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A correlation of the Tethyan Maiolica Formation of the Breggia section (southern Switzerland) with Early Cretaceous coccolith oozes of Site 534A, DSDP Leg 76 in the western Atlantic

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ABSTRACT

The aptychi of the type section of the Maiolica Formation in southern Switzerland were investigated and compared with the aptychi previously described from the Blake-Bahama Formation (Leg 76, Hole 534A and Leg 44, Hole 391C) in the western Atlantic. The base of the two formations is given by the conspicuous colour change from red to white which marks the top of the Rosso ad Aptici Formation and of the Cat Gap Formation, respectively.

56 forms of aptychi are figured and described (Pl. 1–5). They indicate Tithonian, Berriasian, Valanginian, Hauterivian and Barremian ages.

Aptychi provided the means of recognizing the approximate boundaries between the Early Cretaceous stages Berriasian, Valanginian, Hauterivian and Barremian in the Maiolica type section and in the Blake-Bahama Formation. The much smaller thickness of the Maiolica with respect to the coeval Blake-Bahama Formation is interpreted largely to be due to reduction by diagenetic processes which took place under an overburden of several kilometers.

ZUSAMMENFASSUNG

Die Aptychen aus dem Typusprofil der Maiolica-Formation in der Südschweiz wurden untersucht und verglichen mit früher beschriebenen Aptychen aus der Blake-Bahama-Formation von Leg 76, Hole 534A, und von Leg 44, Hole 391C, im westlichen Atlantik. Die Basis der beiden Formationen ist durch einen auffallenden Wechsel in der Farbe von Rot zu Weiss gegeben, welcher die Obergrenze der Rosso-ad-Aptici-Formation gegen die Basis der Maiolica-Formation abgrenzt.

Die Aptychen erlauben eine vorläufige Abgrenzung von Tithon zu Berriasian, Valanginian, Hauterivian und Barremian am Typusprofil der Maiolica-Formation und ebenso in der Blake-Bahama-Formation. Die auffallend geringe Mächtigkeit der Maiolica-Formation verglichen mit der gleichaltrigen Blake-Bahama-Formation ist grösstenteils auf diagenetische Prozesse zurückzuführen, welche die überlagernden, einige Kilometer mächtigen Sedimente beeinflussten.

56 Formen von Aptychen wurden beschrieben und abgebildet (Tf. 1–5). Diese weisen auf die Stufen Tithon, Berriasian, Valanginian, Hauterivian und Barremian.

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A. Introduction

The Jurassic and Lower Cretaceous deep water sediments of the Tethyan realm are underlain by sediments of a complex southern Tethyan margin, while coeval Jurassic sediments in the Blake-Bahama area rest on oceanic basement. Uniform conditions of deep water sedimentation testify to the connection between Tethys and the early Atlantic created during the Jurassic. They are reflected in the similarity of the macrofaunal contents of the Maiolica and the Blake-Bahama Formation which instigated the present study.

In a contribution for Volume 76 of the Deep Sea Drilling Project several ammonites and aptychi, assembled from Holes 391C and 534A in the Blake-Bahama Basin, east of the Blake Plateau, were described (Renz 1978, p. 899–909, and Renz 1983, p. 639–643). The age of the fossils ranges from Late Jurassic to Early Cretaceous. Based on the results, a correlation with other DSDP holes in the Atlantic and with a surface section in the Lombardian Alps was attempted.

An appropriate surface section in the Lombardian Alps is exposed in the river Breggia, located in southern Switzerland, next to the Italian border (Fig. 3). In this section, deep water pelagic carbonates of Late Jurassic to Early Cretaceous age are referred to as the Rosso ad Aptici Formation (Tithonian) below, and the Maiolica Formation (earliest Berriasian to Barremian) above.

Since the last century both formations have been studied extensively, in particular, their microfaunas and sedimentology. Among the more recent papers are those of Bernoulli (1964), Weissert (1979), and Winterer & Bosellini (1981). The present paper focusses on biostratigraphy of the Maiolica Formation of the Breggia section, where, thanks to numerous new finds of aptychi by the authors, the subdivision of the Early Cretaceous has now been improved, and this in turn allowed a more detailed correlation with the coeval strata of DSDP Site 534A and 391C.

The river Breggia section was selected by Weissert (1979, p. 28, Fig. 3, 2) as type section of the Maiolica Formation (Lombardian sector). Weissert was the first worker who collected aptychi systematically and indicated their position within the Breggia section. This collection was used for the contribution in Volume 76, DSDP (p. 639–644). Additional material was collected by the present authors in the Breggia section. The authors have endeavoured to include in the present publication illustrations of all representative fossils collected by them and by WEISSERT. An improved stratigraphic succession of Early Cretaceous aptychi has been established. This will serve as an indispensable base for a realistic taxonomy of this hitherto little known group of fossils.

B. Initial Reports of the Deep Sea Drilling Project, Leg 76, Site 534A in the Blake-Bahama Basin

Hole 534A of Leg 76 was drilled in the Blake-Bahama Basin, about 500 km east of Florida (latitude 28°20.6′ N; longitude 75°37.00′ W), from where remains of cephalopods were also obtained. The purpose of Hole 534A was to reach the oceanic basement and to determine the oldest sediments deposited over it, assumed to be of Middle Jurassic age.

a) Late Jurassic Cat Gap Formation

In DSDP Hole 534A the limit separating Jurassic from Cretaceous sediments coincides about with a change in facies from red-greyish claystones into light grey calcareous siltstones and claystones. The sequence is little altered diagenetically.

The limit separating red from greyish sediments seems to be connected with a regionally synchronous event, reflected in several holes in the Atlantic, as well as in Tethyan surface sections in southern Europe (BERNOULLI 1972).

In the western Atlantic the brick-red to purplish sediments are referred to as the Cat Gap Formation (Core 51 to Core 91 in Hole 534A). The type section is situated east of the Bahama Banks. The formation attains a thickness of 153 m in Hole 534A. Conchs of ammonites are destroyed by solution, aptychi on the other hand show no indication of being dissolved. Water depth was greater than the Aragonite Compensation Depth.

In the upper part of the Cat Gap Formation, in Core 96, *Lamellaptychus beyrichi* (OPPEL) was recovered. It represents a characteristic form, indicating a Late Jurassic (Tithonian) age. Identical specimens occur abundantly in the Breggia section and in the Apennines (KÄLIN et al. 1979, p. 748, Fig. 11) in lithologically very similar sediments.

b) Early Cretaceous Blake-Bahama Formation

The red Tithonian sediments of the Cat Gap Formation in Hole 534A are followed by the Blake-Bahama Formation, covering the interval between Core 51 to Core 91 (360 m). The sediments consist predominantly of soft, laminated, light grey to whitish pelagic marls, calcareous siltstones and claystones, which are little altered diagenetically.

Lamellaptychi are scattered all over the formation. 15 different forms were isolated. Ammonites are represented by four species, of which two are of considerable value for regional correlation. From the top of the formation, in Core 51, a small-sized *Pulchellia,* indicating a late middle Barremian age, was obtained. In previous publications the respective interval was interpreted as Hauterivian. Furthermore, a fragment of *Neo-*

comites in Core 80, indicating Valanginian, is of great help in interpreting the Berriasian–Valanginian limit.

It is interesting to note that aptychi in the Atlantic are conspicuously accumulated within the interval considered to represent the Valanginian. This coincides also with the distribution of aptychi observed in the Breggia section (Fig. 2).

C. The Breggia section of southern Switzerland

a) Late Jurassic to Barremian post-rift sediments of the southern Tethyan margin

The Late Jurassic and Neocomian sediments of the Southern Alps formed part of the southern continental margin of a narrow Tethyan ocean. Three lithological units, all of them deep water sediments, are distinguished. In ascending order, these are: The Radiolarite Group, the Rosso ad Aptici Formation, and the Maiolica Formation. In a plate tectonic context, these sediments are part of the "Apulia" or "Adria" Plate which according to BIJU-DUVAL (1977) had been detached from the African mother plate in Early Jurassic. The rifting process at the northern end of the Apulian Plate resulted in the birth, probably during Middle Jurassic, of a narrow Tethyan ocean. Crustal stretching of its complex southern margin had been accompanied by the drowning of its shallow-water carbonate platforms during Late Triassic, Early and Middle Jurassic. By Late Jurassic, after the birth of the Tethyan ocean, a post-rift situation had been created with strike slip faulting becoming prominent, possibly due to the rotation of the Adria Plate. The Late Jurassic Tethyan ocean, perhaps subdivided by elongate cordilleras, lasted throughout the remainder of Jurassic time but ceased to widen during the Tithonian (WINTERER & BOSELLINI 1981) and Early Cretaceous. The great ophiolite masses of the Piemont, the Valais, Graubünden and the Malenco Valley – now incorporated in the Penninic and lower Austroalpine nappes – provide ample evidence of its existence. The absence of Mesozoic ophiolites in the Ticino sector is obviously due to later tectonics, such as large-scale uplift of the Penninic Ticino Alps during Late Tertiary and associated compression and strike-slip movement. Most prominent among these faults is the "Insubric line" which separates the Penninic and lower Austroalpine Alps from the Southern Alps with a down-to-the-south vertical offset estimated at 20 km in the Ticino sector (TRÜMPY 1980). The amount of alpine compression, too, seems to reach a maximum in this sector (SPICHER 1980).

The post-rift character of the Radiolarite Group, of the Rosso ad Aptici- and of the Maiolica Formation is reflected in their uniformly moderate thickness corresponding to slow subsidence and a calm tectonic regime (KÄLIN & TRÜMPY 1977, WEISSERT 1979, WINTERER & BOSELLINI 1981).

b) Water depth during Late Jurassic and Early Cretaceous

The Radiolarite Group was deposited below the Calcite Compensation Depth (BERNOULLI & JENKYNS 1974), the Rosso ad Aptici and the Maiolica Formation between the Aragonite Compensation Depth (ACD) and the Calcite Compensation Depth (CCD). The end-Jurassic ACD may have been at 1400 m, the CCD at 4200 m (WINTERER & BOSELLINI 1981); but the uncertainties inherent in their model preclude an exact

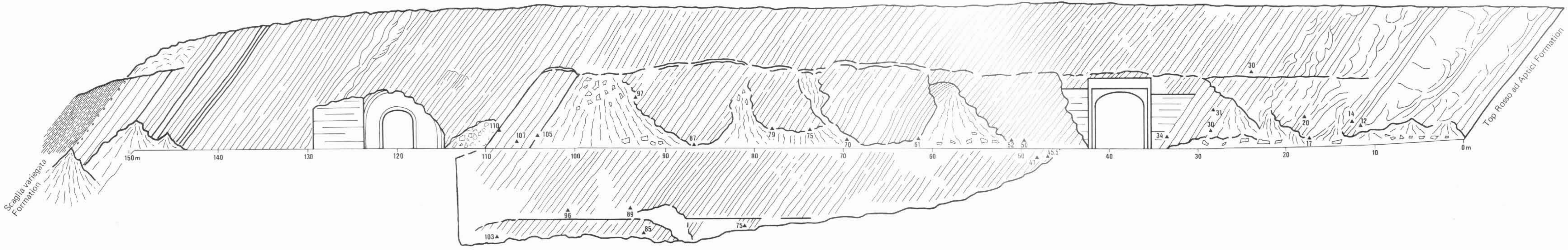

Fig. 1. Outcrop of the Maiolica Formation in the Breggia gorge in southern Switzerland.

definition of the depositional depth of these rock sequences. However, for the Maiolica Formation, the absence of Early Cretaceous planktonic Foraminifera suggests a depositional depth greater than the lysocline for Foraminifera which according to BERGER (1970, 1976) occurs between 2500 and 4500 m. The lysocline for coccolithophorids is presently assumed as deep as 4000 m (BERGER 1973, ROTH & BERGER 1975). These data are in favour of a great depth of deposition for the Maiolica, as it was proposed by BERNOULLI & JENKYNS (1974).

c) Late Jurassic Rosso ad Aptici Formation of the Breggia gorge

The Radiolarite Group (BERNOULLI 1964, p. 90) is overlain concordantly by the Rosso ad Aptici Formation, composed of purplish-red calcilutites and only 15 m in thickness.

Three thin intercalations of smectite are interpreted as devitrified cineritic tuffs (BERNOULLI 1980b). Most conspicuous are aptychi, occurring abundantly. The latest *Laevaptychus (L. latus)* was observed on the top layer of the formation which consists of a red-yellowish, resistant limestone, forming an outstanding dip slope. On its surface aptychi, indicating a late Tithonian age, are exposed abundantly (Pl. 1, Fig. 1).

d) Early Cretaceous Maiolica Formation of the Breggia gorge

At the end of late Tithonian a conspicuous change from red calcilutites (Rosso ad Aptici Formation) into white, platy, fine-grained, cherty limestones (Maiolica Formation) occurred. This facies is widely distributed in the western Tethys where it is also known by other names such as Biancone, Lattimusa, Aptychenkalk and Vigla Limestone (BERNOULLI & JENKYNS 1974).

The white limestones of the Breggia section are uniform in lithology and facies and attain a thickness of 130 m (WEISSERT 1979). The frequently intercalated chert nodules and layers are of vitreous- and grain-supported varieties. Among subordinate lithologies are white, thinly bedded limestones with dark grey, coaly films (75–79 m above base) and thin intercalations of dark grey to black, more or less bituminous shales in the uppermost part (BITTERLI 1965, WEISSERT 1979). Bedding is usually very pronounced, disturbed only occasionally by slumped intervals. Such subaquatic sliding is particularly evident within the basal 15 m of the section (Fig. 1). For detailed description of lithology and sedimentology the reader is referred to WEISSERT (1979).

Contact relationships: The contact of the Maiolica Formation with the underlying Rosso ad Aptici Formation is very distinct and favourably exposed (BERNOULLI 1964). The contact with the overlying Scaglia variegata Formation likewise is very distinct, indicating an abrupt facies change. A glauconitic hardground occurs at the boundary which may indicate an interruption in sedimentation (RIEBER 1977, WEISSERT 1979).

Fossil contents and age: Coccoliths and Radiolaria are the dominant microfossils. The latter are most abundant in grain-supported varieties of chert (WEISSERT 1979) while coccoliths are common in limestone where they occur together with diagenetic calcite. Calpionellids and calcispheres are subordinate microfossils restricted to the stratigraphically lower part of the Maiolica. Of the utmost stratigraphic importance is the occurence of aptychi throughout the section. As explained in chapter D of the present paper, it is now possible to establish a stratigraphic subdivision of the Early Cretaceous based on aptychi. Berriasian, Valanginian, Hauterivian, and Barremian have all been identified by aptychi. Of particular value is an ammonite of the genus *Pulchellia* of Barremian age in the uppermost Maiolica Formation (RIEBER 1977). It allows a safe correlation with Hole 534A in the Blake-Bahama Basin, from where this ammonite has been recognized at the top of the coeval Blake-Bahama Formation. *Pulchellia* indicates a Barremian age for the upper part of the Maiolica Formation, where among aptychi *Lamellaptychus angulocostatus* is representative. Within the white limestones of the Maiolica Formation the presence of Ammonites is indicated by faint impressions. During the present sampling a poorly preserved ammonite *(Neocomites)* was obtained to which a Valanginian age might be assigned (Pl. 5, Fig. 26).

Effects of diagnesis: From the results of DSDP Site 534A it has become evident that the Maiolica limestones originated from coccolith ooze by a succession of diagenetic processes. In the course of these, the very high porosity – up to 70% in calcareous oozes according to MATTER et al. (1975) – was reduced to zero by compaction.

e) Aptian(?) to late Cenomanian deep-water pelagic sediments

The Maiolica of the Breggia section is conformably overlain by 300 m of deep-water pelagic sediments known as Scaglia, a succession composed of varicoloured clays, marls, and marly limestones (GANDOLFI 1942, BITTERLI 1965). It includes one principal layer of bituminous siliceous shale containing fish remains and additional minor bituminous intercalations. On top of the Maiolica about 10–20 cm of greenish glauconitic marl indicates not only a sharp break in the character of sedimentation but possibly also a hiatus (BITTERLI 1965). An open-marine, quiet environment is suggested, with short episodes of oxygen-deficient, stagnant water.

f) Late Cenomanian to Campanian Flysch sediments

Transitionally above the Scaglia follow deep-water shales which alternate with turbiditic sandstones. There are a few occurrences of pebbly mudstones and associated coarser arenites, most conspicuously the Missaglia Megabed (BICHSEL & HÄRING 1981, BERNOULLI et al. 1981). The E–W elongated Flysch trough, bordered in the south by the Malossa High, was fed from the north and east. A total of over 2000 m of Late Cretaceous Flysch was deposited in this trough as the well exposed sections east of Como indicate. These Flysch sediments reflect the early phases of Alpine mountain building. In a plate tectonic context, this phase corresponds to the anticlockwise rotation of Africa–Apulia which ended with the Continent/Continent collision and elimination of the Tethys during uppermost Cretaceous.

g) Diagenesis and Alpine deformation

The compaction process which changed the original coccolith ooze into Maiolica was mainly a consequence of overburden pressure during Late Cretaceous Flysch deposition rather than being caused by Alpine deformation. Stylolite formation in the Maiolica progressed during burial and during Alpine deformation. An analysis of stylolite character and distribution is beyond the scope of the present paper; a few observations, though, may be of interest. Stylolites are most prominent in the slumped section near the base, which may have been a "pièce de résistance". In the thin- and even bedded Maiolica above the basal slumped section stylolites are usually small. Mostly they seem to occur along roughly conjugated and not very regular shear planes at high angles to the bedding. Offsets of one set by the other are not common. Calcite steps (LAUBSCHER 1979), often steeply dipping, are rather frequent and so are calcite-filled tension cracks. Visible dislocations of entire strata are absent or minimal. Degree of organic metamorphism had not advanced very far, the Staplin index of sporomorphs being estimated at around 2 (pers. communication P. A. Hochuli). Obviously, such a level was attained towards the end of the depositional history and ramained practically unchanged during the subsequent Alpine compressional deformation.

Folding, faulting and thrusting affected the Mesozoic rocks of the Monte Generoso–Breggia sector during the Tertiary. The resulting tectonics is in line with the regional compressional tectonic style of the Lombardy Alps which also included the northern Po valley, as demonstrated by ERRICO et al. (1980). The course of events can tentatively be reconstructed in the following manner: During Oligocene/early Miocene: A hinge line formed, spearating the rising Generoso area from the subsiding Po valley to the south, which was being filled with clastics derived from the Alps. During the interval spanning middle Miocene to earliest Pliocene, folding and thrusting occurred, and in consequence of these movements the hinge line was accentuated.

Towards the end of this interval, major thrusting ceased, and erosion and peneplanation affected the Po valley. The hinge zone remained active and a canyon was cut into the folded Cretaceous of the Breggia gorge which was filled with coarse fluviatile clastics (Pontegana Conglomerate) thought to be of early Pliocene (BERNOULLI 1966) or latest Miocene (LAUBSCHER & BERNOULLI 1980) age. Subsequently, marine Pliocene transgressed over the peneplained Po valley, reaching the southern tip of Switzerland at Balerna west of the border town of Chiasso. Both the Pontegana Conglomerate and the marine Pliocene remained in their depositional, nearly horizontal, position.

Tertiary uplift at the site of the Maiolica section of the Breggia gorge is estimated to have amounted to between 2000 and 3000 m, a figure suggested by the estimated combined thickness of the Scaglia, the Flysch, and the Oligocene–early Miocene clastics.

D. Paleontological analysis

Fig. 1, 2; Pl. 1–5

Class Cephalopoda LEACH 1817
Order Ammonoidea ZITTEL 1884
Aptychus MEYER 1829

a) General remarks

Little attention has generally been paid to the occurrence of aptychi, in spite of their value for stratigraphic zonations and correlations with holes in the Atlantic, mainly in sediments deposited below the Aragonite Compensation Depth.

Descriptions of aptychi are stratigraphically arranged, from the top of the Rosso ad Aptici Formation until the contact of the Maiolica Formation against the Scaglia Variegata Formation (Fig. 2).

Many "specific" taxons of aptychi, so far, were established on morphological criteria without considering their biostratigraphic succession. The repetition of morphological features on forms from different levels led to the establishment of "subspecies" based on forms of quite distinct ages. The consideration of the stratigraphic succession of aptychi is thus indispensable to achieve a sound base for taxonomy. Consequently samples of aptychi from the Maiolica Formation deposited in previous collections, without a reference regarding their position within the formation, are not considered.

The aptychi figured by TRAUTH (1938) are described by him in great detail, and we refer to the respective descriptions.

For complete lists of publications dealing with aptychi we also refer to TRAUTH (1938), GASIOROWSKI (1963) and to DURAND DELGA & GASIOROWSKI (1970).

The interpretation and representation of aptychi on Plates 1–5 has been adapted to SCHINDEWOLF (1958, Pl. 1–9, p. 1–46).

An alternative view regarding the function of aptychi has been brought forward by LEHMANN (1972, 1976, p. 93) and MORTON (1981) who define aptychi as lower jaws of ammonites. Recently TANABE & FUKUDA (1983, p. 249) described a lower jaw of a *Gaudryceras,* composed of chitin, from the upper Santonian in Hokkaido, Japan.

The limits of stage boundaries in the Lower Cretaceous are based on ammonite assemblages. As aptychi represent parts of the ammonite conch, the distinct breaks visible on the distribution chart of aptychi (Fig. 1) should be reflected also on respective distribution charts for the ammonites.

The position of fossils within the Maiolica section (Fig. 1) is indicated by a first number (horizontal distance from the base of the Maiolica to its top) followed by a second one in brackets corresponding to the respective levels on the columnar section (Fig. 2).

b) Systematic descriptions of aptychi from the Rosso ad Aptici Formation (late Tithonian) and the Maiolica Formation (Berriasian–Barremian)

Late Tithonian (Fig. 1)

A remarkably rich aptychi assemblage was obtained from the upper surface of the top-layer of the Rosso ad Aptici Formation. This layer, about 10 to 20 cm thick, consists of a light grey-greenish, calcareous matrix with streaks of nodular grey chert. The majority of the components composing the sediment are Radiolaria still silicified. The surface of the layer is irregularly ondulated and light brownish weathered. This layer representing an outstanding dipslope is followed immediately by white Maiolica limestone, contorted by subaquatic sliding events. The basal layers of the Maiolica contain *Calpionella alpina* LORENZ (WEISSERT 1979, p. 39, and REMANE 1983, p. 564).

The age of the aptychi assemblage recovered from the surface of this top layer of the Rosso ad Aptici is late Tithonian. From deeper in the section of the Rosso ad Aptici large specimens of *Laevaptychus latus* (PARKINSON) and *Laevaptychus obliquus* (QUENSTEDT) were observed (J30901, coll. P. O. Baumgartner; J30902, D. Bernoulli).

Laevaptychus longus (MEYER) of *Physodoceras altense* (D'ORBIGNY)
Pl. 1, Fig. 1

1829 *Aptychus laevis longus* MEYER, Pl. 59, Fig. 6, p. 127–131.
1931 *Laevaptychus longus* (MEYER), TRAUTH, Fig. B, 4–7, p. 40.
1958 *Laevaptychus longus* (MEYER), SCHINDEWOLF, Pl. 1, Fig. 1a–b, Pl. 8, Fig. 5.

Occurrence: 0 m, J30728, surface of top-layer of the Rosso ad Aptici Formation.
Age: Late Tithonian.
Remarks: A single, rather thin-shelled valve with a width index of 0.70, can be compared with *Laevaptychus longus*. SCHINDEWOLF (1958, Pl. 1, Fig. 1a–b) figures *L. longus* covering the aperture of a *Physodoceras* cf. *altense* (D'ORBIGNY) from the Malm at the Burgberg of Onstmettingen.

Laevaptychus latissimus TRAUTH
Pl. 1, Fig. 2

1858 *Aptychus laevis* von *Ammonites inflatus* QUENSTEDT, 1858, p. 797, Pl. 98, Fig. 30.
1931 *Laevaptychus latissimus* TRAUTH, p. 105, compare Fig. C, 13, p. 131.

Occurrence: 0 m, J30909, surface of top-layer of the Rosso ad Aptici Formation.
Age: Late Tithonian.
Remarks: The form is distinguished from *Laevaptychus longus* by its large width-length index of about 1.

Laevaptychus longus seriporus TRAUTH
Pl. 1, Fig. 3

1931 *Laevaptychus longus* var. *seripora* TRAUTH, p. 49.

Occurrence: 0 m, J30729, surface of top-layer of the Rosso ad Aptici Formation.
Age: Late Tithonian.
Remarks: A juvenile specimen appears to be identical with forms described by TRAUTH (1931), characterized by concentrically arranged rows of pores around the apex.

Laevaptychus latus vermiporus TRAUTH
Pl. 1, Fig. 4

1931 *Laevaptychus latus vermiporus* TRAUTH, p. 81.
1977 *Laevaptychus latus vermiporus* TRAUTH, RENZ, Pl. 1, Fig. 18a–b, p. 503 (Cap Verde Basin).

Occurrence: 0 m, J30730, surface of top-layer of the Rosso ad Aptici Formation.
Age: Late Tithonian.
Remarks: The pores arranged parallel to the surface of the valve appear as meandring rows.

Lamellaptychus beyrichi (OPPEL)
Pl. 1, Fig. 5, 6

1865 *Aptychus Beyrichi* OPPEL, p. 547.
1873 *Aptychus Beyrichi* OPPEL, GILLIÉRON, Pl. 9, Fig. 9a, b, p. 237.

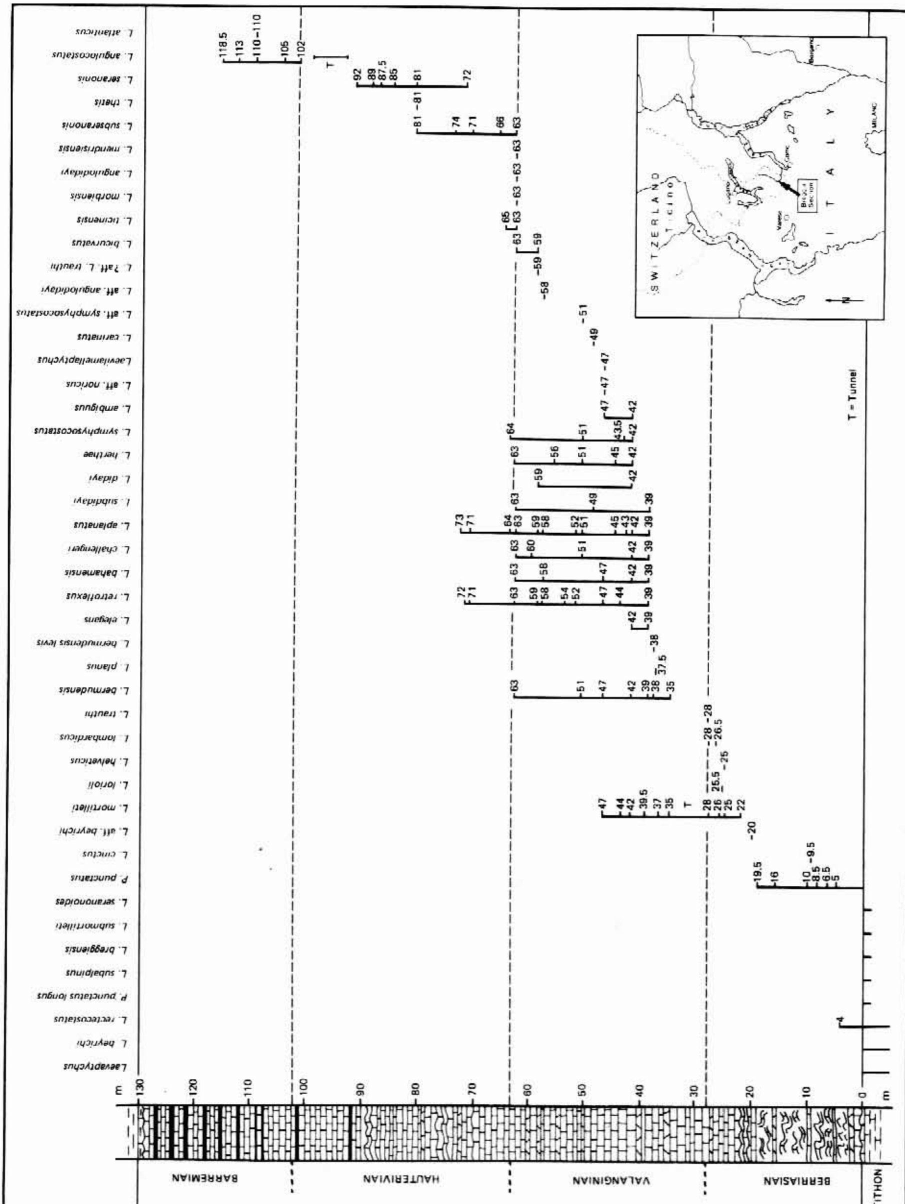

Fig. 2. Distribution chart of aptychi in the Maiolica Formation (Berriasian–Barremian).

1938 *Lamellaptychus beyrichi* (OPPEL), TRAUTH, Pl. 10, Fig. 5, p. 134.
1972 *Lamellaptychus beyrichi* (OPPEL), RENZ, Pl. 2, Fig. 3, p. 614 (Hatteras Abyssal Plain).
1983 *Lamellaptychus beyrichi* (OPPEL), RENZ, Pl. 1, Fig. 19, p. 640 (Blake-Bahama Basin).

Occurrence: 1.5 m below top of Rosso ad Aptici Formation, J30732; surface of top-layer of the Rosso ad Aptici Formation, J30908.
Age: Late Tithonian to Berriasian.
Remarks: L. beyrichi is widely known in the Tithonian throughout the Tethian realm. The figured specimens represent *L. beyrichi* typically, as described by GILLIÉRON (1873). RETOWSKI (1891, p. 220) shows a *Lamellaptychus*, referred to as *L. beyrichi*, covering the aperture of a *Haploceras elimatum* (OPPEL). Owing to poor preservation this connection remains doubtful.

Lamellaptychus rectecostatus (PETERS)
Pl. 1, Fig. 7

1854 *Aptychus rectecostatus* PETERS, p. 442.
1938 *Lamellaptychus rectecostatus* (PETERS), TRAUTH, p. 131, Pl. 10, Fig. 1–3.
1970 *Lamellaptychus rectecostatus* (PETERS), DURAND-DELGA & GASIOROWSKI, p. 769.

Occurrence: 0 m, J30733, surface of top-layer of the Rosso ad Aptici Formation and within the lower 4 m of the Maiolica Formation (fragment J30877, not figured).
Age: Late Tithonian to Berriasian.
Remarks: Transitions from *L. beyrichi* towards *L. rectecostatus* occur in the Rosso ad Aptici Formation.

In the Carpathians and the western Mediterranean, according to DURAND-DELGA & GASIOROWSKI (1970, p. 769), *L. rectecostatus* is associated with ammonites indicating a Berriasian age.

Punctaptychus punctatus longus TRAUTH
Pl. 1, Fig. 8

1875 *Aptychus punctatus* var. très allongée, FAVRE, Pl. 7, Fig. 5, p. 49.
1935 *Punctaptychus punctatus* var. *longa* TRAUTH, Pl. 12, Fig. 7, p. 320.
1965 *Punctaptychus punctatus* TRAUTH, POZZI, Pl. 86, Fig. 12, p. 872.

Occurrence: 0 m, J30734, surface of top-layer of the Rosso ad Aptici Formation.
Age: Late Tithonian.
Remarks: The figured left valve closely resembles the holotype, established by FAVRE (1875) from the Upper Jurassic of the Montagne des Voirons, Haute Savoie.

Lamellaptychus subalpinus (SCHAFHÄUTL)
Pl. 1, Fig. 9

1853 *Aptychus subalpinus* SCHAFHÄUTL, Pl. 6, Fig. 8, p. 405, holotype.
1857 *Trigonellites curvatus* OOSTER, Pl. 5, Fig. 13, p. 20.
1938 *Lamellaptychus beyrichi* var. *subalpina* (SCHAFHÄUTL), TRAUTH, Pl. 10, Fig. 15, p. 140, refigured from OOSTER (1857).

Occurrence: 0 m, J30735, surface of top-layer of the Rosso ad Aptici Formation.
Age: Late Tithonian.
Remarks: On the dorsal half of the specimen the lamellae curve parallel to the lateral margin of the valve and then progress straight, converging towards its ventral end. This form seems to be related closely to *L. breggiensis,* on which, however, the lamellae disperse along the ventral facet.

Lamellaptychus breggiensis new name
Pl. 1, Fig. 10–11

1857 *Trigonellites Studeri* OOSTER, Pl. 7, Fig. 6, p. 26, holotype.
1938 *Lamellaptychus mortilleti* (PICTET & LORIOL), TRAUTH, Pl. 10, Fig. 29, p. 145 (refigured holotype).

Occurrence: 0 m, J30736, Pl. 1, Fig. 10.
0 m, J30737, Pl. 1, Fig. 11, surface of top-layer of the Rosso ad Aptici Formation.
Age: Late Tithonian.
Description: *L. breggiensis* is distinguished by its flat and broad valve, only slightly elevated along its apical-diagonal axis. The width-length index attains 0.70, against 0.55 to 0.57 for *L. mortilleti* from the Breggia section. The juvenile lamellae follow and end along the symphyseal margin in acute angles. Later the lamellae augment in strength getting broader and converging towards the ventral end of the valve. The last marginal lamellae terminate along the ventral facet.

The holotype of *L. breggiensis* (OOSTER 1857, Pl. 7, Fig. 6) has been interpreted by TRAUTH (1938, p. 145) as *Lamellaptychus mortilleti* (PICTET et LORIOL). Owing to its low stratigraphic position below *Lamellaptychus mortilleti* and its occurrence with Tithonian aptychi a separation from the *mortilleti* group is here proposed.

Lamellaptychus form indet.
Pl. 1, Fig. 13, 15

cf. 1857 *Trigonellites curvatus* GIEBEL, OOSTER, Pl. 5, Fig. 11, 16, p. 20.

Occurrence: 0 m, J30738, Pl. 1, Fig. 13.
0 m, J30739, Pl. 1, Fig. 15, surface of top-layer of the Rosso ad Aptici Formation.
Age: Late Tithonian.
Remarks: The present two specimens might best be interpreted as intermediate between *L. beyrichi* and *L. submortilleti.* The straight juvenile lamellae follow the symphyseal margin and end along the ventral facet near the ventral end of the valve (Pl. 1, Fig. 15), as it is typical for *L. beyrichi.* The adult broader and wider spaced lamellae, turn towards the end of the valve before reaching its ventral facet. In this they differ from *L. beyrichi.*

On the juvenile stage of the valve reproduced on Plate 1, Figure 13, the lamellae meet the symphyseal margin acute-angled. The bending of the adult lamellae towards the ventral end of the valve, before reaching the ventral facet, is less distinct than on the specimen on Plate 1, Figure 15. It cannot be excluded that such forms are related to

L. seranonoides on which the juvenile straight lamellae are covered by the adult ones turning right-angled against the symphyseal margin.

It seems premature to propose a new name for the present form until additional material from other sections becomes available.

Lamellaptychus submortilleti Trauth
Pl. 1, Fig. 12, 14

1938 *Lamellaptychus sub-mortilleti* Trauth, Pl. 10, Fig. 23, 25, p. 143.
1979a not *Lamellaptychus submortilleti,* Renz, Pl. 1, Fig. 23–26, p. 594 (Western Bermuda Rise).

Occurrence: 0 m, J30740, Pl. 1, Fig. 12.
0 m, J30741, Pl. 1, Fig. 14, surface of top-layer of the Rosso ad Aptici Formation.
Age: Late Tithonian.
Remarks: The form is characterized by its elongated moderately arched valve, without an apical-ventral elevation and a lateral depression. On the juvenile stage (Pl. 1, Fig. 12) the lamellae follow the symphyseal margin until meeting it acute-angled. With proceeding growth the lamellae get broader what is connected with a distinct bending approaching the margin (Pl. 1, Fig. 14).

The name *"submortilleti"* introduced by Trauth (1938) for such forms seems not appropriate. A connection with true *L. mortilleti* from higher in the section is, so far, not indicated. The introduction of new names for the present varieties also remains questionable, as long as their stratigraphic range is not verified along other sections.

The considerably jounger specimens from the Western Bermuda Rise, compared with *L. submortilleti* by Renz (1979a), are now better interpreted as varieties of typical *L. mortiletti.*

Lamellaptychus seranonoides Trauth
Pl. 1, Fig. 16

1938 *Lamellaptychus beyrichi* var. *seranonoides* Trauth, Pl. 14, Fig. 2, p. 198.

Occurrence: 0 m, J30742, surface of top-layer of the Rosso ad Aptici Formation.
Age: Late Tithonian.
Remarks: The right valve derives from a matrix composed nearly entirely of Radiolaria, still silicified. The pattern of the lamellae on the juvenile stage closely approaches that on *Lamellaptychus* form indet. shown on Pl. 1, Fig. 13, 15. The beginning of the adult stage is indicated by a widening of the lamellae. An about right-angled turn of the first two broader adult lamellae towards the symphyseal margin covers the ends of the previous thinner juvenile lamellae which followed parallel to the symphyseal margin. Thereafter the lamellae again normalize ending along the ventral facet.

Berriasian (Fig. 1)

The lower 34 m (28 m) of the Maiolica Formation consist of massively layered, hard, dense, splintery, white limestone interbedded by irregular layers, lenses and nodules of light grey to light brown chert. The layers within this interval are partly contorted, due to subaquatic sliding (WEISSERT 1979, p. 42). Aptychi, the only macrofossils, are scattered and difficult to be extracted from the hard rock. *Punctaptychus*, by far, is the most abundant form.

The existence of a sedimentary gap between the Rosso ad Aptici and the Maiolica Formation is possible, but it cannot be assertained by the fossils available.

Punctaptychus punctatus VOLTZ
Pl. 1, Fig. 17–19

1935 *Punctaptychus punctatus* (VOLTZ), TRAUTH, Pl. 12, Fig. 1–6, p. 315.
1962 *Punctaptychus punctatus* (VOLTZ), GASIOROWSKI, Pl. 6.
1972 *Punctaptychus punctatus* (VOLTZ), RENZ, Pl. 1, Fig. 5a–b, p. 612 (Hatteras Abyssal Plain).

Occurrence: 6.5 m (5.5 m), J30743.
8.5 m (6.5 m), J30744.
10 m (8.5 m), J30745, Pl. 1, Fig. 17.
10 m (8.5 m), J30895, Pl. 1, Fig. 18.
12 m (10 m), J30746.
20 m (16 m), J30747.
23.5 m (19.5 m) J30748, Pl. 1, Fig. 19, above base of the Maiolica Formation.
Age: Berriasian.
Remarks: Punctaptychus widely mentioned from the Tithonian and Berriasian in the mediterranean region, is not known from the Kimmeridgian in the Jura mountains. According to our present observations in the Breggia section, *Punctaptychus punctatus* seems to be restricted within the lower Maiolica Formation, considered to represent the Berriasian. From older levels of the Rosso ad Aptici Formation in Tuscany other forms of *Punctaptychus (P. triangularis)* are present (KÄLIN et al. 1979, Fig. 11a).

Punctaptychus cf. *cinctus* TRAUTH
Pl. 1, Fig. 20

1935 *Punctaptychus cinctus* TRAUTH, Pl. 12, Fig. 11, 12, p. 326.

Occurrence: 11.5 m (9.5 m), J30749, above base of the Maiolica Formation.
Age: Berriasian.
Remarks: The large, highly arched valve, partly affected by erosion, shows the characteristic curving of the adult lamellae towards the symphyseal margin, meeting it right-angled.

Lamellaptychus ? aff. *beyrichi* (OPPEL)
Pl. 1, Fig. 21

1938 *Lamellaptychus beyrichi* var *moravica* (BLASCHKE), TRAUTH, Pl. 10, Fig. 13, p. 139.

Occurrence: 24 m (20 m), MB11, J30750, above base of the Maiolica Formation.
Age: Most likely late Berriasian.
Remarks: GASIOROWSKY (1962, p. 63) already noticed that *Aptychus moravicus* BLASCHKE (1911, Pl. 1, Fig. 5a–b, p. 152) has nothing in common with *L. beyrichi*.

In the Breggia section the present specimen represents the latest occurrence of a valve displaying features comparable with *L. beyrichi*, from considerably deeper in the section within the Tithonian. It might have evolved from typical *L. beyrichi* from which it differs by its thinner and closer placed lamellae. The specimen could be distinguished by a new name, once its high position in the section will be confirmed at other localities.

Group of *Lamellaptychus mortilleti* (PICTET & LORIOL)

All specimens grouped with *L. mortiletti*, collected between 27 m (22 m) to 57 m (47 m) within the Maiolica section are distinguished by a pronounced apical-diagonal elevation, followed by a lateral depression of the valve. Forms without such a depression, referred to by TRAUTH (1938, Pl. 10, Fig. 23–25, p. 143) as *L. submortilleti* were so far not obtained from the Maiolica Formation. *L. submortilleti* seems to be restricted to the upper layer of the Rosso ad Aptici Formation. No relation of *L. submortilleti* with the true *L. mortiletti* higher in the sections is, so far, indicated in the Breggia section.

Lamellaptychus mortilleti (PICTET & LORIOL)
Pl. 1, Fig. 22–26, Pl. 2, Fig. 1–5

1858 *Aptychus Mortilleti* PICTET & LORIOL, Pl. 11, Fig. 9a–d, p.50.
1938 *Lamellaptychus mortilleti* (PICTET & LORIOL), TRAUTH, Pl. 10, Fig. 30 only, p. 145.
1978 *Lamellaptychus mortilleti* (PICTET & LORIOL), RENZ, Pl. 1, Fig. 3a–b, p. 903 (Blake-Bahama Basin).
1979a *Lamellaptychus mortilleti* (PICTET & LORIOL), RENZ, Pl. 1, Fig. 16–22, p. 594 (Western Bermuda Rise).

Lectotype: PICTET & LORIOL, 1858, Pl. 11, Fig. 9b, refigured by RENZ (1979a) (Leg 43, Pl. 1, Fig. 16, Western Bermuda Rise).
Occurrence: 27 m (22 m), MB14, J30751, Pl. 1, Fig. 23.
30 m (25 m), MB200, J30752, Pl. 1, Fig. 22.
31 m (26 m), J30753a, Pl. 1, Fig. 25.
31 m (26 m), J30753b, Pl. 1, Fig. 26.
34 m (28 m), J30754, Pl. 2, Fig. 1.
34 m (28 m), J30895, Pl. 2, Fig. 2.
44 m (35 m), J30755.
45 m (37 m), J30756, Pl. 2, Fig. 3.
47.5 m (39.5 m), J30757, Pl. 1, Fig. 24.
50 m (42 m), J30758, Pl. 2, Fig. 5.
53 m (44 m), MB204, J30759, Pl. 2, Fig. 4.
57 m (47 m), MB205, J30760.
Age: Late Berriasian–Valanginian.
Remarks: A typical *L. mortilleti*, comparable with the lectotype, has not been figured by TRAUTH (1938). The specimen figured by TRAUTH on Plate 10, Figure 30, represents a broad variety with narrowly placed, fine lamellae. A comparable specimen (Pl. 2, Fig. 3) comes from 45 m (37 m) in the Breggia section.

Additional material from other sections will certainly enable us to establish a more detailed taxonomic subdivision of this variable, long-ranging group than it is possible with the material in hand.

Lamellaptychus lorioli Renz
Pl. 2, Fig. 6

1867 *Aptychus Seranonis* Coquand, Pictet, F. J., Pl. 28, Fig. 9b, p. 123, holotype from Berrias, Dépt. Ardèche.
1938 *Lamellaptychus seranonis* (Coquand), Trauth, Pl. 13, Fig. 29, p. 193, refigured holotype.
1979 *Lamellaptychus lorioli* Renz, Pl. 1, Fig. 5a–b, p. 593 (Western Bermuda Rise).
1978 *Lamellaptychus lorioli* Renz, Pl. 1, Fig. 6a–b, p. 904 (Blake-Bahama Basin).

Occurrence: 30 m (25 m), J30761, above base of the Maiolica Formation.
Age: Late Berriasian to early Valanginian.
Remarks: The present specimen is distinguished from *L. lorioli* from the Western Bermuda Rise by its stronger pronounced rounded apical-diagonal elevation, followed by a flatter lateral depression of the valve. A pecularity of *L. lorioli* seems to be the simultaneous growth of about three lamellae exposed at the ventral end of the valve.

The considerable interval separating *L. lorioli* from younger forms with analogous retroverse curving lamellae patterns, as *L. retroflexus* from 47 m (39 m) to 87 m (72 m) and *L. subseranonis* from 75 m (63 m) to 97 m (81 m), makes a relation of *L. lorioli* towards the *L. seranonis* group unlikely. On the other hand *L. lorioli* could be interpreted as a successor of *L. plicatus* Pillet (1886, Pl. 2, Fig. 6, p. 16) from the Kimmeridgian near Chambéry in the French Alps.

Lamellaptychus helveticus new form
Pl. 2, Fig. 7–9

Occurrence: Holotype, 30 m (25 m), J30762, Pl. 2, Fig. 7, adult stage.
Paratype 1, 30 m (25 m), J30763, Pl. 2, Fig. 8, median stage.
Paratype 2, 30 m (25 m), J30764, Pl. 2, Fig. 9, juvenile stage, above base of the Maiolica Formation.
Age: Late Berriasian to early Valanginian.
Description: The thin-shelled valve representing the holotype shows a broad, flatly-rounded apical-diagonal elevation. Its steeper lateral slope implies a slight lateral depression of the valve, connected with weakly inflected lamellae. The different ways of approach of the lamellae against the symphyseal margin on the juvenile and adult stages seem to be characteristic for this form. On the juvenile stage (Pl. 2, Fig. 9) the lamellae, before nearing the symphyseal margin, bend sharp-angled ventrally, meeting the margin in acute angles. Here the pattern closely resembles to *L. ticinensis* from 38 m higher in the section, at 75 m (63 m). On the median stage (Pl. 2, Fig. 8) the lamellae approach the symphyseal margin right-angled. On the holotype (Pl. 2, Fig. 7, adult stage) a retroverse turning of the last lamellae, comparable to those on *L. retroflexus* from higher in the section, is apparent.

Lamellaptychus lombardicus new form
Pl. 2, Fig. 11

Occurrence: Holotype, 31.5 m (26.5 m), J30765.
Age: Late Berriasian to early Valanginian.

Description: The valve is broadly and flatly arched along the apical-ventral axis and slightly laterally depressed. The semi-angular retroverse turning of the lamellae, getting more rounded towards the adult stage is a characteristic feature of *L. lombardicus*. Nearing the symphyseal margin the lamellae turn ventrally again, meeting the margin in acute angles. On the adult stage the ventral bending gets gradually indistinct.

Lamellaptychi characterized by a retroverse turn of the lamellae, followed by a bending in the opposite direction (ventrally), against the symphyseal margin is repeated higher in the section on *L. bicurvatus* between 71 m (59 m) and 75 m (63 m) of the section (Pl. 3, Fig. 25–28).

Lamellaptychus lombardicus longus new name
Pl. 2, Fig. 10

1938 *Lamellaptychus sub-mortilleti* var. *retroflexa-longa* TRAUTH, Pl. 14, Fig. 7, p. 202, holotype.

Occurrence: 31.5 m (26.5 m), J30766.
Age: Late Berriasian to early Valanginian.
Remarks: The larger holotype comes from the "Grenzschichten des roten und weissen Aptychenkalks von Ober-St. Veit in Wien". Our specimen is preserved as impression from which a positive was prepared. The distinction of this specimen from *L. lombardicus* is its considerable length of the valve (width-length index 0.35, against 0.40 on the larger holotype (TRAUTH 1938, p. 202)). Both display a similar lamellae pattern characterized by a first retroverse bending of the lamellae followed by a ventral turn before touching the symphyseal margin.

Valanginian (Fig. 1)

The interval from 34 m (28 m) to 75 m (63 m) of the Maiolica section, assumed to represent the Valanginian, is conspicuously rich in aptychi. This coincides with observations obtained in cores from Hole 534A and Hole 391C in the Blake-Bahama Basin, as well as from Hole 367 in the Cape Verde Basin (RENZ 1983, Fig. 1, p. 640).

The assemblage of aptychi from Hole 387, Core 49 (Western Bermuda Rise) were considered late Berriasian in age by RENZ (1979a, Fig. 1, p. 591). Based on the results obtained by the present investigations on the Maiolica Formation an early Valanginian age seems more appropriate for this short interval of 4.5 m (Sections 2–4 of Core 49).

Lamellaptychus trauthi new form
Pl. 2, Fig. 12, 13

Occurrence: Holotype, 34 m (28 m), MB201, J30767, Pl. 2, Fig. 12.
Paratype, 34 m (28 m), J30768, Pl. 2, Fig. 13, above base of the Maiolica Formation.
Age: Late Berriasian to early Valanginian.
Description: A round-topped apical-diagonal elevation is dominant on *L. trauthi*. Characteristic are further the narrow lamella curving towards the symphyseal margin and approaching it right-angled, comparable to *L. bermudensis* higher in the section at 42 m

(35 m). From the latter the present form differs by a nearly right-angled bending of the lamellae towards the ventral end of the valve, just before touching the symphyseal margin. The paratype obtained from the same layer displays identical features.

The low position in the section of *L. trauthi* suggests an anchestral relation towards typical *L. bermudensis*.

Lamellaptychus bermudensis Renz
Pl. 2, Fig. 21–24

1977 *Lamellaptychus* sp., indet. 1, Renz, Pl. 1, Fig. 23a–b, p. 504 (Cape Verde Basin), holotype.
1978 *Lamellaptychus postbermudensis* Renz, Pl. 1, Fig. 8a–b, p. 904 (Blake-Bahama Basin).
1979 *Lamellaptychus bermudensis* Renz, Pl. 1, Fig. 2, p. 592 (Western Bermuda Rise).
1983 *Lamellaptychus postbermudensis* Renz, Pl. 1, Fig. 11, p. 640 (Blake-Bahama Basin).

Occurrence: 42 m (35m), J30769.
45 m (38 m), MB203, J30770.
45 m (38 m), J30771.
47 m (39 m), J30772.
50 m (42 m), J30773.
50 m (42 m), J30906, Pl. 2, Fig. 22.
50 m (42 m), J30905, Pl. 2, Fig. 23.
50 m (42 m), J30904, Pl. 2, Fig. 24.
72 m (60 m), J30903, Pl. 2, Fig. 21.
75 m (63 m), J30779.

Age: Valanginian.
Remarks: The outstanding features on this easily recognizable form are remarkably constant. The width-length ratio attains: Blake-Bahama Basin 0.44; Western Bermuda Rise 0.46; Cape Verde Basin 0.50; Breggia section 0.49.

Besides of the type with its high apical-diagonal keel over which the lamellae are partly effaced, specimens occur with a lower broader apical-diagonal elevation crossed by the lamellae without being interrupted. This variety (Pl. 2, Fig. 21) occurs together with the type. We do not distinguish it by a new name, as long as comparable informations from other sections become available.

In the Atlantic the rather small-sized valves are noticeable by their widespread occurrence, what indicates that it was a common form within a thick interval of sediment. This coincides with observations in the Maiolica Formation, where *L. bermudensis* was observed between 42 m (35 m) and 75 m (63 m).

L. bermudensis was collected, as early as 1927, by M. Blumenthal in the Betic Cordillera (southern Spain), near Archidona (Provincia Malaga). There it is associated with *L. ambiguus*.

Lamellaptychus planus new form
Pl. 2, Fig. 15a, b

Occurrence: 45.5 m (37.5 m), J30780, above base of the Maiolica Formation.
Age: Early Valanginian.

Description: The single valve representing the holotype is distinguished from *L. mortilleti* by its faintly perceptible apical-diagonal elevation, resulting in a weak inflection of the lamellae and a weak lateral depression of the valve. In common with *L. mortilleti* is a conspicuous turning ventrally of the lamellae along the symphyseal margin. The last adult lamellae, however, do not converge towards the ventral end of the valve, as typical for the *L. mortilleti* group. Instead they contrarily turn sharply retroverse just before touching the symphyseal margin. The first lamellae turning retroverse than meets the end of the former straight one. A comparable pattern is repeated higher in the section in a more conspicuous style (Pl.3, Fig. 21).

Lamellaptychus?, new form
Pl. 2, Fig. 14

Occurrence: Holotype, 46 m (38 m), MB203, J30781, above base of the Maiolica Formation.
Age: Early Valanginian.
Description: The figured left valve only is available. Its apical-diagonal elevation is flattened, and followed by a shallow lateral depression of the valve, connected with an angular inflection of the lamellae. On the juvenile stage the lamellae meet the symphyseal margin straight with angles of about 30°, comparable to *L. herthae* (Pl. 3, Fig. 16–18). The last five adult lamellae bend retroverse after performing a low hook-like turn.

At present this specimen cannot be compared satisfactorily with any known *Aptychus* from the Lower Cretaceous. Its low position within the interval considered to represent the early Valanginian (together with the first *L. bermudensis*) might suggest some affinities to the *L. didayi* group, appearing 9 m higher at 47 m (39 m). It differs from the latter by its closer placed and also weaker, not vertical and sharp edged lamellae. A relation to *L. helveticus* (Pl. 2, 7–9) cannot be excluded. Here the retroverse turning of the lamellae is still more accentuated.

The specimen, still questionable, is left in open nomenclature, as long as additional material becomes disponible.

Lamellaptychus bermudensis levis new variety
Pl. 2, Fig. 19, 20

Occurrence: Paratype, 46 m (38 m), MB203, J30782, Pl. 2, Fig. 20.
Holotype, 50 m (42 m), J30783, Pl. 2, Fig. 19, above base of the Maiolica Formation.
Age: Early Valanginian.
Description: The two specimens, 4 m apart, derive from platy, silicified layers composed entirely of radiolarians. The valve which represents the holotype, is broadly arched and not keeled apical-ventrally as *L. bermudensis*. In this respect it could be compared with *L. aplanatus*. The lamellae are weakly inflected on the lateral slope, and bend rather narrow-angled towards the symphyseal margin, meeting it straight and right-angled, as typical for *L. bermudensis*. The paratype shows identical features. The dark line crossing this valve diagonally on Figure 20 (Pl. 2,) is caused by a fracture.

Lamellaptychus elegans RENZ
Pl. 2, Fig. 16; Pl. 5, Fig. 17, 18

1979 *Lamellaptychus elegans* RENZ, Pl. 1, Fig. 12a–b, p. 593 (Western Bermuda Rise).

Occurrence: 47 m (39 m), J30784, Pl. 2, Fig. 16.
50 m (42 m), J30911, J30910, Pl. 5, Fig. 17, 18, above base of the Maiolica Formation.

Age: Early Valanginian.

Remarks: The presence of *L. elegans* is indicated by several rather deficiently preserved specimens. Their apical-ventral elevation and the resulting inflection of the lamellae are less pronounced if compared with the holotype. Characteristic features are the strengthening and widening of the adult lamellae along their curving towards the ventral end of the valve. *L. elegans* occurs within the range of *L. mortilleti* and some relation towards this form seems indicated.

Lamellaptychus retroflexus TRAUTH
Pl. 2, Fig. 25–32

1938 *Lamellaptychus aplanatus* var. *retroflexa* TRAUTH, Pl. 13, Fig. 24–25, p. 193 (holotype).
1979 *Lamellaptychus aplanatus retroflexus* TRAUTH, RENZ, Pl. 1, Fig. 3a–b, 4, p. 593 (Western Bermuda Rise).
1983 *Lamellaptychus aplanatus retroflexus* TRAUTH, Pl. 1, Fig. 14, p. 640. (Blake-Bahama Basin).

Occurrence: 47 m (39 m), J30785.
50 m (42 m), J30907, Pl. 2, Fig. 25.
53 m (44 m), MB204, J30786.
57 m (47 m), MB205, J30787, Pl. 2, Fig. 32.
62 m (52 m), J30788, Pl. 2, Fig. 26.
62 m (52 m), J30789, Pl. 2, Fig. 27.
62 m (52 m), MB210, J30790.
65 m (54 m), J30791, Pl. 2, Fig. 28.
71 m (59 m), J30792.
71 m (59 m), J30793, Pl. 2, Fig. 29.
75 m (63 m), J30794, Pl. 2, Fig. 31.
86 m (71 m), J30795, Pl. 2, Fig. 30.
87 m (72 m), J30796, above base of the Maiolica Formation.

Remarks: We propose to interprete *L. aplanatus retroflexus* TRAUTH as a separate form, not connected with *L. aplanatus* (GILLIÉRON). The range of *L. retroflexus*, 49 m (39 m) to 87 m (72 m), about coincides with that of *L. aplanatus* from 47 m (39 m) to 87 m (72 m). The intensity of retroverse turning of the lamellae, as well as the hight of the valve seem to be quite unstable features. The retroverse directed lamellae, following the symphyseal margin before touching it, occasionally form a faintly indicated adsymphyseal ridge.

The perfectly preserved valves from 50 m (42 m) and from 62 m (52 m), Plate 2, Figures 25–26, differ from the holotype mainly by their flatness and a slight lateral depression, connected with distinctly inflected lamellae. Before introducing a new name, additional specimens from other sections are wanted.

Lamellaptychus bahamensis RENZ
Pl. 2, Fig. 17, 18; Pl. 5, Fig. 21–24

1978 *Lamellaptychus bahamensis* RENZ, Pl. 1, Fig. 2, p. 903 (Blake-Bahama Basin).

Occurrence: 47 m (39 m), J30797, Pl. 2, Fig. 17.
50 m (42 m), J30913, J30914, J30915, J30916, Pl. 5, Fig. 21–24.
70 m (58 m), J30798, Pl. 2, Fig. 18.
75 m (63 m), J30799, above base of the Maiolica Formation.

Age: Late Valanginian.

Remarks: Main features are a pronounced apical-diagonal elevation followed laterally by a flat depression, connected with a marked angular inflection of the lamellae which follow the symphyseal margin, touching it acute-angled. The adult lamellae follow along the ventral facet and do not converge towards the ventral end of the valve, as on *L. mortilleti* (RENZ 1978, Fig. 2, p. 902).

The form might be interpreted as a precursor of *L. morbiensis* (Pl. 4, Fig. 4, 10) higher in the section at 75 m (63 m). Here the adult lamellae follow parallel to the symphyseal margin, and end along the ventral facet, comparable to *L. beyrichi*. The variability of this form is displayed by four samples (J30913–J30916), all from an intercalation of coaly shale 0.5 cm thick.

Lamellaptychus challengeri RENZ
Pl. 2, Fig. 33; Pl. 3, Fig. 1, 2

1977 *Lamellaptychus* sp. indet. 2, RENZ, Pl. 1, Fig. 24a–c, p. 504 (Cape Verde Basin).
1978 *Lamellaptychus challengeri* RENZ, Pl. 1, Fig. 4a–b, p. 903 (Blake-Bahama Basin).

Occurrence: 47 m (39 m), J30800.
50 m (42 m), J30801, Pl. 2, Fig. 33.
51 m (43 m), J30803, Pl. 3, Fig. 2.
62 m (51 m), MB210, J30802, Pl. 3, Fig. 1.
72 m (60 m), J30897.
75 m (63 m), J30804, above base of the Maiolica Formation.

Age: Valanginian.

Remarks: In the Breggia section this readily recognizable form is less abundant, and has a more restricted range than *L. bermudensis*. It is easily to be distinguished from *L. bermudensis* by its greater width of the valve (width-length ratio 0.61, against 0.50 for *L. bermudensis*). *L. challengeri* is accompanied by *L. symphysocostatus*.

Lamellaptychus aplanatus (GILLIÉRON)
Pl. 3, Fig. 4–11

1873 *Aptychus aplanatus* (GILLIÉRON, Pl. 10, Fig. 4, p. 238.
1938 *Lamellaptychus aplanatus* (GILLIÉRON), TRAUTH, Pl. 12, Fig. 8–10, p. 171.
1977 *Lamellaptychus aplanatus* (GILLIÉRON), RENZ, Pl. 1, Fig. 25a–b, p. 504 (Cap Verde Basin).

1978 *Lamellaptychus aplanatus* (GILLIÉRON), RENZ, Pl. 1, Fig. 7, p. 904 (Blake-Bahama Basin).

Occurrence: 47 m (39 m), J30805.
47 m (39 m), J30816, Pl. 3, Fig. 9.
50 m (42 m), J30806.
51 m (43 m), J30807.
54 m (45 m), J30808, Pl. 3, Fig. 4.
61.5 m (51 m), J30810, Pl. 3, Fig. 11.
62 m (51 m), MB209, J30809.
70 m (58 m), J30811.
71 m (59 m), J30812, Pl. 3, Fig. 5.
75 m (63 m), J30813, Pl. 3, Fig. 6.
75 m (63 m), J30814, Pl. 3, Fig. 7.
78 m (64 m), MB208, J30815, Pl. 3, Fig. 8.
87 m (72 m), MB61, J30817.
87 m (72 m), J30818, Pl. 3, Fig. 10, above base of the Maiolica Formation.

Age: Valanginian.

Remarks: Within the Maiolica Formation *L. aplanatus* is distinguished by its long range, abundance and considerable variations.

The predominantly medium-sized valves are broadly arched without a marked apical-diagonal keel and a lateral depression of the valve. Specimens with a slight lateral depression might be interpreted as transitions towards *L. herthae* (Pl. 3, Fig. 16–18). The lamellae on typical specimens lie flat and are broad (Pl. 3, Fig. 6–9). What concerns the height of the valve and the width (spacing) of the lamellae, *L. aplanatus* is quite variable.

The specimens 54 m (45 m), Pl. 3, Fig. 4, and 75 m (63 m), Pl. 3, Fig. 7, represent such variations. The slender valves are remarkable by their densely-spaced and narrow lamellae. A relation of the varieties to their stratigraphic position cannot be recognized with the material in hand. The introduction of additional names seems therefore premature.

Lamellaptychus subdidayi TRAUTH
Pl. 3, Fig. 3

1867 *Aptychus Didayi* PICTET, Pl. 28, Fig. 6a–b, p. 122.
1938 *Lamellaptychus subdidayi* TRAUTH, Pl. 12, Fig. 25, refigured holotype: Pl. 12, Fig. 26–28.

Occurrence: 47 m (39 m), J30898.
59 m (49 m), MB206, J30833, Pl. 3, Fig. 3.
75 m (63 m), J30834, above base of the Maiolica Formation.

Age: Valanginian.

Remarks: The lamellae on the juvenile stage meet the symphyseal margin in acute angles. Progressively the angles widen and the lamellae simultaneously get broader, steeper and sharp edged. On the adult stage the widely curved lamellae meet the symphyseal margin near to right-angled, ending in a distinct adsymphyseal ridge.

In the Breggia section *L. subdidayi,* so far, seems to be restricted within the range of *L. bermudensis* and *L. retroflexus*.

Lamellaptychus didayi (Coquand)
Pl. 4, Fig. 5, 6

1841 *Aptychus didayi* Coquand, Pl. 1, Fig. 10, p. 389.
1858 *Aptychus didayi* Coquand, Pictet & Loriol, Pl. 10, Fig. 2, p. 46.
1867 *Aptychus didayi* Coquand, Pictet, Pl. 28, Fig. 6, 7, p. 122.
1868 *Aptychus didayi* Coquand, Winkler, Pl. 4, Fig. 16, p. 28.
1938 *Lamellaptychus didayi* (Coquand), Trauth, Pl. 14, Fig. 3 only, p. 198, reproduction of holotype.
1977 *Lamellaptychus didayi* (Coquand), Renz, Pl. 1, Fig. 26a–c, p. 505 (Cape Verde Basin).

Occurrence: 50 m (42 m), J30819, Pl. 4, Fig. 5.
71 m (59 m), J30820, Pl. 4, Fig. 6, above base of the Maiolica Formation.
Age: Valanginian.
Remarks: The juvenile stage of *L. didayi* is characterized by narrow and thin lamellae meeting the symphyseal margin in acute angles. Soon a retroverse bending of the lamellae begins what is connected with a broadening and steepening and getting sharp-edged along the curving. A distinct adsymphyseal ridge which seems connected with the retroverse turning of the lamellae (continuation along the symphysis) is developed along the symphyseal margin.

Lamellaptychus herthae (Winkler)
Pl. 3, Fig. 16–18

1868 *Aptychus Herthae* Winkler, Pl. 4, Fig. 12, p. 28.
1938 *Lamellaptychus herthae* (Winkler), Trauth, Pl. 12, Fig. 22, p. 178.
1977 *Lamellaptychus* aff. *herthae* (Winkler), Renz, Pl. 1, Fig. 31, 32, p. 505 (Cape Verde Basin).
1978 *Lamellaptychus* cf. *herthae* (Winkler), Renz, Pl. 1, Fig. 11a–b, p. 904 (Blake-Bahama Basin).
1983 *Lamellaptychus herthae* (Winkler), Renz, Pl. 1, Fig. 17, p. 640 (Blake-Bahama Basin).

Occurrence: 50 m (42 m), J30821.
54 m (45 m), J30822, Pl. 3, Fig. 16.
62 m (51 m), MB209, J30823, Pl. 3, Fig. 17.
68 m (56 m), J30824, Pl. 3, Fig. 18.
75 m (63 m), J30825, above base of the Maiolica Formation.
Age: Late Valanginian.
Remarks: *L. herthae* is distinguished by a broad apical-diagonal elevation with an adjoining lateral depression of the valve. This differs *L. herthae* from *L. aplanatus,* without a lateral depression. The lamellae are distinctly inflected and meet the symphyseal margin straight within angles of 30° to 40°.

In the Breggia section *L. herthae* is accompanied by *L. bermudensis,* as well as *L. challengeri.*

The comparison of juvenile, rather deficiently preserved specimens from the Atlantic with *L. herthae* (Renz 1977, p. 505, and 1978, p. 904) remains questionable.

Lamellaptychus symphysocostatus TRAUTH
Pl. 3, Fig. 12–14

1938 *Lamellaptychus angulocostatus* var. *symphysocostata* TRAUTH, Pl. 14, Fig. 15, 16, p. 208.

Occurrence: 50 m (42 m), J30826.
51 m (43 m), J30827, Pl. 3, Fig. 12.
62 m (51 m), J30828.
78 m (64 m), MB208, J30829, Pl. 3, Fig. 13, above base of the Maiolica Formation.

Age: Valanginian.

Remarks: The pattern of the lamellae resembles closely to that on *L. angulocostatus* from the Barremian, as indicated by the name given by TRAUTH (1938, p. 208). Decisive for a separation of the present specimens from *L. angulocostatus* are not primarily morphological aspects, but mainly the considerable interval of time parting the two forms. This evidently should be reflected also in the taxonomy.

L. symphysocostatus is characterized by a first sharp-angled, later rounded retroverse turning of the lamellae, close to the symphyseal margin. A further characteristic feature is the continuation of the lamellae, diagonally over the symphyseal facet, meeting the edge of the symphysis on the concave side of the valve, with angles of about 60° (Pl. 3, Fig. 13).

For comparison we reproduce a well preserved specimen (Pl. 3, Fig. 14, J30877), collected by M. Blumenthal, during 1927, in the Betic Cordillera (southern Spain), near Archidona (Provincia Malaga). Its stratigraphic position remains unknown.

Lamellaptychus ambiguus RENZ
Pl. 3, Fig. 21, 22

1979 *Lamellaptychus ambiguus* RENZ, Pl. 1, Fig. 13a–b, p. 593 (Western Bermuda Rise).

Occurrence: about 50 m (42 m), J30830, Pl. 3, Fig. 22.
58 m (47 m), J30831, Pl. 3, Fig. 21, above base of the Maiolica Formation.

Holotype: The reconstruction of the holotype as drafted by RENZ (1979, Pl. 1, Fig. 13b) is not correct, as shown by completer preserved material available at present.

Age: Valanginian.

Remarks: On the juvenile stage the lamellae lean towards the symphyseal margin before ending against it. Later, approaching the adult stage, the lamellae broaden and bend ventrally just before meeting the margin. Suddenly a retroverse turn of the lamellae sets in, such that the end of the first retroverse lamella meets the end of the former straight one. The retroverse ends of the lamellae merge into an outstanding adsymphyseal ridge.

Lamellaptychus aff. *ambiguus* RENZ
Pl. 5, Fig. 19, 20

Occurrence: 50 m (42 m), J30918, J30919, Pl. 5, Fig. 19, 20, above base of the Maiolica Formation.

Age: Valanganian.

Remarks: From typical *L. ambiguus* the present two specimens differ by a distinct interference between the lamellae which follow parallel to the symphyseal margin on the juvenile stage with the lamellae turning towards the margin, meeting it right-angled towards the adult stage.

A separation of the present specimen from *L. ambiguus* (Pl. 3, Fig. 21) might be indicated. This only can be confirmed by additional material.

Lamellaptychus aff. *noricus* (WINKLER)
Pl. 3, Fig. 19

1868 *Aptychus noricus* WINKLER, Pl. 4, Fig. 14, p. 27.
1938 *Lamellaptychus noricus* WINKLER, Pl. 13, Fig. 5, p. 89.
1979a *Lamellaptychus mortilleti noricus* Trauth, Renz, Pl. 1, Fig. 6–7, p. 593 (Western Bermuda Rise).

Occurrence: 57 m (47 m), MB205, J30832, above base of the Maiolica Formation.
Age: Valanganian.
Remarks: The single specimen, with its ventral end missing, can best be compared with the larger sized holotype, as well as with a juvenile pair of valves from the Western Bermuda Rise. The subrectangular outline of the valve seems to be a typical feature. The densely-spaced narrow lamellae follow the lateral and ventral facets and meet the symphyseal margin near to right-angled towards the adult stage.

Laevilamellaptychus ? new form
Pl. 5, Fig. 25

1897 *Aptychus* sp., STEUER, Pl. 24, Fig. 3, p. 19, 78 (Argentina).
1936a *Laevilamellaptychus* f., TRAUTH, Pl. 3, Fig. 8, 9, p. 136 (reproduction of specimens from Argentina).

Occurrence: 57 m (47 m), MB205, J30912, Pl. 5, Fig. 25.
Age: Valanginian.
Remarks: The name *Laevilamellaptychus* TRAUTH is based on specimens from the Dogger in Germany (TRAUTH 1930, p. 363.). Earlier such specimens formed part of *Cornaptychus* (TRAUTH 1927, p. 237).

The Valanginian age of our specimen of *Laevilamellaptychus* is confirmed by the presence of *L. bermudensis, L. retroflexus* and *L. ambiguus* within 57 m (47 m). Most outstanding features on our specimen, are the very slender elongated outline of the valve, its acute ventral end leaving no space for a lateral facet and its high keel falling-off steep towards the symphyseal margin. Also the sculpture consisting of very narrow and thin lamellae which meet the symphyseal margin with angles of about 30° are comparable with the specimens from the Andes in Argentina (Arroyo Cieneguita, Sierra de Malargue). The age of the specimen from Argentina is indicated as early Tithonian.

Our knowledge on this form is still very restricted. This prevents us to introduce a new name for the specimen from the Maiolica Formation.

Lamellaptychus carinatus new form
Pl. 3, Fig. 20a, b

Occurrence: 59 m (49 m), MB206, J30835, above base of the Maiolica Formation.
Age: Valanginian.
Remarks: The present specimen is distinguished by its very pronounced apical-diagonal keel, declining nearly vertical laterally. The adult lamellae on the lateral slope of the keel are partly angularly inflected. Along the less steep slope towards the symphyseal margin the lamellae first bend sinuously ventrally before curving towards the symphyseal margin, meeting it in acute angles. This second bending implies a widening of the lamellae, similar to *L. elegans* (Pl. 2, Fig. 16). The last lamellae converge towards the ventral end of the valve, comparable to *L. mortilleti.*

Lamellaptychus aff. *symphysocostatus* Trauth
Pl. 3, Fig. 15a–b

Occurrence: 62 m (51 m), MB209, J30836, above base of the Maiolica Formation.
Age: Valanginian.
Remarks: This single valve was found within the range of typical *L. symphysocostatus.* The feature common with the latter are the retroverse turning of the lamellae close to the symphyseal margin. The present specimen differs from the holotype of *L. symphysocostatus* Trauth (1938) by its very narrowly placed lamellae some of which are branching towards the adult stage.

A new name for the present form might be justified when additional material clarifies the relation to typical *L. symphysocostatus.*

Lamellaptychus aff. *angulodidayi* Trauth
Pl. 3, Fig. 23

Occurrence: 70 m (58 m), J30837, above base of the Maiolica Formation.
Age: Late Valanganian.
Remarks: On the present specimen not all features coincide satisfactorily with those on the holotype of *L. angulodidayi* from Castellane (Département Basses Alpes) in southern France. A specimen from higher in the section at 75 m (63 m) shows *L. angulodidayi* more convincingly represented (Pl. 4, Fig. 7).

On the juvenile stage the rather narrow lamellae approach the symphyseal margin following and touching it very acute-angled. The broader adult lamellae turn retroverse quite close to the symphyseal margin without forming an adsymphyseal ridge. This mainly distinguishes the present specimen from typical *L. angulodidayi* (Pl. 4, Fig. 7). On *L. ambiguus* (Pl. 3, Fig. 21, 22) from deeper in the section, 50 m (42 m) to 58 m (47 m), the retroverse turn of the last adult lamellae is still less pronounced.

Additional specimens of this group of lamellaptychi might help to clarify the taxonomic value concerning the apparent unstable approach of the lamellae towards the symphyseal margin with progressing age.

Lamellaptychus bicurvatus new name
Pl. 3, Fig. 25–28

1938 *Lamellaptychus sub-mortilleti* var. *retroflexa* TRAUTH, Pl. 14, Fig. 6, p. 201, holotype.
1961 *Lamellaptychus submortilleti* var. *retroflexa* TRAUTH, STEPHANOV, Pl. 3, Fig. 7, p. 220 (Bulgaria).

Occurrence: 71 m (59 m), J30838, Pl. 3, Fig. 25.
71 m (59 m), J30839, Pl. 3, Fig. 27.
71 m (59 m), J30840, Pl. 3, Fig. 28.
75 m (63 m), J30841, Pl. 3, Fig. 26, above base of the Maiolica Formation.
Age: Late Valanginian.
Remarks: The valve is broadly arched along the apical-diagonal line. On its juvenile stage the lamellae approaching the symphyseal margin bend ventrally, closely following the margin before touching it. Towards the adult stage the lamellae strengthen and their width increases consecutively. They turn retroverse in a broad bow, and before touching the symphyseal margin, reverse ventrally again before meeting the margin, The lamellae on our specimens are weakly inflected, what is not visible on the holotype from Gresten in the Austrian Alps, because its dorsal half is missing.

L. bicurvatus seems not related to *L. lombardicus* (early Valanginian) displaying a comparable lamellae pattern (Pl. 2, Fig. 10, 11).

The flatness of the valve induced TRAUTH (1938) to unite this form with *L. submortilleti:* "... durch das Fehlen einer Flankendepression und einer deutlichen apicaldiagonalen Kielwölbung ..." (p. 201).

Lamellaptychus ? aff. *L. bicurvatus* new form?
Pl. 3, Fig. 24

Occurrence: 71 m (59 m), J30842, above base of the Maiolica Formation.
Age: Late Valanginian.
Description: The fragment representing an adult stage can possibly be attached to *L. bicurvatus* (Pl. 3, Fig. 25–28). The juvenile lamellae (upper right end on Fig. 24) touch the symphyseal margin in acute angles. Later the lamellae perform acute-angled bends before approaching the symphyseal margin right-angled, and just before touching the margin they turn ventrally again, comparable to *L. bicurvatus* (Pl. 3, Fig. 25–28) from the same strata. The last preserved lamellae then turn slightly retroverse towards the margin touching it straight. An adsymphyseal ridge is not developed.

This still questionable fragment cannot be interpreted without fully preserved additional specimens.

Lamellaptychus ticinensis new name
Pl. 3, Fig. 29–31; Pl. 4, Fig. 1–3

1867 *Aptychus Seranonis* COQUAND, PICTET (partim), Pl. 28, Fig. 10b, c, p. 123, holotype.
1938 *Lamellaptychus mortilleti* (PICTET & LORIOL), TRAUTH, Pl. 10, Fig. 27–28, p. 145 (refigured holotype).

Occurrence: 75 m (63 m), J30843, Pl. 3, Fig. 29.
75 m (63 m), J30844, Pl. 3, Fig. 30.
75 m (63 m), J30845, Pl. 3, Fig. 31.
75 m (63 m), J30846, Pl. 4, Fig. 1.
75 m (63 m), J30847, Pl. 4, Fig. 2.
79 m (65 m), J30848, Pl. 4, Fig. 3, above base of the Maiolica Formation.

Age: Late Valanginian.

Description: 12 specimens from an interval about 2 m thick are available. All display stable features coinciding satisfactorily with the holotype from Berrias (Ardèche). The present specimens are broadly arched and highest along the apical-diagonal line, which is followed by a flat lateral depression of the valve, connected with a feeble inflection of the lamellae. Shortly before touching the symphyseal margin the lamellae turn ventrally in wide angles.

Variations within the material disponible are restricted to the adult lamellae which broaden and than meet the symphyseal margin right-angled or even faintly retroverse (Pl. 3, Fig. 31; Pl. 4, Fig. 2).

Lamellaptychus morbiensis new form
Pl. 4, Fig. 4, 10

Occurrence: 75 m (63 m), J30849, Pl. 4, Fig. 4, holotype.
75 m (63 m), J30850, Pl. 4, Fig. 10, paratype, above base of the Maiolica Formation.

Age: Late Valanginian.

Description: The narrowly and highly-arched valve along the apical-diagonal line is laterally slightly depressed. The narrow, closely placed lamellae are distinctly angularly inflected. Approaching the symphyseal margin they slightly curve towards the ventral end of the valve, meeting the margin in acute angles. The lamellae converge towards the ventral termination of the valve, the last ones ending along the ventral facet.

L. mortilleti from considerably deeper in the section shows a similar lamellae pattern. No indications for a relation between the two forms are, however, indicated so far. Additional material might allow new perceptions.

Lamellaptychus angulodidayi TRAUTH
Pl. 4, Fig. 7

1846 *Aptychus Didayi* QUENSTEDT, Pl. 22, Fig. 21, p. 314.
1938 *Lamellaptychus angulo-didayi* TRAUTH, Pl. 14, Fig. 28–29 only, p. 212, refigured holotype.

Occurrence: 75 m (63 m), J30851, above base of the Maiolica Formation.

Age: Late Valanginian.

Remarks: Our specimen differs from the holotype by its less pronounced, wider angulated and weak retroverse turn of the lamellae on the adult stage. An adsymphyseal ridge is not developed. A crossing of the lamellae over the symphyseal facet, observed on the holotype, is not visible.

Lamellaptychus form indet.
Pl. 4, Fig. 8

Occurrence: 75 m (63 m), J30852, above base of the Maiolica Formation.
Age: Late Valanginian.
Remarks: The juvenile lamellae on this still questionable fragment perform a hook-like bending before turning slightly retroverse. The last three adult lamellae approach the symphyseal margin first straight, later slightly retroverse (last two lamellae). A prominent adsymphyseal ridge is developed.

Lamellaptychus mendrisiensis new form
Pl. 4, Fig. 9

Occurrence: 75 m (63 m), J30853, above base of the Maiolica Formation.
Age: Late Valanginian.
Description: The single valve available is broadly and highly arched along the apical-diagonal axis. The steeply declining lateral slope of the valve is not depressed, nevertheless the lamellae are distinctly inflected. On the juvenile stage the lamellae approaching the symphyseal margin bend ventrally, and meet the margin in very acute angles. On the adult stage the last six straight lamellae progress parallel to the margin ending narrowly placed along the ventral facet, nearby the ventral termination of the valve.

A connection of *L. mendrisiensis* with *L. beyrichi* from the late Tithonian seems improbable. A relation of *L. bahamensis* from lower in the section, at 70 m (58 m), to the present form might be considered. Additional material is wanted for a clarification.

Hauterivian (Fig. 1)

The interval delimited between 75 m (63 m) and 110 m (92 m) of the Maiolica Formation is attributed to the Hauterivian. It is distinguished by its scarcity of specimens, as well as forms of aptychi. This observation is not restricted to the Breggia section. In DSDP holes in the northern Atlantic comparable conditions are indicated. Concerning its background nothing conclusive is known at present.

All aptychi, so far obtained from the interval, are distinguished by a distinct retroverse turn of the lamellae.

Lamellaptychus subseranonis Renz
Pl. 4, Fig. 11–16, 18, 21

1978 *Lamellaptychus subseranonis* Renz, Pl. 1, Fig. 12, p. 904 (Blake-Bahama Basin).
1983 *Lamellaptychus subseranonis* Renz, Pl. 1, Fig. 9, p. 640 (Blake-Bahama Basin).

Occurrence: 75 m (63 m), J30854, Pl. 4, Fig. 11.
75 m (63 m), J30855, Pl. 4, Fig. 12.
79 m (66 m), J30856.
86 m (71 m), J30899.
86 m (71 m), J30857, MB61, Pl. 4, Fig. 13.
86 m (71 m), J30858, Pl. 4, Fig. 14.
86 m (71 m), J30859, Pl. 4, Fig. 15.

86 m (71 m), J30860, Pl. 4, Fig. 16.
86 m (71 m), J30866, Pl. 4, Fig. 21.
89 m (74 m), J30861, Pl. 4, Fig. 18.
97 m (81 m), J30900.

Age: Late Valanginian to Hauterivian.

Remarks: According to present observations *L. subseranonis* is found within an interval of 18 m of the Maiolica section. The form is distinguished by its considerable variability mainly in what the hight of the valves and their outlines are concerned. The valves from 75 m (63 m) on Plate 1, Figures 11 and 12, are slightly laterally depressed causing a weak inflection of the lamellae. On specimens from higher in the section the depression disappears and the lamellae straighten. Generally a distinct adsymphyseal ridge is developed.

The name indicates that *L. subseranonis* might be interpreted as an antecedent of typical *L. seranonis* from somewhat higher in the section. This assumption, however, is not sufficiently verified with the material in hand. Correlations with other sections are necessary.

Lamellaptychus seranonis (COQUAND)
Pl. 4, Fig. 17, 19, 23; Pl. 5, Fig. 2–6

1841 *Aptychus Seranonis* COQUAND, Pl. 9, Fig. 13, p. 390.
1858 *Aptychus Seranonis* COQUAND, PICTET & LORIOL, Pl. 11, Fig. 1–8, p. 48.
1867 Non *Aptychus seranonis* COQUAND, PICTET, Pl. 28, Fig. 9b, p. 123.
1938 *Lamellaptychus seranonis* (COQUAND), TRAUTH, Pl. 13, Fig. 27, 28 only, p. 193.
1972 *Lamellaptychus seranonis* (COQUAND), RENZ, Pl. 3, Fig. 4, 5, p. 615 (Hatteras Abyssal Plain).
1977 *Lamellaptychus seranonis* (COQUAND), RENZ, Pl. 1, Fig. 27–29, p. 506 (Cape Verde Basin).
1978 *Lamellaptychus seranonis* (COQUAND), RENZ, Pl. 1, Fig. 13, 15, p. 905 (Blake-Bahama Basin).
1983 *Lamellaptychus seranonis* (COQUAND), RENZ, Pl. 1, Fig. 6, p. 640 (Blake-Bahama Basin).

Occurrence: 87 m (72 m), J30863, Pl. 4, Fig. 17.
97 m (81 m), J30864, Pl. 4, Fig. 19.
103 m (85 m), J30865.
105 m (87 m), J30983.
110 m (92 m), J30867, Pl. 4, Fig. 23.
110 m (92 m), J30889–30893, Pl. 5, Fig. 2–6.

Age: Hauterivian.

Remarks: *L. seranonis,* so far, seems to be restricted to a relatively narrow interval between 87 m (72 m) and 110 m (92 m). An adsymphyseal ridge, as common on *L. subseranonis* deeper in the section is not developed. The specimens figured show considerable variations, especially what the intensity of inflection of the lamellae is concerned.

Lamellaptychus seranonis fractocostus TRAUTH
Pl. 4, Fig. 20, 24, 25; Pl. 5, Fig. 1

1938 *Lamellaptychus seranonis* var. *fractocosta* TRAUTH, p. 197 (not figured).
1978 *Lamellaptychus seranonis fractocostus* TRAUTH, RENZ 1978, Pl. 1, Fig. 14, p. 905 (Blake-Bahama Basin), holotype here designated.

Occurrence: 97 m (81 m), J30869, Pl. 4, Fig. 20.
107 m (89 m), J30870, Pl. 4, Fig. 25.
110 m (92 m), J30871, Pl. 4, Fig. 24.
110 m (92 m), J30882, Pl. 5, Fig. 1.

Age: Hauterivian.

Remarks: The intensity of inflection ("fracturing") of the lamellae is a variable feature. Conform with typical *L. seranonis* an adsymphyseal ridge is not developed on such variations from the Breggia section.

Lamellaptychus tethis new form
Pl. 4, Fig. 22

1979b *Lamellaptychus* sp., RENZ, Pl. 2, Fig. 8 (west of the Iberian Peninsula, south of Vigo Seamount (DSDP Site 398D)).

Occurrence: 97 m (81 m), J30862, above base of the Maiolica Formation.

Age: About mid Hauterivian.

Description: The ventral half of a left valve compares conspicuously well with a similar fragment (J28220) from the Aptian in Site 398D (40°70.6 N; 10°43.1 W). The steep and high, sharp-edged, very wide-spaced lamellae curve retroverse in a wider bow and merge with a pronounced adsymphyseal ridge, what implies deep hollows between the lamellae adjoining the ridge. Evidently additional material is necessary to appreciate this form.

Barremian (Fig. 1)

The presence of the ammonite genus *Pulchellia* beneath the top of the Blake-Bahama Formation (Leg 76, Site 534A, DSDP, Core 51, Section 1, 101–104 cm) implies a revision of age assignments for sediments containing *L. angulocostatus*. In previous DSDP contributions on aptychi the respective deposits were considered to be Hauterivian in age. According to present knowledge, based on *Pulchellia*, a Barremian age seems more appropriate for intervals containing *L. angulocostatus* in the Blake-Bahama Formation, as well as in the Maiolica Formation.

In the upper 30 m of the Maiolica Formation the group of *L. angulocostatus* dominates and it is typically developed.

Lamellaptychus angulocostatus (PETERS)
Pl. 5, Fig. 9, 10, 12, 15

1858 *Aptychus angulocostatus* PETERS, PICTET & LORIOL, Pl. 10, Fig. 3–12, p. 46.
1938 *Lamellaptychus angulocostatus* (PETERS), TRAUTH, Pl. 14, Fig. 12–13, p. 204.
1942 *Lamellaptychus angulocostatus* (PETERS), IMLAY, Pl. 11, Fig. 8–10, p. 1459.

1961 *Lamellaptychus angulocostatus* (PETERS), STEPHANOV, Pl. 1, Fig. 1–4, 6, p. 212 (Bulgaria).
1965 *Lamellaptychus angulocostatus* (PETERS), FAZZINI, Pl. 1, Fig. 1–8, Pl. 1 (cum synon.).
1972 *Lamellaptychus angulocostatus* (PETERS), RENZ, Pl. 4, Fig. 1–5, p. 616 (Hatteras Abyssal Plain).
1973 *Lamellaptychus* sp., RENZ, Pl. 1, Fig. 5, p. 896 (Magellan Rise, Central Pacific).
1974 *Lamellaptychus angulocostatus* (PETERS), HOUSA, Pl. 1–10, p. 1–57 (cum synon.).
1977 *Lamellaptychus angulocostatus* (PETERS), RENZ, Pl. 1, Fig. 35; Pl. 2, Fig. 1–2, p. 506 (Cape Verde Basin).
1978 *Lamellaptychus angulocostatus planus* (RENZ), Pl. 1, Fig. 16, p. 905 (Blake-Bahama Basin).
1979b *Lamellaptychus angulocostatus* (PETERS), RENZ, Pl. 2, Fig. 9, p. 361 (south of Vigo Seamount, west of Iberian Peninsula).
1983 *Lamellaptychus angulocostatus* (PETERS), RENZ, Pl. 1, Fig. 2, 5, p. 640 (Blake-Bahama Basin).

Occurrence: 109.5 m, DB 2718b, J30872, Pl. 5, Fig. 9.
118.5 m, DB 2720, J30884, Pl. 5, Fig. 12.
123 m (102 m), J30900.
133 m (110 m), MB87c, J30885, Pl. 5, Fig. 10.
136 m (113 m), J30830.
144 m (118.5 m), DB 2721, J30894, Pl. 5, Fig. 15, above base of the Maiolica Formation.

Age: Barremian.

Remarks: A transition of *L. seranonis* towards *L. angulocostatus* is indicated on specimen Figure 6 (Pl. 5). This specimen from 110 m (92 m), shows the juvenile stage of *L. seranonis* where the lamellae approach the symphyseal margin in a retroverse bow. In the middle of the valve the bow turns faintly angular and later on the adult stage rounded again. On *L. angulocostatus cristobalensis* on Plate 5, Figure 7, 109.5 m, the angular turn of the lamellae persists from the juvenile until the adult stage where a gradual rounding occurs.

Lamellaptychus angulocostatus cristobalensis (O'CONNELL)
Pl. 5, Fig. 7, 11, 13

1921 *Aptychus cristobalensis* O'CONNELL, Fig. 7, p. 7.
1938 *Lamellaptychus angulocostatus* var. *cristobalensis* (O'CONNELL), TRAUTH, Pl. 14, Fig. 26, p. 211.
1961 *Lamellaptychus angulocostatus cristobalensis* (O'CONNELL), STEPHANOV, Pl. 1, Fig. 11, p. 213 (Bulgaria).
1977 *Lamellaptychus angulocostatus* aff. *cristobalensis* (O'CONNELL), RENZ 1977, Pl. 2, Fig. 3, p. 507 (Cape Verde Basin).

Occurrence: 109.5 m, DB 2718a, J30886, Pl. 5, Fig. 7.
133 m (110 m), MB87, J30876, Pl. 5, Fig. 11.
133 m (110 m), MB87b, J30887, Pl. 5, Fig. 13, above base of the Maiolica Formation.

Age: Barremian.

Remarks: Three specimens are distinguished by round curving instead of angulate lamellae on the adult stage. The variety occurs contemporaneously with typical *L. angulocostatus*.

Lamellaptychus aff. *angulocostatus* (PETERS)
Pl. 5, Fig. 8

cf. 1961 *Lamellaptychus angulocostatus* var. *atlantica* (HENNIG), STEPHANOV, Pl. 1, Fig. 12, p. 215 (Bulgaria).

Occurrence: 126 m (105 m), MB81, J30883, above base of the Maiolica Formation.
Age: Barremian.
Remarks: From typical *L. angulocostatus* this specimen differs by its angular turning of the lamellae remarkably close to the symphyseal margin. In this respect it approximates *L. symphysocostatus* TRAUTH (1938, Pl. 14, Fig. 15, 16, p. 208) which, however, occurs lower in the section between 50 m (42 m) and 78 m (64 m).

Lamellaptychus atlanticus (HENNIG)
Pl. 5, Fig. 14, 16

1913 *Aptychus atlanticus* (HENNIG, Pl. 2, Fig. 1a–b, p. 155.
1938 *Lamellaptychus angulocostatus* var. *atlantica* (HENNIG), TRAUTH, Pl. 14, Fig. 19, p. 210, refigured holotype.
1972 *Lamellaptychus angulocostatus atlanticus* (HENNIG), RENZ 1972, Pl. 4, Fig. 2a, 3, p. 617 (Hatteras Abyssal Plain).
1974 *Lamellaptychus atlanticus* HENNIG, HOUSA, Pl. 8, Fig. 2, p. 72.
1983 *Lamellaptychus angulocostatus atlanticus* (HENNIG), RENZ, Pl. 1, Fig. 3, p. 640 (Blake-Bahama Basin).

Occurrence: 133 m (110 m), MB87b, J30917, Pl. 5, Fig. 16.
144 m (119 m), DB 2720, J30900, Pl. 5, Fig. 14, above base of the Maiolica Formation.
Remarks: This small, widely known form shows angulate retroverse turning lamellae restricted on the juvenile stage. Soon the narrowly placed lamellae turn rounded and remain so until the adult stage.

E. Correlation of the Maiolica Formation in the Breggia river with the Blake-Bahama Formation in the North Atlantic (Fig. 3).

Accurately defined boundaries delimiting stages between Tithonian and Barremian, based on aptychi and on a few compressed ammonites have so far, not been established in holes drilled in the North Atlantic. Intervals with remains of Cephalopoda are scattered, particularly in the Atlantic (Holes 434A and 391C, Blake-Bahama Basin).

For the correlation proposed here two groups of observations are of fundamental importance.

a) Apparently synchronous changes in lithology observed in the western North Atlantic as well as in the Breggia section, suggesting correlations of the Rosso ad Aptici with the Cat Gap Formation and of the Maiolica with the Blake-Bahama Formation.

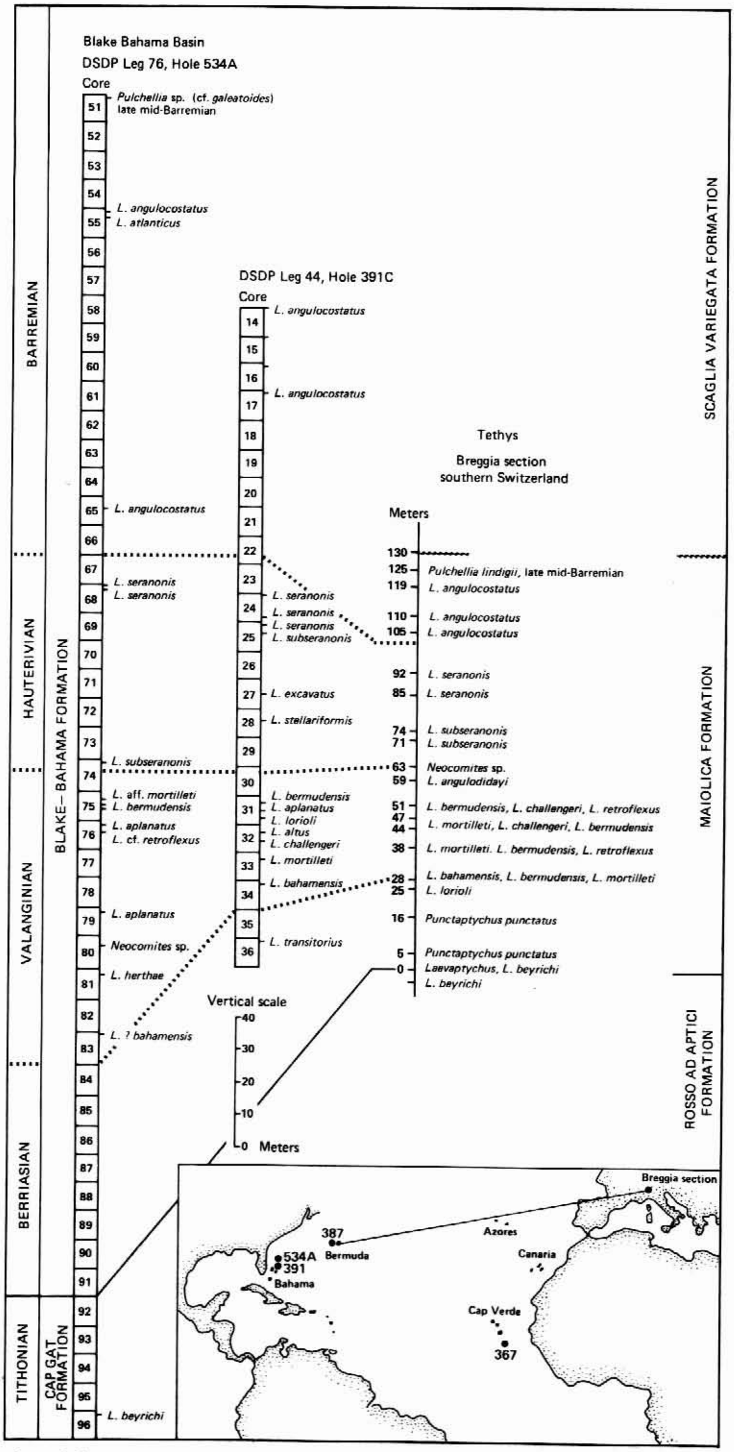

Fig. 3. Correlation of the Maiolica Formation with DSDP Leg 76, Hole 534A, and Leg 44, Hole 391C, in the Blake-Bahama Basin in the western Atlantic.

b) Within the Valanginian interval of the Breggia section a pronounced diversity of aptychi, coupled with an abundance of specimens, is observed. A similar concentration of identical species occurs within the upper part of the lower half of the Blake-Bahama Formation.

The considerable difference in thickness between the Blake-Bahama Formation and the Maiolica Formation is obviously due to factors not relevant to correlation, such as subsidence, sedimentation rate and diagenetic compaction which mainly affected the Maiolica Formation.

Tithonian

From the upper part of the purplish-coloured Cat Gap Formation, *Lamellaptychus beyrichi* (Hole 534A, Core 96, Tithonian) correlates with identical forms from the Rosso ad Aptici in the Breggia. Based on this observation a time equivalence of the Cat Gap Formation (Core 92 to 96) with the Rosso ad Aptici Formation is indicated. This correlation is confirmed also by calpionellids in the Blake-Bahama Formation (REMANE 1984, p. 561). We herewith can conclude that the change in facies from purplish marls (Cat Gap Formation) into white nannofossil ooze (Blake-Bahama Formation) coincides with the limit separating Jurassic (Tithonian) from Cretaceous (Berriasian).

L. beyrichi also has been mentioned from the red marls within a stratigraphical identical position, in southern Tuscany, in central Italy (KÄLIN et al., 1979).

Berriasian (0 m to 28 m)

From the lower part of the Blake-Bahama Formation (Hole 534A, Core 91 to 83), assumed to represent the Berriasian, no remains of Cephalopoda were obtained. In the lower 20 m of the Maiolica Formation, *Punctapychus* indicating Berriasian, is the most outstanding guide fossil. It is obvious that the placement fo the Berriasian–Valanginian boundary within the Blake-Bahama Formation must remain tentative.

Valanginian (28 m to 63 m)

The interval assumed to represent the Valanginian is distinguished by a conspicuous accumulation of different forms of aptychi in the Maiolica Formation, as well as in the Atlantic (Core 75 to about Core 82 in DSDP Leg 76, Hole 534A). Ammonites in the Maiolica Formation are restricted to Neocomitinae from the top of the interval assigned to the Valanginian at 75 m (63 m). In Hole 534A, Core 80, a partly preserved imprint, determined as *Neocomites* (Pl. 1, Fig. 16a–b, p. 641) suggests also a Valanginian age. Among aptychi *Lamellaptychus bermudensis* (Hole 391C, Pl. 1, Fig. 8, and Hole 534A, Pl. 1, Fig. 11) and *L. challengeri* (Hole 391C, Pl. 1, Fig. 4), so far assumed to be restricted to the Atlantic, were abundantly recovered from the interval supposed to be Valanginian in age in the Breggia. The two forms seem to represent very useful guide fossils indicating Valanginian.

Hauterivian (63 m to 102 m)

The Valanginian–Hauterivian boundary in Hole 534A has been placed near Core 73 and near Core 30 in Hole 391C, both in the Blake-Bahama Basin. These levels about coincide with the 75 m (63 m) mark at the Maiolica section. Here, at the top of the Valanginian, a very conspicuous break in variability and abundance of aptychi can be observed, as displayed on the distribution chart (Fig. 2). This distribution of aptychi, we may assume, should also be reflected in ammonite assemblages from close to the Valanginian–Hauterivian boundary.

The intervals between 63 m and 92 m at the Maiolica section and between Core 67 to Core 68 in Hole 534A, and Core 24 to 25 in Hole 391C, both in the Blake-Bahama Basin, are dominated by aptychi distinguished by retroverse curving lamellae patterns. They belong to the group of *Lamellaptychus seranonis,* a form restricted according to present knowledge to the Hauterivian.

Barremian (102 to 130 m)

In the Blake-Bahama Basin (Hole 391A) and the Cape Verde Basin (Hole 367) considerable gaps without remains of Cephalopoda hamper the fixation of the Hauterivian–Barremian boundary.

Within the Maiolica section an interval (tunnel, Fig. 1) without aptychi of 9 m thickness separates the last *L. seranonis* (Hauterivian) from the first *L. angulocostatus,* a widely distributed form within the Tethys, indicating a Barremian age. The limit Hauterivian–Barremian thus remains unclear.

From 5 m below the top of the Maiolica Formation, near 125 m, an ammonite assemblage has been described by RIEBER (1977). The presence of *Pulchellia* and *Karsteniceras,* widely known from Europe (Spain) and northern South America (Colombia, Trinidad) represent a reliable indication for a Barremian age.

The discovery of *Pulchellia,* although flattened and poorly preserved, from Hole 534A in the Blake-Bahama Basin is of the greatest value for regional correlation. Our present correlation is based mainly on the occurrence of *Pulchellia* in Hole 534A, and in the Maiolica section.

F. Conclusions

The present study on aptychi assemblages from the Maiolica Formation in the river Breggia, based on detailed stratigraphic collecting of the fossils, permits a preliminary correlation with holes drilled in the northern Atlantic by the Deep Sea Drilling Project. Regional correlations, based on aptychi from sections exposed within the Tethyan realm of Europe have so far not been attempted, the main reason being the consecutive repetition of nearly identical lamellae patterns of aptychi during the Jurassic–Cretaceous Periods.

Specimens with very similar morphological features (homeomorph) occur within levels of quite different ages. In most publications on aptychi little attention has been paid to the stratigraphical order in spite of its significance for taxonomy. This is demonstrated by the synonymy lists included in the present paper.

The aptychi obtained from the Deep Sea Drilling Project provided an ideal opportunity for investigations of aptychi, this being a main reason for carrying out the present study.

At present we just begin to understand the biochronologic significance of aptychi assemblages, especially in sediments from the Tethys.

The results, evidently, need confirmation at other sections. We propose to study additional sections of deep water Tethyan sediments containing aptychi. Of special interest in this respect are the Jurassic and Cretaceous deposits in the Betic Cordillera in southern Spain, as shown by a few specimens from old collections figured here.

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Plate 1

Late Tithonian, Rosso ad Aptici Formation

Fig. 1 *Laevaptychus longus* (MEYER) of *Physodoceras altense* (d'ORBIGNY)
0 m, J30728, 1.5×. p. 391

Fig. 2 *Laevaptychus latissimus* TRAUTH
0 m, J30909, 1.5×. p. 391

Fig. 3 *Laevaptychus longus seriporus* TRAUTH
0 m, J30729, 3×. p. 391

Fig. 4 *Laevaptychus latus vermiporus* TRAUTH
0 m, J30730, 3×. p. 391

Fig. 5 *Lamellaptychus beyrichi* (OPPEL)
1.5 m below top layer of Rosso ad Aptici Formation, J30732, 1×. p. 391

Fig. 6 *Lamellaptychus beyrichi* (OPPEL)
0 m, J30908, 1×. p. 393

Fig. 7 *Lamellaptychus rectecostatus* (PETERS)
0 m, J30733, 1×. p. 393

Fig. 8 *Punctaptychus punctatus longus* TRAUTH
0 m, J30734, 1×. p. 393

Fig. 9 *Lamellaptychus subalpinus* (SCHAFHÄUTL)
0 m, J30735, 2×. p. 393

Fig. 10 *Lamellaptychus breggiensis* new name
0 m, J30736, 2×. p. 394

Fig. 11 *Lamellaptychus breggiensis* new name
0 m, J30737, 2×. p. 394

Fig. 12 *Lamellaptychus submortilleti* TRAUTH
0 m, J30740, 2×. p. 395

Fig. 13 *Lamellaptychus* form indet.
0 m, J30738, 2×. p. 394

Fig. 14 *Lamellaptychus submortilleti* TRAUTH
0 m, J30741, 2×. p. 395

Fig. 15 *Lamellaptychus* form indet.
0 m, J30739, 2×. p. 394

Fig. 16 *Lamellaptychus seranonoides* TRAUTH
0 m, J30742, 2×. p. 395

Berriasian, Maiolica Formation

Fig. 17 *Punctaptychus punctatus* (VOLTZ)
10 m (8.5 m), J30745, 2×. p. 396

Fig. 18 *Punctaptychus punctatus* (VOLTZ)
10 m (8.5 m), J30895, 2×. p. 396

Fig. 19 *Punctaptychus punctatus* (VOLTZ)
23.5 m (19.5 m), J30748, 2×. p. 396

Fig. 20 *Lamellaptychus* cf. *cinctus* TRAUTH
11.5 m (9.5 m), J30749, 1×. p. 396

Fig. 21 *Lamellaptychus* ?aff. *beyrichi* (OPPEL)
24 m (20 m), MB11, J30750, 2×. p. 396

Fig. 22a, b *Lamellaptychus mortilleti* (PICTET & LORIOL)
30 m (25 m), J30752, 3×. p. 397

Fig. 23 *Lamellaptychus mortilleti* (PICTET & LORIOL)
27 m (22 m), MB14, J30751, 1×. p. 397

Valanginian, Maiolica Formation

Fig. 24 *Lamellaptychus mortilleti* (PICTET & LORIOL)
47.5 m (39.5 m), J30757, 3×. p. 397

Fig. 25 *Lamellaptychus mortilleti* (PICTET & LORIOL)
31 m (26 m), J30753a, 3×. p. 397

Fig. 26 *Lamellaptychus mortilleti* (PICTET & LORIOL)
31 m (26 m), J30753b, 3×. p. 397

MB = Specimens collected by H. J. Weissert
DB = Specimens collected by D. Bernoulli


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Plate 2

Valanginian continued

Fig. 1	*Lamellaptychus mortilleti* (Pictet & Loriol) 34.2 m (28 m), J30754, 3×.	p. 397
Fig. 2	*Lamellaptychus mortilleti* (Pictet & Loriol) 34.2 m (28 m), J30895, 3×.	p. 397
Fig. 3	*Lamellaptychus* aff. *mortilleti* (Pictet & Loriol) 45 m (37 m), J30756, 3×.	p. 397
Fig. 4a, b	*Lamellaptychus mortilleti* (Pictet & Loriol), juvenile 53 m (44 m), MB204, J30759, 2×.	p. 397
Fig. 5	*Lamellaptychus mortilleti* (Pictet & Loriol) 50 m (42 m), J30758, 2×.	p. 397
Fig. 6	*Lamellaptychus lorioli* Renz 30 m (25 m), J30761, 2×.	p. 398
Fig. 7	*Lamellaptychus helveticus* new form, holotype 30 m (25 m), J30762, 2×.	p. 398
Fig. 8	*Lamellaptychus helveticus* new form, paratype 1 30 m (25 m), J30763, 2×.	p. 398
Fig. 9	*Lamellaptychus helveticus* new form, paratype 2 30 m (25 m), J30764, 2×.	p. 398
Fig. 10	*Lamellaptychus lombardicus longus* new name 31.5 m (26.5 m), J30766, 2×.	p. 399
Fig. 11	*Lamellaptychus lombardicus* new form 31.5 m (26.5 m), J30765, 2×.	p. 398
Fig. 12	*Lamellaptychus trauthi* new form, holotype 34 m (28 m), J30767, 3×.	p. 399
Fig. 13	*Lamellaptychus trauthi* new form, paratype 34 m (28 m), MB201, J30768, 2×.	p. 399
Fig. 14	*Lamellaptychus* ? new form 46 m (38 m), MB203, J30781, 2×.	p. 401
Fig. 15a, b	*Lamellaptychus planus* new form 45.5 m (37.5 m), J30780, 2×.	p. 400
Fig. 16	*Lamellaptychus elegans* Renz 47 m (39 m), J30784, 3×.	p. 402
Fig. 17	*Lamellaptychus bahamensis* Renz 47 m (39 m), J30797, 3×.	p. 403
Fig. 18	*Lamellaptychus bahamensis* Renz 70 m (58 m), J30798, 3×.	p. 403
Fig. 19	*Lamellaptychus bermudensis levis*, new variety 50 m (42 m), J30783, 3×, holotype	p. 401
Fig. 20	*Lamellaptychus bermudensis levis*, new variety 46 m (38 m), MB203, J30782, 2×, paratype	p. 401
Fig. 21	*Lamellaptychus bermudensis* Renz 72 m (60 m), J30903, 2×.	p. 400
Fig. 22	*Lamellaptychus bermudensis* Renz 50 m (42 m), J30906, 2×.	p. 400
Fig. 23	*Lamellaptychus bermudensis* Renz 50 m (42 m), J30905, 2×.	p. 400
Fig. 24	*Lamellaptychus bermudensis* Renz 50 m (42 m), J30904, 2×.	p. 400
Fig. 25	*Lamellaptychus* aff. *retroflexus* Trauth 50 m (42 m), J30907, 2×.	p. 402
Fig. 26	*Lamellaptychus* aff. *retroflexus* Trauth 62 m (52 m), J30788, 2×.	p. 402
Fig. 27	*Lamellaptychus retroflexus* Trauth 62 m (52 m), J30789, 2×.	p. 402
Fig. 28	*Lamellaptychus retroflexus* Trauth 65 m (54 m), J30791, 2×.	p. 402
Fig. 29	*Lamellaptychus retroflexus* Trauth 71 m (59 m), J30793, 2×.	p. 402
Fig. 30	*Lamellaptychus retroflexus* Trauth 86 m (71 m), J30795, 3×.	p. 402
Fig. 31	*Lamellaptychus retroflexus* Trauth 75 m (63 m), J30794, 3×.	p. 402
Fig. 32	*Lamellaptychus retroflexus* Trauth 57 m (47 m), MB205, J30787, 2×.	p. 402
Fig. 33	*Lamellaptychus challengeri* Renz 50 m (42 m), J30801, 3×.	p. 403


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Plate 3

Valanginian continued

Fig. 1	*Lamellaptychus challengeri* RENZ 62 m (51 m), MB210, J30802, 2×.	p. 403
Fig. 2	*Lamellaptychus challengeri* RENZ 51 m (53 m), J30803, 3×.	p. 403
Fig. 3	*Lamellaptychus subdidayi* TRAUTH 59 m (49 m), MB206, J30833, 3×.	p. 404
Fig. 4	*Lamellaptychus* aff. *aplanatus* GILLIÉRON 54 m (45 m), J30808, 3×.	p. 403
Fig. 5	*Lamellaptychus aplanatus* GILLIÉRON 71 m (59 m), J30812, 3×.	p. 402
Fig. 6	*Lamellaptychus aplanatus* GILLIÉRON 75 m (63 m), J30813, 2×.	p. 403
Fig. 7	*Lamellaptychus* aff. *aplanatus* GILLIÉRON 75 m (63 m), J30814, 2×.	p. 403
Fig. 8	*Lamellaptychus aplanatus* GILLIÉRON 78 m (64 m), MB208, J30815, 2×.	p. 403
Fig. 9	*Lamellaptychus aplanatus* GILLIÉRON 47 m (39 m), J30816, 3×.	p. 403
Fig. 10	*Lamellaptychus aplanatus* GILLIÉRON 87 m (72 m), J30818, 3×.	p. 403
Fig. 11	*Lamellaptychus* aff. *aplanatus* GILLIÉRON 61.5 m (51 m), J30810, 3×.	p. 403
Fig. 12	*Lamellaptychus symphysocostatus* TRAUTH 51 m (53 m), J30827, 3×.	p. 406
Fig. 13	*Lamellaptychus symphysocostatus* TRAUTH 78 m (64 m), MB208, J30829, 3×.	p. 406
Fig. 14	*Lamellaptychus symphysocostatus* TRAUTH Betic Cordillera, Archidona, Provincia Malaga, Spain, J30888, 3×.	p. 406
Fig. 15a, b	*Lamellaptychus* aff. *symphysocostatus* TRAUTH 62 m (51 m), MB209, J30836, 2×, 15a slightly enlarged	p. 408
Fig. 16	*Lamellaptychus herthae* (WINKLER) 54 m (45 m), J30822, 2×.	p. 405
Fig. 17	*Lamellaptychus herthae* (WINKLER) 62 m (51 m), MB209, J30823, 2×.	p. 405
Fig. 18	*Lamellaptychus herthae* (WINKLER) 68 m (56 m), J30824, 1×.	p. 405
Fig. 19	*Lamellaptychus* aff. *noricus* (WINKLER) 57 m (47 m), MB205, J30832, 2×.	p. 407
Fig. 20a, b	*Lamellaptychus carinatus* new form 59 m (49 m), MB206, J30835, 2×.	p. 408
Fig. 21	*Lamellaptychus ambiguus* RENZ 58 m (47 m), J30831, 2×.	p. 406
Fig. 22	*Lamellaptychus ambiguus* RENZ 50 m (42 m), J30830, 3×.	p. 406
Fig. 23	*Lamellaptychus* aff. *angulodidayi* TRAUTH 70 m (58 m), J30837, 2×.	p. 408
Fig. 24	*Lamellaptychus* ? aff. *L. bicurvatus* new form 71 m (59 m), J30842, 2×.	p. 409
Fig. 25	*Lamellaptychus bicurvatus* new name 71 m (59 m), J30838, 2×.	p. 409
Fig. 26	*Lamellaptychus bicurvatus* new name 75 m (63 m), J30841, 2×.	p. 409
Fig. 27	*Lamellaptychus bicurvatus* new name 71 m (59 m), J30839, 2×.	p. 409
Fig. 28	*Lamellaptychus bicurvatus* new name 71 m (59 m), J30840, 2×.	p. 409
Fig. 29	*Lamellaptychus ticinensis* new name 75 m (63 m), J30843, 2×.	p. 409
Fig. 30	*Lamellaptychus ticinensis* new name 75 m (63 m), J30844, 3×.	p. 409
Fig. 31	*Lamellaptychus* ? aff. *ticinensis* new name 75 m (63 m), J30845, 3×.	p. 409


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Plate 4

Valanginian continued

Fig. 1	*Lamellaptychus ticinensis* new name 75 m (63 m), J30846, 3×.	p. 403
Fig. 2	*Lamellaptychus ticinensis* new name 75 m (63 m), J30847, 2×.	p. 403
Fig. 3	*Lamellaptychus ticinensis* new name 79 m (65 m); J30848, 3×.	p. 409
Fig. 4	*Lamellaptychus morbiensis* new form 75 m (63 m), J30849, 3×, holotype	p. 410
Fig. 5	*Lamellaptychus didayi* TRAUTH 50 m (42 m), J30819, 3×.	p. 405
Fig. 6	*Lamellaptychus didayi* TRAUTH 71 m (59 m), J30820, 2×.	p. 405
Fig. 7	*Lamellaptychus angulodidayi* TRAUTH 75 m (63 m), J30851, 2×.	p. 410
Fig. 8	*Lamellaptychus* form indet. 75 m (63 m), J30852, 2×.	p. 410
Fig. 9	*Lamellaptychus mendrisiensis* new form 75 m (63 m), J30853, 3×.	p. 411
Fig. 10	*Lamellaptychus morbiensis* new form 75 m (63 m), J30850, 3×, paratype	p. 410
Fig. 11	*Lamellaptychus subseranonis* RENZ 75 m (63 m), J30854. 3×.	p. 411
Fig. 12	*Lamellaptychus subseranonis* RENZ 75 m (63 m), J30855, 3×.	p. 411

Hauterivian, Maiolica Formation

Fig. 13	*Lamellaptychus subseranonis* RENZ 86 m (71 m), MB61, J30857, 2×.	p. 411
Fig. 14	*Lamellaptychus subseranonis* RENZ 86 m (71 m), J30858, 2×.	p. 411
Fig. 15	*Lamellaptychus subseranonis* RENZ 86 m (71 m), J30859, 2×.	p. 411
Fig. 16	*Lamellaptychus subseranonis* RENZ 86 m (71 m), J30860, 3×.	p. 411
Fig. 17	*Lamellaptychus seranonis* COQUAND 87 m (72 m), J30863, 3×.	p. 412
Fig. 18	*Lamellaptychus subseranonis* RENZ 89 m (74 m), J30861, 2×.	p. 411
Fig. 19	*Lamellaptychus seranonis* COQUAND 97 m (81 m), J30864, 3×.	p. 412
Fig. 20	*Lamellaptychus seranonis fractocostus* TRAUTH 97 m (81 m), J30869, 3×.	p. 413
Fig. 21	*Lamellaptychus subseranonis* RENZ 86 m (71 m), J30866, 2×.	p. 411
Fig. 22	*Lamellaptychus tethis* new name 97 m (81 m), J30862, 2×.	p. 413
Fig. 23	*Lamellaptychus seranonis* COQUAND 110 m (92 m), J30867, 2×.	p. 413
Fig. 24	*Lamellaptychus seranonis fractocostus* TRAUTH 110 m (92 m), J30871, 2×.	p. 413
Fig. 25	*Lamellaptychus seranonis fractocostus* TRAUTH 107 m (89 m), J30870, 3×.	p. 413


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Plate 5

Hauterivian continued

Fig. 1 *Lamellaptychus seranonis fractocostus* Trauth
110 m (92 m), J30882, 3×. p. 412

Fig. 2 *Lamellaptychus seranonis* (Coquand)
110 m (92 m), J30889, 2×. p. 412

Fig. 3 *Lamellaptychus seranonis* (Coquand)
110 m (92 m), J30890, 2×. p. 412

Fig. 4 *Lamellaptychus seranonis* (Coquand)
110 m (92 m), J30891, 3×. p. 412

Fig. 5 *Lamellaptychus seranonis* (Coquand)
110 m (92 m), J30892, 2×. p. 412

Fig. 6 *Lamellaptychus seranonis* (Coquand)
110 m (92 m), J30893, 3×. p. 412

Barremian, Maiolica Formation

Fig. 7 *Lamellaptychus angulocostatus cristobalensis* O'Connell
109.5 m, DB2718a, J30886, 2×. p. 414

Fig. 8 *Lamellaptychus* aff. *angulocostatus* (Peters)
126 m (105 m), MB81, J30883, 1.5×. p. 415

Fig. 9 *Lamellaptychus angulocostatus* (Peters)
109.5 m DB2718b, J30872, 2×. p. 413

Fig. 10 *Lamellaptychus angulocostatus* (Peters)
133 m (110 m), MB87c, J30885, 1.5×. p. 413

Fig. 11 *Lamellaptychus angulocostatus cristobalensis* (O'Connell)
133 m (110 m), MB87, J30876, 2×. p. 414

Fig. 12 *Lamellaptychus angulocostatus* (Peters)
118.5 m DB2720, J30884, 3×. p. 413

Fig. 13 *Lamellaptychus angulocostatus cristobalensis* (O'Connell)
133 m (110 m), MB87b, J30887, 1.5×. p. 414

Fig. 14 *Lamellaptychus atlanticus* (Hennig)
144 m (119 m), DB2720, J30900, 3×. p. 415

Fig. 15 *Lamellaptychus angulocostatus* (Peters)
144 m (119 m), DB2721, J30894, 2×. p. 413

Fig. 16 *Lamellaptychus atlanticus* (Hennig)
133 m (110 m), MB87b, J30917, 1.5×. p. 415

Addenda, Valanginian

Fig. 17 *Lamellaptychus elegans* Renz
50 m (42 m), J30911, 2×. p. 402

Fig. 18 *Lamellaptychus elegans* Renz
50 m (42 m), J30910, 2×. p. 402

Fig. 19 *Lamellaptychus* aff. *ambiguus* Renz
50 m (42 m), J30918, 2.5×. p. 406

Fig. 20 *Lamellaptychus* aff. *ambiguus* Renz
50 m (42 m), J30919, 2.5×. p. 406

Fig. 21 *Lamellaptychus bahamensis* Renz
50 m (42 m), J30916, 2.5×. p. 403

Fig. 22 *Lamellaptychus bahamensis* Renz
50 m (42 m), J30915, 2×. p. 403

Fig. 23 *Lamellaptychus bahamensis* Renz
50 m (42 m), J30914, 2.5×. p. 403

Fig. 24 *Lamellaptychus bahamensis* Renz
50 m (42 m), J30913, 2.5×. p. 403

Fig. 25 *Laevilamellaptychus* ? new form
57 m (47 m), MB205, J30912, 3×. p. 407

Fig. 26 *Neocomites* sp. indet.
75 m (63 m), J30920, 2×. p. 388


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