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# Upper Jurassic coral assemblages of the Central Polish Uplands

ABSTRACT: The Upper Jurassic coral assemblages of the Holy Cross Mts and Polish Jura Chain are composed of: a) foliaceous and submassive colonies, b) branching colonies and c) massive subspherical colonies. The character of corals and associated fauna and flora, as well as deposits in which the assemblages occur indicate a very shallow-water environment. The character of this environment and the process of sedimentation, which accompanied the growth, indicate *i.a.* that the assemblages were formed by the accretion of colonies at a rate equalling that of the sedimentation. An increase in the rate of sedimentation caused the end of their development. The assemblages discussed did not supply detrital material to the sediment and did not exert a decisive influence on the course of sedimentation, which makes them similar to Recent patch reefs of the Bahamas.

## INTRODUCTION

Several data concerning the character of the Upper Jurassic corals from the Holy Cross Mts and their life environment, are given in the paleontological monograph of corals (E. Roniewicz 1966) as well as in works dealing with the lithology and sedimentation of the Upper Jurassic limestones (Kutek 1969, E. Roniewicz 1966, Roniewicz & Roniewicz 1968 and others).

The present paper makes up an attempt at general characteristics of coral formations, based on an analysis of coral assemblages and associated calcareous deposits. The studies included the outcrops in north-eastern and south-western margins of the Holy Cross Mts, as well as — for comparative purposes — a coral-bearing locality, an only one known so far from the Polish Jura Chain (Fig. 1).

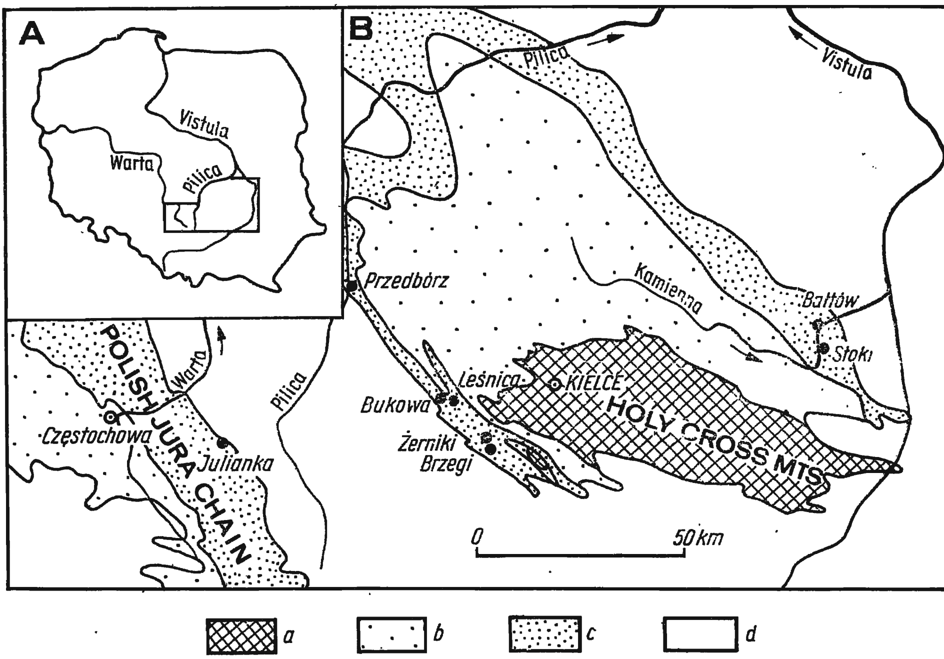



Fig. 1

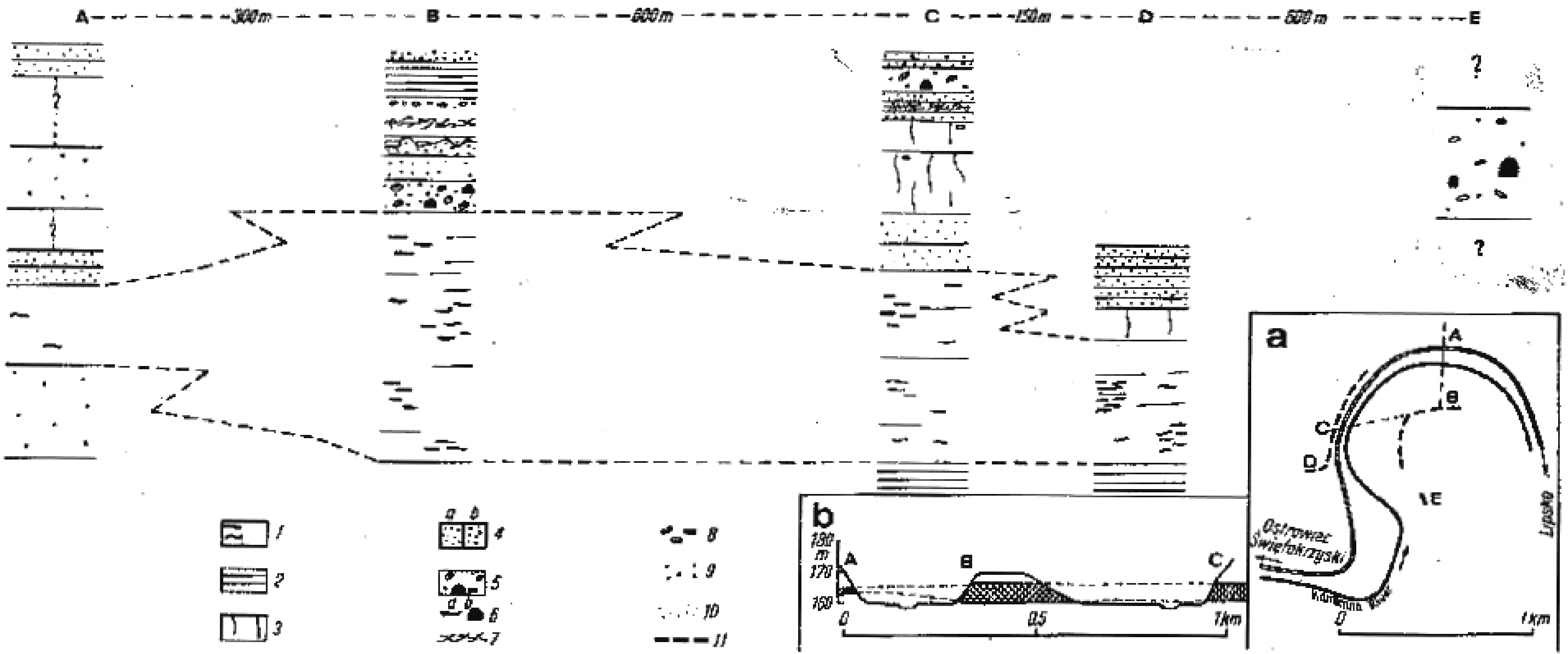
General map of Poland (*A*) and geological sketch map of the discussed regions (*B*) showing Upper Jurassic coraliferous localities in the Holy Cross Mts and Polish Jura Chain

*a* Palaeozoic massif of the Holy Cross Mts, *b* Mesozoic deposits of pre-Upper Jurassic age, *c* Upper Jurassic, *d* post-Upper Jurassic deposits (Cretaceous and Tertiary)

Poly-specific coral assemblages, which locally play a rock-building role and which were formed by the accretion of successive generations of corals during an indeterminable period, make up the subject of the present considerations. Thus defined assemblages cannot be identified with the bottom community, which is an assemblage of organisms that lived during the same period. Only some of the described assemblages and which are composed of a single generation of corals may be considered as a community.

Coral assemblages, together with various associated calcareous deposits, represent a heterochronous facies, which appears in the upper part of the Middle Oxfordian in the eastern part of the Holy Cross Mts and in the Kimmeridgian of the western part of this region. In the Polish Jura Chain this facies appears in the uppermost Oxfordian.

Coral assemblages occur in the environment of various shallow-water calcareous deposits, the detailed characteristics of which for the south--western part of the Holy Cross Mts are given by Kutek (1969). In earlier




Profiles (*A, B, C, D, E*) of the Middle Oxfordian coral-bearing deposits at Bałtów

*a* location of outcrops and profiles (*A—E*), *b* simplified section through the coral-bearing deposits. *1* pelitic, nonstratified limestone with coral assemblages, *2* stratified pelitic limestone, *3* chalky limestone, *4* pelletal limestone (*a* pure, *b* with microonkolites), *5* onkolitic limestone with corals, *6* coral colonies (*a* foliaceous, *b* subspherical), *7* burrows, *8* macroonkolites, *9* microonkolites, *10* pellets, *11* zone of outcrops works (Świdziński 1931), the coral assemblages under study were termed as reefs. Not going into the details of the characteristics of these assemblages, we should like to emphasize that they are not reef assemblages as accepted by most authors after Wilson's (1950) definition, which has already earlier been pointed out by E. Roniewicz (1966) and Kutek (1969).

## LITHOLOGICAL CHARACTERISTICS OF CORAL BEARING DEPOSITS

In the Upper Jurassic calcareous deposits, the corals occur usually as a subordinate faunal component. Their considerable concentrations, defined as coral assemblages, may be observed in few localities discussed below.

### *North-eastern margin of the Holy Cross Mts*

Coral-bearing deposits are known from the environs of Ostrowiec Świętokrzyski where they stretch in a 15 km long belt from Olechów through Bałtów to Stoki. The best outcrops are situated in the Kamienna river valley at Bałtów (Figs 2 and 3). These deposits have hitherto been assigned to the Epipeltoceras bimammatum Zone (Lewiński 1902). According to recent data (J. Kutek, *personal* communication), these deposits belong to the upper part of the Gregoryceras transversarium Zone.

At Bałtów (Fig. 2), a complex of coraliferous and accompanying limestones overlies white pelitic platy limestones. Conspicuously bedded, transitional beds between these two assemblages are composed of a fine-grained micrite with an admixture of very fine organic detritus.

The complex of coraliferous and accompanying limestones is *c.* 15 m thick and consists of non-bedded parts (*1* in Fig. 2) and overlaying them, bedded parts (*3—5* in Fig. 2). The non-bedded or indistinctly bedded parts form a continuous horizon varying in thickness between 4 and 10 m and occupying lower and middle parts of the profiles. They are composed of a coral limestone and pelitic limestone which occur in various proportions. They are accompanied by small inclusions of grain limestones, composed of organodetrital material a few millimetres in diameter and of microonkolites. In the coraliferous limestone, the coral assemblages are composed of foliaceous and submassive colonies. Spaces between colonies are filled up by pelitic or chalky (*sensu* Kutek 1969) limestone with a variable content of organic detritus. The pelitic limestone consists of a grainy micrite with an admixture of a very fine organic detritus. A scant macrofauna is represented, among other organisms, by single coral colonies. Both types of limestones contain structures visible on we-

Fig. 3 — Rocklets built of the limestones with foliaceous colonies of corals at Bałtów (right edge of the Kamienna valley); overlying are the pelletal limestones with microonkolites

athered surfaces and invisible in thin sections which are probably outlines of the thalli of calcareous algae or nonskeletal structures formed as a result of the life activity of blue green algae.

The bedded parts consist of limestones considerably variable lithologically and forming distinct, 1 to 1.5 m thick beds. These are grain (*4* and *5* in Fig. 2; Pl. 3, Figs 2—5) and chalky (*3* in Fig. 2) limestones. In grain limestones, fairly frequent are horizons with burrows most likely to be formed by crabs (Pl. 6, Fig. 2).

The entire set is rather similar to the limestones from the Chalky Limestone Member of the Lower Kimmeridgian in the south-western margin of the Holy Cross Mts (cf. Kutek 1969). The bedded limestone of the chalky type is composed of micrite in which aggregation grains may be observed in thin sections. These also occur thin-coated onkolites developed on organic remains. The organic detritus is poorly selected and usually partly micritized. Among grain limestones, the most common are pelletal limestones which, depending on the admixture of microonkolites, organic detritus and the type of either micritic, or sparitic cement, form varieties considerably differing in their macroscopic appearance (cf. *4a, b* in Fig. 2).

An onkolitic limestone, containing coral assemblages with massive colonies, is a characteristic component. At Bałtów, it is poorly developed (Fig. 2*B*) in contradistinction to an area situated further to the south, where, beginning with point *E* in Fig. 2, it reaches a thickness of 3 m. It consists of thin-coated onkolites, developed on fragmentary and complete shells of molluscs, plates and spines of echinoids, on small subspherical colonies of corals, solenopores, etc. Pellets and aggregation grains are visible in the cement.

At Stoki, the coraliferous and accompanying limestones are considerably more grainy than those at Bałtów. Limestones composed almost exclusively of the remains of echinoderms (Pl. 3, Fig. 6), occur at the base of coral-bearing limestones. Overlaying coral assemblages are surrounded by chalky limestone which locally contains a considerable amount of organic detritus of gravel and sandy dimension. Like at Bałtów, pellet limestones are also here developed.

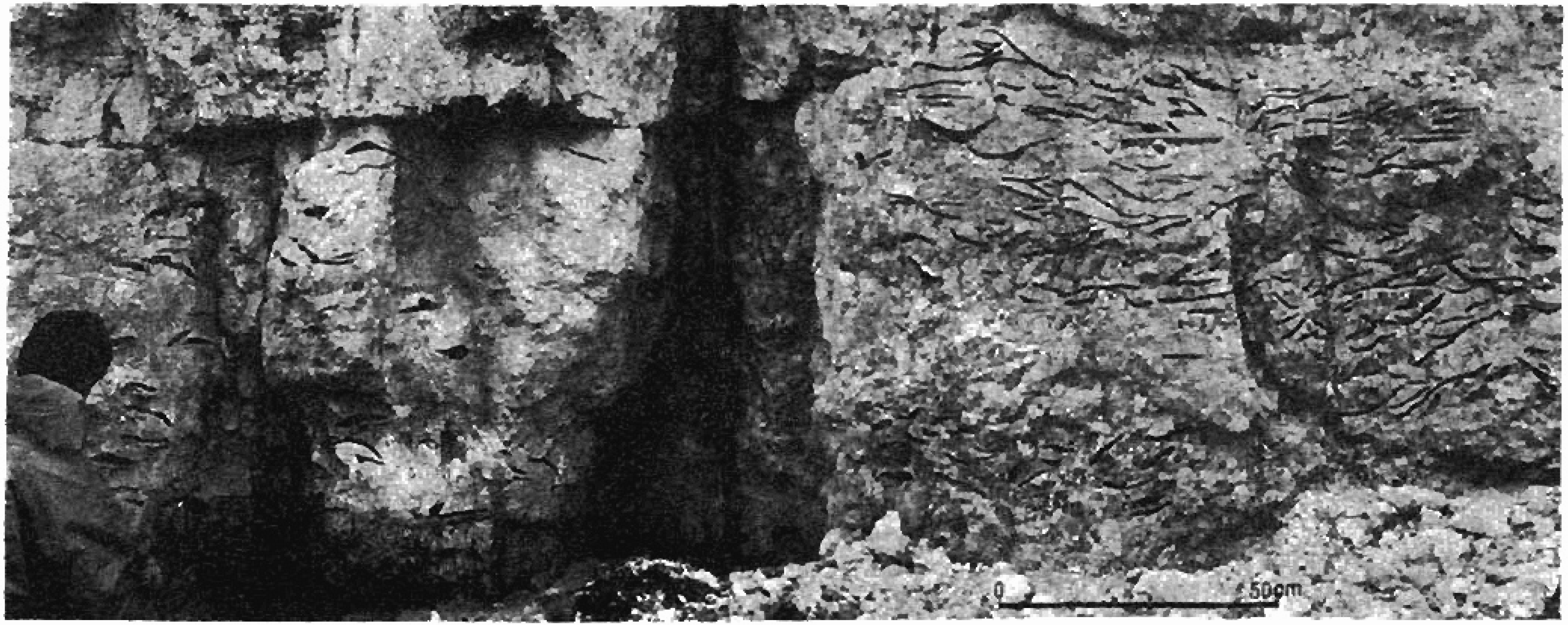
In the above presented deposits several components indicate their conspicuously shallow-water character. In addition to corals, these are primarily calcareous algae, onkolites and microonkolites. It may be safely assumed that the deposits of all types were formed in a basin at most some dozen or so meters deep. The differences in the composition of the deposit and in the ratio of grain components to micrite result from the differences in hydrodynamic conditions during sedimentation. The variability in such conditions is characteristic of a shallow-water zone of the carbonate sedimentation as follows from the data on the Recent patch reefs of the Bahamas (Purdy 1963).

An assemblage of onkolitic limestones should be considered as the most turbulent environment, the rest of the deposit types representing calmer conditions. The absence of oolites is especially remarkable as compared with the mass occurrence of micro- and macroonkolites. This gives ample evidence for a considerable role that was played by blue green algae which probably formed algal films on the bottom and thus made the oolitization process difficult.

In the substrate of the entire complex (Fig. 2), deposits display fairly uniform conditions of sedimentation in an environment devoid of any stronger movements of water, which is indicated by a lack of grain components, except for a small admixture of a fine organodetrital material. These deposits originated in deeper and calmer environment than the overlaying ones. The gradual increase in the amount of the organodetrital material in overlaying chalky limestones, the occurrence of detritus in the form of streaks and concentrations and, finally, the presence of single onkolites and microonkolites indicate an increase in the mobility of water. The irregular accumulations and streaks of detritus suggest the occurrence of surface waving currents which transported this material from yet more shallow-water zones.

At that time, foliaceous coral colonies started to develop on the bottom. Their existence caused a differentiation of the bottom conditions which in turn affected the differentiation in sedimentation. A finer material was as a rule deposited between the colonies within the assemblage rather, than between the asemblages. The existence of coral assemblages exerted a rather complex influence on the types of deposits formed laterally. The corals did not supply here detrital material to the deposit which indicates that their colonies probably did not form assemblages considerably elevated over the bottom and the spaces between colonies were probably rapidly filled with sediment as the assemblage grew upwards. In part of the Stoki area, the sedimentary environment was more mobile which is indicated by a large amount of organodetrital material. After the completion of the development of the foliaceous coral assemblages, a general increase occurred in the mobility of environment expressed in the appearance of a massive coral assemblage with onkolites.

The occurrence of dolomites has for a long time been recorded (Pożaryska & Pożaryski 1953) in the described Upper Jurassic deposits of the Bałtów area. The dolomitization covers all lithological varieties of limestones, the coraliferous deposits included. It is of the nature of irregular nests. The degree of dolomitization varies from single crystals of dolomite scattered in limestone (Pl. 3, Fig. 1) to a nearly complete repla-




Arrangement of the foliaceous colonies of *Microsolena agariciformis* ÉT. at Stoki: at the right side of the outcrop — dense concentration of colonies, at left — loose packing of colonies cement of the calcium carbonate by dolomite which leads to a total obliteration of the orginal structure of the rock. The calcitic organic remains are least susceptible to dolomitization. The character of dolomitization and its spatial distribution seem to indicate that it took place after the deposition of the entire complex of carbonate Upper Jurassic deposits. No symptoms of dolomitization are known either from older, or younger deposits than the Upper Jurassic. It may be supposed, therefore, that this was a postsedimentary dolomitization connected with the process of the lithification of deposits. It took place at a moment when an accretion of sediments not compensated by subsidence, led to the formation of isolated basins with a highly concentrated brine. A continental--lagoonal facies, from which dolomitic deposits with gypsum and anhydrite are known, predominates in the Upper Jurassic of Eastern Poland (Żelichowski 1961), relatively not very far from the territory under study. The filling-up of the basin caused an extension of this facies onto the zone of former marine sedimentation. The concentrated brine penetrated the previously deposited sediments, dolomitizing them more intensively along the zones of a larger porosity and hence the irregular character of dolomitization. A dolomitization of a similar type covered in fact the Jurassic deposits situated considerably further to the west and its symptoms are known from a borehole at Magnuszew on the Vistula.

Much the same as dolomitization, the silification probably took place in the process of lithification. Organic remains occurring in flints in identical amounts with those in the surrounding limestone, are indicative of a postsedimentary character of the process. The postsedimentary character of dolomitization and silification is typical of such epicontinental deposits (Dapples 1967) as here described ones.

### *South-western margin of the Holy Cross Mts*

In this region coral assemblages occur in the Lower and Middle Kimmeridgian limestones (Kutek 1968); the best outcrops being known at Bukowa, on the Kościółek hill (environs of Leśnica), at Brzegi and Żerniki. Once, they were also exposed in the environs of Przedbórz. Since closer characteristics of the Kimmeridgian limestones are given in Kutek's (1969) work, the data given below include only the most essential lithological characters of the members which directly accompany coral concentrations.

In regard to the development of coral assemblages, the most important is a quarry at Bukowa with outcrops of limestones of the upper part of the chalky limestones (the lower part of the Sutneria platynota zone) and deposits overlaying chalky limestones (Kutek 1968).

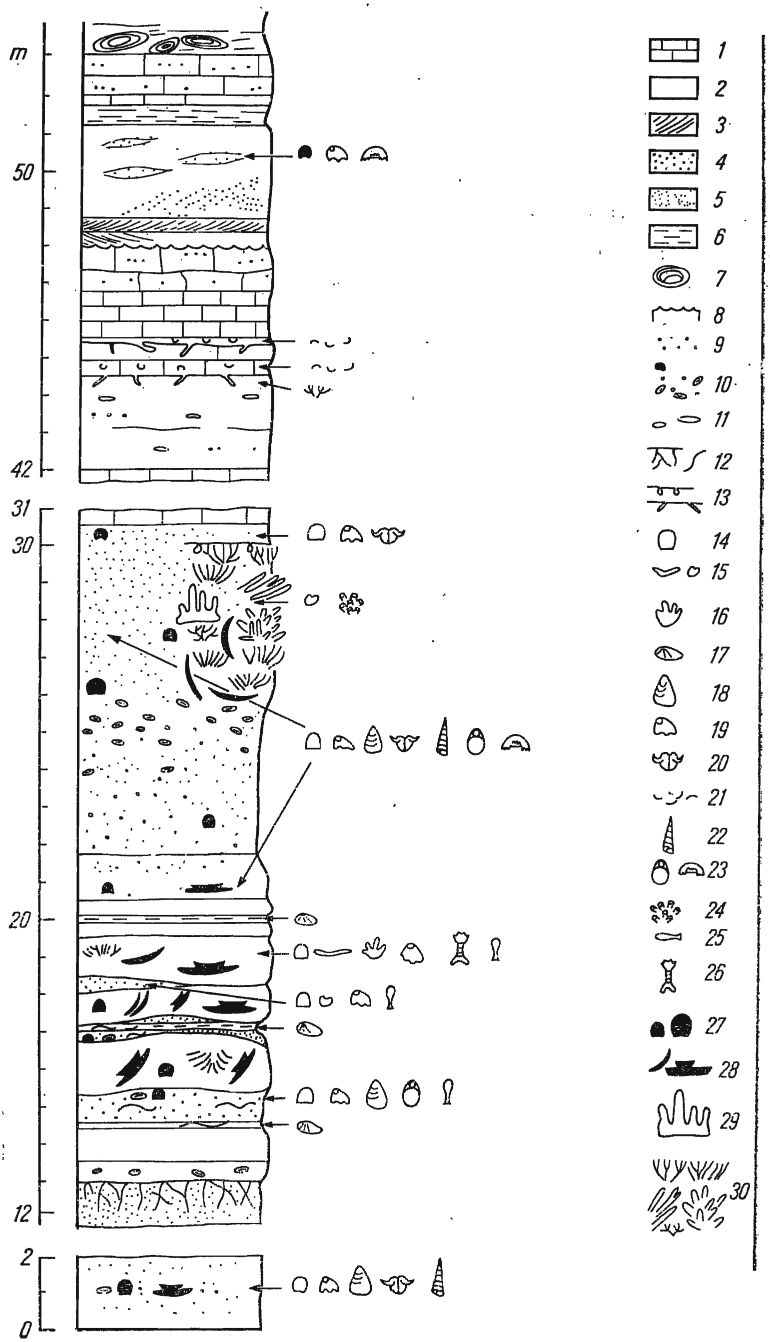



Fig. 5

Lower Kimmeridgian coral-bearing deposits at Bukowa

*1* pelitic, thin-stratified limestones lacking of fossils, *2* pelitic, thick-stratified limestones with fossils, *3* pelitic limestones with ooids, diagonally stratified, *4* organodetrital limestones, *5* chalky limestones, *6* marly limestones, *7* slump balls, *8* ripple marks, *9* ooids, *10* onkolites, *11* intraclasts of pelitic limestone, *12* burrows, *13* borings, *14* *Solenopora*, *15* sponges, *16* branching hydrozoans, *17* myid pelecypods, *18* *Trichites*, *19* ostreids, *20* *Diceras*, *21* thin-shelled pelecypods, *22* nerineids, *23* brachiopods, *24* encrusting bryozoans, *25* echinoid prickles, *26* thick-stemmed crinoids, *27—30* coral colonies (*27* massive, subspherical, *28* foliaceous and submassive, *29* pillar shaped, *30* branching)

Tender chalky limestones with inclusions of compact, pelitic limestones (Fig. 5) represent a main part of the profile at Bukowa. This member is marked by a rather monotonous composition, in which differences are expressed in a variable ratio of grain components, microonkolites, onkolites, pellets and fine organic detritus with the micritic or sparitic cement. Concentrations of corals form two distinct coral horizons. In the remaining part of the profile, corals occur sporadically or are absent. The lower part of the member (Fig. 5, 0—15 m) is composed of white, tender, indistinctly bedded limestones, characterized by the occurrence of fauna in lenses or in a scattered state. It terminates in a horizon with burrows. Due to the monotony of lithology, considerable part of this member is omitted in the drawing of the profile. The next part (Fig. 5, 15—20 m) consists of hard limestones the bedding of which results from the occurrence of intercalations of more marly limestones. These limestones are lithologically differentiated within the bed into two types. A dominant one is compact, micritic limestone with numerous microonkolites and pellets and in which more or less compact concentrations of foliaceous and submassive coral colonies are developed locally. This limestone occurs throughout the thickness of the beds or forms lenses, irregularly connected with each other and surrounded by grain limestone. The last-named contains many organic fragments of a sandy fraction, as well as onkolites embedded in micrite. Coral concentrations of pelitic limestones make up the lower coral horizon at Bukowa. The last part (Fig. 5, 20—30 m) is very similar lithologically to the first one. Within this part, coral concentrations with branching colonies, which make up the upper coral horizon, occur above the middle part, containing an increased amount of onkolites. These concentrations are shaped like irregular solids *c.* 4 m in thickness and over 10 m long, which distinguish themselves from the surrounding rock by crowded coral skeletons. These concentrations overlap the surrounding deposits. This is expressed in narrowing or lateral extension of their range which is observed over their entire vertical stretch.

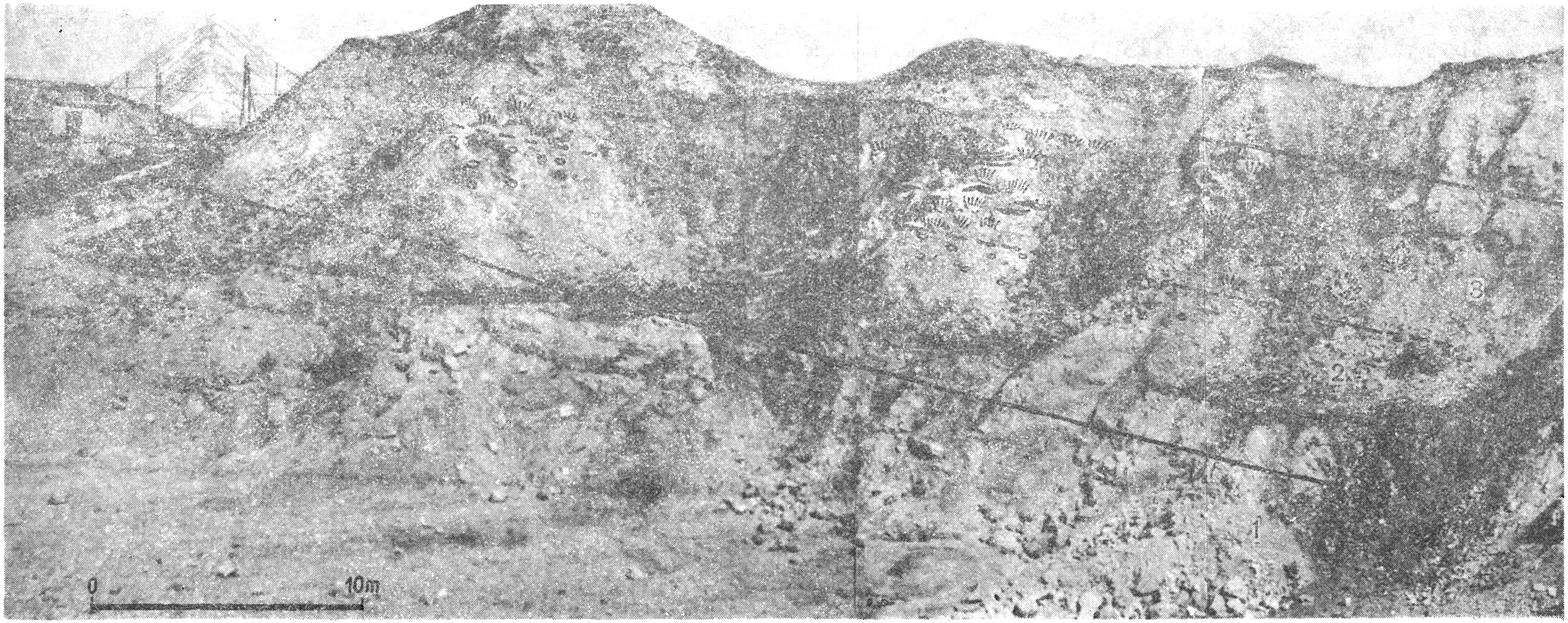
The chalky limestones are overlaid by strongly bedded, lithologically variable limestones, the most important of them being pelitic and oolitic limestones and marls (Fig. 5, part from 30 m upwards). In this part of the profile, several sedimentary structures are indicative of a shallow-water environments. These are repeatedly occurring sedimentary discontinuities of the hard ground type, cross bedding and ripple marks (P. Roniewicz 1967).

The coral assemblages at Bukowa are connected with the facies of chalky limestones which on the whole are characterized by a certain monotony of sedimentation and constancy of its conditions, manifested by a lack of distinct stratification. Much the same as at Bałtów, these deposits do not display any evidence of the activity of currents in the form of cross stratification or erosional surfaces. On the other hand, there occur a fine organodetrital material, as well as indices of a shallow-water environment expressed in faunal components, calcareous algae, occurrence of micro- and onkolites. Attention is attracted to the occurrence of a distinct horizon with burrows which may be evidence for a certain slowing--down of sedimentation, if not for a complete stoppage. From the occurrence of onkolites and pellets, the latter giving the impression as if they were formed by activity of blue green algae, one can conclude on the existence of algal films on the bottom.

No corals are recorded in the uppermost deposits in the Bukowa profile. At the same time, there occur cross bedded oolites and the deposit displays a variable rate of sedimentation with gaps manifested by various sedimentary discontinuities. This is, therefore, a different environment than that of the underlaying chalky limestones. Both are shallow--water environments and the difference consists mainly in a different dynamics of the water. This new environment was not already favourable to the development of coral assemblages.

The assemblages from Brzegi and Żerniki are similar to those from Bukowa. They occur within well-bedded limestones assigned to the Ataxioceras hypselocyclum Zone (Kutek 1968) and thus they are younger than those from Bukowa. Two types of assemblages may be distinguished in a *c.* 3 m thick profile. The lower one, composed of massive subspherical colonies, occurs within microonkolitic limestones and it is overlaid by an assemblage of branching corals, surrounded by pelitic and organodetrital, fine-grained limestones, the latter containing onkolites. The top of this coral assemblage is truncated by a distinct hardground surface, beginning with which the branches of corals were dissolved and the canals after them were filled up with pelite or oolites. The character of the deposit accompanying corals and in particular the presence of hard bottom with evidences of chemical corrosion, which perhaps took place during an extreme shallowness (cf. Roniewicz & Roniewicz 1968), give evidence of exceptional shallow-water environment.

A special character is revealed by the coral assemblages from the Kościółek hill, near Leśnica. It may be observed in a profile which begins with bedded chalky limestones overlaid with a 4 m thick set of granular, poorly selected and stratified limestones. Pellets, organogenic detritus, colonies of *Marinella* 3 to 5 mm in diameter, micro- and macroonkolites are main components of these deposits. The top of this sequence displays a hardground surface overlaid by the coral assemblage consisting of massive colonies and occurring within a conglomeratic limestone. The latter is composed of solenopores, spherical hydrozoans, *Diceras* and nerineid shells, as well as pebbles of pelitic limestone to 5 cm in diameter.




Coral assemblages composed mostly of branching colonies in the chalky limestones at the Bukowa quarry (upper coral horizon)

*1* pelitic or detrital limestones lacking of corals, *2* chalky limestones with onkolites, *3* chalky limestones with coral patches (upper coral horizon); other symbols the same as in Fig. 5

These components are cemented by a grain limestone. Most components named above bear traces of rounding indicative of their allochthonous character, or are covered with onkolitic coatings. Large, massive colonies, which make up a main component of the coral assemblage, are an autochthonous element.

The character of the deposits indicates that they was formed under a strong turbulence and, maybe, with the participation of currents which covered the surface of the hardground with a sediment swept and transported from adjoining areas. This would be an example of a most mobile environment in which the occurrence of a coral assemblage has ever been recorded in the Holy Cross Jurassic.

### *Polish Jura Chain*

Apart of the margin of the Holy Cross Mts, larger coral concentrations are recorded in the uppermost part of the Idoceras planula Zone in the eastern part of Polish Jura Chain (cf. Fig. 1), for instance, a coral assemblage from the Julianka quarry, found by Dr. A. Wierzbowski. This coral assemblage occurs within poorly bedded chalky limestones and consists of foliaceous colonies which makes it similar to the assemblages from Bałtów and Stoki. It, however, contains only one or at most two species of the genus *Microsolena*. The character of the deposits in which it occurs is similar to that of the upper coraliferous horizon from Bukowa. Thus, it was formed in an environment with a moderate turbulence and — considering the fact that limestones with many sponges are known from a quarry near Julianka — maybe, at a larger depth.

## CORAL ASSEMBLAGES

The presented coral assemblages are composed primarily of Scleractinian colonies with a small addition of the skeletons of other organisms. Three types of coral assemblages, discussed in the forthcoming chapters, may be distinguished on the basis of the predominating shape of colonies. All the assemblages are rather loosely related to definite types of a deposit filling the spaces between colonies. Regardless of their shape, the colonies were developed both on the sediment and rock bottom, the latter being the colonies of older generations. The colonies mostly occur in their life position, the foliaceous ones resting horizontally to the substrate and the branching ones raising their stipes upwards. There are, however, exceptions to this manner of growth which seem to be an evidence of the activity of peculiar factors in this environment.

Thus, for instance, frequent are foliaceous colonies arranged at various angles to the substrate with their calicinal surfaces, in colonies situated one along another, oriented in one direction (Pl. 4, Figs 1—2; Pl. 5, Fig. 2). At present, corals in corresponding zones of reefs take this position depending on the direction of tidal currents to which they orient themselves perpendicularly (cf. Chevalier 1968). In some cases, orientation of branches indicates that the growth of a colony took place diagonally downwards (cf. Fig. 7). A similar manner of growth is met with at present when a strong waving prevents an upward growth of delicate, branching colonies attached to objects raised above the bottom (cf. Chevalier 1968, Chevalier & al. 1969).

### *Coral assemblages composed of foliaceous and submassive colonies*

This is a most frequent type of coral assemblages in which colonies are unifacial and their inferior surface is covered with holotheca even in the case in which colonies are not oriented horizontally. If such is the case, small parts of the inferior surface happen to be occupied by calices. Depending on the conditions, foliaceous colonies may be either purely foliaceous in character, or tend to pass to the massive type. Such colonies, here called submassive, have their diameter a few times larger than the height and the calices and lower surfaces more or less parallel to each other. Their height diameter ratio and a relatively flat calicinal surface differ them from massive colonies which take subspherical shapes. In the asemblages of this type, the most common are the species having porous, rapidly growing skeletons (microsolenids and actinacidids). Usually, they are accompanied by more or less pelitic deposits, but they are also known from organodetrital deposits.

Comparing the sequence of colonies within assemblages (cf. Fig. 8) one may conclude on requirements of some types of colonies concerning the properties of the substrate. The corals of foliaceous colonies seem to be more tolerant to the substrate than those with other types of colonies and, frequently, they are pioneers which settled the bottom. This is probaly the reason why the colonies of the foliaceous type are so common in the discussed Jurassic deposits. Such colonies are in fact the most frequent also outside the dense coral concentrations in these deposits.

The most typically developed assemblages of this kind occur at Bukowa, Bałtów and Julianka.

At Bukowa, they are developed in particular layer of pelitic limestones in which they form the lower coraliferous horizon (Figs 5 and 7; Pl. 4, Fig. 1). Phaceloid colonies, found within this assemblage, are of a minor importance. A complete list of species was given by E. Roniewicz (1966, Table 1; Bukowa assemblage *2*). In regard to their frequency, the most important are: *Isastrea helianthoides* (Goldf.), *Fungiastraea multicincta* (Koby), *Complexastraea thevenini* (Ét.), *Microsolena agariciformis* Ét., *Thamnasteria concinna* (Goldf.) and *Actinaraea granulata* (Münst.). The first four have colonies reaching 20 and 30 cm in height. Usually, all these species, accompanied by a few others, form in a certain area and within one bed loose concentrations differing from each other in their specific composition. Some examples of the assemblages observed at Bukowa are as follows:

a) foliaceous and submassive colonies of *Microsolena agariciformis* Ét. and *Thamnasteria concinna* (Goldf.), less numerous colonies of *Fungiastraea multicincta* (Koby), numerous, small massive colonies of a few species of the genus *Pseudocoenia* d'Orb., as well as *Convexastraea sexradiata* (Goldf.), *Comoseris minima* Beauv., *Myriophyllia rastellina* Mich., *Microphyllia macropora* (d'Orb.) and, as accessory ones, small phaceloid colonies of *Thecosmilia* sp. and *Calamophylliopsis stockesi* (M.-Edw. & H.);

b) submassive colonies of some thamnasterids, phaceloid colonies of *Calamophylliopsis stockesi* (M.-Edw. & H.), few submassive colonies of *Fungiastraea multicincta* (Koby) and *Microsolena agariciformis* Ét. and sporadically occurring colonies of *Comoseris minima* Beauv. and *Stylina* sp. (Fig. 7);

c) submassive colonies of *Microsolena agariciformis* Ét., *Fungiastraea multicincta* (Koby), thin-foliaceous colonies of *Actinaraea granulata* (Münst.) and, as accessory ones, massive pseudocoenias, *Convexastraea sexradiata* (Goldf.), *Microphyllia macropora* (d'Orb.) and phaceloid colonies of *Goniocora annulata* Ron. and *Calamophylliopsis stockesi* (M.-Edw. & H.) (vide Pl. 4, Figs 1—2).

These above listed colonies are usually bored by lithophags. The composition of a scattered, accompanying fauna is shown in Fig. 5.

The assemblages of foliaceous corals at Bałtów and Stoki are different than those at Bukowa (a complete list of species given by E. Roniewicz 1966, Table 1, Bałtów assemblage *1*, supplemented by this same author in 1968 and 1970). They form concentrations reaching a few meters in thickness and developed in a poorly bedded or unbedded, frequently organodetrital limestone (Pl. 2, Fig. 2). Colonies are either submassive, scattered, or foliaceous, concentrated. In the latter case, a differentiation in the size of colonies is observed in particular concentrations, being probably connected with specific properties and sometimes with the rate of sedimentation. In some concentrations, colonies exceed 50 cm in diameter and are about 3 to 6 cm high (*Comoseris baltovensis* Ron., *Microsolena thurmanni* Koby), in some others they are thin, reaching 1.5 cm in height and 20 to 30 cm in diameter, as *e.g.* *Microsolena agariciformis* Ét., *Thamnasteria* cf. *concinna* (Goldf.), *Fungiastraea arachnoides* (Park.), *Actinaraea minuta* Ron., and — in still others — they take a foliaceous form and reach a height of 0.5 cm and a diameter of some dozen or so centimeters (*Microsolena thurmanni* Koby and *Actinaraea minuta* Ron.). Thick colonies are spaced at about 10 to 20 cm and thin ones at 1 to 3 cm.

In these localities, much the same as at Bukowa, an inclined orientation of calicinal surfaces is observed here and there. Particular thin-foliaceous, compact assemblages from Bałtów and Stoki (Fig. 4; Pl. 1, Fig. 1), as well as from Julianka (Pl. 1, Fig. 2) are homogenous specifically. Some of them consist of one only or two to three coral species. In less compact assemblages (Pl. 2, Fig. 1), a considerable specific heterogeneity is observed similar to that at Bukowa. For example, the colonies of the following species have been taken out of an 8×4 m wall of the quarry in which no conspicuous concentration of colonies could be observed: *Isastraea*

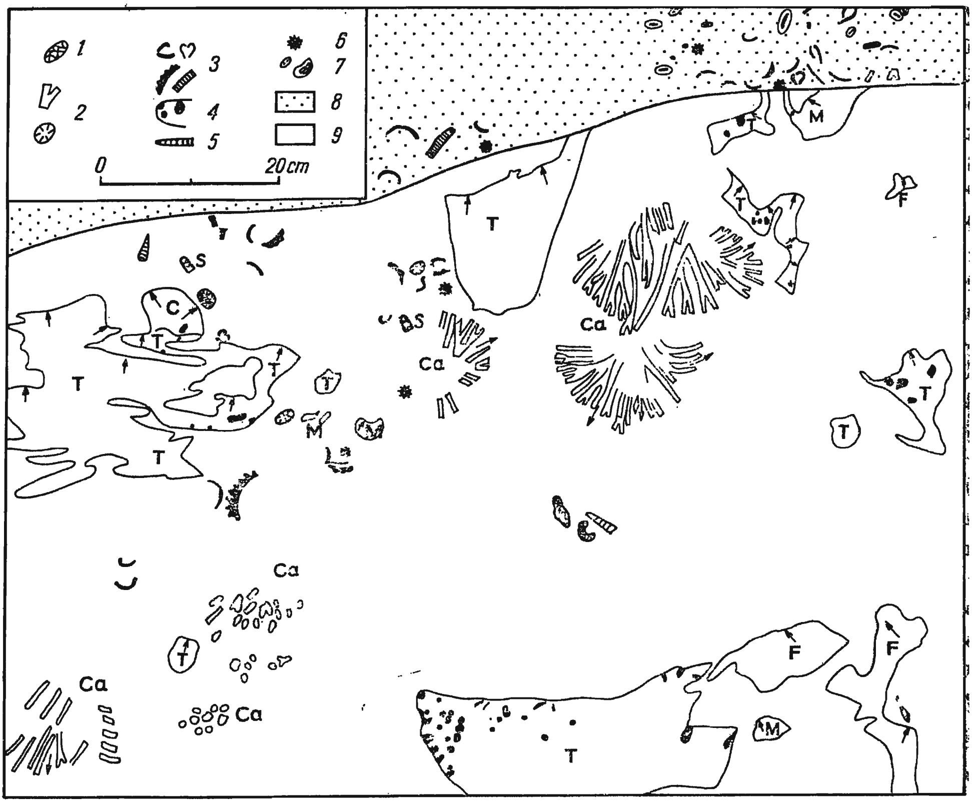



Fig. 7

Arrangement of coral colonies in the chalky limestone at Bukowa (lower coral horizon); section perpendicular to the bedding

The coral colonies are signed: C — *Comoseris minima* Beauvais, Ca — *Calamopylliopsis stockesi* (M.-Edw. & H.), F — *Fungiastraea multicincta* (Koby), M — *Microsolena agariciformis* Ét., S — *Stylina* sp., T — Thamnasteridae; the arrows show the growth direction of the colonies. *1* sponges, *2* single branches of corals, *3* pelecypods, *4* pelecypod borings in the coral colonies, *5* gastropods, *6* echinoid prickles, *7* onkolites, *8* organodetrital limestone, *9* pelitic limestone

sp., *Thamnasteria* cf. *concinna* (Goldf.), *Microsolena thurmanni* Koby, *Fungiastraea* sp., *Pseudocoenia baltovensis* Ron., *Allocoenia matheyi* Koby, *Comoseris baltovensis* Ron., *Clausastraea parva* M.-Edw. & H., *Heliocoenia variabilis* Ét., *Thecosmilia* sp., *Actinaraea minuta* Ron., *A. robusta* Ron. and others. In such places, the accompanying fauna is varied; for instance, in a 4-sq-m area the following forms have been stated — a calcareous sponge, a few species of branched bryozoans, numerous brachiopods as, *Craniscus bipartitus* (Münst.), *C. antiquor* (Jelly), *C. corallinus* (Quenst.), *Praelacazella ulmensis* (Quenst.), *P. baltoviensis* Barczyk, *Agerinella lyrata* Paj. & Patr., *Moorellina septata* (Moore), *Cheirothyris* sp., *Dictyothyropsis loricata* (Schloth.), *Ismenia pectunculoides* (Schloth.), *I. recta* (Quenst.); spines of regular echinoids, starfish ossicles, pelecypods — *Arctostraea hastellata* (Schloth.), *Plicatula* sp., and numerous serpulids, of which *Glomerula gordialis* (Schloth.) is the most frequent.

As indicated by the variety and character of the corals and accompanying fauna, as well as the presence of calcareous and blue-green algae, the assemblages of foliaceous and submassive corals represent shallow-water environments. Such a conclusion is also confirmed by the character of associate deposits. In some cases as, for instance, at Bukowa (Figs 5 and 7), this was probably a very shallow-water environment, ample evidence for which being given by the presence of overhanging branched colonies whose upward growth was hindered by strong waving. In other cases, as those of Bałtów and Julianka, the environment might be somewhat deeper or at any rate marked by a calmer water. A calmer environment is here indicated not only by the character of coral colonies, frequently very delicate, but also by the accompanying fauna. At Bałtów, the role of such an environmental index is played by thecideans, considered as inhabitants of shallow, but calm waters (Pajaud 1970). On the other hand, in the case of Julianka, the proximity of sponge facies, which may be an evidence of a somewhat deeper environment, should be taken into account.

Finding an accurate equivalent of the Jurassic assemblages of foliaceous corals among the Recent corals encounters difficulties. The first difference is the character of the bottom being settled by the corals. The Jurassic corals lived on a sediment bottom, while the Recent foliaceous corals occur on a rocky bottom. The second difference consists in the fact that the Recent corals do not form such homogenous concentrations as did the Jurassic ones and that they make up a rather secondary component of reef assemblages which occur outside the zone of surf (cf. leeward reefs, Chevalier 1968). Perhaps, most characters in common are displayed by the Recent shallow-water assemblages of foliaceous corals which have not the character of reefs and which are mentioned by Yabe & Sugiyama (1935) from Japanese Islands.

### *Coral assemblages composed of branching colonies*

The assemblages of this type consist of branching colonies only, or either such colonies make up their predominant component. These are phaceloid and ramose plocoid, meandroid and other colonies, which occur within chalky and pelitic limestones. This type, although less common than the former one, is easier to notice and, therefore, generally known so far. The best-outcropped assemblages of this type are known from Bukowa (Figs 4 and 6), Brzegi and Żerniki.

The assemblage from Bukowa, forming the upper coraliferous horizon contains 30 species (cf. E. Roniewicz 1966, Table 1; Bukowa assemblage *3* completed in further papers of this author, 1968, 1970), more than a half of them having branching colonies and the rest being predominantly foliaceous. Corals with subspherical colonies make up only about 10 per cent. Due to their large volume and numerical predominance over the colonies of other types, the branching colonies are all the more a predominant rock-building element. The most important of all the species are *Calamophylliopsis stockesi* (M.-Edw. & H.), *Meandrophyllia amedei* (Ét.), ramose pseudocoenias of the species *Pseudocoenia limbata* (Goldf.) and *P. longiseptata* Ron., as well as amphiastreid species *Pleurophyllia trichotoma* de From. and *Mitrodendron ogilviae* Geyer, both rarely met in other regions of the Holy Cross Mts. The most important of foliaceous and submassive corals are *Isastraea helianthoides* (Goldf.) and *Thamnasteria concinna* (Goldf.) and of massive corals — the colonies of *Comoseris minima* Beauvais and *Kobyastraea bourgeati* (Ét.).

In the Bukowa assemblage, all colonies occur in a life position. The branching colonies are 0.15 to 1.5 m high (Pl. 5, Fig. 1), foliaceous ones 1 to 10 cm thick and up to *c.* 1 m in diameter. The foliaceous colonies either lay horizontally, or are arranged laterally with their calicinal surface oriented to one side, which, like at Bałtów, may be considered as resulted from the direction of water movement. The subspherical colonies are, within the assemblage, considerably smaller than the colonies of this same species, *Comoseris minima* Beauv., found outside of it. In this assemblage, striking is a small part of the species with porous skeletons.

The Bukowa coral assemblage is of the nature of a coral massif growing together with the accretion of the surrounding deposit, which is indicated by their intercalation (Fig. 6) and, therefore, distinct differences here observed in the coral fauna between the lower and upper part of the assemblages may be interpreted as a sequence of faunas in time. This sequence suggests the changes in the environment. Since no changes occur in the type of surrounding deposit, the sequence of faunas seems to be connected with a change in the character of substrate on which successive faunas settled. In this assemblage, the original coral fauna which settled on the sediment bottom, muddy to a considerable extent, was of a foliaceous type. It is only above than that a branching fauna occurs which probably used the underlaying colonies as a rock bottom (Fig. 8*B*). Particular faunas, succeeding each other, display only small differences in their specific composition. Differences become distinct in the comparison of the original and final faunas which indicates a gradual character of the changes in the sequence of coral communities. The pioneers settling the bottom, in this case a muddy sediment with onkolites, were represented by few foliaceous *Thamnasteria concinna* (Goldf.), *Isastraea helianthoides* (Goldf.) (cf. Pl. 5, Fig. 2), *Actinaraea granulata* (Münst.), *Actinaraeopsis exilis* Ron. and *Fungiastraea multicincta* (Koby). Just after than, there abundantly occur phaceloid *Calamophyllopsis stockesi* (M.-Edw. & H.), *Aplophyllia sexradiata* Ron. and *Goniocora pumila* (Quenst.). Next, there appeared branching colonies of other types, first *Pseudocoenia limbata* (Goldf.), then *P. longiseptata* Ron., *Stylina parcicosta* Koby, *Meandrophyllia amedei* (Ét.) (cf. Pl. 5, Fig. 1) and, finally, pillar-shaped colonies of *Pseudocoenia suboctonis* d'Orb. and three species, of subspheric colonies, a cosmopolitic *Comeseris minima* Beauv., *Kobyastraea bourgeati* (Ét.) and *Latiastraea variabilis* (Ét.). In the final stage, the most numerous are in this locality the phaceloid amphiastreids of the species *Pleurophyllia trichotoma* de From. and *Mitrodendron ogilviae* Geyer. The remaining nine species, here found, occur as a secondary component in the middle and upper part of the assemblage.

Within this assemblage, the accompanying fauna is very scarce and little — differentiated specifically. It is limited to single, small ostreids, calcareous sponges, few bryozoans (*e.g. Stomatopora* sp., *Berenicea* sp.) scattered in the sediment and encrusting the lower surfaces of coral colonies. Very few are also pelecypods boring massive colonies. Within the assemblages, the solenopores are scattered, small and

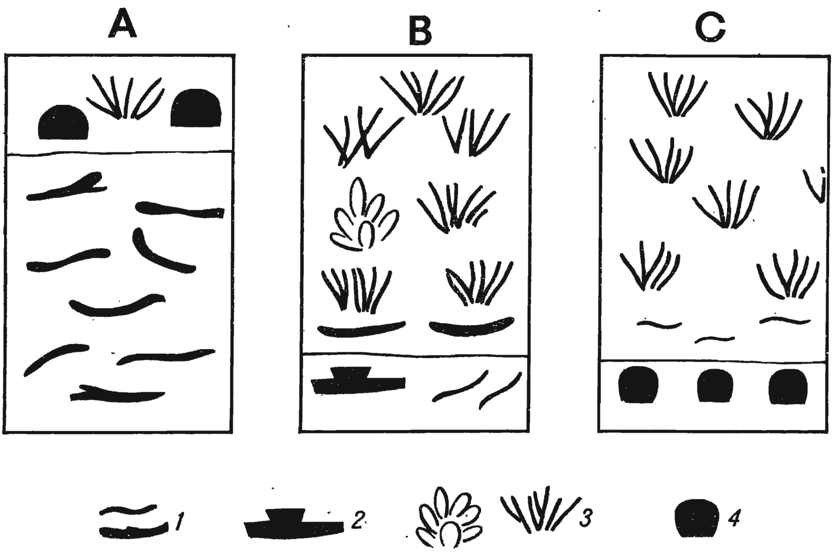



Fig. 8

Succession of the coral assemblages at Bałtów (*A*), Bukowa (*B*), Brzegi and Żerniki (*C*)

*1* foliaceous colonies, *2* submassive colonies, *3* branching colonies, *4* spherical colonies

sometimes encrusting smaller branching corals. In fact, these red algae are not much more numerous outside the assemblages.

The assemblage of branching corals from Brzegi and Żerniki is the most extensive of all known from the Holy Cross Mts. It consists (cf. E. Roniewicz 1966, Roniewicz & Roniewicz 1968) of colonies which overgrow each other and represent (cf. Pl. 6, Fig. 1) only one species, *Calamophyllopsis stockesi* (M. Edw. & H.). The assemblage forms a 1—1.5 m thick biostrome observed over a few square kilometers. Noteworthy are here rare foliaceous colonies of ?*Thamnasteria* sp., directly underlying the branching colonies assemblage (Fig. 8*B*, *C*), which resembles the sequence observed at Bukowa.

The assemblages of branching corals above described display a considerable similarity to Recent assemblages from reef zones situated outside the surf, and of depths 0 to 3 and at most 10 m, both of the Atlantic (Newell & al. 1959) and Pacific (Umbgrove 1929, 1947; Ladd & al. 1950; Chevalier 1968; Chevalier & al. 1969). Specifically variable, ramose, plocoid, meandroid and thamnasteroid colonies, accompanied by few foliaceous and massive colonies and calcareous algae are a complete equivalent of coral assemblages of these zones. However, the discussed Jurassic assemblages contain an element, frequently predominant or only making up their component, which is of a minor importance to the structure of the Recent reefs, that is, phaceloid colonies. Their Recent, more exuberant development is rather a non-typical phenomenon (*e.g.* patches of *Caulastraea*, cf. Yabe & Sugiyama 1935).

A general presence of phaceloid corals and their predominance among the branching corals in the Upper Jurassic (cf. Speyer 1912; Arkell 1928; Geyer 1954; Beauvais 1958, 1959) confirm the differences between shallow-water, Upper Jurassic environments settled by corals and the Recent reef areas, displaying a different type of sedimentation. It seems that phaceloid corals were particularly well adopted to the environment with turbid water, containing much calcareous mud which was formed by an abundant precipitation of calcium carbonate. Under such conditions pelitic and chalky deposits were formed here and the corals settled. The disappearance of phaceloid corals, as a predominating element of the shallow-water coral fauna, is probably connected with a wanishing of this facies.

### *Coral assemblages composed of massive, subspherical colonies*

The assemblages of this type are primarily composed of variously sized subspherical colonies, which may be accompanied by colonies of other types. They are found in grained limestones which are 20 to 100 cm thick and occur as intercalations between limestones of other types. The only exception are onkolitic limestones with corals occurring in the environs of Bałtów and reaching 2 to 3 m in thickness. They include assemblages which occur in oolitic limestones from Żerniki and Brzegi, in onkolitic limestones with corals from Bałtów and its environs and, finally, in conglomeratic limestones on the Kościółek hill near Leśnica.

The coral assemblage from onkolitic limestones occurring at Bałtów and its environs is highly differentiated specifically. It contains more than 30 species, including mostly stylinids and montlivaultids, a few species with porous skeletons (microsolenids) and fairly frequent individuals of the genus *Rhipidogyra*. This is the Bałtów assemblage 2, a specific composition of which was given by E. Roniewicz (1966). Large submassive and massive colonies such as, *Isastraea* sp., *Puschastraea kamiennae* Ron., some stylinids and branching colonies of *Goniocora* sp., *Mitrodendron ogilviae* Geyer, *Latomeandra* sp., *Thecosmilia* sp., undoubtedly occur in their life position. Subspherical colonies up to a few centimeters in diameter are enveloped by thin onkolitic coatings, much the same as fragmentary coral branches and skeletons of other organisms as spherical colonies of hydrozoans, conical colonies of solenopores occurring in accidental positions, spines of echinoids and nerineid shells. The presence of onkolitic coatings and the accidental position of small colonies of solenopores supply ample evidence of the sediment movement on the bottom.

In the conglomeratic limestones from the Kościółek hill, colonies of corals, hydrozoans and solenopores are mostly sub- and hemispherical, complete or fragmentary, larger ones being abundantly bored by the boring pelecypods. An intensive water movement is indicated by rounding of very numerous, small specimens about 2 to 3 cm in diameter. These are colonies of corals, mostly *Heliocoenia variabilis* Ét., as well as hydrozoans, small solenopores and fragmentary branching corals. Large-sized colonies, but not exceeding 20 to 30 cm in diameter, belong to species with massive skeletons such as, *Complexastraea* sp., *Thamnoseris* sp., *Microphyllia* sp. or with porous skeletons the most frequent of them being *Comoseris minima* Beauv. and *Actinaraeopsis exilis* Ron. In addition to the hydrozoans, the accompanying fauna includes dicerases and nerineids, along with less numerous ostreids.

The coral assemblage from the microonkolitic limestone at Brzegi and Żerniki differs from those above described in its specific monotony and in its being composed of the colonies of one generation only and thus it makes up a fossil coral community. It consists of hemispherical colonies of *Heliocoenia variabilis* Ét. found in their life position. They are distributed at a distance of 5 to 30 cm from each other which represents as if a coral carpet, lining extensive areas of the bottom, and observable in outcrops along a few kilometers. Remarkable is the poverty of the accompanying fauna which in fact is limited to the pelecypods boring the coral colonies. As calicinal surfaces of colonies are abraded, the environment seems to be characterized by a mobile water which, transporting the sediment, abraded the colonies.

The assemblages of massive corals from the Holy Cross Jurassic are on the whole characterized by a considerable specific differentiation, in which a considerable part of stylinids is worth emphasizing. Corals of this suborder, strongly differentiated specifically, make up a main element of these assemblages. In regard to the conditions under which they developed, it may be stated that the characters of deposits, in which these assemblage occur, indicate an environment distinguished by strongly mobile water. In the case of Żerniki and Brzegi, the environment seems to be of the sandy bottom type, similar to a sandy bottom covered with *Diploria* mats which occur in extra-lagoonal, unprotected environs of Bimini in the Bahamas (cf. Squires 1958). In these areas of the bottom, the sandy sediment is transported by a strong water movement. The onkolitic limestones with corals from the environs of Bałtów are indicative of a very shallow-water environment with a high biological productivity and considerable water mobility. As shown by the character of the limestone, in which the assemblage from the Kościółek hill occurs, this assemblage developed in an environment which was the most mobile of all the environments examined and was marked by hydrodynamic characters typical of the sublittoral conditions.

## FINAL REMARKS

The poly-specific character of the discussed Upper Jurassic coral assemblages as well as the fauna accompanying the corals, in particular ostreids (Pugaczewska 1971), cranias and thecideans (Barczyk 1968, 1970), and the presence of onkolites (Kutek & Radwański 1965), are indicative of shallow water environments of some dozen or so meters. Certain variable sequences of three discussed types of assemblages (Fig. 8) sometimes depict radical changes in the environment which were caused by changes of water mobility rather than those of the depth.

In the deposits accompanying the coral assemblages, there is a lack of distinct characters which might indicate the activity of permanent currents, *e.g.* cross bedding, current ripples or erosional surfaces. It is only within the assemblages themselves that an orientation of calicinal surfaces may be observed which in Recent deposits is caused by the activity of currents. In such cases, corals orient these surfaces perpendicularly to the current direction. Several components of the deposit, such as organodetrital material and onkolites, indicate that the environment in which corals developed was mostly mobile. From the proportions of these components in the deposit and from the character of coral colonies, one may conclude on the intensity of water movement. The assemblages of massive colonies accompanied by large onkolites at Bałtów, or a similar assemblage, in which limestone pebbles occur, from the Kościółek hill, represent conditions of the highest degree of turbulence. The assemblages of branching corals were accompanied by a more moderate water movement. It is not unlikely that precisely a coral thicket of this type exerted a slowing-down influence on water movement and, consequently, caused a predominance of the pelitic and fine-grained sedimentation in their neighbourhood. The formation of foliaceous colonies was accompanied by relatively calm conditions.

The water movement was caused by superficial waving, by the swelling of water on the shallows by the wind and — it is quite likely — by the activity of tides. Except for the tides, the set of these factors is by its nature fairly chaotic in its activity in inner zones of shallows, that is, in the areas in which coral assemblages occurred. This may well be one of the reasons why no distinct directional structures occur within the deposits.

In the Upper Jurassic carbonate sedimentation accompanying corals, a considerable role was undoubtedly played by blue green algae, which is indicated by a large amount of various algal lumps (organic aggregates *sensu* Purdy 1963), which, according to recent data (Monty 1967) are of blue-green algal origin, much the same as onkolites, in formation of which blue green algae play an essential role. Under calmer conditions, blue green algae formed on the bottom a film, which cemented the calcareous fine granular components, thus preventing their replacement. This is a probable reason of the lack of cross bedding and ripples. This film also prevented the oolitization process, since potential nuclei of ooids became coated by the algal film which precluded their suspension necessary for oolitization. An environment, marked generally by a fairly rapid and, to a considerable extent, muddy sedimentation, was favourable to corals and algae. The Bukowa profile (Fig. 5) indicates that the disappearance of coral assemblages associated with chalky limestones is connected with the cross bedded oolites. The conditions, marked by a variable rate and interrupted by periods of gaps and erosion, as well as by migrating oolitic banks, was unfavourable to the development of coral assemblages. These deposits are equally shallow-water in character as those containing corals and, therefore, the conditions of origin of both types of deposits did not depend on the depth, but on the hydrodynamics and type of sedimentation.

The corals which formed assemblages started their development on a flat bottom composed of muddy or sandy, non-consolidated deposits. That was a typical and probably quaggy sediment bottom. The development of colonies took place at a spot where the bottom was, for local reasons, more stable. The character of the bottom caused that an assemblage grew upwards, gradually extending laterally. Thus, the succeeding generations growing on top of their predecesors found the hard bottom formed of their coralla. During the development of an assemblage, the surface of the bottom was differentiated into zones which differed from each other in microenvironment, which was caused by different types of water movement and appearance of the communities accompanying corals. However, neither barriers, nor distinct domes are formed by corals on the bottom, since their growth was constantly accompanied by sedimentation which filled up the spaces between colonies and their assemblages. The occurrence of rapidly growing coral species and the upward growth of the assemblages are evidence of the existence of a fairly rapid sedimentation. Both these characters protected assemblages against burying in the sediment. There existed an unstable equilibrium and only one generation projected over the bottom, the previous ones being already covered with sediments. A slight increase in the rate of sedimentation completed the existence of any assemblage by burying it in the sediment. The mechanism described explains why, despite a high degree of turbulence, no crushed remains of corals occur in the deposits. Simply, they were not sufficiently projecting above the bottom to be effectively destroyed by hydrodynamic factors.

The Upper Jurassic deposits are typically epicontinental and their members containing coral assemblages represent the stages of sedimentation in which sediments filled up the basin almost to the water level. The lack of tectonic or eustatic movements made precluded the growth of corals to any considerable thickness, since they were permanently limited by the water level and progressing sedimentation which represented a threat of burying them. This peculiar epicontinental character of the Jurassic coral deposits was emphasized by Rutten & Jansonius (1956) for the area of the Paris Basin and their opinion was confirmed, in the case of the Holy Cross Mts, by E. Roniewicz (1966) and Kutek

(1969). Obviously, no Jurassic equivalents can be found in the present zone of the Pacific, since the reefs, formed in that area as a result of the Quaternary, eustatic movements and the tectonic mobility of the substrate, have appropriate conditions for reaching a considerable thickness. Besides, the existence of slopes is favourable to the destruction of coral structures and the formation of great masses of the detrital material of the reef origin in the form of talus, which, for the lack of adequate conditions, is absent in the Jurassic deposits. Some similarities to that region may of course be found in small details. Thus, for instance, small concentrations on the sea bottom, formed by coral assemblages in the region of the northern Japanese Islands (Yabe & Sugiyama 1935), are composed of foliaceous and faceloid colonies which do not yield detrital material as opposed to the areas situated more to the south in which typical reefs occur.

A similarity also occurs, in particular in the manner of the development of the Jurassic assemblages, to successive development stages of the deep-water banks distinguished by Squires (1964) from the Neogene of New Zealand. These assemblages are geometrically similar to the *thicket, coppice* and, locally, even *bank* stages. Obviously, here is the end of these similarities, since these deposits are deep-water ones and developed in cold waters. Most similarities may be found to the coral assemblages from the Bahamas. The Upper Jurassic assemblages from Poland are similar to patches of corals which develop on the shallows outside the margin of the Bahama Bank and which are known as patch reefs. This similarity is evident as the entire sedimentary environment of the Holy Cross Oxfordian and Kimmeridgian is to a great extent comparable to this of the Bahama Bank (cf. Kutek 1969). On the whole, the character of the Upper Jurasic assemblages is, however, fairly peculiar and uniform in the European areas of epicontinental carbonate sedimentation. Several of the described characters of both coral assemblages and accompanying deposits, concern not only the area of Poland, but also other classical European territories in which the Upper Jurassic deposits occur (France, Germany, Great Britain). This indicates that the conditions which were predominant in this part of the Upper Jurassic sea differed in many respects from those of the seas of other epochs, as well as from those observed in the majority of the Recent basins.

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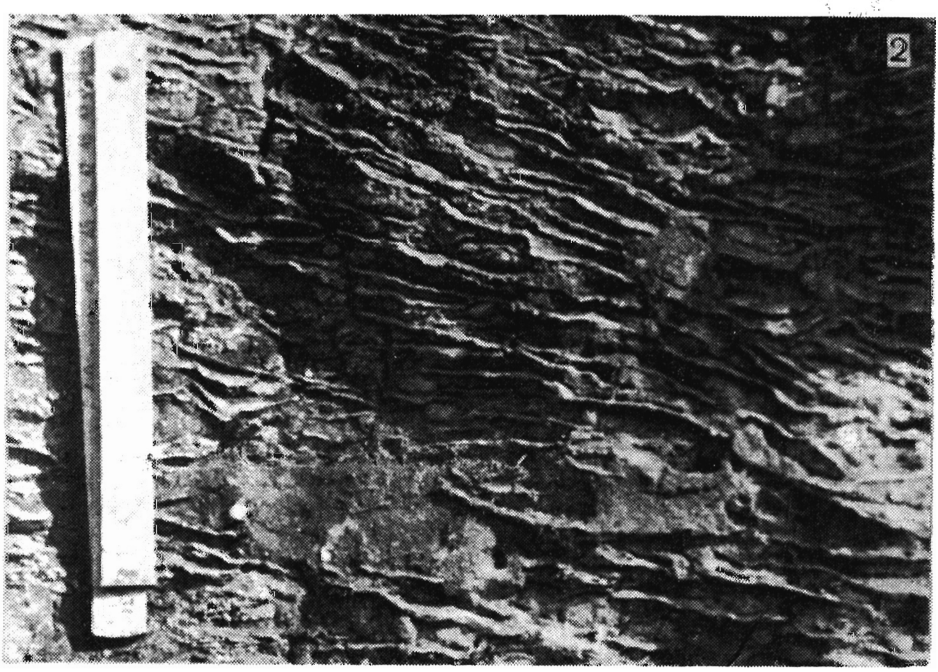
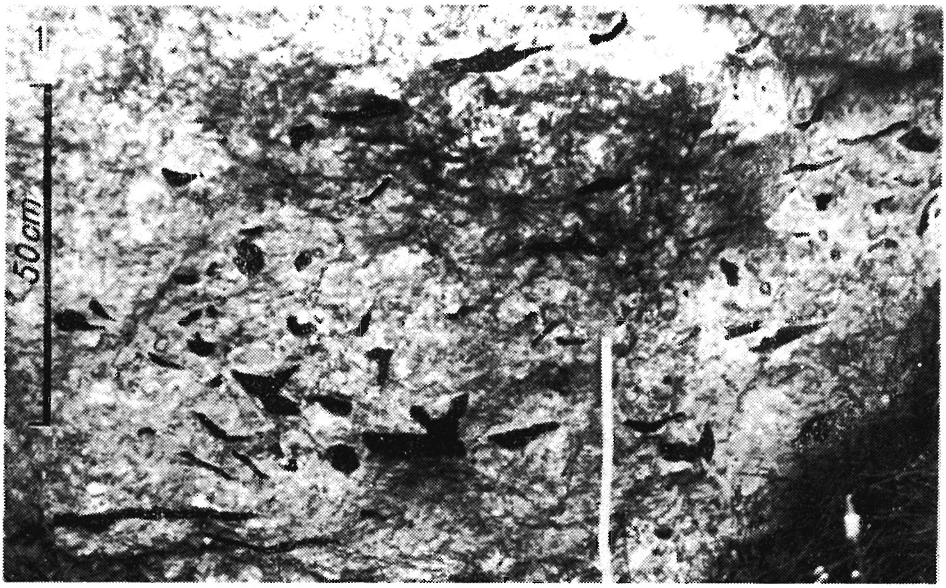


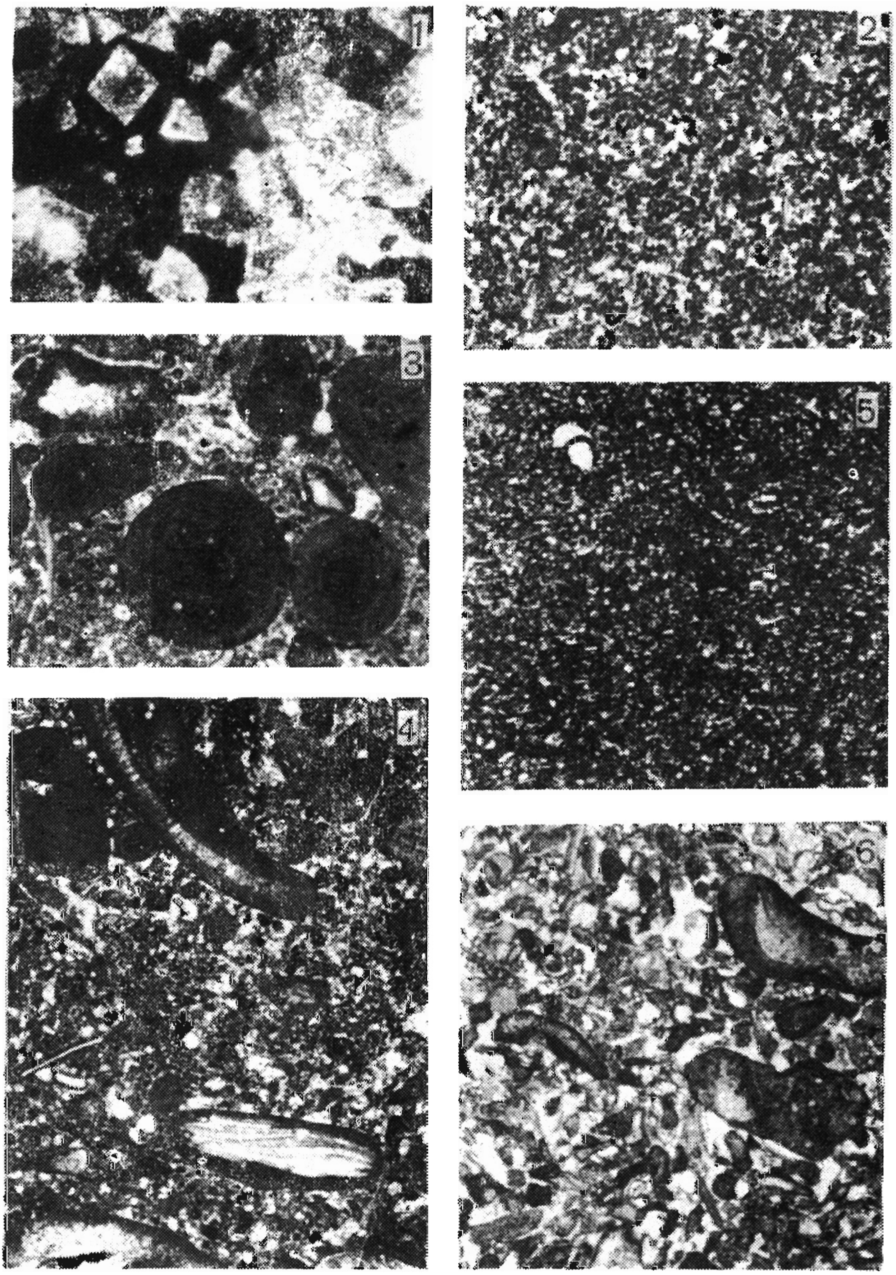
1 — Group of foliaceous colonies of *Microsolena agariciformis* Ét.; besides, a branching colony of *Dactylaraea* sp. (at centre) and thick-shelled gastropods and pelecypods (right at the top) are visible; interspaces filled with fine-grained limestone; locality Stoki.
2 — Group of foliaceous colonies of *Microsolena* sp. in the chalky limestone at Julianka.





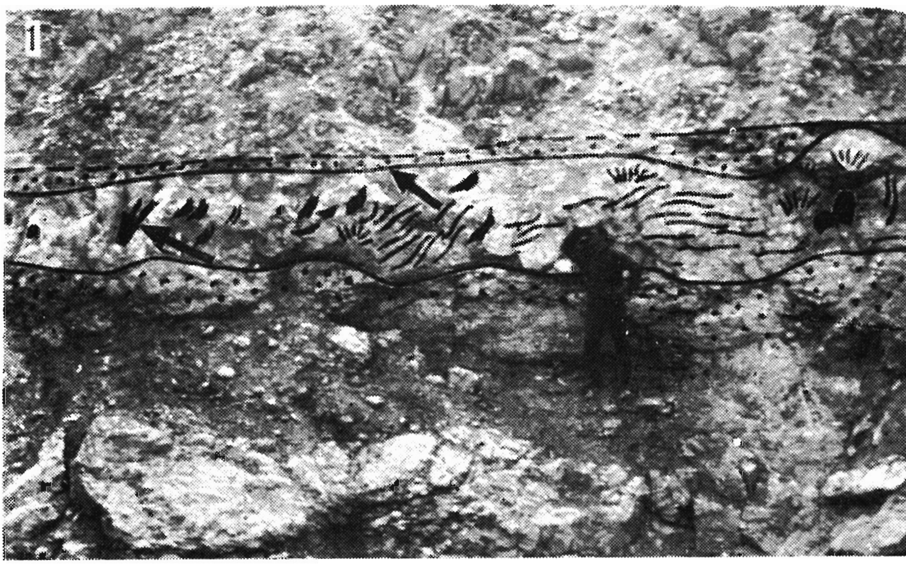
1 — Arrangement of colonies in a loose group of submassive colonies at Bałtów (bottom part of the profile B in Text-fig. 2).

2 — Foliaceous colonies in the organodetrital limestone at Stoki.



Limestones associated with coral assemblages

1 — Partly dolomitized limestone composed mostly of the micritic grains; Bałtów, × 40.
2 — Pelletal limestone with sparry cement; Bałtów, × 10.
3 — Pelletal limestone with micritic-sparry cement and microonkolites; Bałtów, × 20.
4 — Organodetrital limestone (organic debris partly micritized) with microonkolites and sparry cement; Bałtów, × 10.
5 — Grained limestone composed of micritic grains and organic debris; Bałtów (stratified pelitic-limestone unit), × 20.
6 — Organodetrital limestone composed of the echinoderm debris; Stoki, × 10.



1 — Coral assemblage with foliaceous and submassive colonies; lower coral horizon at Bukowa (symbols the same as in Text-fig. 5).

2 — Magnified fragment of the preceding figure, presenting a submassive colony of *Microsolena agariciformis* Ét. (the arrows show the growth direction of the colony).



1 — Ramose colony of *Meandrophyllia amedei* (Ét.); upper coral horizon at Bukowa.

2 — Foliaceous colonies of *Thamnasteria concinna* (Goldf.) and *Isastraea helianthoides* (Goldf.) in the lowermost part of the upper coral horizon at Bukowa; the colonies rest perpendicularly to the bottom, and with their calicinal surface faced to the left.

1 — Colonies of *Calamophylliopsis stockesi* (M.-Edw. & H.) composing the coral assemblage at Brzegi.
2 — Burrows of decapods in the Bałtów section (cf. Text-fig. 2).

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## ZESPOŁY KORALOWE W MALMIE GÓR ŚWIĘTOKRZYSKICH I JURY POLSKIEJ

### (Streszczenie)

Zespoły koralowe występujące w osadach węglanowych oksfordu pn.-wschodniej części obrzeżenia mezozoicznego Gór Świętokrzyskich oraz dolnego kimerydu pd.-zachodniej części tego obrzeżenia i Jury Polskiej (por. fig. 1) powstały przez narastanie kolejnych generacji kolonii w tempie równym tworzeniu się osadów towarzyszących. Wszystkie rozważane zespoły (por. fig. 2—6 oraz pl. 1—6) są wyraźnie płytkowodne, na co wskazuje m.in. zestaw gatunków (por. także E. Roniewicz 1966), istnienie kolonii zawieszonych, wzrastających ku dołowi (fig. 7), co współcześnie ma miejsce, gdy kolonia sięga do lustra wody (Chevalier 1968), obecność glonów wapiennych oraz skład fauny towarzyszącej, istnienie w sąsiedztwie zespołów śladów żerowania krabów (pl. 6, fig. 2), a także występowanie (*por.* Roniewicz & Roniewicz 1968) powierzchni korozji chemicznej o charakterze twardego dna powstałego w warunkach wybitnie płytkomorskich. Analiza sedymentologiczna osadów, w których występują zespoły koralowe, wskazuje, że panowało tu środowisko bardzo ruchliwej wody. Na ruchliwość taką wskazuje także orientacja powierzchni kielichowych, co w dzisiejszych morzach wywoływane jest (*vide* Chevalier 1968, 1969) wzrostem kolonii w warunkach silnych prądów.

Omawiane zespoły koralowe powstawały w momencie, gdy epikontynentalny zbiornik jurajski wypełniany był przez osady prawie do lustra wody. Brak ruchów podłoża i eustatycznych zmian poziomu morza uniemożliwiał powstanie typowych utworów rafowych (por. także Kutek 1969). Pod względem swego charakteru, rozpatrywane zespoły najbardziej są podobne do utworów koralowych górnej jury Basenu Paryskiego (*por.* Rutten & Jansonius 1956) i innych obszarów występowania epikontynentalnego malmu; posiadają one też podobieństwa do zespołów tworzących współcześnie kępy koralowe (ang. *patch reefs*) na Wielkiej Ławicy Bahamskiej.

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