20. APTYCHI (AMMONOIDEA) FROM THE UPPER JURASSIC AND LOWER CRETACEOUS OF THE WESTERN NORTH ATLANTIC (SITE 105, LEG 11, DSDP)

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ABSTRACT

At Site 105 (34° 53.73'N, 69° 10.40'W) two distinctly different faunas of aptychi can be recognized. The older fauna is distributed within the interval ranging from 5819 to 5864 meters.[1] The corresponding sediments are conspicuously similar to the Rosso- ad Aptici facies, known from the Mediterranean Jurassic (see chapter of D. Bernoulli in this volume). Among the twelve specimens recovered are six Lamellaptychi, three Punctaptychi, one Laevaptychus and two Laevilamellaptychi. The most frequent aptychi belong thus to the Lamellaptychi which here are characterized by the following common features: They are all without a lateral depression and the lamina-pattern can be concentric (Lamellaptychus beyrichi OPPEL, Plate 2, Figure 3), or radial (L. rectecostatus crassocostatus TRAUTH, Plate 3, Figure 2) but not retroverse. All the forms determined are common in the Alpine-Mediterranean province, where they are recorded predominantly from the Kimmeridgian-Tithonian.

The younger aptychi-fauna, of early Cretaceous age, is separated from the Upper Jurassic by a sediment column ranging between 5691 to 5819 meters in which so far no aptychi have been recovered.

This younger fauna, composed of 9 specimens, is restricted to Core 18, taken between 5682 and 5691 meters. The aptychi within this short interval are all Lamellaptychi which, in contrast to the forms of the Upper Jurassic, are characterized by a retroverse lamina-pattern. Moreover, they all possess a well-developed lateral depression, and the furrows separating the laminae are not covered by an outer layer of calcite. The polygonal tops of the prismatic tubes composing the middle layer are thus exposed and filled with sediment.

With the exception of one apparently new specimen, all the recovered forms from the Lower Cretaceous are also known from the Alpine-Mediterranean province. Based on the stratigraphical investigations of Gasiorowski (1962) in the Carpathians and other regions, the aptychi from Core 18 might be of late Valanginian-Hauterivian age.

One of the forms found in Core 18 (L. angulocostatus atlanticus HENNIG, 1913) has been described from possibly lower Cretaceous (Neocomian) deposits of the Cape Verde Islands. Imlay (1942) records several aptychi, which are comparable to the present forms, from the Viñales Formation in Cuba.

Based on an ammonite-fauna, the age of the Viñales Formation is indicated to be Portlandian (Tithonian). It is, however,

[1] Drill pipe measurements from derrick floor to sea floor.

not yet definitely known if the aptychi-fauna was really obtained from the same level as the ammonites.

The terminology used in this report (see Text-figure 1) is based on the investigations of Schindewolf (1958).

INTRODUCTION

The material was brought to Basel in June, 1970 by Dr. H. P. Luterbacher. The cores, still moist and impregnated by sea water, were dried slowly for several weeks in a refrigerator in order to avoid cracking. The surfaces of the fragile valves of aptychi were then cleaned of sediment with fine needles and brushes.

This paper was prepared at the museum of Natural History in Basel, Switzerland.

Much help had been received from Dr. H. P. Luterbacher (EPR-E in Begles, France) from Dr. H. Kugler of the Museum and from Dr. D. Bernoulli of the Geological Institute of the University in Basel. The minerals were determined by Dr. S. Graeser (from the Museum) by X-ray diffraction.

The writer is especially grateful to Mr. J. B. Saunders (Texaco Trinidad Inc.) for reading the manuscript critically and with great care. The numerous valuable suggestions brought forward are incorporated in the text.

The photographic work was carried out by Mr. W. Suter of the Museum of Natural History. The micrographs were taken with a Stereoscan electron microscope by Mr. R. Guggenheim from the Geological Institute.

HISTORICAL REVIEW

In the course of the past century many different interpretations of the nature and function of aptychi have been brought forward. The view that aptychi represent the opercular structures of ammonoids was first expressed by Rüppell, 1829. Since then a great number of important publications have appeared discussing the stratigraphical distribution, internal structures and terminology of these remains. A historical review of the numerous interpretations has been carefully compiled by Trauth, 1927-1938.

One of the most important findings in the history of the study of aptychi was an aptychus in the original position closing the aperture of an *Oppelia*. This specimen collected in the Bajocian of Dundry in England has been described by Woodward, 1860 (p. 328 with figure; refigured by Trauth, 1930, pl. 3, figs. 25, 26). However, this finding was neglected because of numerous new occurrences of aptychi actually lying within the body chambers of ammonite shells.

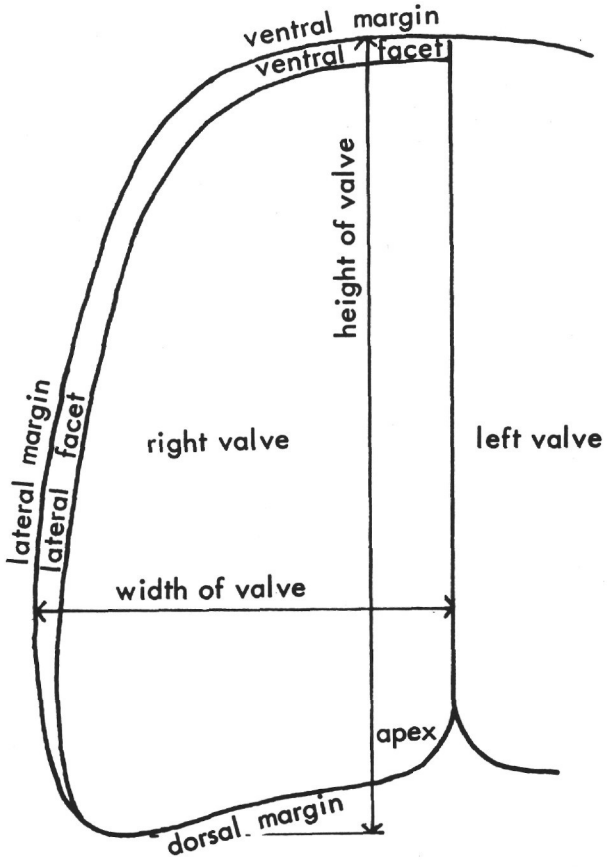

Figure 1. *Terminology of the aptychus-valve adapted to the ammonite-shell (based on SCHINDEWOLF 1958).*

In 1927, Trauth began a specialized study of aptychi and thus started a new period of investigation of these fossils. He came to the firm conclusion that aptychi do indeed represent opercular structures of ammonites (p. 175: "die allein richtige Deutung der Aptychen als äussere Deckelverschlüsse der Ammonoideen"). Having not taken sufficiently into consideration the finding of the *Oppelia* of Dundry, Trauth assumed that aptychi are to be interpreted as ammonite opercula, which when not in a position closing the aperture, were withdrawn within a mantle-fold, situated on the ventral side of the body chamber. The dorsal end of the aptychus was then directed forward (Trauth, 1927; figs. 1 and 2, p. 184-185; 1931, fig. A, p. 18). This interpretation has been accepted by most students and also taken over by Arkell in the Treatise (1957, L 82).

In 1958, E. Wannenwetsch made an important new finding in the Weissjura gamma on the Burgberg near Onstmettingen (Schwäbische Alb) in Germany. It is a *Physodoceras* (Family Aspidoceratidae Zittel, 1895)

with its aptychus in a position closing the aperture of the shell. This finding was studied by Schindewolf, 1958 (pl. 1 fig. 1a, 1b) and it induced him to reinvestigate the numerous, yet unsolved, problems concerning the relation between aptychi and ammonite shells, including their internal structure and their formation. Based on the *Physodoceras* with its aptychus in the original position, Schindewolf (fig. 6, p. 22) places the aptychus in such a way that its dorsal margin fits on the dorsal inner wall of the aperture. The soft parts, which secreted the aptychus valve, would thus not correspond to the mantle but would rather cover the dorsal side of the ammonite shell and the convex outer side of the valve. This interpretation would explain satisfactorily the different composition of the aptychus (calcite) and the ammonite shell (aragonite).

According to the investigations of earlier authors and also of Trauth (1927-1938) the valves of all aptychi are composed of three separate layers: 1) A thin inner layer covering the concave inner side of the valve. Growth lines beginning at the apex and advancing concentrically towards the rim of the valve are always visible. 2) A thick middle cellular layer composed entirely of prismatic, often irregular tubes. 3) A dense calcitic outer layer formed of parallel thin lamellae, which might cover the middle layer completely or only partly.

According to the new investigations of Schindewolf (p. 8-17) the most important feature of aptychi valves are concentric growth segments, each of which embraces the earlier ones (Schindewolf, fig. 2, p. 12). Due to peripheral accumulation of shell material the valve grows in size. Each growth segment is made up of the three layers: the thin inner layer composed of growth lamellae, the middle prismatic layer and the outer lamellar layer which reaches its greatest thickness in the apical region, owing to the successive accumulation of parallel layers. None of these layers are independent features, they are thus genetically connected to each other.

Gasiorowski (1962) and Durand-Delga and Gasiorowski (1970) studied extensive collections of aptychi from the Western Carpathian Mountains and the Mediterranean, which range from Middle Bajocian to Lower Barremian. Eight aptychi-horizons could be distinguished. They are based on the vertical variability of some features, especially the pattern of laminae on the outer part of the valve. Within the six "genera" of "ribbed" aptychi, four patterns of sculpture are distinguished: A) a radial-, B) an oblique-, C) a concentric- and D) a retroverse pattern (fig. 5, p. 96). Accordingly, all "ribbed" aptychi are placed in four groups. The grouping of these types (A-D) into six "genera" and the vertical distribution is shown on their figure 1 (p. 12).

TERMINOLOGY

The older terminology, as illustrated in the Treatise by Arkell, 1957 (fig. 556, L 438) does not bear a clear relationship to the terminology in use for the ammonite shell and, therefore, Schindewolf proposed new terms to describe the morphological features of aptychi valves. In the present report the terms of Schindewolf are used. For the convenience of readers some morphological features are shown on Text-figure 1.

PALEOZOOLOGICAL DESCRIPTIONS

Aptychi from the Upper Jurassic

The aptychi described here from the Upper Jurassic and the Lower Cretaceous are all derived from Site 105, the coordinates of which are 34°53, 73 N and 69°10, 40′ W.

The Upper Jurassic part of the section ranges between 5819 meters and 5864 meters. Within this interval the lithology is rather constant. The deposits consist of brick red, weakly consolidated, extremely fine-grained argillaceous calcilutite, which swells and disintegrates to tiny flakes immediately when brought into contact with water. Under the Stereoscan electron microscope the fine calcareous fraction appears to be composed almost entirely of coccoliths. Much of the sediment has been deformed by penecontemporaneous slumping. The slumped beds often contain layers of harder pebbles of white to grayish limestones yielding calcitized Radiolaria, occasional Globigerinidae, Aptychi, Inoceramus-fragments and some plates belonging possibly to *Zeugomatolepas* of the Family *Scalpellidae* (Plate 4, Figures 7, 8 and 9). The thickness of such a layer (105-37-5, 32 to 35 centimeters) reaches about 2 centimeters.

Sometimes the slumped beds are associated with graded mudpebble conglomerates, which pass upwards into calcarenite and homogenous calcilutites, which apparently represent turbidity layers genetically linked to the slump movements (see Bernoulli, Chapter in this volume). This association of pelagic argillaceous calcilutites with slumped beds and turbidites of pelagic composition is almost identical with the typical marly Ammonitico Rosso facies and Rosso ad Aptici facies occurring in the Tethyan Jurassic (Bernoulli, 1969, in press). From these facies a fauna of aptychi, comparable to the one of Site 105 has been collected by D. Bernoulli from the Rosso ad Aptici near Ligornetto in the Southern Alps (Canton Ticino, Switzerland).

In the oldest available core a completely flattened ammonite, apparently belonging to the genus *Aspidoceras*, could be detected.

TABLE 1
Stratigraphical Distribution of Aptychi in Site 105

Core	Section	Interval	
18	4	74- 75cm	Lamellaptychus seranonis (COQUAND, 1841); Plate 3, Figure 4
	4	95- 97	Lamellaptychus angulocostatus (PETERS, 1854); Plate 4, Figure 1
	4	126-127	Lamellaptychus angulocostatus atlanticus (HENNIG, 1913); Plate 4, Figure 4
	4	140-142	Lamellaptychus angulocostatus atlanticusradiatus (TRAUTH, 1938); Plate 3, Figure 3
	5	28- 29	Lamellaptychus angulocostatus atlanticus (HENNIG, 1913); Plate 4, Figure 3 Lamellaptychus cf. angulocostatus (PETERS); Plate 4, Figure 5
	5	38- 39	Lamellaptychus seranonis (COQUAND, 1841); Plate 3, Figure 5
	5	108-110	Lamellaptychus joides n. form; Plate 4, Figure 6
	5	131-132	Lamellaptychus angulocostatus atlanticus (HENNIG, 1903); Plate 4, Figure 2
		Interval Without Aptychi Recovered	
33	2	86- 88	Lamellaptychus cf. lamellosus (PARKINSON, 1811); Plate 2, Figure 2
	2	89- 91	Punctaptychus punctatus (VOLTZ, 1837); Plate 1, Figure 5
	3	44- 45	Lamellaptychus rectecostatus crassocostatus TRAUTH, 1938; Plate 3, Figure 2
34	3	114-115	Lamellaptychus beyrichi (OPPEL, 1865); Plate 2, Figure 3
35	4	13- 15	Lamellaptychus sp.
36	1	?	Punctaptychus monsalvensis TRAUTH, 1935; Plate 2, Figure 1
37	1	127-130	Flattened *Aspidoceras* possibly *A. pawlowi* BURCKHARDT; Plate 1, Figure 1
	2	34- 36	Lamellaptychus murocostatus TRAUTH, 1938; Plate 3, Figure 1
	2	105-107	Laevilamellaptychus of *Haploceras aporus* (OPPEL, 1863); Plate 1, Figures 3, 4
	5	32- 35	Laevaptychus sp., group of L. latus (PARKINSON, 1811); Plate 1, Figure 2 Scalpellidae (possibly *Zeugomatolepas* WITHERS, 1913); Plate 4, Figures 7-9
	6	105-106	Lamellaptychus lamellosus (PARKINSON, 1811); Plate 2, Figure 4 Punctaptychus sp. juv.; Plate 1, Figure 6

Aspidoceras ? cf. *pawlowi* Burckhardt 1912
(Plate 1, Figure 1, Text-figure 2)

From Sample 11-105-37-1, 127 to 130 centimeters, at a depth of 5856.30 meters, a quarter of a whorl of a flattened ammonite has been detected. Its whorl height reaches 28 millimeters. A little above the assumed umbilical edge, four elongated, bullae-like tubercles which are slightly directed forward are faintly visible. A second row of tubercles which could be expected within the middle part of the flank cannot be traced. The outline of the ventral margin is conspicuously irregular, possibly indicating that a form with a broad venter has been pressed together. Rather surprisingly, remains of the suture line could be recognized and drawn under the microscope (Text-figure 2). The dorsal half of the external saddle, a trifid lateral lobe and two umbilical lobes are visible on the flank. The ventral half of the external saddle thus must have been situated on the venter of the shell which also supports the above assumption of a broad venter.

A comparable *Aspidoceras* with an equally wide umbilicus and with only one row of umbilical tubercles has been figured by Burckhardt, 1912 (pl. 19, fig. 1-3, 5, 9 (sutur), p. 77). It was collected in the lower San Pedro Formation in Mexico (Kimmeridgian) and named *Aspidoceras pawlowi.* The external suture line of this species also possesses a trifid lateral lobe and two very similar umbilical lobes. It is impossible that the Site 105 impression represents an *Aspidoceras* that might be compared with the Mexican form.

Laevaptychus sp., group of L. latus (Parkinson, 1811)
(Plate 1, Figure 2a-d)

1931 Laevaptychus latus (PARKINSON), Trauth, pl. 1, fig. 3, fig. C1-4, p. 66, cum syn.
1954 Laevaptychus latus (PARKINSON), Valduga, pl. 8, fig. 6a-d, p. 31.

The only Laevaptychus present in the collection comes from Sample 11-105-37-5, 32 to 35 centimeters from a depth of 5861.35 meters.

This right valve was collected from the above mentioned thin intercalation, composed mostly of harder, light grayish pebbles, containing few *Globigerinae.* This material possibly slid from a nearby faultscarp and therefore might be somewhat older than the surrounding sediment.

Measurements: The relation of the width of the valve to its height: width-index is 0.69; and the relation of the length of the symphysis to the height of the valve known as the symphysal-index reaches 0.81. The outline of the valve suggests a form belonging to the group of Laevaptychus latus.

The Site 105 specimen shows on its outer surface irregularities which were probably caused by damage to the tissue which covered the surface and excreted the calcite (Schindewolf, 1958, p. 29).

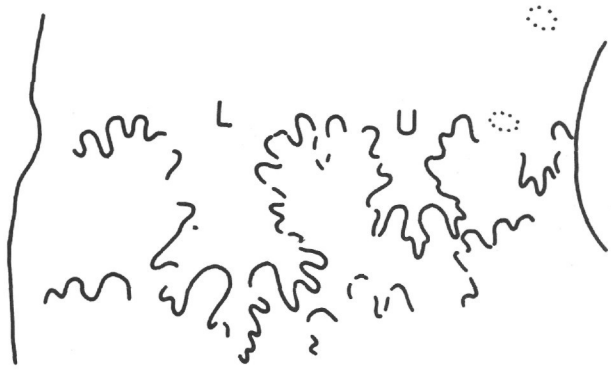

Figure 2. *Sutur line of* Aspidoceras *sp. cf.* A. pawlowi *BURCHHARDT, 1912. 2.67X.*

On the surface of the convex (outer) side, smaller and larger rounded pores which are rather irregularly distributed can be observed (Plate 1, Figure 2b). On those parts of the concave (inner) side that could be freed from sediment, the laminae dipping gently towards the apex display a finely perforated surface (Plate 1, Figure 2c, d). Along broken edges it can be seen that these pores possibly communicate with the much wider tubes of the "middle layer".

Similar but much larger forms with outer surfaces characterized by larger and smaller pores have been described by Krantz, 1926 (pl. 17, fig. 7-8, p. 455) from the Tithonian of Argentina (Laevaptychus tenuibrevis TRAUTH, 1931, p. 99).

Occurrence: Laevaptychus latus occurs throughout the Upper Jurassic and represents one of the most common forms. It is abundant in the Alpine-Mediterranean region as well as in the Jura Mountains of Switzerland and Germany. Moreover the form is mentioned from Southern Arabia, Tunisia, Somaliland (Valduga, 1954), Abyssinia (Venzo, 1959), East Africa and Mexico (Sierra de Catorce in San Luis Potosi, Burckhardt, 1930). It also has been collected by the writer from the Upper Jurassic of the Guajira Peninsula in Colombia.

Laevilamellaptychus of *Haploceras aporus*
(OPPEL, 1863)
(Plate 1, Figures 3, 4a-b)

1863 Aptychus of *Ammonites aporus* Oppel, pl. 37, fig. 1-2, p. 258.
1931 Laevilamellaptychus aporus (OPPEL), Trauth, p. 22.
1936 Laevilamellaptychus aporus (OPPEL), Trauth, pl. 3, fig. 2-4, p. 131.
1962 Laevilamellaptychus aporus (OPPEL), Gasiorowski, pl. 6, fig. 39.

Two small, apparently juvenile, right valves were detected when one of the two pieces available from Sample 11-105-37-1, 105 to 107 centimeters from a depth of 5863.57 meters disintegrated in water.

Very similar valves were observed by Oppel, 1863 (pl. 73, fig. 2) within the body chamber of a specimen of *Haploceras aporus* Oppel from the Upper Jurassic (Malm zeta) of Solinhofen (Bavaria).

Measurements: Plate 1, Figure 3: width-index (W:H) = 0.57; symphysal-index (S:H) = 0.83; apical angle = ? 115°. Plate 1, Figure 4: width-index (W:H) = 0.57; symphysal-index (S:H) = 0.85; apical angle = 107°.

The convex outer sides of the valves are also entirely smooth, when viewed under the Stereoscan electron microscope. Remains of a thin layer, displaying fine riblets, running about parallel to the growth-lines, cover the concave side. According to Schindewolf, 1958 (p. 14), this layer represents the only independent one of the aptychus valve.

Punctaptychus sp. juv.
(Plate 1, Figure 6a-c)

The small left valve from Sample 11-105-37-6, 105 to 106 centimeters, extracted from a depth of 5863.56 meters, lay with its convex side downward near a Lamellaptychus lamellosus (PARKINSON).

Measurements: width-index (W:H) = 0.78, symphysal-index (S:H) = 0.87, apical angle = 115°.

The valve of this small Punctaptychus is very broad in relation to all other forms and rather resembles the contours of Lamellaptychus latissimus TRAUTH, 1931. The laminae are irregularly overlapping and the punctation therefore appears correspondingly irregular.

A well-preserved very thin calcareous layer covers the concave surface. It displays regular, equidistant very-fine ribs overlapping the growth-lines slightly obliquely (Plate 1, Figure 6c).

Punctaptychus monsalvensis TRAUTH, 1935
(Plate 2, Figure 1a, b)

1868 Aptychus punctatus OPPEL, Zittel, pl. 1, fig. 15a, p. 52.
1880 Aptychus sp. indet., Favre, pl. 3, fig. 16a, b, p. 43.
1935 Punctaptychus monsalvensis TRAUTH, text fig. 2, reproduction from Favre, 1880, p. 324.
1962 Punctaptychus monsalvensis TRAUTH, Gasiorowski, pl. 6, fig. 1-2.

A right valve from Sample 11-105-36-1, ? centimeters, from a depth somewhere between 5846 and 5847.50 meters.

The dorsal margin and the apex are destroyed and had to be reconstructed.

Measurements: width-index (W:H) = 0.48, symphysal-index (S:H) = 0.90.

The width-index of the holotype from Favre (1880) reaches 0.58 (Trauth, p. 326). The present valve therefore is remarkably more slender.

Punctaptychus monsalvensis differs from P. punctatus mainly by its sculpture. The seams separating the overlapping laminae are not effaced by overlying calcite as in P. punctatus where only the pores remain open. The rim of the laminae is dentated and therefore the openings are small and often irregularly elongated. Towards the ventral half of the valve the laminae become completely detached and rise into a steep position, disclosing the bottoms of the furrows. They converge towards the ventral termination of the valve. The outer rim of the laminae is also here dentated. At the bottoms of the furrows some elongated wrinkles, more or less vertical to the direction of the laminae, are developed. They seem to disappear towards the middle of the valve.

Occurrence: This form is known from the Tithonian of the Carpathians and from Canton Fribourg (Monsalvens) in Switzerland.

Punctaptychus punctatus (VOLTZ, 1837)
(plate 1, Figure 5a-c)

1837 Aptychus punctatus VOLTZ, lecture, p. 435.
1854 Aptychus profundus PICTET, pl. 47, fig. 15, p. 556.
1867 Aptychus Malbosi PICTET, pl. 28, fig. 11 a-d, p. 124.
1867-81 Aptychus profundus PICTET, Meneghini, pl. 25, fig. 5a-c, 7a-b, p. 122.
1880 Aptychus punctatus VOLTZ, Favre, pl. 3, fig. 14-15, p. 42.
1886 Aptychus punctatus VOLTZ, Sokoloff, pl. 3, fig. 1-3, p. 23.
1927 Punctaptychus punctatus (VOLTZ), Trauth, p. 173.
1932 Aptychus punctatus VOLTZ, Cohen, pl. 5, fig. 26, p. 32.
1935 Punctaptychus punctatus (VOLTZ), Trauth, pl. 12, fig. 1-6, p. 315.
1959 Aptychus (Lamellaptychus) aff. punctatus VOLTZ, Collignon, pl. 133, fig. 505a, b.
1962 Punctaptychus punctatus (VOLTZ), Cuzzi, pl. 17, fig. 1-3, p. 48.
1962 Punctaptychus punctatus (VOLTZ) Gasiorowski, pl. 6, fig. 15-17.
1963 Punctaptychus punctatus (VOLTZ), Bachmayer, pl. 4, fig. 7a-b, p. 130.

1964 Punctaptychus, group A, punctatus (VOLTZ), Turculet, pl. 5, fig. 7, p. 62.
1965 Punctaptychus punctatus (VOLTZ), Pozzi, pl. 86, fig. 9-11, p. 871.

The only well-preserved right valve from Sample 11-105-33-2, 89 to 91 centimeters, 5821.41 meters depth was lying with its concave side upward. In order to free the convex side from sediment the core was embedded in plaster.

Measurements: width-index (W:H) = 0.57, symphysal-index (S:H) = 0.93, apical angle 99°. These figures compare satisfactorily with those of Trauth (p. 316).

The slightly sigmoidal laminae are partly terminating along the lateral margin with some converging towards the terminal point. On the flank the overlapping laminae are welded together by a layer of calcite, leaving the rows of equidistant pores open. Towards the ventral margin of the valve the laminae rise slightly and separate, thus assuming an identical position as in Lamellaptychus (Plate 1, Figure 5c). Near the ventral end of the valve a network of low wrinkles is present at the bottoms of the furrows. A coating of brownish-violet calcite on the central part of the valve might be a remnant of original coloring (Reyment, 1957).

A radially oriented thin-section by Trauth, 1935 (pl. 12, fig. 5) displays the growth segments distinctly.

From the Upper Jurassic of Italy Meneghini (1867-81, p. 116, 124) mentions a Punctaptychus punctatus (or P. monsalvensis) together with *Haploceras elimatum* (OPPEL) (compare Trauth, 1935, p. 314, 319). Retowski (1891, p. 220) observed in the Tithonian of the Crimea Peninsula a Lamellaptychus beyrichi as an operculum of the same ammonite species. To solve this contradiction a revision of the respective ammonite determinations is necessary.

Occurrence: Punctaptychus punctatus, according to our present knowledge, seems to be restricted to the Alpine-Mediterranean province. Its greatest development was during the Kimmeridgian and Tithonian. It has been mentioned from the Crimea Peninsula, the Carpathians, Austria, the Swiss Alps, France, the Apennines, Sicily, Rhodes, Spain and Northern Africa. It is remarkable that a Punctaptychus similar to the present form has been figured by Collignon, 1959, from the Kimmeridgian (Zone á *Streblites pictus*) of Madagascar.

Lamellaptychus TRAUTH, 1927

All Lamellaptychi from the Upper Jurassic of Site 105 are without a lateral depression. The lamina-pattern is concentric (Lamellaptychus beyrichi OPPEL) or radial (L. rectecostatus crassicostatus TRAUTH) but not retroverse.

Five forms of Lamellaptychi could be distinguished. They are restricted to Cores 33 to 37 and thus occur between a depth of 5819 to 5864 meters.

Within the interval corresponding to the Cores 19 to 32 (5691 and 5819 meters) no aptychi, as yet, have been recovered. The aptychi of the Lower Cretaceous, which are all Lamellaptychi, are restricted to Core 18 ranging between 5682 and 5691 meters. All these Lamellaptychi, in contrast to those of the Upper Jurassic, possess a retroverse lamina-pattern.

Lamellaptychus lamellosus (PARKINSON, 1811) (Plate 2, Figure 4a-c)

1811 Trigonellites lamellosus PARKINSON, pl. 13, fig. 10, 11, p. 184.
1846-49 Aptychus lamellosus PARKINSON, Quenstedt, pl. 22, fig. 20a-b, 23, p. 312.
1857 Trigonellites imbricatus OOSTER, pl. 5, fig. 7-8, pl. 7, fig. 21, p. 19.
1858 Aptychus lamellosus PARKINSON, Quenstedt, pl. 74, fig. 12, 13, p. 596.
1927 Aptychus (Lamellaptychus) lamellosus (PARKINSON), Trauth, p. 197.
1929 Lamellaptychus lamellosus (PARKINSON), Trauth, p. 76-79.
1938 Lamellaptychus lamellosus (PARKINSON), Trauth, pl. 11, fig. 1-5, p. 149.
1962 Lamellaptychus lamellosus (PARKINSON), Gasiorowski, pl. 3 (Horizon 2), pl. 4 (Horizon 3), pl. 5 (Horizon 4-5).
1965 Lamellaptychus lamellosus (PARKINSON), Pozzi, pl. 86, fig. 7, p. 869.

Only a small, fragile, right valve of this widely distributed form is available. It is recovered from Sample 11-105-37-6 105 to 106 centimeters (5863.56 meters). The valve was lying with its concave side upwards and the core had to be put in plaster in order to free the convex side from sediment.

Measurements: width-index (W:H) = 0.46, symphysal-index (S:H) = 0.90, apical angle 90°. According to Trauth (1938, p. 152) the width-index varies between 0.40 and 0.60. Consequently the width of the present valve is rather narrow.

The valve is so flat that lateral and dorsal facets are poorly developed; the slope towards the symphysis is gentle and a very narrow symphysal plate is indicated. The laminae are slightly sigmoidal and meet the symphysis at acute angles. Only one lamina ends along the gently curved lateral margin. The bottoms of the deep furrows are, as far as exposed, without any sculpture.

Numerous Radiolaria are lodged within the furrows (Plate 2, Figure 4c).

Occurrence: According to the observations of Gasiorowski, 1962, in the Carpathians, the vertical distribution of this form ranges from the Lower Oxfordian to the Lower Kimmeridgian. L. lamellosus occurs in the Alpine-Mediterranean province as well as in the non-Alpine regions of Europe. Lately it has been reported by Pozzi, 1965, from the Isle of Rhodes.

Lamellaptychus murocostatus TRAUTH, 1938
(Plate 3, Figure 1a-b, Text-figure 3)

1929 Lamellaptychus murocostatus TRAUTH, p. 77.
1938 Lamellaptychus murocostatus TRAUTH, pl. 10, fig. 21-22, p. 142.

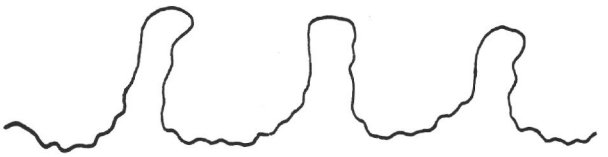

Figure 3. *Section across the wall-like laminae of Lamellaptychus murocostatus TRAUTH 5.58X.*

The holotype is derived from the Tithonian of the Roten Berg near Vienna.

This characteristic form is represented by a left valve from Sample 11-105-37-2, 34 to 36 centimeters (5856.85 meters) which lay with its convex side downwards. The core had to be embedded in plaster in order to free the convex side from sediment. Unfortunately the dorsal region of the valve is partly destroyed.

After reconstruction the measurements are: width-index (W:H) = 0.53, symphysal-index (S:H) = 0.91.

The laminae follow precisely the outline of the lateral margin. They are, however, not superposed one upon another, but stand vertically like walls or are even very slightly overturned. Their upper edges are flattened and partly, slightly inclined towards the apex (Text-figure 3). Along an axis, which meets the symphysis near the apex at an angle of 20°, the laminae bend towards the symphysal margin, where they terminate against a narrow symphysal plate. The broad furrows separating the vertical laminae display a pattern of wrinkles and pustules. The first ones usually form a right angle with the laminae and rise upon their sides.

Lamellaptychus beyrichi (OPPEL, 1865)
(Plate 2, Figure 3a-b)

1865 Aptychus Beyrichi OPPEL, p. 547.
1867-81 Aptychus profundus MENEGHINI, pl. 25, fig. 3-6-8a-b, p. 125.
1868 Aptychus Beyrichi OPPEL, Zittel, pl. 1, fig. 16-19, p. 54.
1868-76 Aptychus Beyrichi OPPEL, Gemmellaro, pl. 3, fig. 17, p. 25.
1873 Aptychus Beyrichi OPPEL, Gillieron, pl. 9, fig. 9a-b, p. 237.
1875 Aptychus Beyrichi OPPEL, Favre, pl. 7, fig. 10-11, p. 52.
1875 Aptychus imbricatus PILLET et FROMENTEL, pl. 3, fig. 6, p. 27.
1880 Aptychus Beyrichi OPPEL, Favre, pl. 3, fig. 17-19, p. 42.
1927 Aptychus (= Lamellaptychus) Beyrichi OPPEL, Trauth, p. 173.
1938 Lamellaptychus beyrichi (OPPEL), Trauth, pl. 9, fig. 5-5a, pl. 10, fig. 5-9, p. 134 (refigured from PILLET et FROMENTEL).
1958 Lamellaptychus beyrichi (OPPEL), Cuzzi, pl. 1, fig. 3-5a, p. 265.
1962 Lamellaptychus beyrichi (OPPEL), Gasiorowski, pl. 6, fig. 45-46.
1963 Lamellaptychus beyrichi (OPPEL), Bachmayer, pl. 1, fig. 4, p. 126.
1964 Lamellaptychus, group A, beyrichi (OPPEL), Turculet, pl. 2, fig. 7-9, pl. 3, fig. 1-6, p. 59.
1965 Lamellaptychus beyrichi (OPPEL), Pozzi, pl. 86, fig. 1-2, p. 864.

The Lamellaptychus drawn by Pillet and Fromentel, 1875, and refigured by Trauth, 1938 (pl, 10, fig. 5) compares satisfactorily with the specimen from Sample 11-105-34-3, 114 to 115 centimeters (5832.15 meters).

Measurements: width-index (W:H) = 0.57, symphysal-index (S:H) = 0.94, apical angle 94°.

Most of the laminae thin out along the gentle symphysal slope, and end along the symphysis. They are affected here by an inflection (Plage 2, Figure 3b). The few laminae terminating along the lateral margin are very slightly sigmoidal. As far as observed on our specimen, the bottoms of the furrows have no sculpture.

Lamellaptychus beyrichi has been observed on various occasions together with ammonites belonging to the genus *Haploceras*. Such occurrences have been mentioned by Zittel (1868, p. 55) and Retowski (1891, p. 220).

Occurrence: According to the observations from Gasiorowski (1962, pl. 6) in the Carpathians, L. beyrichi is restricted to Horizon 6, corresponding to the Tithonian. In Europe this form occurs abundantly in the Alpine-Mediterranean province and has been mentioned from the Crimea Peninsula, the Alps of Austria and Switzerland and also from Italy, Greece, Rhodes, Spain and Morocco. L. beyrichi seems to be restricted to the Kimmeridgian and more particularly to the Tithonian of the Mediterranean province.

Lamellaptychus cf. lamellosus (PARKINSON)
(Plate 2, Figure 2a-b)

A right valve with a lamina pattern characteristic of Lamellaptychus lamellosus and an outline tending towards Lamellaptychus inflexicostatus latus TRAUTH, 1938 (pl. 12, fig. 6, p. 170) has been found from Sample 11-105-33-2, 86 to 88 centimeters (5821.38 meters).

Measurements: width-index (W:H) = 0.63, symphysal-index (S:H) = 1. The apical angle is about 90°.

The bottoms of the furrows of the present form are covered by a very thin "upper layer" composed of dense calcite. The photograph (Plate 2, Figure 2b), made under water, shows the polygonal ends of the prismatic tubes shining through the calcite.

Also here, beautifully preserved Radiolaria are lodged between the furrows; one is visible in the lower right corner of Figure 2b.

We may assume that this valve is more closely related to L. lamellosus than to L. inflexicostatus TRAUTH (pl. 12, fig. 2-4, p. 168). It might represent a broader variety of L. lamellosus.

Lamellaptychus rectecostatus crassocostatus
TRAUTH, 1938
(plate 3, Figure 2a-c)

1938 Lamellaptychus rectecostatus (PETERS) var. crassocostata TRAUTH, pl. 10, fig. 4, p. 133.

The dorsal part of the holotype is not preserved and Trauth reconstructed the valve. The Site 105 specimen, found from Sample 11-105-33-3, 44 to 45 centimeters (5829.45 meters), was slightly damaged owing to its position just near the rim of the core.

Measurements: width-index (W:H) = 0.57, symphysal-index (S:H) = 0.80, apical angle 105°.

The width-index corresponds exactly to the approximation arrived at by Trauth.

The variety is distinguished from the type (Lamellaptychus rectecostatus PETERS, 1854) by wider furrows separating the gentle, dipping laminae. The ventral margin is reached by seven straight laminae. A weak imbrication crossing the flank is present on the dorsal half of the valve. The axis of this feature meets the symphysis at an angle of about 40°. The furrows show no signs of sculpture at their bottoms (Plate 3, Figure 2c).

Attention might be drawn to a sessil *Bullopora* (Plate 3, Figure 2b).

Occurrence: This form is known from red aptychi-limestone on the Roter Berg near Vienna (Kimmeridgian-Tithonian).

Aptychi from the Lower Cretaceous

Among the Lamellaptychi from the Upper Jurassic from Site 105, none have a flank depression or a retroverse lamina-pattern. The Lamellaptychi derived from the Lower Cretaceous, however, are all characterized by a flank depressions and a retroverse lamina-pattern. The two groups of aptychi are separated by 128 meters of sediment.

All the Lamellaptychi described hereafter come from Core 18, which was taken between 5682 and 5691 meters. Within this interval white to dark gray, partly slumped, argillaceous calcilutite, also mainly composed of calcareous nannoplankton, predominate. Throughout Core 18 small fragments of carbonized plant remains are abundant.

Lamellaptychus seranonis (COQUAND, 1841)
(Plate 3, Figures 4, 5a-c)

1841 Aptychus Seranonis COQUAND, pl. 9, fig. 13, p. 390.
1858 Aptychus Seranonis (COQUAND), Pictet *et* Loriol, pl. 11, fig. 1-2, 4, 7-8, p. 48.
1921 Aptychus cubanensis O'CONNELL, fig. 9-13, p. 9.
1929 Lamellaptychus Seranonis (COQUAND), Trauth, p. 79.
1936a Lamellaptychus seranonis (COQUAND), Trauth, p. 73.
1938 Lamellaptychus seranonis (COQUAND), Trauth, pl. 13, fig. 27-29, p. 193.
1942 Lamellaptychus seranonis (COQUAND), Imlay, pl. 11, fig. 4, 6, p. 1460.
1962 Lamellaptychus seranonis (COQUAND), Gasiorowski, table 1, pl. 8, fig. 13-14.

Two specimens from Sample 11-105-18-4, 74 to 75 centimeters (5687.25 meters) and Sample 11-105-18-5, 38 to 39 centimeters (5688.39 meters) are present. They are both small but of different sizes, and might therefore be interpreted as juvenile. They partly are impregnated with pyrite.

Measurements: Plate 3, Figure 4: width-index (W:H) = 0.43, symphysal-index (S:H) = 0.87, apical angle = 105°. Plate 3, Figure 5a: width-index (W:H) = 0.44, symphysal-index (S:H) = 0.88, apical angle = 104°.

The small and thin valves are destroyed along their dorsal margins, and had to be reconstructed, which affects the determinations of the apical angles. The W:H ratio coincides with that of the Lamellaptychus angulocostatus described hereafter. In contrast to L.

angulocostatus, the thickness of the valves does not increase, at least at this juvenile stage, towards the ventral margin; and, high facets are therefore not developed. For the same reason a lateral facet cannot be seen. The laminae follow precisely the lateral margin of the valve and bend into a rounded arch towards the symphysis, which they meet at an acute angle. The lamina-pattern is thus typically retroverse. The furrows are covered by the slightly inclined laminae, which overlie each other like tiles. Fine stripes crossing over the laminae, as well as over the furrows, are recognizable (Plate 3, Figure 5c). They coincide with the growth lines of the concave side and reflect the concentric growth segments.

Comparing the pair of valves (Plate 3, Figure 5a) we can observe considerably different course of the laminae. The right valve (left on the photograph) possesses a well-developed inflection following the axis of the lateral depression. Nothing of this feature is visible on the left valve (right on the photograph); also, the bending of the laminae occurs slightly differently on each of the two valves: on the right one the bend of the laminae is markedly less regular and more angular, compared with the left one.

Occurrence: In the Carpathians, according to Gasiorowski (table 1, p. 22), Lamellaptychus seranonis is restricted to the Upper Valanginian and Lower Hauterivian. Trauth (1938, p. 196) mentioned this form from the Neocomian of the Alpine-Mediterranean region. It occurs in the Austrian and Swiss Alps, in Southern France and Southern Spain. It also is recorded by Trauth (1936a) from Cuba. Imlay (1942) describes this form from the Viñales Limestone, which reaches a thickness of 1700 to 5000 feet (p. 1420) and which, based on Ammonite faunas, is regarded to be of Portlandian (Tithonian) age (table 5, p. 1438).

Imlay (p. 1429) states that "most of the aptychi are identical with species from Southern Europe. The affinities of the normal ammonites are predominantly with the late Jurassic ammonites of Mexico and Argentina and to a lesser extent with those of the Alpine-Mediterranean province. The affinities of the uncoiled ammonites and aptychi are predominantly with the early Lower Cretaceous faunas of the Alpine-Mediterranean province and slightly with any known late Jurassic faunas". These observations leave it uncertain as to whether the aptychi-fauna in the Viñales Limestone really derives from the same levels as the ammonites.

Recently the Viñales Limestone has been revised by Judoley and Furrazola-Bermudez, 1965, (fig. 1). Its upper 250 to 300 meters, with abundant Aptychi, are separated under the name Artemisia Formation. The age of this interval, not studied in detail by the authors, is considered to be Lower to Middle Tithonian.

Lamellaptychus angulocostatus (PETERS, 1854)
(Plate 4, Figure 1a-b)

1854 Aptychus angulocostatus PETERS, p. 440.
1858 Aptychus angulocostatus PETERS, Pictet *et* Loriol, pl. 10, fig. 3. (reproduced by Trauth, pl. 14, fig. 12), 5a-c, 6a-d, 7, 8b-d, 9, 10-12, p. 46.
1892 Aptychus angulocostatus PETERS, Toula, pl. 6, fig. 11, p. 34.
1921 Aptychus pimientensis O'CONNELL, fig. 15-16, 18, p. 10.
1927 Aptychus (Lamellaptychus) angulicostatus PETERS, Trauth, p. 77.
1929 Lamellaptychus angulocostatus (PETERS), Trauth, p. 77.
1936a Lamellaptychus angulocostatus (PETERS), Trauth, p. 70 (Cuba).
1938 Lamellaptychus angulocostatus (PETERS), Trauth, pl. 14, fig. 12-13, p. 204.
1942 Lamellaptychus angulocostatus (PETERS), Imlay, pl. 11, fig. 8-10, p. 1459.
1957 Lamellaptychus angulocostatus (PETERS), Cassinis, pl. 12, fig. 1a-b, p. 236.
1962 Lamellaptychus angulocostatus (PETERS), Gasiorowski, table 1; pl. 8, fig. 1-4.

Lamellaptychus angulocostatus differs from L. seranonis by its acute angled laminae. The two valves of the specimen in hand display distinct differences in their lamina-patterns. On the left valve the laminae are not inflected along the weakly developed lateral depression, whereas on the right valve a clear inflection is developed. Moreover, the turn of the laminae is acute-angled on the right valve compared to rather rounded (seranonis-like) on the left. These differences point to the variability of the sculpture, at least for this group of aptychi of the Lower Cretaceous.

The pair of valves was found in Sample 11-105-18-4, 95 to 97 centimeters (5687.47 meters).

Measurements: width-index (W:H) = 0.47, symphysal-index (0.98), apical angle 0.98°. These figures coincide well with Trauth's observations, which indicate a width-index between 0.40 and 0.56.

An enlarged view (Figure 1b) of the wide flat furrows separating the laminae at their turn in a retroverse position shows the open polygonal ends of the prisms composing the "middle layer"; they are not covered by a layer of calcite, as on the forms discussed from the Upper Jurassic.

Small tetrahedrons of sphalerite as well as poorly crystallized marcasite are present on the surface of the valves.

The Site 105 specimen agrees in form and sculpture well with the one figured by Imlay (pl. 11, fig. 8) from the Viñales Formation from Cuba.

Occurrence: Lamellaptychus angulocostatus is widely distributed in the Alpine-Mediterranean province. According to Trauth (1938, p. 207) it is especially abundant during the Hauterivian. Within sediments of Barremian age this form appears rarely. From the Carpathians Gasiorowski (table 1) mentions L. angulocostatus from the uppermost Valangian and the Hauterivian (Horizon 8). From Cuba it has been recorded by Trauth (1936a) from various localities. The specimens described by Imlay (1942) were collected from the Viñales Limestone assumed to be of Portlandian (Tithonian) age. From the Southern Alps Cassinis (1957, p. 227) reports this form from the Valangian-Hauterivian (Maiolica facies).

Lamellaptychus cf. angulocostatus (PETERS)
(Plate 4, Figure 5)

A very small, apparently juvenile specimen from Sample 11-105-18-5, 28 to 29 centimeters (5688.29 meters) might be united with Lamellaptychus angulocostatus. Its height reaches only 5.5 millimeters and its width 2.5 millimeters. The measurements are: width-index (W:H) = 0.45, symphysal-index (S:H) = 0.85, apical angle 106°.

The width-index coincides with the type; the symphysal-index, however, is lower, possibly due to the small size of the valve.

Both valves are partly impregnated by impure pyrite, and the concave sides of the valves are coated, also, with this ore. A part of the left valve has been turned to make this coating visible.

Lamellaptychus angulocostatus atlanticus
(HENNIG, 1913)
(Plate 4, Figures 2a-b, 3, 4)

1913 Aptychus atlanticus HENNIG, pl. 2, fig. 1a-b, p. 155.
1936a Lamellaptychus angulocostatus var. atlantica (HENNIG), Trauth, p. 72 (Cuba).
1938 Lamellaptychus angulocostatus var. atlantica (HENNIG), Trauth, pl. 14, fig. 19, p. 210.
1962 Lamellaptychus angulocostatus var. atlantica (HENNIG), Gasiorowski, pl. 8, fig. 11.

This variety of Lamellaptychus angulocostatus has been recovered from three levels:

11-105-18-4, 126 to 127 centimeters (5687.77 meters), pl. 4, fig. 4;

11-105-18-5, 28 to 29 centimeters (5688.29 meters), pl. 4, fig. 3;

11-105-18-5, 131 to 132 centimeters (5689.32 meters), pl. 4, fig. 2.

Measurements: Plate 4, Figure 2a: width-index (W:H) = 0.46, symphysal-index (S:H) = 0.94, apical angle 100°. Plate 4, Figure 3: width-index (W:H) = 0.49, symphysal-index (S:H) = 0.93, apical angle 98°.

The example on Plate 4, Figure 3 might represent this form typically. During the juvenile stage the laminae are acute-angled as in L. angulocostatus. Their outline changes towards the ventral margin into broad, backwardly directed curves as in L. seranonis. The rim of the laminae are irregularly fringed and they are separated by narrow furrows not covered by an outer layer. A fine lineation indicates the growth segments.

On the left valve reproduced on Plate 4, Figure 2a the acute-angled laminae persist until near the ventral margin, changing there rather abruptly into smooth rounded bends. This pattern is more related to the type of L. angulocostatus. The rather flat furrows separating the laminae are wider and they expose the polygonal ends of the tubes very clearly. A linear pattern crossing over the laminae suggests the surfaces of the concentric growth segments (Plate 4, Figure 2b).

A pair of valves (Plate 4, Figure 4) which, however, is partly destroyed merits some attention. On the left valve the laminae are acute-angled whereas they turn around in a smooth bend on the right valve, which very much resembles the holotype from the Cape Verde Islands (Hennig, pl. 2; fig. 1a-b).

Occurrence: In the Carpathians the form is mentioned by Gasiorowski (1962; table 1 and pl. 8, fig. 11) from Horizon 8, corresponding to the Valanginian-Hauterivian. Trauth has recorded this form in the Neocomian of the Austrian, Swiss, and French Alps. The occurrence in the Neocomian from the Cape Verde Islands is of special interest as the distance from this locality to Site 105 is only about 5500 kilometers. In Cuba this form has been mentioned by Trauth (1936a) from the Santa-Clara and the Pinar del Rio Provinces. Imlay (1942) described it from the Viñales Limestone.

Lamellaptychus angulocostatus atlanticusradiatus
TRAUTH, 1938
(Plate 3, Figure 3a-b)

1938 Lamellaptychus angulocostatus (PETERS) var. atlantica-radiata TRAUTH, pl. 14, fig. 20-25, p. 211.
1962 Lamellaptychus angulocostatus var. atlantica-radiata TRAUTH, Gasiorowski, pl. 8, fig. 6.

The dorsal part of this pair of valves, from Sample 11-105-18-4, 140 to 142 centimeters (5687.92 meters) has unfortunately been cut off. The retroverse laminae with fringed rims form an obtuse angle, which then changes into a rounded bend towards the ventral margin of the valve. On the gentle slope towards the

symphysis several fine straight stripes can be recognized which begin, according to Trauth (p. 211), near the apex and terminate at the ventral margin. The external facet is as high and massively built as in L. angulocostatus (PETERS). Within the broad and flat furrows the linear arrangement of the pores reflects the concentric pattern of the growth segments (Plate 3, Figure 3b).

Radiolaria with their shell substance replaced by pyrite are lying on the surface of the valves.

Occurrence: In the Carpathians this form is known in Horizon 8, corresponding to the Upper Valanginian and Hauterivian (Gasiorowski, 1962). From Southern France it has been mentioned from the Barremian.

Lamellaptychus joides n. form
(Plate 4, Figure 6a-c.)

This apparently unknown form comes from Sample 11-105-18-5, 108 to 110 centimeters (5689.10 meters). Unfortunately the thin shelled dorsal margin and adjoining parts of the lateral margin are broken off.

Measurements: width-index (W:H) = 0.60, symphysal-index (S:H) = 0.86, apical angle 118°.

The laminae turn around in a wide rounded arch, which turns backwards towards the apex, just before reaching the symphysis. The lamina-pattern is dominated by straight stripes beginning in the middle of the valve and diverging radially towards the ventral margin. These stripes displace the laminae at their crossing points in such a way that hook-like features, pointing towards the apex, result (Text-figure 4). The laminae are very low, especially on the external half of the valve, where they are reduced to flat and narrow ridges which are separated by wide low furrows exposing the polygonal ends of the prismatic tubes composing the "middle layer" (Plate 4, Figure 6c).

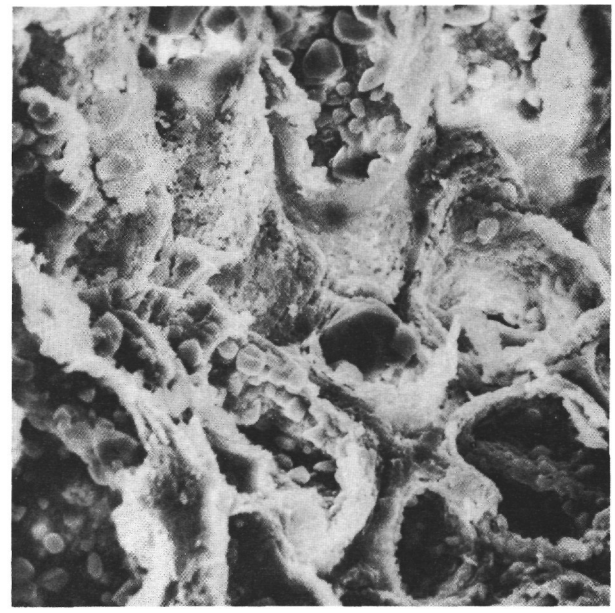

Figure 4. *A fresh broken surface across the layer of prismatic tubes of Lamellaptychus angulocostatus atlanticus TRAUTH (105-18-5, 28-29 cm). The inner walls of the tubes are coated with rounded calcite crystals, whereas the outer surfaces expose a dense pattern of small openings (middle upper part of the photograph). Stereoscan electron micrograph, 900X.*

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PLATE 1
Aptychi from the Upper Jurassic

Figure 1 — Flattened *Aspidoceras* possibly related to *A. pawlowi*, described by Burckhardt, 1912 (pl. 19, fig. 1-3, 5, 9, p. 77) from the San Pedro Formation, Kimmeridgian, Mexico. Core 37 from 5856.30 meters, nat. size.

Figure 2 — a: Laevaptychus sp., group of Laevaptychus latus (PARKINSON, 1811), pathological specimen. Core 37 from 5861.35 meters. 2.67X.
b: Outer convex surface showing larger and smaller pores. 15X.
c-d: Inner concave surface with very small pores. 2c=30X, 2d=15X.

Figure 3 — Laevilamellaptychus of *Haploceras aporus* (Oppel, 1863), outer surface of a slightly crushed left valve. Core 37 from 5857.57 meters. 5.58X.

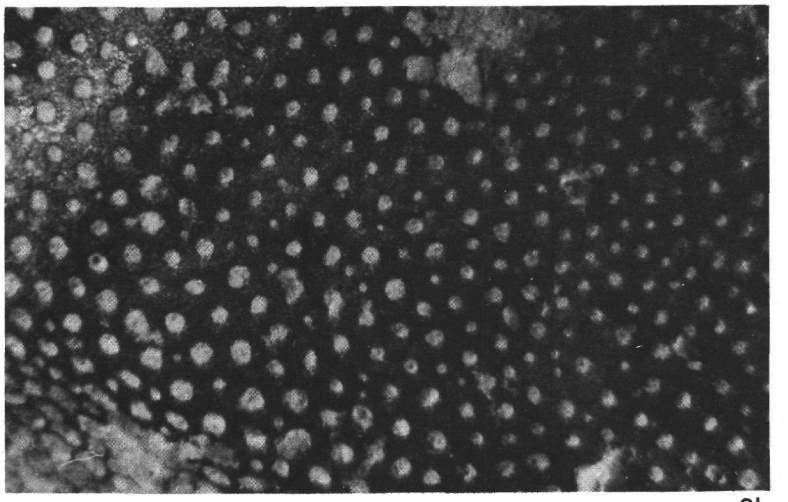
Figure 4 — a: Laevilamellaptychus of *Haploceras aporus* (Oppel, 1863), outer surface without sculpture. Core 37, from 5857.57 meters. 6X.
b: Concave inner side. 6X.

Figure 5 — a: Punctaptychus punctatus (VOLTZ, 1837), outer surface of a right valve. Core 33 from 5821.41 meters. 2X.
b: Concave inner surface with growth lines. 2X.
c: Transition of the punctuated to the laminated surface of the valve. 15X.

Figure 6 — a: Punctaptychus sp. juv., outer surface of the left valve. Core 37 from 5863.56 meters. 6X.
b: Inner surface. 6X.
c: Thin-ribbed layer covering the lamellac of the concave surface. Stereoscan electron micrograph. 50X.

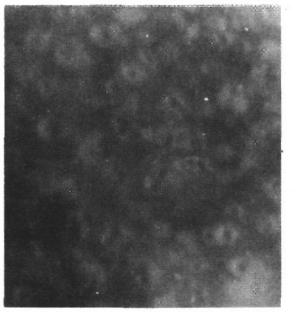
PLATE 1

1



2b

2a



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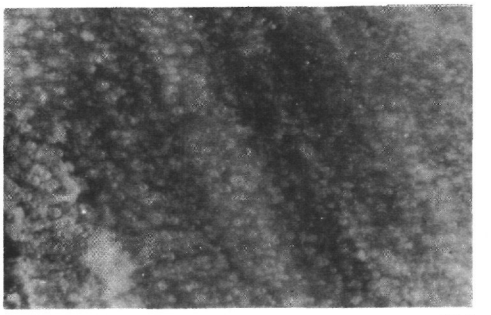

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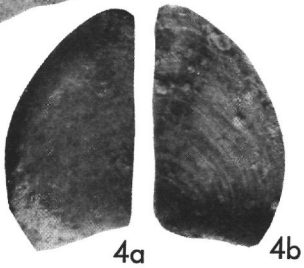
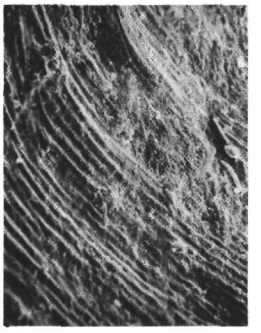


4a

4b

3



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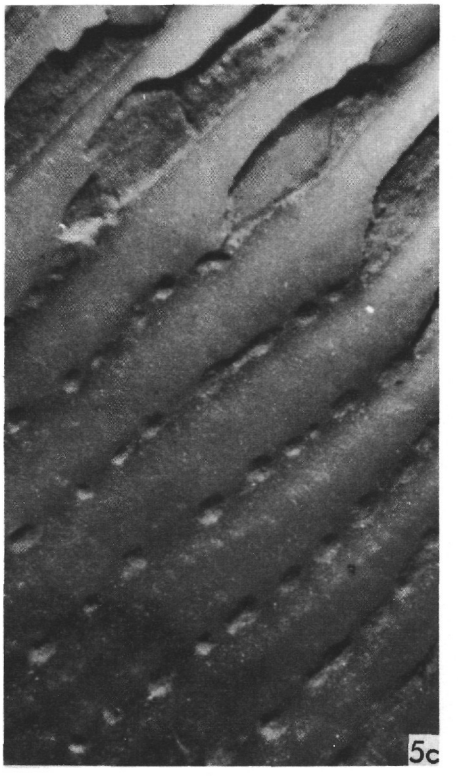
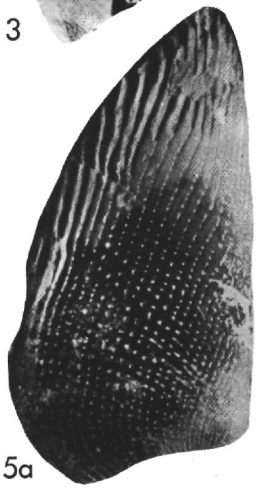


5c

5b



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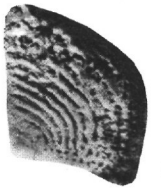

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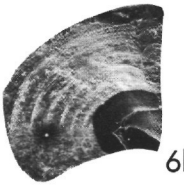


6b

PLATE 2
Aptychi from the Upper Jurassic

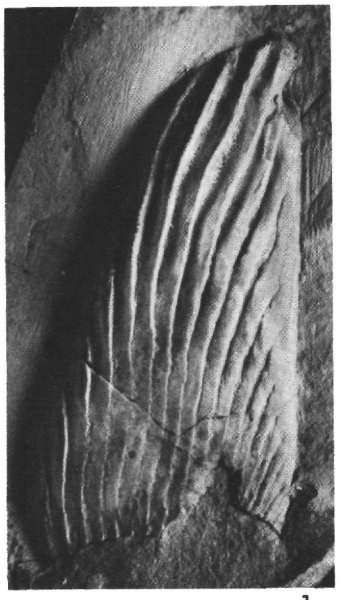
Figure 1 — a: Punctaptychus monsalvensis TRAUTH, 1935, right valve. Core 36 from between 5846 and 5847.50 meters. 2X.
b: Outer surface showing the transition from the punctated to the laminated surface. The rims of the laminae are irregularly fringed. 15X.

Figure 2 — a: Lamellaptychus c. lamellosus (PARKINSON, 1811), right valve. Core 33 from 5821.38 meters. 2X.
b: Outer surface at the inflexion of the laminae. The tops of the prisms shine through a thin layer of calcite (photographed below water). 15X.

Figure 3 — a: Lamellaptychus beyrichi (OPPEL, 1865), left valve. Core 34 from 5832.75 meters. 2X.
b: Outer surface at the inflexion of the laminae. The bottom of the furrows is not sculptured. 10X.

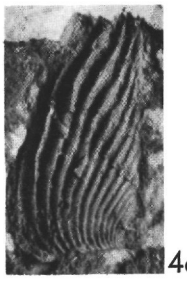
Figure 4 — a: Lamellaptychus lamellosus (PARKINSON, 1811), right valve. Core 37 from 5863.56 meters. 2X.
b: Concave inner side of the valve. 2X.
c: Detail of outer surface with Radiolaria between the lamellae. 15X.

PLATE 2



1a

2a



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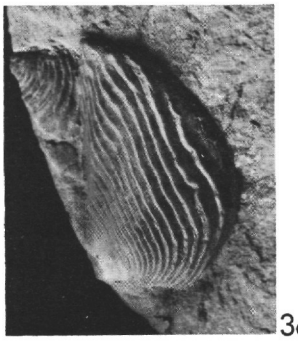

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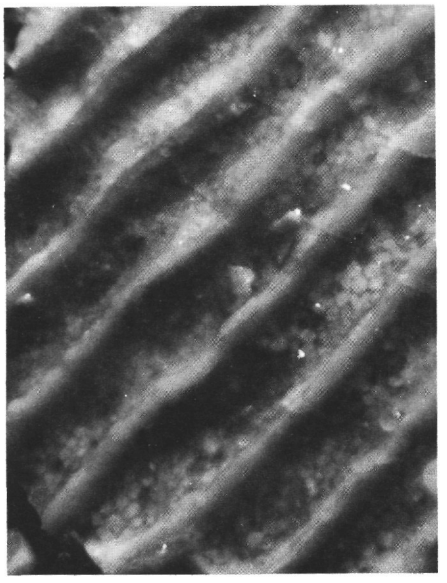
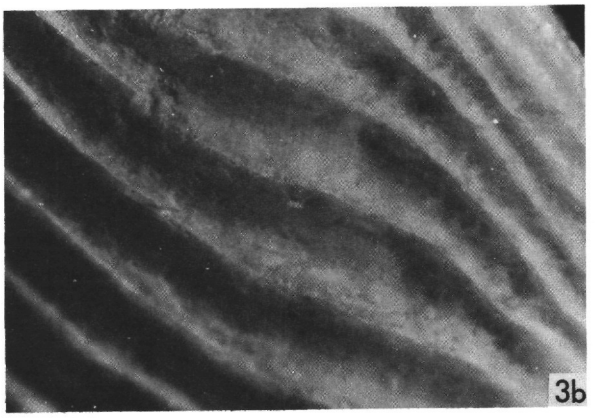
4b



2b

1b

4c



3b

PLATE 3

Aptychi from the Upper Jurassic

Figure 1 — a: Lamellaptychus murocostatus TRAUTH 1938, left valve. Core 37 from 5856.86 meters. 2X.
b: Concave inner side of the valve. 2X.

Figure 2 — a: Lamellaptychus rectecostatus crassocostatus TRAUTH, 1938, right valve. Core 33 from 5822.45 meters. 2X.
b: A sessile *Bullopora* (foraminifera) within a furrow. 15X.
c: Outer surface without any signs of sculpture. 15X.

Aptychi from the Lower Cretaceous

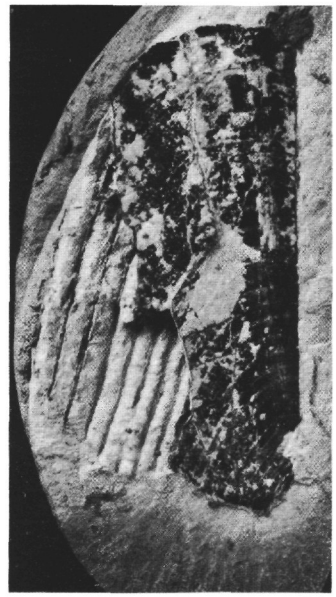
Figure 3 — a: Lamellaptychus angulocostatus atlanticus radiatus TRAUTH, 1938. Lying at the edge of the core; the dorsal halves of the valves were cut off. Core 18 from 5687.92 meters. 2X.
b: Outer surface with the tops of the prisms exposed within the furrows. A lineation oblique to the laminae indicates the growth segments. 15X.

Figure 4 — Lamellaptychus seranonis (COQUAND, 1841). Core 18 from 5687.25 meters. 2X.

Figure 5 — a, b: Lamellaptychus seranonis (COQUAND, 1841). Core 28 from 5688.39 meters. 5a=2X; 5b=4X.
c: Outer surface of the ventral half of the valve. The faintly indicated lines crossing over the laminae might reflect the growth segments.

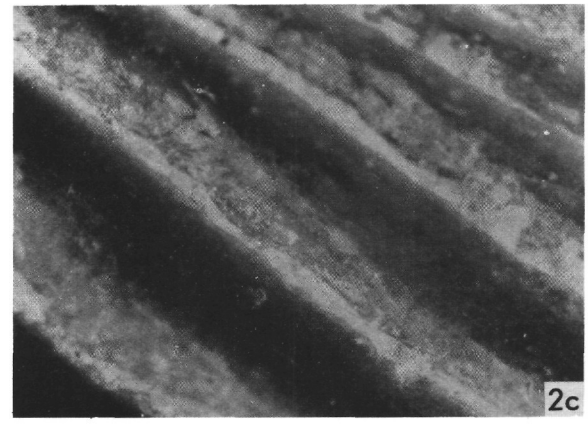
PLATE 3


1a


1b


2a


2b

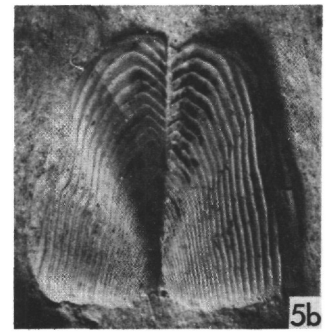

2c


3a


3b


4


5a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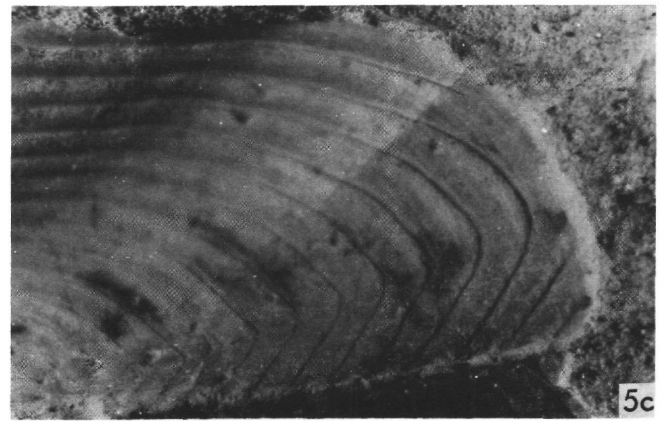

5c

PLATE 4

Aptychi from the Lower Cretaceous

Figure 1 — a: Lamellaptychus angulocostatus (PETERS, 1854), a pair of valves. Core 18, from 5687.47 meters. 2X.
b: Outer surface at the turn of the laminae. The tops of the prisms from the "middle layer" are exposed within the furrows. 15X.

Figure 2 — a: Lamellaptychus angulocostatus atlanticus (HENNIG, 1913), left valve. Core 18 from 5689.32 meters. 2X.
b: Outer surface at the turn of the laminae. The uncovered tops of the prisms are exposed. 15X.

Figure 3 — Lamellaptychus angulocostatus atlanticus (HENNIG, 1913), a more densely laminated left valve. Core 18 from 5688.29 meters. 2X.

Figure 4 — Lamellaptychus angulocostatus atlanticus (HENNIG, 1913), a partly destroyed pair of valves. Core 18 from 5687.77 meters. 2X.

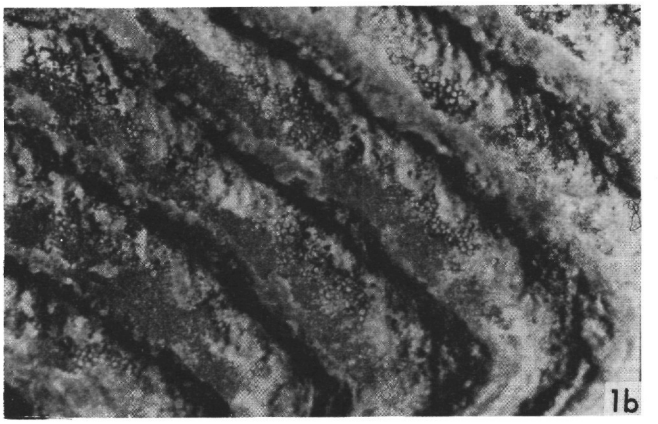
Figure 5 — Lamellaptychus cf. angulocostatus (PETERS), a small, possibly juvenile specimen. The black coating on the inner side of the right valve (left side of photograph) is pyrite. Core 18 from 5688.29 meters. 3X.

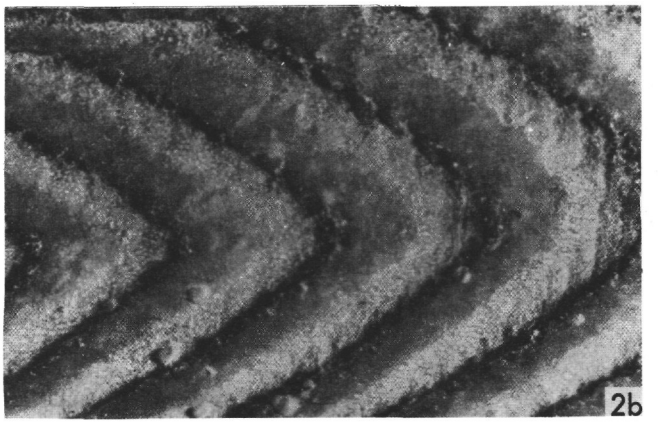
Figure 6 — a, b: Lamellaptychus joides n. form, right valve. Core 18 from 5689.10 meters. 6a=2X; 6b=6X.
c: Outer surface towards the ventral margin, where the laminae are replaced by low ridges. Most of the surface is covered by the ends of the prismatic tubes of the "middle layer". Core 18 from 5689.10 meters. 15X.

Figures 7-9 — Plates of *Scalpellidae*, possibly belonging to *Zeugmatolepas* Withers, 1913. Core 37 from 5861.35 meters. 6X.

PLATE 4

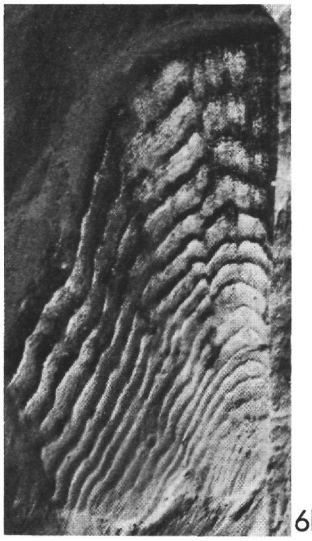

1a


1b


2b

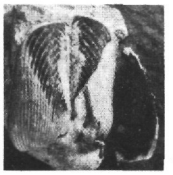

2a


3

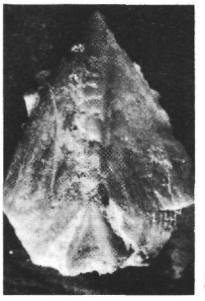

6b


6c


4


5


7


8


9


6a