Middle Jurassic and tithonian aptychi

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MIDDLE JURASSIC AND TITHONIAN APTYCHI

In the uppermost part of the Marne a Posidonia and in the Rosso ad Aptici of the Jurassic sequences exposed in the Monti di Poggiano, east of Rapolano and near Cintoia, a total of 49 determinable aptychi were collected. Two assemblages, of Middle Jurassic (Callovian) and Tithonian age respectively, can be distinguished; one single specimen suggests an Early Cretaceous (Berriasian) age (Fig. 11). An investigation of these assemblages contributes to a better knowledge of the stratigraphic ranges of some aptychus species of the Tethyan Jurassic.

In connection with the faunas collected by the Deep-Sea Drilling Project the assemblage of Tithonian age is of particular interest. Only a few aptychi indicating Tithonian age were so far recovered from the Atlantic. From Site 105, Leg 11, situated in the western Central Atlantic, at the foot of the continental rise off the coast of New York, *Punctaptychus punctatus* (VOLTZ), *Lamellaptychus beyrichi* (OPPEL) and *Lamellaptychus rectecostatus crassocostatus* TRAUTH were described from Cores 33-35 (RENZ 1972). This association suggests a Tithonian age and compares well with our present fauna. In the Cape Verde Basin, *Granulaptychus planulati* (QUENSTEDT) has been recovered in Core 34 at Site 367, Leg 41 (RENZ 1977). This aptychus is known from the Weisser Jura ζ in Southern Germany. In the area studied, this stratigraphic interval, that is the uppermost Kimmeridgian / lowermost Tithonian (upper part of the Beckeri Zone and lower part of the Gravesia Zone; ZIEGLER 1977), could not be reliably documented palaeontologically and it seems to be included in the slightly calcareous, upper part of the Diaspri, devoid of any macrofossils.

Aptychi from the upper part of the Marne a Posidonia, Middle Jurassic (Callovian)

Cornaptychus TRAUTH 1927

From the Middle Jurassic, 15 specimens representing 3 species of *Cornaptychus* are available. The morphology of *Cornaptychus* has been studied recently by FARINACCI et al. (1976); on this subject we refer to their paper. In the Poggiano section *Cornaptychus hectici* (QUENSTEDT), known from the Brauner Jura ζ (= Callovian p.p.) in Southern Germany, is present in several varieties. One (Fig. 11*L*) is *C. hectici brevis* TRAUTH (1930, p. 352, Pl. 3, Fig. 10), described from the Brauner Jura ζ in Württemberg. Width-index is 0.57, against 0.61 for the holotype.

Slender, strongly arched valves are predominant; these have not been described previously. Thus we propose the name

Cornaptychus rapolanus n. sp.

Fig. 11*A*-*F*; Fig. 12*a*-*f*

Holotypus: J 28359[7]); Fig. 11*C*; Fig. 12*a*, *b*.
Locus typicus: small quarry (in the upper part of the Marne a Posidonia) near

[7]) Numbers refer to the collection of the Museum of Natural History, Basel.

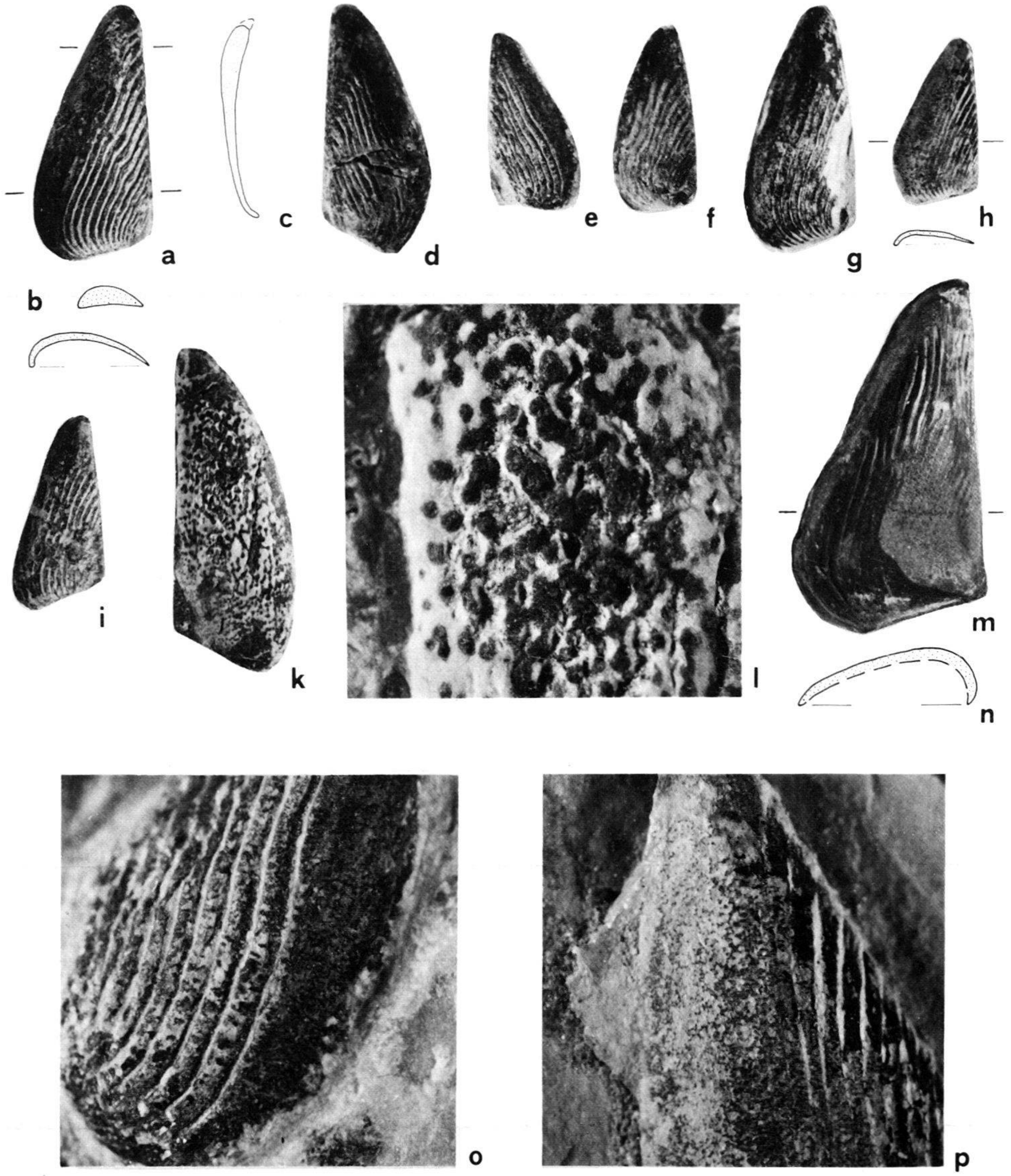

Fig. 12. Aptychi from Southeastern Tuscany.

a *Cornaptychus rapolanus* n.sp., J28359; holotype (see Fig. 11*C*); Rapolano; 1½×.

b Cross-sections of the valve; 1½×.

c *Cornaptychus rapolanus* n.sp., J28400; longitudinal section; Rapolano; 1½×.

d *Cornaptychus* cf. *rapolanus* n.sp., J28360 (see Fig. 11*B*); Rapolano; 1½×.

e *Cornaptychus rapolanus* n.sp., J28383 (see Fig. 11*D*); Rapolano, 1½×.

f *Cornaptychus* cf. *rapolanus* n.sp., J28382 (see Fig. 11*E*); Rapolano; 1½×.

g *Cornaptychus* cf. *hectici* (Quenstedt), J28357; Monti di Poggiano (see Fig. 11*K*); 1½×.

h *Cornaptychus* cf. *hectici* (Quenstedt), J28356; Monti di Poggiano (see Fig. 11*M*); 1½×.

Podere Monte Camerini about 1 km southeast of Rapolano (prov. Siena), Southeastern Tuscany, Italy.

The valve consists of dark grey, coarse calcite crystals (recrystallization fabric). It is highly arched, falling off vertically towards the symphysis, and less steeply towards the lateral margin. The ventral termination of the valve is narrowly rounded. The valve thickness is greatest near the ventral margin (Fig. 12*c*) and diminishes constantly towards the dorsal side, where it is thinnest around the apex. The width-index of the holotype is 0.46, but it ranges between 0.4 and 0.5. The sculpture consists of widely spaced lamellae running obliquely to the symphysis with angles of 30° and turning slightly towards the apex just before reaching the symphysis. The lamellae fade out towards the ventral margin of the valve. The broad lateral facet is covered by irregular, low wrinkles, better exposed on a paratype from the Monti di Poggiano (Fig. 12*p*). From *Laevilamellaptychus xestus* TRAUTH (1930, p. 374) *C. rapolanus* differs by its strongly arched valve and by its well developed lamellae.

In the Southern Alps, *Cornaptychus rapolanus* has been collected by D. Bernoulli near Molina di sopra, southwest of Clivio (Italian/Swiss border), at approximately 1.5 m beneath the Radiolarite Formation (BERNOULLI 1964, p. 79; determined by G. Pasquarè as *Laevilamellaptychus xestus* TRAUTH). In addition, a single specimen of *C. rapolanus* is known from the Upper "Posidonia" Beds of the Ionian facies belt (Acarnania, Western Greece; coll. C. Renz, J 28399).

In the Monti di Poggiano, about 9 m below the beds containing *Cornaptychus hectici*, one additional aptychus referable to *Cornaptychus* has been found. It is possibly related to *Cornaptychus stenelasma davilaigranulatus* TRAUTH (1936, p. 23, Pl. 3, Fig. 6) from the Posidonia Beds (Schwarzer Jura ε) of Ohmden in Württemberg. However, to our knowledge a specimen similar to the present one has not been described. Thus we introduce it as a new species under the name

Cornaptychus toscanensis n. sp.

Fig. 11*N*; Fig. 12*k*, *l*

Holotypus: J 28386; Fig. 11*N*; Fig. 12*k*, *l*.
Locus typicus: Monti di Poggiano, about 2 km west of Montepulciano (prov. Siena), Southeastern Tuscany, Italy.

This slender and thin valve has a rounded ventral termination, and attains a width-index of 0.39. Its convex side is characterized by deep meandering furrows

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i *Cornaptychus* cf. *hectici* (QUENSTEDT), J 28358 (see Fig. 11*G*); Monti di Poggiano; 1½ ×.

k *Cornaptychus toscanensis* n. sp., J 28386; holotype (see Fig. 11*N*); Monti di Poggiano; 1½ ×.

l *Cornaptychus toscanensis* n. sp., J 28386: wrinkled concave surface with spines; Monti di Poggiano; 6 ×.

m *Punctaptychus triangularis* n. sp. J 28351; holotype (see Fig. 11*e*); Rapolano; 1½ ×.

n Cross-sections of the valve; 1½ ×.

o *Cornaptychus rapolanus* n. sp., J 28383; wrinkled concave surface; Rapolano; 6 ×.

p *Cornaptychus* cf. *hectici* (QUENSTEDT), J 28356; finely wrinkled surface of the lateral facet; Monti di Poggiano; 6 ×.

and holes (Fig. 12*k*), separated by ridges which are covered with spines and warty granulations of varying size, arranged along faintly visible lines. Figure 11*N* shows the distribution of spines during an early stage of sample preparation, when just their tops became visible. Later, the embedding sediment has been removed in places, in order to free the wrinkled surface of the valve (Fig. 12*l*).

Aptychi from the Rosso ad Aptici, Upper Jurassic (Tithonian)

The aptychus fauna collected from the Rosso ad Aptici includes 25 Lamellaptychi and 8 Punctaptychi; Laevaptychi are not represented.

Punctaptychus TRAUTH 1927

Among the Punctaptychi, 3 specimens belong to *P. punctatus* (VOLTZ), one to *P. punctatus longus* (TRAUTH) (1935, p. 320), and 3 are juvenile and not identifiable. One specimen has not been previously described and it is recorded here under the name

Punctaptychus triangularis n. sp.

Fig. 11*e;* Fig. 12*m, n*

Holotypus: J. 28352; Fig. 11*e;* Fig. 12*m, n.*
Locus typicus: section along state road No. 326, about 1 km ENE of Rapolano (prov. Siena), Southeastern Tuscany, Italy.

This new species is characterized by a strikingly triangular outline and by a broad lateral facet against which the lamellae end consecutively. Its short ventral margin forms an angle of 68° with the symphysis, and only a few lamellae terminate against it. On the other hand, in *Punctaptychus punctatus* the lamellae end against a broad ventral margin. Moreover, *P. triangularis* is more strongly arched than *P. punctatus.* The valve slopes steeply towards the symphysis, and overturns just before reaching the symphysis. Towards the lateral margin, the slope is rather gentle up to the lateral facet, which again is more steeply inclined (Fig. 12*n*).

Lamellaptychus TRAUTH 1927

The Lamellaptychi mainly belong to three species, namely *Lamellaptychus beyrichi* (11 determinable specimens), *L. submortilleti* (7 specimens) and *L. rectecostatus* (4 specimens). A single, small (immature) valve (Fig. 11*k*), derived from about 10 m above the base of the Rosso ad Aptici in the Rapolano section is possibly referable to *Lamellaptychus lamellosus* (PARKINSON).

Lamellaptychus beyrichi (OPPEL)

A characteristic example of this variable species is reproduced in Figure 11*w*. It displays pronounced elongated inflections of the lamellae. The zone of inflection crosses diagonally over the valve from the apex towards the ventral margin. Both the intensity and the longitudinal extension of the inflections may vary considerably among specimens and, as mentioned by TRAUTH (1938, p. 135), transitional forms between *L. beyrichi* and *L. rectecostatus* exist (e.g. Fig. 11*i*). Width-indices of the specimens available in the present collection range from 0.47 to 0.66 (TRAUTH 1938, p. 136: width-index = 0.4 to 0.67), suggesting different ammonite species.

Among the subspecies, the following can be distinguished:

L. beyrichi fractocostatus TRAUTH (1938, p. 138, Pl. 10, Fig. 10); width-index 0.5, against 0.4 to 0.67 for the specimens studied by TRAUTH; (Fig. 11*c*).
L. beyrichi subalpinus SCHAFHÄUTL (1853, p. 404, Pl. 6, Fig. 8); width-index 0.64, against 0.68 for the holotype; (Fig. 11*b*).
L. beyrichi longus TRAUTH (1938, p. 139, Pl. 10, Fig. 14); width-index is 0.4, against 0.35 for the holotype figured by TRAUTH (Pl. 10, Fig. 12); (Fig. 11*y*).

In the Alpine-Mediterranean region *L. beyrichi* is a long-ranging species; it has been recorded predominantly from the Tithonian, but also from the Kimmeridgian (TRAUTH 1938; GASIOROWSKI 1962, Table 1, p. 26).

Lamellaptychus submortilleti TRAUTH

Fig. 11*f, h, l, m, q, r, s*

This species, represented by 7 specimens, is variable in outline as well as sculpture (cf. TRAUTH 1938, p. 143, Pl. 10, Fig. 23–25). It is characterized by a flatly arched valve, but in contrast to *Lamellaptychus mortilleti* (PICTET & LORIOL), it lacks a keel. The lamellae are less distinctly inflected than those of *L. beyrichi.* They meet the symphysal edge with acute angles, and only the outermost terminate against the ventral margin of the valve. The width-indices range from 0.48 to 0.61.

In the Western Carpathians, *L. submortilleti* occurs in the Tithonian (GASIOROWSKI 1962).

Lamellaptychus rectecostatus (PETERS)

Fig. 11g, *o, p*

Each specimen available is relatively large, flatly arched and without sign of a depression of the valve. In the apical region, the lamellae may be slightly inflected (Fig. 11*p*). Towards the central region, they cross straight over the valve, ending against its ventral margin. Although the convex outer surfaces of the present specimens are not weathered as they were carefully extracted from the embedding siliceous limestone or shale, we did not find an upper, calcitic layer covering the lamellae. Such a layer, composed of a "Basalblatt" and a "Decklage" (TRAUTH 1935, p. 312), covers the lamellae in *Punctaptychus* and this has led several authors to suggest that the majority of the Lamellaptychi are merely weathered forms of *Punctaptychus* (for a full discussion on this topic cf. FARINACCI et al. 1976, p. 115).

In fact, there do exist specimens where such an upper calcitic layer appears, but it is restricted to the apical region of the valve. Such transitional forms between *Punctaptychus* and *Lamellaptychus rectecostatus* were described by CUZZI (1960, p. 44) and named *Punctaptychus rectecostatus.* During DSDP Leg 17, at Site 167, on the Magellan Rise in the Central Pacific, a silicified specimen with a thin, originally calcitic cover around its apex has been found and compared with *Lamellaptychus* *rectecostatus* (PETERS) (RENZ 1973, p. 895, Pl. 1, 2). A specimen recently found in the Blake-Bahama Basin (DSDP Leg 44, Hole 391 C) displays an identical calcitic cover around its apex; it is thought to belong to the *Lamellaptychus beyrichi* group (*L. transitorius* RENZ 1978).

Lamellaptychus sp.

Fig. 11*n*

This specimen agrees in outline and sculpture with *Trigonellites studeri* OOSTER (1857, Pl. 7, Fig. 6), but has no keel and no depression of the valve. TRAUTH (1938, p. 145, Pl. 10, Fig. 29) united the specimen described by OOSTER with *Lamellaptychus mortilleti* (PICTET & LORIOL) which is characterized by both a keel and a depression of the valve. The present valve displays a width-index of 0.5; however, additional material is required before a systematic description can be made.

Lamellaptychus sp.

Fig. 11*d*

This questionable specimen derives from the top of the Rosso ad Aptici in the Poggiano section. It is a broad and flatly arched aptychus with a width-index of 0.71. The lamellae meet the symphysal edge with angles of about 40°. The present form differs from *L. inflexicostatus latus* TRAUTH (1938, p. 170, Pl. 12, Fig. 6) with a width-index of 0.63 by the absence of lamellae following the symphysis towards the ventral end of the valve.

A comparable specimen (width-index 0.63) from Site 105, Core 33 of DSDP Leg 11 has been determined as *Lamellaptychus* cf. *lamellosus* (RENZ 1972, p. 615, Pl. 2, Fig. 2*a, b*), and a possible affinity to *L. inflexicostatus latus* has been assumed.

Aptychus from the base of the Maiolica, Lower Cretaceous (Berriasian)

From about 2 m above the Rosso ad Aptici / Maiolica contact in the Rapolano section one single small aptychus has been recovered (Fig. 11*a*). It compares with *Lamellaptychus aplanatus* (GILLIÉRON). However, it differs from the holotype (GILLIÉRON 1873, p. 238, Pl. 10, Fig. 4; TRAUTH 1938, p. 171, Pl. 12, Fig. 8) by a less steep slope of the valve towards the symphysis, and by the lamellae not following the lateral margin in a strictly parallel trend. Its width-index is 0.54 compared with 0.43 for the holotype. In Europe, *L. aplanatus* is known from the Tithonian-Neocomian (TRAUTH 1938, p. 172; Tithonian-Berriasian, GASIOROWSKI 1962). The accompanying calpionellid association suggests a Berriasian age for the present specimen.

SUMMARY AND CONCLUSIONS

Sedimentological evidence shows that the Tuscan sequences exposed in the Monti di Poggiano, near Rapolano and in the Chianti region were deposited in a morphological basin. This basin was part of the southern continental margin of the

Tethys and subsided throughout the Jurassic to a depth of severe calcite dissolution. Break-up of the former carbonate platform (Calcare Massiccio) and the time of inception of basin foundering could not be determined at the localities dealt with in the present study, but Early Sinemurian can be inferred from the more complete Jurassic sequence exposed in the adjacent Monte Cetona area (FISCHER 1972 and own unpubl. data) and from the Jurassic sedimentary evolution of the Tuscan belt in general (BERNOULLI et al. 1979).

The oldest rock unit considered here is the Middle Liassic *Calcare Selcifero.* It comprises grey, bioturbated sponge spicule / radiolarian lime mudstones and wackestones, normally evenly bedded and with intervening thin marls, but in part with the bedding disturbed and distorted by penecontemporaneous gravity sliding and slumping. In our area, the intercalated gravity-flow deposits typically involve both reworked intraformational material and displaced shallow-water lime sand. However, no rock fragments of older formations are present, as would be found in clastics deposited along prominent, active fault-scarps.

We think that the Calcare Selcifero sequence of the Monti di Poggiano accumulated near the toe of a gently dipping depositional basin slope. The presence of neritic material in the gravity-flow deposits implies that this slope was linked to a topographic high with persistent shallow-water carbonate deposition, i.e. a remainder of the Calcare Massiccio platform. The location of this source area cannot, however, be deduced from the actual outcrops.

Indirect evidence for the persistance of shallow-water settings into the Middle Liassic comes not only from the Poggiano area; but also penecontemporaneously displaced shallow-water particles are fairly common in the Calcare Selcifero of Southeastern Tuscany, whereas no such occurrences are known to us from Liassic sequences located west of the Montagnola Senese - Monte Argentario metamorphic belt (for location cf. Fig. 1).

As can be assessed from formational thicknesses and approximate age range, the Calcare Selcifero of Southeastern Tuscany accumulated at average rates matching those estimated for the partly coeval Corniola Formation in the contiguous Umbrian realm and for other, similar Liassic basinal limestone formations deposited along the southern Tethyan margin. These rates are of the order of 15 to 25 mm / 1000 years (cf. BERNOULLI 1972), and they obviously depend on the depositional setting and the relative importance of redeposited material within a given section.

As for the original constituents of the fine-grained carbonate sediment making up the bulk of the Calcare Selcifero, we are largely left to speculations because of extensive neomorphism. The only identifiable component, which apparently contributed significant amounts of carbonate to the rock, is the incertae sedis *Schizosphaerella,* a widespread planktonic nanno-organism in the Tethyan Lower and Middle Jurassic (cf. BERNOULLI & JENKYNS 1970). The apparent absence of other conspicuous pelagic sources of carbonate in the actual record, of course, does not preclude their possible initial presence. However, it seems unlikely that carbonate mud was originally supplied from pelagic sources only. Sedimentation rates for lithified pelagic oozes of the Tethyan Mesozoic (e.g. the Early Cretaceous Maiolica

Formation) typically are around 10 mm / 1000 years (BOSELLINI & WINTERER 1975) or less and, on the other hand, there is no indication for a higher production of calcareous nannoplankton during the Early Jurassic than during the Early Cretaceous. On the contrary, it appears that the production strongly increased towards the close of the Jurassic Period (e.g. GARRISON & FISCHER 1969). Thus we think that the fine-grained sediment of the Calcare Selcifero and of related Early Jurassic basinal limestone formations was peri-platform ooze originally; i.e. that these deposits include major amounts of carbonate lutum swept from circumjacent shallow banks and dispersed over the basin by surface and near surface currents (cf. NEUMANN & LAND 1975, SCHLAGER & JAMES 1978). This interpretation is consistent with a marked drop of the sedimentation rate following the submergence of the shallow-water sites (see below).

The sudden lithologic change from the hemipelagic limestones of the Calcare Selcifero to the *Marne a Posidonia* is likely to have occurred during the early Toarcian, and thus would coincide with the Corniola / Rosso Ammonitico transition in the basinal sequences of the Umbrian zone. The top of the Marne a Posidonia, on the other hand, can be assigned to the Callovian on the basis of the *Cornaptychus* assemblage recovered during this survey.

Over a major portion of the Marne a Posidonia, red, (hemi)pelagic marls prevail. They are thinly interlayered with skeletal limestones which contain mainly valves of nekto-planktonic posidoniids and their fragments, and were - to judge from minor sedimentary structures - produced by both winnowing bottom currents and turbidity currents. Only in its uppermost quarter, the unit reveals a different bedding pattern and the overall carbonate content increases markedly, yet this trend can be seen to be chiefly a consequence of an enhanced volumetric contribution of relatively carbonate-rich, fine-grained resediment derived exclusively from deeper-marine sources. Obviously, deposition of the Marne a Posidonia was highly discontinuous: slow, pelagic "background" sedimentation was repeatedly interrupted by both periods of selective erosion and non-deposition (lumachelles) and intervals of fast accretion (turbidites).

The absence of shallow-water detritus in the gravity-flow deposits occurring throughout the Marne a Posidonia indicates that on adjacent topographic highs shallow-water sedimentation did not keep pace with subsidence beyond Middle Liassic time and - as was the case in Umbria at about the same time - the shallow banks were submerged, and turned into seamounts. The presence of rock fragments derived from the underlying Calcare Selcifero in occasional coarse clastic beds in turn might reflect an accentuation of the basin slope profile, in that the Calcare Selcifero must have been exposed locally, either at steep scarps or in erosional channels through which sediment gravity flows reached the basin.

For the Marne a Posidonia, a mean rate of accumulation of about 2 mm / 1000 years can be estimated; this corresponds to a decrease in rate by one order of magnitude with respect to the Calcare Selcifero. In view of our interpretation of the Calcare Selcifero sediment as peri-platform ooze, cessation of sediment supply from shoal-water areas due to their submergence beneath the photic zone must be a major cause for this drastic drop of the average sedimentation rate. However, increased dissolution of carbonate due to a continued deepening of the basin is considered as an additional principal factor. With the exception of the fauna at Monte Cetona (cf. p. 726), the Tuscan Marne a Posidonia contain virtually no remains of ammonite phragmocones, but merely occasional aptychi and belemnites, suggesting deposition within a bathymetric zone of effective aragonite dissolution (cf. SCHLAGER 1974, BOSELLINI & WINTERER 1975). During normal, (hemi)pelagic sedimentation, most of the aragonite supplied presumably was removed at the sea-floor before burial, but some might have been leached in the very shallow burial only, and the dissolved carbonate might have contributed to early cementation along lumachelle layers.

Upward, the Marne a Posidonia pass into a unit of highly siliceous limestones and cherts with interbedded shales - the *Diaspri*. The palaeontological data presented suggest that the Diaspri range in age from the uppermost Callovian to the Tithonian, a large part of which in turn seems to be represented by a sequence of aptychus-bearing limestones and marls, called here *Rosso ad Aptici*. The Tuscan radiolarites thus would appear to coincide in age with their lithologic counterparts in the South-alpine sedimentary sequence (cf. GAETANI 1975) and likewise correlate with the Calcari Diasprigni in Umbria (cf. COLACICCHI et al. 1970); moreover, there seem at present to be no data incompatible with an approximate isochrony of the radiolarites found on remnants of Early to Middle Jurassic oceanic crust in Liguria (cf. FOLK & MCBRIDE 1978, p. 1071).

In the study area, the Diaspri can be subdivided into four types of facies, distinguished in outcrop mainly by the style of bedding. Close inspection, however, revealed additional distinctive features, comprising minor sedimentary structures, textures and degree of biogenic reworking. Thus it appears that the different bedding patterns are not merely the product of diagenetic processes, but rather reflect the sedimentary process(es) accounting primarily for sediment dispersal and deposition in each respective facies. These processes include: pelagic settling, low-flow-regime bottom currents and turbidity currents, probably of both low and high velocity type (cf. NISBET & PRICE 1974, FOLK & MCBRIDE 1978). The average accumulation rate of the Diaspri was of the order of 3-4 mm / 1000 years.

The lack of carbonate in parts of the unit suggests that, in Late Jurassic time, the basin floor had reached a depth close to or even beneath the carbonate compensation surface, which then might have been some 2500 m deep, for reasons outlined e.g. by BOSELLINI & WINTERER (1975) and HSÜ (1976).

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