JURASSIC STROMATOLITES OF THE VILLÁNY MOUNTAINS (SOUTHERN HUNGARY)

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ABSTRACT

The morphology and origin of the stromatolites from the Middle Jurassic ammonite-bearing layer at Villány (Villány Mountains, Southern Hungary) are presented. Of the stromatolites, both columnar as well as spheroidal forms (oncolites) occur there. Columnar stromatolites usually form bigger associations of a clump or clod type, which cover the sediment – the knobby layer – rich in Bathonian and Callovian ammonites (Lóczy's fauna). The morphology of the stromatolites and the structure of associated sediments have been used as indicators of the en-vironment. Both the knobby layer with Lóczy's ammonites and the stromatolites developed during the Callovian within the intertidal zone of the marine shoal.

Introduction

The stromatolites at Villány had been recognized a few years ago by the Polish geologist J. Znosko (1961). In the course of the present authors' investigations of Jurassic stromatolites in Poland it was interesting to do comparative studies on the Hungarian material as Jurassic stromatolites are very rare all over the world. Visiting the Villány Mts. and the collecting of material was possible owing to the courtesy of our Hungarian colleagues, especially Dr. E. Végh and Dr. A. Kaszap, both of the University of Budapest, who facilitated the stay in Hungary of the first author (A. Radwański) during the summer of 1964. Dr. A. Kaszap also introduced him to the geology of the Villány Mts., discussed many problems and helped during the field work. To both of them the Authors offer their sincere thanks.

General situation of the Villány stromatolites

The stromatolites occur in Middle Jurassic limestones of the Templom-hegy (Church hill) at Villány village, situated in the eastern part of the Villány Mountains. Middle Jurassic clastic and calcareous sediments overlie there with a sedimentary gap the Middle Triassic carbonate rocks (Anisian dolomites; (Rakusz and Strausz 1953, Kaszap 1963). Of the Middle

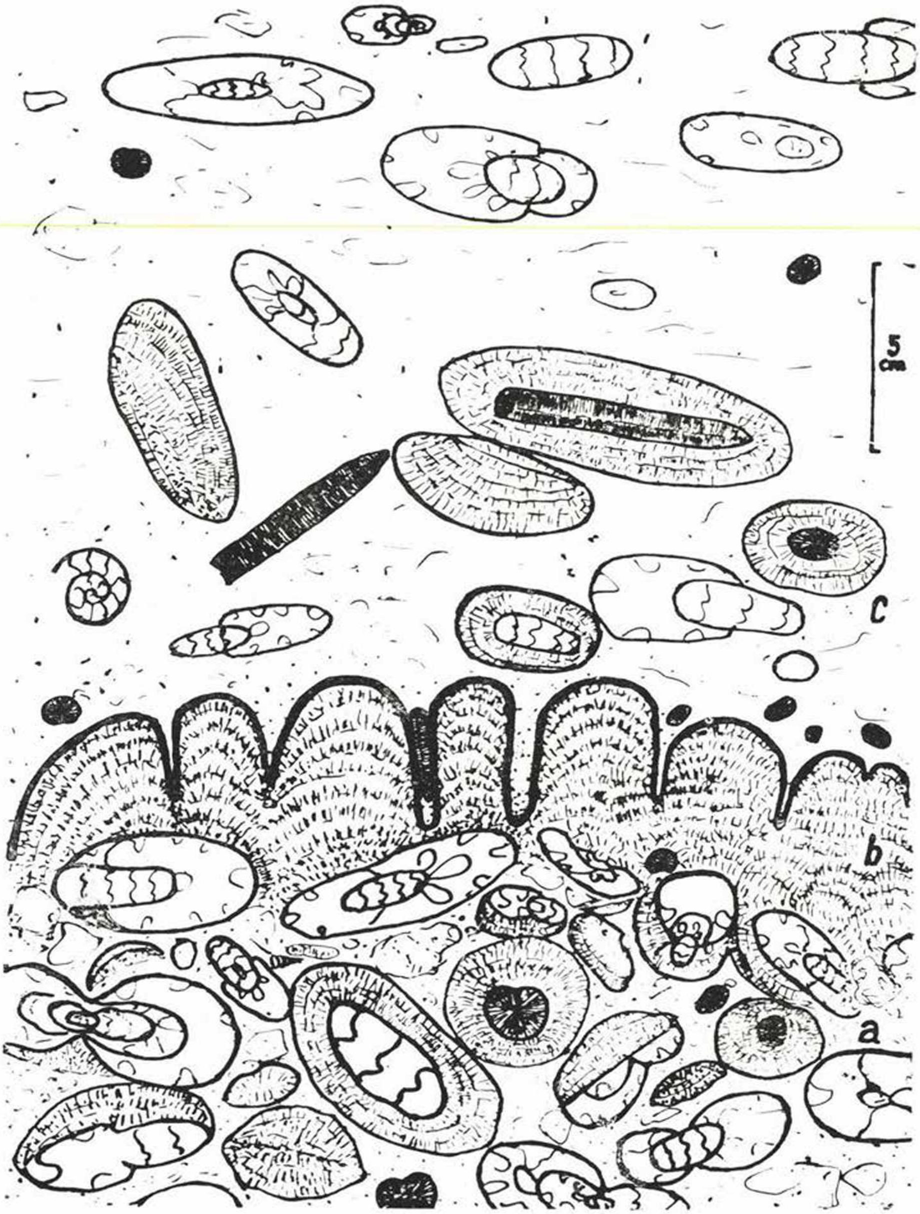

Fig. 1. Sketch drawing of ammonite and stromatolite bearing layer at Villány: *a* – knobby horizon ("knobby layer"), *b* – main stromatolite horizon, *c* – upper horizon over stromatolites. Scale is given

Jurassic sediments the very famous ammonitiferous layer is of the greatest interest. According to L. L ó c z y Jr. (1915) who monographed these ammonites, the age of their parent layer is Lower and Middle Callovian. W. J. A r k e l l (1956) showed that the ammonite fauna is Middle and Upper Callovian in age but that it also comprises representatives of the Bathonian. A similar conclusion on the basis of the new finds at Siklós in the central part of the Villány Mts. was drawn by A. K a s z a p (1959, 1961). The latter author recognized a full stratigraphic sequence of ammonites from the *Clydoniceras hollandi* zone (Upper Bathonian) to the *Peltoceras athleta* zone (Upper Callovian) at Siklós and Villány. An opinion claiming a Callovian, more specifically Upper Callovian age of the ammonitiferous layer was given by J. Z n o s k o (1961). Thus the point whether the age of the ammonites and their deposition in their present site is identical – as claimed by previous authors – or not is still debated. Present authors' remark on this subject will be presented later on.

Other Middle Jurassic sediments underlying the ammonitic layer are regarded as Bathonian (A r k e l l, 1956) or Bathonian-Lower Callovian (Z n o s k o, 1961). More detailed data and the general outlines of Villány stratigraphy are given in the papers of G. R a k u s z and L. S t r a u s z (1953) and of E. V a d á s z (1961).

The stromatolites at Villány occur only in the ammonite-bearing layer, usually covering the ammonite-shell aggregations (Fig. 1.). Ammonite shells over the stromatolites are considerably less frequent and less well-preserved.

Morphological types of the stromatolites

Crusts

The crusts, i.e. low and isolated stromatolites, are incrustations over ammonite shells or sediment knobs anchored to the bottom (Fig. 2*a*; Pl. 4. Fig. 1.). They cover continuously only those parts of the objects on the bottom which rise above the sediment surface. Usually the crusts are distincly low (Fig. 2*a*) but taller forms also appear (Fig. 5*a*). All the crusts are composed of dome-shaped continuous laminae repeating their outlines consequentially from the base to the top. Laminae usually strongly overlap at the sides of the incrusted objects.

Columnar stromatolites

Columnar stromatolites are tall forms attached to the bottom surface associated in larger groups covering some area of the bottom (Fig. 3; Pl. 1–3.). The stromatolites in associations do not touch directly but are separated by narrow fissures called interstices. These are filled with sediment that has no stromatolitic structure. Of the associations one can distinguish two types.

The first type, called here a stromatolite clump, consists of stromatolites of unequal height (maximum to 6 cm), wider at their base and decreasing in diameter at the top (Fig. 3*a*; Pl. 2, Fig. 2.). Thus the interstices grow gradually narrower toward the bottom in the manner of a fuhnel. The upper surface of the clumps is uneven, and the pattern of interstices is irregular (Pl. 2, Fig. 1.).

The second type, called here a stromatolite clod, consists of stromatolites of equal height (up to 7 cm) and equal width along the individuals (Fig. 3*b*; Pl. 1, Fig. 1.; Pl. 3, Fig. 2.). Thus the interstices are of the same width from bottom to top; on the other hand, they are also similar in any place of the clod. All these stromatolites are flattened at their tops and they are densely packed.

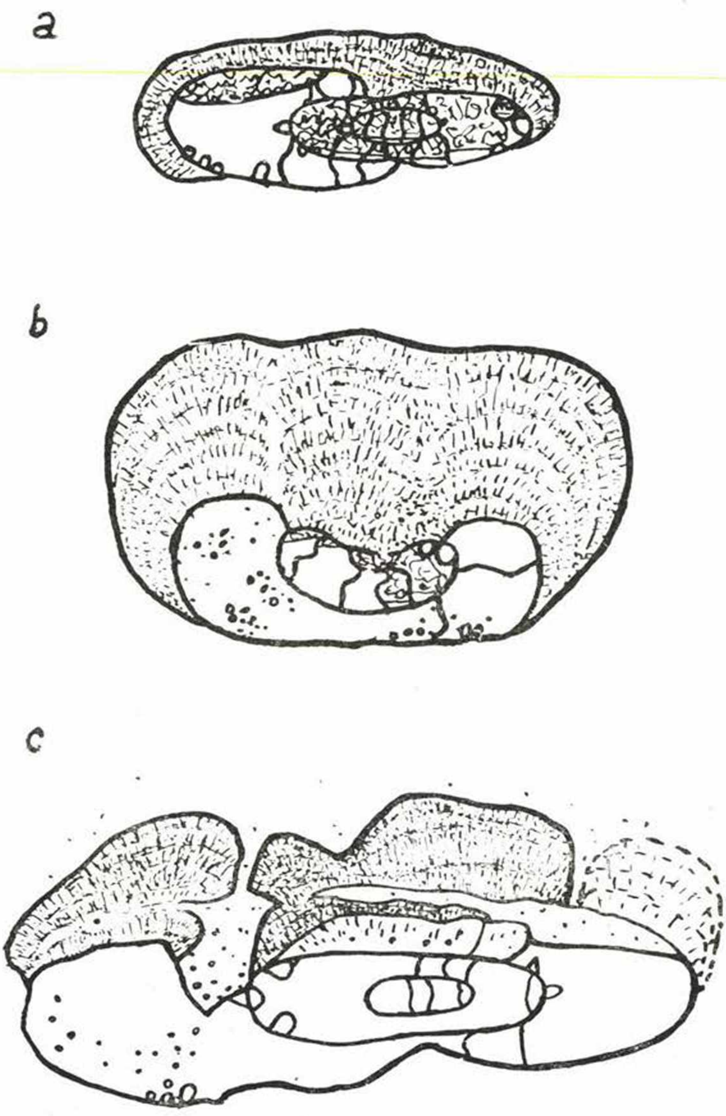

Fig. 2. Stromatolitic coatings of the ammonite shells:
a – initial stromatolite (crust), *b* – stromatolite bunch composed of three stromatolites overcrusting the shell, *c* – small, diverse shaped stromatolites with deep interstices. Nat. size

Thus in a vertical view the clods exhibit a flat surface with the stromatolites only slightly curved at their sides (Pl. 3, Fig. 1.). The interstices in this view are usually straight, sharply limited and arranged in a polygonal pattern.

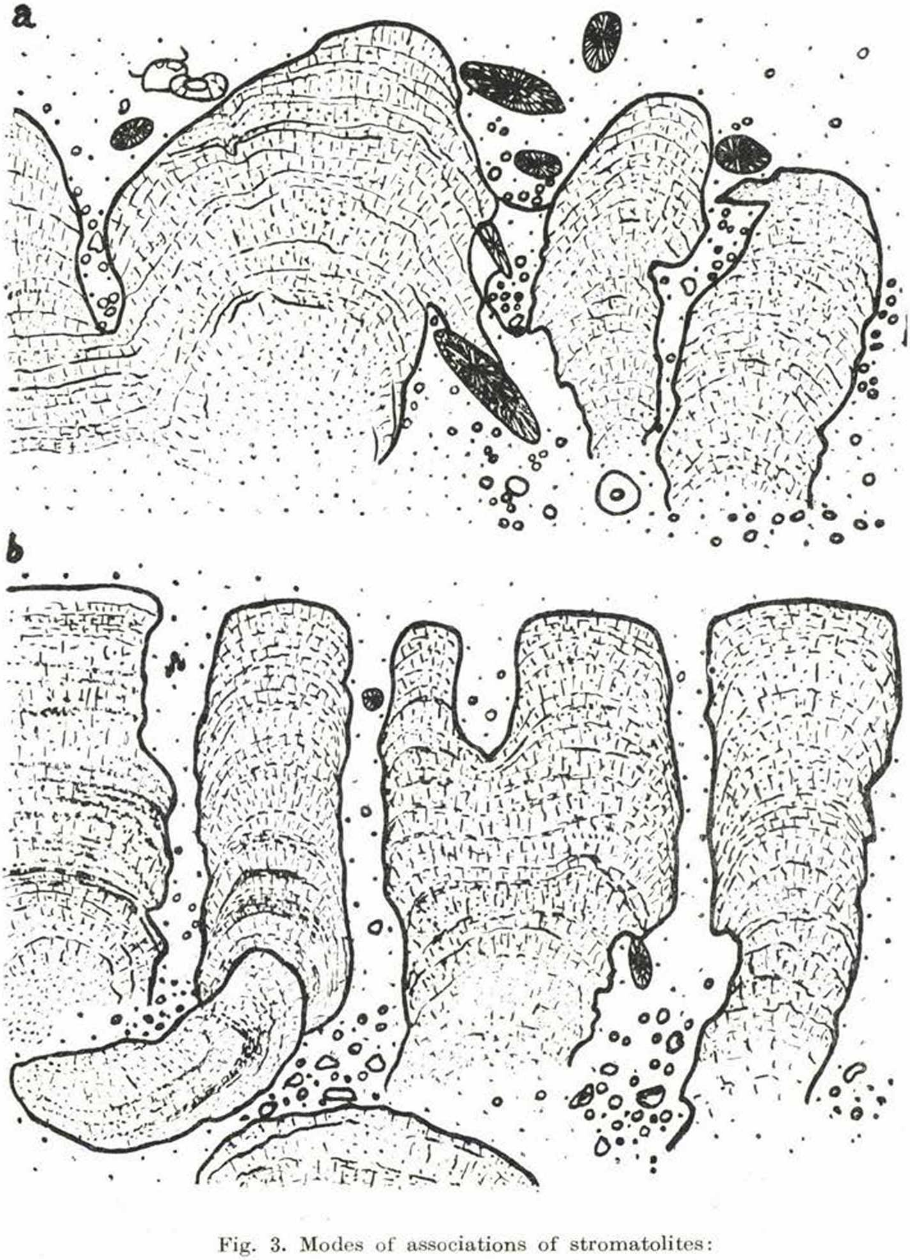

Fig. 3. Modes of associations of stromatolites:
a – stromatolite clump, *b* – stromatolite clod. Nat. size

In both types of the stromatolite associations the interestices are filled by pelitic, somewhat detritic calcareous sediment with chamosite ooids, now strongly limonitised. Coarser material, mainly clastic grains, belemnite guards, shell detritus etc. is a accumulated either in the whole space of interstices or only at their bottom (see Fig. 3. — sketch drawing of specimens presented in Pl. 2 and 3). Such coarser material occurs only in the interstices and never within the stromatolites themselves.

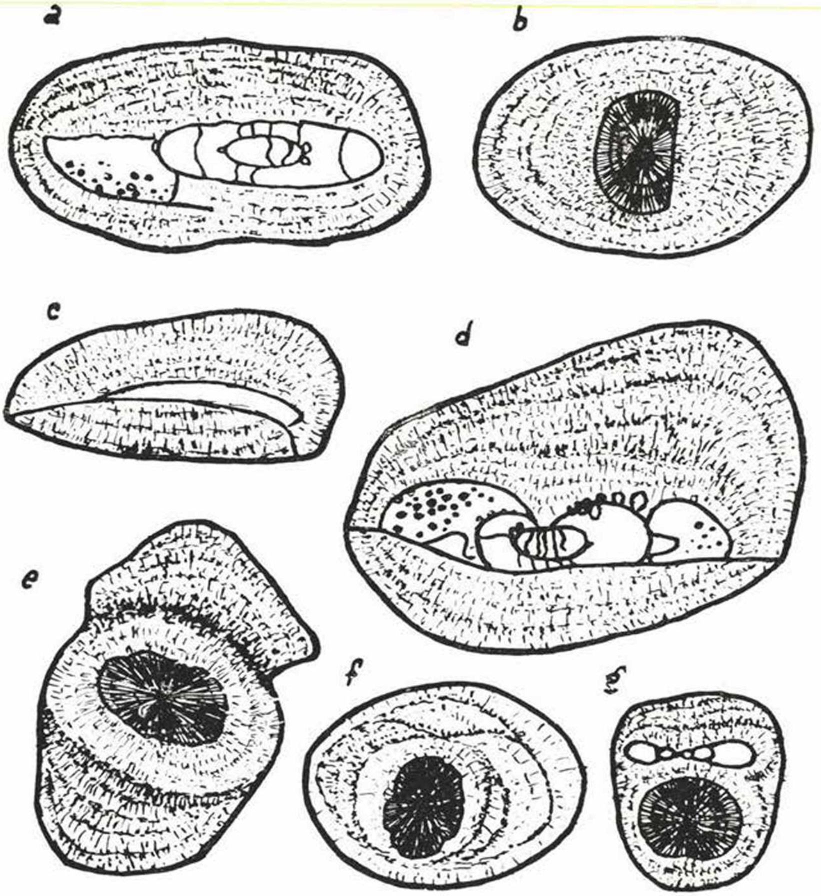

Fig. 4. Diverse modes of oncolites (spheroidal stromatolites):

a – mode "C" with corroded ammonite shell as a core, *b* – mode "C" with belemnite guard cut by previous erosion, as a core, *c* – mode "I" with a fragment of ammonite shell in the first-staged crust, *d* – mode "I" with a corroded ammonite shell in the first-staged crust (for explanation of origin see text – Fig. 5.), *e* – mode "C" with corroded belemnite guard as a core, and two younger crusts on its surface, *f* – mode "R" with similar core (the first and last envelopes are of mode "C"), *g* – composite form of mode "C" – a small ammonite shell embedded between envelopes. Nat. size

Spheroidal stromatolites (oncolites)

Spheroidal stromatolites, i.e. oncolites, may be divided into three groups (modes) according to their internal structure.

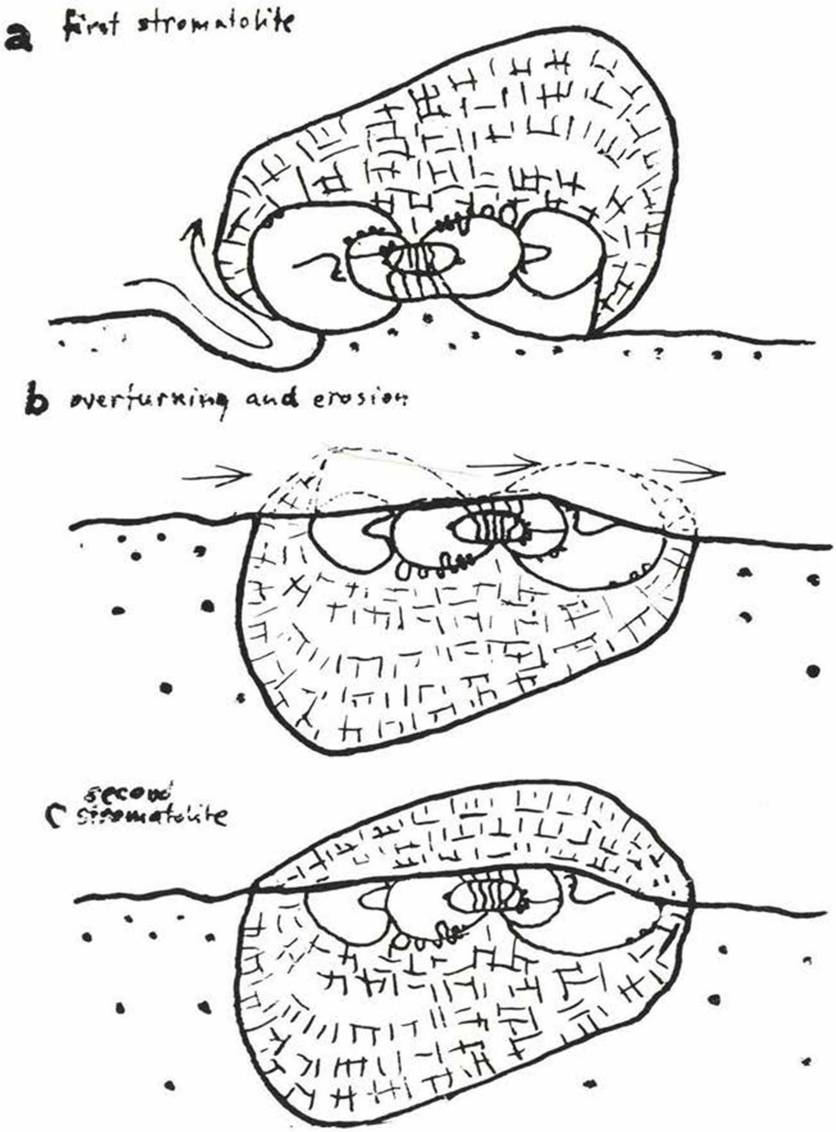

Fig. 5. Origin of a mode "I" onkolite; three successive *(a, b, c)* stages on the sea bottom are shown in simplification. Nat. size

In the first mode (mode "C" after Logan, Rezak and Ginsburg 1964) the laminae are concentrically wrapped around an ammonite shell or belemnite guard as a core (Fig. 4*a*, *b*, *e*, *g*; Pl. 4, Figs. 2–5.). The shape of such oncolites is highly varied depending on the shape of the core. Ammonite shells bearing oncolites are usually of a flat ovoid shape (Fig. 4*a*; Pl. 4, Fig 5.) whereas those on belemnite guards are of spindle form (Pl. 4, Fig. 3.). Some oncolites of this mode may possess knobby crusts on their surface (Fig. 4*e*). In one case a small ammonite shell has been found in such a crust (Fig. 4*g*; Pl. 4. Figs. 3–4.).

In the second mode the oncolites form, apart from concentrically wrapped laminae, also randomly stacked ones around the core are present. The core is formed as a rule by a belemnite guard (Fig. 4*f*; Pl. 4, Fig. 6.). This mode includes transitional forms between modes "C" and "R" after Logan, Rezak and Ginsburg (1964). Individual oncolites more or less resemble one of these forms.

In the third mode (mode "I" after Logan, Rezak and Ginsburg 1964) there are two different crusts stacked in an inverted position (Fig. 4*c*, *d*). Such oncolites usually have an ammonite-shell fragment inside, which plays the role of a core but which is really a fragment of substratum of the first-originated crust (see Fig. 5.). The shape depends strongly on the shape of the first crusts, which may be sometimes obliterated by the last envelope or envelopes of the "C" mode.

Microscopic structure of the stromatolites

The microscopic structure of the crusts, columnar stromatolites and oncolites is the same. All the stromatolitic laminae are composed of organic material – mainly thin-shelled pelecypod debris ("filaments"), zoospores (Globochaete alpina Lombard) as well as in a minor part of foraminifera tests, echinoderm debris and other unrecognized detritus – mixed with pelitic calcite of algal dust type (see Wood 1961). Silt-sized quartz and glauconite grains occur sporadically. In any stromatolite the frequency of these materials changes many times, increasing and decreasing in the successive laminae which usually are not too sharply limited against one another (Pl. 5–6). Longer fragments, especially thin-shelled pelecypod debris, if present, lie subparallel to the lamination both in columnar and spheroidal stromatolites.

The vertical pattern in the stromatolitic laminae is marked by very thin limonite impregnations (Pl. 6), formed probably after the blue-green alga colonies. Larger dendroid forms of Maslov's (1960) frutexites type, filled with secondary calcite, are developed only in some laminae (Pl. 5, Fig. 2.). More frequent, randomly oriented ones appear only directly on the ammonite shells resting at the base of the stromatolite (Pl. 6).

Origin and growth of the stromatolites

Stromatolites are biosedimentary structures originating by active influence of blue-green algae on the sediment. The blue-green algae bind and trap the sediment within their colonies or associations into a firm aggregation. The superficial part of the sediment, chemical, organodetritic or clastic, stabilized by active blue-green algae, is called an algal mat. The growth of the different stromatolite types depends on different mat evolution.

In the Villány basin the continuous mats that covered uniformly greater bottom areas most probably did not exist or have hot been preserved in the sediment. The mats cover only smaller areas in which they did not form continuous coats but were fragmented into small parts. The successive development of the mat in these places led to the origin of individual stromatolites that grew continuously. The areas between the stromatolites premanently lacked an active mat and as a result they formed the interstices separating the individual stromatolites. Morphological details of the stromatolites and interstices depended on many environmental factors (see Logan, Rezak and Ginsburg 1964). These details are similar in many stromatolites growing beside one another and clustering in larger groups. On such a basis, stromatolite clumps and clods may be distinguished (Fig. 3.). Both clumps and clods are the result of permanent conditions in a given area, mainly the conditions of water circulation.

In the case of stromatolite clumps, the differences of water circulation and its intensity are responsible for differences in the width of waterways. As a result the pattern of waterways, i.e. of interstices, changed during the growth of stromatolites. Thus in a section the interstices are of irregular shape and exhibit inconstant shape and width (Fig. 3*a*). The inconstant water circulation conditions made it possible for an active mat to enter a water-circulation area: thus the growing stromatolites widened mushroom fashion over nearby sediment, sometimes consisting of a coarser detritic material (e.g. belemnite guards in the median interstice in Fig. 3*a*). The changes of water circulation conditions and their distinctly weak intensity led to the gradual filling of waterways simultaneously with stromatolite growth. In this case the stromatolites did not extend too high above the bottom and their laminae were moderate dome shapes stacked one over another (Fig. 3*a*). Periodic increase of the water circulation intensity induced erosion of the sediment deposited previously in the original interstices. Such erosional limits, often limonitised, are seen e.g. in Fig. 3*a*. The second deposition of sediment in a future interstice usually begins with the settling of some coarser detritic material that rests with a sharp limit over previous fine-grained sediment.

In the case of stromatolite clods, the water circulation was more intense and the degree of intensity did not yield greater changes. Water-circulation ways possessed a permanent width and exhibited the same pattern. As a result, deep interstices originated that had a constant width and vertical course (Fig. 3*b*). The growing stromatolites extended high above the bottom and their successive laminae were strongly convex, extending beyond the former ones although not enlarging their convexity radius. The interstices were probably empty till the end of stromatolite growth, and only on their bottom was a small quantity of coarser detrital material accumulated (Fig. 3*b*). The residuum of the sediment was transported through these channels. The final filling of the interstices with sediment took place after the end of stromatolite growth. This sediment, as was shown above, is quite different from that building up the stromatolites.

In the remaining areas of the bottom the blue-green algae activity was limited to small objects, such as ammonite shells and sediment knobs, but never belemnite guards, extending over the bottom surface and anchored in it. The fragmental mats originated on such objects developed into crusts (Fig. 2*a*) and in more favourable conditions, into composite forms of a stromatolite bunch type (Fig. 2*b*). Detached objects, not anchored to the bottom — mainly ammonite shells and belemnite guards — were covered by an active mat on all their sides or only in part during momentary standstill. As a result the oncolites were formed — mode "C" in the first case and mode "C", partly "R" in the second one. The developing of an algal mat on the overturned crusts led to the formation of mode "I" oncolites (Fig. 5.).

Terminological note

As it has been shown, the shape of the stromatolites (crusts, columnar and spheroidal forms) depended on abiological conditions of the environment. Only sedimentary processes are responsible for their formation. Thus the using of "generic" and "specific" names in a biologic style for stromatolites has no reason (see also Claud 1942). Also the shape of individual stromatolites is so variable that the use of several "specific" names for one form would be necessary, which is ridiculous. On the other hand, the microscopic structure of all stromatolites is the same and cannot be a basis for their classification. The new classification of stromatolites given by Logan, Rezak and Ginsburg (1964) is very instructive but in the Villány material it is not acceptable except for oncolites for which it has indeed been used. In columnar stromatolites of Villány, the shapes of the laminae (hemispheroids according to Logan, Rezak and Ginsburg) and shape of whole stromatolites differ distincly from schematic forms distinguished by these authors. Thus some individual stromatolites or their parts only could be named in this manner. For these reasons the more exact classification of columnar stromatolites is omitted here.

Composition of the stromatolite-bearing layer

The stromatolites at Villány have been developed only in a single layer, the ammonitiferous one. In this layer (Fig. 1.) one can distinguish three not quite persistent horizons: 1. "knobby" part ("knobby layer" recognized by Znosko 1961) at the bottom, very rich in ammonites, with crusts and oncolites of stromatolitic structure (*a* in Fig. 1); 2. the main stromatolite horizon with various columnar stromatolites usually clustering into clumps or clods (*b* in Fig. 1); 3. the upper part, also with ammonites, but only with oncolites of stromatolites (*c* in Fig. 1.). The thickness of the whole layer is ca. 30 cm. The boundary is very sharp at the top, but very indistinct at the bottom. In some places the knobby part passes gradually into the underlying limestone, very poor in ammonites.

The knobby part (layer) is composed of sediment knobs, and abundant ammonite shells, belemnite guards (other fauna — brachiopods, pelecypods, small gastropods, etc. — is very rare), oncolites and crusts. The oncolites are of all modes; the crusts are fixed to the bottom objects or are free, detached and overturned. The crusts over the knobs are usually indistinct with a very weak lamination. Ammonite shells caught in oncolites as well as the free ones are very often corroded in part or over their entire surface (Fig. 2*b*, *c*; Fig. 4*a*, *d*; Fig. 5.; Pl. 1, Fig. 2.; Pl. 4, Fig. 5.; Pl. 5, Fig. 2.; Pl. 6), similar corrosion in belemnite guards is also visible (Fig. 4*b*, *e*, *f*; Pl. 5, Fig. 1.). Most of the ammonite shells are entirely filled with sediment, but some of them, lying directly beneath the main stromatolite clusters, have the upper parts of their body chambers or last whorls empty. Completely filled shells sometimes show a sediment little differing from that outside. There is no stratification within the knobby layer – the components settled fortuitously in a subparallel arrangement or none at all. These facts, and especially the occurrence of sediment knobs, show the syn-sedimentary reworking of the bottom material by hydromechanical agents. The force of these agents decreased at the top of the knobby layer, where a weak stratification is visible and partly empty ammonite shells are preserved.

In the second horizon both stromatolite clumps and clods are abundant. In some places the stromatolite clumps change into separate groups of stromatolites (stromatolite bunches) or single, usually very low stromatolitic incrustations. Sporadically, the stromatolites are completely absent. Generally speaking, the base of the stromatolite clusters is even, but in some places it matches the morphology of the substratum, ammonite shells (Fig. 2*c*, Pl. 1, Fig. 2.), overturned crusts (Fig. 3*b*), oncolites, knobs of sediment (Pl. 1, Dig. 1.) and so on.

The third horizon over the stromatolite groups is represented by a more pelitic sediment with ammonite shells, belemnite guards and various oncolites. In the lower part of this horizon there is no stratification; in its upper, and especially uppermost part the ammonite shells are arranged horizontally. On the other hand, in this latter part stromatolites are absent (Fig. 3*c*).

Facial conditions and sedimentary environment

The Villány stromatolites occur in the top part of Middle Jurassic sediments. All of these latter, sandstones, quavelly sandstones and sandy limestones represent a very shallow-water sedimentation probably connected with an intensive deposition of terrigenous material. During the gradual decrease of the supply of terrigenous debris the purer calcareous sedimentation increased – marly limerstones or limestones with very abundant ammonite shells were formed. Reworking of these latter sediments gave rise to the knobbly layer. Then, during the formation of this layer, the stromatolite sedimentation started.

The stromatolites began to originate amongst and above the limy knobs and shells lying on the bottom. In the first stages the strong agitation of the sea water by waves and currents led to the destruction of algal mats that could have developed only on objects anchored in the bottom or moving over the bottom surface. Thus only crusts and oncolites were formed, the first being very often redeposited many times. Probably no stromatolite crusts were preserved in their original attitude. All these crusts, oncolites and other bottom material, were agitated in the water, picked up from the bottom, worn and mixed, and deposited without any orientation. This process may have been repeated a few times. During such conditions the ammonite shells as well as belemnite guards were partly corroded (see Hollmann 1962, Seilacher 1963), mainly at their tops when lying on and somewhat extending from the bottom. In this time the belemnite guards became a habitat for lithophagous polychaetes (Pl. 5, Fig. 1.) also. As it was previously said these are indicators of successive decrease of water agitation and reworking of bottom material at the top of the knobby layer beneath the main stromatolite horizon lying above.

Returning to the problem of the age of ammonites that is under discussion (Lóczy v. Lócz 1915; Arkell 1956; Kaszap 1959, 1961; Znosko 1961) it may be postulated that controversial opinions about their Callovian or Bathonian-Callovian age had the source in overlooking the character of the sediment. This is a reworked sediment that includes probably Bathonian as well as Callovian ammonites from succesive layers, which were next deposited in a new layer (the knobby layer) without respecting their previous sequency. It is a typical pseudoassociation *sensu* D. V. Ager (1963). Thus the reworking of polytemporary sediments led to the great accumulation of ammonites. Monotemporary conditions such as floating to the beach and similar processes postulated by previous authors (Lóczy v. Lócz 1915, Kaszap 1961, Vadász 1961, Znosko 1961) seem to have had a smaller role or none. Also, Bathonian ammonites did not live till Callovian time here as J. Znosko (1961) estimated, but they had been dug out of the Bathonian sediment and redeposited into the Callovian one. It is only the present authors' own opinion of course, very difficult to be confirmed because of a very bad state of outcrop now and impossibility of collecting a material as zich as Lóczy's. In future it ought to be necessary to look for ammonites inch by inch throughout the layer. Stratigraphically the youngest ammonites, Upper Callovian if up-to-date specific and stratigraphic determinations are correct, should be contained only above the main stromatolite level, in the third horizon of the layer.

The main stromatolite horizon started to form during a gradual decreasing of water agitation. The stromatolite structures such as crusts or larger mats could grow quietly in columnar forms clustering into greater associations of a clump or sod type. The stromatolitic coat of the bottom has changed in its development from place to place similarly as recent stromatolites of Shark Bay in Western Australia (see Logan 1961, especially Fig. 2. on his Pl. 2). The stromatolite sods being comparatively the most lofty forms, flattened at their tops, represent probably the most upgrown stromatolites. The flattening of their tops was probably caused by the agent of extremal possibility of growing — by the highest position of the water level there. It is the high water mark of the tides which terminates the grouth of stromatolites (Logan 1961; Logan, Rezak and Ginsburg 1964). This level indicated signed the extreme uplift of the bottom in the Middle and Upper Jurassic sedimentary basin of Villány.

All the types of the Villány stromatolites, comparable to analogous types of recent marine stromatolites of the Bahamas (Black 1933, Florida (Ginsburg 1955, Ginsburg and Lowenstam 1958) and Western

Australia (Logan 1961) show that the intertidal environment which is the only possible one for the formation of recent marine stromatolites (Black 1933; Rezak 1957; Logan 1961; Logan, Rezak and Ginsburg 1964) and which is suggested for many fossil ones (Young 1935, Rezak 1957, Ginsburg 1960, Logan 1961, Szulczewski 1963) is also fully acceptable for the Villány environment. It is also very probable that the same environment also existed there previously, i.e. in other words, the formation of the knobby layer was the result of intertidal agents – waves or storm waves and bottom currents on a marine shoal.

The reaching of the high water mark was one of the reasons which limited the growth of the stromatolites. The second that definitely stopped their formation in any state of development was a quite opposite one, namely the deepening of the basin and drowning of the stromatolites. The shoal sank and formation of the third horizon started. The stromatolites both attached to the bottom and to oncolites formed in the neighbouring areas. Crushed crusts and abundant oncolites were together with ammonite shells and belemnite guards deposited over the stable stromatolite clusters. At the top of the horizon and of the layer these shells are more frequent and lie horizontally, being quietly settled on the bottom. The sedimentation was in that moment presumably rather slow. The upper surface of the layer has an appearance of a sedimentary gap (Lower Oxfordian, Arkell 1956). Overlyingl pelitic limestones without ammonites show a new period of sedimentation (Upper Oxfordian after Arkell 1956, Oxfordian-Tithonian after Kaszap 1963).

Final remarks

The Villány stromatolites reveal many different structural types depending on the character of substratum and facial conditions. Usually in a fossil state one can trace only one prevailing type of stromatolites.

All the structures of the Villány stromatolites suggest their formation in a very shallow, marine shoal environment, more exactly an intertidal and low submerged one. In other conditions these structures could not be explained.

The connection of oncolites with columnar stromatolites at Villàny and their identical microstructure show that the oncolites are really only one of the stromatolite types and form in the same conditions as it was postulated already by J. Pia (1927) and nowadays confirmed by R. N. Ginsburg (1960) and others (Logan, Rezak and Ginsburg 1964). In most fossil records the oncolites occur singly without attached stromatolites (see e.g. Johnson 1964, Kutek and Radwański 1965) which makes more exact facial comparisons more complicated.

The sequence of the stromatolite-bearing series of Villány has some resemblance to analogous series in Poland, both to that in the Tatra Mts. and to that of the Cracow-Częstochowa Upland. In the Tatra Mts., in folded parts of their so-called High-Tatric unit, the Bathonian stromatolites occur in some places on the ammonitiferous sediment and they are composed and covered with a sediment very similar to that of Villány (see Szulczewski 1963). In the Cracow-Częstochowa Upland the Callovian stromatolites occur directly over the knobby, likewise ammonitiferous layer

(R ó z y c k i 1953). Thus it is evident that during the Middle Jurassic time (Bathonian – Callovian) very similar phenomena, facial conditions and sedimentary sequence occurred in several places of Central Europe.

The situation of the knobby layer directly beneath the stromatolite clusters both in the Villány Mts. and in the Cracow-Częstochowa Upland suggests that such knobby layers may have been connected with the same facial conditions and sedimentary agents as the stromatolites. These Middle Jurassic knobby layers probably represent the reworking of sediments by waving and currents in shoal conditions (shallow sea or elose offshoze). Simultaneous reworking and stirring up of the buried ammonite shells of various age created a new assemblage, but an artificial one – a pseudoassociation *sensu* D. V. A g e r (1963) that is very typical for both these Middle Jurassic knobby layers.

The last problem is a very great similarity of the stratigraphic and sedimentary sequence in the Villány Mts. and in the folded part of the High-Tatric series of the Tatra Mts. In both regions the transgressive Middle Jurassic sediments lie with a gap on the Middle Triassic, in both there are stromatolites and similar sediments in the Upper Jurassic (pelitic limestones of the Oxfordian, microoncolitic ones with Saccocoma ossicles as microoncolite cores in the Kimmeridgian-Tithonian, additionally in the latter stage with scarce Tintinnids – see L e f e l d and R a d w a ń s k i 1960, K o t a ń s k i 1961, K a s z a p 1963, S z u l c z e w s k i 1963 and others). Both these regions, in which the stromatolites in the Middle Jurassic and shallow water microoncolitic limestones in the Upper Jurassic occur, are the only possessing such sediments in the Tethyan geosyncline. In the Tatra Mts. the transgressive Middle Jurassic with stromatolites occurs mainly in folded units of the High-Tatric series. According to Z. K o t a ń s k i (1961) who gave a paleogeographic reconstruction of the High-Tatric basin, these units represented the intrageoantyclinal "ridge" areas of the High-Tatric intra geosyncline. It seems that the region of the Villány Mts. played a similar role in the Hungarian part of the Tethyan geosyncline.

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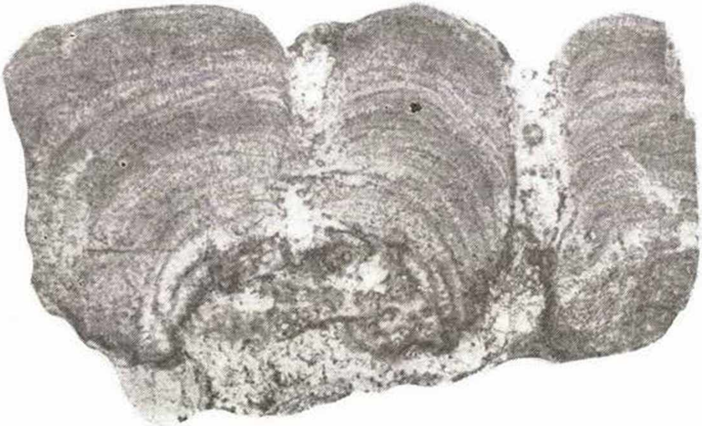
1



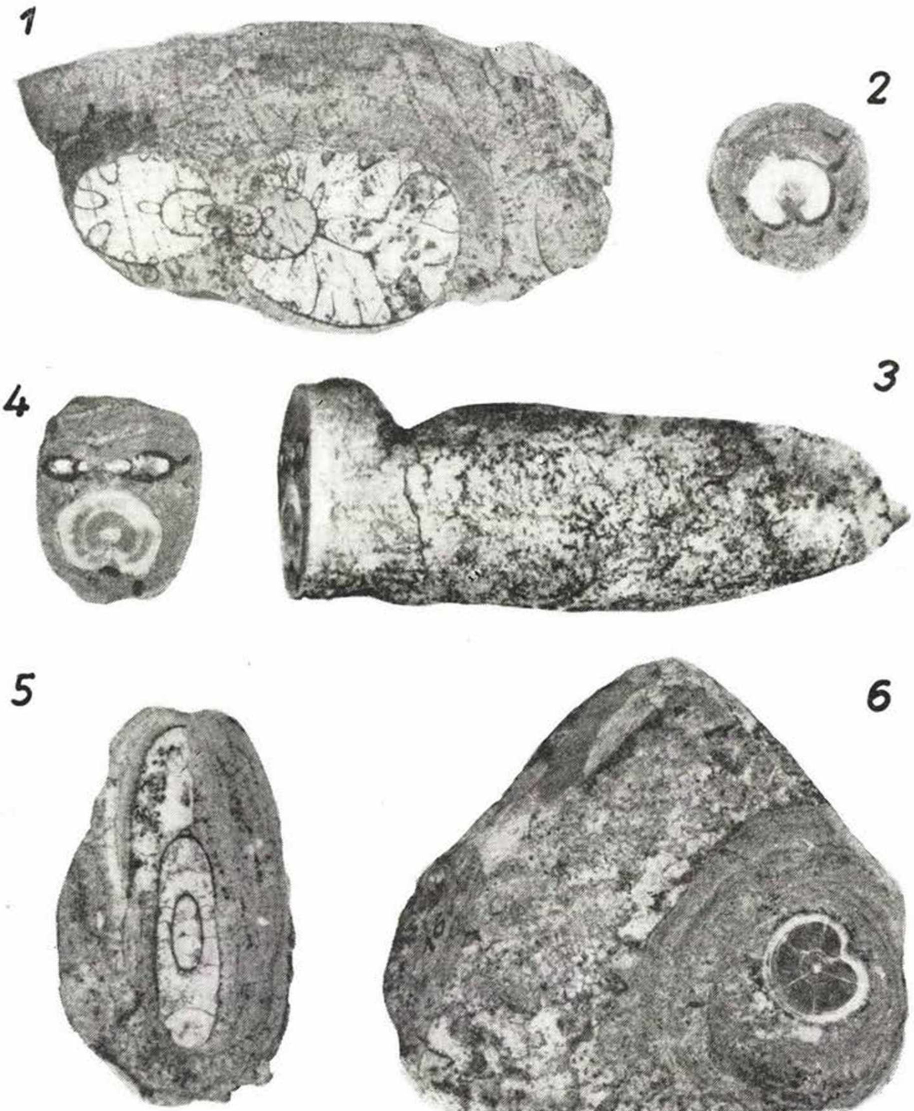
2

Pl 1. Fig. 1. Three stromatolites separated by deep interstices, and growing (the first two at left) over a sediment knob. Nat. size

Fig. 2. Three stromatolites separated by indistinct and weakly developed interstices. All stromatolites growing over an ammonite shell, partly corroded (at left). Nat. size

Pl 2. Fig. 1. Vertical view of the stromatolite clump. Nat. size
Fig. 2. Side view of the clump; polished cut. Nat. size

Pl 3. Fig. 1. Vertical view of the stromatolite clod. Nat. size
Fig. 2. Side view of the clod; polished cut. Nat. size



Pl 4. Fig. 1. Stromatolite crust over an ammonite shell covered with a few onkolitic coatings. Nat. size

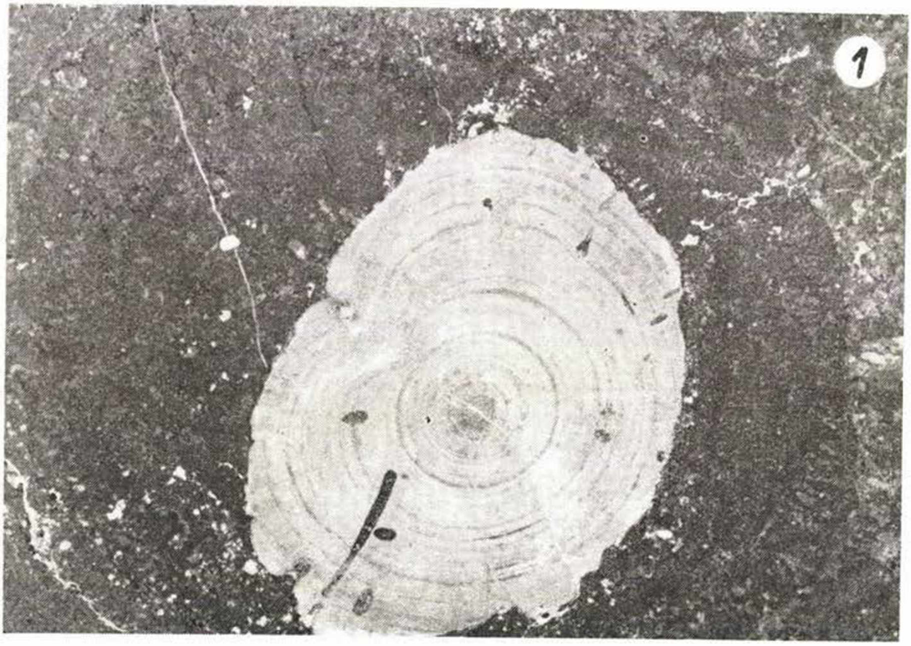
Fig. 2. Onkolite of "C" mode, with a belemnite guard as a core. Nat. size

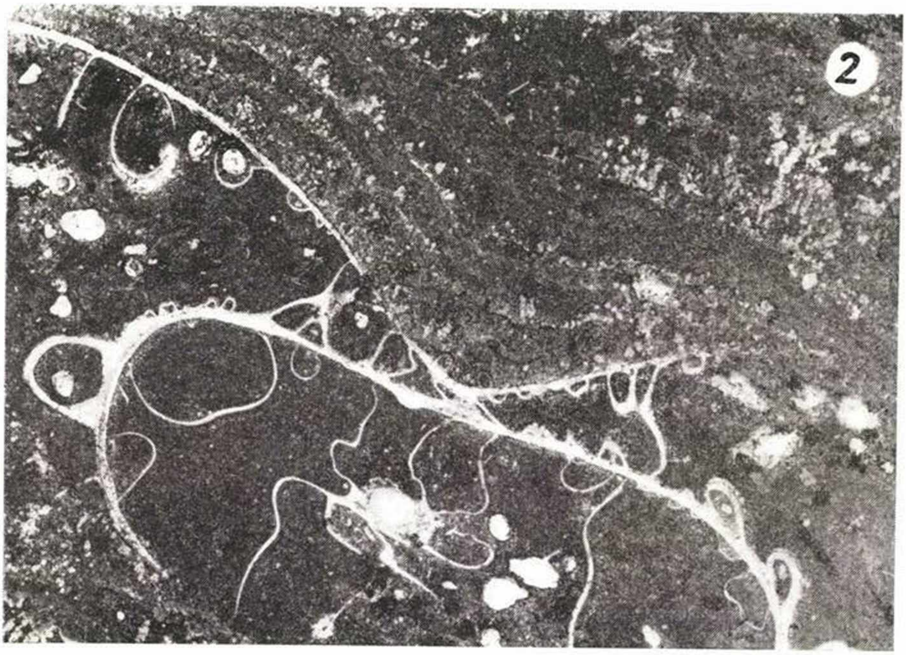
Fig. 3. Side view of a spindle shaped oncolite, mode "C", with belemnite guard as a core. The guard juts out with its distal end when the oncolitic envelopes have been stripped oft. At left a knobby crust over an ammonite shell fixed to the oncolite and covered by a next envelope. Nat. size

Fig. 4. Transverse section of the same oncolite through the ammonite-shell bearing crust. Nat. size

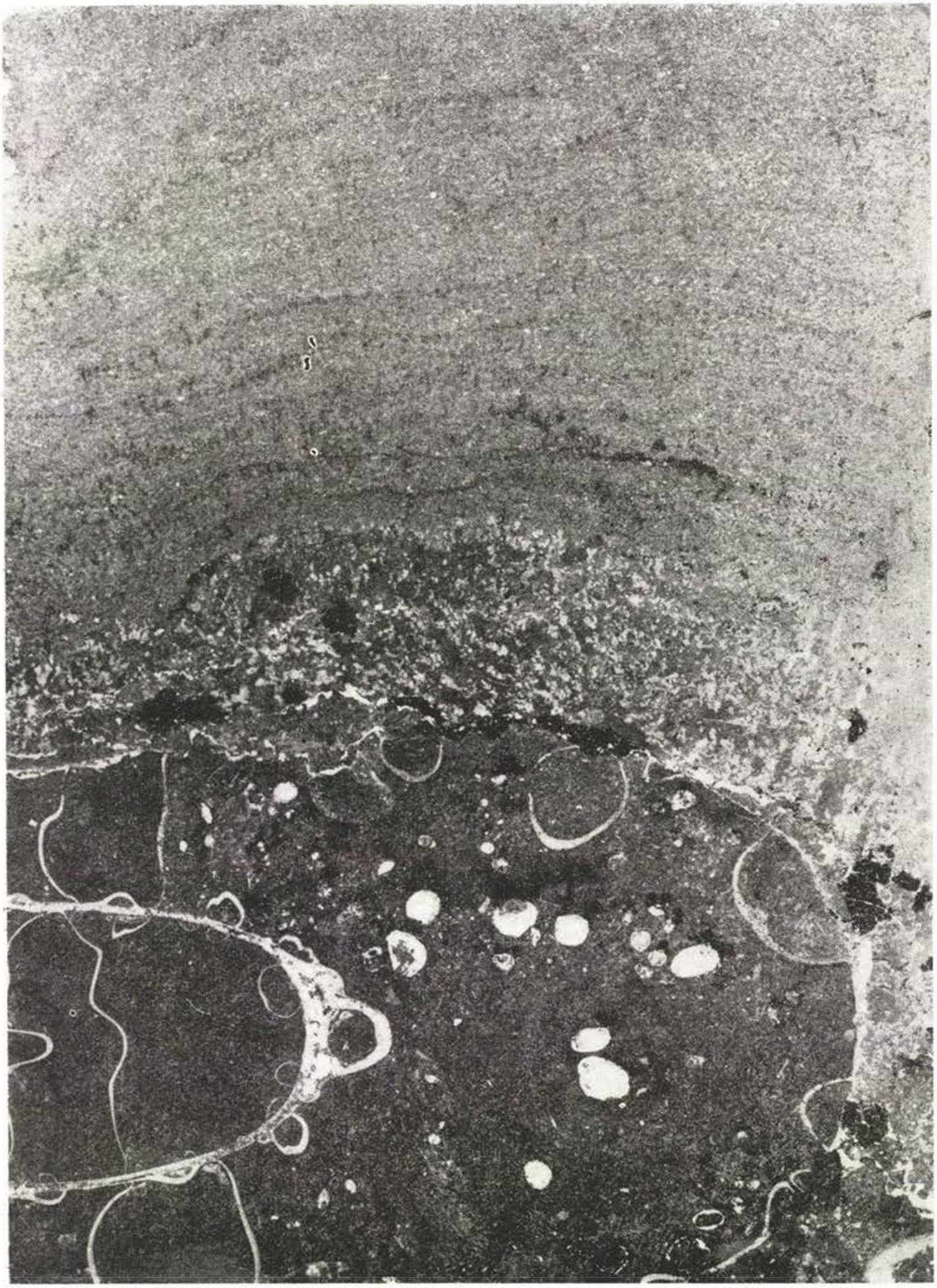
Fig. 5. Oncolite, mode "C", with an ammonite shell partly corroded as a core. Nat. size

Fig. 6. Belemnite-guard bearing oncolite of "C", partly "R" mode. Associated sediment, differece in structure is visible. Nat. size





Pl 5. Fig. 1. Belemnite guard bored by polychaetes and partly corroded, as an oncolite core. x5
Fig. 2. Stromatolitic lamination over an ammonite shell partly corroded (at right). Dendritic frutexites forms visible within repeating laminae. x5



Pl 6. Similar lamination, but frutexites forms only developed directly over the ammonite shell. x5