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Stanisław LORENC*, Jerzy MROCZKOWSKI**

THE SEDIMENTATION AND PETROGRAPHY OF ZECHSTEIN AND LOWERMOST TRIASSIC DEPOSITS IN THE VICINITY OF KOCHANÓW (INTRA-SUDETIC TROUGH)

CONTENTS

Abstract

The Zechstein and Lower Triassic rocks in the northern part of the Intra-Sudetic trough are represented by the clastic-carbonate deposits which pass upwards to the clastics. In the vicinity of Kochanów, these deposits display a four-member structure. The environment was changed from coastal and/or lagoonal (members A, B, C) to non-marine one (member D) during the sedimentation of rocks of this sequence. The boundary between the Zechstein and the Triassic has been established by the authors between the members C and D — in the place where the discussed deposits display a marked change of environment. This change relied likely upon the climatic variations and/or intensification of diastrophic movements.

INTRODUCTION

Clastic and carbonate rocks exposed in a few abandoned quarries and natural outcrops were investigated in the vicinity of Kochanów, a small village situated in the Kamienne Góry, Central Sudetes between the towns of Kamienna Góra and Mieroszów.

From the geological point of view the described area represents a small part of northeastern flank of the Intra-Sudetic trough, one of the sedimentary basins which existed in the Sudetes from the Carboniferous to the Lower Triassic and during the Upper Cretaceous.

* Institute of Geological Sciences, the University, ul. Cybulskiego 30, 50—205 Wroclaw.
** Institute of Geological Sciences of the Polish Academy of Sciences, ul. Cybulskiego 30, 50—205 Wroclaw.

The present authors' studies have been focused upon sedimentary rocks which in recent regional literature are believed to be of Zechstein and Lower Triassic age. This work was done as a part of extensive investigations on the problem of Geodynamics of Regions of Poland — Problem I—16.

A REVIEW OF PRIOR RESEARCHES ON THE PROBLEM OF ZECHSTEIN—TRIASSIC SEQUENCE IN THE INTRA-SUDETIC TROUGH

The earliest reference to the presence of Zechstein and Triassic deposits in the Intra-Sudetic trough was published by Zimmermann and Berg in 1904, who claimed that the part of sedimentary rocks, which had in earlier works been ascribed to the Rotliegendes (Beyrich *et al.* 1867, Flegel *et al.* 1904), exhibit unquestionable lithological resemblance to Zechstein and Lower Triassic rocks of the North--Sudetic trough. Shortly later, Berg (1905) proposed a more detailed stratigraphical division of the part of sedimentary sequence in the Intra-Sudetic trough. He included into Zechstein the dolomitic arkoses and limestones of total thickness of about 20 m and into Bunter the red sandstones with pebbles and white kaolinite sandstones (thickness about 75 m).

The Zechstein Triassic deposits are, according to Berg (*op. cit.*), separated by unconformities from the underlying Rotliegendes and overlying Cretaceous rocks. Such a stratigraphical scheme was presented on geological maps compiled by Dathe and Berg (1912), by Berg (1909, 1938) and by Dathe and Petrascheck (1933). Meanwhile, it was Müller (1930) who included only to the Zechstein the whole complex of sediments believed by the above named authors to be of Zechstein and Triassic age.

According to Muller these sediments were developed in a continental environment. The latter view was shared by Scupin (1937) whose work was based upon the results of Müller's investigations. But Müller's and Scupin's opinion about the age of the discussed rocks remained isolated. In later papers concerning sedimentary rocks in the Intra--Sudetic trough the view persisted that the sedimentary rocks of both Zechstein and Bunter ages occurred between the Rotliegendes and the Cretaceous (Berg 1938; Tasler 1961, 1966; Valin 1961, 1964).

Because of the lack of fauna, the stratigraphy of Zechstein and Triassic deposits in the Intra-Sudetic trough has been based on lithostratigraphical correlation to Permian and Triassic rocks of the North--Sudetic trough. In the North-Sudetic trough, the low--er members of the Zechstein and Rhoethian (upper--most Bunter) are evidenced paleontologically. But still the boundary between Zechstein and Triassic deposits in the North-Sudetic trough is difficult to be defined accurately (Mroczkowski 1972). In the Intra-Sudetic trough where Zechstein fauna has never been found and where Rhoethian and Muschelkalk are lacking the problem of Zechstein Triassic boundary is even more complicated. Moreover, the existence of such a boundary may sometimes be denied by geologists (vide Müller 1930; Scupin 1937a, 1937b).

According to Berg (1905, 1938), dolomitic arkoses and limestones should be included into the Zechstein. They are separated from Lower Triassic sandstones only by a thin layer of red clays. In the Czechoslovakian part of the Intra-Sudetic trough, the Zechstein sequence is represented by calcacerous and dolomitic sandstones which pass into conglomerates. The most typical are unstratified dolomitic sandstones in which the amount of carbonates may locally increase towards pure dolomite (Tasler 1961). At the top of Zechstein sequence medium-and coarse--grained light-grey arkosic sandstones occur, having sometimes a calcacerous cement. They are occasionally interbedded with claystones and medium grained sandstones. In Tasler's opinion (*op. cit.*) the total thickness of the Zechstein in this region amounts 30—40 m. A similar spectrum of Zechstein deposits was presented by Valin (1964), who described the so called "vrstvy bohuslavicke" (Bohuslavice beds).

These beds were developed owing to a cyclic process which was pronaunced by the presence of sediments getting finer and finer towards the top of the sequence. Tasler (1966) described the "vrstvy bohuslavicke" as a new megacycle in relation to the lower part of Permian deposits. An internal structure of this megacycle is not cyclic and its lower boundary has been precisely determined nowhere.

The thickness of the "vrstvy bohuslavicke" decreases northeastwards. According to the named author, Zechstein deposits underlies the whole area of Bunter occurrence in the Intra-Sudetic trough and therefore it is impossible to study thoroughly the inferred unconformity between those formations. The Zechstein/Lower Triassic boundary should be, according to Tasler, placed above the carbonate sediments, at the bottom of the first bed of the coarse-grained and pink-coloured arkosic sandstones.

Following Dathe and Petrascheck, Tassler included these sandstones as thick as 100—120 m into the Lower Triassic. The presence of Zechstein and Lower Triassic deposits has been shown on Dathe's and Petrascheck's (1933) 1:100000 geological map, to occur over the whole area of the Intra-Sudetic trough. In the northern and central part of this through, the occurrence of Zechstein and Lower Triassic rocks has been reported in numerous above cited papers. But the presence of the both geological formations is still questionable in its south-eastern part. In no outcrops can be observed rocks similar to the Triassic sandstones known from the vicinity of Chełmsko and Łączna, the well exposed and well known northern part of the Intra-Sudetic trough. Zechstein age of the carbonate rocks occurring in southern part of this trough, in the vicinity of Radków, has recently been questioned by Śliwiński (1976) who considers these rocks to be a caliche developed in clastic desert deposits of the Lower Permian. It is worthy to add that similar opinion about the origin of at least part of the described carbonate rocks had earlier been expressed by Dziedzic (1961) who, however, did not question the age of these rocks.

The above brief review of opinions on the occurrence and origin of Zechstein and Triassic deposits in the Intra-Sudetic trough, shows clearly how old and controversial this problem is. It still remains unsolved, despite the views expressed in recent text-books of regional geology.

But the problem is by no means so simple. Zechstein deposits in the discussed region are not typical and they differ remarkably from Zechstein rocks occurring in the adjacent areas. Moreover, this formation has not been studied sedimentologically and biostratigraphical evidence is absent from it. Therefore, both the age of the questioned deposits and their origin may be variously viewed upon (e.g. Śliwiński 1976). Sedimentary passage to the overlying Lower Triassic deposits also devoid of faunistic evidence multiplies the possible interpretations, especially in the Polish part of the discussed unit. In this situation the present authors attempt to explain at least some of the above featured problems on the basis of investigations which have been carried out over a small but relatively well exposed area in the vicinity of Kochanów in the northern part of the Intra-Sudetic trough.

A complete sequence of the studied deposits is exposed nowhere. Thus, it was necessary to find any suitable criterion in order to correlate rocks from various exposures and to construct an inferred synoptic profile.

Petrographical features have appeared to be decisive here. In the view of lack of direct stratigraphical data and difficulties in relating the questioned rocks to the Zechstein-Triassic rocks recognised in the adjacent areas, the present authors attempted the reconstruction of the environment in which rocks of the Kochanów region had been deposited.

The significant change in an environmental character could possibly mark the boundary or transition zone between Zechstein and Triassic deposits. The Perm/Triassic boundary recognised in this way could not, of course, be considered as a boundary between chronostratigraphical units. The reconstruction of the sedimentary environment was based on investigations of sedimentary structures, measurements of transport directions as well as on petrographic textural and chemical studies of the questioned rocks.

LITHOLOGICAL AND PETROGRAPHICAL DESCRIPTION

Rocks of the investigated sequence were observed in a few outcrops in the vicinity of Kochanów (fig. 1). They vary from limestones and sandy limestones to calcacerous sandstones and more or less pure sandstones containing occasionally gravel or pebble admixture. The main features of these rocks are various and irregular bedding and lack of the sharp boundaries between individual lithological types. Petrographical investigations allowed to correlate the rocks observed in isolated exposures.

It was recognised that nearly the whole sequence can be studied in outcrop No 1. Only its lowermost part was missing there but the bottom members were found in outcrop No 2. (see fig. 2). Petrographical investigations proved that the investigated profile exhibits a four member structure.

MEMBER A

The lowermost member is built of sandy limestones and/or strongly calcacerous sandstones. The exposed part of this member reaches about 4—5 m in its thickness. The deposits of the lowermost member are light-grey to dark-tan-coloured. In outcrop No 1, dominate the sandy limestones having fine crystalline

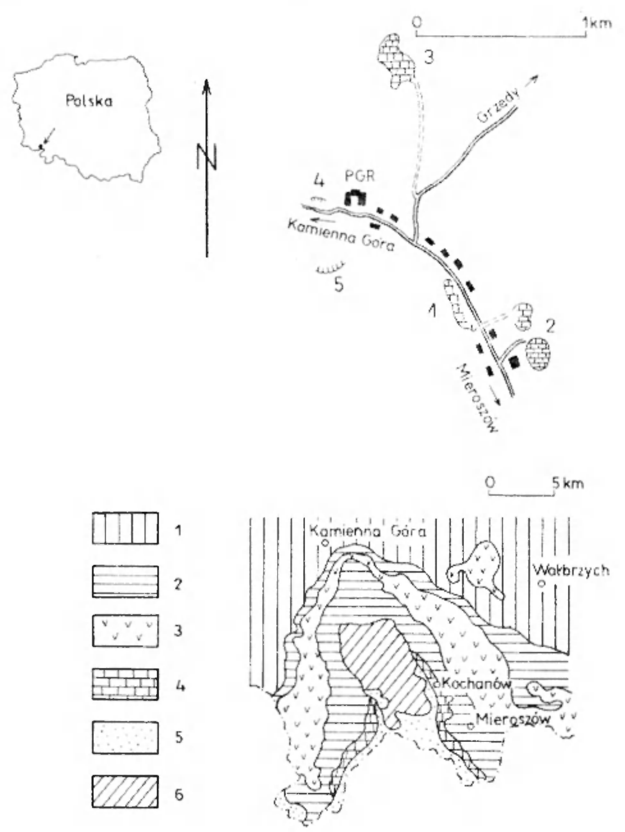

Fig. 1

Topographic sketch showing localization of the outcrops described in the text (top) and schematic geological map of the northern part of the Intra-Sudetic trough (generalized according to Grocholski 1969); (bottom)

1 — sedimentary Carboniferous rocks; *2* — sedimentary Rotliegendes rocks; *3* — eruptives of Carboniferous and Rotliegendes age; *4* — sedimentary Zechstein rocks; *5* — sedimentary Bunter rocks; *6* — sedimentary Cretaceous rocks

Szkic sytuacyjny opisywanych odsłonięć w rejonie Kochanowa (u góry) oraz schematyczna mapa geologiczna północnej części niecki śródsudeckiej, zgeneralizowana (według Grocholskiego 1969); (u dołu)

1 — skały osadowe karbonu; *2* — skały osadowe czerwonego spągowca; *3* — skały wylewne karbonu i czerwonego spągowca; *4* — skały osadowe cechsztynu; *5* — skały osadowe pstrego piaskowca; *6* — skały osadowe kredy

fabric they pass into fine-grained strongly calcacerous sandstones at the top of the member.

In the sandy limestones, cavities up to several millimetres in their size occur occasionally. Sometimes they are filled with minute calcite druses. In outcrops Nos 2 and 3 the calcacerous sandstones with dolomitic clods strongly prevail in the uppermost part of the discussed member.

Calcacerous conglomerates (about 1 m thick) occur among sandy limestones in outcrop No 1.

Elongated pebbles of sandstones as well as sandy limestones are met in this conglomerate. The pebbles have more than 10 cm in their diameter. Detrital constituents of the described rocks are quartz, potash feldspar and plagioclases. Rock fragments, mainly metamorphic and eruptive, are rare. The detrital constitutens differ in their size ranging from 0,2 mm to 1,5 mm (see tab. 1); their roundness degree is low.

Table 1

Textural data

Dane granulometryczne

Member Człon	Md [mm]	So	QDa [mm]	Mz (Ø)	Σ (Ø)	Sk (Ø)	KG (Ø)
A	0,42	1,41	0,15	1,27	0,86	0,32	1,23
A	0,35	1,42	0,12	1,60	0,82	0,26	1,19
A	0,34	1,30	0,09	1,60	0,63	0,05	1,38
A	0,46	1,28	0,115	1,16	0,63	0,21	1,28
C	0,30	1,79	0,16	1,95	1,58	0,65	1,43
C	0,27	1,49	0,10	2,00	0,80	0,32	0,85
C	0,38	1,42	0,165	1,30	0,82	0,09	0,97
C	0,57	1,39	0,20	0,89	0,74	0,25	1,06
C	0,35	1,34	0,10	1,57	0,91	0,11	1,23
C	0,56	1,51	0,22	0,70	1,19	0,46	1,54
C	0,23	1,54	0,11	2,10	0,85	−0,052	0,88
C	0,53	1,35	0,15	1,06	0,79	0,38	1,35
C–D	0,32	1,45	0,11	1,80	0,88	0,26	0,60
D	0,50	1,33	0,14	1,10	0,69	0,30	1,23
D	0,41	1,44	0,15	1,33	0,82	0,26	1,08
D	0,42	1,42	0,155	1,25	0,83	0,15	1,23
D	0,43	1,71	0,23	1,40	1,69	0,28	2,69
D	0,52	1,36	0,145	1,16	0,74	0,59	1,18
D	0,35	1,36	0,11	1,53	0,80	0,25	1,43
D	0,50	1,23	0,105	1,07	0,63	0,17	1,18
D	0,52	1,50	0,21	0,74	0,78	0,36	0,99
D	0,53	1,49	0,225	1,00	1,02	0,33	1,45
D	0,47	1,35	0,19	1,16	0,68	0,21	1,03
D	0,55	1,37		0,98	0,69	0,34	0,88
D	0,60	1,36	0,175	0,88	0,66	0,38	0,94

The cement of the rocks is commonly micritic and occasionally represented by micritic-sparite calcacerous material making several to over 70% of the rock volume. The percentage of calcacerous material in the questioned rocks varies from place to place, but it generally increases westerly towards the axis of the Intra-Sudetic trough. Also clayey and ferric-clayey material plays the role of cement. The clay minerals are mainly due to the chemical weathering of feldspars, which can be seen in numerous examples beneath the microscope. The most corroded parts of feldspars are attacked and replaced by carbonates. In many cases one can decipher only faint shapes of the previous feldspar grains. Especially intensive weathering and subsequent replacement by carbonate minerals are observed along the surfaces of cleavage and twinnings of feldspars. Besides chemical weathering some grains of feldspars show effects of physical weathering as well. The latter is due to insolation or day-and-night-temperature variations. An example of such weathering is shown on plate II, *2*.

An interesting example was observed in a sample taken from outcrop No 2. A grain of plagioclase having nearly 5 mm in length, is divided perpendicularly to its longer axis into several sections, which display the same optical orientation (pl. II, *2*). The cracks between the individual sections reaches even 0,6 mm, and in some of them the detrital quartz grains having 0,3 mm in diameter may be found. Now the feldspar and quartzes are cemented with micrite-sparite material. In the authors' opinion the best explanation of this phenomenon is that the grain after its deposition along with other material, was in an immediate contact with the atmosphere and owing to day-night temperature variations it broke into pieces. Next, the cracks were filled with fine grains of quartz. Algal aureolae around detrital constituents are characteristic of the rocks of the described member. The quartz and feldspar grains as well as other rock fragments are usually surrounded by subtle aureoles of organogenic micrite reaching 0,1 mm in their thickness (pl. II, *3*). Therse algal aureolae remarkably increase in number in outcrop No 1, so that in the extreme case the rock could be described as a contaminated biomicrite. Such a biomicrite is occasionally laminated and then resembles deposits of the algal zone. From the chemical point of view on the basis of Ca/Mg ratio (1,72—1,90), it is possible to determine the rocks of member A as poorly calcacerous dolomite (criteria as in Chilingar 1956)

MEMBER B

This unit is composed of homogenous, light-grey and light-grey-tan limestones with micro-cavities. They are sandy at the top part, having 2 m in thickness.

The limestones are biomicrite or biomicrosparite with numerous algal structures of a stromatolitic character (pl. II, *8*, pl. III, *1*, *3*). Stromatolite structures may be observed more frequently in the thin-sections of limestones taken from outcrop No 1. The micritic basic material is composed of crystals having less than 10μ in their size. In the described rock occur both laminated and dome algal structures (Szulczewski 1968). Such laminae may be as thick as 0,4 mm and the size of the individual domes reaches 5 mm. Intra-laminae spaces and pores in the micrite mass are filled with sparite cement. Rhomboedric calcite cement is the most common but in some cases it is possible to identify calcite drusy mosaic cement, (pl. III, *2*) which fills up voids in a characteristic manner: the size of crystals increases towards the centre of the void. The greatest grains of cement are up to 0,18 mm large. The presence of drusy mosaic cement is an indication of the diagenetic conditions (see eg. Schneider 1977). Most probably the diagenesis took place during at least temporary emergence of the sediment above the sea-level in semi-arid and rather warm climate. Apart from the above mentioned organic structures, intrablasts above 2 mm in size and rare pellets were observed in thin-sections. Fine grained silica (crystal size up to 0,09 mm) occurs sometimes in the carbonate mass. It fills up cracks and the empty voids devoid of calcite cement. Sometimes algal structures are also internally silicated. Detrital quartz grains of an average size of about 0,3 mm (maximum 0,9 mm) occur in limestones in outcrop No 1. The quantity of quartz grains clearly decreases towards the trough axis. From the chemical point of view the limestones of member **B** characterised by 1,60—1,83 Ca/Mg should be described as dolomites and poorly calcacerous dolomites.

MEMBER C

The deposits of this member are mainly sandy or sandy-conglomerate in character. The lowermost part of this member is built of calcacerous sandstones and conglomerates which contain pebbles of limestones and clods or nodules of dolomite.

The latter ones reach about 50 cm in their diameter. Sandstones and conglomerates with clay and/or ferric cement occur above. They are distinctly bedded and light-tan or reddish-tan coloured. In the described member a bed of fine-laminated dark-tan sandstones may be distinguished. This sandstone bed is about 1 m. thick and it can be seen well in two outcrops: Nos 1 and 3 (fig. 2).

The total thickness of member **B** amounts nearly 6 m. The boundary between **B** and **C** members seems to be erosive. It is true about at least some parts of the described outcrops. Such an opinion might be confirmed by the occurrence of limestone pebbles mentioned above, in the set of sandstone and conglomerate beds. These pebbles represent fragments of biomicrite with numerous stromatolite structures. They reach up to 10 cm in diameter and their roundness is very low. They probably were originated from member **B** which had been destroyed immediately after diagenesis. The chemical composition of the pebbles is very similar to the composition of the limestones that occur in member **B**, and their Ca/Mg ratio is 1,60—1,80. The above described pebbles occur mainly in outcrop No 3 which is situated nearer to the marigin of the trough. Besides limestone pebbles, the fragments of calcacerous sandstones scattered in the sandy material also occur. In the described member, especially in the upper part of the sequence, the dolomite clods (a few cm

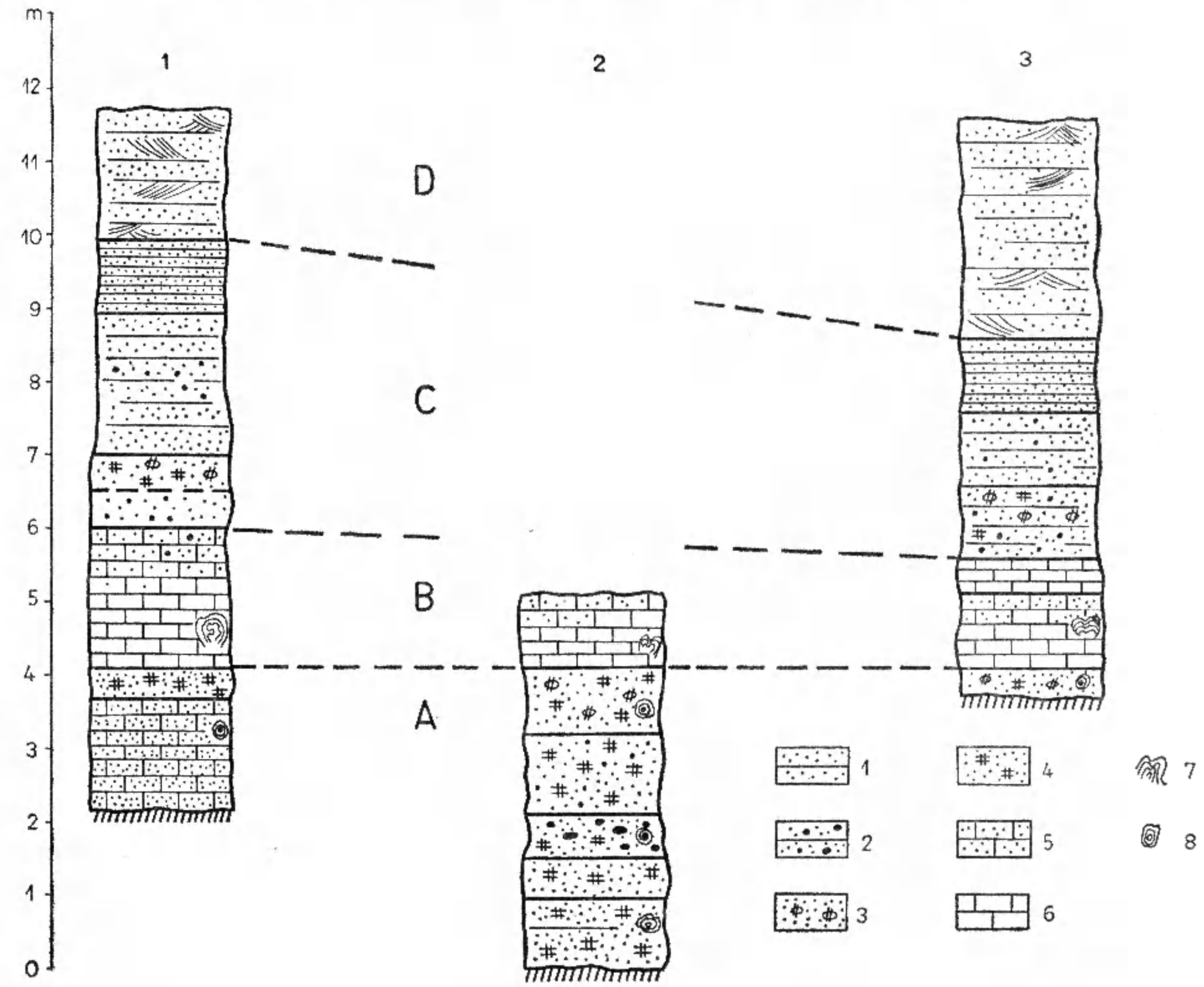

Fig. 2

Schematic profile of outcrops 1, 2 and 3 correlated on the basis of the present author's investigations

1 — sandstones; *2* — sandstones and conglomerates; *3* — carbonate clods and nodules in the sandstone; *4* — sandstones with carbonate cement; *5* — carbonate rocks with admixed sand; *6* — carbonate rocks; *7* — stromatolitic structures; *8* — detrital grains with algal aureoles

Schematyczne profile odsłonięć 1, 2 i 3 skorelowane na podstawie przeprowadzonych badań

1 — piaskowce; *2* — piaskowce i zlepieńce; *3* — gruzły i buły węglanowe w piaskowcu; *4* — piaskowce o spoiwie węglanowym; *5* — zapiaszczone skały węglanowe; *6* — skały węglanowe; *7* — struktury stromatolitowe; *8* — otoczaki algowe wokół ziarn detrytycznych

in size) and occasional larger nodules occur. They are visible in the sandy material owing to their light-grey-brown colour, but the boundaries between the clods, nodules and the surrounding sandstones are not too sharp. The transition zones between clods or nodules and sandstones have usually several millimetres in width. Both clods and nodules are typically early-diagenetic. They were developed owing to the concentration of calcacerous material which previously was dispersed in the rock matrix. Similar phenomena in the lateral Zechstein facies of East Thuringia and Saxony, were described by Ullrich (1964). The detrital components of member C are characterized by textural parameters (tab. 1).

The results of the spectral analyses of the rocks which belong to members A, B, C are shown in table 2. The contents of chemical elements are typical of sandstones and limestones (see eg. Rosler, Lange 1975).

The difference between carbonate rocks of member B and clastic rocks of members A and C is marked by the change in quantity of Ga, Ni and Ti; these elements occur tens times more frequently in calcacerous rocks.

MEMBER D

Deposits of this member are represented exclusively by clastic rocks which were observed at the highest parts of outcrops No 1 and No 3. They are well exposed in outcrops No 4 and No 5, too.

The rocks of member D are mainly sandstones. The main component of these sandstones is quartz. It makes 73% to more than 90% of the rock volume.

Table 2

Results of approximate spectral analyses of the sediments of members A, B and C

Wyniki orientacyjnych analiz spektralnych osadów z członów A, B i C

Element Pierwiastek	Content (ppm) Zawartość	Remarks Uwagi
Pb	1–100	
Ga	0–100	absent from sediments of member B brak w osadach członu B
Ni	0–10	,,
Sn	0–1	
V	0–1	
Ti	0–100	absent from sediments of member B brak w osadach członu B
Cu	1–10	
Ag	1–10	
Co	0–1	

Feldspars occur in the amounts varying from 3% to over 20%. Micas occur in extremely low quantities ranging from fractions of a per cent to several per-cent. Fragments of rocks are rare and make several per cent of the sandstone. The matrix varies in its amount from 0 to over 20 per cent. Textural parameters of sandstones are shown in table 1. According to Gilbert's classification (Williams *et al.* 1955), the sandstones of member D in the study region are feldspar arenites and feldspar wackes, quartz wackes being less frequent. The variety of clastic rocks in the Intra-Sudetic trough is in general greater than that in the vicinity of Kochanów, but the clastic constituents themselves do not differ significantly in their character. The clastic rocks differ mostly in the percentage of carbonates, which decreases to zero in member D (trace quantities may be found in the lowermost part of this member). Other members contain even more than 50% of carbonate material especially in member B. The diagrams in figure 3 refer to the samples taken from both the vicinity of Kochanów and adjacent areas of the northern Intra--Sudetic-trough. As Gilbert's classification triangles (Williams *et al.* 1955) have been used, the diagrams presented refer only to the interrelations between the clastic constituents, not carbonate ones. Therefore it is apparent that the composition of clastic material in member D does not differ from that of lower members of the sequence. The sandstones of member D contain few pebbles and fragments of mudstones or claystones, which are randomly distributed throughout the rock. They are more frequently met in the upper part of member D, and they usually appear in sandstones several metres above the bottom of this member. Their occurrence in sandstones was described before (Mroczkowski 1977).

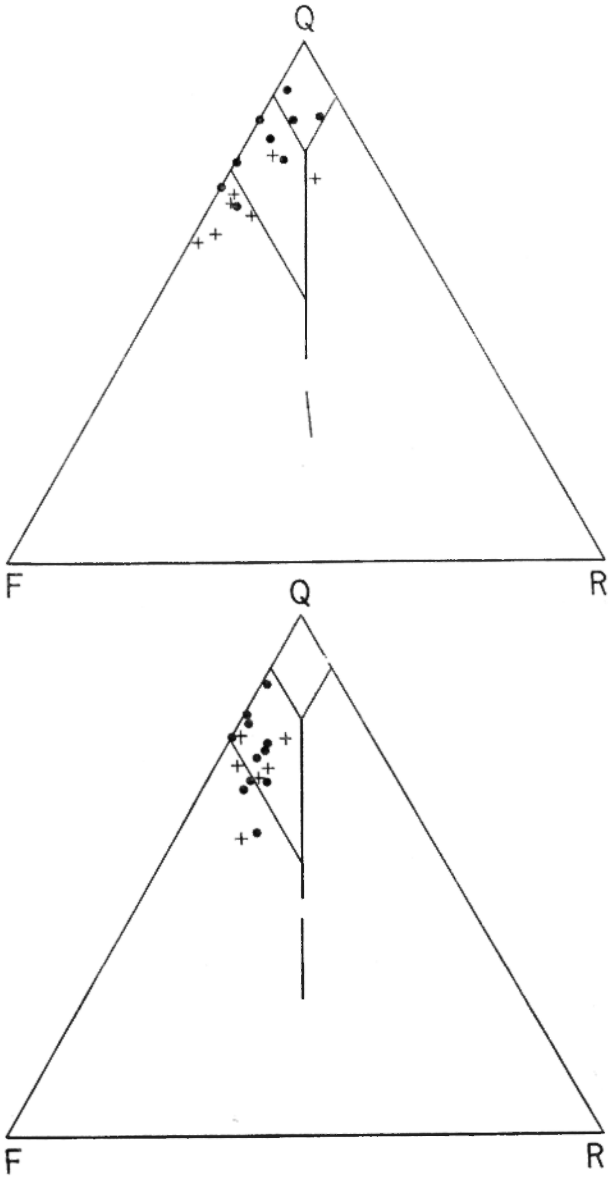

Fig. 3
Mineral composition against Gilbert's classification triangle; wackes (upper triangle) and arenites (lower triangle) crosses—samples of members A, B and C, full dots—samples of member D

Skład mineralny na trójkątach klasyfikacyjnych Gilberta (u góry) i arenitów (u dołu), krzyżyki—próby z członów A, B i C, kropki—próby z członu D

TEXTURES

The discussed rocks were texturally investigated by means of measuring the grains in the thin-sections. To obtain textural parameters, the present authors used Friedman's technique of transformation of measurements to sieve-size equivalents (Friedman 1958). Only the most typical specimens of the questioned sequence were investigated. Thus, neither small intercalations and lenses of mudstones nor gravel lenses and scattered pebbles were taken into account. Also the rocks containing more than 50 percent of carbonates were excluded.

Therefore the member B was not involved in this study.

The following textural parameters have been taken into considerations: median (Md), sorting (So), quartille deviation (QDa), mean diameter (Mz), standard deviation (σ), skewness (Sk), and kurtosis (KG). The values obtained are listed in table 1. According to Wentworth's classification (fide Pettijohn 1972), the sandstones of member A are medium grained and fairly well sorted (the quality of sorting was determined on the basis of sorting coefficient after Gradziński *et al.* 1976). The sandstones of member C are mainly medium-grained. They pass sometimes into fine-grained or coarse-grained varieties. Their sorting is moderate to poor. In member D the medium-grained or occasionally coarse-grained sandstones occur. Their sorting changes from well to poor. The textural data indicate that there is no important difference between the sandstones belonging

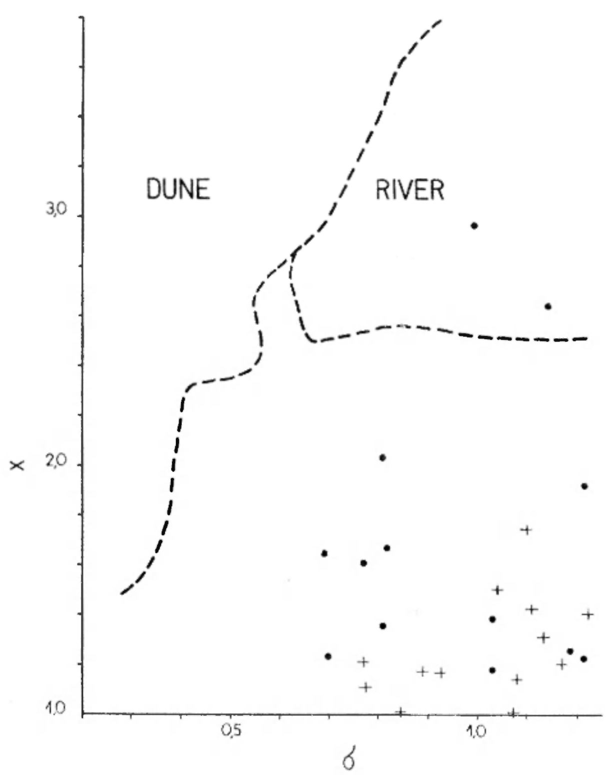

Fig. 4

Mean diameter (x̄) versus standard deviaton (σ), crosses—samples of member A and C, full dots—samples of member D

Diagram średnich średnic ziarn badanych piaskowców (x̄) i ich odchylenia standardowego (σ), krzyżyki—próby z członów A i C, kropki—próby z członu D

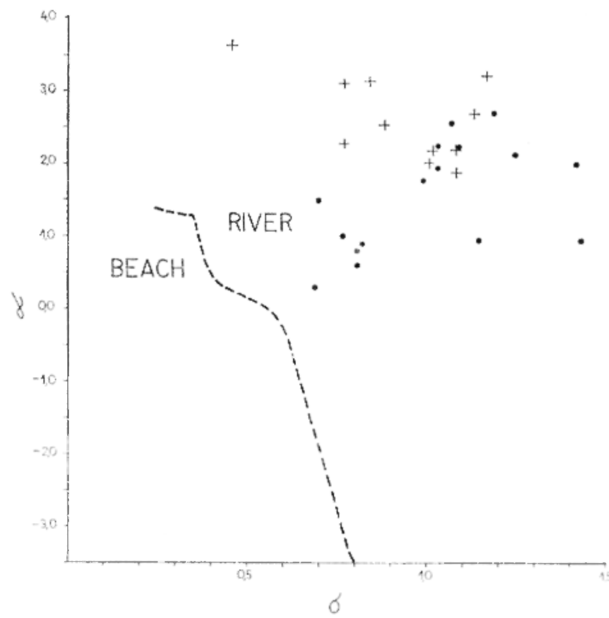

Fig. 5

Skewness (α) versus standard deviation (x̄), crosses—samples of members A and C, full dots—samples of member D

Diagram skośności rozkładu badanych piaskowców (α) i ich odchylenia standardowego (x̄), krzyżyki—próby z członów A i C, kropki—próby z członu D

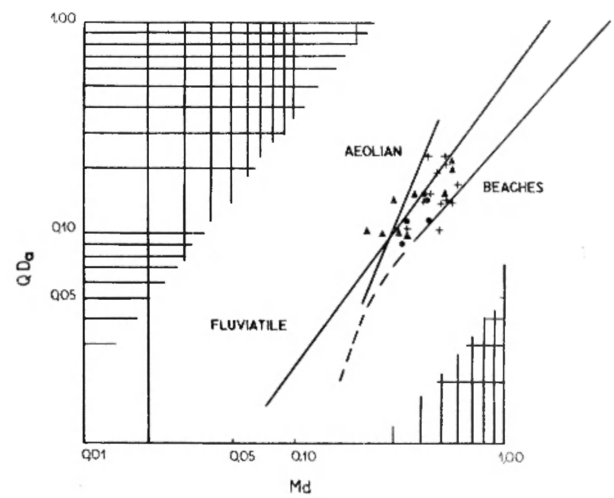

Fig. 6

Median diameter (Md) versus quartile deviation (QDa), full dots—samples of member A, triangles—samples of member C, crosses—samples of member D

Diagram median i odchylenia kwartyli badanych piaskowców, kropki—próby z członu A, trójkąty—próby z członu C, krzyżyki—próby z członu D to various members. The variability within each member is of the same range as that between the members. The only exception is member B, where the amount of carbonate material exceeds the amount of clastic material but this lies beyond the textural studies. Apart from the above mentioned parameters, the moments I, II and III were calculated in order to obtain the data to be plotted against the textural diagrams according to Friedman's (1961) method. The diagram in figure 4 gives no information about the environment as the plotted data are highly dispersed. On the other diagram (fig. 5) the points corresponding to sandstones of members A, C and D appear in a field of river deposits. It is startling in the case of members A and C because another data point rather to sea, lagoonal or lacustrine environment. It is possible, however, that the textural composition of the sandstones reflects the dynamics of river currents running into the basin, without an important change of character. An alternative explanation assumes a reworking of the sediments being earlier deposited under another conditions.

It should be stressed that the evidence for the redeposition occurs throughout the investigated sequence. The next diagram was constructed in terms of median/quartille deviation ratio (fig. 6). The trend lines on this diagram are assumed following Buller and McManus (1972). The points to represent each member have their own symbols. The pattern of point distribution related to the trend lines suggests the following: 1°. Points referring to samples of member A are clustered around the trend line of river or beach deposits. 2°. Samples of member C are mainly gathered along the trend line of aeolian deposits, less frequently along that of river sediments and only occassionaly, along the trend lines of beach deposits. 3°. Points referring to samples of member D are distributed mostly along the river deposits trend line, less frequently along the beach deposits trend line, and only in one case along the aeolian deposits trend line. It appears from the interpretation of these diagram that rocks of the featured sequence do not represent any well-defined environment. It is neccessary to remind here that the textural investigations refer only to small parts of members A and C. These two members are built mostly of non-clastic rocks. The member B is practically entirely represented by carbonates of probable marine origin. Hence, it may be assumed that the member A was deposited in the beach environment, member B in the tidal zone, member C in the supratidal environment with increasing, influence of terrigenous sedimentation, and member D under non-marine conditions, probably in mainly fluviatile environment.

SEDIMENTARY STRUCTURES

Cross bedding and parallel bedding are the most frequently met sedimentary structures in the described deposits. In the lower part of the presented sequence (member A) the both bedding may only be occassionally observed in the sandstones and mudstones, which in general are structureless. The rare cross-bedding is developed on a small or medium scale, and it usually is only slightly marked on outcrop faces. This bedding dips at an angle of 20—25°. In member C cross-bedding occurs more frequently and is more distinct. The medium-scale structures are more frequent than the small-scale ones, and sometimes large-scale cross-bedding can be observed as well. The orientations of dips of cross-bedding surfaces in rocks of members A, B and C, are illustrated in figure 7. Cross-bedding is frequent in member D where it is a very characteristic structure. Cross-bedding structures are developed on a small and medium scale, occasionally — on a large scale. Their dip directions are shown in figure 7. The angles of dips of the cross-bedding range from nearly 10° to more than 30°.

Erosive channels are the next type of structures that may be observed in the whole profile. They are often visible in the lower part of the profile (members A and B). The width of these erosive channels ranges from 1 to 3 m. They are filled with sandy--gravel material which passes upwards into fine sand or mud. It should be noticed that numerous structures of this sort have been recognised in the vicinity of Chełmsko (several kilometres from Kochanów) in rocks of the same age as those described above. The erosive structures encountered in the vicinity of Chełmsko will not be described here in detail as they are exposed beyond our studies' area. However, the occurrence of numerous channels throws some light on the character and dynamics of the sedimentary environment. In the upper part of the profile (members C and especially D), the erosive channels are less frequently met and they are usually filled with finer sandy material.

Vortex-casts were observed only in one old quarry of limestone (outcrop No 3). The vortex-casts are small about 3 cm deep.

In the same outcrop enigmatic structures, probably load-casts or structures which result from unstable density stratification (as described in Dżułyński 1966) may rarely be found. Both vortex-casts and unstable density stratification structures occur in member B.

Ripplemarks are encountered occasionally. They have amplitudes of the order of 10 cm and their wave-length amounts 1—1,5 m. In the described area the ripplemarks occur in members A, B and C, and outside this area in member D as well. Macroscopic biogenic structures have been observed only in outcrop No 3. They are the mud beds stirred by bioturbations but individual traces of organisms have not been found there. The biogenic structures seem to be restricted to members A and B.

One of the most interesting phenomena in the presented profile is the occurrence of mass-flow structures. Such structures were observed in two exposures. In outcrop No 1, the large blocks of limestone (tens centimetres in size) were embedded in the muddy-sandy sediment. The blocks are packed tightly close to one another, being seperated by thin rims of clastic material.

Faintly bedded limestones of these blocks do not permit to tell whether the blocks occupy their primary (in situ) position or are removed from it. This may be decided only in the ceiling of one of the small old galleries, where the purest portions of limestone were mined. In the other exposure (ouctrop No 3), the fragments of poorly compacted sandstones, occur as large as ten to tens centimetres. The fragments of sandstones are randomly scattered within the sandy material. They are well visible owing to the presence of distinct cross- and parallel-bedding both in these fragments and the surrounding sandy material (fig. 9). In the first of the above described cases, the mass-flow structures occur at the boundary between members B and C, in the second — within member C (fig. 2).

TRANSPORT DIRECTIONS

The transport direction analysis has been based on studies of orientation of various sedimentary structures mostly cross-beddings but erosive channels, ripplemarks and vortex-casts have also been taken into consideration. The readings obtained were plotted against the diagrams (fig. 7, 8) which revealed that clastic material in the whole carbonate — sandstones sequence was transported in general from SE towards NW. This direction is common in the Lower Triassic deposits in the northern part of the Intra-Sudetic trough, being controlled by the shape of this sedimentary basin (Mroczkowski 1977). The transport directions in Lower Permian deposits of the Intra-Sudetic trough reported by Dziedzic (1962) are very similar to the above presented paleocurrent directions in Zechstein and Lower Triassic deposits. This seems to suggest that the sedimentary basin existing in the discussed region since the Lower Permian had a well marked and remarkably constant shape or at least outline of its northeastern border. Such a long-termed, stable sedimentary basin must have been represented by a fairly deep depression in morphology. The published diagrams (fig. 7, 8) present not only the directions of clastic material transportation but also offer other informations. In the lower part of the profile where carbonate material prevails, the directions and dispersion of paleocurrents differ from those recognised in clastic sediments of the upper part of the sequence. But the diagrams should be interpreted cautiously because of low number

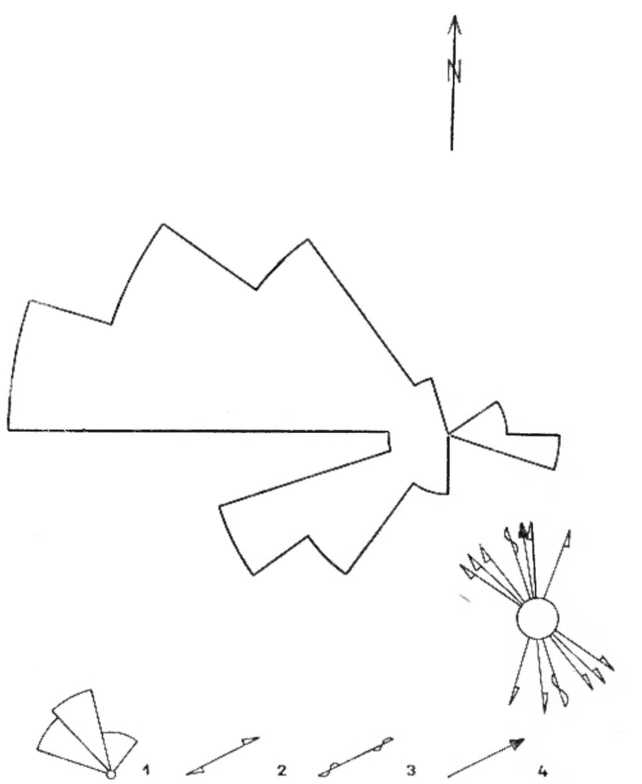

Fig. 7

Diagram to show transport direction of the clastic material, lower part of profile; members A, B and C

1 — cross-beddings; *2* — erosive channel axes; *3* — axes of ripplemarks; *4* — vortex-casts

Diagram kierunków transportu materiału klastycznego w dolnej części badanego profilu; człony A, B i C

1 — skośne warstwowanie; *2* — osie kanałów erozyjnych; *3* — osie grzbietów riplemarków; *4* — jamki wirowe

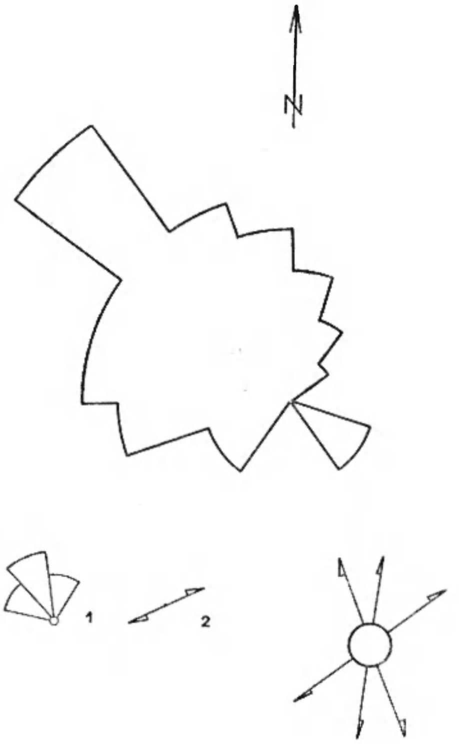

Fig. 8
Diagram showing transport direction of the clastic material, upper part of profile: member D
1 — cross-beddings; *2* — erosive channels axes

Diagram kierunków transportu materiału klastycznego w górnej części badanego profilu; człon D
1 — skośne warstwowanie; *2* — osie kanałów erozyjnych

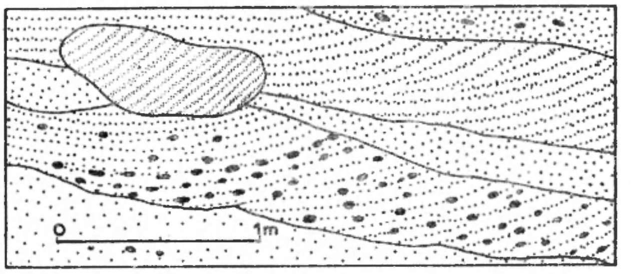

Fig. 9
Fragment of southern face of the quarry (outcrop No 1 member C). Marked are fragments of bedded sandstone bodies appearing randomly in bedded sandstone groundmass

Fragment ściany w południowej części odsłonięcia nr 1 (człon C). Zaznaczono fragmenty piaskowca z zachowanym warstwowaniem tkwiące w piaszczystym tle również wykazującym warstwowanie

of measurements resulting from the scarcity of exposures.

It is worthy to mention that the dispersion of paleocurrents similar to those presented above (fig. 7), was described by Selley (1967, 1968). According to him (Selley *op. cit.*) such a bimodal pattern may result either from the action of unidirectional current in a fluviatile or coastal environment (if it is able to form antidunes) or in a coastal environment as an effect of tidal currents, especially in estuaries. It is interesting that the similar pattern of current directions was recognised by Selley (1967) in coastal sediments composed of terrigenous quartz sand and marine carbonate detritus. One can notice that the case described by Selley (*op. cit.*) resembles situation in the lower part of the sequence featured by the present authors. The authors, however fail to observe antidunes which play an important role in Selley's model. Therefore, in spite of close resemblance of the paleocurrent diagrams in figure 8 to those presented in Selley's (1968) paper, they cannot draw any conclusions going too far.

CONCLUSIONS

SEDIMENTARY AND DIAGENETIC CONDITIONS

Certain conclusions referring to the investigations carried out by means of various methods have already been presented in the preceeding chapters. The correctness of some of these partial results has also been checked by using other methods. Then the results obtained may be treated as well proved ones. Applying this scheme of data processing, the authors tried to reconstruct the sedimentary environment of rocks outcropping in the vicinity of Kochanów.

1°. Clastic-carbonate deposits of member A were most probably developed partly in the shallow coastal zone of a marine basin and partly on beaches, the deposits being influenced by a significant amount of terrigenic material derived from the basin sides. This is evidenced mostly by clastic sediments, their petrographical and textural composition, and the presence of stromatolitic structures yet rare and fragmentaric in this member.

2°. Carbonate deposits of member B were developed in the tidal zone of a marine basin, in warm or hot climate. The clastic material was provided in very small quantities, which might be connected with the absence of greater rainfalls on the land and/or lowering of land relief. In the present authors' opinion, this is evidenced by numerous stromatolitic structures, presence of drusy mosaic cement, presence of certain sedimentary structures and generally organogenic-chemical nature of the discussed sediments.

3°. Clastic- carbonate deposits of member C were developed mainly in the supratidal zone affected increasingly by the clastic material coming from the land. This clastic material was added to the coarse-grained carbonate material originating from the destroyed deposits of member B.

Deposits of member C are characterized by an increase of energy of environment, which may be connected with the intensification of diastrophic movements.

Such an idea is confirmed by the appearance of mass-flow-structures in the deposits of member C and even at the B/C members boundary. The terrigenic material had been supplied more intensly as it may be infered from petrographical and textural analyses.

4°. The clastic deposits of member D consequently exhibit the features of a nonmarine fluviatile environment. In this member one can observe the sedimentary structures and textural features typical of fluviatile environment. Carbonate material is absent from rocks of this member.

The opinions presented concerning the development of rocks of individual members could be summarized as follows: the presented profile reflects the steadily changing sedimentary conditions from coastal to fluviatile ones. The part of the questioned deposits developed in a marine or lagoon environment exhibits some variability which reflects the shore-linie oscillation. This resembles a certain section of the profile described by Vissner, Grobler (1972). The rocks of members A, B, and C were finally formed by the diagenetic processes, namely: cementation, dolomitization, and development of concretions. Different types of cement were observed in rocks of member B, including a drusy-mosaic cement produced in the early diagenetic phase. Similar sorts of cement were found by Peryt, Piątkowski (1976) in Zechstein deposits of NW Poland.

STRATIGRAPHICAL POSITION

The lack of paleontological evidence has made the present authors discuss the problems of stratigraphical position merely in terms of the reconstruction of the sedimentary environment and changes of this environment (in time). As it has been mentioned above, in the presented sequence, the transition may be observed from the deposits which show significant influence of a marine or lagoon environment (members A, B and C) to the non-marine sediments of fluviatile type (member D). The whole complex under discussion lies above relatively well evidenced rocks of the Rotliegendes, and beneath Cretaceous rocks with fauna. Jurassic deposits are absent from the Sudetes, and in the Intra-Sudetic trough the rocks that could be included to the Roethian or Middle and upper Triassic have not been observed either. Therefore, the described sequence of sedimentary rocks must have been deposited during the Zechstein and the Early Triassic. The well recognised and paleontologically evidenced Zechstein deposits in both the adjacent areas and in the whole Middle Europe, are in general, of marine or lagoon origin. In these deposits, the chemical and organic sediments play an important role. Lower Triassic deposits in these regions are most of all non-marine, clastic rocks. Only exceptionally, but not in the Sudetes, they have thin marine intercalations. The beds of Kochanów are similar in their facies development to marine or lagoonal Zechstein deposits in the lower part of the profile (members A, B and C), but in its upper part (member D) — to fluviatile deposits of the Lower Triassic. In consequence the authors find that the complex of beds from Kochanów represents an undertermined part of the Zechstein and lower units of Bunter.

This complex was developed essentially continuously without important interruptions. Transitions between particular members are fluent. The deposits of members A, B and C represent various zones of the same marine or lagoon environment but the rocks of member D were deposited in a quite different, non-marine environment.

Therefore the present authors propose to locate the Zechstein/Triassic boundary between members C and D.

The changes of environment might result from diastrophic movements apart from the climatic variations. Most probably the mass-flow-structures in member C were due to diastrophic movements. The movements likely affected the whole area of the Intra-Sudetic trough and caused a remarkable re-juvenation of topographic relief (see eg. Holoub 1975); they vanished in the Early Triassic. The paleogeographical development of the Kochanów region is as follows. In the Zechstein period, there was a shallow-water basin of a marine gulf or lagoon type with the labile shore-line. Both oscillations of this shore-line and climatic variations caused the periodic transport of clastic material from the adjacent areas into the basin. From a certain moment the basin was more and more intensly filled with the fine-grained clastic material supplied by rivers and streams. Finally the organo-chemical sedimentation was ended. Instead the fluviatile sedimentation displaying features of the high energy environment, started to develop.

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Stanisław LORENC* Jerzy MROCZKOWSKI**

SEDYMENTACJA I PETROGRAFIA UTWORÓW CECHSZTYNU I NAJNIŻSZEGO TRIASU W REJONIE KOCHANOWA (NIECKA ŚRÓDSUDECKA)

Streszczenie

Pierwsze wzmianki o występowaniu utworów cechsztynu i triasu w niecce północnosudeckiej zamieszczone są w pracy Zimmermanna i Berga z 1904 r. Badacze ci stwierdzili, że część osadów, zaliczanych poprzednio do czerwonego spągowca (Beyrich *et al.* 1867, Flegel *et al.* 1904), wykazuje duże podobieństwo litologiczne do skał cechsztynu i triasu z niecki północnosudeckiej. Wkrótce potem Berg (1905) przedstawił dokładniejsze propozycje podziału stratygraficznego dla części profilu skał osadowych w niecce śródsudeckiej, zaliczając do cechsztynu dolomityczne arkozy i wapienie o łącznej miąższości około 20 m, a do piaskowca pstrego czerwone piaskowce z otoczakami i białe piaskowce, osiągające razem około 75 m miąższości. Przedstawiony schemat stratygraficzny został zastosowany w mapach geologicznych Dathego i Berga (1912), Berga (1909, 1938), Dathego i Petrascheck'a (1933). W międzyczasie ukazała się obszerna praca Mullera (1930), który całemu kompleksowi osadów zaliczanych przez wyżej wspomnianych autorów do cechsztynu i triasu przypisał wiek cechsztyński. Pogląd Mullera (*op. cit.*) podtrzymywany jedynie przez Scupina (1937) pozostał odosobniony i w późniejszych publikacjach konsekwentnie przyjmowano występowanie w niecce śródsudeckiej zarówno cechsztynu, jak i dolnego triasu (Berg 1938, Tasler 1961, 1966; Valin 1964). Wobec braku fauny stratygrafia osadów cechsztynu i triasu została oparta na korelacji litostratygraficznej z utworami permu i triasu niecki północnosudeckiej. W tej sytuacji istnieją jednak duże trudności w jednoznacznym określeniu granicy między permem a triasem, stawianej w różnych miejscach profilu przez cytowanych wyżej autorów. Problematyczny jest również zasięg występowania utworów cechsztynu i triasu. Według mapy Dathego i Petrascheck'a (1933) utwory te występują w całej niecce śródsudeckiej; jednakże w południowo-wschodniej części niecki nie obserwuje się piaskowców wykazujących podobieństwo do osadów dolnotriasowych z dobrze poznanego obszaru Łącznej, Chełmska czy Kochanowa w północnej części niecki. Cechsztyński wiek osadów węglanowych w południowej części niecki, w rejonie Radkowa został ostatnio zakwestionowany przez Śliwińskiego (1976), który uznał je za osady typu caliche rozwinięte w dolnopermskich osadach klastycznych.

Odrębne niż w innych partiach Sudetów wykształcenie utworów cechsztynu wraz z sedymentacyjnym przejściem tychże do dolnotriasowych stwarza możliwość dość dowolnych interpretacji stratygraficznych. W tej sytuacji autorzy podjęli próbę wyjaśnienia przynajmniej części wyżej wspomnianych problemów na podstawie badań wykonanych na niewielkim, lecz stosunkowo dobrze odsłoniętym obszarze Kochanowa, w północnej części niecki śródsudeckiej (fig. 1). Wobec braku odsłonięć ukazujących kompletny profil badanych osadów konieczne było przede wszystkim ustalenie zasad korelacji, które pozwoliłyby na zestawienie z poszczególnych fragmentów, obserwowanych w różnych odsłonięciach, profilu syntetycznego. Dokonano tego na podstawie badań petrograficznych. Następnym etapem pracy była próba rekonstrukcji środowisk, w jakich były osadzane skały omawianego profilu, co z kolei pozwoliło na wyciągnięcie wniosków stratygraficznych. Autorzy wyszli z założenia, że wyraźna zmiana środowiska powinna nastąpić na przejściu perm/trias. Oczywiście w ten sposób określona granica stratygraficzna będzie nieostra i nie może być traktowana jako granica pomiędzy jednostkami chronostratygraficznymi. Rekonstrukcję środowisk oparto na badaniach struktur sedymentacyjnych, pomiarach kierunków transportu (fig. 7, 8), badaniach petrograficznych (fig. 3), granulometrycznych (tab. 1; fig. 4, 5, 6) i chemicznych (tab. 2).

W badanym profilu wyróżnić można cztery człony (A, B, C, D) różniące się od siebie pod względem składu litologicznego. Najbardziej kompletny profil można obserwować w odsłonięciu nr 1, gdzie brak jedynie części spągowej, występującej z kolei w odsłonięciu nr 2 (fig. 2).

Najniżej leżący w profilu człon A, o miąższości około 4–5 m, reprezentują wapienie piaszczyste i silnie wapniste piaskowce. Mikrokawerny w wapieniach są czasem wypełnione drobną szczotką kalcytową, a w obrębie wapnistych piaskowców obserwuje się gruzły dolomityczne kilkucentymetrowej średnicy. W obrębie opisywanego członu obserwuje się także wapniste zlepieńce o miąższości 1 m, gdzie bloczki wapnistych piaskowców i wapieni osiągają długości rzędu kilkudziesięciu cm. Określony pod mikroskopem skład petrograficzny materiału klastycznego członu A przedstawia się następująco: kwarc, skalenie potasowe

* Instytut Nauk Geologicznych Uniwersytetu Wrocławskiego, ul. Cybulskiego 30, 50–205 Wrocław.
** Zakład Nauk Geologicznych PAN, Pracownia Geologii Starych Struktur, ul. Cybulskiego 30, 50–205 Wrocław.

i plagioklazy, rzadko fragmenty skał metamorficznych i wylewnych (fig. 3). Wielkość składników detrytycznych oraz inne parametry teksturalne przedstawiono w tabeli 1. Rolę spoiwa pełni substancja mikrytowa lub rzadziej mikrytowo-sparytowa, zajmująca od kilkunastu do ponad 70% objętości skały. Ilość substancji węglanowej w skale jest zmienna, z tendencją do zwiększania się w kierunku osi niecki. W niewielkim stopniu rolę spoiwa pełni substancja ilasta lub ilasto-żelazista. Pochodzenie minerałów ilastych należy wiązać głównie z rozkładem skaleni, które ulegają też korodowaniu przez węglany. Oprócz wietrzenia chemicznego w niektórych ziarnach detrytycznych obserwuje się wietrzenie fizyczne polegające na pękaniu ziarn, najprawdopodobniej na skutek dobowych zmian temperatury. Zjawisko to musiało zachodzić w warunkach nadwodnych, w klimacie pustynnym lub półpustynnym. Bardzo charakterystyczną cechą skał członu A jest występowanie w nich otoczek algowych wokół składników detrytycznych. W niektórych partiach skały nagromadzenie otoczek jest tak znaczne, że skałę można już określić jako biomikryt. Sporadycznie ten biomikryt jest laminowany i wykazuje podobieństwo do osadów mat algowych. Ze względu na skład chemiczny, skały węglanowe tego członu należy zaliczyć do słabo wapiennych dolomitów.

Człon B budują homogeniczne wapienie, w stropie nieco zapiaszczone, o miąższości około 2 m. Są to biomikryty lub biomikrosparyty z licznymi strukturami algowymi o charakterze stromatolitów. Struktury te obserwowano w płytach cienkich z prób wapieni pobranych w odsłonięciu nr 1. Puste przestrzenie w masie mikrytowej wypełnia cement sparytowy. Obok kalcytowego cementu romboedrycznego (por. Beales 1971) w kilku przypadkach udało się stwierdzić cement druzowato mozaikowy, co wskazuje na diagenezę osadu w warunkach przynajmniej okresowego wynurzenia i pod działaniem klimatu pustynnego lub półpustynnego. Pod względem chemicznym skały członu B są dolomitami i słabo wapiennymi dolomitami. Czasem w masie węglanowej występuje drobnokrystaliczna krzemionka i sporadycznie ziarna detrytycznego kwarcu, których ilość spada w kierunku osi niecki.

Osady członu C wykazują głównie piaszczysty lub piaszczysto-zlepieńcowaty charakter. W spągu występują wapniste piaskowce i zlepieńce zawierające głównie bloczki wapieni oraz buły i gruzły dolomitowe osiągające do 50 cm średnicy. Wyżej występują piaskowce i zlepieńce o spoiwie ilastym lub ilasto-żelazistym, dość wyraźnie uławicone. Łączną miąższość osadów członu C ocenia się na około 6 m. Znaczna część materiału, szczególnie z dolnej części członu C pochodzi z erodowanych osadów członu B.

Człon D reprezentują wyłącznie osady klastyczne, obserwowane w stropowych partiach odsłonięć nr 1 i nr 3 oraz w małych odsłonięciach nr 4 i nr 5 (fig. 1). Są to głównie piaskowce nie różniące się w sposób istotny od piaskowców spotykanych w niższej części profilu; głównym składnikiem jest kwarc stanowiący w badanych próbach od 73% do ponad 90% objętości skały. Resztę składników stanowią skalenie, rzadziej łyszczyki i fragmenty skał. Matrix występuje w bardzo zmiennych ilościach od 0 do ponad 20%. Według klasyfikacji Gilberta (Williams *et al.* 1955) piaskowce te należą do arenitów skaleniowych lub wak skaleniowych, rzadziej do wak kwarcowych (fig. 3). Dane granulometryczne piaskowców przedstawiono w tabeli nr 1.

Spośród obserwowanych w badanym profilu struktur sedymentacyjnych najbardziej rozpowszechnione są warstwowania skośne lub równoległe. Najwięcej tych struktur pojawia się w członach C i D, gdzie szczególnie skośne warstwowania stają się strukturą bardzo charakterystyczną dla wyglądu skał. W tej części profilu pojawiają się sporadycznie skośne warstwowania w dużej skali, które nie są spotykane w dolnej części. Kierunki nachylenia skośnych warstwowań przedstawiono na diagramach (fig. 7, 8).

Strukturami, które można obserwować również w całym badanym profilu są kanały erozyjne. Najczęściej spotyka się je w dolnej części profilu (człony A i B), w przekrojach zbliżonych do poprzecznych. Są to niewielkie formy o szerokości kilkudziesięciu cm (wyjątkowo 1—3 m) wypełnione materiałem żwirowo-piaszczystym przechodzącym ku górze w mułowcowy. W górnej części profilu (człony C i D) kanały spotyka się rzadziej i z reguły są one wypełnione drobniejszym materiałem.

W jednym tylko miejscu, w odsłonięciu nr 3 (człon B), można obserwować jamki wirowe o głębokości 3 cm oraz niewyraźnie wykształcone struktury powstałe w wyniku niestatecznego warstwowania gęstościowego. Również bardzo rzadko spotyka się riplemarki o amplitudach rzędu 10 cm i długości fali 1-1,5 m. Riplemarki na badanym obszarze obserwowano w członach A, B i C, wiadomo jednak z obserwacji prowadzonych poza obszarem Kochanowa, że występują one także w członie D.

Widoczne makroskopowo struktury biogeniczne, a mianowicie bioturbacyjne zaburzenia warstw znaleziono w jednym tylko miejscu, w odsłonięciu nr 3, w osadach członów A i B.

Jednym z najbardziej interesujących zjawisk w opisywanym profilu są spływy masowe. Struktury powstałe w wyniku spływów obserwuje się w odsłonięciu nr 3 na granicy B i C oraz w odsłonięciu nr 1, w członie C (fig. 9). W pierwszym przypadku widoczne są kilkudziesięciocentymetrowe bloki wapienia tkwiące w mułowcowo-piaszczystym osadzie, a w drugim — kilkudziesięciocentymetrowe bloki słabo zwięzłego piaskowca o zachowanym warstwowaniu, tkwiące w różnych położeniach, w piaszczystym tle.

Na podstawie obserwacji i pomiarów sedymentacyjnych struktur kierunkowych: skośnych warstwowań, kanałów erozyjnych, riplemarków, jamek wirowych dokonano analizy kierunków transportu (fig. 7, 8). Jak się okazało, transport materiału klastycznego odbywał się w czasie sedymentacji osadów całego badanego profilu z południowego wschodu na północny zachód. Kierunek ten jest zbliżony do kierunku transportu w dolnym permie w tym fragmencie niecki śródsudeckiej (por. Dziedzic 1962) i odpowiada kierunkom transportu stwierdzonym w piaskowcu pstrym na obszarze północnej części niecki. Wiąże się to prawdopodobnie z istnieniem co najmniej od dolnego permu do dolnego triasu basenu sedymentacyjnego, którego wschodni i północno-wschodni brzeg przebiegały mniej więcej zgodnie ze współczesnym zarysem granic geologicznych omawianej części niecki śródsudeckiej.

Rekonstrukcja warunków, w jakich powstawały osady poszczególnych członów profilu wygląda następująco: 1. Klastyczno-węglanowe osady członu A powstały najprawdopodobniej częściowo w płytkiej przybrzeżnej części zbiornika morskiego, a częściowo w strefie plaż, przy znacznym wpływie materiału terygenicznego dostarczanego z brzegów basenu. Świadczy o tym klastyczny przeważnie charakter osadu i jego skład petrograficzny i granulometryczny oraz nieliczne jeszcze i fragmentarycznie wykształcone struktury stromatolitowe; 2. Węglanowe osady członu B stanowią osady strefy pływów zbiornika morskiego w klimacie ciepłym lub gorącym. Ograniczenie ilości materiału klastycznego wynikło prawdopodobnie z obniżenia reliefu lądu i zmniejszenia ilości opadów. Takie wnioski autorzy opierają na licznie występujących w tym członie strukturach stromatolitowych, obecności cementu druzowato-mozaikowego i na obserwacji struktur sedymentacyjnych; 3. Klastyczno-węglanowe osady członu C powstały głównie powyżej średniego zasięgu pływów, przy wzrastającym udziale materiału okruchowego pochodzącego z niszczonych osadów członu B i z brzegów basenu, w warunkach wyraźnie zwiększonej energii środowiska. Wnioski te autorzy wyciągnęli z obserwacji składu granulometrycznego i petrograficznego oraz z obecności spływów masowych; 4. Klastyczne osady członu D wykazują dość konsekwentnie cechy środowiska lądowego, rzecznego. Taki obraz wynika z obserwacji struktur sedymentacyjnych, składu petrograficznego (całkowity brak węglanów) i z parametrów granulometrycznych.

Istotną rolę w ostatecznym ukształtowaniu skał występujących w członach A, B, C odegrały także procesy diagenetyczne.

Problem przynależności stratygraficznej skał z omawianego profilu wobec braku danych biostratygraficznych rozpatrywany był na podstawie rekonstrukcji środowiska. Na podstawie wcześniejszych badań (cytowanych w tej pracy) przyjęto, że wiek badanych skał zawiera się pomiędzy dolnym permem a retem. Autorzy są zdania, że można tu podjąć próbę dokładniejszego wskazania wieku na podstawie analogii środowisk sedymentacji lepiej udokumentowanych stratygraficznie utworów cechsztynu i triasu w obszarach sąsiednich do zrekonstruowanych środowisk, w jakich powstawały osady omawianego profilu. Najbardziej uzasadnione wydaje się zaliczenie członów A, B i C, utworzonych w warunkach przybrzeżno-morskich czy lagunowych do cechsztynu. Osady członu D utworzone w środowisku fluwiatylnym należałyby już do dolnego triasu. Tam gdzie zarysowuje się najbardziej wyraźna zmiana środowiska spowodowana obok zmian klimatycznych ruchami diastroficznymi między członami C i D należy zdaniem autorów stawiać granicę między utworami permu i triasu. Należy jednak podkreślić, że wszystkie przejścia pomiędzy poszczególnymi członami mają charakter sedymentacyjny i odzwierciedlają stopniowe zastępowanie jednego typu sedymentacji przez drugi. Nie ma więc mowy o postawieniu tu, w świetle dotychczasowych badań, ostrej granicy stratygraficznej, ponadto granica ta nie może być uważana za granicę w sensie chronostratygraficznym.

PLANSZE I OBJAŚNIENIA

PLATE I

PLANSZA I

1. Deposits of member B in outcrop No 3; general view
Osady członu B w odsłonięciu nr 3. Widok ogólny

2. Deposits of member B (lower part) and member C (upper part) in outcrop No 3; general view
Osady członu B (u dołu) i członu C (u góry) w odsłonięciu nr 3. Widok ogólny

3. Deposits of member C (lower part) and member D (upper part) in outcrop No 1; general view
Osady członu C (u dołu) i członu D (u góry) w odsłonięciu nr 1. Widok ogólny

4. Transition from deposits of member C to member D in outcrop No 1
Przejście osadów członu C w osady członu D. Szczegół z odsłonięcia nr 1.

PLATE I
PLANSZA I

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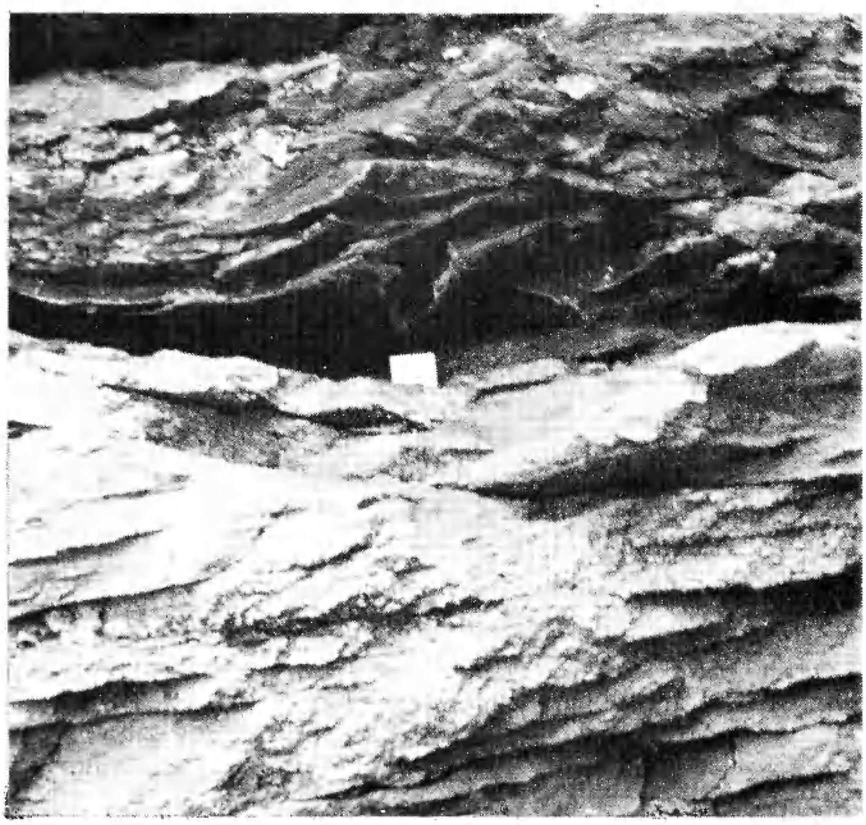

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Stanisław LORENC, Jerzy MROCZKOWSKI — The sedimentation and petrography of Zechstein and lowermost Triassic deposits in the vicinity of Kochanów (Intra-Sudetic trough)
Sedymentacja i petrografia utworów cechsztynu i najniższego triasu w rejonie Kochanowa (niecka śródsudecka)

PLATE II

PLANSZA II

1. Clastic deposits of member A. Visible are quartz, feldspar grains and carbonate cement. Mag. 30×. Crossed nicols

Osady klastyczne członu A. Widoczne ziarna kwarcu i skaleni oraz węglanowe spoiwo. Pow. 30×. Nikole skrzyżowane

2. Deposits of member A. Visible plagioclase grain divided due to physical weathering into fragments having the same optical orientation. Fine grains of quartz occur between the fragments. Mag. 20×. Crossed nicols

Osady członu A. Widoczne ziarno plagioklazu rozdzielone wskutek wietrzenia na fragmenty o identycznej orientacji optycznej. Między fragmentami plagioklazu występują drobne ziarna kwarcu. Pow. 20×. Nikole skrzyżowane

3. Deposits of member A. Visible are quartz grains with algal aureoles cemented by carbonate material. Mag. 28×. One nicol

Osady członu A. Widoczne ziarna kwarcu otoczone obwódkami algowymi i spojone substancją węglanową. Pow. 28×. Pojedynczy nikol

4. Deposits of member A. Alternation of carbonate (dark) and clastic laminate. Mag. 7 x. One nicol

Osady członu A. Widoczne naprzemianległe niewyraźne laminy węglanowe (ciemne) i klastyczne. Pow. 7×. Pojedynczy niko

5. Deposits of member A. Rare clastic grains with algal aureoles in biomicritic mass with discernible algal coloniec. Mag. 40×. One nicol

Osady członu A. Nieliczne detrytyczne ziarna z otoczkami algowymi tkwią w masie biomikrytowej, w której widoczne są kolonie alg. Pow. 40×. Pojedynczy nikol

6. Strongly recrystalized carbonate deposits of member B having dolomite composition. Mag. 40×. One nicol

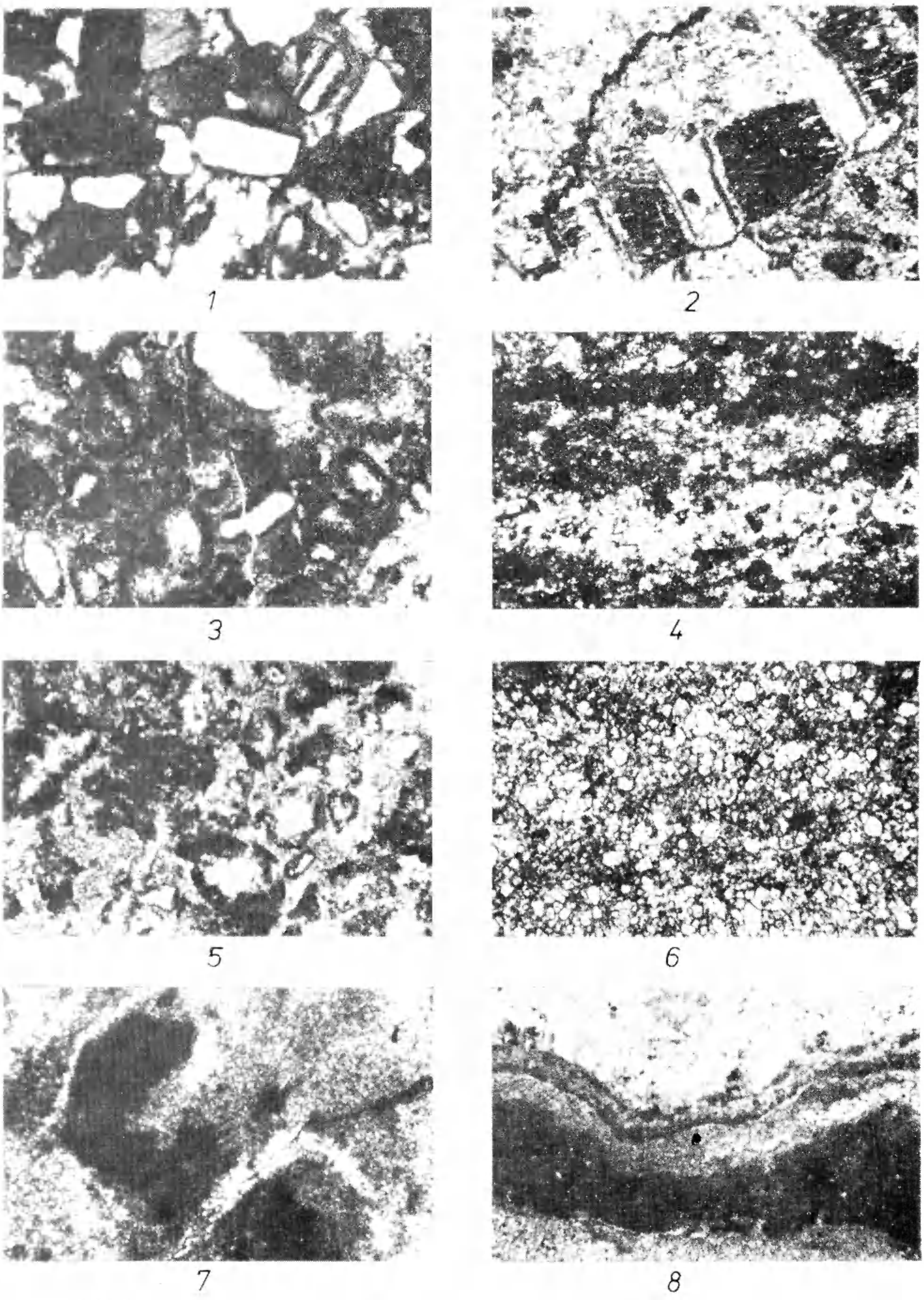
Osady węglanowe członu B, silnie zrekrystalizowane, o składzie dolomitu. Pow. 40×. Pojedynczy nikol

7. Carbonate deposits of member B. Visible intraclasts in micritic material. Mag. 35×. One nicol

Osady węglanowe członu B. Widoczne intraklasty tkwiące w mikrytowym tle. Pow. 35×. Pojedynczy nikol

8. Carbonate deposits of member B. Deflected laminae of biomicrite (dark) and carbonate cement in the intra-lamina spaces. Mag. 33×. One nicol

Osady węglanowe członu B. Widoczne powyginane laminy biomikrytu (ciemne) oraz węglanowy cement wykształcony w przestrzeniach między laminami. Pow. 33×. Pojedynczy nikol



Stanisław LORENC, Jerzy MROCZKOWSKI – The sedimentation and petrography of Zechstein and lowermost Triassic deposits in the vicinity of Kochanów (Intra-Sudetic trough)
Sedymentacja i petrografia utworów cechsztynu i najniższego triasu w rejonie Kochanowa (niecka śródsudecka)

PLATE III

PLANSZA III

1. Carbonate deposits of member B. Deflected laminae of biomicrite (dark); carbonate cement in intra-lamina spaces. Mag. 36 ×. One nicol

Osady węglanowe członu B. Widoczne powyginane laminy biomikrytu (ciemne) oraz węglanowy cement wykształcony w przestrzeniach między laminami. Pow. 36×. Pojedynczy nikol

2. Carbonate deposits of member B. Visible laminae of biomicrite and different generations of cement; at the top — drusy mosaic cement. Mag. 36 ×. One nicol

Osady węglanowe członu B. Widoczne laminy ciemnego biomikrytu i różne generacje cementu, w tym także cement druzowato-mozaikowy (w górnej części). Pow. 36×. Pojedynczy nikol

3. Carbonate deposits of member B, with structures of oncoide-type. Mag. 28 ×. One nicol

Osady węglanowe członu B ze strukturami organogenicznymi o charakterze onkoidów. Pow. 28×. Pojedynczy nikol

4. Unidentified organogenic-like structure (bryozca?) in the carbonate deposits of member B. Mag. 26 ×. One nicol

Niezidentyfikowana struktura organogeniczna (mszywioł?) w osadach węglanowych członu B. Pow. 26×. Pojedynczy nikol

5. Clastic deposits of member C containing carbonate cement. Visible plagioclase grain corroded by carbonate. Mag. 23×. Crossed nicols

Osady klastyczne członu C ze spoiwem węglanowym. Widoczne ziarno plagioklazu trawionego przez węglany. Pow. 23 ×. Nikole skrzyżowane

6. Clastic deposits of member C. Fragment of recrystallized carbonate sediment (dolomite) coming from member B. Mag. 66×. Crossed nicols

Osady klastyczne członu C z fragmentami rekrystalizowanego osadu węglanowego (dolomitu) z członu B. Pow. 66 ×. Nikole skrzyżowane

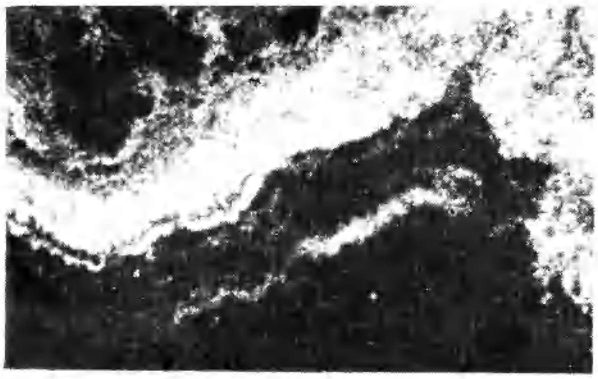
7. Fine-grained deposits of member C. Weakly diagenesed fragment of sediment of member B. Mag. 45 ×. Crossed nicols

Drobnoklastyczne osady członu C z fragmentem słabo zdiagenezowanego osadu węglanowego członu B. Pow. 45×. Nikole skrzyżowane

8. Clastic deposits of member C containing carbonate-clayey cement. Mag. 30×. Crossed nicols

Osady klastyczne członu C z węglanowo-ilastym spoiwem. Pow. 30×. Nikole skrzyżowane

PLATE III
PLANSZA III



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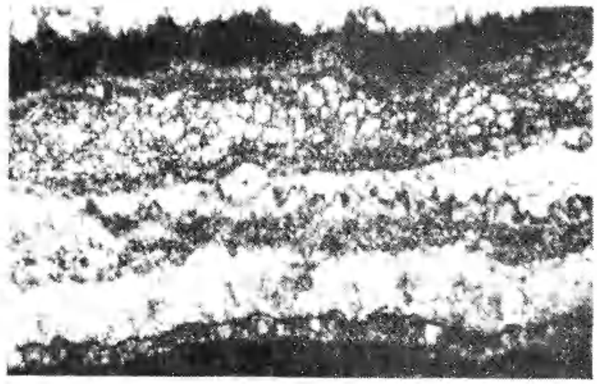

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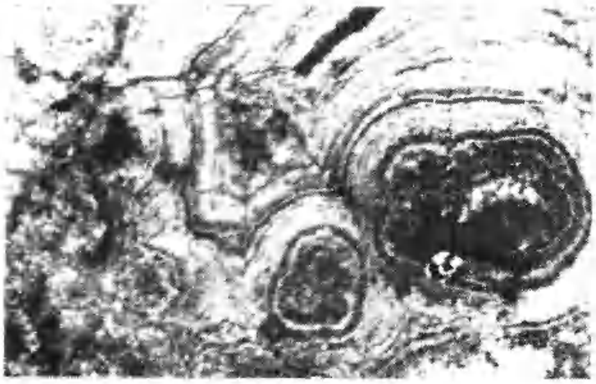

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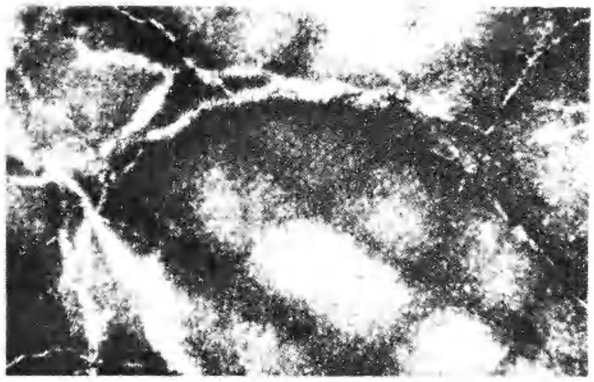

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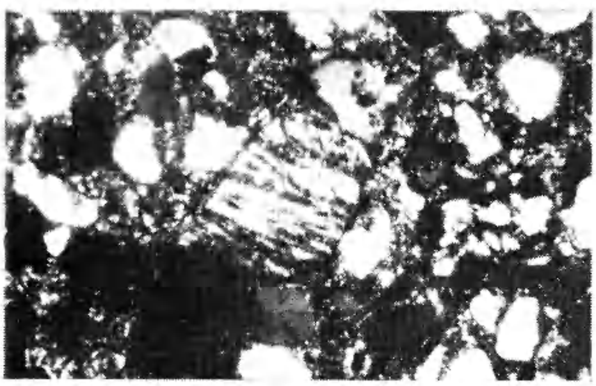

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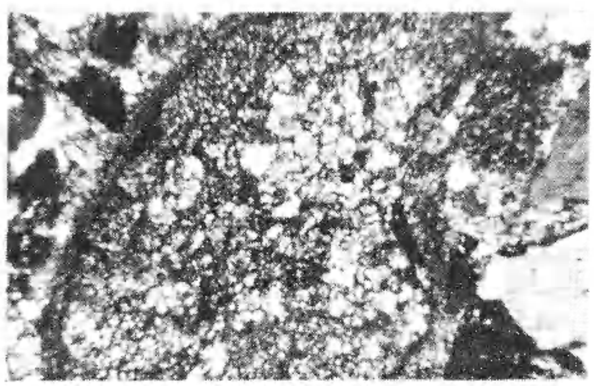

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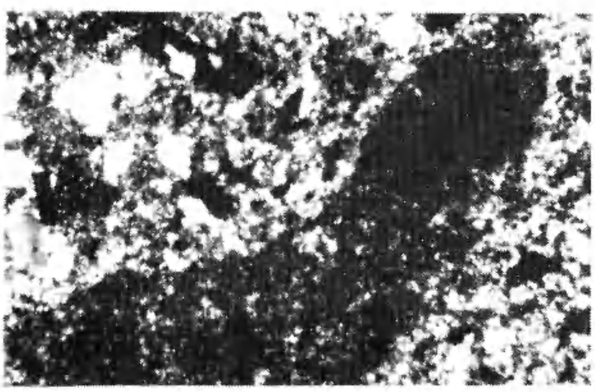

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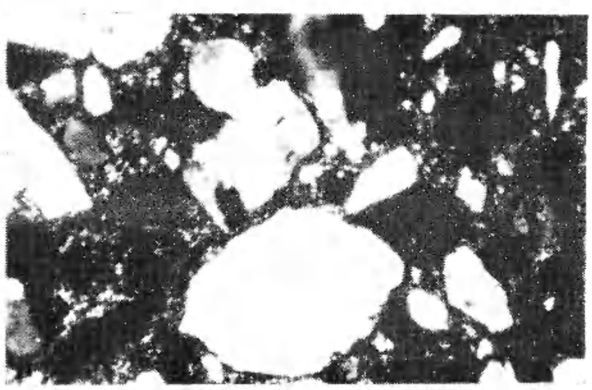

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Stanisław LORENC, Jerzy MROCZKOWSKI — The sedimentation and petrography of Zechstein and lowermost Triassic deposits in the vicinity of Kochanów (Intra-Sudetic trough)
Sedymentacja i petrografia utworów cechsztynu i najniższego triasu w rejonie Kochanowa (niecka śródsudecka)