like limbus, separated by a preglabellar furrow from the glabella. Of the Silurian representatives of the subfamily Calymeninae, *Calymene blumenbachi* Brongniart, 1822, *C. lata* Shirley, 1936, *C. aspera* Shirley, 1936 and *C. laevis* Lindström, 1885, which do not exceed the range of the

Lower Ludlovian, have their anterior limbus almost completely adhering glabella and, as viewed in profile, not reaching its surface. In these species, the preglabellar furrow is deep and very narrow. In species younger stratigraphically, such as *Calymene intermedia* Lindström and *C. beyeri* R. & E. Richter, the preglabellar furrow is wide and the border also not projecting above glabella. The species *Diacalymene diademata* (Barrande) displays conspicuous changes in the development of the anterior part of its cranidium. The genus *Diacalymene* Kegel, 1928 was separated due to its characteristic diadem-like border, separated from glabella by a deep but narrow furrow. Describing the profiles of cephalons of individual species of Calymeninae, Shirley (1930) attracted attention to the fact that the border in *Diacalymene* was formed owing to the "subsidiary ridge". It is, however, not only the profile, but also width (*tr.*), measured anteriorly, that should be taken into account when considering the shape of the preglabellar area. This is of fundamental importance in comparing *Diacalymene* Kegel and *Spathacalymene* Tillman, since the latter genus is marked by a pronouncedly anteriorly narrowing U-shaped or even widely open V-shaped (*S. brevis*) anterior process. The type species *Spathacalymene nasuta* (Ulrich), as well as *S. linguata* n. sp. have a very distinct, spatulate or rather tongue-like cranidial process. In addition to the three new species of *Spathacalymene, Calymene pompeckji* Kummerow and *C. nodulosa* Shirley (= *C. tuberculosa* Salter, 1848) are assigned by the writer to this genus. On account of the length of cranidial processes and the angle of their inclination to the glabella, the assignment of the last-named two species and *S. flexuosa* n. sp. to the genus *Spathacalymene* may arouse certain doubts. *Spathacalymene nodulosa* (Shirley), previously described by Salter as *Calymene tuberculosa* Salter, was assigned by Kegel (1928) to the genus *Diacalymene*. The shape of the anterior border of cranidium, "produced into a snout" and differing from that in other *Calymene* which was clearly emphasized by Salter (1865, p. 91), seems, however, to correspond rather to the process of *Spathacalymene* narrowing anteriorly and projecting above the glabella.

Besides *Diacalymene*, the Middle Silurian *Papillicalymene* Shirley is another genus which is to a certain extent related to *Spathacalymene*. According to Lindström's drawing (1885, Pl. 16, Figs. 1 and 3), the anterior border in *Papillicalymene excavata* (Lindström) is similar to a spatulate process occurring in *Spathacalymene*, but so bent upwards above glabella that it obscures its anterior lobe.

Spathacalymene brevis n. sp., *S. flexuosa* n. sp. and *S. linguata* n. sp. have a wide preglabellar furrow and their preglabellar area extends anteriorly to form a tongue-like process more or less inflected towards glabella. Only *S. nasuta* (Ulrich) has a very narrow and deep preglabellar furrow which separates the process, fairly closely adhering to glabella at the base. Even in this species, the process arises, however, from the

whole frontal part of cranidium which is especially clearly visible in Figs. 7-8 (Tillman, 1960, Pl. 116). Discussing the manner of developing various processes on cranidium, Tillman mentioned four developmental ways determining the process in *Spathacalymene* "as expansion of the anterior border". This process seems, however, to be formed "as expansion of frontal area".

Both due to its bell-like shape and its three pairs of lateral lobes conspicuously separated from each other, the glabella of *Spathacalymene* is typical of Calymeninae as was earlier emphasized by Tillman (1960). In *S. linguata* n. sp. and *S. flexuosa* n. sp., even the fourth pair of lateral lobes is marked. Elles (1924) attracted attention to the fact that the number of lateral lobes on the glabella of Calymenidae increases during the evolutional development. Shirley (1936) maintains, however, that the evolution of the glabella in Calymenidae displayed the tendency to deepen the glabellar furrows and, consequently, to a more distinct separation of lateral lobes on glabella and to the appearance of supplementary furrows and intermediate lobes. In addition, the last-named author set great store to the progressive tendency to extend the glabella in relation to fixed cheeks. As a basis for classification he assumed, however, either "papillate" or "non-papillate" shape of glabellar lobes. According to this author, the "papillate" group includes *Calymene* Brongniart, 1822, *Diacalymene* Kegel, 1938 and *Papillicalymene* Shirley, 1936. The problem of the correctness of using this division and, strictly speaking, of a proper understanding and application of this term is discussed by Stumm & Kauffman (1958). The authors emphasize that the term "papillate" should be used only in the case in which a "papilla-shaped" lateral lobes have "corresponding buttresses" on the fixed cheak. In the case of *Spathacalymene,* this problem presents a certain difficulty. In his description of the species *S. nasuta* (Ulrich), Tillman (1960) speaks of the shallowing of the axial furrow near the middle lateral lobe caused by the presence "of a projection, or buttress, extending lobe-ward from fixed cheek. Buttress is met by lobe to produce papillate condition." In *Spathacalymene linguata* n. sp., *S. flexuosa* n. sp. and *S. brevis* n. sp., a small ridge, clearly marked in a wide axial furrows, perpendicular to them and considerably shallowing them in these places, run between the fixed cheeks and glabella on a level of S_3. This may be an equivalent of "buttresses", observed in other Calymeninae. It does not, however, pass over the axial furrows to form a "bridge", but it runs pronouncedly under the furrows. This is probably the reason why it does not exert an influence on the shape of glabella, rounded lobes and fixed cheeks which do not display any tendency to form "buttresses". In all the three species, glabellar furrows S_1, S_2 and S_3 are deep, reach the level of dorsal furrows and clearly separate individual lobes. Only in *Spathacalymene linguata* and *S. flexuosa,* there occur furrows S_4, which are short, shallow and sepa-

rating the fourth lobes. L_1, L_2 and L_3 are accurately separated from each other and were it not for their clearly rounded shape, they could be called papillate. Thus, the Polish *Spathacalymene* might be assigned to the "papillate" group only if the "small ridge", running between the fixed cheeks and L_3 would be considered an equivalent of papilla and buttress.

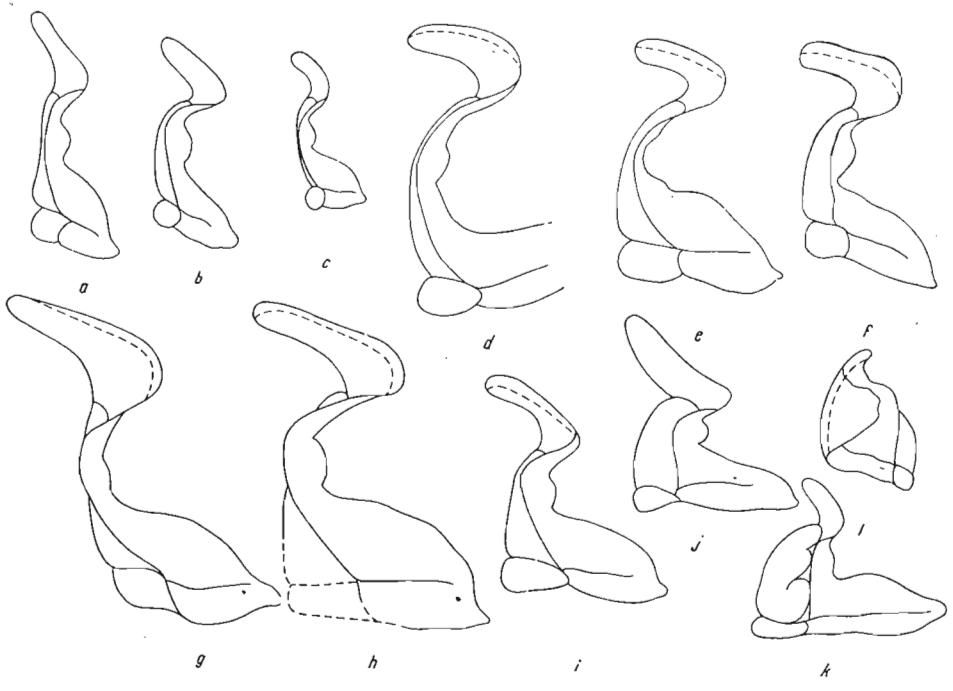


Fig. 4. — Comparison of the most characteristic profiles of cranidia of different species of *Spathacalymene*. *a-c Spathacalymene brevis* n. sp. *a* IG. 1169.II.52-holotype, *b* IG. 1169.II.12, *c* IG. 1169.II.3; *d-f S. flexuosa* n. sp.: *d* IG. 1169.II.7-holotype, *e* IG. 1169.II.1, *f* IG. 1169.II.2; *g-i S. linguata* n. sp.: *g* IG. 1169.II.5-holotype, *h* IG. 1169.II.60, *i* IG. 1169.II.15; *j S. nasuta* (Ulrich, 1879), after Tillman, 1960, Pl. 116, Fig. 1; *k S. nodulosa* (Shirley, 1933), after Salter, 1865, Pl. 8, Fig. 3; *l S. pompeckji* (Kummerow, 1928), after Kummerow, 1928, Pl. 1, Fig. 5 b.

In Polish species of *Spathacalymene*, the anterior lobe is quite low and gently sloping towards the preglabellar furrow, which in Calymeninae is a very rare character and which is clearly visible in the profiles of particular species of *Spathacalymene* (Fig. 4 *a-i*). It is almost equal to fixed cheeks and only rarely passes anteriorly. On the other hand, in the type species *S. nasuta* (Ulrich), both the fixed cheeks and, a very convex anterior lobe steeply slope to the preglabellar furrow (Fig. 4*j*) so that even the "anterior lobe is suspended and partly concealed in space formed by deep preglabellar furrow." At the same time, Tillman (1960) maintains that anterior lobe expands 4 mm forward of fixed cheeks. It should be emphasized, however, that the glabella in *S. nasuta* is all very convex and strongly protruding above the surface of fixed cheeks, whereas in Polish

Spathacalymene, the ocular cheeks are strongly raised, protruding above the level of glabella and, in the anterior part, steeply sloping anteriorly (Fig. 4). On the basis of a drawing (Salter, 1865, Pl. 8, Fig. 3), the anterior lobe in *S. nodulosa* (Shirley, 1933) seems to be low, much the same as in Polish *Spathacalymene*, but, on the other hand, the fixed cheeks are situated lower than the glabella (Fig. 4*k*). According to Salter (*l.c.*, p. 91), "Cheeks gibbous, often more elevated than the glabella", which more strongly confirms the correctness of the present writer's standpoint concerning the assignment of this species to *Spathacalymene*. The fixed cheeks in, for instance, *Diacalymene diademata* (Barrande, 1846) are completely flat, which has been noticed by the writer in the material from both the Polish and Bohemian Silurian (Tomczykowa, 1957). On the basis of the drawing presented, fixed cheeks (Fig. 4*l*) in *Spathacalymene pompeckji* (Kummerow) seem to be high and projecting above the glabella the same as in *S. flexuosa* n. sp. The lack of a comparative material and imperfect illustrations of Kummerow (*l.c.*, 1928, Pl. 1, Fig. 5 a-b) do not allow one for more detailed comparisons.

The differences between individual species established by the present writer on the Polish material, are discussed together with comparisons. They mostly concern shape, position and length of the preglabellar process. The comparison of profiles for a few most characteristic specimens of each species presented above, allows one to catch accurately the differences between particular species. On the other hand, a graphic comparison with the type species and the remaining species of this genus was difficult for the lack of a direct comparative material and, therefore, the figures were drawn on the basis of illustrations published in pertinent works. The outline of doublure in particular species of *Spathacalymene* depicts changes taking place in its shape. They are closely connected with the shape of rostrum which is subject to distinct changes in various genera of Calymeninae. Differences are observed even in individual species (Fig. 5 *a-i*).

The rostrum in *Calymene blumenbachi* (Fig. 5*a*) has the form of a narrow (*sag.*) plate, the rostral suture being almost straight. *C. aspera* (Fig. 5*b*) has a slightly arcuate rostral and hypostomal sutures, but the rostral plate is equally narrow as that in the former species, while doublure is narrower (*sag.*) than rostrum. Rostrum in *Diacalymene diademata* (Fig. 5*c*) is pronouncedly wider (*sag.*) than doublure; rostral and hypostomal sutures are strongly arcuate. Strongly arcuate is also the rostral suture in *Papillicalymene excavata* (Fig. 5*d*) whose hypostomal suture is very short. The width (*sag.*) of rostrum equals a half of the length (tr.),[1] whereas in *Calymene blumenbachi* and *C. aspera* this ratio

[1] The dimensions of rostrum are measured in the following way: width (*sag.*) — along the axial line and length (*tr.*) — as a distance between angles formed at the junction of the rostral suture with connecting sutures.

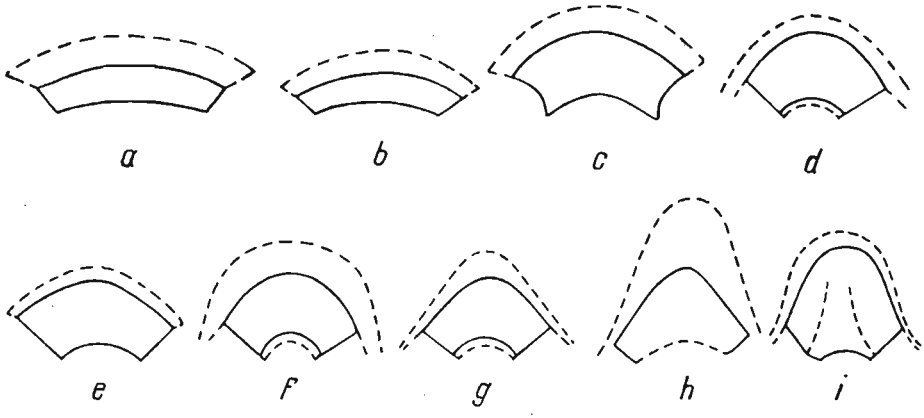


Fig. 5. — Comparison of rostra in different species of the subfamily Calymeninae: *a Calymene blumenbachi* Brongniart, 1822, after Shirley 1936, p. 413, Fig. 4B; *b C. aspera* Shirley, 1936, after Shirley, 1936, p. 413, Fig. 4A; *c Diacalymene diademata* (Barrande, 1846), after specimen from Kaplonosy boring, 709 m; *d Papillicalymene excavata* (Lindstrom, 1885), after Lindstrom, 1885, Pl. 16, Fig. 4; *e Spathacalymene flexuosa* n.sp.; *f S. nodulosa* (Shirley, 1933), after Salter, 1865, Pl. 8, Fig. 4; *g S. brevis* n. sp.; *h S. nasuta* (Ulrich, 1879), after Tillman, 1960, Pl. 116, Fig. 11; *i S. linguata* n. sp.

amounts to 1/5 and in *Diacalymene diademata* — to about 1/3. A similar width-length ratio of the rostrum as that in *Papillicallymene excavata* is recorded in *Spathacalymene flexuosa* (Fig. 5*e*), but in the last-named species the doublure is almost twice as wide (*sag.*) as in *P. excavata*. The rostrum in *Spathacalymene nodulosa* (Fig. 5*f*) is copied from Salter's (1865, Pl. 8, Fig. 4) drawing, on the basis of which its width (*sag.*) seems to equal 1/3 of the length. Although Salter speaks (*l. c.*, p. 91). "... curved rostral shield, half as long as broad...", but what is called length by Salter, is determined by the present writer as width (*sag.*). The ratio of dimensions of the rostral plate in *S. nodulosa* is the same as that in *S. flexuosa* n. sp. In *Spathacalymene brevis* n. sp. (Fig. 5*g*) the rostrum is also a half as long as wide, but its doublure is axially somewhat wider than that in *S. flexuosa*. A very wide doublure is observed in *Spathacalymene nasuta* (Fig. 5*h*) but the posterior margin of rostrum and the trace of the hypostomal suture remain unknown. On the basis of the specimen U.S.N.M. 41 871 (Tillman, 1960, Pl. 116, Fig. 11), we may assume that its rostrum was not much wider (*sag.*) and, therefore, its width would almost exactly equal the width (*sag.*) of doublure but, at the same time, a half of the length (*tr.*) of rostrum much the same as in the above discussed species of *Spathacalymene*. Only *S. linguata* (Fig. 5*i*) departs from this standard. A spatulate rostrum makes up a reflection of the shape of the process, the doublure, parallel to its margin, being very narrow. On the other hand, the width (*sag.*) of rostrum equals its length (*tr.*).

A "distinct flattening of tops of axial and pleural thoracic lobes..." (Tillman, 1960, p. 892), very characteristic of *Spathacalymene nasuta*

(Ulrich, 1879), does not occur in Polish representatives of this genus, whereas pygidia in both, the type species and in Polish species, have important common characters. Although the number of rings of the pygidial axis differs in particular species, only four, short and truncate ribs occur on pleura in all cases. Accordingly, the ribbed part of pleurae has a very characteristic conical shape (cf. Pl. III, Figs. 9, 10). The terminal part of the axis is surrounded by a sort of the fifth pair of ribs shaped like a more or less distinct rim. The most characteristic is, however, the lack of interpleural furrows in *Spathacalymene linguata* n. sp., *S. flexuosa* n. sp. and *S. brevis* n. sp. As to *S. nasuta*, Tillman (1960, p. 895) speaks: "Faint interpleural furrows present on inner part of pleural lobes but outer one-third of lobes lacking furrows of any kind." Since in most representatives of Calymeninae the interpleural furrows do occur and are particularly distinct in the outer part of pleura, for instance, in all species of *Calymene* and *Diacalymene*, this is a very characteristic feature. On the other hand, in *Spathacalymene*, the margin of pygidium is wide, smooth and without traces of furrows.

Spathacalymene linguata n. sp.

(Pl. III, Figs. 9-10; Pl. IV, Figs. 1-4, 6-9; Pl. V, Figs. 6-7, 9-12; Text-figs. 4 *g-i*, 5*i*)

Holotype: IG. 1169.II.5; Pl. IV, Figs. 3 *a-d*.
Type horizon: Silurian, *Cucullograptus hemiaversus* zone.
Type locality: Poland, Platform area, Mielnik borehole.
Derivation of the name: Lat. *lingua* = the tongue, after the tongue-like process.

Material. — Twenty five more or less complete cranidia, five free cheeks, four rostra, ten more or less complete pygidia and some fragments.

Dimensions (in mm):

	IG. 1169. II.			
	5	10	15	50
Length of cranidium (together with process)	10.5	8.4	7.1	10.0
Width of cranidium	19.0	16.0	12.0	—
Length of glabella (without occipital ring)	5.2	4.5	3.5	5.8
Width of glabella across frontal lobe . .	3.2	2.6	2.0	3.3
Width of glabella across L_1	5.6	4.7	3.4	5.8

Diagnosis. — Cranidial proces tongue-like, anteriorly narrowing; doublure narrow; rostrum spatulate.

Description. — Cephalon semicircular without process. Cranidium with a tongue like process, anteriorly narrowed, more or less extended anteriorly. Glabella bell-shaped, slightly convex, anteriorly gradually sloping,

with four lateral lobes, L_4 being very small. L_1, L_2 and L_3 separated from each other by deep furrows and rounded. Axial furrows, posteriorly deep and narrow, anteriorly considerably widening and shallowing, in particular near L_4, where a distinct roll-like ridge runs perpendicularly to axial furrows. Anteriorly, the presence of antennular pits is observed in axial furrows. Preglabellar furrow wide and shallow. Occipital ring wide, equalling almost $^1/_4$ of the length of glabella, from which it is separated by a fairly wide and shallow furrow. Palpebral lobes small, equalling $^1/_5$ of the length (*exag.*) of fixed cheeks. Ocular cheeks strongly convex. Postocular cheeks typical of *Calymene*. Free cheeks not very large, sharply terminating anteriorly, with a wide limbus rounded posteriorly. Rostral suture parabolic shaped like an inverted U. Rostrum large, spatulate, posteriorly concealing the entire surface of the tongue-shaped process. Doublure very narrow, parallel to the margin of process, considerably thinning laterally and disappearing at the point of contact with the end of facial suture (Fig. 5*i*). Granulation irregular; glabella, in particular in its anterior part, and ocular cheeks coarse-granular with the admixture of fine grains. Posteriorly granulation becomes finer and finer; doublure and rostrum regularly fine-granular; postocular cheeks and free cheeks almost completely smooth. Thorax with pleura rounded at their ends; typical of *Calymene*. Pygidium semicircular, posteriorly and axially slightly upturned which, viewed posteriorly, looks like an inverted, widely open V. Axis conical, not reaching the margin and consisting of six rings. Pleurae with four, short and narrow ribs, without interpleural furrows. Pleural furrows very characteristic: narrow near dorsal furrows, slightly widening towards the middle of pleura and sharply pointed at the end. Margin wide, almost equalling the ribbed part. Terminal part of axis surrounded by a sort of fifth pair of ribs parallel to it and shaped like a rim, visible in well-preserved specimens only (Pl. III, Figs. 9 and 10). The entire surface of pygidium regularly fine-granular; furrows smooth.

Remarks. — Owing to its tongue-like cranidial process, of all species assigned by the writer to the genus *Spathacalymene*, *S. linguata* n. sp. is most similar to the type species. This similarity primarily consists in the presence of a U-shaped spatulate anterior process. In *S. nasuta* (Ulrich), this process is long, sometimes equalling the length of glabella and situated at an obtuse angle, but variously inclined, to glabella. It develops, however, only behind a narrow and deep preglabellar furrow. In *S. linguata* n. sp., this process develops somewhat differently. Preglabellar furrow, wide and shallow at the base of anterior lobe, passes into preglabellar area which anteriorly considerably extends and narrows forming a tongue-shaped process, incurving toward glabella at a variable angle which is, however, always larger than 90°. Since it is impossible to deter-

mine which part belongs to preglabellar furrow, which to preglabellar area, and which to anterior border, the writer believes that this process is formed by the narrowing of the whole anterior part of cranidium. Its length is variable and fluctuates within limits of $^2/_3$ of the length of glabella.

The differences between *Spathacalymene nasuta* (Ulrich) and *S. linguata* n. sp. are given in the following table:

	S. nasuta (Ulrich, 1879)	*S. linguata* n. sp.
Glabella(in profile)	convex, projecting above cheeks	lower or equalling the height of cheeks
Preglabellar furrow	deep and narrow	shallow and wide
Lateral lobes	3 pairs (L_2 papillate)	4 pairs, rounded
Anterior lobe	large, convex, steeply slopping to the preglabellar furrow	small, low, gently sloping anteriorly
Ocular cheeks (in profile)	convex, reaching halfway the height of glabella	high, mostly higher than glabella
Doublure	wide (*sag.*), equalling $^1/_2$ of the length of process	narrow (*sag.*), equalling $^1/_4$ of the length of process
Rostral suture	rounded, inverted, open V	shaped like an inverted U
Axial rings of pygidium	5	6
Interpleural furrows	faint	obsolete

The differences between these two species, presented above, are distinct but probably contained within one and the same genus, whereas the differences between *S. linguata* n. sp. and the remaining new species are much smaller and mostly consist in the angle of inclination to glabella length and shape of process (cf. p. 83).

Occurrence. — Poland, Platform area, Mielnik and Gołdap boreholes, uppermost part of the Lower Ludlovian, Upper Mielnik Beds, zones of *Cucullograptus hemiaversus, C. aversus;* within the range of occurrence of *Saetograptus leintwardinensis.*

Spathacalymene flexuosa n. sp.

(Pl. I, Figs. 8-9; Pl. II, Figs. 1-3, 5-7; Pl. III, Figs. 2-3, 11-16; Pl. IV, Figs. 5 *a-c*; Pl. V, Figs. 5 *a-b*, 8; Text-figs. 4 *d-f*, 5*e*)

Holotype: IG. 1169. II. 7; Pl. II, Figs. 5 *a-c*.

Type horizon: Silurian, *Saetograptus leintwardinensis* zone.

Type locality: Poland, Platform area, Mielnik borehole.

Derivation of the name: Lat. *flexuosus* — after cranidial process, inflected to glabella at an angle of almost 90°.

Material. — Thirty more or less complete cranidia, five free cheeks, four rostral plates, a fragmentary hypostom with seven segments of thorax and five pygidia.

Dimensions (in mm):

	IG. 1169. II.			
	1	2	7	22
Length of cranidium (together with process)	7.9	7.0	10.5	10.2
Width of cranidium	13.5	13 0	20.0	22.0
Length of glabella (without occipital ring)	5.2	4.0	6.3	6.3
Width of glabella across frontal lobe	3.8	3.2	3.2	3.4
Width of glabella across L_1	4.4	4.1	4.4	6.6

Diagnosis. — Process perpendicular to glabella; preglabellar furrow wide; glabella slightly widening posteriorly, convex, equal to or somewhat lower than ocular cheeks.

Description. — Cranidium semicircular, with a fairly long process perpendicularly incurved to glabella. Preglabellar furrow wide, separating glabella and fixed cheeks from the process. Glabella bell-shaped, with four pairs of lateral furrows, S_4 being clearly visible in larger specimens. Axial furrows deep and narrow, widening and shallowing anteriorly. A roll-like ridge, behind which antennular pits occur in the anterior part of axial furrows, runs parallel to S_3 and across the axial furrows. Occipital ring wide, convex, separated from glabella by a wide and shallow furrow. Ocular cheeks convex, equal to or slightly protruding above the surface of glabella, the width (*tr.*) measured across palpebral lobes being equal to the width (*tr.*) of glabella at the level of these lobes. Postocular cheeks typical of *Calymene*, slightly elongated (*tr.*). Free cheeks triangular, anteriorly sharpened, with a wide, posteriorly rounded border. Palpebral lobes are less than $^1/_3$ of the length of glabella. Only fragmentary thorax known. Axis wide and convex, pleura rounded at their ends in a manner typical of *Calymene*. Pygidium semicircular. Axis with seven rings, gradually narrowing posteriorly, not reaching the margin, slightly convex, somewhat protruding above pleurae. Pleurae with four, short ribs, with-

out interpleural furrows. Margin wide, narrowing posteriorly. The entire surface of the shield covered with a fine, fairly dense granulation, less frequently coarser granules irregularly scattered. Ocular cheeks and glabella more densely and coarsely granular.

Remarks. — *Spathacalymene flexuosa* n. sp. considerably differs from the type species. *S. nasuta* (Ulrich), is larger, more convex and has a longer, anteriorly extended, spatulate cranidial process which is separated from glabella by a very deep and narrow preglabellar furrow. *S. flexuosa* n. sp. is very similar to *S. linguata* n. sp., from which it differs in the position of cranidial process perpendicular to glabella. The material examined includes many specimens transitional from the typical form of *S. linguata* to that of *S. flexuosa,* which is particularly clearly visible in the forms from the Mielnik borehole. Within 24 m of thickness of deposits, the occurrence of typical forms of *S. linguata* may be observed whose cranidial processes, at first long and deflected at a large angle, display a gradual tendency, in specimens which are younger stratigraphically, to incurve toward glabella. The importance of these observations is yet more strongly emphasized by the fact that the holotype of *S. linguata* comes from a depth of 959.1 m, i. e. from the oldest deposits in which specimens of *Spathacalymene* were found, while the most typical specimens occur from this depth up to 949.9 m. On the other hand, the holotype of *S. flexuosa* occurs at a depth of 940.5 m, i. e. in younger deposits and the occurrence of typical specimens does not exceed a depth of 946.0 m. The transitional specimens mostly occur at depths ranging between 949.9 and 942.4 m. At a depth of 937.0, a specimen (IG. 1.169.II.10) occurs which is still assigned by the writer to *S. linguata* because of its cranidial process considerably narrower than that in *S. flexuosa* (Pl. V, Fig. 7) and having rostrum characteristic of *S. linguata.* A similar developmental interdependence may be also traced between *S. flexuosa* and *S. brevis.* The present writer supposes that the reduction of cranidial processes, which in *S. brevis* are much shorter, takes place in the same manner as the incurving of these processes perpendicularly to glabella observed in the evolutional development between *S. linguata* and *S. flexuosa.* Within the range of depths between 948.0 and 937.5 m, in addition to *S. flexuosa,* there appear specimens, assigned by the writer to *S. brevis* n. sp. and having a considerably reduced cranidial process more or less incurved toward glabella and slightly thickened at the end.

The incurving of the process and its reduction discussed above were traced by the writer only in the profile of the Mielnik borehole. In the Gołdap borehole, specimens of *Spathacalymene* occur only within the range of 3 m. A not very abundant material obtained from that borehole has been assigned to *S. linguata* n. sp. and *S. brevis* n. sp. It should be emphasized that some specimens have a very long, spatulate cranidial process, which is considerably incurved toward glabella (Pl. V, Fig. 9),

whereas in other specimens these processes are more deflected from glabella (Pl. IV, Figs. 7 and 8; Pl. V, Fig. 11). It may be guessed that the material from Gołdap corresponds to a transitional series, i. e. a series in which, in the profile of Mielnik, the occurrence of *S. linguata* coincides with that of *S. brevis*. On the other hand, specimens from the Terespol borehole probably come from a higher series in which the occurrence of *S. flexuosa* coincides with that of *S. brevis*.

S. nodulosa (Shirley) and *S. pompeckji* (Kummerow) are very similar to *S. flexuosa* n. sp. According to Salter (1865, pp. 91-92; Pl. 8, Figs. 1-6), *Calymene tuberculosa* Salter, 1848 (=*Calymene nodulosa* Shirley, 1933) differs from other *Calymene* in "being greatly more depressed and having a projecting recurved snout..." Further, this author maintains that "the production forwards of the snout is not always in the same degree", which would indicate that the specimens assigned to this species are considerably differentiated. A similarly differentiated and rich material is also observed concerning *S. flexuosa* n. sp.

Occurrence. — Poland, Platform area, Mielnik and Terespol boreholes, the uppermost part of the Lower Ludlovian, Upper Mielnik Beds. Zones of *Cucullograptus aversus, Saetograptus leintwardinensis.*

Spathacalymene brevis n. sp.

(Pl. I, Figs. 1-7; Pl. II, Fig. 4 *a-b*; Pl. III, Figs. 1, 4-8; Pl. V, Figs. 1-4; Text-figs. 4 *a-c*, 5*g*)

Holotype: IG. 1169.II.52, Pl. I, Fig. 7 *a-c*.
Type horizon: Silurian, *Saetograptus leintwardinensis* zone.
Type locality: Poland, Platform area, borehole Gołdap.
Derivation of the name: Lat. *brevis* — after a short cranidial process.

Material. — A complete enrolled specimen, ten cranidia, four free cheeks, two rostral plates and three pygidia.

Dimensions (in mm):

	IG. 1169. II.			
	12	6	53	52
Length of cranidium (together with process)	6.4	4.3	6.8	7.8
Width of cranidium . . .	12.0	7.5	13.0	14.5
Length of glabella (without occipital ring)	3.5	2.7	4.2	4.2
Width of glabella across frontal lobe	2.2	1.8	2.3	2.6
Width of glabella across L_1 .	3.8	2.4	3.9	4.5

Diagnosis. — Cranidium triangular, cranidial process short, more or less incurved toward glabella; three pairs of glabellar lobes.

Description. — Cranidium triangular, its length (*sag.*) together with

process makes up almost a half of a maximum width; process short, not reaching a half of the length of glabella. Glabella bell-shaped almost completely flat, with distinct three pairs of lateral lobes, separated by short deep furrows S_1, S_2 and S_3. S_1 running obliquely posteriorly and cutting off triangular but rounded L_1. S_2 and S_3 short, parallel to the occipital furrow. L_2 round. Axial furrows narrow, fairly shallow and converging anteriorly. Preglabellar furrow shallow separates a flat glabella from a not very wide (*tr.*) preglabellar area which passes into a subtriangular process, slightly thickened at the end. Occipital ring wide, almost equalling $^1/_4$ of the length of glabella, separated from it by a narrow and deep furrow. Ocular lobes fairly large, almost equalling $^1/_3$ of the width (*exag.*) of fixed cheeks. Ocular cheeks convex. Postocular cheeks mostly conspicuously deflected posteriorly. Free cheeks triangular, sharply terminating anteriorly with a wide border rounded posteriorly. Doublure narrow, slightly widened axially. The width (*sag.*) of rostrum equals a half of its length (*tr.*). Thorax consisting of 13 segments. Axis convex, rings rounded and uniform in width (*sag.*). Axis makes up almost a half of the width (*tr.*) of pleural part; pleurae rounded at the ends. Pygidium semicircular with five axial rings and four ribs on pleurae. Four pleural furrows reaching halfway the pleura. Margin wide, devoid of furrows, almost equalling the ribbed part. Ribs short and narrow, without interpleural furrows. The whole surface of carapace is very finely and densely granulated.

Remarks. — *Spathacalymene brevis* n. sp. considerably differs from *S. nasuta* (Ulrich). A short cranidial process, narrow doublure and almost completely flat cranidium are principal characters in which it differs

	S. linguata	*S. flexuosa*	*S. brevis*
Anterior process	long, extended anteriorly	fairly long, incurved toward glabella at an angle of almost 90°	short, extended anteriorly
Glabella (in profile)	all slightly convex	slightly convex, particularly so posteriorly	flat
Lateral lobes	4 pairs	4 pairs	3 pairs
Ocular cheeks (in profile)	mostly higher than glabella	higher than or equalling glabella	lower than or equalling glabella
Width (*sag.*) of rostrum	equalling length	equalling a half of length	equalling a half length
Number of axial rings of pygidium	6	7	5

from the type species. The differences observed between the three new species are as follows:

Occurrence. — Poland, Platform area, Mielnik, Terespol and Gołdap boreholes, uppermost part of the Lower Ludlovian, Upper Mielnik Beds. Zones of *Cucullograptus aversus* and *Saetograptus leintwardinensis.*

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EWA TOMCZYKOWA

TRYLOBITY *SPATHACALYMENE* TILLMAN, 1960 W SYLURZE POLSKI

Streszczenie

W ciągu ostatnich lat, w otworach wiertniczych: Mielnik, Gołdap i Terespol w Polsce północno-wschodniej (Fig. 1) znalezione zostały w warstwach mielnickich (Tomczyk, 1962) liczne okazy trylobitów należących do rodzaju *Spathacalymene* Tillman, 1960. Powyższy materiał pozwolił na wydzielenie trzech nowych gatunków: *Spathacalymene linguata* n. sp., *S. flexuosa* n. sp. i *S. brevis* n. sp., które różnią się między sobą kształtem, wielkością i pozycją charakterystycznego wyrostka przedglabelarnego. Pod względem stratygraficznym gatunki te wykazują bardzo mały zasięg pionowy i mogą stanowić charakterystyczny poziom trylobitowy dla stropu dolnego ludlowu.

W otworze Mielnik pierwsze gatunki rodzaju *Spathacalymene* pojawiają się (Fig. 2) 20 m ponad zasięgiem *Lobograptus scanicus parascanicus* i występują w osadach obejmujących (Urbanek, 1966) poziomy: *Cucullograptus hemiaversus* i *C. aversus*, ginąc wraz z zasięgiem poziomu *Saetograptus leintwardinensis* (Tab. I). Poziom ten (Tomczyk, 1962, 1970) stanowi strop warstw mielnickich odpowiadających dolnym łupkom z Ludlow (Elles & Wood, 1918), w których na klasycznym dla syluru obszarze Wielkiej Brytanii, poziom *Saetograptus leintwardinensis* kończy pionowy zasięg facji graptolitowej.

W Polsce, pod koniec dolnego ludlowu, w związku z ruchami fazy krakowskiej (Łydka *et al.*, 1963) następuje zróżnicowanie litofacjalne w obrębie zbiornika morskiego. W Górach Świętokrzyskich w poziomie *Saetograptus leintwardinensis* kończy się cykl sedymentacji ilastej z graptolitami. Na obszarze Niżu Polski w poziomie tym zaznacza się kilka stref litofacjalnych (Fig. 1) od mułowcowej przez ilastą

i ilasto-wapienną do strefy płytszej marglisto-wapiennej. Strefa ta przebiegała z NW na SE od wschodniej części obniżenia perybałtyckiego w rejonie otworu Gołdap, poprzez wyniesienie mazursko-suwalskie, gdzie uległa zapewne denudacji przedpermskiej. Zachowała się natomiast we wschodniej części obniżenia podlaskiego w otworach Mielnik i Terespol, skąd przechodziła dalej w kierunku południowo-wschodnim. W litofacji tej, obok licznych graptolitów, występują charakterystyczne trylobity rodzaju *Spathacalymene* opisane w niniejszej pracy. Mają one szczególnie duże znaczenie dla osadów strefy płytkiej zbiornika morskiego, gdzie istniały dogodne warunki dla rozwoju fauny bentonicznej, a gdzie plankton graptolitowy mógł już nie docierać. Wartość ich podnosi mały zasięg stratygraficzny, ograniczony do stropu dolnego ludlowu, odpowiadającego występowaniu *Saetograptus leintwardinensis*.

ЭВА ТОМЧИКОВА

ТРИЛОБИТЫ *SPATHACALYMENE* TILLMAN, 1960 В СИЛУРЕ ПОЛЬШИ

Резюме

В последние годы буровыми скважинами Мельник, Голдап и Тересполь в северо-восточной Польше (фиг. 1) были вскрыты мельникские слои (Tomczyk, 1962), в которых встречены многочисленные экземпляры трилобитов рода *Spathacalymene* Tillman, 1960. Среди них описано три новых вида: *Spathacalymene linguata* n. sp., *S. flexuosa* n. sp. и *S. brevis* n. sp., которые отличаются друг от друга своей формой, величиной и положением характерного предглабелярного отростка. В стратиграфическом отношении эти виды отличаются очень узким интервалом вертикального распространения и определяют характерный трилобитовый горизонт в кровле нижнего лудлова.

В разрезе скважины Мельник первые виды рода *Spathacalymene* появляются в 20 м выше границы распространения *Lobograptus scanicus parascanicus* (фиг. 2) и распространены в отложениях, охватывающих (Urbanek, 1966) горизонты *Cucullograptus hemiaversus* и *C. aversus*, исчезая вместе с границей горизонта *Saetograptus leintwardinensis* (табл. I). Этот горизонт (Tomczyk, 1962, 1970) составляет кровлю мельникских слоев, эквивалентных нижним сланцам из Лудлоу в Великобритании (Elles & Wood, 1918), в которых горизонт *Saetograptus leintwardinensis* завершает вертикальное распространение граптолитовой фации.

В морском бассейне Польши, в конце раннего лудлова, движения краковской фазы (Łydka *et al.*, 1963) вызвали изменения литофаций. В Свентокшиских горах горизонтом *Saetograptus leintwardinensis* заканчивается цикл образования глинистых осадков с граптолитами. На Польской низменности в этом горизонте

отмечается несколько литофациальных зон (фиг. 1): от алевритовой, глинистой и известково-глинистой до известково-мергелистой, более мелководной зоны. Эта зона простиралась с СЗ на ЮВ, от восточной части Перибалтийского понижения в районе скважины Голдап, через Мазурско-Сувалковское поднятие, где ее осадки подверглись, вероятно, допермской денудации. Они сохранились в восточной части Подлясского понижения (скважины Мельник и Тересполь); отсюда эта зона простиралась далее в юго-восточном направлении. В этой литофации, кроме многочисленных граптолитов, представлены характерные трилобиты рода *Spathacalymene*, описанные в настоящей работе. Они имеют особенно важное значение для отложений мелководной зоны морского бассейна, в которой существовали благоприятные условия для развития бентонной фауны, но граптолитовый планктон не достигал уже этой зоны. Их значение возрастает в связи с узким стратиграфическим распространением, ограничивающимся кровлей нижнего лудлова, что соответствует распространению *Saetograptus leintwardinensis*.

PLATES

Plate I

Spathacalymene brevis n. sp.

Fig. 1. Incomplete cranidium: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.55). Borehole Gołdap, 1203.6 m.

Fig. 2. Cranidium slightly compressed: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.6). Borehole Mielnik, 939 m.

Fig. 3. Cranidium with the glabellar shield broken: *a* frontal view, *b* side view (IG. 1169.II.3). Borehole Mielnik, 947.5 m.

Fig. 4. Incomplete cranidium: *a* frontal view, *b* side view, *c* anterior view (IG. 1169.II.54). Borehole Gołdap, 1203.6 m.

Fig. 5. Cranidium slightly compressed: *a* frontal view, *b* side view, *c* anterior view (IG. 1169.II.56). Borehole Gołdap, 1203.6 m.

Fig. 6. Cranidium with the shield broken: *a* frontal view, *b* side view, *c* anterior view, *d* posterior view (IG. 1169.II.53). Borehole Gołdap, 1206 m.

Fig. 7. Cranidium — holotype: *a* frontal view, *b* side view, *c* anterior view (IG. 1169.II.52). Borehole Gołdap, 1203.6 m.

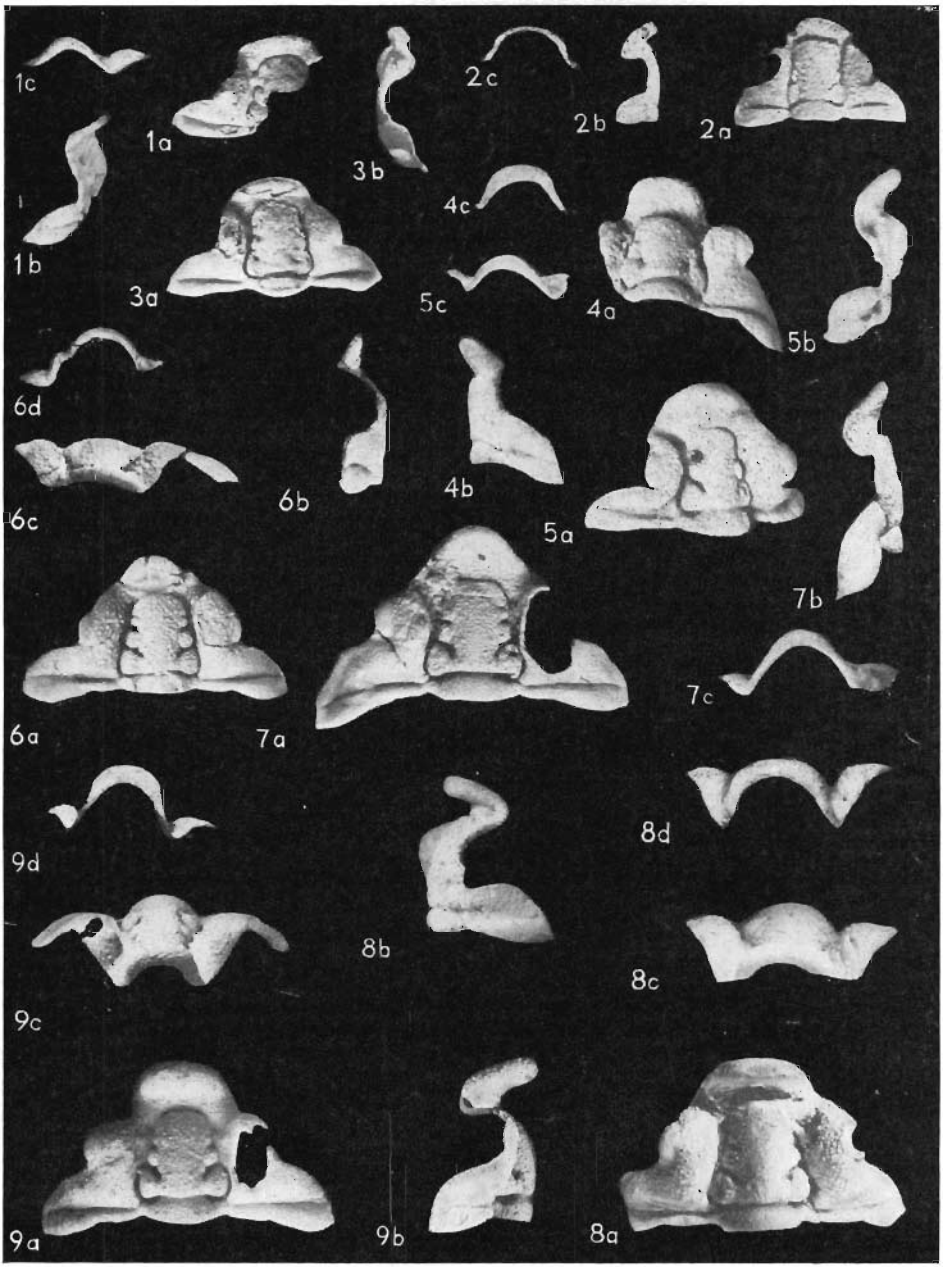
Spathacalymene flexuosa n. sp.

Fig. 8. Cranidium: *a* frontal view, b side view, *c* anterior view, *d* posterior view (IG. 1169.II.1). Borehole Mielnik, 936 m.

Fig. 9. Other cranidium: *a* frontal view, *b* side view, *c* anterior view, *d* posterior view (IG. 1169.II.2). Borehole Mielnik, 943.3 m.

Uppermost Lower Ludlovian, Upper Mielnik Beds

All figures ×3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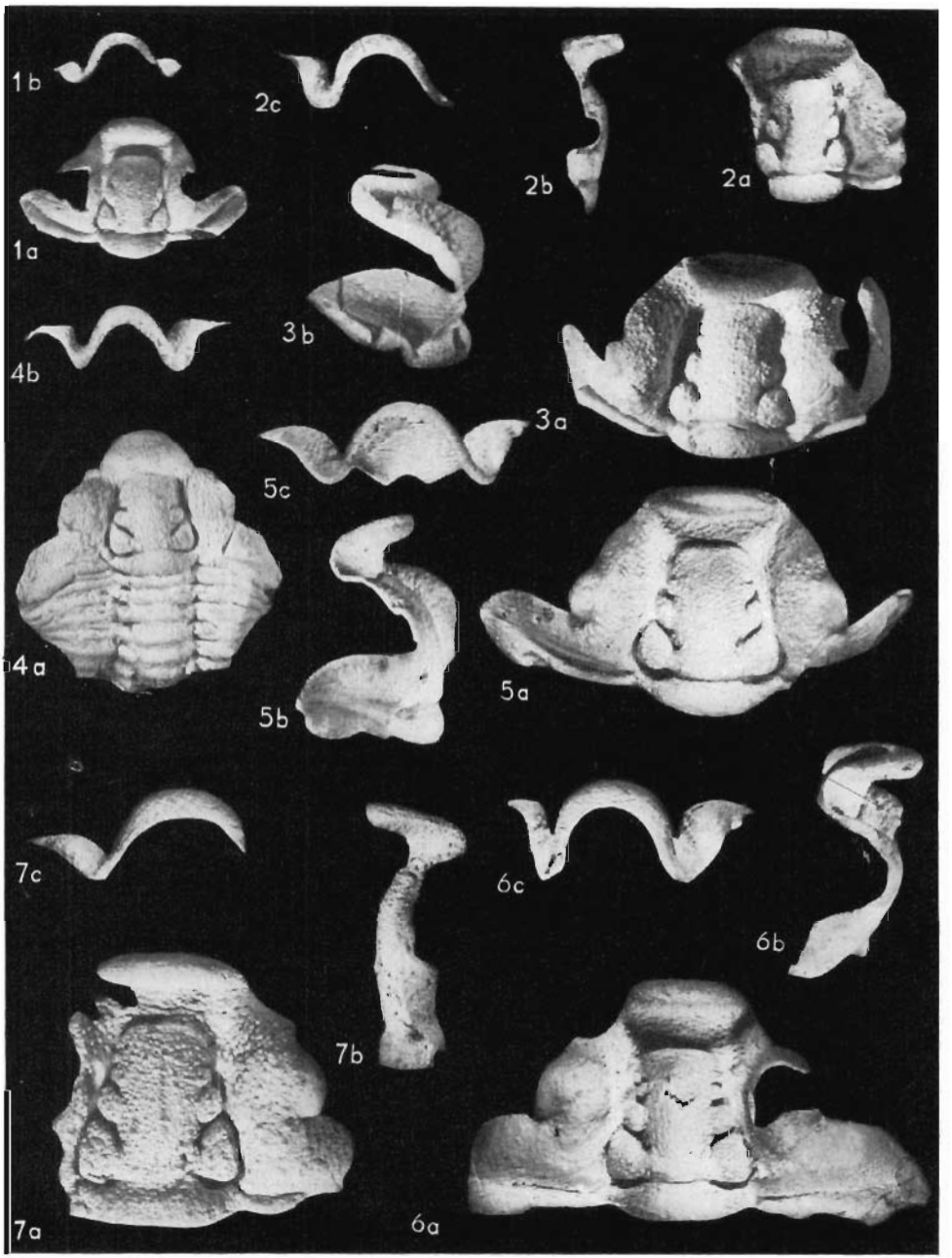
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Plate II

Spathacalymene flexuosa n. sp.

Fig. 1. Small cranidium: a frontal view, b anterior view (IG. 1169.II.9). Mielnik, 438 m.

Fig. 2. Incomplete cranidium: *a* frontal view, *b* side view, *c* anterior view (IG. 1169.II.17). Mielnik, 937 m.

Fig. 3. Cranidium with the spatulate process broken and incurved over the glabella: *a* frontal view, *b* side view (IG. 1169.II.24). Mielnik 944.2 m.

Fig. 5. Cranidium with rostral plate, holotype: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.7). Mielnik, 940.5 m.

Fig. 6. Rather big cranidium: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.22). Mielnik, 943.3 m.

Fig. 7. Incomplete rather big cranidium: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.23). Mielnik, 940.5 m.

Spathacalymene brevis n. sp.

Fig. 4. Cranidium with 6 thoracic segments: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.12). Mielnik, 947.5 m.

Uppermost Lower Ludlovian, Upper Mielnik Beds

All figures ×3

Plate III

Spathacalymene brevis n. sp.

Fig. 1. Rostral plate (IG. 1169.II.45a). Terespol, 608-614.9 m.
Fig. 4. Rather small pygidium (IG. 1169.II.42). Terespol, 608-6114.9 m.
Fig. 5. Pygidium (IG. 1169.II.46a). Terespol, 608-614.9 m.
Fig. 6. Whole specimen rolled: a side view, *b* posterior view (IG. 1169.II.25). Mielnik, 944,2 m.
Fig. 7. Pygidium (IG. 1169.II.47). Terespol, 608-614.9 m.
Fig. 8. Free cheek (IG. 1169.II.156). Gołdap, 1203.6 m.

Spathacalymene linguata n. sp.

Fig. 9. Pygidium with the shield partly broken: *a* frontal view, *b* posterior view (IG. 1169.II.4). Mielnik, 947.5 m.
Fig. 10. Pygidium: a frontal view, *b* posterior view (IG. 1169.II.58). Gołdap, 1206 m.

Spathacalymene flexuosa n. sp.

Fig. 2. Rostrum (IG. 1169.II.29). Mielnik, 936 m.
Fig. 3. Rostrum (IG. 1169.II.45b). Terespol, 608-614.9 m.
Fig. 11. Pygidium (IG. 1169.II.32). Mielnik, 940-946 m.
Fig. 12. Free cheek (IG. 1169.II.30). Mielnik, 941 m.
Fig. 13. Cranidium partly broken: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.21). Mielnik, 943.3 m.
Fig. 14. Pygidium, with 7 thoracic segments (IG. 1169.II.34). Mielnik 945 m.
Fig. 15. Cranidium: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II). Mielnik. 944.2 m.
Fig. 16. Incomplete cranidium: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.36). Terespol, 608-614.9 m.

Uppermost Lower Ludlovian, Upper Mielnik Beds

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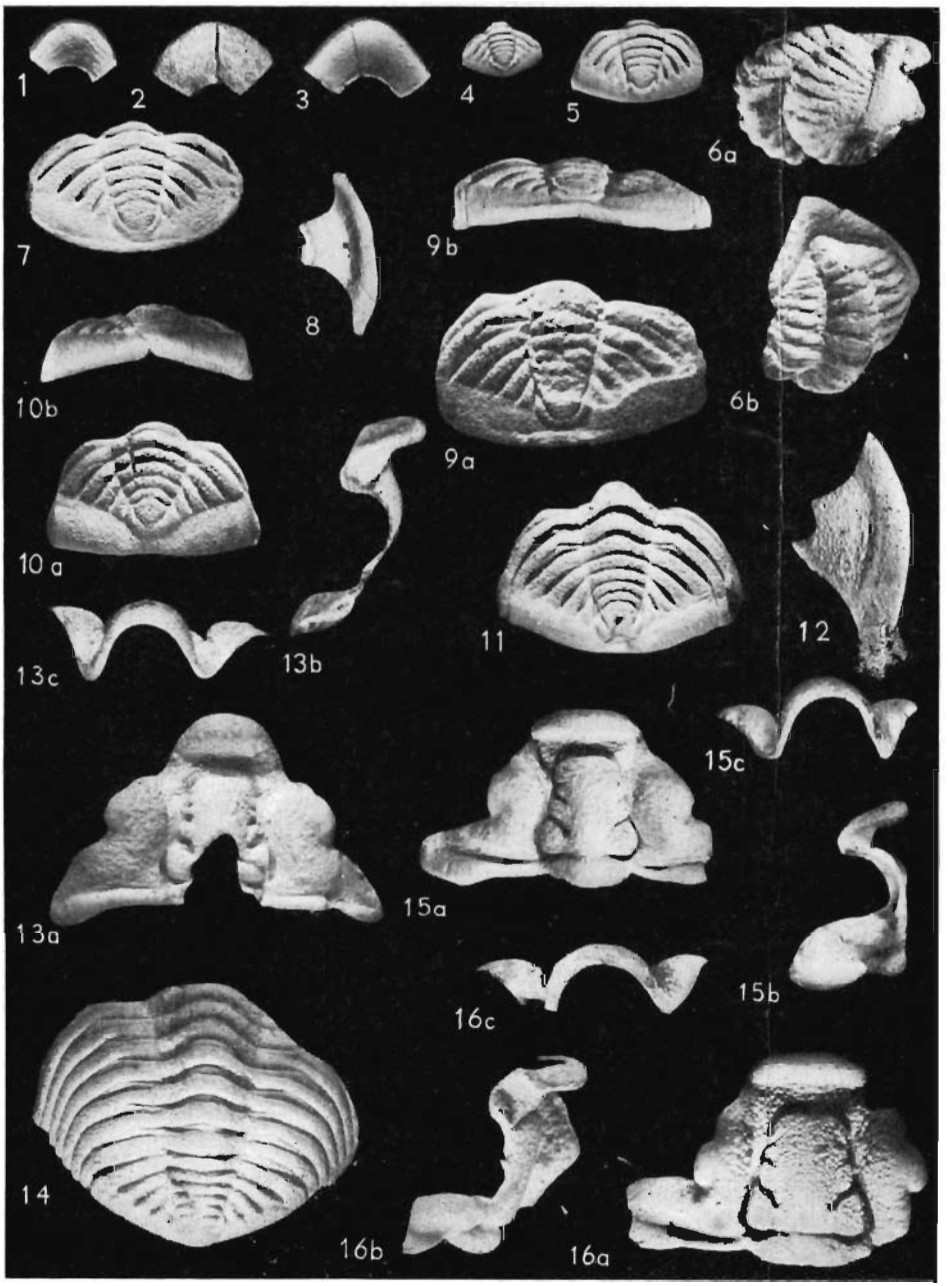
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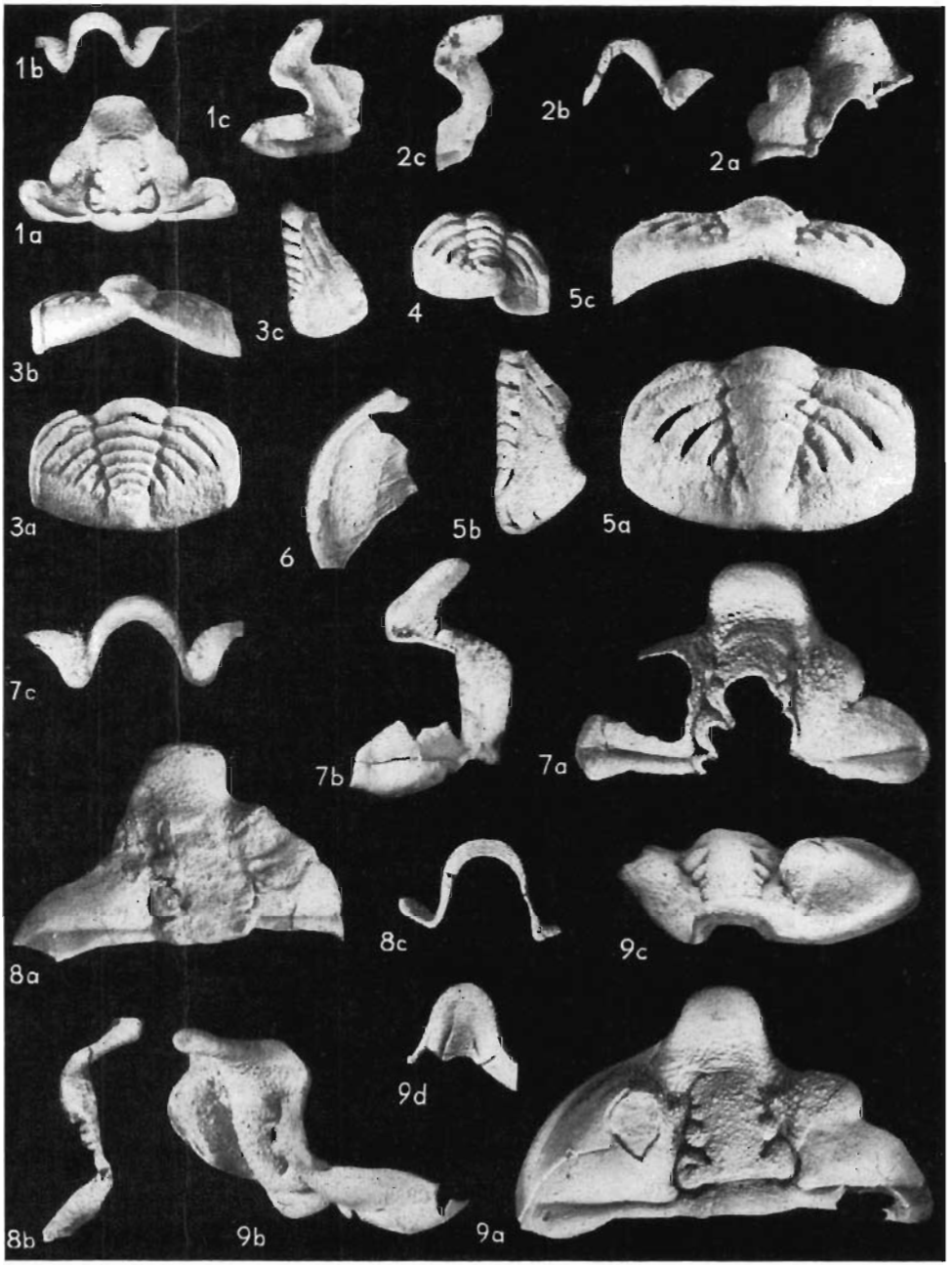
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Plate IV

Spathacalymene linguata n. sp.

Fig. 1. Small cranidium: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.16). Mielnik, 952.9 m.

Fig. 2. Incomplete cranidium: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.57) .Gołdap, 1204.8 m.

Fig. 3. Pygidium: *a* frontal view, *b* posterior view, *c* side view (IG. 1169.II.61). Gołdap, 1204.8 m.

Fig. 4. Pygidium crushed (IG. 1169.II.168). Gołdap, 1203.6 m.

Fig. 6. Negative of free cheek (IG. 1169.II.68). Gołdap, 1203.6 m.

Fig. 7. Incomplete cranidium: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.60). Gołdap, 1204.8 m.

Fig. 8. Cranidium with the shield broken: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.49). Gołdap, 1204.8 m.

Fig. 9. Cranidium well preserved, holotype: *a* frontal view, *b* side view, *c* anterior view, *d* posterior view with visible rostrum (IG. 1169.II.5). Mielnik, 959.1 m.

Spathacalymene flexuosa n. sp.

Fig. 5. Pygidium: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.22a). Mielnik, 943.3 m.

Uppermost Lower Ludlovian, Upper Mielnik Beds

All figures ×3

Plate V

Spathacalymene brevis n. sp.

Fig. 1. Free cheek (IG. 1169.II.41). Terespol, 608-614.9 m.
Fig. 2. Free cheek (IG. 1169.II.43). Terespol, 608-614.9 m.
Fig. 3. Small pygidium (IG. 1169.II.62). Gołdap, 1204.8 m.
Fig. 4. Incomplete pygidium (IG. 1169.II.46b).

Spathacalymene flexuosa n. sp.

Fig. 5. Pygidium: *a* frontal view, *b* posterior view (IG. 1169.II.26). Mielnik, 942.4 m.
Fig. 8. Free cheek (IG. 1169.II.44). Terespol, 608-614.9 m.

Spathacalymene linguata n. sp.

Fig. 6. Cephalon broken: *a* frontal view, *b* posterior view with visible rostrum (IG. 1169.II.15). Mielnik, 949.9 m.
Fig. 7. Incomplete cephalon with process strongly incurved over the glabella (IG. 1169.II.10). Mielnik, 937 m.
Fig. 9. Cranidium: a frontal view, *b* side view, *c* anterior view, *d* posterior view (IG. 1169.II.48). Gołdap, 1204.8 m.
Fig. 10. Incomplete cranidium: *a* frontal view, *b* side view, *c* posterior view, with visible rostrum (IG. 1169.II.11). Mielnik, 953.9 m.
Fig. 11. Cranidium: *a* frontal view, *b* side view (IG. 1169.II.50). Gołdap, 1204.8 m.
Fig. 12. Cranidium with process strongly incurved over the glabella: *a* frontal view, *b* side view, *c* posterior view (IG. 1169.II.20). Mielnik, 942.4 m.

Uppermost Lower Ludlovian, Upper Mielnik Beds

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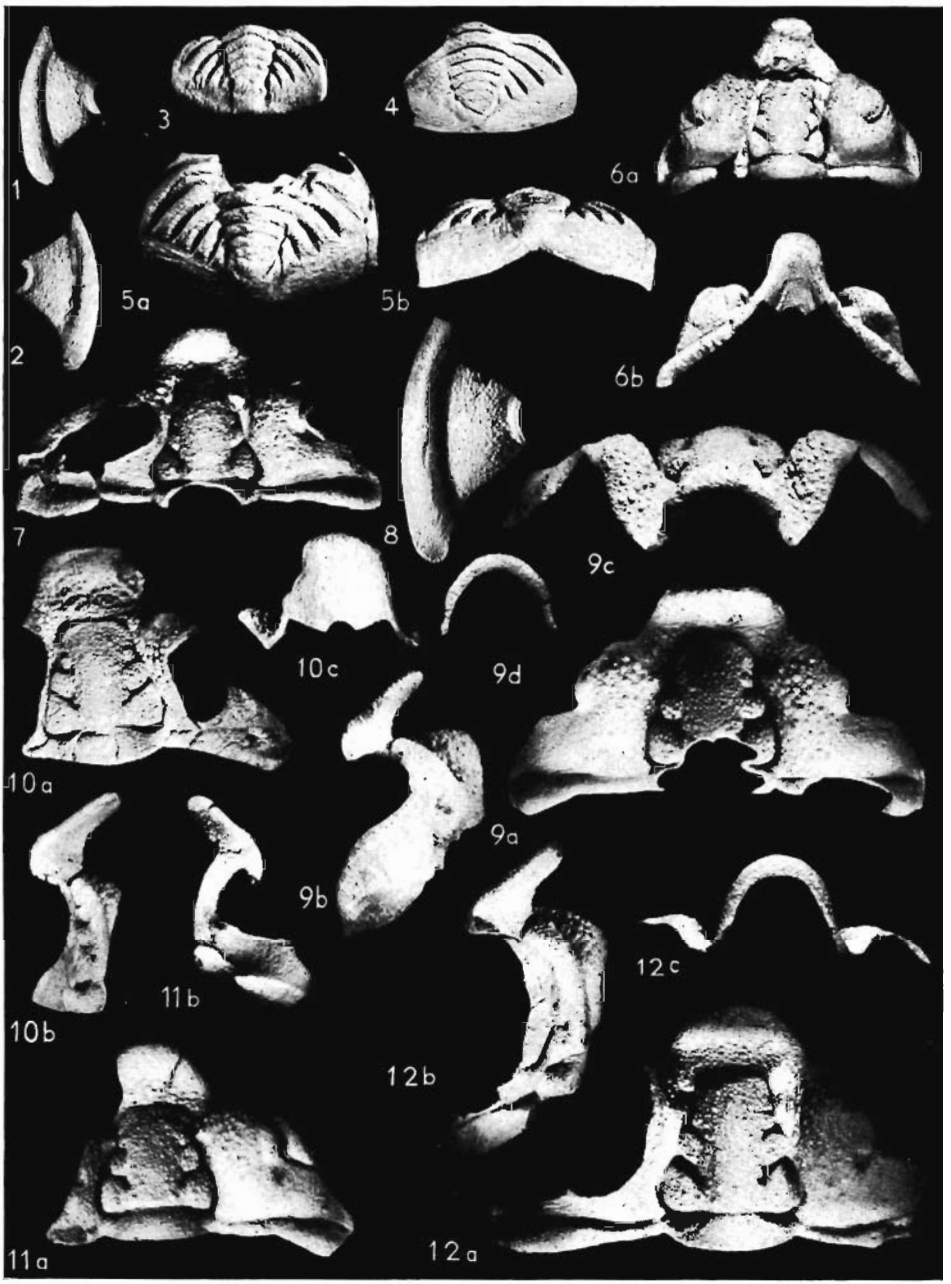
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