ANNALES SOCIETATIS GEOLOGORUM POLONIAE
ROCZNIK POLSKIEGO TOWARZYSTWA GEOLOGICZNEGO

v. 54–1/2: 65–77 Kraków 1984

Ewa RONIEWICZ

# ARAGONITIC JURASSIC CORALS FROM ERRATIC BOULDERS ON THE SOUTH BALTIC COAST

(Pl. I–IV and 2 Figs.)

# *Eratykowe korale jurajskie z południowego obrzeżenia Bałtyku*

(Pl. I–IV i 2 fig.)

Ewa Roniewicz: Aragonitic Jurassic corals from erratic boulders on the South Baltic coast. Ann. Soc. Geol. Poloniae, 54-1/2:65–77.

Abstract. Oxfordian-Kimmeridgian coral species are known from glacial deposits of the northern parts of Poland, German Democratic Republic and Federal Republic of Germany. The original coral-bearing rock is a ferruginous sandstone and sandy limestone. The corals inhabited shoals on the Scandinavian shelf, in the south-western part of the present Baltic. Circumrotatory and multicentric growth forms resulted from a peculiar environment of unstable bottom conditions and high rate of clastic sedimentation in rather low energy water. The aragonite skeleton is preserved.

Key words: Corals, ecology, erratic boulders, Oxfordian–Kimmerigian, South Baltic coast.

Ewa Roniewicz: Zakład Paleobiologii PAN, Al. Żwirki i Wigury 93, 02-089 Warszawa.

manuscript received: October, 1982 accepted: November, 1982

Treść: Praca zawiera charakterystykę zespołu oksfordzko-kimerydzkich korali znajdowanych w głazach narzutowych na północy Polski, Niemieckiej Republiki Demokratycznej i Republiki Federalnej Niemiec. Korale są znajdowane z fragmentami oryginalnego osadu – syderytów piaszczystych, piaskowców syderytycznych i wapieni żelazisto-piaszczystych. Zasiedlały one płycizny szelfu skandynawskiego, w rejonie znajdującym się w południowo-zachodniej części dzisiejszego Bałtyku. Częste są wśród nich kolonie subsferyczne, które żyły nieprzytwierdzone do podłoża, swobodnie przetaczane po dnie. Przez analogię do tak żyjących korali w morzach dzisiejszych i do pewnych korali kopalnych, zostały one uznane za wskaźnik środowiska niestabilnego dna i strefy o niewysokiej energii wody. Szkielet korali jest zachowany w postaci aragonitu.

## INTRODUCTION

The geological literature, mainly that of the beginning of the century gives much information on the Jurassic erratic boulders occurring along the southern

Baltic coast, in a belt up to 300 km wide and more than 800 km long (Jentzsch, 1888; Oppenheim, 1902; Felix, 1905; Deecke, 1904, 1907; Kegel, 1918; Brinkmann, 1924; Frebold, 1926; Richter, 1931*a*; Dietrich, 1936; Kopczyńska-Żandarska, 1970). Among them, especially in the vicinity of the mouth of the Odra, corals isolated from matrix caught the attention of several workers (Oppenheim, 1902; Felix, 1905; Deecke, 1904; Kegel, 1918).

Deecke (1904: 22) and then Kegel (1918: 221, fig. 2) gave detailed localities for the material. The following species of Mesozoic corals have so far been listed from erratics: numerous records of *Thamnasteria concinna*, and single findings of *Th. microconos*, *Montlivaltia* sp., *Epismilia* sp. and *Trochosmilia* sp. In my collection, the following species are represented: *Thamnasteria concinna* (Goldfuss, 1826), *Dimorphastraea* sp., *Actinaraeopsis exilis* Roniewicz, 1968, *Isastraea* cf. *bernensis* Etallon, 1861, *Thecosmilia* sp., and *Stephanastraea* sp.

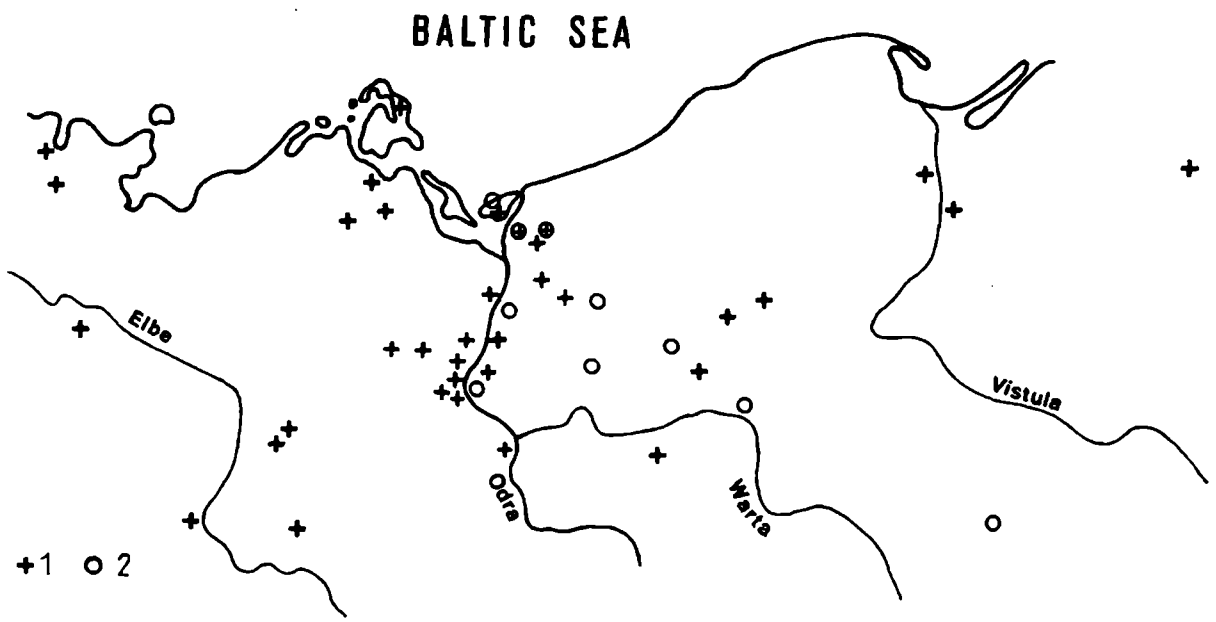



Fig. 1. Localities of erratic *Thamnasteria concinna* Goldfuss colonies: *1* – earlier data (after Kegel, 1918), *2* – new localities

Fig. 1. Rozmieszczenie eratykowych kolonii *Thamnasteria concinna* Goldfuss: *1* – wcześniejsze znaleziska (wg Kegela, 1918), *2* – nowe miejsca znalezienia

In Poland, the richest source of erratic corals occurs in the vicinity of Wolin Island, at Ostromice (= Wustermitz or Wusterwitz: Deecke 1904 and other authors). This is the only outcrop which I have methodically explored. The remaining sites, which did not promise an abundant collection, were sampled at random (Fig. 1). At Ostromice I found colonies of *Th. concinna*, *A. exilis* and *I.* cf. *bernensis*; at Resko – *Th. concinna* and *Dimorphastraea* sp. Only *Th. concinna* was found at the remaining sites. The skeletons of all colonies (excepting *Thecosmilia* sp. and *Stephanastraea* sp., see below) in this collection are preserved as aragonite. All colonies originate from the same ferruginous host rock. A colony identical in appearance and preservation to the Pomeranian colonies was found some distance from this region, southward, in central Poland (at Zgierz). With the growing distan-

ce from the coast, the fragments of colonies decrease in size, as their abrasion increases.

The specimens of *Thecosmilia* sp. and *Stephanastraea* sp. listed above were found in the vicinity of Piła (Fig. 1). They are entirely calcified. They will not be discussed here as they originate from a different lithological horizon to that of the remaining Pomeranian specimens, i.e. from a white limestone.

Observations presented here are based on Pomeranian collections gathered in the years 1977 – 1982. The collection numbers over 1000 colonies. Several specimens from Resko and Oborniki were given to me by the late Professor Maria Różkowska, and one specimen from central Poland (Zgierz) by Dr. Jerzy Dzik. The collection is housed at the Institute of Paleobiology, Polish Academy of Sciences, Warsaw (ZPAL).

The $SrCO_3$ content was determined using the Philips 1450 AHP Spectrometer.

Acknowledgements. – Thanks are due to Miss Marta Dobrucka for determining the Sr content and to Dr. Bożena Łącka for petrographic identifications. I am particularly indebted to Dr. C.T. Scrutton for the linguistic revision of the English text. Thanks are also due to Prof. Elżbieta Morycowa for her valuable remarks and kindly review of the typescript.

## LITHOLOGY

Primary rock fills depressions in the colony surface and borings penetrating the colonies. Invariably, it is a strongly ferruginous and sandy rock, which, however, depending on changing proportions between clastic components and matrix can be characterized as sandstone or a sandy carbonate rock. The main clastic components are organic debris and angular quartz grains in variable mutual proportions, un-altered feldspars, epidote, fragments of granitoid rocks, sandstones, lydites and in some specimens – chamosite ooids, in others – oval phosphatic bodies, which are probably fecal pellets. The matrix is composed of iron oxides and hydroxides, or of calcium carbonate with iron oxides, or of siderite. Organic detrital elements consist of fragments of brachiopods, bivalves, echinoderms, coral detritus, and also of undamaged benthic foraminifera and the spherical calcareous reproductive parts of the green alga *Acicularia*. Erratics of this same rock type are known. Some of them are conglomeratic in character, consisting of sandstone intraclasts, fragments of the skeleton of *Th. concinna* and sandy-ferruginous matrix. For the lithology of the erratics see also Kegel (1918).

## CORAL CHARACTERISTICS

Coral-bearing gravels are accessible in the old gravel-pit at Ostromice, in the profile several meters thick of the Vistulian stage glacial sediments. I found numerous colonies in a bedded complex of sand and gravels and sporadic specimens in till which overlies the complex. The gravels contain boulders of igneous

and sedimentary rocks of varied size and geological age. The diameters of the colonies range from 1 to 20 cm.

Damage to natural surfaces during glacial deposition hasn't changed completely the original state of preservation of the coralla. The degree of abrasion varies. In many colonies large areas of untouched colony surface with its delicate structures (calices, epitheca) are preserved. It proves that, generally, during primary bed deposition, the colonies were not reworked. However, some colonies have surface primarily obliterated, for example those serving for the settlement for epifauna: when the overgrowing organism is removed the smooth abraded surface appears.

The collection, which cannot be regarded as respresentative of the original fauna, show, however, some very informative features for the restoration of the living community and its environment:

1. Domination of massive and submassive colonies of rounded shapes. Lamellate colonies represent mainly the earliest growth stages of *Th. concinna.* Branched colonies are entirely lacking. The proportions between the two groups: 1. massive-submassive and 2. lamellate-branched colony forms are thus inverted as compared to other Upper Jurassic coralline formations in Europe. There, branches and lamellate (foliaceous) growth forms prevail (Roniewicz and Roniewicz 1971).

The roundish shape of the colonies must have been favoured by the environment: its dominance is not only the effect of selection during transportation by fluvioglacial waters. All the submassive colonies of *Th. concinna* are of this shape. Subspherical colonies of circumrotatory growth form (free-living colonies devoid of any attachment to a substratum, see Kissling, 1973) with the entire surface covered with calices, account for a considerable percentage of the collection of *A. exilis.*

Lamellate (foliaceous) colony – upper and lower colony surfaces subparallel, colony thin in comparison with the diameter.

Submassive colony – upper and lower colony surfaces subparallel, thickness and diameter subequal. Colony shape originating from lamellate forms.

Massive colony – upper colony surface convex, lower surface horizontal: circumrotatory colonies are a particular case.

2. The common multicolumnar growth form. The adult colonies consist of subcolonial units, here named columns (Pls. 3 and 4). The shape of an individual column is subcylindrical. Columns are subparallel in submassive colonies or subradial in subspherical colonies of circumrotatory growth. Each of them is a cluster of corallites arranged in a fountain-like manner (Fig. 2): in the centre, the corallites are vertical, marginally they diverge toward sides of the column. The top of a column shows on the colony surface as a hemispherical mamilla. Mamillae are bound together by an intermediary zone of corallites arranged subvertically in non-columnar manner, which is marked on the surface as a depression, or they are sharply separated from each other by a groove (Pl. 3: 1, 2). An intense extratentacular gemmation takes place

on the tops of the columns. The young individuals displace the older ones towards the sides. Those from neighbouring columns, in the case of very close packing, meet in the groove. They merge and temporarily form multiseptal, mono- and bi-centric individuals. Subsequently, they become overgrown by new individuals (Fig. 2).

The mamillar colony surface in these corals resembles that of monticular colonies of Palaeozoic stenolaemate bryozoans (for the intepretation of bryozoan colony structure and development in terms of morphophysiological gradients see Anstey et al. 1976). But, unlike bryozoans, no monarchic individuals which would control subcolonial growth, are present in these corals. Their columnar growth follows the common pattern of colonial growth in branching plocoid or cerioid scleractinians and in tabulates.

Most specimens of *Th. concinna* are either fragments or entire multicolumnar submassive colonies with mammillar surfaces. All adult *A. exilis* colonies are multicolumnar and subspherical in shape; they are of massive growth form if attached, or circumrotatory if overturned.

3. Poor species spectrum. The primary feature of this fauna is a rather small specific differentiation; richer, however, than that observed in

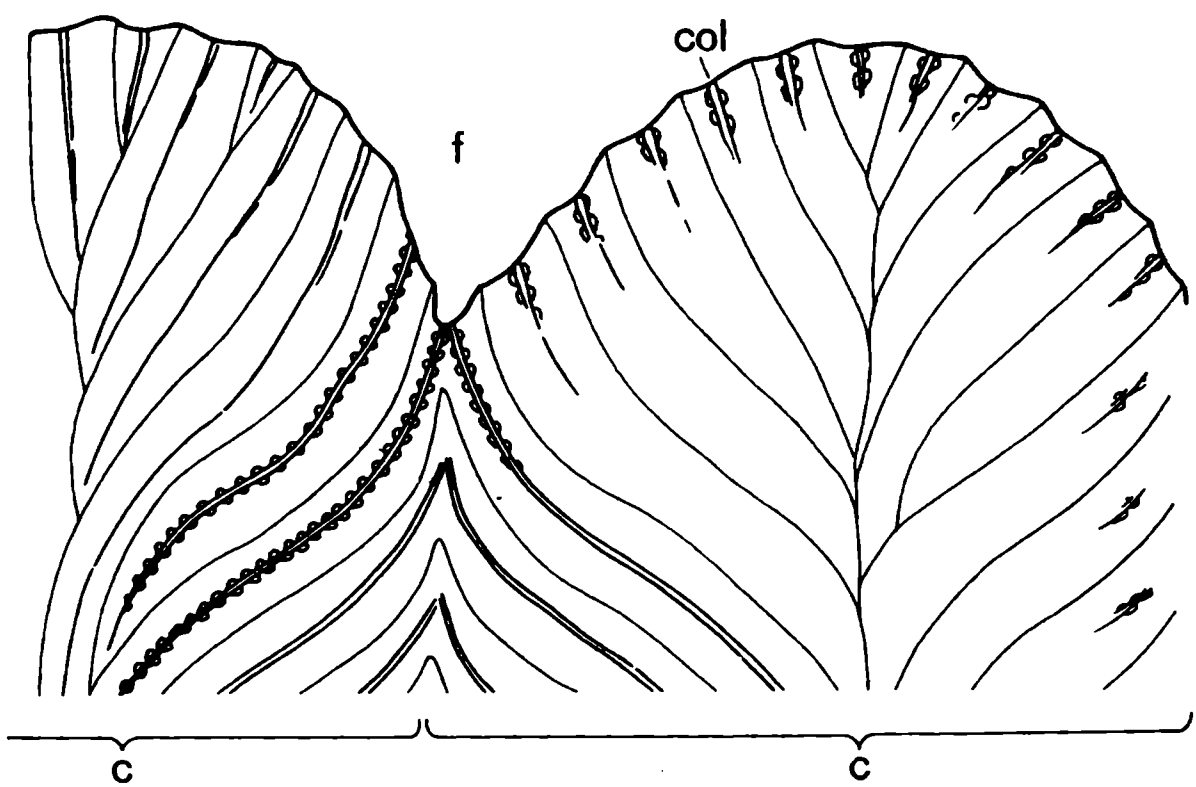



Fig. 2. Scheme of corallite arrangement in subcolonies of *Thamnasteria concinna* Goldfuss shown in longitudinal section: *c* – columns (subcolonies), *f* – furrow developed on the contact line between the columns, *col* – columella; an imaginary line delimits the corallites in a thamnasterioid colony (after Roniewicz, 1982)

Fig. 2. Schemat rozmieszczenia koralitów w kolumnach wzrostowych (subkoloniach) w kolonii *Thamnasteria concinna* Goldfuss, przekrój podłużny: *c* – kolumny (subkolonie), *f* – rowek na linii zetknięcia kolumn, *col* – słupek; nieistniejące w rzeczywistości granice między koralitami kolonii tamnasterioidalnej zostały na rysunku zaznaczone linią (wg Roniewicza, 1982)

the erratics (four species in the whole region studied). Taking into account the domination of massive or submassive colonies, one should expect to find stylinids, so common in the Jurassic. However, so far no representative of this suborder has been found in the erratics.

4. Domination of *Thamnasteria concinna* and *Actinaraeopsis exilis*. In a collection numbering 1004 specimens from 11 sites, the species breakdown is as follows: 3 fragments of *I.* cf. *bernensis*, 1 fragment of *Dimorphastraea* sp., 83 *A. exilis* colonies, the rest being complete and fragmentary *Th. concinna* colonies. The method of collection, systematic at just one site, does not affect these proportions. It is a fact that one species, *Th. concinna*, definitely dominates the whole region (see also Brinkmann 1924). The second in abundance is *A. exilis*. Mechanical factors like the disintegration of *Th. concinna* colonies into elements (columns) must have greatly influenced its frequency in the secondary beds. But the domination of this species in the living environment is affirmed by the domination of fine detritus of *concinna* skeletons in matrix.

5. Coral colonies as a substratum for boring and encrusting organisms. Coral colonies are heavily bored by diverse organisms. The infauna is rich: boring bivalves such as *Lithophaga*, *Gastrochaena* (*Gastrochaena*), *G.* (*Spengleria*), *Gastrochaenopsis* (determinations by A. Pisera), straight polychaete borings (*Trypanites*), and frequent (?) sponge borings. The borings are either grouped on one side of the colony or cover it uniformly.

Oysters, solenoporids, and serpulids settled on the calicular surface of coralla. Also corals overgrew each other. Most frequently, colonies of *Th. concinna* served as a substratum. The following examples of coral/coral overgrowth were observed: fifteen T/T, seven A/T, five T/A, one A/A, one A/I and one I/T (T – *Th. concinna*, A – *A. exilis*, I – *I.* cf. *bernensis*).

6. Preservation of the aragonite skeleton. The coral skeletons are preserved in the form of aragonite. Long, well differentiated "fibers", that seem to represent the tufts of Jell (1974), or, in *I. cf. bernensis* even larger units analogous to the clusters of Sorauf (1972), are the elementary units of the skeletal structure in the colonies examined (Felix, 1905: text-fig. on page 8; Roniewicz, 1982).

The $SrCO_3$ content in skeletons ranges from 1.12% to 1.31%, depending on the specimen. Strontium content (in ppm) amounts to: 6.700 – one sample, 7.300 – two samples, 7.400 – two samples, 7.500 – two samples. The higher of the values are within the range characteristic of Recent colonies (samples from the Cuban coast examined for comparison show a Sr content of from 7.300 to 8.300 ppm).

## ECOLOGICAL OBSERVATIONS

Corals were autochtonous in the original deposit; the following traits of the assemblage suggest this: (1) lack of whatever selection: the size and form of colonies is variable; (2) well preserved, unabraded surfaces of colonies (despite

the transport to the secondary deposit); (3) the colony growth form is adequate to the original rock type: lamellar and circumrotatory colonies are located in the fine-grained sediment.

The low degree of abrasion of the erratic colonies from Ostromice indicates short glacial and fluvioglacial transportation. Corals colonised shoals on this part of the Scandinavian shelf which, in its western part, extended into the area of the Recent south Baltic coast (see also Deecke, 1904 and Kegel, 1918). The influx of quartz detritus and iron compounds from weathering crystalline rocks was a strong ecological agent in the coral environment. Benthos developed abundantly, especially corals, appearing as a locally dominating faunal element. High productivity of the biocoenosis is suggested by the number of colonies scattered by fluvioglacial waters over a vast area. Only a few species, however, found conditions there suitable for life. The bottom sediment, unstable sand, sandy mud, or psammitic organo-detrital sediment, was a factor limiting the diversity of corals.

*Th. concinna* was an unquestionable pioneer among sessile organisms colonizing the environment (for the role of lamellate *Th. concinna* and *Microsolena* species in Oxfordian/Kimmeridgian environments see: Roniewicz and Roniewicz, 1971). Elsewhere, this common Upper Jurassic species is known as thinly or thickly lamellated colonies, this shape being considered as its specific feature. In this environment, *Th. concinna* apparently based its strategy for survival on high reproductive potential, the ability to settle on the unstable bottom, to form lamellate non-floundering colonies in early developmental stages and subsequently to transform them if necessary into submassive colonies of polycentric, multicolumnar growth. As can be estimated from the abundance of small, thin foliaceous colonies, the rate of mortality in the early stages was considerable and this was the critical stage in the life of colony. It might have been due to an inability to clean sediment from the flat colony surface. Dead thin foliaceous colonies of *Th. concinna* often served as a substratum for other colonies. The next stage of development shows a multicentered colonial growth causing the morphological differentiation of its surface. The capacity to remove sediment was undoubtedly increased by a suitable configuration of the colony surface in these next stages, and by the formation of zones of more active corallites. These zones are as follows: (1) column tips (mamillae) crowded with young individuals and (2) grooves separating them, filled with strongly elongated or partially fused, multitentaculate polyps. The grooves form a network which might facilitate an intensive water flow over the colony surface. I know of similarly shaped colonies of various species in other distinctly detrital sedimens, e.g.: *Th. concinna* in sandy marls in the Pomeranian Upper Kimmeridgian (Roniewicz 1977). *A. exilis* and *Etallonia minima* in organodetrital limestones in the Świętokrzyskie Mts. Poland. Colonies of such a growth form are not rare in the European Jurassic, e.g. *Th. concinna* from the Oxfordian of England (Talbot, 1972). *Th. mammosa* from the Middle Jurassic of England (M.-Edwards and Haime, 1854) and Switzerland (Koby, 1887), *Etallonia minima* (describes as *Con-*

*vexastraea minima*) from the Upper Jurassic of the Jura Mts. (Koby, 1881) and others.

*A. exilis* based its strategy for survival on another set of attributes adapted to an environment of intense detrital sedimentation and unstable bottom. As opposed to *Th. concinna*, these colonies are all multicolumnar in structure and display from the earliest stages a tendency to create massive forms and to avoid thin foliaceous forms. This species seems to be controlled in the larval stage by the substratum. The youngest colonies are nodular and convex. If overturned in unstable bottom conditions, they were subcjected to water movement resulting in their centrifugal circumrotatory growth and spherical shape. Judging from their frequency in the secondary beds, colonies of this growth form were abundant in the environment. In circumrotatory colonies the columns are oriented radially or chaotically. Other, stabilized colonies, show rather parallel growth direction. The circumrotatory growth of *A. exilis* colonies is thus a couterpart of colonial and simple coral growth courring in either fossil or Recent low energy environments with unstable bottom conditions (Gill, 1972; Kissling, 1973; Pichon, 1974; Glynn, 1974; Gill and Coates, 1977).

Dead coral colonies were frequently overturned as one can judge from the distribution of the infauna. Some have primarily obliterated surfaces, but well preserved surfaces prevail. The abundance of borings made by adult individuals proves that boring organisms were not disturbed in their development by strong, perpetual agitation and rolling of corals. This is in agreement with the presence of circumrotatory coral growth indicating a low energy environment. In the earlier literature, roundish shapes of coralla were interpreted by authors as primarily strongly reworked. For example Kegel (1918) considered *Th. concinna* colonies contained in beds thought to be conglomeratic in character, as the product of reworking of an older Lower Oxfordian coral bearing bed. However, the arguments referred to at the beginning of this chapter contradict the redepositional interpretation of the coral fauna in these Jurassic beds. One can assume that, in general, the environment was rather low energy but influenced by accidental rough water movements which caused overturning of coralla. In places, however, coral colonies might have been worn as pebbles as well.

## REMARKS ON DIAGENESIS

The preservation of unaltered aragonite skeletons is connected with unusual sedimentation and early diagenetic conditions. The inhibition of aragonite transformation into calcite is not an isolated phenomenon in the Mesozoic (Triassic corals: Zapfe, 1936; Cuif, 1972; Montanaro-Gallitelli et al., 1973; Montanaro-Gallitelli 1974; Scherer, 1977; Lower Cretaceous corals: Morycowa, 1971; Upper Cretaceous corals: Felix, 1903, as one can judge from illustrations of microstructures). The non-alteration of aragonite in this case can be connected with the abundance of $Fe^{2+}$ in the primary sediment, the ions inhibiting the process of aragonite-calcite transformation (Lipmann, 1973).

## AGE OF ERRATIC SCLERACTINIANS

All colonies examined are characterized by the same type of preservation, similar morphological differentiation and the same taxonomical monotony. The lithology of the primary rock in the samples examined is similar. Thus, it can be assumed, without the risk of significant error, that they all originated from the same local coral horizon. Most probably, as is usually in the Upper Jurassic, they occurred in local mass concentrations within layers several tens of centimeters thick. As to their stratigraphic situation, a few direct data are known. The coral species are of a wide Oxfordian-Kimmeridgian range. The mass occurrence of *Acicularia* in the matrix may indicate the equivalence of this horizon with that known as the "Lower Astartian" beds, with a mass of *Acicularia*, occurring in borehole cores from a vast area of the Eastern Polish Lowlands (Radlicz, 1965). Deecke (1907) considered the Pomeranian erratic corals as originating from the interval between the Upper Callovian and Upper Oxfordian. Kegel (1918) estimated their age, on lithological and general faunal data, as Cordatum Zone. Data supplied by Richter (1931b) may prove the same or a slightly younger age: in a borehole drilled in 1923 in Czarnogłowy (Zarnglaff) quarry, a conglimeratic bed was observed which in its stratigraphic position and faunal content could correspond to the hypothetical coral horizon. Sandstone pebbles and *Th. concinna* colonies extensively drilled by boring organisms were associated with fragments of other corals (*Dermosmilia* sp.), molluscs (*Delphinula, Opis, Astarte*, etc.) and otoliths. The horizon succeeded beds of Cordatum Zone age and was overlain by Alternans Zone beds. This situation changes the stratigraphical range of the coral species discussed here which were not previously known from beds older than the Gregoryceras transversarium Zone (Świętokrzyskie Mts, Poland).

*translated by Agnieszka Szymańska*

## REFERENCES – WYKAZ LITERATURY


Anstey R.L., Pachut J.F. and Prezbindowski D.R. (1976), Morhogenetic gradients in Paleozoic bryozoan colonies. *Paleobiology*, 2, 2: 131–146. Chicago.

Brinkmann R. (1924), Der Dogger und Oxford des Sudbalticums. *Jb. Preuss. geol. Landesanst.*, 44 (1923); 477–513. Berlin.

Cuif J.P. (1972), Note sur des Madréporaires triasiques a fibres araganitiques conservées. *C.R. Acad. Sci., D*, 274: 1272–1275. Paris.

Deecke W. (1904), Geologische Miscellen aus Pommern. 2. Die jurassische Korallen aus dem Diluvialsënde Hinterpommerns. *Mitt Naturwiss. Ver. Neuvorpommern u. Rügen in Greifswald*, 35: 19–27. Greifswald.

Deecke W. (1907), Geologie von Pommern 302 p. Berlin.

Dietrich W.O. (1936), Neue jurassische Geschiebekorallen aus Ostpommern. *Zt. Geschiebef. Flachlandes Geol.*, 12: 123–136. Berlin.

Felix J. (1903), Die Anthozoen der Gosauschichten in den Ostalpen. *Palaeontographica*, 49 (1902): 163–359 Stuttgart.

Felix J. (1905), Ueber einige norddeutche Geschiebe, ihre Natur, Heimat und Transportart. *Sitz.-Ber. Naturforsch. Ges. Leipzig*, Jhg. 30/31: 5–16. Leipzig.

Frebold M. (1926), Unterer Kimmeridge in ostpreussischen Geschieben. *N. Jb. Miner., Beil. Bd.* 54, B. Stuttgart.

Gill G. (1972), Croissance vers le bas et possibilité d'un deplacement autonome chez *Genabacia*, Madreporaire en petite colonie libre du Dogger. *C.R.Acad. Sc. Paris*, 274: 2459–2462. Paris.

Gill G. and Coates A.G. (1977), Mobility, growth patterns and substrate in some fossil and Recent corals. *Lethaia*, 10: 119–134. Oslo.

Glynn P.W. (1974), Rolling stones among the Scleractinia: mobile corallites in the Gulf of Panama. Proc 2nd Coral Reef Symp. 2: 183–198. Great Barrier Reef Committee. Brisbane.

Jentzsch A. (1888), Oxford in Ostpreussen. *Jb. Preuss. Geol. Landesanst.*, 9: 379–389, Berlin.

Jell J.S. (1974), The microstructure of some scleractinian corals. *Proc. 2nd Coral Reef Symp.*, 2: 301–320. Great Barrier Reef Committee. Brisbane.

Kegel W. (1918), Ueber Oxford-Geschiebe aus Pommern. *Jb. Preuss. Geol. Landesanst.*, 37 1916, 1: 197–224. Berlin.

Kissling D.L. (1973), Circumrotatory growth form in Recent and Silurian corals. *In*: R.S. Boardmann, A.H. Cheetam and W.A. Oliver (eds). Animal Colonies: 43–58. Standsburg, Pennsylvania, Hutchinson and Ross. Dowden.

Koby F. (1881, 1887), Monographie des polypiers jurassiques de la Suisse. *Mém. Soc. Paléont. Suisse*, 8: 61–108; 14: 353–400.

Kopczyńska-Żandarska K. (1970), Stratygrafia starszego i środkowego plejstocenu północno-zachodniego Pomorza na tle rozwoju paleogeomorfologicznego. *Studia Geol. Polonica*, 33: 7–112. Warszawa.

Lippmann F. (1973), Sedimentary Carbonate Minerals. Springer-Verlag, Berlin. Heildelberg. New York.

Milne-Edwards H. and Haime J. (1850–1854), A monograph of the British fossil corals. *Palaeont. Soc. London*: 72–145.

Montanaro-Gallitelli E. (1974), Biochemistry of Triassic Coelenterata. *In*: B.S. Sokolov (ed.), Ancient Cnidaria, 1. *Trans. Inst. Geol. Geoph. Acad Sci. USSR, Siberian branch*, 201: 61–62. Novosibirsk.

Montanaro-Gallitelli E., Morandi N. and Pirani R. (1973), Carollofauna triassica aragonitica ad alto contenuto in stronzio. Studio analitica e considerazioni. *Bull. Soc. Paleont. Italiana*, 12, 2: 130–144. Modena.

Morycowa E. (1971), Hexacorallia et Octocorallia du Crétacé inférieur de Rarău(Carpathes Orientales Roumanes). *Acta Paleont. Polonica*, 16, 1–2: 3–119. Warszawa.

Oppenheim P. (1902), Ueber ein reiches Vorkommen oberjurassischer Riffkorallen im norddeutschen Diluvium. *Zt. Deutsch. Geol. Ges.*, 54: 84–89. Berlin.

Pichon M. (1974), Free living scleractinian coral communities in the coral reefs of Madagascar. Proc. 2nd Intern. Coral Reef Symp., 2: 173–181. Great Barrier Reef Committee. Brisbane.

Radlicz K. (1965), O nowym znalezisku glonów z rodzaju *Acicularia. Kwart. Geol.*, 9, 3: 597–602. Warszawa.

Richter K. (1931a), Palaeogeographische Deutung von Malmgeschieben. *Zt. Geschiebeforsch.*, 7: 27–115. Berlin.

Richter K. (1931b), Geologische Führer durch die Zarnglaff-Schwanteschagener Malmbrüche. *Mitt. Geol. Polaeont. Inst., Univ. Greifswald*, 7: 3–24, Greifswald.

Roniewicz E. (1977), Upper Kimmeridgian Scleractinia of Pomerania (Poland). *Ann Soc. Geol. Pologne*, 47, 4: 613–622. Kraków.

Roniewicz E. (1982), Pennular and non-pennular Jurassic scleractinians – some examples. *Acta Palaeont. Polonica*, 27; 1–4: 157–193. Warszawa.

Roniewicz E. and Roniewicz P. (1971), Upper Jurassic coral assemblages of the Central Polish uplands. *Acta Geol. Polonica*, 21, 3: 399–423. Warszawa.

Scherer M. (1977), Preservation, alteration and multiple cementation of aragonitic skeletons from

the Cassian Beds Upper Triassic, S Alps: Petrographic and geochemical evidence. *N. Jb. Geol. Palaeont.*, 151: 213–262. Stuttgart.

Sorauf J. (1972), Skeletal microstructure and microarchitecture in Scleractinia (Coelenterata). *Palaeontology*, 15, 1: 88–107. London.

Talbot M.R. (1972), The preservation of scleractinian corals by calcite in the Corallian beds (Oxfordian) of southern England. *Geol. Rund*, 61: 731–741. Stuttgart.

Zapfe H. (1936), Die Erhaltungsmöglichkeit des Aragonit im Fossilizationsprozess, untersucht mit Hilfe des Reagens von Feigl und Leitmeter. *Sitz. Acad. Wiss. Wien, mat.-natur. Kl.*, 7 Mai 1936: 1–2. Wien.

## STRESZCZENIE

Zbadane tu korale, znane z wtórnego złoża, przedstawiają cenny materiał paleontologiczny przede wszystkim ze względu na to, że ich pierwotny szkielet aragonitowy nie uległ kalcytyzacji. Poza tym mają one szczególny zestaw cech, który świadczy o pewnej odrębności ich środowiska życiowego od innych późnojurajskich środowisk koralowych Europy.

Dotychczasowa literatura geologiczna, zwłaszcza z początku XX wieku, przyniosła wiele informacji na temat występowania jurajskich eratyków wzdłuż południowych wybrzeży Bałtyku (Oppenheim, 1902; Felix, 1905; Deecke, 1904; 1907; Kegel, 1918; Brinkmann, 1924; Frebold 1926; Richter, 1931a; Dietrich, 1936; Kopczyńska-Żandarska, 1970). Wśród nich uwagę autorów zwracały izolowane ze skały kolonie koralowe (Oppenheim, 1902; Felix, 1905; Deecke, 1904; Kegel, 1918).

Kolekcja zebrana przeze mnie z Pomorza (fig. 1) obejmuje następujące gatunki: *Thamnasteria concinna* (Goldfuss), *Dimorphastraea* sp., *Actinaraeopsis exilis* Roniewicz, *Isastraea* cf. *bernensis Etallon* i liczy około 1000 okazów. Korale zostały znalezione w osadach zlodowacenia Vistulian, w żwirach i piaskach zandrowych i w glinie zwałowej. Stan zachowania kolonii z okolic Wolina (Ostromice – stara żwirownia) pozwala przypuszczać, że przeszły one mały transport, a ich siedlisko znajdowało się w obrębie szelfu skandynawskiego w południowo-zachodniej części dzisiejszego Bałtyku. Zebrałam całe i fragmentaryczne kolonie *Th. concinna* w liczbie ponad 900 okazów, około 80 okazów *A. exilis* oraz kilka okazów *I.* cf. *bernensis* i jeden *Dimorphastraea* sp. Macierzysta skała koralonośna znana jest tylko z fragmentów przylegających do kolonii i okruchów występujących samodzielnie. Jest to piaskowiec żelazisty składający się przede wszystkim z ostrokrawędzistych ziaren kwarcu i detrytusu organogenicznego. Oprócz nich występują skalenie potasowe, epidot, fragmenty piaskowców, granitoidów i lidytów, ooidy szamozytowe i prawdopodobnie grudki fekalne (fecal pellets) w postaci owalnych ciał fosforanowych. Spoiwo składa się z tlenków i wodorotlenków żelaza, niekiedy jest to węglan wapnia lub żelaza. Wśród okruchów organogenicznych zwraca uwagę częstość występowania wapiennych organów reprodukcyjnych zielenicy z rodzaju *Acicularia*.

Cechy zbioru koralowego są następujące:

1. Przewaga kolonii submasywnych i masywnych o kształtach zaokrąglonych,

nie zaś jak powszechnie w osadach górnej jury Europy – warstwowych i rozgałęzionych;

2. Występowanie subsferycznych kolonii bez przyczepu (*A. exilis*) należących do typu kolonii swobodnie przetaczanych ruchem wody;

3. Ubogi zestaw gatunkowy korali i dominacja *Th. concinna* i *A. exilis*, co jest cechą pierwotną zespołu;

4. Charakterystyczny wielocentrowy sposób organizacji kolonii, który prowadzi do wyodrębnienia słupowatych subkolonii. Intensywny wzrost odbywał się na szczycie słupów, które zaznaczały się na powierzchni kolonii jako mamillarne wyniosłości;

5. Kolonie korali stanowią podłoże dla urozmaiconej epi- i infauny: małży borujących *Gastrochaena* (*Gastrochaena*), *G.* (*Spengleria*), *Lithophaga*, *Gastrochaenopsis*; wieloszczetów o prostych korytarzach typu *Trypanites*, licznych drążeń gąbek (?). Korale są porośnięte ostrygami, solenoporami, serpulami i koloniami innych korali;

6. Szkielet koralowy jest aragonitowy o zawartości $SrCO_3$ dochodzącej do 1,31%. Zawartość Sr mieści się w zbadanych próbach między 6700 a 7500 ppm. Najwyższe wartości mieszczą się w zakresie wartości charakterystycznych dla korali dzisiejszych.

Sprecyzowanie wieku korali eratykowych jest trudne wobec braku skamieniałości przewodnich w osadzie pierwotnym. Przez analogię do litologii i składu faunistycznego uważam poziom koralonośny, reprezentowany przez korale eratykowe, za odpowiednik zlepieńca granicznego występującego nad warstwami poziomu kordatowego, a pokrytego warstwami poziomu alternansowego (Richter, 1931b).

Oksfordzkie korale z szelfu skandynawskiego żyły w warunkach odmiennych od powszechnie panujących w środowiskach koralowych późnej jury Europy. Nieskonsolidowane dno – muł lub niezwiązany osad piaszczysty – ograniczało możliwości rozwoju formacji rafowej. Wśród dojrzałych kolonii poważny udział mają kolonie bez przyczepu, swobodnie przetaczane ruchem wody po dnie. Obrona przed piaskiem osiadającym na powierzchni kielichowej kolonii polegałaby na stworzeniu na tej powierzchni systemu stref o wyraźnie zróżnicowanej aktywności koralitów (szczyty mamilli i sieć bruzd między nimi), ułatwiającego oczyszczanie.

Wyjątkowe zachowanie aragonitowego szkieletu zawdzięcza się żelazistości skały macierzystej – obecności jonów $Fe^{2+}$ hamujących przemianę aragonitu w kalcyt.

## EXPLANATIONS OF PLATES – OBJAŚNIENIA PLANSZ

### Plate – Plansza I

Fig. 1. Fragment of a coral-bearing erratic of ferruginous sandstone. Ostromice, erratic boulder No ZPAL H. IV/215. × 5.

Fig. 1. Fragment koralonośnego piaskowca żelazistego. Ostromice, głaz narzutowy No ZPAL H. IV/215. × 5.

Fig. 2. Sandy siderite with coral colony fragments. Ostromice, erratic boulder No ZPAL H. IV/217. × 5.

Fig. 2. Syderyt piaszczysty z fragmentami kolonii koralowych. Ostromice, głaz narzutowy No ZPAL H. IV/217. × 5.

Plate – Plansza II

Fig. 1. Fragment of a *Thamnasteria concinna* colony with partially preserved original surface. Resko, erratic boulder No ZPAL H. IV/20. × 2.

Fig. 1. Fragment kolonii *Thamnasteria concinna* z częściowo zachowaną oryginalną powierzchnią. Resko, głaz narzutowy No ZPAL H. IV/20. × 2.

Fig. 2. Fragment of a well preserved calicular surface of *Thamnasteria concinna colony*. Ostromice, erratic boulder No ZPAL H. IV/335. × 4.

Fig. 2. Fragment dobrze zachowanej powierzchni kielichowej kolonii *Thamnasteria concinna*. Ostromice, głaz narzutowy No ZPAL H. IV/335. × 4.

Fig. 3. Organodetrital sandy limestone with *Thamnasteria concinna* skeletal fragments. Ostromice, erratic boulder No ZPAL H. IV/747. × 5.

Fig. 3. Organodetrytyczny wapień piaszczysty z fragmentami szkieletu *Thammasteria concinna*. Ostromice, głaz narzutowy No ZPAL H. IV/747. × 5.

Plate – Plansza III

Fig. 1, 2. *Thamnasteria concinna* (Goldfuss, 1826): mamillar surface of submassive colonies. Corallites of the two colonies differ in diameter. Ostromice, erratic boulder No ZPAL H. IV/345 (see also Pl. 4:1) and 170. × 1.

Fig. 1, 2. *Thamnasteria concinna* (Goldfuss, 1926): mamillarna powierzchnia kolonii. Korality dwóch kolonii różnią się średnicami. Ostromice, głazy narzutowe No ZPAL H. IV/345 (patrz też pl. 4:1) i 170. × 1.

Fig. 3. *Actinaraeopsis exilis* Roniewicz, 1968: subspherical colony of circumrotatory growth-form. Calicular surface abraded, infaunal traces numerous. Ostromice, erratic boulder No ZPAL H. IV/358, × 0.6.

Fig. 3. *Actinaraeopsis exilis* Roniewicz, 1968: subsferyczna kolonia o kielichach rozmieszczonych na całej powierzchni. Powierzchnia zabradowana, liczne ślady organizmów wiercących. Ostromice, głaz narzutowy No ZPAL H. IV/358. × 0,6.

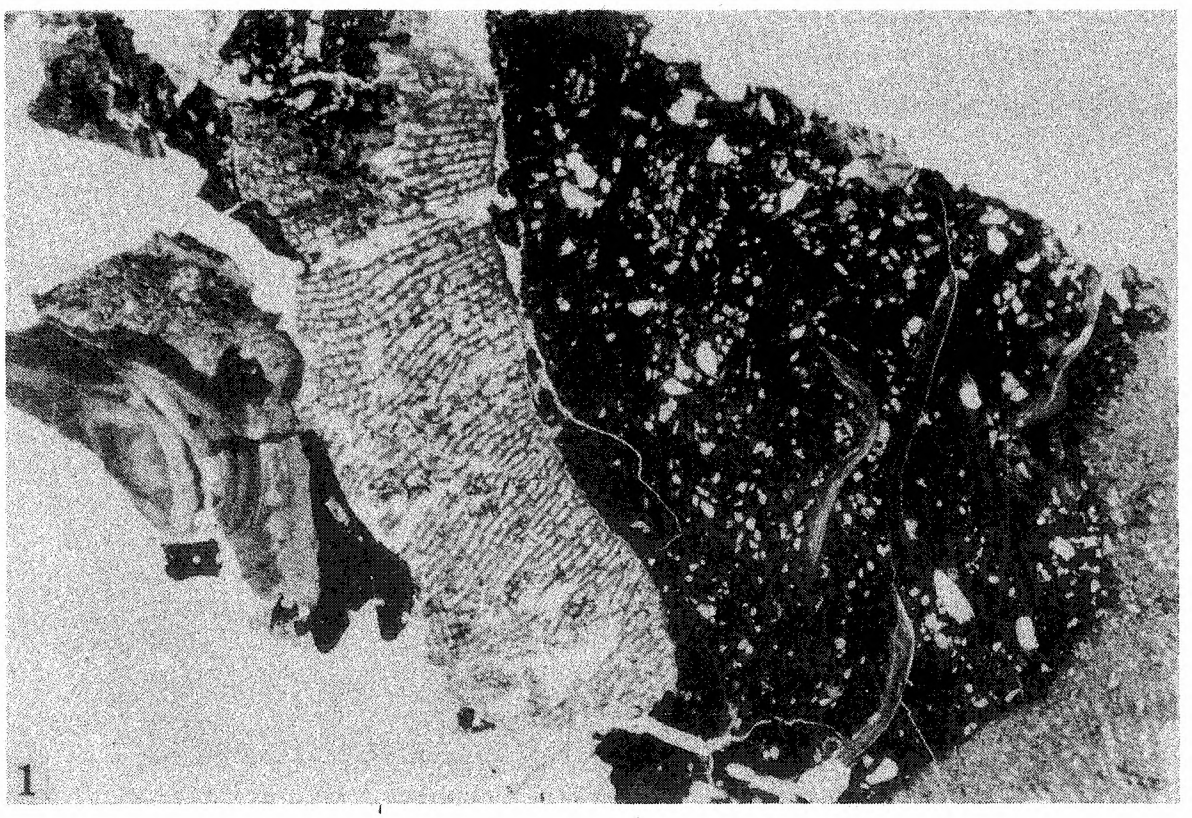
Plate – Plansza IV

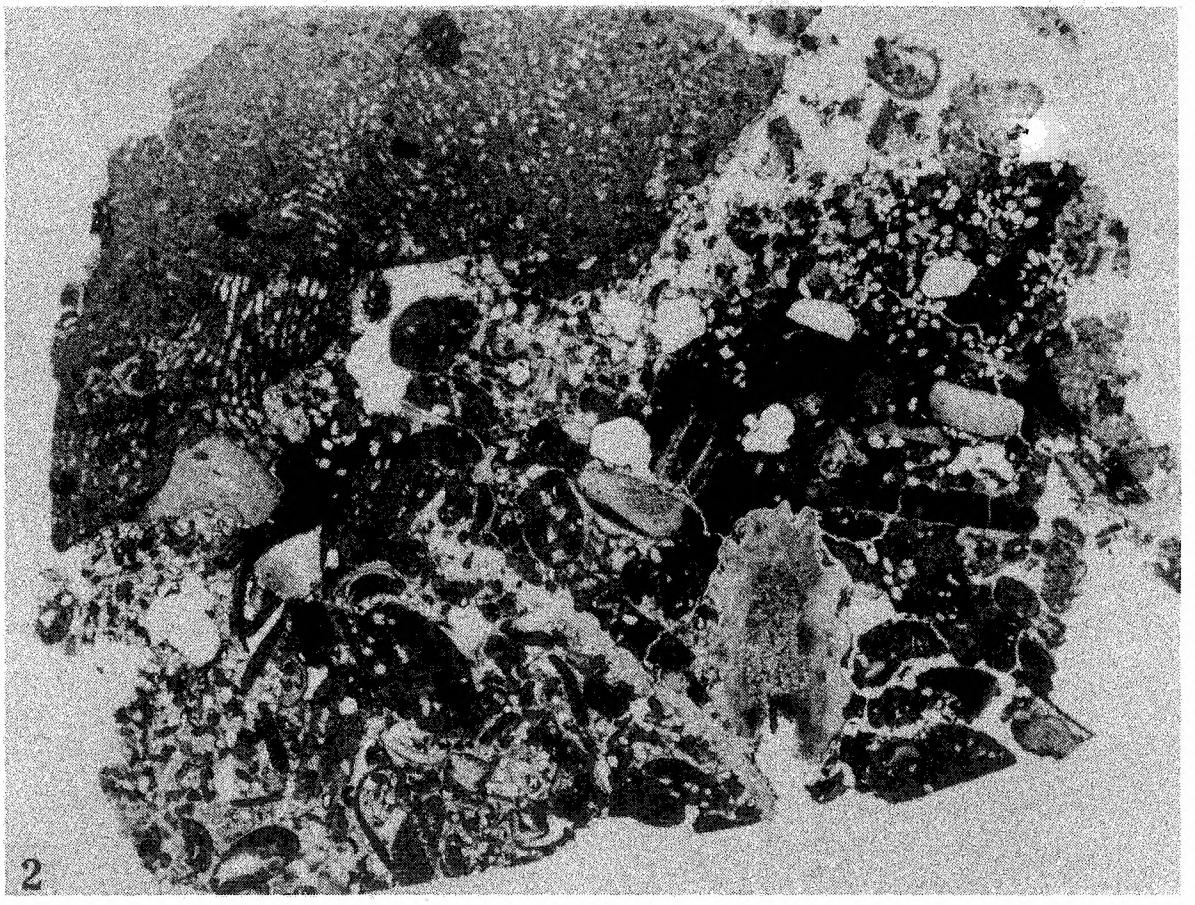
Fig. 1. *Thamnasteria concinna* (Goldfuss, 1826): side view of a broken submassive colony with columns clearly visible. Ostromice, erratic boulder No ZPAL H. IV/358 (see also Pl. 3:1). × 1.

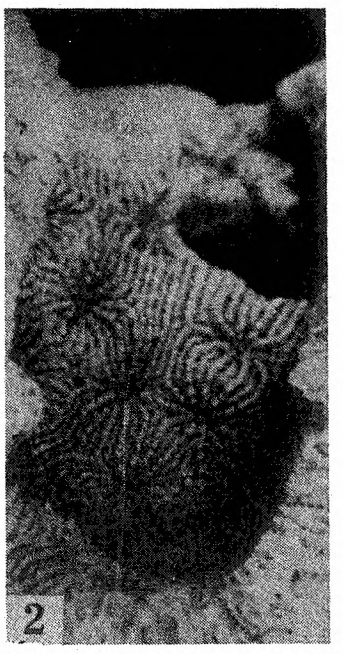
Fig. 1. *Thamnasteria concinna* (Goldfuss, 1826): pęknięta wzdłuż kolonia z kolumnami wzrostowymi oglądanymi z boku. Ostromice, głaz narzutowy No ZPAL H. IV/358 (patrz też pl. 3:1). × 1.

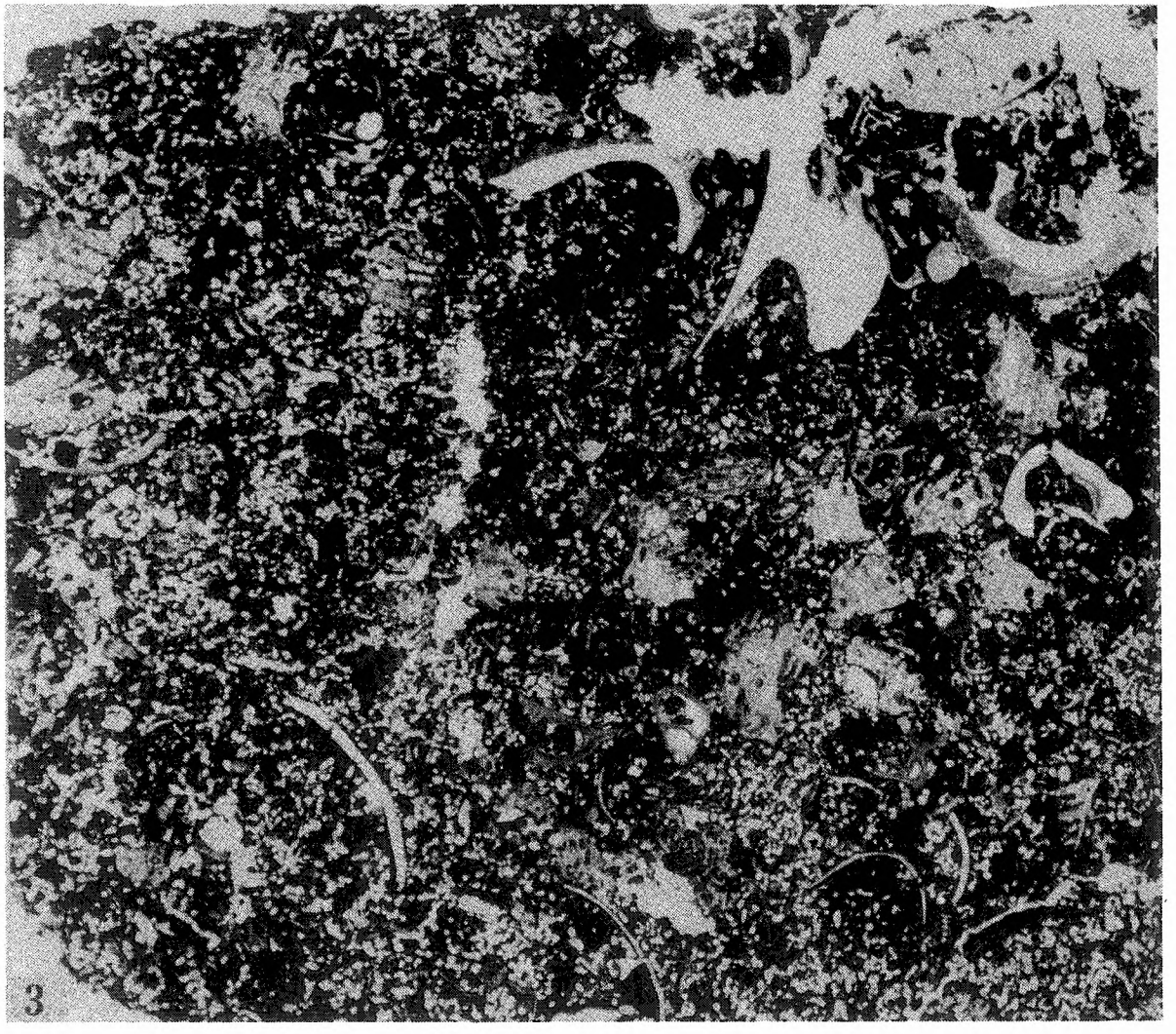
Fig. 2. *Actinaraeopsis exilis* Roniewicz, 1968: massive colony of subparallel columns: colony surface strongly abraded. Ostromice, erratic boulder No ZPAL H. IV/272. × 2.

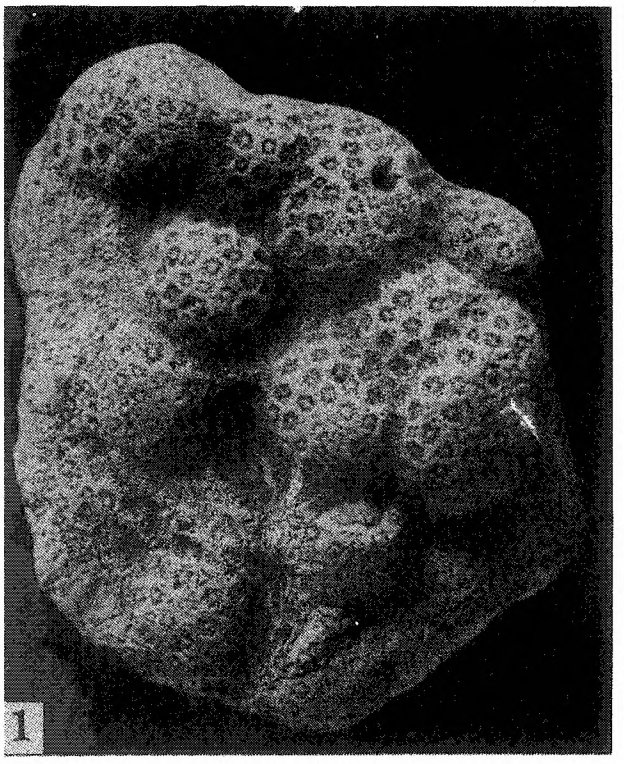
Fig. 2. *Actinaraeopsis exilis* Roniewicz, 1968: kolonia zbudowana z niemal równoległych kolumn wzrostowych; powierzchnia silnie zabradowana. Ostromice, głaz narzutowy No ZPAL H. IV/272. × 2.

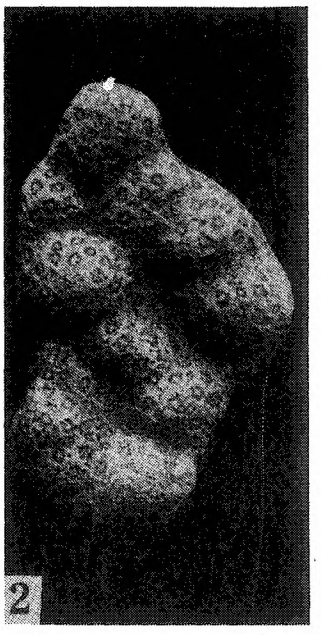

1

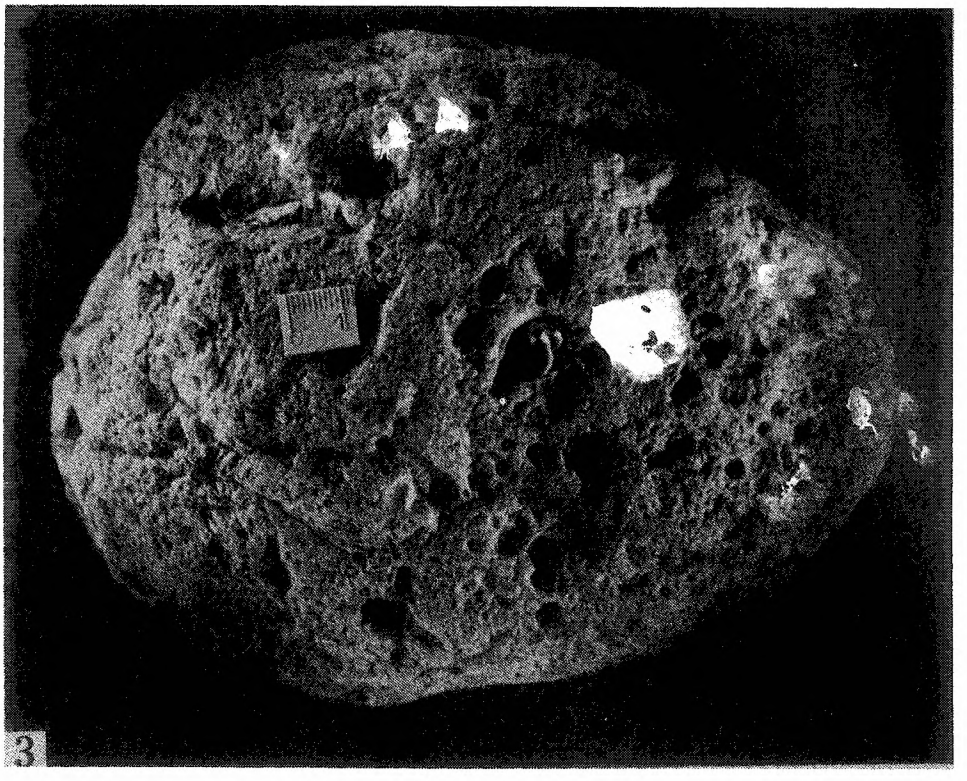

2

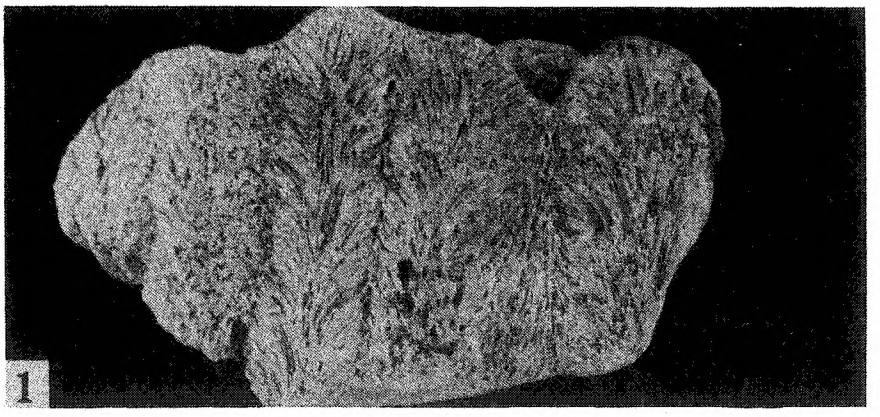












1

2