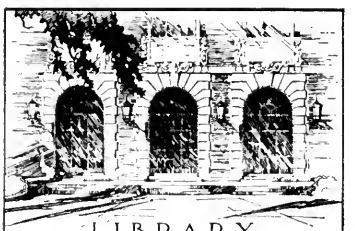


GEOLOGICAL SERIES
OF
FIELD MUSEUM OF NATURAL HISTORY

Volume VI | CHICAGO, DECEMBER 11, 1933 | Pages 67–82

A NEW DEVONIAN TRILOBITE FROM SOUTHERN ILLINOIS

BY SHARAT KUMAR ROY
ASSISTANT CURATOR OF INVERTEBRATE PALEONTOLOGY

INTRODUCTION

The trilobite here described and illustrated was collected by the late Henry Pratten in 1850 from a chert bed at the Devil's Back Bone, near Grand Tower, Jackson County, southern Illinois. In 1912, Field Museum acquired it with several other fossils and a small collection of rocks and minerals, by purchase from Mr. Pratten's daughter-in-law, Mrs. Josie Pratten of Chicago. The present writer, however, was not aware of this purchase and it was only recently, while going through the study collections of Devonian trilobites, that this remarkable specimen first came to his attention.

Henry Pratten was assistant to David Dale Owen in field work, the results of which were afterward published in 1852 as "Owen's Geological Survey of Wisconsin, Iowa and Minnesota." The library of the Museum has three volumes of Pratten's original field notes which he took while he was connected with Owen and later with James G. Norwood. Nowhere in these notes, however, could any reference to the present specimen be found.

The writer here wishes to express his appreciation to Dr. Carey Croneis of the University of Chicago for giving helpful suggestions and reading the entire manuscript, and to Dr. B. F. Howell of Princeton University and his secretary, Miss Della A. Mauer, for providing him with a complete bibliographic index of the Devonian *Dalmanites* which has greatly aided in the preparation of this paper.

The reconstructions (Figs. 3, 4*a*) were made by Mr. Carl F. Gronemann, Illustrator of Field Museum.

GENERAL REMARKS

The species here described is represented by a single, nearly complete specimen enrolled in a somewhat unusual fashion. The

manner of enrollment suggests that the carapace was subjected to a sudden extraneous force. Posterior to the tenth thoracic segment, the carapace, including the last or eleventh segment and the pygidium, has retained its original horizontal position, whereas anterior to the eleventh thoracic segment the carapace has formed a semicircular arch overlying nearly two-thirds of the ventral side of the pygidium. The remaining portion of the pygidium projects out but is completely obscured ventrally by a mass of adhering matrix, much of which also forms a mold of the greater part of the cephalon and conceals it. The pygidium is broken through the fourteenth segment, and so it is possible to pull apart the broken portion and with it the adhering cephalic mold. Thus the entire cephalon may be exposed.

It is pertinent to mention here that it is somewhat difficult to detect the line of union between thorax and pygidium in the present specimen. The reasons are: (1) The pygidium is as strongly segmented as the thorax; and (2) the enrolling has taken place anterior to the eleventh thoracic segment instead of along the line of articulation between the pygidium and the thorax. Consequently, the eleventh thoracic segment superficially appears to be more a segment of the pygidium than of the thorax.

The occipital ring and the posterior marginal borders of the cephalon, a part of the right axial and pleural segments of the thorax, and portions of the right and left pleural segments of the pygidium are not preserved in the specimen. The erect caudal spine, with the exception of its base, is also wanting.

The specific name is in honor of the late Henry Pratten, the collector of the specimen.

Horizon and locality.—Devonian. Devil's Back Bone, near Grand Tower, Jackson County, southern Illinois.

No. P 16704 Field Museum.

Holotype.

SPECIFIC DESCRIPTION

Class **Crustacea**
Subclass **Trilobita** Walch
Order **Proparia** Beecher
Family **Phacopidae** Corda
Subfamily **Dalmanitinae** Reed
Genus **Dalmanites** Barrande

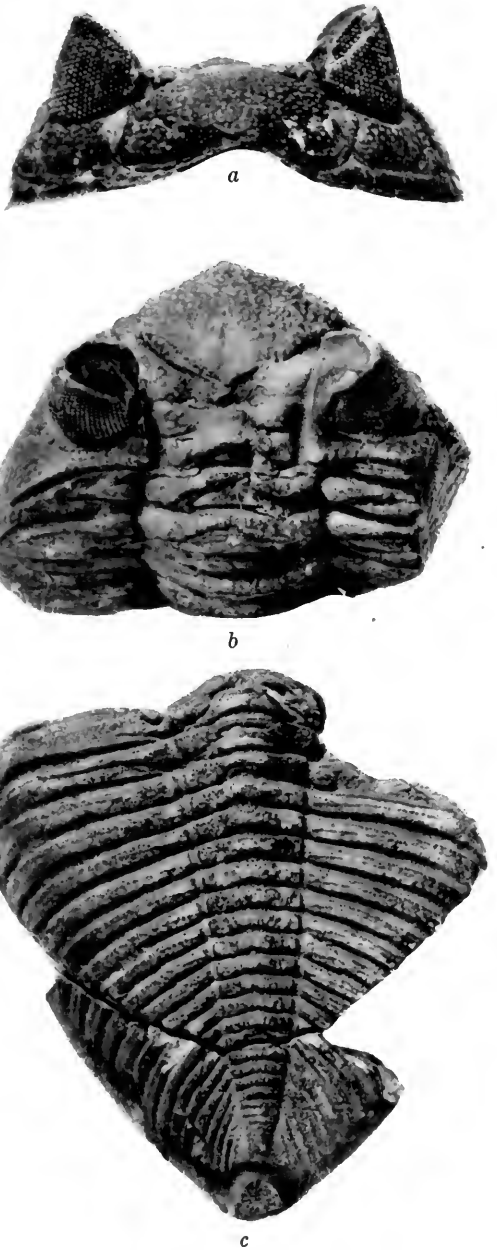


FIG. 1. *Dalmanites pratteni* Roy, sp. nov. *a*, Front view of head. *b*, Dorsal view of cephalon and portion of enrolled thorax. *c*, Pygidium, including ninth, tenth, and eleventh thoracic segments. No. P 16704 Field Museum.

Dalmanites pratteni Roy, sp. nov. Figs. 1–4.

General form and proportions.—Body subelliptical in outline, rounded or slightly produced at the extremities. Surface moderately convex, distinctly trilobate. Length to width as 2 to 1.

Cephalon more than twice as wide as long, strongly convex, subcrescentic in outline with a slight median lip-like extension in front. Surface sloping rapidly to the marginal borders.

Glabella subpentagonal, broadest near the anterior margin of the frontal lobe, width along the posterior margin one-half the maximum width, bounded laterally by moderately wide, deep, and gradually diverging dorsal furrows except at the junction of the anterior half of the first lateral glabellar lobes with the palpebral lobes where the furrows become shallow and very much elevated. Length of glabella about seven-tenths its maximum width.

Frontal lobe subrhomboidal, rounded in front but interrupted by a slight extension at the middle. Surface of the frontal lobe moderately convex and characterized by a shallow line of depression at the middle of the posterior end.

First lateral lobes subtriangular to subrhomboidal, widest and most elevated at their outer margin, sloping and gradually becoming narrower within and abruptly depressed close to the median portion of the glabella. Anterior margins of the first lateral lobes oblique outwardly and inwardly, posterior margins nearly straight in transverse direction.

Second lateral lobes similar to the first but smaller, also less elevated at their outer margins and less depressed near the median portion of the glabella. They are partially coalescent externally with the first lateral lobes as a result of the shallowing of the second lateral furrows.

Third lateral lobes subrectangular, smaller and less elevated at the outer margins than the second and wholly separated from them. They slope upward and inwardly with a slight anterior arch at the median portion which at this point is the most elevated portion of the glabella.

Occipital ring not preserved.

First lateral furrows the longest, of moderate width, deeply impressed, a little arched postero-laterally, extending obliquely inwards and backwards, not joined across the median portion of the glabella which here is very narrow and rounded, the rounding caused by the depressed inner ends of the first lateral lobes and deeply impressed second lateral furrows.

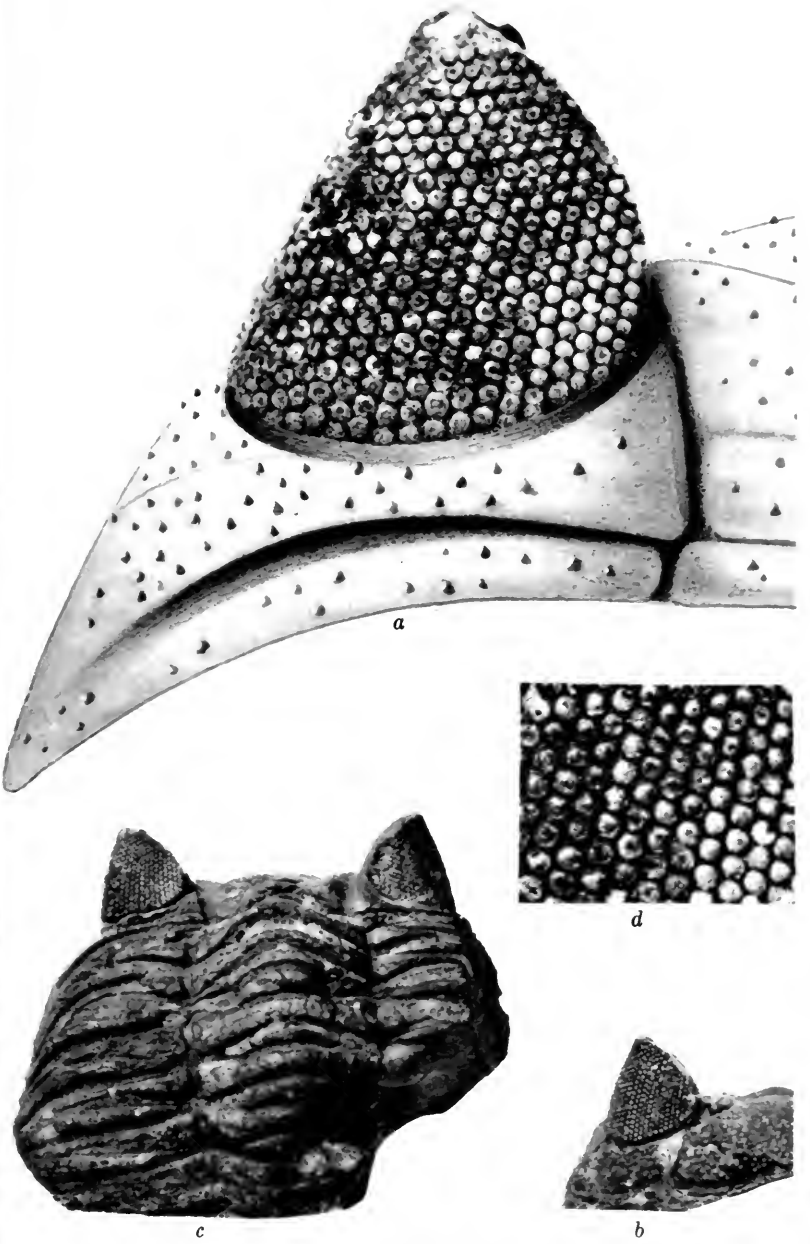


FIG. 2. *Dalmanites pratteni* Roy, sp. nov. *a*, Enlargement of left eye. Rear view. ×4. Field Museum photograph No. 78079. *b*, Right eye. Front view. *c*, Dorsal view, showing height of eye above glabella and portion of enrolled thorax. *d*, Enlargement of section of lenses. ×5. No. P 16704 Field Museum.

Second lateral furrows much less oblique than the first, joined across the glabella with deep excavation but not extended to the dorsal furrows.

Third lateral furrows transversely straight, distinctly defined but not deeply impressed. They do not join across the glabella but extend to the dorsal furrows.

Occipital furrow moderately wide, deeply incised and arched slightly forward in its median portion.

Cheeks subtriangular in outline; large and convex. Postero-lateral angles not preserved, but the indications are that they were produced slightly into short, blunt spines. Surface of cheeks dips abruptly from the deeply undercut furrows at the base of the faceted surface of the eyes to the marginal borders laterally and anteriorly, more abruptly anteriorly where the cheeks are also most prominent. The sloping of the cheeks, however, is interrupted by the cheek furrows which are moderately deep and wide. Posteriorly the cheeks are marked by a marginal furrow which arches forward at the middle and which is continuous with the occipital furrow.

Anterior limbs of the facial suture extend from the anterior extremities of the eyes and follow the antero-lateral and anterior margin of the frontal lobe where they unite.

Posterior limbs of the facial sutures directed laterally from the posterior extremities of the eyes with a slight sigmoidal flexure, terminating at the lateral marginal borders at or a little below a line through the occipital furrow.

Marginal border wide laterally, becoming suddenly narrow anteriorly and constricted at the middle of the front.

Postcephalic marginal border not preserved.

Eyes subconical, of unusual appearance, remarkably large and of extraordinary height. They are situated close to the dorsal furrows and cover a large portion of the free cheeks. Their anterior extremities are opposite the anterior extremities of the first lateral glabellar lobes and their posterior extremities opposite the middle or little below the middle of second lateral glabellar lobes. They are bounded externally around the base of the faceted surface by a deep, moderately wide, undercut furrow. Faceted surface nearly vertical at the anterior and posterior extremities, becoming more and more inclined towards the middle where the inclination is about seventy degrees. Lenses biconvex, variable in size, the majority being of the same size (.6 mm.), many with a concave border as well as with a central pit-like depression suggesting that the membrane

has collapsed there. Each lens is enclosed in a socket of its own and has a separate cornea. Interspace between lenses is free from pustules. There is a total of forty-two vertical rows of lenses on each eye, the rows consisting of ten to twenty lenses which are closely set. The exact number of lenses cannot be determined, as not all of them are preserved, nor are the areas which they occupied distinctly outlined. It is, however, certain that there are not less than 770 lenses on each eye. This is the largest number known to occur in the family of Phacopidae.

Palpebral lobes large, their lateral and anterior margins forming a parabolic curve. The lobes slope abruptly upward from the dorsal furrows and are elevated at the middle.

Thorax strongly trilobate, subquadrate in normal position, a little wider than long, consisting of eleven segments. The third thoracic segment (of which the axial ring as well as the anterior pleural bands are not preserved) appears to have been pushed over the second segment during enrollment. As a result the line of demarkation between the second and third thoracic segments cannot be readily detected.

Axial lobe strongly convex, occupying less than a third of the body. First axial ring narrower than the second, the width of the second to the fifth practically uniform, the remaining portion of the axis tapering very gradually to the pygidium. Axial rings widest along the dorsal furrow, narrowing gradually and curving upward at the middle. Articulating half rings prominent, axial furrows moderately wide and deeply incised.

Pleural lobes somewhat flattened about one-third their width from the axial furrows, then rising gradually and sloping to the lateral margins. Pleurae conspicuously grooved longitudinally, the grooves originating at the axial furrow and becoming obsolete at the distal extremity. The anterior pleural band is wide proximally, becoming rapidly narrower distally; the posterior pleural band is narrow and rounded proximally, becoming gradually wider distally.

Pygidium subtriangular in outline, wider than long, with an erect caudal spine. The caudal spine is not preserved. Its upturned base, however, clearly indicates that its position was not only at right angles or nearly so to the plane of the axis, but also that the spine was three-sided, the sides being slightly rounded.

Axial lobe convex, sharply separated from the pleural lobes by deeply incised dorsal furrows, conspicuously narrow, its greatest width one-fifth of the maximum width of the pygidium. It tapers

gently posteriorly and terminates at the edge of a furrow which cuts the postaxial region and separates the axis from the caudal spine. It is divided into twenty-three annulations which are slightly wider at the dorsal furrows than at the middle.

Pleural lobes gently arched for more than half the width from the dorsal furrows, sloping rather abruptly at the sides to the lateral margins. The lobes are divided into twenty-two grooved segments which curve backward, reaching just within the lateral margins. The segments are wider and more flattened distally than within.

It is difficult to determine satisfactorily the nature of the margin or the marginal border of the pygidium from the present state of its preservation. There are strong indications, however, that the margin is entire and the marginal border narrow, widening at the posterior extremity and bending upward to produce into a stout, erect spine. The structure of the broken caudal spine and the character of the postaxial region are such as to leave no doubt that the caudal spine is the posterior, upturned extension of the marginal border rather than a similar extension of the axis proper.

Surface ornamentation.—The entire surface of the cephalon, especially the frontal lobe, is heavily studded with rounded and subrounded tubercles of varying size. In addition to the tubercles, the frontal lobe bears on its posterior portion a short scar placed centrally, almost overlapping the median axis. The frontal lobe also bears two pairs of anterior and posterior pits or impressions symmetrically situated with reference to the median axis. The meaning of these impressions and of the median scar has not been definitely determined. They are, however, believed to be muscle impressions, although the myology of the trilobite is so imperfectly known that no definite inference can be made here now. If they are muscle impressions, the paired ones are probably points of attachment of hypostomial muscles. There is a remote possibility that the anterior pair might have been connected with the antennae, but as the antennae are generally believed to have been attached to the dorsal furrows at the sides of the hypostoma, such a possibility can hardly deserve serious consideration. The median scar is probably the place of insertion of the muscles of the heart or of the alimentary canal, if the interpretation and position of these organs as described by previous writers (E. Beyrich, 1846, p. 30; J. Barrande, 1852, p. 229; A. von Volborth, 1863, Plate I, fig. 12; C. D. Walcott, 1881, p. 200; P. E. Raymond, 1920, pp. 81, 85, 93, figs. 24, 26–27, and 29) are accepted.

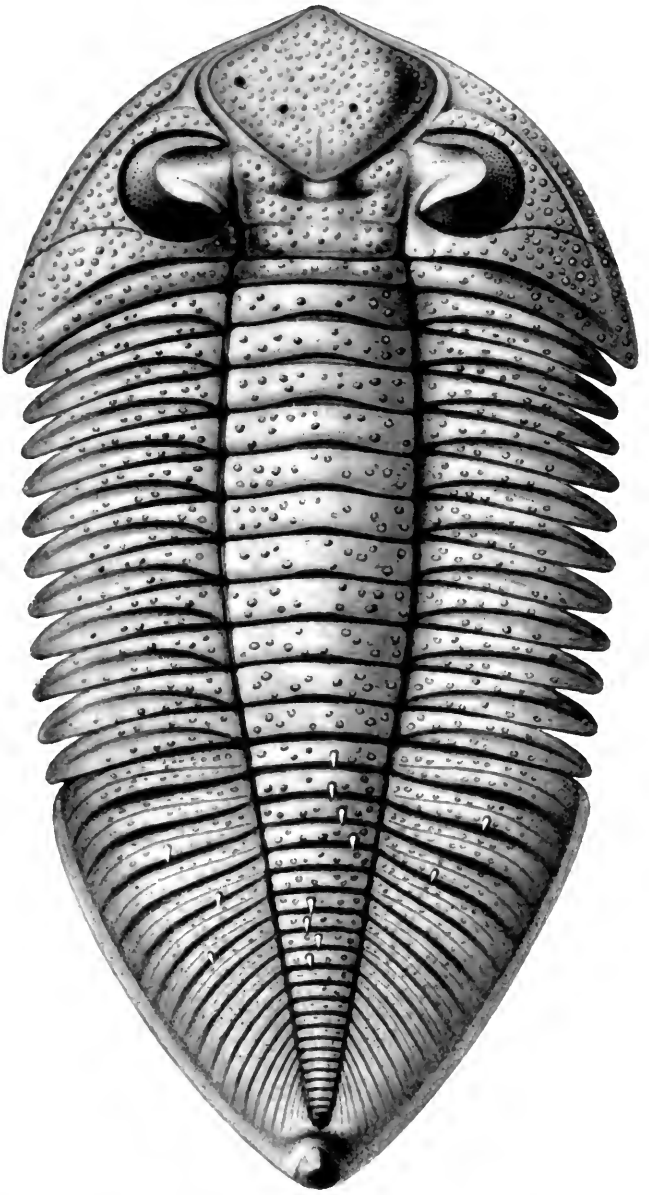


FIG. 3. *Dalmanites pratteni* Roy, sp. nov. Reconstruction drawing. Dorsal side. Field Museum photograph No. 78081. No. P 16704 Field Museum.

It may be of interest to note that another species of *Dalmanites*, namely, *D. phacoptyx* Hall and Clarke, bears on its frontal lobe a single pair of elevated blunt spinules (J. M. Clarke, 1908, p. 123, text fig.) almost exactly at the same points as the posterior pair of impressions of this species are situated. What the true significance of these spinules might have been could not be ascertained. If they were points of insertion of muscles as the similarly placed impressions of the present species were believed to be, it would seem possible that they were merely evaginated impressions.

The thorax is also tubercled. Scattered among the tubercles are a few irregularly placed spinules which are all broken, and their height, therefore, is not determinable. The tubercles on the axial lobe of the pygidium have no definite arrangement, whereas they are more or less regularly arranged in two transverse rows along the anterior and posterior bands of the pleural segments.

Caudal spine.—Mention may be made here of the erect caudal spine of this species and its probable function. It is generally accepted that the members of the Phacopidae were both crawlers and swimmers, and occasionally burrowers. *Dalmanites pratteni*, doubtless, was primarily an active swimmer, as shown by the character of its eyes and the large pygidium. It probably never was a burrower inasmuch as following such a habit it could not have developed its extraordinary eyes, nor could it have buried its head without damaging them. Furthermore, the erectness of the spine would have been a decided hindrance rather than an advantage in burrowing. Admittedly, the true significance of the spine cannot be clearly demonstrated. If it were a defensive weapon, or a balancing mechanism or even an organ to help cutting water while swimming by the undulatory movement of the pygidium, it might conceivably have been useful but certainly was not indispensable.

Dimensions.—The dimensions are of the enrolled specimen.

	mm.
Length of entire specimen	157.5
Width at fourth thoracic segment, which is best preserved	86.0
Length of cephalon excluding occipital ring	32.0
Height of eye	15.0
Length of thorax	63.0
Width of axial lobe of thorax at front	24.0
Width of axial lobe of thorax at back	20.0
Length of pygidium	60.0
Width of pygidium at front	75.0
Width of pygidium at postaxial region	18.0
Length of axial lobe of pygidium	53.0
Width of axial lobe of pygidium at front	18.0
Width of axial lobe of pygidium at posterior extremity	3.0

It is to be expected that the dimensions given on the preceding page will somewhat vary from the measurements of Fig. 3, which has been drawn to show the natural position.

Comparison with other species.—There are no described species to which the present one can be directly referred. The character of its eyes and of the caudal spine alone sharply distinguish it from all other known species of the genus. Of nearly one hundred Devonian *Dalmanites* known, only three, *Dalmanites* (Chasmops) *anchiops* (Hall), *Dalmanites* (Coronura) *aspectans* (Hall), and *Dalmanites phacoptyx* Hall and Clarke, may be conveniently mentioned here as having certain resemblances to the species of this paper. For comparative purposes the principal specific features of each is here given.

D. anchiops (Hall).

Cephalon.—Short and wide, crescentic, slightly produced on the frontal margin; frontal border crenulated. Glabella subpentagonal, first and second glabellar lobes coalescent. Facial sutures normal. Eyes lunate, somewhat elevated, with about 180 lenses. Occipital ring bearing a central spine. Surface pustulose.

Pygidium.—Subtriangular, length and maximum width about equal; axial annulations 9–14; pleural segments 8–9, faintly grooved distally. Margin entire, border narrow, posterior extremity produced into an upwardly curved spine, not elevated axially. Surface tubercled.

Horizon.—Onondaga, Schoharie, Oriskany, Upper Helderberg.

D. phacoptyx Hall and Clarke.

Cephalon.—Only imperfectly known. Border broad and uninterrupted. Frontal lobe bears a single pair of elevated blunt spinules symmetrically placed with reference to the median axis. Facial sutures depressed. Eyes elevated bearing not less than 500 lenses.

Pygidium.—Broadly triangular, length on three sides nearly equal; margin entire, border narrow. Axial annulations 13–16; pleural segments 12–14, grooved. Caudal spine bent upward,[1] elevated axially. Surface tubercled and spinose, axial tubercles irregularly arranged, pleural ones on anterior limbs only.

Horizon.—Onondaga, Oriskany, Upper Helderberg.

D. aspectans[2] (Hall).

Cephalon.—Known from detached portions only. Semielliptical, border flat. Glabellar structure unknown. Facial sutures about normal. Eyes subsemicylindrical, remarkably elevated, reaching a height of 9 mm., bearing not less than 700 lenses, each surrounded by a hexagonal frame.

[1] The nature of the caudal spine of *D. phacoptyx* is somewhat confusing. It has been variously interpreted as "long, cylindric tail spine," "stout spine, strongly bent upward," and "caudal spine quite slender, usually absent."

[2] A closely allied species is *Dalmanites* (Coronura) *myrmecophorus* (Green).

Pygidium.—Subovate-triangular, much wider than long, border fringed with spines, terminal spines separated by a distance equal to the width of the anteriormost axial annulation. Axial annulations 16–20; pleural segments 16–18, faintly grooved. Surface tubercled to smooth.

Horizon.— Onondaga, Schoharie, Upper Helderberg.

D. pratteni Roy.

Cephalon.—Short and wide, crescentic, slightly produced in front, frontal border smooth. Glabella subpentagonal, frontal lobe bearing two pairs of impressions symmetrically placed with reference to the median axis and a single median scar situated posteriorly, first and second glabellar lobes coalescent. Facial sutures normal. Eyes extraordinarily elevated, having not less than 770 lenses, each separated by a rounded interspace.

Pygidium.—Subtriangular, wider than long, margin smooth, border narrow. Axial annulations 23; pleural segments 22, grooved. Caudal spine erect, not elevated axially. Surface tubercled and sparsely spinose, axial tubercles irregularly arranged, pleural ones arranged in two transverse rows along the anterior and posterior bands.

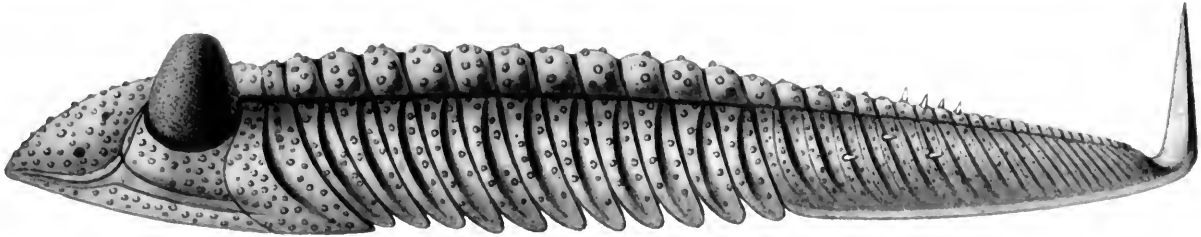
Horizon: Devonian.

It is apparent that none of the species listed above shows, as a complete individual, close relationship with *Dalmanites pratteni* Roy. However, when isolated parts of these species, either the cephalon or the pygidium (but not both together of any one species) are compared with the corresponding parts of *D. pratteni*, certain definite similarities may be readily observed. Obviously, *D. pratteni* reached its high degree of specialization, as illustrated by the structure of its glabella, eyes, and pygidium, by branching off from the main *Dalmanites* stem early in its history and by pursuing an independent and probably eccentric course. It is, however, a formidable, if not an impossible task, to trace its history back to the point where it might have branched off and to follow the developmental history of its specific characters in chronological succession. In fact, none of the species known at present can furnish the necessary data.

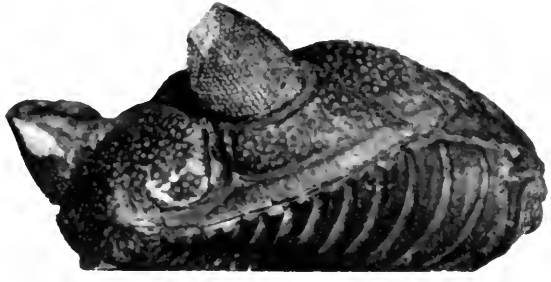
STRATIGRAPHICAL NOTES

It has been already mentioned in the Introduction that the trilobite here described was purchased in 1912. Data that accompanied it, however, did not include its stratigraphical position. Only the name of the collector, the year of collection, and the locality are available.

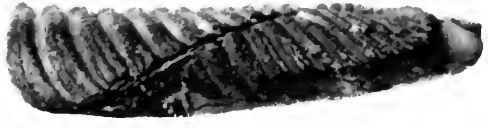
Attempts to establish the exact horizon have been made but no evidence, direct or indirect, which is at hand permits a definite conclusion. None of the other fossils included in the purchase was from the same locality, and none shows similar lithological characters,



a



b



c

FIG. 4. *Dalmanites pratteni* Roy, sp. nov. *a*, Reconstruction drawing. Lateral view, showing height of eye and erect caudal spine. Field Museum photograph No. 78080a. *b*, Lateral view, showing nature of enrollment. Posterior portion of pygidium and adhering cephalic mold removed to expose head. *c*, Lateral view of pygidium, including portion of thorax. No. P 16704 Field Museum.

nor does the matrix adhering to the fossil in question contain any other fossil as a possible clue for the determination of the horizon.

At present, all that is known of the age of the specimen is that it is Devonian, as the beds of the locality where it was found are known to be Devonian. Even if the locality were not known, one would not, judging from the structure of the cephalon and the large number of axial rings of the pygidium, long hesitate to refer it to the Devonian. It should be mentioned, however, that structural specialization in the members of *Dalmanites* has not gone on in chronological succession, and it is not always possible to determine the stratigraphic position of a *Dalmanites* on the basis of the degree of its structural development. Certain Silurian species of *Dalmanites* show evident signs of greater advance in development than some of the Devonian ones. The same irregular developmental relationship is also found among certain species of Ordovician and Silurian *Dalmanites*.

The Devil's Back Bone, near Grand Tower, Jackson County, southern Illinois, where the specimen was found, is a narrow ridge, about one hundred feet high and one-half mile long. Its detailed stratigraphy is not known, although this locality has been long recognized (Norwood and Pratten, 1855, pp. 23–32; James Hall, 1867; Stuart Weller, 1897, pp. 625–635) as a favorable collecting ground for Devonian fossils. Weller (1897, pp. 626–635) gives the results of his faunal studies of a section about 167 feet thick of the Devil's Bake Oven which he considers to be really the northern end of the Devil's Back Bone although isolated from it by an interval of several hundred feet. He finds the faunas of the lowest beds correspond to the Upper Helderberg series and those of the uppermost beds to the Hamilton. He also sets forth conclusively the fact that the Devonian faunas of southern Illinois are a western extension of the faunas of the eastern interior province, namely, the faunas of New York.

The Devonian geology of the Alto Pass quadrangle (Charles F. Basset, 1925, pp. 360–368), which includes the Devil's Back Bone area, is better known and may be considered as typical of the Devonian of southern Illinois. Comparative generalized sections of the Devonian of southern Illinois and New York are given on page 81.

It will be seen from the section that the rocks composing the Devonian formations of southern Illinois are limestone, chert, shale, and sandstone. Chert is very abundant. Grassy Knob chert is believed to be 225 feet thick. In addition to the chert formations

referred to in the section, numerous interbeds of cherts occur in practically all other formations. The reason for emphasizing the occurrence of chert formations and interbeds of chert in the Devonian sequence is to make more evident the difficulty of determining the particular chert bed from which the specimen under discussion might have been collected. Doubtless it would be interesting to know the exact horizon. *Dalmanites pratteni* is a highly specialized form, probably the most highly specialized form known, and it would be significant to know if the culmination of specialization took place earlier in its history or just before the genus became extinct.

COMPARATIVE SECTIONS OF DEVONIAN FORMATIONS

Period		New York		Southern Illinois
		Series	Formation	Formation
Devonian	Upper	Chautauquan	Chattanooga shale	Mountain Glen shale
		Senecan	Portage	Alto formation
	Middle	Erian	Hamilton	Lingle shale
		Ulsterian	Onondaga	Grand Tower limestone Dutch Creek sandstone Clear Creek chert
		Oriskanian	Oriskany	Backbone limestone Grassy Knob chert
	Lower	Helderbergian	New Scotland	Bailey limestone

PHYSICAL CHARACTERS AND CHEMICAL COMPOSITION[1] OF THE CHERT MATRIX ADHERING TO *DALMANITES PRATTENI* ROY

Chert may often vary in physical characters and chemical composition, and, occasionally, stratigraphical correlation is possible on the basis of lithological similarities. For this reason, the physical characters and chemical composition of the matrix of the present specimen are here given as these data may be useful in the future

[1] Analysis by H. W. Nichols and Sharat K. Roy.

as corroborative evidence in determining the horizon not known at present.

PHYSICAL CHARACTERS			CHEMICAL COMPOSITION		
Color	Texture	Hardness	SiO_2	Al_2O_3, Fe_2O_3	Minor components not determined
Exposed surface reddish yellow; white when freshly chipped	Fine grained	Very hard	97.23	2.32	.45

BIBLIOGRAPHY

BARRANDE, J.
1852. Systême silurien du centre de la Bohême, **1**.

BASSETT, C. F.
1925. Trans. Ill. State Acad. Sci., Ann. Rept., **18**.

BEYRICH, E.
1846. Untersuchungen ueber Trilobiten, **2**.

CLARKE, J. M.
1908. N. Y. State Mus., Mem. 9, pp. 120–134.

HALL, J.
1859. Nat. Hist. N. Y., Pal., **3**, pp. 359–364.
1862. N. Y. State Cab. Nat. Hist., 15th Ann. Rept., pp. 83–92.
1867. Nat. Hist. N. Y., Pal., **4**.
1876. N. Y. State Geol. Surv., Adv. Ill. Dev. Fossils, Crustacea.

HALL, J. and CLARKE, J. M.
1888. Nat. Hist. N. Y., Pal., **7**, pp. 28–68.

LINDSTROEM, G.
1901. Researches on the Visual Organs of the Trilobites. K. svenska Vet.= Akad. Handl., New Ser., **34**, pp. 1–86, Plates 1–6.

MEEK, F. B. and WORTHEN, A. H.
1858. Geol. Surv. Ill., Chap. 4.

NORWOOD, J. G. and PRATTEN, H.
1855. Jour. Acad. Nat. Sci. Phila., Ser. 2, **3**, pp. 23–32.

RAYMOND, P. E.
1920. The Appendages, Anatomy, and Relationships of Trilobites. Mem. Conn. Acad. Arts and Sciences, **7**.

REED, F. R. C.
1905. The Classification of the Phacopidae. Geol. Mag., New Ser., Dec. V, **2**, No. 4, pp. 172–178, 224–228.

VOLBORTH, A. VON
1863. Ueber die mit glatten Rumpfgliedern versehenen russischen Trilobiten, nebst einem Anhange ueber die Bewegungsorgane und ueber das Herz derselben. Mem. Acad. Imp. Sci. St. Petersburg, Ser. 7, **6**, No. 2.

WALCOTT, C. D.
1881. The Trilobite: New and Old Evidence Relating to Its Organization. Bull. Mus. Comp. Zool., **8**.

WELLER, S.
1897. Correlation of the Devonian Faunas in Southern Illinois. Jour. Geol., **5**.