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J. A. Jeletzky

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BY

P. Harker and D. J. McLaren

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PREFACE

The first of the two papers comprising this Bulletin describes two new varieties of the belemnoid genus *Actinocamax* from Manitoba, and presents a critical review of the genus in the light of the author's European experience. The relationships of the Manitoba varieties to their European equivalents are discussed. Belemnoids in the past have received little attention from Canadian palæontologists, and the present paper is useful in demonstrating the value of *Actinocamax* species as guide fossils. The paper clarifies the terminology, and draws attention to the principal diagnostic features of the genus and species and their varieties.

The second paper describes a new genus of a rugose coral collected in 1912 but not previously studied. Its affinities with other genera are critically discussed.

GEORGE HANSON,
Chief Geologist, Geological Survey of Canada

OTTAWA, July 15, 1949

ACTINOCAMAX FROM THE UPPER CRETACEOUS OF MANITOBA

By J. A. Jeletzky

INTRODUCTION AND ACKNOWLEDGMENTS

Whiteaves (1889) was apparently the first to describe belemnoid remains from the Upper Cretaceous beds of the Canadian Interior Plains. He referred belemnoid remains found in the Assiniboine member of the Favel formation of Manitoba to the genus *Belemnitella* d'Orbigny, 1842[1], and to a new species *Belemnitella manitobensis*.

Since then all Upper Cretaceous belemnoid remains found in this or adjacent parts of the Interior Plains have been referred to this species. Because all belemnoids so far known from this region were said to be strictly confined to the Assiniboine member (Kirk, 1930, p. 121; Wickenden, 1945, p. 32)[2] their persistent reference to a single species was not at all unreasonable.

The original figures and description of *Belemnitella manitobensis* (Whiteaves, 1889, pp. 189-190, Pl. 26, figs. 3a-b) are poor, and the writer was always doubtful of the generic nature of this form, particularly because of its occurrence in an Upper Cretaceous formation equivalent to the Turonian or Coniacian of Europe. Up to the present, no representative of the genus *Belemnitella* d'Orbigny, 1842, emend. Jeletzky, 1941, nor any other *Belemnitella*-like form has been found below the base of the later Santonian stage or its equivalents. Such a discovery would be most unlikely because the most primitive *Belemnitella* forms make their first appearance in the lowermost Santonian and merge gradually into typical *Actinocamax* species of the Upper Coniacian. The same applies to the other *Belemnitella*-like branches of the family Belemnitellidae Pavlow, 1913; for instance, the first representative of the genus *Gonioteuthis* Bayle, 1878—*Gonioteuthis westphalica-granulata* (Stolley, 1897)— arises out of *Actinocamax westphalicus* Schlüter at about the same time as Belemnitella. The first *Belemnitella*-like representative of the genus *Belemnella* (Nowak, 1913, subgenus) Jeletzky, 1941, appears much later in the basal Maestrichtian stage.

Recently the writer was able to undertake a thorough revision of almost all available belemnoid material from the Upper Cretaceous of the Canadian Interior Plains. It includes the collections of the Geological Survey of Canada and those of the institutions and individuals mentioned below.

[1] It should be mentioned that Whiteaves (1889) used the conception of d'Orbigny according to which practically all Upper Cretaceous belemnites were referred to the genus *Belemnitella* d'Orbigny, 1842, *sensu lato*. Many authors (e.g., Sharpe, 1853-57; Meek and Hayden, 1876) regarded this conception as valid at the time. The restriction of the genus *Belemnitella* d'Orbigny, proposed by Schlüter (1876), and his reinstatement of the genus *Actinocamax* Miller, 1826, were not yet in common use. Whiteaves' identification was, therefore, quite sound at the time.

[2] Names, dates, etc., are those of references listed at end of this report.

This revision showed that in actual fact none of the studied belemnoid guards belongs to the genus *Belemnitella* d'Orbigny, 1842, emend. Jeletzky, 1941, nor to any other *Belemnitella*-like form. They belong to the genus *Actinocamax* Miller, 1826, *sensu stricto,* and are very closely related to European species of *Actinocamax* from Cenomanian, Turonian, and lower Coniacian beds. Accordingly, these Canadian belemnoids are regarded as the first recorded representatives of this, so far strictly Eurasian, genus on the North American continent. This paper is devoted to the description of these forms of *Actinocamax* and to some taxonomic, stratigraphic, and palæogeographic conclusions that follow from their unexpectedly close relations to Eurasian species.

The writer gratefully acknowledges the loan of material from Mr. Norris-Elye, Director of the Manitoba Museum, Mr. A. G. Lawrence, Public Health Department, Winnipeg, Mr. E. T. Leith, University of Manitoba, Mr. P. H. Stokes and Mr. E. Helyar of Winnipeg, and Professor P. S. Warren, University of Alberta.

PALÆONTOLOGICAL DESCRIPTION

Family, *Belemnitellidae* Pavlow, 1913

Diagnosis. Belemnoids with a deep, conical alveolus, embracing the phragmacone for its entire length without interspace. In some instances the alveolar part of the guard, wholly or in part, was composed apparently of some unstable, presumably organic, substance that was invariably destroyed during fossilization. This commonly gave rise to differentially developed, sculptured 'pseudoalveolus' or protruding 'actinocamaxoid', alveolar ends. A true alveolar fissure with 'ostracumlamelles' is present, and in some species is accompanied by ventral furrows and 'splitting surfaces'. Double dorso-lateral and single lateral furrows are present on both sides of the guard. Dorso-lateral, double furrows are in their upper part embedded in broad dorso-lateral, longitudinal depressions. The surface of the guard is covered by a more or less prominent net of ramifying vascular impressions, fine or coarse granulation, or longitudinal striæ. All three forms of ornamentation may occur together. The only known sculpture on the phragmacone consists of longitudinal striæ and a prominent dorsal keel, which has a counterpart in a dorsal furrow on the inner surface of the alveolus.

Stratigraphic Distribution. Upper Cretaceous series, from Middle Cenomanian to Upper Maestrichtian inclusive.

Geographic Distribution. Boreal province of Northern Eurasia from Siberia to England (very common), Greenland, Canada, and United States. A few representatives, for example, *Gonioteuthis quadrata* (Blainville) and *Belemnitella mucronata* (Schlotheim), have been collected in a few localities in the Mediterranean province of Eurasia (Transcaucasus, Turkey, Bulgaria, Provence). In Australia, New Zealand, South America, Antarctic, Africa, Japan, and Indonesia the family is so far unknown, and supposedly its place is taken by representatives of the family Dmitobelidae Whitehouse (1924).

Genus, ACTINOCAMAX Miller, 1826, *sensu stricto*

Genotype, *Actinocamax verus* Miller, 1826

Diagnosis. Belemnitelloid genus without, or nearly without, a preserved alveolar cavity and ventral fissure; ventral alveolar furrow and the bottom of ventral fissure or 'splitting surface' commonly present; alveolar end of the guard more or less protruding, bearing a small hole of the embryonic bulb at its centre, or excavated, showing a very shallow pseudoalveolus not exceeding one-ninth to one-eighth of the total length of the guard; protruding alveolar end or pseudoalveolus always displays specific "actinocamaxoid" concentric lamellar structure and radial ridges; ramose vascular impressions, granulation, or longitudinal striæ commonly present, but mostly feebly developed.

Stratigraphic Distribution. Middle Cenomanian-Lower Campanian.

Geographic Distribution. As for the family (*See* page 2).

Remarks. The genus *Actinocamax* was described by Miller (1826) on the basis of a single species from the Margate Chalk of England. It was frequently confused with different Lower Cretaceous and Jurassic species without alveolar cavity, or denied recognition altogether by later authors (d'Orbigny, 1842; Phillips, 1856; Quenstedt, 1849; Saemann, 1861-62; and others). But the genus was accepted, although thoroughly revised, by Schlüter (1876). He included in it all Upper Cretaceous belemnoid forms with a calcified guard separated from the usual conical phragmacone by a more or less pronounced interspace. Following Saemann (1861-62), Schlüter (1876) presumed that this space was originally filled with an unstable cartilaginous substance, which was invariably destroyed during fossilization. At the same time he restricted the genus *Belemnitella* d'Orbigny to Upper Cretaceous belemnoid forms not showing any interspace between the phragmacone and the calcified guard. This conception of the genera *Actinocamax* and *Belemnitella* was almost universally accepted (for example by Moberg, 1885; Stolley, 1897; Crick, 1904; Arkhangelsky, 1912; Naef, 1922, etc.). The writer (1941, 1946) does not agree in so far as *Actinocamax* is concerned, and considers the original conception of this genus by Miller (1826) to be more nearly correct. The diagnosis given above represents his conception of the genus *Actinocamax* Miller *sensu stricto*. The belemnitelloid forms with relatively deep, preserved alveolar cavity and ventral fissure, but nevertheless possessing an interspace between the phragmacone and the calcified edge of the guard, and some other particular characters (*Belemnites* of the *quadratus* group of Blainville (1827); *Belemnites* of the *mammillatus* group of Nilsson (1817)) should, in the writer's opinion, be generically separated from *Actinocamax, Belemnitella*, and *Belemnella*. The name *Gonioteuthis* Bayle, 1878, is employed by the writer for *Belemnites quadratus* (Blainville) and related forms. A new subgeneric or even a generic name should probably be given to the group of *Belemnites mammillatus* Nilsson, although not advisable now due to very inadequate knowledge of morphology and phylogeny of this belemnitelloid group.

It should be mentioned that most representatives of the genus *Actinocamax* Miller, as restricted above, are very generalized forms. All Cenomanian and most Turonian and Coniacian forms are of this kind. They are not only generalized but also extremely variable in nearly all their morphological characters. This applies not only to the form of the guard, but even to the more important characters such as the ventral groove or structure of the alveolar end of the guard. This circumstance makes it very difficult to distinguish between different species of the group, but at the same time it gives considerable support to the opinion of the writer (1946, 1948a) that all the younger branches of Belemnitellidae, however different morphologically, have probably evolved monophyletically from these generalized Cenomanian-Turonian *Actinocamax*. The same origin applies to the more specialized *Actinocamax* of Upper Turonian, Coniacian, and Santonian (granulated stock of *A. verus* Miller, 1826, and relatives). Transitional forms between the generalized *Actinocamax* and this branch are already known from the Upper Turonian of Czechoslovakia, Saxonia, and Westphalia. It is unfortunate, however, that the genotype of *Actinocamax* (*A. verus* Miller) was chosen from this granulated stock and not from the older, more generalized, and typical forms. Nevertheless, the writer does not think there is any necessity for subgeneric distinctions within the genus *Actinocamax* Miller as above understood, as these granulated forms are very close to the non-granulated in all other morphological features.

Actinocamax manitobensis (Whiteaves, 1889)

Figure 1; Plate I, figures 1-5; Plate II, figure 4

Diagnosis. Guard generally subcylindrical, long, but reasonably stout, and tapers rapidly to a point in the apical quarter of its length; ventral surface flattened except in the laterally compressed alveolar region where a short, feeble, ventral furrow is developed; well-preserved surface bears weak longitudinal striæ; alveolar end mostly depressed, with shallow pseudoalveolus, 4-7 mm. in depth.

Type Specimen. A lectotype is, herewith, chosen (Pl. I, fig. 2) from Whiteaves' (1889, pp. 189) six cotypes. It is reported to have been collected by D. Armit in 1876 on the east bank of Assiniboine River, a short distance below the mouth of Little Souris River, Manitoba, and is preserved in the collection of the Geological Survey of Canada, No. 5066.

The other specimens of Whiteaves' cotypes are rejected, as only the specimen selected is sufficiently well preserved to allow a positive specific or even generic determination. Of the remaining five cotypes, one is missing and four are mere apical fragments without the whole of the alveolar part of the guard. Their rejection, particularly of the one figured by Whiteaves (1889, Pl. 26, figs. 3a-b), which should normally be chosen as the lectotype, is quite justified in these circumstances, and does not transgress the Rules of Zoological Nomenclature. It is quite apparent that it would be inadvisable to choose as lectotype a fragment that cannot be positively determined specifically or even generically in accordance with any classification of Belemnitellidae now in use. The specimen figured by Whiteaves and two of the indeterminate fragments are, consequently, here referred to *Actinocamax*? sp. indet. The fourth, more complete, fragment is tentatively referred to *Actinocamax* sp. aff. *strelensis* Fritsch and Schloenbach on account of the peculiar form of the guard.

Description. Guard long, subcylindrical or somewhat lanceolate, fairly stout; ventrally, its form varies from subcylindrical to somewhat lanceolate; laterally, it varies from subcylindrical to other forms that taper gently and evenly from the edge of the alveolus. From both aspects, at three-fourths of the length from the alveolar edge, the guard begins to taper rapidly, but evenly, to a point. The apex is acute, and only slightly mucronate. From the alveolar edge, for a quarter of its length, the guard is markedly compressed laterally; farther down, a dorso-ventral compres-

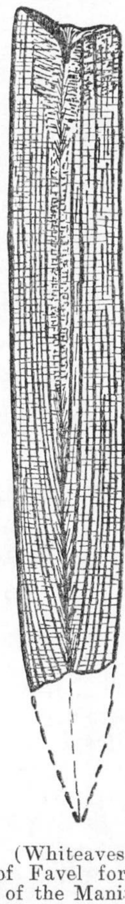

Figure 1. *Actinocamax manitobensis* (Whiteaves); Assiniboine River near Treherne, Manitoba; Assiniboine member of Favel formation; collected by Charles Pearce, Treherne, Manitoba; in collection of the Manitoba Museum, Winnipeg, No. 115. The drawing shows a specimen transitional from *A. manitobensis* (Whiteaves) typical form to var. *lawrencii* nov. var., and was drawn from the specimen figured in Pl. I, fig. 3b.

sion prevails, and the ventral side of the guard is more or less flattened nearly to the apex. The dorsal surface protrudes in its alveolar third between converging dorso-lateral depressions; its apical two-thirds is more rounded, and does not show marked edging or flattening. Both sides of the guard show distinct and typical double dorso-lateral and single lateral grooves. In the alveolar third, double dorso-lateral grooves become very indistinct and are situated at the bottom of broad dorso-lateral depressions. Quite feeble longitudinal markings and striæ are sometimes visible on the generally smooth surface of the guard. The dimensions of the species are as a rule somewhat greater than those of any other of the genus *Actinocamax* as above restricted, except in the group of *Actinocamax mammillatus* (Nilsson). As may be seen from the above description and from the illustrations (Pl. I, figs. 1-5) the form of the guard is very variable even within the limited number of specimens studied. Only the ventral flattening and the lateral compression of the alveolar quarter of the guard seem to be more or less constant features.

The truncated alveolar end is ovate in cross-section, its dorso-ventral diameter exceeding the lateral (14 and 10·5 mm. respectively in the lectotype). This end is more or less depressed, forming a shallow pseudoalveolus, 4-7 mm. in depth, and never protrudes. The depressed surface shows the edges of the concentric layers composing the guard, displaying a lamellar and radial pattern and radial ridges typical of *Actinocamax*. In the lectotype and in a few other guards (Pl. I, figs. 1c, 2c, 4c; Pl. II, fig. 4) the truncated surface is only slightly depressed except for its middle part around the embryonic bulb. There a small, irregularly rounded hollow, with steep, conical sides and 3-6 mm. deep, occurs, and has a similar pattern in its walls, the embryonic bulb lying at the bottom. The presence of the embryonic bulb at the apex of this hollow shows that the pseudoalveolus persists only into its upper part. In other specimens, however (Pl. I, figs. 3c, 5c), the walls of the pseudoalveolus extend more steeply to the embryonic bulb in its centre, without forming any pronounced edge between the outer and inner part of the pseudoalveolus. In such specimens the relative depth of the pseudoalveolus also is increased. These variations in the character of the pseudoalveolus intergrade with some regularity. The variants with the sharp edge inside the pseudoalveolus, by decrease in size and depth of the above mentioned steep conical hollow, and by flattening or even slight protrudence of the outer depressed zone, grade into forms that have a distinctly protruding alveolar end and only a small hole on top. These are described below as *Actinocamax manitobensis* (Whiteaves) var. *trehernensis* nov. var. The forms without an edge intergrade into the above described sharply edged form, which the writer assumes to be typical of *Actinocamax manitobensis*. They are also connected by intermediate forms with one possessing a much deeper and rounded pseudoalveolus, which is described below under the name *Actinocamax manitobensis* (Whiteaves) var. *lawrencii* nov. var. (Pl. II, figs. 1, 2). This last mentioned form has no sign of an inner edge in the pseudoalveolus, which deepens more or less uniformly and steeply from the margins to the embryonic bulb, and the pseudoalveolus is also relatively deeper than that in the slightly edged variant of *A. manitobensis* (Whiteaves). This intergradation of characters of the pseudoalveolus suggests the close affinity of all above mentioned belemnoid forms that seem to form a morphological series.

Owing to the above circumstances, the writer has not given specific rank to the forms described below as *A. manitobensis* var. *trehernensis* and A. *manitobensis* var. *lawrencii,* despite their pronounced morphological differences from one another and from the intermediate typical *Actinocamax manitobensis.* It is indeed possible that all these forms, however different morphologically, may be nothing more than extreme variants of the same specific type, and present an example of the plasticity of *Actinocamax* species to which reference has already been made. One may say, however, that such a wide range of variation in such morphologically important and normally stable characters as the form and depth of pseudoalveolus would hardly be expected, and certainly it is not present in any other belemnitelloid group, or at least as far as the genera *Belemnitella, Belemnella,* and *Gonioteuthis* are concerned. Yet the *Actinocamax* forms of the Cenomanian, Turonian, and even Santonian stages are so generalized and labile in all their known morphological characters that such a possibility cannot be denied. It is enough to point out that the difference in the structure of the alveolar end of the guard of *A. plenus* (Blainville) as figured by Sharpe (1853-57, Pl. I, figs. 12, 14, 15), and confirmed by the writer for his own material, are only slightly less than those described above. The same applies to *Actinocamax verus* Miller as figured by Stolley (1897, Pl. IV, figs. 2-5) or Moberg (1885, Pl. IV, figs. 15-26).

It is not certain whether the variations of *Actinocamax manitobensis* are phylogenetical, leading successively from *A. manitobensis* var. *trehernensis* through the typical form of *A. manitobensis* to the slightly edged variant and to *A. manitobensis* var. *lawrencii,* from horizon to horizon within the Assiniboine member, or whether all these forms are mere contemporary variants of this species occurring together in the same succession of beds. According to our present knowledge of the mode of evolution of the alveolar end of the guard in the different branches of Belemnitellidae, the first seems to be the more likely possibility. In several branches of Eurasian Belemnitellidae (Jeletzky, 1948a, pp. 230-231), the depth and the form of the pseudoalveolus remain fairly constant at the same horizon, but change steadily in the same direction in an ascending succession of beds, trending nearly invariably towards the completely calcified alveolus of *Belemnitella* type. Instances of broad variation of the pseudoalveolus within a single species from a narrow zone are much less numerous. It is to be hoped that careful stratigraphic collecting of belemnoids from the Favel formation will permit a positive solution to this interesting problem.

The ventral side of the pseudoalveolus bears a more or less deeply incised furrow (Pl. I, figs. 1a, 2a, 5a), which, apparently, represents the lowermost part of the ventral fissure or 'splitting surface' (or possibly both). These characters should, accordingly, be represented on the unstable, noncalcified alveolar part of the guard (Jeletzky, 1946, pp. 100-101, text fig. 3a). Apparently this furrow was subsequently deepened and broadened by weathering along the line of weakness, but it is impossible to estimate the amount of secondarily imposed destruction, and thus to restore the original outline of the bottom of the fissure or the 'splitting surface' and to prove its true nature. This furrow cuts the wall of the central steep part of the pseudoalveolus, and seemingly ends very close to the embryonic bulb. On the other hand, it extends as a feeble, short furrow to the ventral side of the guard just below the edge of the pseudoalveolus. In some specimens this last furrow, which in the material studied never exceeds 4 or 5 mm., is also apparently secondarily incised by weathering and decay of the substance of the guard around the primarily slightly imposed furrow. A comparison of both furrows with those of well-preserved specimens of other

Actinocamax species leaves no doubt that their present character was essentially shaped by weathering-out of original very narrow and shallow furrows.

The character of the ontogenetic development is as yet only imperfectly known, as it could only be studied in two specimens split longitudinally (Fig. 1; Pl. II, fig. 2c). Few changes are apparent during the growth of the guard, except for the relatively greater slenderness and length of the young stages, which are less than half or two-thirds of the adult guard. This may, however, suggest that *A. manitobensis* evolved from more elongated and slender ancestral forms, which in their adult stage were similar to *Actinocamax* sp. aff. *strelensis* (Fritsch and Schloenbach, 1872) emend. Stolley, 1916. Unfortunately, it was impossible to observe the very young stages of the guards due to their obliteration by weathering and recrystallization. Accordingly, as no more guards could be studied ontogentically and no polished plates prepared, no positive conclusions about the phylogeny of *A. manitobensis* are yet possible. Moreover, in the present state of our knowledge, it is not always safe to infer recapitulation of ancestral adult characters in the ontogeny of descendants unless the stratigraphic succession of the forms concerned is established beyond reasonable doubt. The numerous classical examples of "prophetic phases" discovered in the ontogeny of Jurassic amnonoids may be mentioned as a warning against unreserved use of the general "phylogenetic law" in palæontology.

Material and Localities. The above chosen lectotype of *Actinocamax manitobensis* (Whiteaves) is said to have been collected from beds of "Niobrara-Benton" age, but the formation is not indicated. According to the most recent report and map (Wickenden, 1945), only Riding Mountain and Vermilion River formations might occur in and around the locality where the lectotype is reported to have been found. The Assiniboine member of the Favel formation, from which, apparently, all other belemnoids of Manitoba and Saskatchewan were derived, has no known exposures near this locality, its nearest known outcrop lying more than 30 miles to the east. According to Wickenden (personal communication), the region in the vicinity of the fossil locality is drift covered, and any outcrops of Upper Cretaceous beds are highly improbable. It seems quite probable, therefore, that this guard of *A. manitobensis* was collected from the drift, and not from any particular Upper Cretaceous formation in situ. A younger age than that of all other belemnoid remains hitherto discovered in the Upper Cretaceous of the Canadian Interior can scarcely be assumed. Such assumption would be particularly doubtful because all other specimens of *A. manitobensis* studied by the writer were quite evidently collected from the Assiniboine member of the Favel formation, and are apparently contemporary with other belemnoid forms described later in this report.

In addition to the lectotype of the species, the writer has been able to study seven complete guards and several fragments referable to typical *A. manitobensis*. All these were collected in the vicinity of Treherne, Manitoba, on the banks of Assiniboine River, and all may be assumed to have been derived from the Assiniboine member of the Favel formation. Two guards were collected by B. Mayhew, Treherne, and are preserved in the Manitoba Museum, Winnipeg, Nos. 115-116. Another two were collected by E. Leith and H. Rand from the shales of the Assiniboine member near the site of the discovery of a plesiosaur, described by Russell (1935): they are preserved in the private collection of E. Leith at the University of Manitoba, Nos. L 1/1 and L 2/1. One specimen, transitional to var. *lawrencii* nov. var., was collected by A. C. Lawrence, Winnipeg, together with the holotype of this variant. The sixth specimen is without locality or registered number, and is in the collections of the Geological Survey of Canada. One more specimen transitional to var. *lawrencii* nov. var. was collected on the south bank of Assiniboine River 8 miles northwest of Treherne, Manitoba, by P. H. Stokes, Winnipeg, from grey shale of Assiniboine age, and is preserved in his private collection.

Of these seven specimens, only two agree fairly well with the lectotype of the species; two others are clearly intermediate between the typical form and var. *trehernensis* nov. var.; two are intermediate between the typical form and var. *lawrencii* nov. var.; and the last one (Pl. I, fig. 5) shows such considerable differences from the type specimen that it is referred to the typical form with certain reservations. It may almost as well be referred to the var. *lawrencii*.

Stratigraphic Horizon. Together with all other belemnoids of the Canadian Interior Plains, typical *A. manitobensis* occurs, apparently, exclusively in the Assiniboine member of the Favel formation.

Affinities and Differences. Typical *A. manitobensis* and *A. manitobensis* var. *lawrencii* can be readily differentiated from all other Canadian *Actinocamax* according to such peculiar progressive features as the presence of a more or less shallow depressed pseudoalveolus and the feebler development of a ventral alveolar furrow (Jeletzky, 1946, pp. 100-101). Also their stouter, and often more or less lanceolate, guard may be helpful in identification. It is not so easy to distinguish var. *trehernensis*, which always has a more or less protruding alveolar end of the guard like *Actinocamax* sp. aff. *strelensis* and *A.* sp. aff. *plenus* described below. Yet this variant can be safely distinguished from both these forms by means of its feebler and shorter alveolar ventral furrow, stouter and bigger guard, and by the more regular nearly cylindrical and circular form of the guard.

A. manitobensis and both its variants are apparently distinct from any Eurasian *Actinocamax* form so far known. *A. strelensis* (Fritsch and Schloenbach, 1872), emend. Stolley, 1916 (as figured by Fritsch and Schloenbach, 1872, Pl. 16, figs. 10, 11) seems to be the closest known ally of *A. manitobensis.* Yet the two are quite apparently specifically distinct, as the Canadian form has much feebler and shorter ventral alveolar furrow, different and much stouter form of guard, and much larger size. This question is discussed more fully in the description of *A.* sp. aff. *strelensis.*

Typical *A. manitobensis* and *A. manitobensis* var. *lawrencii* show also certain similarity to *A. lundgreni* Stolley and *A. westphalicus* Schlüter in the shape of the guard and in the structure of the pseudoalveolus. Yet they are undoubtedly distinct from these Eurasian forms in their more shallow pseudoalveolus, much greater size, and relatively greater elongation and slenderness of the guard. It should be mentioned, however, that var. *lawrencii* is much more like these forms than the typical *A. manitobensis.* From *A. plenus* (Blainville) and *A. primus* Arkhangelsky, the typical form and var. *lawrencii* are markedly differentiated by the presence of progressive characters described above. *A. manitobensis* var. *trehernensis* is, on the contrary, much closer to these Eurasian species in the structure of its alveolar end. Yet it can be distinguished from these forms by the different form of the guard, and much larger dimensions. Essentially the same differences as mark it from *A.* sp. aff. *strelensis* distinguish it from all other known Eurasian *Actinocamax,* and in particular from the relatively closely related *A. bohemicus* Stolley, 1916, and *A. padebornensis* Schlüter, 1892.

Actinocamax manitobensis (Whiteaves) var. *trehernensis* nov. var.

Plate II, figure 3; Plate III, figure 3

Diagnosis. Guard nearly perfectly cylindrical, rounded towards the apex and ending in an acute point; alveolar end protruding and forming a low, more or less regular cone, with the hole for the embryonic bulb at its top.

Type Specimen. The holotype (Pl. III, fig. 3) is herewith chosen from specimens collected by B. Mayhew, Treherne, Manitoba, from the bank of Assiniboine River near Treherne. The formation is not indicated, but beyond reasonable doubt the guard was derived from the Assiniboine member of the Favel formation, which is well exposed in that vicinity. This specimen, No. 97, is preserved in the collection of the Manitoba Museum.

Description. The guard is similar to that of the typical form in shape, dimensions, and character of the surface. In these respects the only difference noted is in the nearly perfectly cylindrical form of the guard as compared with prevailing lanceolate shape of the guard of the typical form and of var. *lawrencii,* at least in the ventral view. Also the ventral furrow, and that on the ventral side of the truncated surface of the alveolar end of the guard, are quite similar to those in both other forms of the species. The main, and apparently only, important difference is in the shape of the alveolar end of the guard, which in var. *trehernensis* is not excavated, but always more or less protruding. It forms a low cone of more or less regular, circular contour, with only a small hole for the embryonic bulb at its top (Pl. II, fig. 3; Pl. III, fig. 3). This morphologic distinction, however, would seem to be important enough to justify the specific separation of var. *trehernensis* from typical *Actinocamax manitobensis* according to the taxonomic standards now in use for *Actinocamax* were it not for reasons fully discussed above in the description of the typical form.

Stratigraphic Horizon. No reliable information is yet available for assuming any difference in the stratigraphic range of *A.* var. *trehernensis* from that of other variants of the species and other *Actinocamax* forms of the Canadian Interior described below, although some suggestions contrary to this conclusion were presented on earlier pages. The Assiniboine member of the Favel formation is accepted as the stratigraphic range of this variant.

Localities and Number of Specimens Studied. All specimens of var. *trehernensis* studied are from the vicinity of Treherne, Manitoba. Three readily determinable guards of this variant are present in the collection of Charles Pearce, and are preserved in the Manitoba Museum, Nos. 115-116. The figured specimen (Pl. II, fig. 3) is from this lot. Another collection from the same locality, made by B. Mayhew, Treherne, includes three guards, one of which is transitional to the typical form. In the same lot there is also a primitive specimen of typical *A. manitobensis* transitional to var. *trehernensis* (Pl. II, fig. 4). The holotype, No. 97, Manitoba Museum, is also from this lot. Two more specimens were collected by E. Helyar, Winnipeg, from the banks of Assiniboine River near Treherne.

Origin of the Name. From the village of Treherne, Manitoba, where all studied material of this form originates.

Affinities and Differences. The relation with typical *A. manitobensis* and *A. manitobensis* var. *lawrencii* have been already discussed. It should only be added that the shape of the guard of var. *trehernensis* is variable. The distinctive characters between *A. manitobensis* var. *trehernensis*, *A.* sp. aff. *strelensis*, and *A.* sp. aff. *plenus* and Eurasian *Actinocamax* are described in the discussion of these forms, and of *A. manitobensis*, elsewhere in this report.

Actinocamax manitobensis (Whiteaves) var. *lawrencii* nov. var.

Plate II, figures 1, 2

Diagnosis. Guard markedly lanceolate, moderately stout, and tapers rapidly to a point in the apical quarter of its length; ventral surface somewhat flattened except in the laterally compressed alveolar region where a short, but pronounced, ventral furrow is developed; alveolar end with a relatively deep and rounded pseudoalveolus, 9 mm. deep, of which the surface is relatively feebly sculptured.

Type Specimen. The specimen herewith designated as holotype (Pl. II, fig. 1) was collected by A. G. Lawrence, Winnipeg, from the shore of the right bank of Assiniboine River northwest of Treherne, Manitoba, near exposures noted by Kirk (1930, p. 120). The specimen, therefore, is inferred to have come from the Assiniboine member of the Favel formation. The original is preserved in the collection of the Geological Survey of Canada, No. 9671.

Description. Variant *lawrencii* differs from the typical form as well as from var. *trehernensis* in the more pronounced lanceolate form of the guard and in a deeper, more regularly shaped pseudoalveolus. Besides its greater depth, which exceeds 9 mm., and nearly round form, the pseudoalveolus of var. *lawrencii* does not show the 'actinocamaxoid' pattern of its surface nearly as well as does the typical form. The surface of pseudoalveolus is much more even, and nearly smooth in places. In addition, in a few places another sculpture, consisting of irregular tubercles and intervening little pits and furrows, may be seen. This was referred to in an earlier paper by the writer (1948, pp. 219-220). Another difference from the typical form is in the stronger development of the ventral furrow, which in fact nearly merges into the true ventral fissure (Jeletzky, 1946, pp. 93-95). The taxonomic significance of these differences of var. *lawrencii* from the typical form, and their probable taxonomic relations, were more fully discussed in preceding pages. In fact, var. *lawrencii* has progressed more toward the *Belemnitella*-like stage than has typical *A. manitobensis*, and much more than var. *trehernensis*. It could be recognized as an independent new species were it not for the presence of the intermediate forms and lack of knowledge as to the sequence of these variations. The circumstance, too, that only two guards of this form are known, has restrained the writer from giving the form specific rank. The two specimens studied that showed transitional characters between typical *A. manitobensis* and var. *lawrencii* are both figured (Pl. I, figs. 3, 5); one of them is in fact so close to var. *lawrencii* that only the lesser depth of the pseudoalveolus and more pronounced '*Actinocamax*-like' sculpture, decided the writer to leave it with *A. manitobensis*. On the other hand, it comes from the same locality as the holotype of var. *lawrencii.*

Material and Stratigraphic Horizon. The only specimen known other than the holotype was apparently derived from the Assiniboine member of the Favel formation. It was collected by E. Helyar of Winnipeg from the banks of Assiniboine River, near Treherne, Manitoba. No evidence favours a different stratigraphic horizon for this form than for other belemnoid forms of the Canadian Interior.

Origin of the Name. The writer named this interesting form in honour of Mr. A. G. Lawrence, Winnipeg, who collected the holotype and kindly sent it to him for study.

Affinities and Differences. The differences separating var. *lawrencii* from the typical form, from var. *trehernensis* and other Canadian *Actinocamax* forms, and from Eurasian species of *Actinocamax,* have already been discussed.

Actinocamax sp. aff. *strelensis* (Fritsch and Schloenbach, 1872) emend. Stolley, 1916

Figure 2; Plate III, figures 1, 4, 5

Diagnosis. Guard long, very slender, tapering in lateral view gently and evenly from the edge of the alveolar end for some two-thirds of its length, and in ventral aspect, subcylindrical; farther down the guard tapers more rapidly but uniformly to an acute point in both lateral and ventral aspects; ventral surface somewhat flattened except in the laterally compressed alveolar region where a pronounced furrow, 10-20 mm. long, is present; alveolar end somewhat protruding, forming a more or less rounded low cone, with a small hole for the embryonic bulb at the top.

Type Specimen. The figured specimen (Pl. III, fig. 4) was collected by W. A. Johnston, 1917, from the Favel formation, Duck Mountain, 4 miles from Cowan station, Manitoba, and is preserved in the collection of the Geological Survey of Canada, No. 9670.

Description. The guard is long and very slender; it is subcylindrical for some two-thirds of its length ventrally, and tapers in lateral view gently and evenly from the edge of the alveolar end for this distance. Apically, it tapers more rapidly but uniformly to an acute point. Unfortunately, all the guards studied, including that of the type, are more or less incomplete. Figure 2 is an attempt to reconstruct the whole guard from the fragments available. The surface is generally smooth, yet showing very feeble, longitudinal striæ on the entire ventral and dorsal surfaces in all better preserved specimens. These were not observed on the flanks of these specimens. The ventral side of the guard is moderately flattened almost in its whole length below the alveolar region where it is pronouncedly compressed laterally. The dorsal side is distinctly protruding between the converging dorso-lateral depressions in its upper third. The alveolar end is more or less protruding and ovate in section, forming a more or less regular low cone that bears a small hole for the embryonic bulb at its top. The protruding truncated surface of the alveolar end shows a typical 'actinocamaxoid' sculpture, as in *A. manitobensis*. Its ventral side shows a narrow, deeply cut groove, cutting the ventral wall of the above-mentioned

Figure 2. ***Actinocamax sp.*** aff. ***strelensis*** (Fritsch and Schloenbach) emend. Stolley. Duck Mountain, 4 miles from Cowan station, Manitoba; Assiniboine member of Favel formation (?); collected by W. A. Johnston, 1917; in collection of the Geological Survey, Canada, 16239/2. The drawing was prepared from the longitudinal polished plate of a specimen figured in Pl. III, fig. 1, and the outline of the complete guard reconstructed according to the evidence furnished by the specimens figured in Pl. III, figs. 4a-c, 5. Note that the younger stages of the guard seem to be somewhat shorter and stouter as compared with the adult stage. This ontogeny seems to be fundamentally different from that of *A. mantiobensis* (Whiteaves). (*See* Figure 1 and Pl. II, fig. 2c.)

small hole, and connecting it with the pronounced and relatively long (10-20 mm.), ventral, alveolar furrow, which is always present just below the edge of the truncated alveolar surface. These furrows are apparently of the same origin as those in *A. manitobensis*, but seem to be much less affected by weathering and decay of the guard around them, judging from their mode of preservation. It is remarkable that the beginning of the furrow on the ventral wall of the small hole for the embryonic bulb is situated so close to the bulb itself, being no more than 2-3 mm. above it. This distance is a very important character in younger branches of Belemnitellidae (Jeletzky, 1941, 1946) and were it possible to observe it in species of *Actinocamax* would permit important taxonomic-phylogenetic conclusions. However, it remains uncertain whether or not this furrow accurately represents the original position of the beginning and the further course of the bottom of the ventral fissure, and uncertain, too, whether it represents the bottom of the true fissure or of a 'splitting surface'. The facts that this furrow is developed similarly in all observed specimens of *Actinocamax* sp. aff. *strelensis,* regardless of the condition of weathering, and that a similar distance separates the apparent beginning of the ventral fissure and the embryonic bulb, make it probable that the original conditions are fairly well represented. Further study of this character on better preserved and more numerous specimens is badly needed in order to learn the degree of its taxonomic importance in *Actinocamax.*

Dorso-lateral double, and lateral single grooves are always present in well-preserved specimens; their development is quite similar to that of *A. manitobensis.*

The ontogenetic development of *Actinocamax* sp. aff. *strelensis* could only be studied in one polished section (*See* Figure 2 and Pl. III, fig. 1) owing to the few specimens available. Nevertheless, it presents certain peculiarities worth mentioning. It seems that, contrary to conditions in *A. manitobensis,* the young stages do not show any tendency towards greater relative length and slenderness. They even seem to become somewhat stouter while retaining the same general form. The earliest stages are rather indistinct, however. This difference in the ontogenetic development between the above-mentioned forms, if proved to be genuine, would certainly suggest their specific independence. As it is, having studied the ontogenetic development only in a single, insufficiently preserved guard of *A.* sp. aff. *strelensis* and in two guards of *A. manitobensis,* the writer considers it somewhat hazardous to build any positive conclusions.

The writer refrained from giving a taxonomic name to this form, despite the circumstance that all available evidence seems to justify its specific independence from all other described species of *Actinocamax.* This restraint was due to the following reasons: (1) all specimens studied were incomplete, lacking either apical or alveolar part of the guard, not excluding the type; (2) the number of specimens studied was relatively small; accordingly, it was impossible to study in detail the ontogenetic development of the guard, and to ascertain the stability of morphological elements characterizing this form; (3) the extreme variability and generalization of many *Actinocamax* forms, and particularly of contemporary *A. manitobensis,* raises the possibility that a species founded on a single specimen or a few specimens will later be proved to be only an extreme variant of some other already known species, despite all pronounced morphological differences. In the case of *Actinocamax* sp. aff. *strelensis* this is most unlikely, taking into account both morphological and ontogenetical differences and the apparent lack of intermediate forms between this and other Canadian *Actinocamax.* Nevertheless, the possibility that the former form may eventually intergrade with apparently the contemporary and sufficiently closely allied *A. manitobensis* var. *trehernensis* cannot be excluded. Nor still less, as discussed below, may the possibility of its specific identity with European *Actinocamax strelensis* be denied. Accordingly, the writer preferred to leave its taxonomic position open, beyond stressing an assumed close relationship with the European species.

Affinities and Differences. *A.* sp. aff. *strelensis* is readily distinguishable from typical *A. manitobensis* and *A. manitobensis* var. *lawrencii.* Apart from showing striking differences in the structure of the alveolar end and in the ventral furrow, it differs in the form of the guard. On the other hand, it shows considerable likeness to *A. manitobensis* var. *trehernensis* in the structure of the alveolar end of the guard, although otherwise the two forms are readily distinguishable by means of the greater slenderness and different shape of the guard, and by the much stronger development of the ventral alveolar furrow in *A.* sp. aff. *strelensis.* Moreover, no intermediate forms are known to lie between these two. From *A.* sp. aff. *plenus* (Blainville) *A.* sp. aff. *strelensis* is easy to distinguish by the totally different shape of the guard, and particularly by its much stronger flattening (*See* Pl. III, figs. 2, 4).

The writer has already stressed his opinion that it is unlikely that *A.* sp. aff. *strelensis* is directly related to any other Canadian *Actinocamax* forms described in this report, with the doubtful exception of *A. manitobensis* var. *trehernensis.* On the contrary it seems to show much closer affinity to certain Eurasian forms. Its closest Eurasian allies seem to be *A. strelensis* and *A. bohemicus* Stolley, 1916 (Fritsch and Schloenbach, 1872, Pl. 16, figs. 10a-b, 11a-c, 17a-b; Geinitz, 1872-75, pt. II, Pl. 31, figs. 13, 14 *non* 15; Stolley, 1916, pp. 100, 101). It is nearly impossible to distinguish Canadian forms from the guards of the first species as figured by Geinitz, its much greater size being the only distinction. Yet at the same time Figures 10 and 11 of Fritsch and Schloenbach, which are the legitimate cotypes of the species, show differences from *A.* sp. aff. *strelensis* in the shape of the guard and in the structure of its alveolar end. These differences, together with a lack of personal knowledge of the corresponding West European originals, prevent the writer from uniting *A.* sp. aff. *strelensis* to *A. strelensis* as a variant or subspecies, yet possibly *A. strelensis* still is an artificial unit, partly identical with *A.* sp. aff. *strelensis* and partly allied to *A. manitobensis.*

Actinocamax bohemicus Stolley, 1916 (Fritsch and Schloenbach, 1872, Pl. 16, figs. 17a-b) is even more like *A.* sp. aff. *strelensis* in the form of the guard, character of its alveolar end, and the development of the alveolar furrow. Yet both forms cannot be united, for *A. bohemicus* is pronouncedly granulated, and thus belongs to another phylogenetical branch of the genus *Actinocamax* (Stolley, 1916, pp. 100-101). The same applies to *A. padebornensis* Schlüter, 1892, which is also granulated. The Russian Turonian and Coniacian form *Actinocamax intermedius* Arkhangelsky (1912, pp. 582-585, Pl. IX, figs. 30-31; Pl. X, figs. 6, 16-18) also seems to be closely related to *A.* sp. aff. *strelensis* and to its West European allies, but is too imperfectly known and badly figured to be certain of its relationships. It should be noted that *A.* sp. aff. *strelensis* is very similar in all its most essential characters to *Actinocamax primus* Arkhangelsky, 1912 (*Belemnites lanceolatus* Sowerby, 1929, *non* Schlotheim, 1813), and in particular to its slender, and, in the opinion of the writer, typical variant *elongata* Arknangelsky, 1912 (Jeletzky, 1948c, pp. 339-341, text figs. 1, 2). From this last mentioned, the Canadian form can only be distinguished by its much greater size. They have, however, a quite different stratigraphic range. It is possible that, in further studies, *A.* sp. aff. *strelensis, A. strelensis, A. primus,* and *A. primus* var. *elongata* will prove to be merely variants and mutations (in the sense of Waagen) of the same phylogenetical branch of *Actinocamax.*

The third group of Eurasian *Actinocamax* to which *A.* sp. aff. *strelensis* seems to be closely related is that of *Actinocamax mammillatus* (Nilsson, 1817). This group embraces several, big, ventrally flattened forms from the Santonian and Lower Campanian of Eurasia, all of which show extremely slender, needle-like youth stages of the guard (Jeletzky, 1941, 1946, 1948a, 1949c). Some of them remain very slender and elongated during adult stages as well (*A. alfridi* Janet, 1891, *A. blackmorei* Crick, 1907), but this last character is confined only to the oldest known representatives of the group (Santonian). *A.* sp. aff. *strelensis* is very similar to *A. alfridi* Janet, 1891, *A. blackmorei* Crick, or *Actinocamax* sp. Crick in so far as the shape of the guard is concerned. Unfortunately, no extensive comparison of these forms is yet possible, for these three European species are known from a single guard each, and were never sufficiently described or figured. The possibility of *A.* sp. aff. *strelensis* being an ancestor of these particular forms and of the whole Eurasian *"mammillata"* group cannot be overlooked. In its slender, very elongated, and nearly spindle-like guard this form shows so much resemblance to the needle-like ontogenetic stage of development of *A. mammillatus* that it is only natural to assume that this last may be nothing else than a recapitulated stage of an older ancestral form such as *A.* sp. aff. *strelensis.* The fact that older representatives of the *"mammillata"* group in the strata between Lower Campanian, where *A. mammillatus* is common, and Uppermost Turonian or Lower Coniacian, which is the range of *A.* sp. aff. *strelensis,* are intermediate between these forms in all their characters (although much closer to the latter) support such a view. A possible phylogenetic branch may be suggested proceeding from *A. primus* var. *elongata* Arkhangelsky (Cenomanian) through *A.* sp. aff. *strelensis* (Upper Turonian?) to *A. blackmorei* Crick or *A. alfridi* Janet, or *Actinocamax* sp. Crick, 1907 (Santonian or lowermost Campanian). At the same time it is not impossible to see in *A.* sp. aff. *strelensis* a common ancestor of the genus *Belemnella* (Nowak, 1913, subgenus) Jeletzky, 1941, and the *"mammillata"* branch, for it does not show any characters peculiar to either but only those common to both. The above-mentioned suggestion of the small interval between the embryonic bulb and the beginning of the alveolar fissure on the inner wall of the small hole on the top of the protruding end of its guard, fits in well with such an assumption. So far as Eurasian representatives of this supposed branch are concerned, this problem was fully discussed by the writer (1949b), who is inclined simply to put *A.* sp. aff. *strelensis* into it, and to consider it to be the common ancestor of the branch leading to the genus *Belemnella* and of another branch leading to the *"mammillata"* group *sensu stricto.*

Stratigraphic Horizon. All specimens of *A.* sp. aff. *strelensis* studied were collected from the Favel formation of Manitoba and Saskatchewan. Unfortunately, it is impossible to determine the range of this form more accurately. It should be mentioned, however, that nearly all specimens studied, judging from the remnants of matrix on the guards and from their colouring, seem to be derived from limestone and not from shale as were all other forms. This may suggest their occurrence in a different layer of this member as compared with other forms.

Material and Localities. Five readily determinable, although incomplete, specimens (including the type specimen) from Duck Mountain, 4 miles from Cowan station, Manitoba, were studied. All are in collections of the Geological Survey of Canada, locality No. 16239, and were collected by W. A. Johnston in 1917. The formation is not indicated on the label, but according to the geological map (No. 713A, Assiniboine) the locality is underlain by the Favel formation. Two determinable fragments, locality 16237, collected by F. H. McLearn in 1935 from south of Hudson Bay Junction on the south bank of Red Deer River in Saskatchewan, were also studied. These are definitely from the Favel formation. A guard from Whiteaves cotypes of *"Belemnitella" manitobensis* from Vermilion River (*See* Pl. III, fig. 5) is tentatively referred to this form, despite the lack of the alveolar part. It is quite probable that the guards from the type locality of the Favel formation (Wickenden, 1945, p. 25) preserved in the collections of the Geological Survey, locality 16224, belong to this species, but they are too incomplete for specific determination.

Actinocamax sp. aff. *plenus* (Blainville, 1827)

Plate III, figure 2

Diagnosis. Guard pronouncedly lanceolate ventrally and feebly lanceolate laterally; strongly flattened in dorso-ventral direction except for the nearly circular alveolar region, where a marked ventral furrow, 25 mm. long, is present; alveolar end protruding, forming a more or less rounded low cone, with a small hole for the embryonic bulb at the top; apical end rounded and pronouncedly mucronate.

Type Specimen. The figured specimen (Pl. III, fig. 2) is the only complete guard of this form yet known. It comes from the Assiniboine member of the Favel formation, sec. 16, tp. 9, rge. 10, W. Princ. mer., Assiniboine River, northwest of Treherne, Manitoba; was collected by E. Leith and H. Rand, together with the plesiosaur described by Russell (1935), and is preserved in the private collection of E. Leith at the University of Manitoba, No. L 2/2.

Description. Guard, pronouncedly lanceolate in ventral aspect and feebly lanceolate in lateral aspect; the greatest ventral and lateral diameters are situated very low in the apical quarter. From this point the guard tapers markedly both in alveolar and apical directions, the apical contraction being much more pronounced and rapid. The apical end of the guard is rounded and carries a pronounced mucronated point. The smallest diameters are at the extreme alveolar end. The guard is strongly flattened in the dorso-ventral direction for nearly its entire length, except in the alveolar region, where lateral and dorso-ventral diameters are nearly equal. The cross-section of the guard is an elongated oval throughout the whole post-alveolar part and somewhat quadrate in the alveolar region. Alveolar end truncated and protruding, forming a low cone, with a small hole for the embryonic bulb on its top. The protruding surface of the alveolar end bears a typical actinocamaxoid pattern, and several pronounced radial ribs in dorsal and ventral segments. A marked, deeply incised groove on the ventral side of the truncated alveolar surface connects the above-mentioned small hole with a marked ventral alveolar furrow developed just below the alveolar edge; this last furrow is some 20-25 mm. long, deep in its orad part, and flattens and disappears gradually apically. The groove on the truncated surface of the alveolar end cuts through the wall of the small hole and ends no more than 2 to 2·5 mm. above the embryonic bulb. The surface of the guard is essentially smooth, only weak longitudinal striæ could be observed in places; it bears the usual double dorso-ventral and single lateral grooves on each side. The first are indistinct in the alveolar half of the guard, where they seem to be replaced by broader, flat, single, longitudinal depressions; in the apical direction these depressions flatten gradually and finally disappear.

Stratigraphic Horizon. Assiniboine member, Favel formation.

Material and Localities. In addition to the type, one incomplete guard referable to this form was collected by P. H. Stokes of Winnipeg, on the south bank of Assiniboine River, 8 miles northwest of Treherne, Manitoba, from grey shales. One more fragment referable to this form was studied. It was in the same lot as the holotype of *Actinocamax manitobensis* var. *lawrencii.* Two, small-sized guards from Treherne, lot N 89 P, referred above to *A.* var. *trehernensis,* are possibly intermediate between this variant and *A.* sp. aff. *plenus,* as they are much more lanceolate and flattened than the rest of the guards referred to that variety, although retaining the typically protruding alveolar end of the guard. However, their preservation is too poor to allow a definite decision as to their nature.

Affinities and Differences. A. sp. aff. *plenus* is readily distinguishable from all other Canadian *Actinocamax* hitherto known, due to its pronouncedly lanceolate form, very strong flattening in ventro-dorsal direction, rounded apical end, with a distinct mucronated point strongly tapering all the way in the alveolar direction, and the quadrate-circular cross-section of the alveolar end of the guard. None of the other above described Canadian *Actinocamax* forms shows either a combination of these features or as strong a development of any of them. Thus, this form, like *A.* sp. aff. *strelensis,* seems to be isolated from all other Canadian forms. Notwithstanding, it would be unwarranted to deny the possibility of its close relations with any of them solely on the evidence of strong morphological differences. The writer has already pointed out that it is probable that two of the guards previously referred to *A. manitobensis* var. *trehernensis* may be actually transitional forms between that variant and *A.* sp. aff. *plenus.* Until more and better preserved material of Canadian *Actinocamax,* and in particular of *A.* sp. aff. *plenus,* is available it is not possible to state its phylogenetical position as isolated on the basis of pronounced morphological differences, bearing in mind how most *Actinocamax* forms are plastic and variable in important morphological characters.

Of all Eurasian *Actinocamax,* the Canadian form here discussed seems to be most closely related to *Actinocamax plenus* (Blainville, 1827). In fact it only differs in: (1) more pronounced dorso-ventral flattening of the guard; and (2) more pronounced tapering of the guard toward the aveolar end, resulting in a relatively very small diameter of the cross-section there.

These morphological differences seem to be of no great taxonomic importance, nor are they stable so far as *A. plenus* is concerned. Though the dorso-ventral flattening of the guard in *A. plenus* is usually much less than in *A.* sp. aff. *plenus,* the writer was able to study a few guards of this species from the British and Russian *plenus* zone, which are nearly as strongly flattened as the Canadian species. The same applies to the strong tapering of the guard toward the alveolar end. The writer would probably disregard these differences altogether and refer the Canadian form to *A. plenus* as one of its variants, if it were not for the pronounced difference in their stratigraphic occurrence. So far as known, *A. plenus* is confined to the uppermost Cenomanian and lowermost Turonian (*Inoceramus labiatus* zone) throughout Eurasia. In some countries (England) it is even unknown from the *labiatus* beds (cf. Jeletzky, 1948c, pp. 341-43). It has never yet been recorded from Middle or Upper Turonian, that is, from the beds above the *labiatus* zone. Canadian *A.* sp. aff. *plenus* seems to occur in beds much younger than those of the *labiatus* zone, and apparently younger than Middle Turonian. Therefore, the above-mentioned differences, should they prove to be constant, may be of greater taxonomic value than previously assumed. Unfortunately, only one well-preserved specimen is known, and the stability of the above-mentioned characters remains doubtful. Accordingly, the writer prefers to describe it by the means of open nomenclature, stressing its assumed affinity with the older *A. plenus.* It is possible, indeed, that it is a direct descendant of typical *A. plenus,* but whether a new species or a mere mutation (in the sense of Waagen) is uncertain. It may eventually prove to be more closely related to *A. manitobensis* var. *trehernensis,* as already noted by the writer, although this seems unlikely. As to its morphological similarity to *Actinocamax toucasi* Janet as described and figured by Janet (1891, pp. 719-20, Pl. XIV, fig. 4) and Arkhangelsky (1912, pp. 596-97, Pl. X, figs. 7-9), no definite statement is yet possible, owing to the inadequate knowledge of both last-mentioned forms. This likeness may be purely homeomorphical, yet it may also mean direct kinship.

Actinocamax ? spp. indet.

In all collections of Canadian *Actinocamax* studied there is a fair amount of belemnoid fragments that cannot be determined specifically in the present state of our knowledge. Even their generic nature remains uncertain, though they all undoubtedly belong to the family *Belemnitellidae.* As stated above (*See* page 4), cotypes of Whiteaves mostly belong to this category. As they all seem to be derived from the same formation as the *Actinocamax* forms above described, and as they show no characters that would contradict their tentative reference to the genus *Actinocamax* as above defined, they are here referred to as *Actinocamax* ? spp. indet.

STRATIGRAPHIC OCCURRENCE OF CANADIAN ACTINOCAMAX AND AGE OF THE FAVEL FORMATION

According to data available (Kirk, 1930, p. 121; Wickenden, 1945, p. 32), all Canadian *Actinocamax* are strictly confined to the Favel formation of Manitoba and Saskatchewan. According to both of the above-mentioned authors, they occur only in the upper, Assiniboine member of the formation. However, no data are available as to their vertical distribution within the Assiniboine beds. In the type section of Favel formation (Wickenden, 1945, p. 25), the uppermost layer of the Assiniboine member is specified as the bed with belemnites. Unfortunately, the belemnoids from this layer are fragmental and could not be determined positively, although possibly they belong to *Actinocamax* sp. aff. *strelensis*. Judging by the circumstance that some belemnoids studied were taken from limestone and others from shale, it may be assumed that they are not everywhere strictly confined to any particular bed of the Assiniboine member. Yet, as no positive evidence is available, the writer is forced to regard all the above-described belemnoid forms as contemporary, and to discuss only the problem of the age of the Assiniboine member in general. The stratigraphic importance of belemnoids for this end is emphasized by the fact that they are the only index fossils with a broad horizontal distribution found so far in this member. There are no ammonoids, and the *Inocerami* are new forms not known elsewhere (Wickenden, 1945, p. 32). The most reliable source of our evidence is *Actinocamax* sp. aff. *strelensis*, which is so closely related to *Actinocamax strelensis* from the Upper Turonian of western Europe (Saxonia, Czechoslovakia) that one may doubt whether these forms are specifically distinct. This evidence is also supported by the fact that some other *Actinocamax* (for example, a typical *A. manitobensis* and *A. manitobensis* var. *trehernensis*) likewise show close resemblance to Eurasian Upper Turonian species belonging to the group of *A. strelensis* (Fritsch and Schloenbach, emend. Stolley). However, some other forms, as *Actinocamax manitobensis* var. *lawrencii*, seem to resemble more closely some Coniacian species of Eurasia, as, for example, *A. lundgreni* Stolley. The writer infers that the above evidence is sufficient to indicate an Upper Turonian age for at least part of the Assiniboine member of the Favel formation, though some Coniacian beds may also be represented.

The above conclusion does not conflict with evidence for the age of underlying Keld beds of the Favel formation. These carry the abundant *Inoceramus labiatus* (Schlotheim), which, according to Wickenden (1945, p. 32), is confined to a zone in the lower part of this member, the upper part of the member being characterized by the occurrence of *Inoceramus capulus* Shumard. In as much as *Inoceramus labiatus* is an excellent index fossil of the Lower Turonian practically the world over, it is sufficiently safe to accept a Lower Turonian age for the lower part of the Keld member, which would permit a possible Middle Turonian age for the upper part of the member and a late Turonian age for part or all of the Assiniboine member. Further investigation and careful collection of belemnoid and *Inocerami* fauna is needed, however, for a more positive age correlation.

ORIGIN OF CANADIAN ACTINOCAMAX AND SOME PALÆOGEOGRAPHIC CONCLUSIONS

Belemnoids are unknown in the Canadian Interior Plains from any Upper Cretaceous beds older or younger than those of the Favel formation. Only one doubtful form is known from the Niobrara group of the Western Interior of the United States. It is, therefore, impossible to assume that Canadian *Actinocamax* is an aboriginal stock that arose and evolved within the North American Interior Upper Cretaceous Sea. The forms are, apparently, immigrants, and their close relationship with certain *Actinocamax* species of the Eurasian boreal sea strongly suggests their migration from that province. It still remains to be decided whether they reached the North American Interior Sea from the south or from the north. The discovery of *Belemnitella baculus* Logan, 1898, in Kansas might be interpreted to favour a route from the south. Unfortunately, Logan's description and figure (1898, p. 479, Pl. CX, fig. 2) are insufficient even to prove that this form is a belemnoid. If a belemnoid, this fossil, according to its stratigraphic range (Niobrara) could scarcely belong to *Belemnitella* or to any other *Belemnitella*-like form, but might be another North American representative of the genus *Actinocamax* Miller *sensu stricto*.[1]

There is a further objection to a southern route of immigration of *Actinocamax*. Judging by its fauna and sediments, the Upper Cretaceous Sea of Texas and adjacent areas was quite warm, and represented a transition from the mediterranean (Mexico, West Indies, etc.) to the "boreal" province (United States and Canadian Interior Sea) of North America during the whole of Upper Cretaceous time. Yet almost all Belemnitellidae were exclusive inhabitants of "boreal" Upper Cretaceous

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[1] After this paper had gone to the printer, the writer received from the United States National Museum a substantial belemnoid collection from the Upper Cretaceous of the United States of America. The writer thankfully acknowledges the kind co-operation of Dr. John B. Reeside, Jr., and Dr. G. Arthur Cooper of the said Museum in making this collection available for study.

The four lots of belemnoids from the Colorado group of the United States Western Interior included in this collection deserve to be mentioned here as giving substantial support to the writer's opinion about the *Actinocamax* nature of *Belemnitella baculus* Logan, 1898, and also about the broad horizontal range and more or less common occurrence of *Actinocamax* in North America.

Lot 2017 collected "loose (?) near Fort Benton, Mont.," consists of two small *Actinocamax* guards, which appear to be closely allied to *Actinocamax verus* Miller, 1826. Lot 9380 from the drift of Black Hawk county, Iowa, consists of one guard, which seems to be specifically identical with *Actinocamax manitobensis* var. *trehernensis* (a young specimen). Lot 28623 from the Colorado group on Missouri River 10 miles below Fort Benton, Mont., consists of one indeterminable belemnoid fragment and a guard, which apparently can only belong to a representative of the family *Dmitobelidæ* Whitehouse, 1924. This family has never yet been recorded outside of the Indo-Pacific province of the Upper Cretaceous. The last lot, 28632, from the Colorado group on Missouri River 7 miles below Fort Benton, Mont., consists of eight poorly preserved mostly juvenile *Actinocamax* fragments, which may be tentatively referred to *Actinocamax* sp. cf. *manitobensis* (Whiteaves), and one insufficiently preserved complete guard that closely resembles *Actinocamax plenus* Blainville.

This unexpected diversity in the belemnoid fauna of the Colorado group of the United States seems to indicate at least two belemnoid horizons of different age. These may range from Turonian to Santonian.

The close affinity or even specific identity of some specimens of United States *Actinocamax* with those of Manitoba implies that the Favel *Actinocamax* fauna apparently extends all the way southward into Montana, and possibly into Kansas as well. The lot with *Actinocamax* sp. aff. *verus* Miller represents a new belemnoid fauna that may be younger in age, although this has not yet been proved. The representative of the family *Dmitobelidæ* Whitehouse, 1924, may or may not occur together with *Actinocamax* ex gr. *manitobensis* (Whiteaves) in Montana.

seas. Only a few have ever been found outside of the "boreal" province of Eurasia. Consequently, one cannot expect their migration to the "boreal" sea of the North American Interior through the Mediterranean province of North America. The same argument holds for North American Campanian and Maestrichtian *Belemnitella*. They abound in the northwestern corner of the Atlantic belt of Upper Cretaceous deposits (New Jersey, Delaware) but become progressively scarce towards the south, and are very rare in the Navarro group of Texas (Stephenson, 1941, pp. 437-38). They are even more scarce in the Upper Cretaceous Sea of the Western Interior of the United States, where, to the present, only a few specimens have been recorded, nor have any yet been discovered in contemporaneous formations of the Canadian Interior.

The evidence in favour of a northern route of immigration is in the writer's opinion much stronger, and seems to be sufficient to assume that Canadian *Actinocamax* reached this country via the Canadian Arctic Archipelago and the Mackenzie basin. An Upper Cretaceous fauna with strong Canadian affinities was discovered recently at several localities along the Arctic shore of Siberia. Ryabukhin (1940, pp. 24-25) mentions such forms as *Inoceramus* cf. *flaccidus* White, *Inoceramus* ex gr. *cardissoides* Schlüt., *Scaphites* sp. aff. *ventricosus* Meek and Hayden, *Braculites ovatus* Say, and *Actinocamax intermedius* Arkhangelsky from the Lower Yenissey River. Eynor (1940, pp. 77-78) discovered *Inoceramus steenstrupi* Loriol also on the Pay Hoy Peninsula. These *Inocerami*-species are identical with or fairly close to the Canadian *Inoceramus lundbreckensis* McLearn (1937, pp. 117-18; 1943, p. 40). On the eastern slope of the northern Urals, *Scaphites cuvieri* Morton (the name is an invalid synonym of *Scaphites hippocrepis* DeKay), *Scaphites* sp., and *Baculites obtusus* Meek were recently recorded from the sandstones on Sosva River (Besrukoff, 1934, pp. 169-183). Swinnerton (1943) recently described *Actinocamax* cf. *plenus* (Blainville), *Actinocamax* cf. *blackmorei* Crick, and *Actinocamax* sp. from the eastern shore of Greenland. Loriol (1883, p. 206) mentions an occurrence of an indeterminable fragment of *Belemnites* or *Belemnitella*, together with *Inoceramus steenstrupi* Loriol and *Inoceramus patootensis* Loriol (both closely related to *I. cardissoides*), and *Scaphites* of North American affinities from Senonian deposits in the vicinity of Disco Bay, West Greenland. These *Scaphites* were later described by Ravn (1918) as *Scaphites nicoletti* Morton (= *S. roemeri* d'Orbigny). All species of *Inoceramus* above mentioned are doubtless closely related to, and partly identical with, some Canadian forms of *Inoceramus lundbreckensis* McLearn. Quite recently Rosenkrantz (1940, pp. 657-58) has reported also the presence of marine Turonian-Coniacian deposits with *Parapuzosia* sp. ind. and of marine Coniacian deposits with *Scaphites* ex gr. *ventricosus* Meek and Hayden in the vicinity of Disco Bay. As we see, also, Coniacian fauna of West Greenland shows Canadian affinities.

As compared with this palæontological evidence, the absence of Upper Cretaceous marine deposits in the whole Canadian Arctic Achipelago between the mouth of Mackenzie River and the west coast of Greenland cannot be treated as a serious objection to the assumed direct connection of the Canadian Upper Cretaceous boreal sea with that of Greenland, Novaya Zemlya, and Siberia. The same applies to the apparent absence of *Actinocamax* in Canada north of Saskatchewan River, for our present knowledge of this vast area is still fragmentary[1].

A good illustration of the inadequacy of present knowledge of the palæontology of the Canadian Arctic Archipelago is provided by the discovery during the summer of 1948 of a belemnoid fragment on the shore of western Ellesmere Island (Slidre Fiord). This fragment was collected by J. R. Weir, of the Canadian Geographical Bureau, and submitted to the writer for identification. Despite its poor preservation, it is apparent that this fragment cannot belong to any known Triassic or Upper Cretaceous belemnoid form. Also, it is quite unlikely that it belongs to any Liassic group or to the family Belemnopsidae Naef emend. Jeletzky. It might belong to any of the following belemnoid families: Oxyteuthidae Stolley, 1919 (most likely), Cylindroteuthidae Stolley, 1919, or Pachyteuthidae Stolley, 1919. Accordingly, it suggests an age from Middle Jurassic to deep Lower Cretaceous (Neocomian) for the strata concerned, although no beds of such age have yet been reported from this geographical province.

It may be noted that Teichert (in Balk and Ruedemann, 1939, pp. 154-156) accepts the submergence of a great part of the Canadian Arctic Archipelago during Upper Cretaceous time. He even suggests the deep penetration of an Upper Cretaceous sea from Ellesmere Island area toward Disco Bay. Such a sea-arm between Greenland and Baffin Land may have connected the beds of the Disco Bay area with the Canadian Western Archipelago. If such were the case, it would be logical to assume that another contemporaneous sea-arm extended toward the mouth of Mackenzie River. The close resemblance of the Upper Cretaceous fauna of Greenland, Northern Siberia, Pay Hoy Peninsula, and the northern Urals with contemporaneous faunas of the Western Interior Sea of Canada completely justifies such assumption. The available palæontological evidence seems to the writer to suggest that direct and easy Arctic connections of the Canadian Western Interior Upper Cretaceous Sea may have persisted somewhat longer than has been accepted by Canadian and United States authors. Canadian *Actinocamax* and *Inoceramus labiatus* Schlotheim, as well as Siberian *Inoceramus* cf. *flaccidus* White and *Scaphites* sp. (aff. *ventricosus* Meek and Hayden), certainly suggest such connection during all Turonian and Coniacian time, in accordance with Russell (1939) and other North American authors. At the same time the presence of such North American Santonian and Lower Campanian forms as *Inoceramus* from the group *cardissoides* Goldfuss, *Inoceramus steenstrupi* Loriol, *Baculites ovatus* Say, *Baculites obtusus* Meek and Hayden, and *Scaphites hippocrepus* DeKay in northern Siberia, Pay Hoy Peninsula, and the northern Urals, and of *Inoceramus steenstrupi* Loriol and *Inoceramus patootensis* Loriol in Western Greenland, suggests that this connection persisted during the whole of Santonian and possibly also during Lower Campanian (uppermost Alberta and Pakowki) time. The discovery of *Scaphites nicoletti* Morton in Western Greenland tentatively suggests that this connection may have

[1] That this is so, is verified by a quite recent discovery of *"Belemnites"* sp. associated with the Turonian fauna in Mackenzie River Valley by Warren (1947, p. 119). Although this belemnoid was only mentioned and not described, there is strong reason to believe that it may belong to the genus *Actinocamax* as no other belemnoid genera are known to occur in the Turonian of Eurasia and North America.

existed also during Bearpaw (Upper Campanian and Lower Maestrichtian) time. Therefore, the commonly accepted conception of the definite closing of the northern outlet of the Canadian Western Interior Sea as early as Lower Santonian (uppermost Alberta) time, with its successive gradual retreat toward the south, interrupted by a few minor transgressions, may be subject to later adjustments. It may be that the apparent lack of all Upper Cretaceous deposits younger than the Alberta shale throughout northern Canada is due to their later removal rather than to primary non-deposition, and they may yet be found in some part of this vast area. In the opinion of the writer, the Pakowki, and for a short time even the Bearpaw Sea, may have had an outlet to the Canadian Arctic Archipelago and Western Greenland via Mackenzie or Coppermine River basins. The solution of this interesting palæogeographical problem must await further geological exploration.

CANADIAN ACTINOCAMAX AS INDEX FOSSILS

It is uncertain whether the above-described Canadian *Actinocamax* forms will prove to be important as index fossils for correlation of Canadian beds, and particularly for tracing of equivalents of the Assiniboine member of the Favel formation throughout the Western Interior. Nevertheless, one might assume such importance, for Upper Cretaceous belemnites, together with inocerami, form the backbone of every stratigraphic scheme for correlation and subdivision of the boreal Upper Cretaceous series of Eurasia. The crucial question, which cannot be answered now, is whether or not these *Actinocamax* forms are widespread and common enough in the Canadian Interior to be useful in correlation. Their relative scarcity in collections of the Geological Survey of Canada and in all provincial and private collections could suggest a negative answer. On the other hand, according to R. T. D. Wickenden (personal communication), fragments of belemnites are common in many Upper Cretaceous localities of this area, and he noted a few belemnoid fragments in the samples of deep wells from Alberta and western Saskatchewan. Accordingly, the writer is inclined to ascribe existing paucity of belemnoid remains to non-collection rather than to rarity of occurrence. For the guidance of future collectors it should be mentioned that the apical ends of Upper Cretaceous belemnites, as in many other belemnoids, do not present any characters of specific or even generic value and are, therefore, almost useless for exact determination of fossils. But even small fragments of the alveolar part of the guard may be enough for generic and even specific determination, and thus permit stratigraphic correlation of the enclosing strata. The modern taxonomy of Upper Cretaceous belemnites is largely based on differences in the alveolar part of the guard.

The view, all too prevalent among field geologists on this continent, that belemnoids are of no use for stratigraphic correlation, is not warranted. For example, Upper Cretaceous belemnites in Eurasia constitute one of the most reliable groups of index fossils. When more carefully collected and better studied, Canadian Upper Cretaceous belemnites may well prove to be useful for correlation of some beds and formations of the Canadian Interior Plains. That Upper Cretaceous belemnites of Canada and United States will be of great value for broad regional correlation and for correlation of North American standard divisions with internationally recognized Upper Cretaceous stages of western Europe, as well as for the study of the palæogeography of North America in Upper Cretaceous time, may readily be inferred from the previous discussion. The *Actinocamax* forms in the Favel formation of Canada already add an important contribution to existing tentative correlations of Canadian Interior Upper Cretaceous formations with the standard stages of western Europe. Future collections of belemnoids will undoubtedly be similarly useful, even though belemnoids may be too rare for local correlations and mapping of faunal zones.

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SCIOPHYLLUM, A NEW RUGOSE CORAL FROM THE CANADIAN ARCTIC

By P. Harker and D. J. McLaren

INTRODUCTION

The coral to be described was discovered during a recent re-examination of fossil collections from the Yukon-Alaska Boundary. The specimen was presented to the Geological Survey of Canada by the late H. F. J. Lambart of the International Boundary Survey; it was collected by him in 1912 at a point 96 miles north of the intersection of Porcupine River and the International Boundary in latitude 68° 48′ 40″. The coral is described, assigned to a new genus and species, and its affinities are discussed in the light of the trend concept put forward by Lang (1917, 1923).

It is now generally recognized that many rugose coral genera are polyphyletic and that many different stocks, although unrelated, suffered similar structural modifications during their development. These modifications, which are relatively limited in number, have been called trends, the term being used to indicate a morphological series of modifications that may have been followed by one or several independent lineages.

In the discussion on the affinities of *Sciophyllum* various trends are mentioned, indicating possible modes of development in the ancestry of the coral in question. The suggestion that the diphyphylloid and lonsdaleoid trends acting concurrently have been responsible for the structure of *Sciophyllum* does not necessarily imply relationship with either *Diphyphyllum* or *Lonsdaleia,* but merely that the septa have undergone both axial shortening, combined with a loss of the columella, and peripheral shortening during the phylogenetic development of the coral.

The rates at which trends operate may vary greatly, and compound corals are known in which corallites possess two or more different structures in the same corallum. Were these structures found only in different corralla they would be assigned separate 'generic' names following the old system of coral taxonomy. Smith and Lang (1930, p. 179), however, proposed the term 'genomorph' to describe these forms, which were coeval with the parent genus and were presumably genetically similar although differing phenotypically. The fact that a 'genus' is in point of fact the genomorph of another can only be demonstrated with certainty in the rare event of the two forms being found in corallites of the same corallum (McLaren and Sutherland, 1949).

As trends may operate at varying rates and similar trends may produce striking homoeomorphs from different stocks either at the same or differing stratigraphical horizons, it is plain that compound corals must be used with caution as horizon markers. Nevertheless, the detailed study of species of these corals has proved of the utmost value in Carboniferous stratigraphy in areas where the sequence of faunas has been established, e.g., Hill (1938-41), Dobroljubova (1936).

OCCURRENCE

The locality where the fossil was collected lies within the most northerly of two areas of Carboniferous rocks described by Maddren (1912, p. 306) in his geological reconnaissance of the northern part of the International Boundary. Within these two areas, Carboniferous strata are said to com-

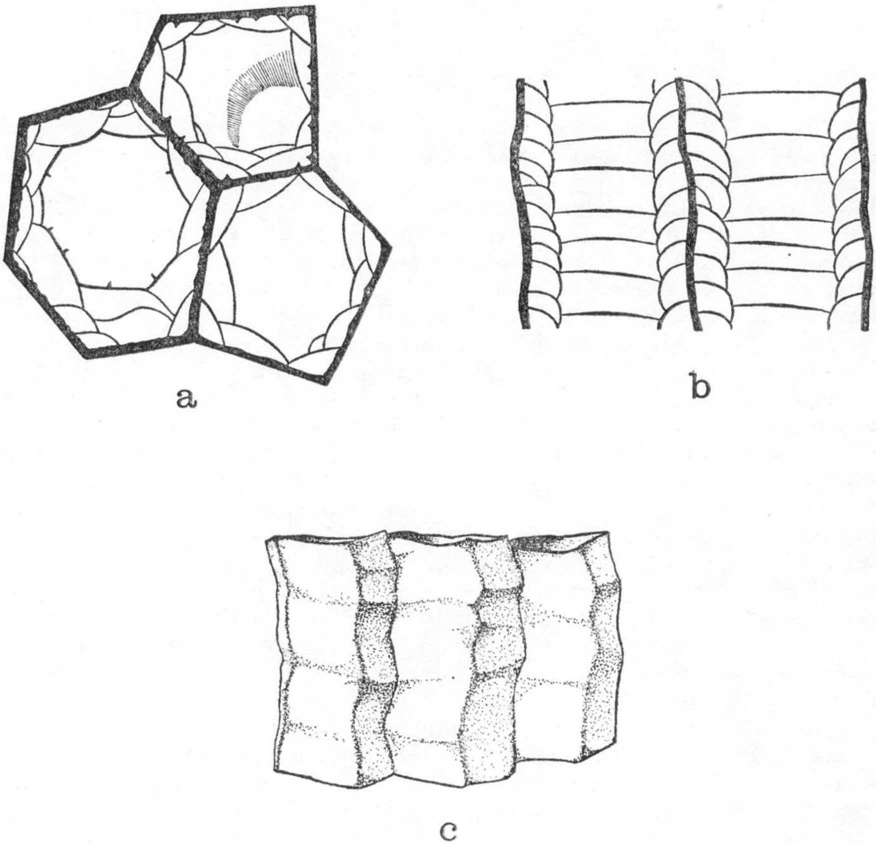

Figure 3. ***Sciophyllum lambarti*** **sp. nov.**

(a) Transverse section of three corallites showing types of septal structure. x 5.
(b) Vertical section of two corallites showing spacing and thickening of the tabulæ. x 5.
(c) External view of three corallites showing corrugation of epithecæ. x 3.

prise almost all exposed strata, with the exception of two small areas of Triassic rocks. The Carboniferous beds consist mainly of greyish or dark limestone with some chert, and, apparently, sufficient fossil evidence has been obtained to justify the systemic position and to show that at least part is of Mississippian age.

The exposed sections are stated to show general similarity to the Carboniferous of Porcupine River, which has been described by Kindle

(1908, p. 331). The Porcupine faunas include elements of an early Mississippian age, and Girty considered that the whole of the Mississippian was represented; the Carboniferous succeeds the Devonian without apparent unconformity in this area. The upper part of the Porcupine sections closely resembles the Calico Bluff formation (Brooks and Kindle, 1908, p. 292) on Yukon River, which has a well-established Mississippian fauna, roughly comparable with the Chester group of the United States. The Upper Carboniferous in Yukon Valley is probably represented by the Nation River formation, which consists of continental deposits and contains a few plants, but has so far yielded no reliable fossil evidence as to age (P. S. Smith, 1939, p. 29).

The stratigraphy of the northern part of the International Boundary is not known in detail, but the evidence is sufficient to say that Lambart's coral is Carboniferous, and may come from a Mississippian horizon.

DESCRIPTION

Genus, SCIOPHYLLUM gen. nov.

Genotype, *Sciophyllum lambarti* sp. nov.

(Name: σκία a shadow; φύλλον a leaf (septum)

Diagnosis[1]. Cerioid rugose corals of basaltiform habit, without columella; complete corallum unknown; dissepimentarium of one or more series of dissepiments, the inner margin forming a well-marked inner wall; tabulæ strong, well spaced and regular, flat or slightly arched; septa absent or reduced to fine vertical striations on the inner side of the epitheca or inside the inner wall; gemmation lateral.

Sciophyllum lambarti sp. nov.

Plate IV

Type. Holotype, G.S.C. No. 9667; from the Carboniferous of the Yukon-Alaska Boundary, long. 141° W., lat. 68° 48′ 40″ N.

Diagnosis. As for genus.

Description. Dimensions of mature corallites in millimetres:

—	Mean	Min.	Max.
Diameter of corallite	4·8	4·6	5·0
Diameter of tabularium	3·1	2·7	3·5
Width of dissepimentarium	0·75	0·6	0·85
Thickness of epitheca	0·13	0·12	0·16
Number of tabulæ in 5 mm	5	3	6
Number of dissepiments in 5 mm	9	8	10

The fragment described is cerioid and has the following dimensions: length 10·2 cm.; breadth 8·0 cm.; height 3·5 cm. Complete corallum is unknown. Axes of the corallites have a general parallelism. There is no

[1] The terminology used in the description follows Hill (1935).

columella. Corallites separate easily; external faces show horizontal striation and gentle corrugation, which causes each corner of the corallite to be sinuous or zigzag. The distance between successive corrugations is about 3 or 4 mm. Epitheca is strongly formed. Dissepiments are well developed, convex and strongly arched; usually only one series forming a dissepimentarium whose inner boundary forms a distinct inner wall. Tabulæ are strong, complete, and evenly spaced. They are flat or faintly arched, thicken slightly towards their centres, and form a tabularium enclosed by the inner margin of the dissepimentarium. Septa are absent or rudimentary; where present they occur on the inside of the epitheca or within the inner wall, rarely on both in the same corallite. They may be visible as fine striations on the inner walls of broken corallites. Septal vestiges, if present on the epitheca, appear to include both major and minor orders and number 25 to 30. Where they occur within the inner wall they number about 15, corresponding with the major septa on the epitheca. Septation is never complete in any one corallite, and the septal count can only be obtained by estimation. Of the total number of observed corallites, about 30 per cent showed some traces of septation. Gemmation is intermural, and young corallites have well-developed epithecæ. No dissepiments appear in the early stages, the tabulæ extending to the epitheca. Not all early tabulæ are complete.

AFFINITIES

The most interesting features of the coral described, a massive cerioid coral whose age is Mississippian or later, are the lack of columella, the almost complete reduction of the septa, and the strengthening of the tabulæ.

The coral is closest in structure to *Diphystrotion* or *Thysanophyllum*, both of which genera may be genomorphs of *Lithostrotion*. *Diphystrotion* is considered to have developed from *Lithostrotion* by a reduction of the columella and an axial shortening of the septa, whereas *Thysanophyllum* may have developed from *Lithostrotionella*, itself a genomorph of *Lithostrotion*, by the action of the same trend, or from *Diphystrotion* by peripheral shortening of the septa. The variation between individual corallites in all the above corals is very great, and both anticipatory and ancestral stages may be seen in different individuals in the same corallum.

Two main trends, therefore, may be considered to have operated within the group under discussion, that of peripheral withdrawal of the septa, the lonsdaleoid trend, and that of axial withdrawal of the septa combined with reduction of the columella, the diphyphylloid trend. These trends have been discussed by Hill (1934, pp. 94-96), who points out that they are probably potential to all rugose corals and may be expressed in any species at any horizon.

As these trends may also operate in the Lonsdaleiidae it is apparent that the extreme resultant of both trends acting on either the Lithostrotiontidae or the Lonsladeiidae would produce a coral with characteristics similar to the specimen described. Indeed, *Sciophyllum* might almost be considered to be the personification of the theoretical end member of these two trends operating on cerioid corals, and it is unnecessary to postulate more than these two broad trends to produce the features observed.

The same trends appear to have operated almost to the same extremes in other groups of Carboniferous rugose corals, producing broadly homeomorphic forms, which, however, differ considerably from *Sciophyllum* in detail. In *Orionastraea breviseptata* Dobroljubova, particularly the specimen figured by Heritsch (1940, Taf. I), the septa are reduced to a mere fringe within the inner wall with occasional vestiges on the epitheca. This coral differs from *Sciophyllum* in that the astraeoid trend has affected its development, in addition to the two already mentioned, and the epitheca is much reduced or absent between contiguous corallites. The septa of *Thysanophyllum aseptatum* Dobroljubova (1936, p. 67) are also reduced or occasionally lacking, and occur both within the epitheca and the inner wall. The size of the corallites and the structure of the dissepiments, as well as the more numerous and stronger septa, distinguish it from *Sciophyllum lambarti*. The species appears to form a morphological link between *Thysanophyllum* and *Sciophyllum* and serves to strengthen the belief that the latter is a genomorphic form of the former.

Although most of the corallites in the specimen described are without vestigial septa, the fact that where these are present they may occur either on the epitheca or on the inner wall suggests a closer affinity to *Thysanophyllum* than to *Diphystrotion*. The size and general form of the corallites as well as the structure of the dissepiments would suggest placing *Sciophyllum* in the family Lithostrotiontidae.

Sciophyllum may well prove to be a genomorph of a form with a less specialized organization, but it would appear necessary in any case to name such an extreme form as this in order to follow the normal procedure in rugose coral taxonomy. No genetic significance can be attached to this new genus, and the name is justifiable only in so far as it serves to distinguish a new structural modification.

Certain alterations of structure would become necessary in order to compensate for the reduced strength of the skeleton following the loss of septa. The flattening of the tabulæ naturally follows the loss of columella, as in *Diphystrotion*, but their slight thickening would clearly increase their strength as structural girders. The dissepiments also appear to be more strongly developed than in the other cerioid corals. The corrugation of the epitheca, producing a sinuous edge to each corallite, may have a strengthening effect, but it may also have resulted from the reduction of horizontal stability in the growing polyp due to the loss of septa.

CONCLUSIONS

(1) The genus *Sciophyllum* appears to be more correctly associated with the Lithostrotiontidae than with any other rugose coral family.

(2) The genus may be considered the resultant of two simplifying trends, which have led to a loss of the columella and an almost complete reduction of the septa.

(3) The loss of these members has resulted in certain structural modifications of a secondary nature.

(4) A new genus is justified, following current coral taxonomy, as a convenient means of distinguishing a new morphological type in rugose corals.

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PLATE 1[1]

Figures 1a-1c. *Actinocamax manitobensis* (Whiteaves), typical form. Assiniboine River northwest of Treherne, sec. 16, tp. 9, rge. 10, W. Princ. mer., found together with plesiosaur remains (Russell, 1935); Assiniboine member of Favel formation (?); coll., E. Leith and H. Rand; in private collection of E. Leith in the University of Manitoba, No. L 1/1; young specimen. (Page 4.)

Figures 2a-2c. *Actinocamax manitobensis* (Whiteaves), typical form. Lectotype. Said to be collected on the east bank of Assiniboine River a short distance below the mouth of Little Souris River, Manitoba, in deposits of Niobrara-Benton age; coll., D. Armit, 1876; collection of the Geological Survey, Canada, No. 5066. (Page 4.)

Figures 3a-3c. *Actinocamax manitobensis* (Whiteaves). Assiniboine River near Treherne, Manitoba; Assinboine member of Favel formation (?); coll., Charles Pearce; in collection of the Manitoba Museum, Winnipeg, No. 115; fig. 3a—ventral view; fig. 3b—the same specimen split longitudinally, lateral view; fig. 3c—view of the alveolus. This specimen is a form transitional from *A. manitobensis* (Whiteaves) typical form to var. *lawrencii* nov. var. (Page 4.)

Figures 4a-4c. *Actinocamax manitobensis* (Whiteaves). Assiniboine River near Treherne, Manitoba; coll., B. Mayhew, Treherne; in collection of the Manitoba Museum, Winnipeg; No. 97 B; Assiniboine member of Favel formation (?); this specimen is transitional from *A. manitobensis* (Whiteaves) typical form to var. *trehernensis* nov. var. Note the form of the guard and the structure of the alveolar end. (Page 4.)

Figures 5a-5c. *Actinocamax manitobensis* (Whiteaves). Right bank of Assiniboine River northwest of Treherne, Manitoba; Assiniboine member of Favel formation; coll., A. G. Lawrence, Winnipeg, Public Health Dept.; private collection of A. G. Lawrence, No. T. 34. This specimen is transitional between *A. manitobensis* typical form and var. *lawrencii* nov. var. (Page 4.)

[1] Unless otherwise suggested in the explanation of Plates I-III, all specimens are displayed in the following aspects and order: (a) ventral view; (b) lateral view; (c) alveolar view. The alveolar views of the guards all show the venter on the bottom. The letter 'v' in the lateral aspect shows the position of the ventral surface of the guard. All specimens are represented natural size.


1a
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V
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4b
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5b
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3b
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V
4c
5c

PLATE II

Figures 1a-1c. ***Actinocamax manitobensis*** (Whiteaves) var. ***lawrencii*** nov. var.; holotype; right bank of Assiniboine River, northwest of Treherne, Manitoba; Assiniboine member of Favel formation; coll., A. G. Lawrence, Public Health Dept., Winnipeg; collection of the Geological Survey, Canada, No. 9671. Note the deep smooth 'pseudoalveolus', which character is diagnostic of this variant. (Page 11.)

Figures 2a-2c. ***Actinocamax manitobensis*** (Whiteaves) var. ***lawrencii*** nov. var. Assiniboine River near Treherne, Manitoba; Assiniboine member of Favel formation (?); coll., E. Helyar; private collection of P. H. Stokes, Winnipeg, No. H. 4; fig. 2a—ventral aspect; fig. 2b lateral aspect, fig. 2c—longitudinal splitting surface of the same specimen. The approximate contour of 'pseudoalveolus' is shown by a dashed line. Note the great slenderness of the earlier stages of the development of the guard as compared with the adult stage, and the great likeness of the ontogenetic changes exhibited by this specimen and that exhibited by *A. manitobensis* (Whiteaves) typical form shown in Figure 1. (Page 11.)

Figures 3a-3c. ***Actinocamax manitobensis*** (Whiteaves) var. ***trehernensis*** nov. var.; from the same locality, horizon, and collector as the specimen figured in Pl. I, figs. 3a-3c; in collection of the Manitoba Museum, Winnipeg, Manitoba, No. 116. In this specimen the shape of the guard and the structure of the alveolar end are typical for this variant. (Page 10.)

Figures 4a-4c. ***Actinocamax manitobensis*** (Whiteaves); Assiniboine River near Treherne, Manitoba; just downstream from locality where the plesiosaur was found (Russell, 1935); Assiniboine member of Favel formation; coll., E. Leith and H. Rand; in private collection of E. Leith at the University of Manitoba, No. L. 2. This specimen is transitional between *A. manitobensis* (Whiteaves) typical form and var. ***trehernensis*** nov. var., and represents a form about midway between the typical specimens of both variants. (Page 4.)

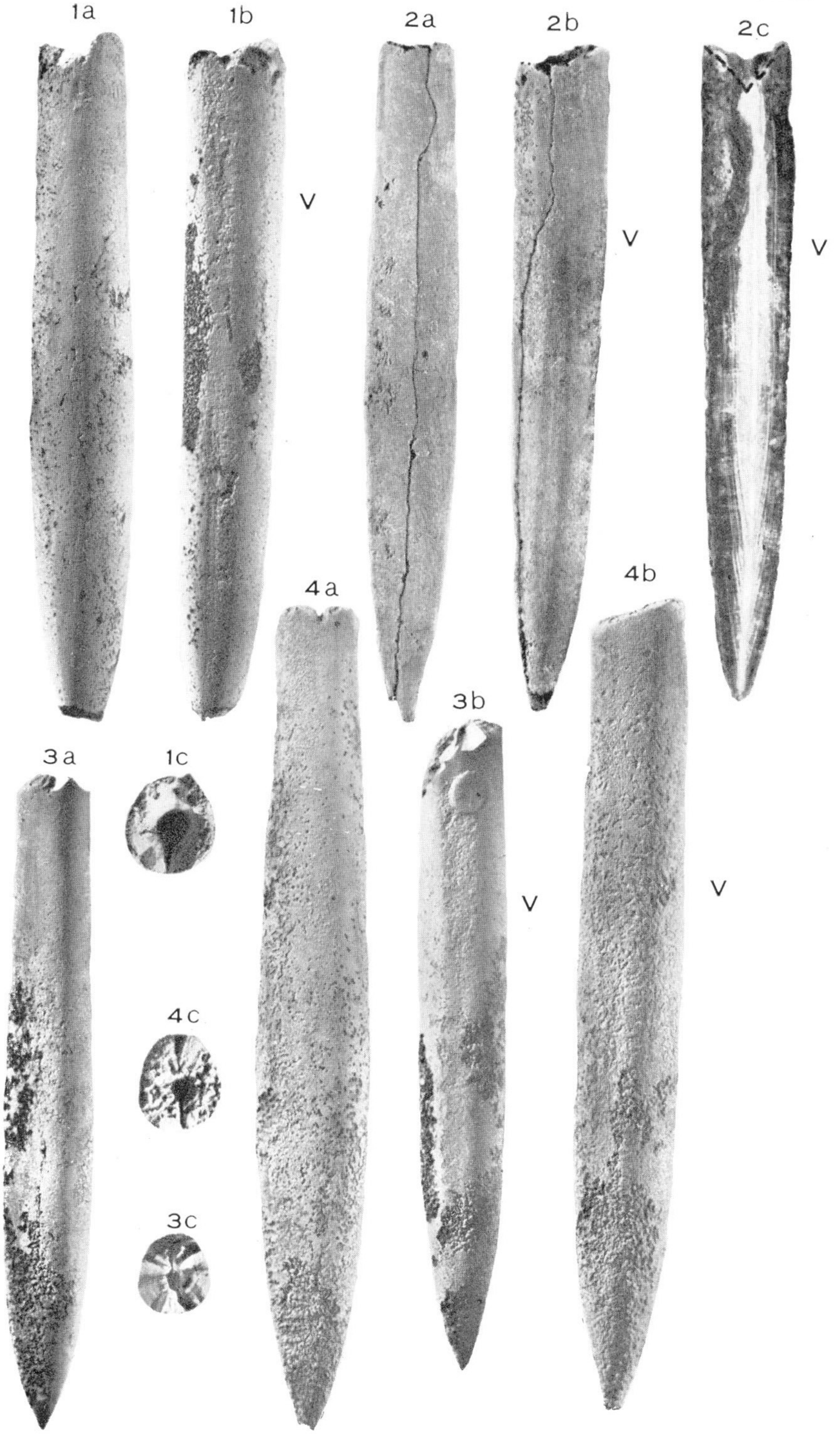
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PLATE III

Figure 1. *Actinocamax* sp. aff. *strelensis* (Fritsch and Schloenbach) emend. Stolley; Duck Mountain, 4 miles from Cowan station, Manitoba; Assiniboine member of Favel formation (?); coll., W. A. Johnston, 1917; in collection of Geological Survey, Canada, No. 16239/2. This photograph was taken from a longitudinal plate prepared from a typical fragment of the type-lot of this form. Growth-lines and the central hole on the protruding alveolar end retouched. (*See* also Figure 2.) (Page 12.)

Figures 2a-2c. *Actinocamax* sp. aff *plenus* (Blainville): holotype; from the same locality and horizon as specimen figured in Pl. I. figs. 1a-1c; coll., E. Leith and H. Rand; in private collection of E. Leith at the University of Manitoba, Winnipeg. No. L. 1/2. (Page 17.)

Figures 3a-3c. *Actinocamax manitobensis* (Whiteaves) var. *treherensis* nov. var.; holotype: Assiniboine River, Treherne, Manitoba; Assiniboine member of Favel formation (?); coll., B. Mayhew, Treherne; in collection of the Manitoba Museum, Winnipeg, No. 97. This is the largest specimen of this variant (and the largest Manitoba *Actinocamax*) known to the writer. (Page 10.)

Figures 4a-4c. *Actinocamax* sp. aff. *strelensis* (Fritsch and Schloenbach) emend. Stölley; hölotype: Duck Mountain, 4 miles from Cowan station, Manitoba; Assiniboine member of Favel formation (?); coll., W. A. Johnston, 1917; collection of the Geological Survey, Canada, No. 9670 (locality number of the lot 16239). (Page 12.)

Figure 5. *Actinocamax* ? sp. aff. *strelensis* (Fritsch and Schloenbach) emend. Stolley; Upper Cretaceous, Niobrara-Benton (presumably Assiniboine member Favel formation?) group; Vermilion River, tp. 24, rge. 2, W. Princ. mer., Manitoba; coll., J. B. Tyrrell, 1877; in collection of the Geological Survey, Canada, No. 5065. This specimen is one of the cotypes of Whiteaves (1889, p. 189). Should it really belong to the form above mentioned, this would mean that it was extremely elongated and slender as compared with other Canadian *Actinocamax*. All of the alveolar part of the guard is broken off, which makes accurate determination impossible. Probably the complete specimen was some 10-15 mm. longer than the fragment figured. (Page 12.)

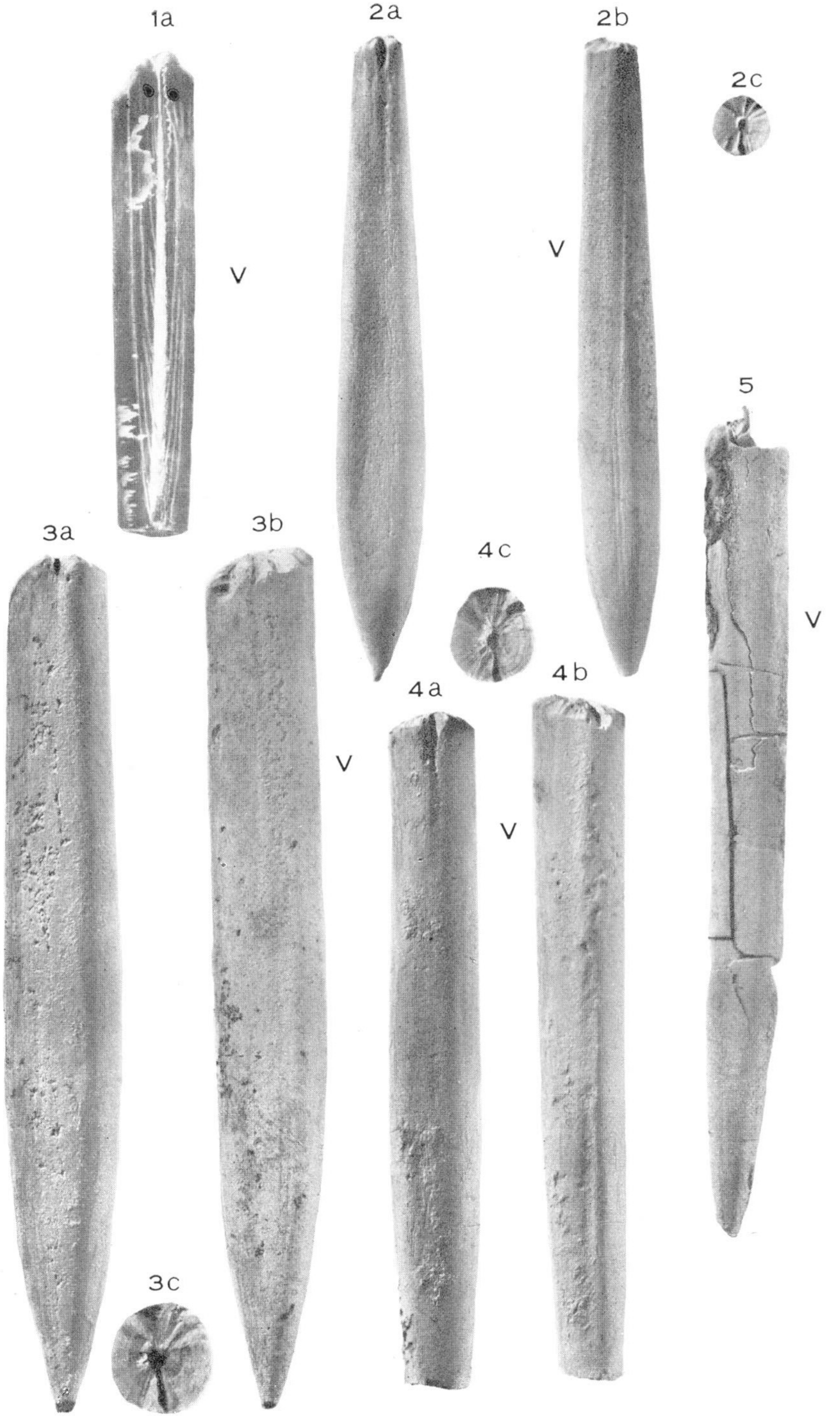
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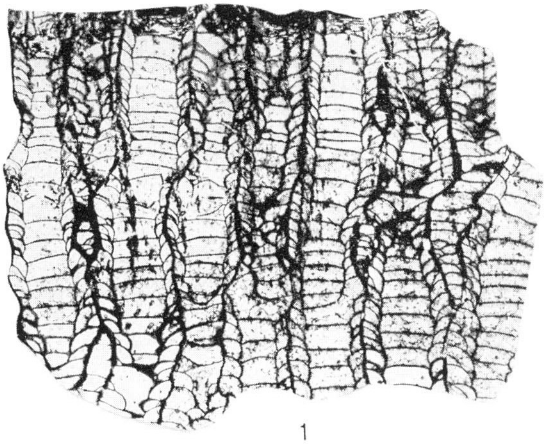
PLATE IV

Figure 1. ***Sciophyllum lambarti*** sp. nov. Holotype, Geological Survey, Canada, No. 9667. Vertical section, x 2. (Page 31.)

Figures 2 and 5. ***Sciophyllum lambarti*** sp. nov. Holotype, Geological Survey, Canada, No. 9667. Transverse sections, x 2. (Page 31.)

Figures 3 and 4. ***Sciophyllum lambarti*** sp. nov. Holotype, Geological Survey, Canada. No. 9667. Natural size. (Page 31.)



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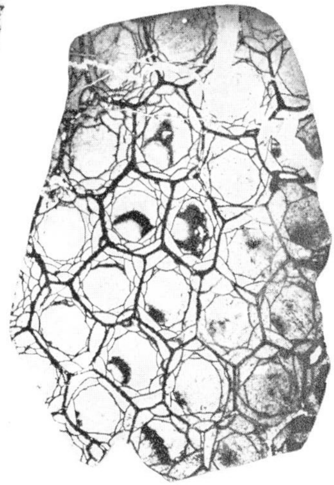

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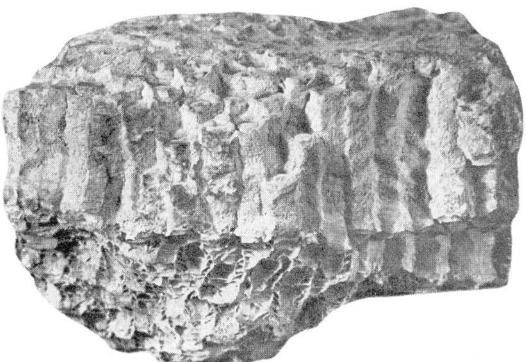

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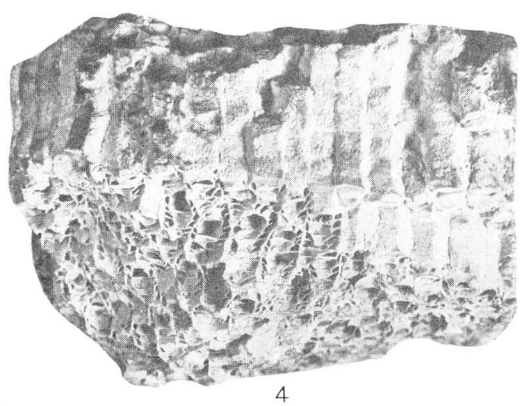

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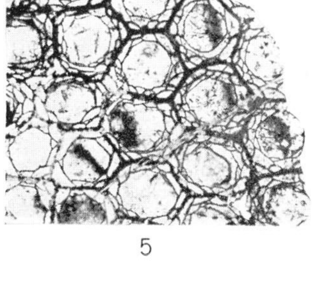

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