KOMITET GEOLOGICZNY POLSKIEJ AKADEMII NAUK

PAŃSTWOWE WYDAWNICTWO NAUKOWE . WARSZAWA

acta geologica polonica

Vol. 21, No. 2 Warszawa 1971

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A flysch/littoral succession in the Sudetic Upper Cretaceous

ABSTRACT: The Coniacian marine sediments of the Nysa graben (Idzików Beds) are divided into the lower member consisting of alterning claystone and sandstone layers, and the upper member comprising sandstones and conglomerates. Sedimentary features of the lower member, especially the type of bedding planes, sole markings, trace fossils, succession of structures and textures indicate that the principal agents controlling the sedimentation were subaqueous mass movements and turbidity currents. The upper member shows the features of shallow water sediments, including medium- and large-scale cross-bedded units and numerous fossils, *i.a.* shallow water lamellibranchs, gastropods and decapods. The sequence and distribution of facies within the Idzików Beds point to a consistent development of the sedimentary basin in which were laid down in succession: distal turbidites, proximal turbidites, shallow water and high-energy littoral deposits. Such a development was closely related and synchronous to the uprising movements in the fore-Sudetic land and in the Śnieżnik and Kłodzko massifs. The tectonic uprising movements which embraced parts of these massifs were coming closer and closer to the Nysa graben, and caused migration of the facies and finally led to the regression of the sea.

INTRODUCTION

Within the Upper Cretaceous marine deposits infilling the Nysa graben, the Idzików clays (*Kieslingswalder Tone*) and younger Idzików sandstones (*Kieslingswalder Sandstein*) were distinguished as early as in the middle of the last century (Geinitz 1843, Beyrich 1855). Originally, these names were used to designate the deposits ranging in the geological profile from the Middle Turonian up to and including the Emscherian (Sturm 1901). Later, they were restricted to the Upper Turonian and Emscherian deposits (Rode 1936). Recently, the Idzików clays and sandstones have been classed as a whole with the Coniacian (Pachucki 1959, Radwańska 1960), and these are threated in the present paper as the Idzików Beds.

The lowest horizon of the Coniacian within the Nysa graben is formed, like in a considerable area of the Bohemian Massif, by the so called clinking shales (Soukup 1959, Pachucki 1959, Svoboda & al. 1966). The overlying, poorly cemented claystones which include numerous sandstone layers (Pl. 1, Figs 1—3) are called in the present paper as the lower member of the Idzików Beds, and they are distinguished from the upper member which comprises mainly sandstones and conglomerates.

In the lower member of the Idzików Beds, the lithofacies of the clayey flysch and of the normal flysch have been distinguished (cf. Dżułyński & Smith 1964). The upper member of these Beds has been also found to consist of two lithofacies: the fine- and medium-grained sandstones exposed chiefly in the vicinity of Stary Waliszów and Idzików, called the Idzików sandstones, and the conglomerates with fine- and medium-grained sandstone layers, regarded as the Idzików conglomerates.

Other lithofacial classifications proposed in former geological studies for the Idzików Beds (Sturm 1901; S. Radwański 1961, 1966) have not been confirmed according to the observations presented in this paper.

Acknowledgements. The author is greatly indebted to Prof. Dr. H. Teisseyre, heading the research work on this subject, for his help in preparing the paper. The author also thanks Prof. Dr. S. Dżułyński for numerous suggestions and explanations concerning problems of flysch sedimentation, Doc. Dr. J. Don for many valuable remarks and discussions, Doc. Dr. A. Radwański for helping in final revision of the text, and Dr. A. Teisseyre for turning the attention to an interesting exposure at Krosnowice.

STRATIGRAPHIC AND TECTONIC POSITION OF THE IDZIKÓW BEDS

The age of the lower member of the Idzików Beds, represented by claystones containing numerous sandstone layers with sharply defined lower limits is not questionable. It evidently belongs to the Coniacian, what is evidenced by the index fossils frequently occurring in the claystones, viz.: *Inoceramus koeneni* G. Müller (cf. Pl. 2, Figs 1—2 with Heinz 1928, p. 37, Pl. 3, Fig. 2; Tröger 1969a, p. 71, Fig. 2 and Pl. 1, Fig. 2) and *Peroniceras tricarinatum* (d'Orbigny) (cf. Pl. 2, Fig. 3—4 with d'Orbigny 1840—1842, p. 307, Pl. 91, Figs. 1—2; Schlüter 1871—1876, p. 44, Pl. 13, Figs 1—4).

Moreover, the works performed so far on the stratigraphy of the lower member of the Idzików Beds have evidenced the occurrence of the following Coniacian fossils: *Inoceramus kleini* G. Müller, *Inoceramus sturmi* Andert (cf. Pachucki 1959), *Inoceramus latus* Mantell, *Inoceramus alatus* Goldfuss (cf. Radwańska 1960) and *Inoceramus involutus* Sowerby (cf. Dvořak 1963a). From the lower member of the Idzików Beds also comes the holotype of the species *Scaphites kieslingswaldensis* Langenhan & Grundey (cf. Langenhan & Grundey 1891), which is well-known from the German Coniacian (Haller 1963, Prescher 1963).

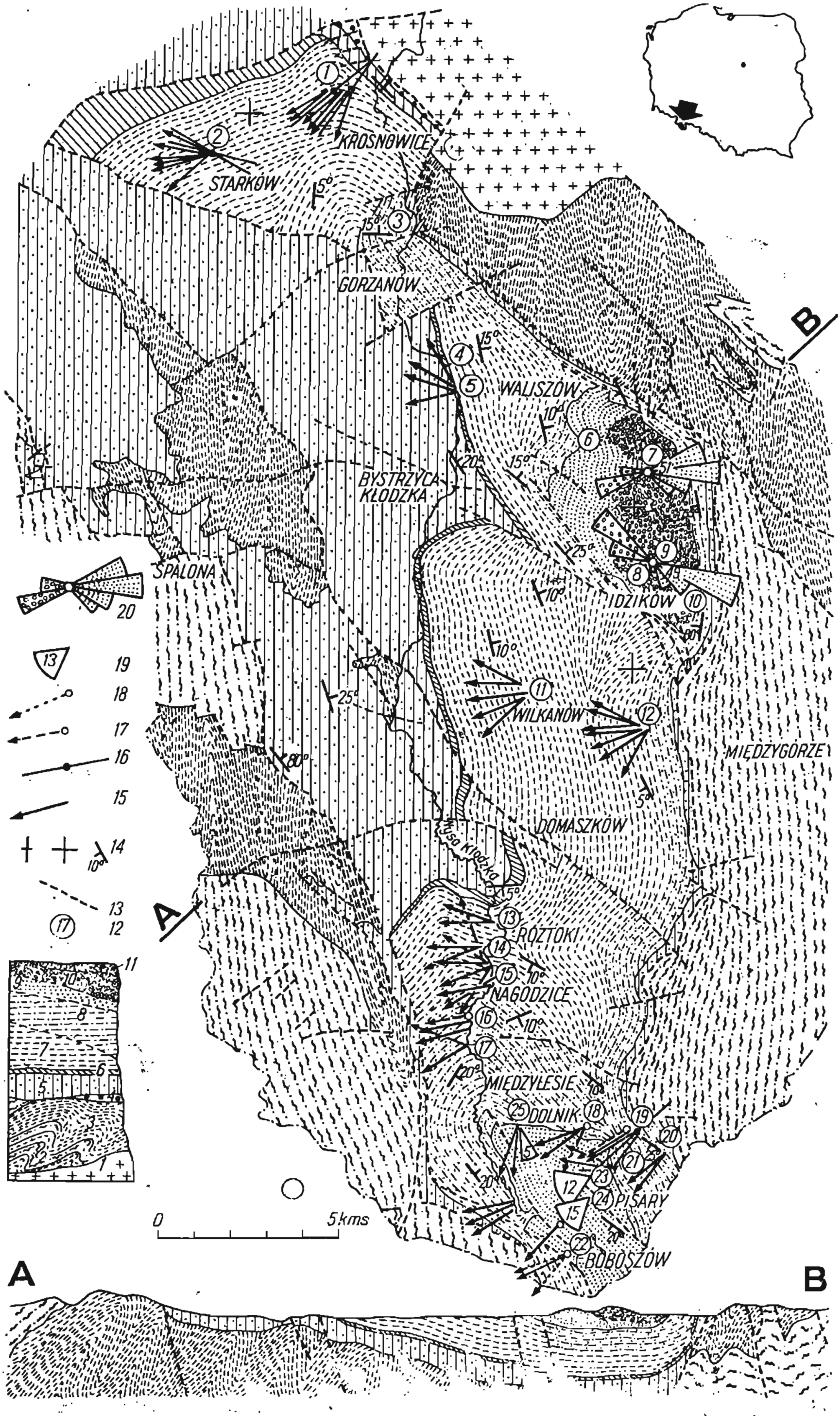
Some of the above-enumerated fossils are also met in the lower parts of the upper member of the Idzików Beds, the age of which has been determined long ago owing to the presence of *Inoceramus involutus* Sowerby (cf. Sturm 1901). In the uppermost part of the Idzików Beds, above the coquina horizon (Fig. 1), the fossils are scarce and no index forms have been found up to the time. It cannot be excluded that these youngest Cretaceous sediments of the Nysa graben may belong to the Santonian (Don & Don 1960, S. Radwański 1961).

The paleontological evidences permit thus to affirm that the lower member and the lower part of the upper member of the Idzików Beds belong to the Coniacian, while their uppermost part occurring in a small core area of the Idzików brachysyncline (cf. Fig. 1) may already belong to the Santonian. It should be noted that the other subdivisions of the Idzików Beds, previously suggested (Sturm 1901; Radwańska 1960; S. Radwański 1961, 1966) have not so far been confirmed paleontologically.

The Idzików Beds, representing the youngest Upper Cretaceous deposits of the Nysa graben, occur directly at the surface, or under a thin cover of Quaternary deposits.

The outcrops of the lower member of the Idzików Beds occupy a major part of the Nysa graben (Fig. 1). Their occurrence area within this tectonic unit and within the Králíky graben, bordering it in the south, is delimited by faults. Originally these sediments occupied a considerably larger area. Outside the Nysa and Králíky grabens, there occur denudation relics of "flysch-like" Coniacian deposits in the Litoměřice region of the České středohoři (these deposits were once ranked as the Oligocene by Hibsch 1924). However, in a mojor part of the Bohemian Massif, the Coniacian deposits, developed as calcareous claystone, have been preserved (Fig. 11, cf. also Soukup 1959, Dvořak 1963b, Svoboda & al. 1966).

The clinking shales within the Nysa graben are underlaid by Middle Turonian and Cenomanian deposits (Pachucki 1959), developed similarly to those known from the Intrasudetic depression (S. Radwański 1966, Jerzykiewicz 1970a). Only the Upper Turonian deposits of the Nysa graben differ in lithological character from their age equivalents of the Intrasudetic depression. In the Nysa graben these are represented exclusively by argillaceous-calcareous rocks, while in the Intrasudetic


KROSNOWICE
STARKÓW
GORZANÓW
WALISZÓW
BYSTRZYCA KŁODZKA
SPALONA
IDZIKÓW
WILKANÓW
MIĘDZYGÓRZE
DOMASZKÓW
Nysa Kłodzka
ROZTOKI
NAGODZICE
MIĘDZYLESIE
DOLNIK
PISARY
BOBOSZÓW
0
5 kms
A
B

depression, additionally and higher up in the profile, by pure quartz sandstones known as the youngest sandstones of the Intrasudetic Cretaceous Basin (Jerzykiewicz 1968). The mutual age relationship of the upper member of the Idzików Beds and the youngest sandstones of the Intrasudetic Basin has long remained unexplained. The controversy (Flegel 1904; Petrascheck 1905, 1934; Schmidt, Herbing & Flegel 1905, Scupin 1935; Rode 1936; S. Radwański 1959) was caused by the lack of paleontological evidence and by the preservation of these deposits in denudation relics. As a result of a recent finding of the inocerams in the argillaceous--calcareous deposits underlying the youngest sandstones (Radwańska 1963), the Upper Turonian age appeared to be evidenced (cf. Jerzykiewicz 1969).

The Upper Cretaceous deposits of the Nysa graben overlay directly the metamorphic rocks of the Śnieżnik Massif and the Bystrzyca Mts. These rocks, together with the Upper Cretaceous cover, are cut by faults into separate blocks displaced vertically to a various extent with respect to each other (Don & Don 1960, Don 1964, Dumicz 1964; cf. also Fig. 1). In the neighbourhood of the faults, the Upper Cretaceous rocks have been heavily disturbed tectonically. However, in a major part of the Nysa graben, the Cretaceous deposits are inclined at small angles and form subordinate tectonic units of a brachysynclinal or brachyanticlinal character (Don & Don 1960, Komuda & Don 1964). The upper member of the Idzików Beds has been preserved as denudation relics only in central parts of the brachysynclines (vicinity of Idzików and Boboszów, Fig. 1). The thickness of the upper member is *c.* 350 m in the core of the Idzików brachysyncline and *c.* 200 m in the Boboszów brachysyncline. The thickness of the lower member of the Idzików Beds, estimated in the limbs of the brachysynclines, varies from *c.* 500 m to *c.* 900 m. In the eastern limb of the Idzików brachysyncline, the lower member of the Idzików Beds is *c.* 500 m thick (Don & Don 1960); in the eastern limb of the Boboszów brachysyncline, between the marginal Śnieżnik fault and

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Fig. 1

Geological position and directions of the sedimentary structures of the Idzików Beds (based on the maps by Don, 1964, Dumicz, 1964, and on the author's results)

1 granitoids of the Kłodzko Massif, *2* and *3* metamorphic rocks of the Śnieżnik Massif and Bystrzyca Mts (*2* gneisses, *3* crystalline schists), *4* Permian deposits, *5* Cenomanian and Turonian deposits, *6—10* Coniacian deposits (*6* siliceous-calcareous siltstones — „clinking shales", *7* clayey flysch of the lower member of the Idzików Beds, *8* normal flysch of the lower member of the Idzików Beds, *9* sandstones of the upper member of the Idzików Beds, *10* conglomerates of the upper member of the Idzików Beds), *11* conglomerates with coquinas at the base, *12* outcrops discussed in the text, *13* faults, *14* dip and strike, *15* orientation of scour and tool moulds, *16* direction of groove moulds, *17* orientation of cross-lamination, *18* orientation of rib-and-furrow structures, *19* orientation of large-scale cross bedding, *20* orientation of medium-scale cross bedding

Pisary, its thickness rises to c. 600 m. In the western direction, these deposits are growing in thickness and attain c. 900 m in the section of the Nysa Kłodzka river, between Roztoki and Międzylesie (Fig. 1). It should be noted that in former studies (Pachucki 1959, S. Radwański 1966) the thickness of the lower member of the Idzików Beds was estimated to be ten times smaller.

LOWER MEMBER OF THE IDZIKÓW BEDS

The lower member of the Idzików Beds consists of alterning claystone and sandstone layers. The claystones show no visible sedimentary structures, while they contain numerous fossils, mainly lamellibranchs, ammonites and foraminifers the latter being usually pelagic (Pachucki 1959).

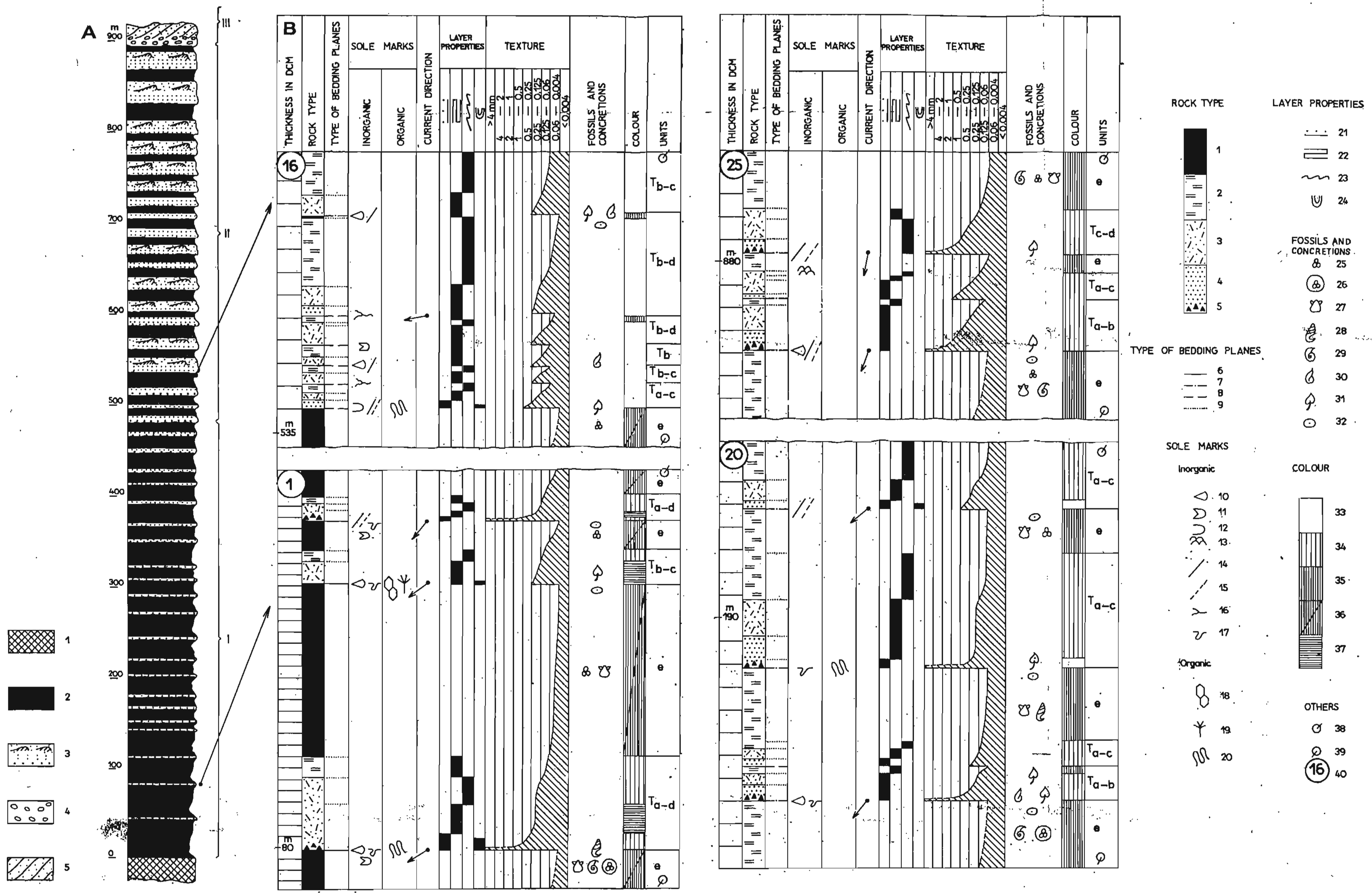
The sandstone layers show all the features characteristic of turbidites (cf. Jerzykiewicz 1970b). They were found to include a succession of structures which are known from the flysch and were described in detail by Bouma (1962). In the lithological respect, the lower member of the Idzików Beds is quite identical with the flysch. The ratio of thickness of the sandstone layers to the pelitic ones in the lower member of the Idzików Beds is variable. For this reason two lithofacies (cf. Dżułyński & A. Smith 1964) are distinguished within this member. The lithofacies of the clayey flysch is taken to include that part of the member where claystones are predominant, and the part where either the layers of sandstones or siltstones occur in equal proportion in relation to the claystones or the sandstones dominate is included with the lithofacies of the normal flysch (cf. Fig. 1 and Fig. 2).

In the present paper, the graphic presentation of the sedimentary properties of standard profiles of the Idzików Beds has been made by the method presented by A. H. Bouma (1962). The description of the sedimentary properties is given in the order of their presentation in Figs 2 and 6.

Thickness

The turbidite layers of the clayey flysch lithofacies vary from several centimetres to over 1 m in thickness. Layers from 20 to 30 cm thick occur most often; the thickest layer measured 1.2 m. The thickness of claystones which separate the turbidite layers is usually larger and varies from several centimetres to several scores of metres.

The thickness of turbidite layers of the normal flysch lithofacies is variable within the limits from a dozen centimetres to several metres. Usually occur layers from 0.5 to 1.5 m thick, which really are often the multiple layers not separated by pelitic sediments (cf. Książkiewicz 1954).



Detail graphic log of sedimentary data in the lower member of the Idzików Beds

A — Schematic profile of the deposits cropping out between Roztoki and Międzylesie

I lithofacies of the clayey flysch, *II* lithofacies of the normal flysch, *III* base of the upper member of the Idzików Beds, *1* siliceous-calcareous siltstones („clinking shales"), *2* claystones, *3* sequences composed of sandstone and siltstone beds, *4* conglomerates, *5* large-scale cross-bedded unit of sandstones

B — Detail graphic log

1 claystones, *2* siltstones, *3* lithic wackes, *4* lithic arenites, *5* microbreccias, *6* very sharp contact, *7* sharp contact, *8* distinct contact, *9* gradual transition hardly visible, *10* flute moulds, *11* obstacle scour moulds, *12* prod moulds, *13* rib-and-furrow structures, *14* groove moulds, *15* striations, *16* longitudinal ridges, *17* load casts, *18* *Paleodictyon*, *19* *Chondrites*, *20* *Helminthoida*, *21* graded bedding or massive beds, *22* parallel lamination, *23* current ripple lamination, *24* burrows, *25* benthic foraminifers, *26* pelagic foraminifers, *27* lamellibranchs, *28* gastropods, *29* ammonites, *30* shell detritus, *31* plant remains, *32* concretions, *33* light gray, *34* medium gray, *35* dark gray, *36* medium to dark gray, *37* alterning light and dark gray, *38* upper bedding plane not exposed, *39* lower bedding plane not exposed, *40* number of the outcrop

Petrography

Turbidites of the lower member of the Idzików Beds represent a mixture of redeposited material and terrigenic grains of gravel, sand, silt and clayey-calcareous material. According to which of these components is predominant, we can distinguish: conglomerates and breccias, arenites, wackes, siltstones and claystones (Fig. 3).

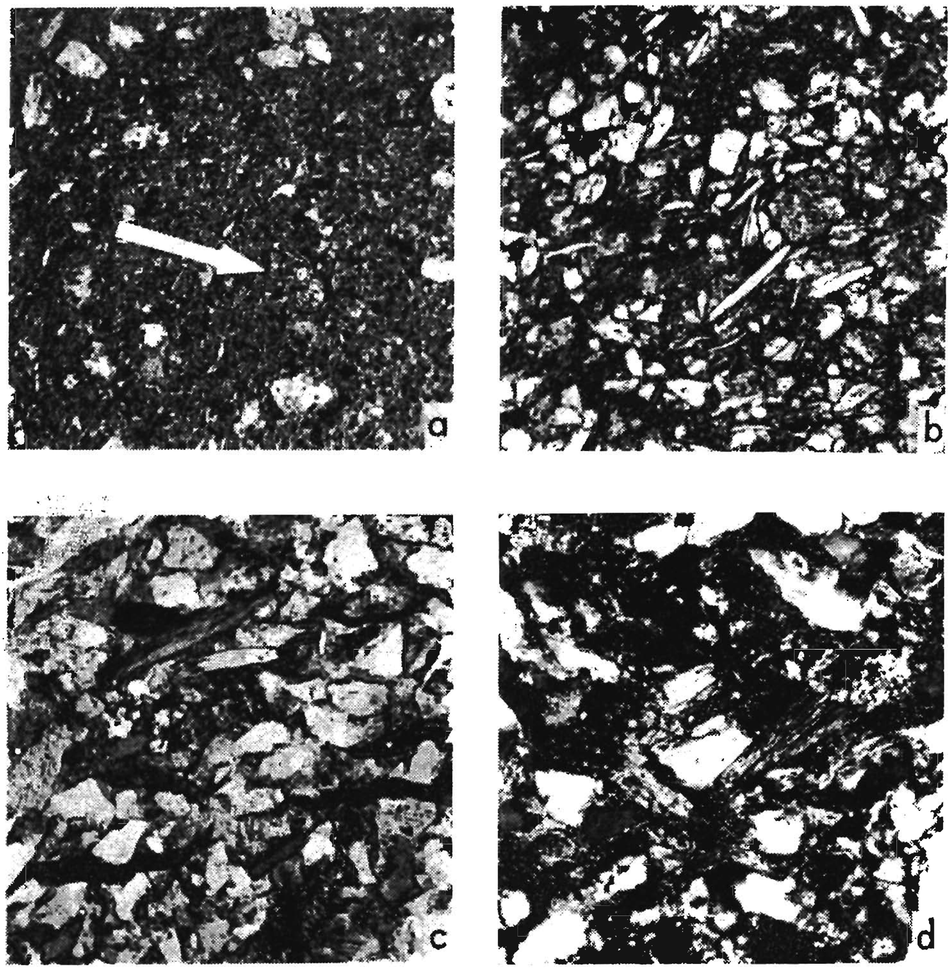


Fig. 3

Main lithological types of the lower member of the Idzików Beds

a claystone with few silty grains (the arrow indicates a pelagic foraminifer); Krosnowice (clayey flysch), outcrop *1*; ord. light, × 80
b siltstone composed mostly of quartz grains, mica and rock fragments; Nagodzice (normal flysch), outcrop *16*; ord. light, × 80
c very fine-grained lithic wacke; Krosnowice (clayey flysch), outcrop *1*; ord. light, × 80
d fine-grained lithic wacke; Nagodzice (normal flysch), outcrop *16*; nicols crossed, × 80

Conglomerates are rather scarce. An example may be observed at Stary Waliszów (Pl. 3, Fig. 1): the layer of the conglomerate lies here on a sandstone layer upper surface of which is deformed due to liquefaction of uncompacted sediment. The conglomerate consists exclusively of pebbles derived from some older deposits, such as sandstones, siltstones and claystones. Among them also occur folded sandstone and siltstone lumps (cf. Książkiewicz 1958). These deposits were formed due to penecontemporaneous fragmentation and redeposition of the deposits of the lower member of the Idzików Beds. The fragmentation and redeposition was most likely connected with a subaqueous slump. These deposits are accompanied by the occurrence of sandstone injections (Dżułyński & Radomski 1957, Dżułyński & Walton 1965). The latter intersect the conglomerate and do not associate with the underlying sandstone layer (Pl. 3, Fig. 1).

Microbreccias consisting of angular fragments of claystones occur in the lower parts of the turbidite layers (cf. Fig. 2). The claystone fragments are most frequently 1 cm in size; rarely occur fragments over 3 cm. The fragments are embedded in the mixture of detritic material which has the mineral composition of lithic arenite or lithic wacke.

Lithic arenites and lithic wackes are main components of the turbidite layers. The arenites occur in the lower parts of the layers belonging to the lithofacies of the normal flysch (cf. Fig. 2, profiles *16*, *20* and *25*). On the other hand, they are not found in the turbidite layers of the clayey flysch (cf. Fig. 2, profile *1*). The sediments of the latter lithofacies comprise sandstones in which the content of the

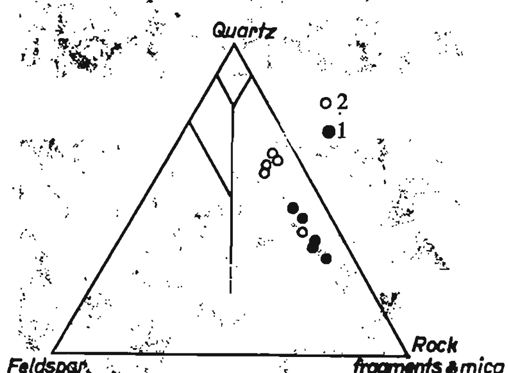


Fig. 4

Detrital framework of sandstones in the lower member of the Idzików Beds

1 from the clayey flysch, *2* from the normal flysch

argillaceous matrix exceeds 10%, and hence, according to the accepted classification given by Gilbert (cf. Williams, Turner & Gilbert 1954), they are rated as wackes. The wackes also occur in the middle parts of the turbidity layers of the normal flysch.

The contents of the grains of quartz, feldspars and micas as well as of rock fragments and matrix in the wackes of the lower member of the Idzików Beds were determined under microscope. The percentages of main components in the detrital framework of the analyzed sandstones, with matrix content exceeding 10% of volume, permit these sediments to be rated as lithic wackes (Fig. 4), in accordance with Gilbert's classification (cf. Williams, Turner & Gilbert 1954).

In the wackes of the normal flysch, the grains of quartz, quarzite and cherts occur in larger quantities (39.9—74.2%) than in the wackes of the clayey flysch (32.3—48.2%). Among rock fragments (44.8—60.4% in the wackes of the clayey flysch, and 28.5—49.2% in the normal flysch) the flakes of mica are predominant. Both muscovite and biotite are present, chlorite occurs much more rarely. Among the more frequent fragments of other rocks were found phyllites, crystalline schists and pelitic rocks (the latter of Upper Cretaceous age). Feldspars occur in almost equal proportion (c. 10%) in the wackes of both the clayey and the normal flysch. Plagioclases as well as potash feldspars were found in them: most often identified were oligoclase, albite and microcline. A similar composition of detrital framework is found in the lithic arenites.

The interstices among the particles of the framework are filled mainly by an argillite-calcareous matrix and in a smaller degree by a calcareous or siliceous cement. The contents of the matrix and cement are variable in wide limits. In the lower parts of the turbidite layers the matrix is present in small quantities. It is mixed there with calcareous-siliceous cement and recrystallized. As a result, the sandstones which form the lower part of the turbidite layers are very hard. In the upward direction the quantity of the matrix grandually increases at the expense of detritic grains, and cement occurs only sporadically. The source of silica might have been provided by detritic grains which, in the sediments in question, often show signs of corrosion by calcite of the matrix (cf. Sharma 1965, Unrug 1968).

Bedding plane properties

The properties of contacts between layers (type of bedding plane) together with sedimentary structures on the surfaces of the layers (inorganic sole markings and trace fossils) combine to give bedding plane properties (cf. Bouma 1962). These sedimentary properties are partly shown in Fig. 2.

Type of bedding plane

The contacts between the layers of sandstone and the underlying claystones are distinct and sharp. They are associated in the first place with differences in grain-size but are also stressed by different degrees of resistance to weathering shown by the sandstones and claystones. The sandstones, as distinguished from the claystones, are impregnated with a secondary cement in the lower parts of the layers. The contacts within the layers, between beds of arenite, wacke and siltstone, and especially the upper contacts of these layers have a character of gradual transition. The lower contacts of layers in the clayey flysch deposits (Fig. 2, profile *1*) are slightly more distinct than the corresponding contacts in the normal flysch (Fig. 2, profiles *16*, *20* and *25*). This fact may be explained by the presence of larger quantities of secondary cement in the sandstones of the lower parts of the clayey flysch layers.

Inorganic sole markings

Commonly occurring sole markings are flute moulds, groove moulds and striations. The flute moulds of various forms and sizes were observed (Pl. 6, Figs 1—5; Pl. 7, Fig. 1 and Pl. 8, Fig. 1); among them are forms known as linguoid and bulbous types, as well as triangular flute moulds (cf. ten Haaf in Dżułyński & Walton 1965, Dżułyński & Walton 1965). They are either flat (Pl. 8, Fig. 1) or highly convex, probably deformed by loading (Pl. 6, Fig. 4). They occur singly (Pl. 6, Fig. 3) or in groups, sometimes forming an oriented pattern (Pl. 6, Fig. 5).

Equally common as flute moulds are in these layers groove moulds and striations. They vary in width from 1 mm or less to several centimetres (Pl. 5, Figs 1—3 and Pl. 7, Fig. 1). In the extension of the groove moulds no objects which were responsible for the formation of grooves are found. However, the form of the moulds, and the composition of the turbidity layers allows to suppose that among such objects, besides sand grains, were fragments of claystones and shells, as well as the plant remains (cf. Dżułyński & Simpson 1966). The prod moulds (Pl. 6, Fig. 4) were met relatively often, while chevron moulds (Pl. 8, Fig. 2) are rare (cf. Dżułyński & Sanders 1962).

In the lithofacies of the normal flysch the occurrence of moulds of longitudinal ridges similar to those described by Dżułyński (1965) was observed additionally. In the sandstones of this lithofacies one may also observe relatively often intersections of cross laminations with the surface of internal parting plane (Pl. 4, Fig. 5).

Among deformational structures, the occurrence of polygonal load cast patterns resulted from instability in density stratification was established (cf. Dżułyński 1966, Dżułyński & Simpson 1966).

The load casts may be deformed by current and in this case they occur as overlapping scaly structures and moulds of longitudinal ridges (Pl. 8, Figs 3—5). Similar structures were formely interpreted (S. Radwański 1961, Pl. 1, Fig. 4) as „current hieroglyphs". Deformational structures which have resulted from instability in density stratification without any horizontal shear (cf. Anketell & al. 1970) take in these deposits the form of unoriented load casts on the underside of layers and undulated surfaces of internal parting (Pl. 9, Figs 1—3).

On the top surfaces of sandstone beds of the normal flysch, polygonal structures known as pseudo-mudcracks (cf. Dżułyński 1963b) are visible sometimes (Pl. 3, Fig. 3). More rarely were the manifestations of the uncompacted sediment observed in the form of clastic injections with compactional wrinkles on their surfaces (Pl. 3, Figs 1—2).

Trace fossils

Among a large number of trace fossils occurring on the bottom surfaces, the following forms were tentatively identified:

?Halymenites sp. (Pl. 4, Fig. 7). These are the most frequent trace fossils, preserved as almost straight, or only slightly curved rolls of elliptical section.

They vary in width from 0.5 to 1.0 cm; rarely are ramified and most often break off or go deep into the layer. They probably belong to the genus *Halymenites* (cf. Książkiewicz 1961, p. 884); a closer determination is, however, impossible as the surface of the rolls is irregular and its ornament is probably lost.

Paleodictyon aff. *minutum* Kindelan. Several well preserved forms (*e.g.* Pl. 11, Fig. 2) consisting of many eyelets, and found in the clayey flysch deposits. These forms are most similar to those presented by Abel (1935, p. 23, Fig. 11) and Voigt & Häntzschel (1964, p. 520, Pl. 8, Fig. 2).

Paleodictyon sp. Only one specimen (Pl. 11, Fig. 3) was found. The difference from the preceding specimens consists in the eyelets cosiderably larger and less regular, and the laths sometimes broken. The specimen resembles the representatives of the genus *Pleurodictyon* Fuchs (cf. Vialov & Golev 1966) as well as the form presented by Abel (1935, p. 24, Fig. 12).

?Gyrochorte sp. The specimen (Pl. 10, Figs 1 and 2) is most similar to that presented by Lessertisseur (1955, p. 44, Fig. 25). It does not possess, however, a distinct central axis, similarly to the form presented by Książkiewicz (1960, p. 742, Pl. 3, Fig. 11).

Asteriacites sp. The specimen (Pl. 10, Fig. 3) resembles in particular *Astropecten irregularis* Seilacher (cf. Lessertisseur 1955, p. 31, Fig. 17).

Phycodes sp. (Pl. 11, Fig. 1). As compared with *Phycodes palmatum* (Hall), presented by Seilacher (*cf.* Schindewolf & Seilacher 1955, p. 383, Pl. 25, Fig. 2), this form is more ramified and its central trunk is considerably thicker than the lateral branches. Similar differences the specimen shows in relation to *Harlania harlani* Prouty & Schwartz (*in* Lessertisseur 1955, p. 55, Fig. 32).

Chondrites cf. *furcillatus* Roemer (Pl. 11, Fig. 4). The branches of this specimen, similarly to those presented by Voigt & Häntzschel (1964, p. 501, Pl. 5, Fig. 2) are broken and occur separately.

Helminthoida cf. *labyrinthica* Heer. The specimen (Pl. 11, Fig. 5) resembles that presented by Lessertisseur (1955, p. 49, Fig. 29); it is considerably smaller as compared with figured by Książkiewicz (1960, p. 739, Pl. 2, Fig. 9).

?Cosmoraphe sp. The specimen (Pl. 11, Fig. 6) resembles the trace fossil which was assigned by Lessertisseur (1955, p. 43, Fig. 24) to *Cosmoraphe*. It is found next to *Helminthoida* cf. *labyrinthica* Heer and has strings of the same thickness. For this reason it may be believed to be the result of life activity of the same animal.

Among other frequently occurring traces of organisms are also shelter dugs of burrows which vary in size and occur either singly or in groups (Pl. 7, Fig. 4).

The presented trace fossils belong for the most part to the „*Nereites Facies*" distinguished by Seilacher (1964), according to whom this ichnofacies is characteristic of bathyal environment with turbidite sedimentation. It should be noted, however, that among the described trace fossils also occur forms which stand near to those characteristic of the „*Cruziana Facies*" (cf. Seilacher 1964). All the same, well preserved and diagnostical traces are too rare to permit a clear determination of the ichnocenose and reconstruction of the ichnotopes in the sedimentary area (cf. A. Radwański & Roniewicz 1970).

Current direction

Current directions were determined from the orientation of tool moulds (mainly grooves) and scour moulds (mainly flutes), as well as from the cross-lamination. All the results of measurements are shown on the map (Fig. 1), some are also shown at the profiles (Fig. 2). In the case of unequivocal current directions, the orientation of both the tool and scour moulds is indicated by arrow [1]; in the case of current directions with doubtful pointing (groove moulds without brush moulds, chevron or prod moulds (cf. Dżułyński 1963a), only the lines of movement are plotted.

The orientation of current marks is also summarized for the whole investigated area in Fig. 5. It shows separately the orientation of tool moulds, scour moulds and cross-lamination. The measurements of unk-

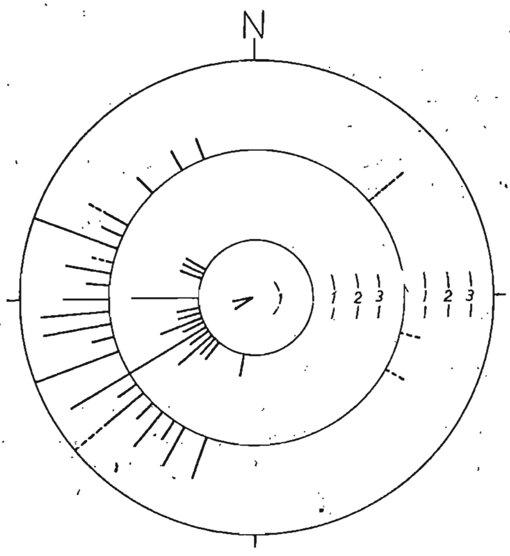


Fig. 5

Summary current-rose diagram of the lower member of the Idzików Beds

In the outer circle are shown directions of tool moulds, in the middle circle — directions of scour moulds, in the inner circle — directions of current ripple-lamination

nown pointing are marked by broken lines. The displayed directional structures show a conformable orientation (cf. Potter & Pettijohn 1963).

The variation of current directions in the investigated area is inconsiderable, similarly as in the case of „small-scale turbidite models" (cf. Selley 1968).

[1] The map does not offer different symbols for these structures, following Dżułyński & Simpson (1966) who has established by the experiment that the frequency of flute moulds is strictly dependent on the presence of objects in the turbidity current. In these experiments the flutes appeared in mass numbers when small objects have been added to artificially induced turbidity currents; these objects could also be responsible for the formation of grooves.

The dominant transport direction during the sedimentation of the lower member of the Idzików Beds was running from the east to the west, with northward or southward deflections (cf. Pl. 1 and Fig. 5). These directions seem to indicate that the starting plots of the turbidity currents were situated to the east, north-east and south-east of the sedimentary area.

Layer properties

In the lower member of the Idzików Beds, the simultaneous occurrence of graded bedding with a parallel lamination and micro-cross lamination was established in the layers composed of sandstones and siltstones (cf. similar sequences described *e.g.* by Kuenen 1953, Książkiewicz 1954, Bouma 1962 and Lombard 1963). These main structures occur in separate intervals similar to those described by Bouma (1962).

The *graded interval* in the clayey flysch consists of wackes which often show gradded bedding. In the bottom part of this interval there occur seams of microbreccias or sporadically claystone fragments (Pl. 4, Fig. 4). Sometimes the gradded bedding is discernible only under microscope. In the normal flysch the graded interval consists of arenites with claystone fragments. In the uppermost part of the normal flysch lithofacies the occurrence of sporadic small pebbles of quartz was also established (Fig. 2, profile *25*).

The *lower interval of parallel lamination* most often consists of alterning wackes and siltstones, both in the clayey and the normal flysch (Pl. 4, Fig. 3).

In the *interval of current lamination* an increase in quantity of the silty and clayey material may be observed, as well as a distinct micro-cross lamination or load-casted ripples (Pl. 4, Figs 1 and 2).

The *upper interval of parallel lamination* consists of clayey and silty material. Most often the lamination is hardly visible. The boundary between this interval and the overlying *pelagic intervals* is difficult to establish, and practically it is indiscernible (cf. Radomski 1960).

The layers showing a complete succession of the above described structures, are rare both in the clayey and in the normal flysch. In the former, the *truncated base cut-out sequences* of type T_{b-c} occur most frequently; in the normal flysch, equally frequent as the latter are the *truncated sequences* of type T_{a-c} (cf. Bouma 1962).

Moreover, in the lowermost parts of the layers the feeding burrows were observed which especially well visible are in the laminated sandstones (Pl. 4, Fig. 6).

Texture

The size analyses were made by thin sections. The technique of measurement as described by Friedman (1958) was used, with some modifications. At each section 300 grains were measured and the obtained values were grouped into 0.50Φ classes. Samples for the detailed analyses were taken from one layer of the clayey flysch and one layer of the normal flysch (cf. Fig. 2, profile *1*, lower layer type T_{a-d} and profile *16*, lower layer type T_{a-c}). The samples were taken starting from the bottom, at 10 cm intervals in the first layer and at 5 cm intervals in the second one. In this manner 11 detailed size analyses were made and used for the determination of grain size of other samples of the sections shown in Fig. 2. The grain size of these remaining samples was determined by comparing their polished surfaces with the polished surfaces of the reference samples. The comparison was made by means of a binocular. This method proved to be relatively quick and useful. Its aim was only to indicate a modal class after the Wentworth-Udden grade scale (cf. Pettijohn 1957). Because of the simplified method used, the results shown in Fig. 2 should be regarded as approximate only. With their help one can only indicate the main textural component in the sample being investigated (cf. Bouma 1962).

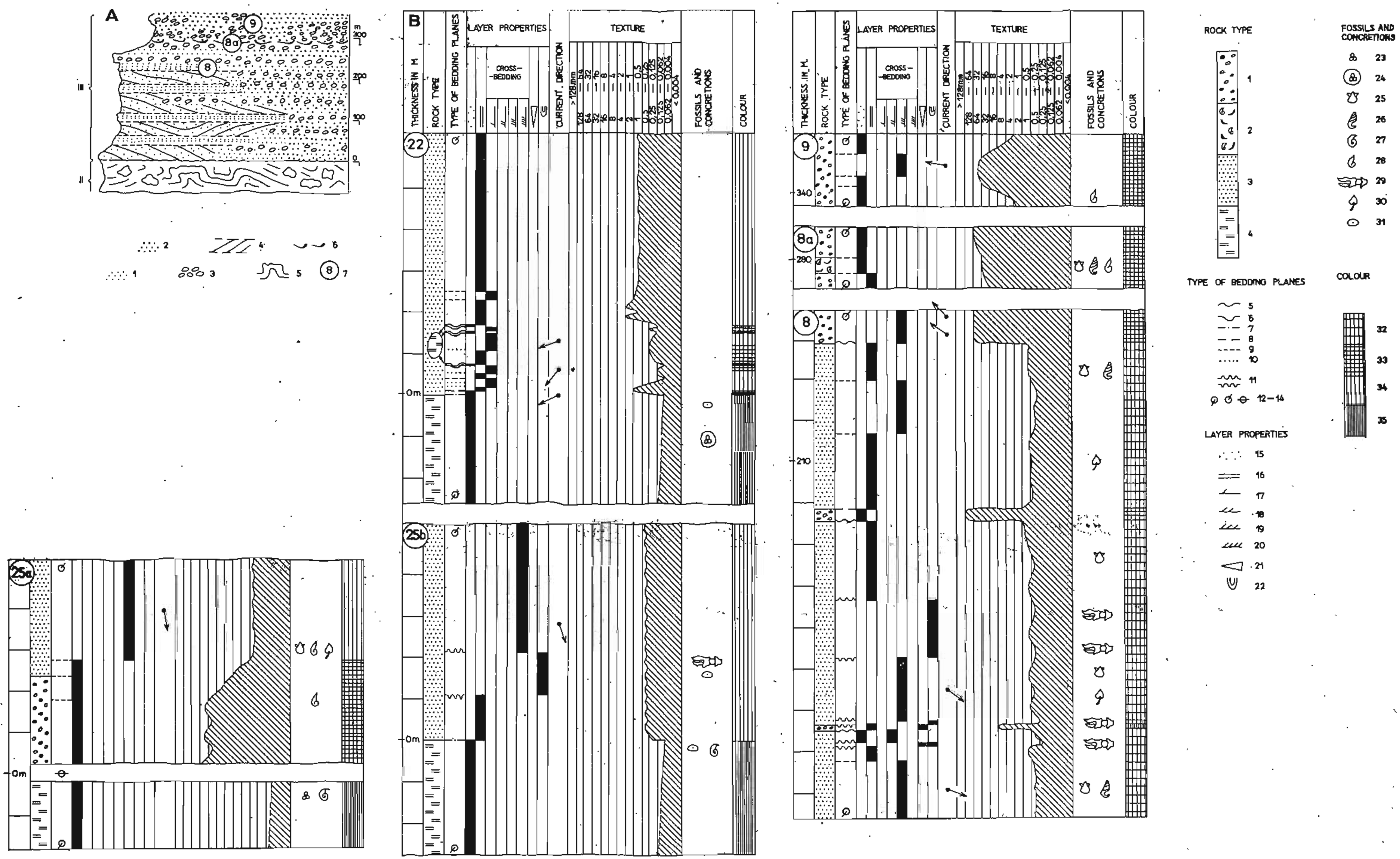
The turbidity layers of the lower member of the Idzików Beds consist of small pebbles, granules, fragments of redeposited claystones, sand grains, silt and clay particles. The proportion of coarse fractions gradually decreases towards the top of the layers.

The layers of the clayey flysch are mainly composed of fine- and very fine-grained sandstones. At the bottom of these layers no terrigenic pebbles were found. The pelagic intervals separating the turbidity layers are often devoid of terrigenic mineral grains larger than the clay fraction (cf. Kuenen 1950).

In the section Roztoki-Międzylesie the layers of the normal flysch are composed mainly of fine-graned sandstones in the lower part, and of medium- and coarse-grained sandstones in the upper part of section (cf. Fig. 2). At the bottom of the layers belonging to the upper part of the section being discussed, small pebbles of quartz occur additionally. The pelagic sediments differ from the corresponding ones in the clayey flysch as they contain grains of the silty fraction. The admixture of silt in the pelagic sediments of the normal flysch increases toward the top of the section. Increase of silt fraction in the pelagic sediments is also observed in the direction from west to east. It may be assumed that all these sediments, considered here as pelagic, might have been deposited by dilute turbidity currents or settled from clouds of finer suspension following the turbidity currents (cf. Radomski 1960).

Fossils

In the pelagic intervals separating the turbidite layers, both in the clayey and the normal flysch lithofacies, there occur foraminifers, lamellibranchs, ammonites, echinoids, as well as gastropods and plant remains



Detail graphic log of sedimentary data in the upper member of the Idzików Beds

A — Schematic profile of the deposits cropping out in the vicinity of Idzików and Waliszów

II uppermost part of the lower member of the Idzików Beds, *III* upper member of the Idzików Beds, *1* fine-grained sandstones, *2* medium and coarse-grained sandstones, *3* conglomerates, *4* medium-scale cross bedding, *5* slump folds, *6* coquina horizon, *7* number of the outcrop

B — Detail graphic log

1 conglomerates, *2* coquinas, *3* lithic arenites, *4* siltstones, *5* irregular erosional contact, *6* undulating loaded contact, *7* sharp contact, *8* distinct contact, *9* gradual transition, *10* gradual trasition, hardly visible, *11* bioturbated contact, *12—14* lower, upper, or lower and upper bedding plane not exposed, *15* massive beds, *16* parallel bedding, *17* micro-cross bedding, *18* small-scale cross bedding, *19* medium-scale cross bedding, *20* large-scale cross bedding, *21* wedge-shaped layers, *22* burrows, *23* benthic foraminifers, *24* pelagic foraminifers, *25* lamellibranchs, *26* gastropods, *27* ammonites, *28* shell reworked, *29* shrimps *Protocallianassa antiqua* (A. Roemer), *30* plant remains, *31* concretions, *32* yellow-brown, *33* brown, *34* medium gray, *35* dark gray

(cf. Pachucki 1959, Radwańska 1960). Among the foraminifers, the genera *Globotruncana* and *Globigerina* are the most fragment; *i.a.* the species *Globotruncana lapparenti* Bolli being considered (Książkiewicz 1956) as characteristic of the Mediterranean province.

Concretions

In the pelagic sediments, the spheroidal and disk-shaped sideritic concretions are very common, usually lying beneath the sandstone layers (cf. Fig. 3). They vary in size from several centimetres to about a metre. These concretions have been known for a long time and regarded to be a good diagnostic feature of the discussed sediments (cf. Soukup 1959, Pachucki 1959, S. Radwański 1966, Svoboda & al. 1966).

Comparison of clayey and normal flysch lithofacies

Within the whole of the lower member of the Idzików Beds, there were observed the sedimentary features characteristic of the turbidites, viz.: alternation of pelagic sediments and terrigenic clastic material, sharp

Table 1

Comparison of clayey and normal flysch lithofacies from the lower member of the Idzików Beds

Clayey flysch	Normal flysch
Thickness of pelagic intervals larger than that of interfingering turbidite intervals	Thickness of pelagic intervals smaller or equal to that of interfingering turbidite intervals
Layers as a rule parallelsided, regulary bedded	Beds sometimes irregular in thickness or wedging out
Layers always separated by pelagic intervals	Layers not always separated by pelagic intervals, amalgamate to form multiple layers
Pelagic sediments consist of pure clay free of admixture of terrigenic grains larger than clay fraction	Pelagic sediments consist of mixed clay silt fraction
Layers consist of fine-grained material; wackes usually form their base	Layers consist of coarse-grained material; at their base occur as a rule arenites, sometimes also terrigenic pebbles
Framework of wackes with lower content of quartz	Framework of wackes with higher content of quartz

lower and gradational upper bedding planes, succession of structures, and both organic and inorganic sole markings. The sediments of the two distinguished lithofacies differ from one another by a number of secondary features (Table 1).

As follows from the table, the distinguished lithofacies were formed at various distances from the source of the turbidity current (cf. Walker 1967, Lovell 1969). It is also confirmed by distribution of these lithofacies at a determined current direction: at the eastern boundary of the Nysa graben the normal flysch occurs already in the bottom part of the profile, while in the central part of the graben (section Roztoki-Międzylesie), it does not appear until the upper part of the profile. The boundary between the two lithofacies is diachronic (cf. Fig. 1). The migration of the lithofacies of normal flysch from east to west within the Nysa graben was most probably associated with the advancing of the source of turbidity currents from that direction.

UPPER MEMBER OF THE IDZIKÓW BEDS

Littoral deposits of the upper member of the Idzików Beds occur as denudation relics in two separate areas: between Waliszów and Idzików, and between Międzylesie and Boboszów (Fig. 1). In the first area, the deposits of the upper member have been divided into two lithofacies, namely the sandstone lithofacies (Idzików sandstones) and the conglomerate lithofacies (Idzików conglomerates). These lithofacies intertongue with each other (cf. Rode 1936, Pachucki 1959, Don & Don 1960); the boundary, as shown on the map (Fig. 1), indicates the westernmost extent of the Idzików conglomerate. In the area between Międzylesie and Boboszów only the first of the two lithofacies is represented.

Contacts between the upper and the lower member

Exposed contacts between the upper and the lower member were observed at Boboszów (cf. Fig. 6, profile *22*, and Pl. 15) and in the area southwest to Międzylesie (fig. 6, profile *25b*). At both these points the uppermost part of the lower member is composed of siltstones revealing the occurrence of pelagic foraminifers. In one of the outcrops (*25*) numerous well preserved ammonites were also observed. Several metres below the contact, the siltstones comprise layers which show the properties of turbidites. In outcrop *22* on the upper surface of the siltstones occurs a bed of coarse-grained sandstone with distinct lower and upper bedding planes. This bed is overlaid by a set of sandstone beds with siltstone laminas which show distinct or loaded contacts. The laminas are often loaded and broken off, and on their upper surfaces the flame structures are visible (Pl. 15, Figs 1 and 5). The sandstone beds show parallel or micro-cross bedding, and on the upper distinct surfaces of some of the beds as well as in their section, loaded ripple marks are present (Pl. 15, Fig. 4). In the upward direction, the sandstone beds grow in thickness, and show medium- and large-scale cross bedding as well as burrows and remains of decapods.

Petrography

The deposits of the upper member of the Idzików Beds consist mainly of petromictic conglomerates and lithic arenites. Other lithologic varieties, as lithic wacke or siltstone, are seldom to be found.

The petromictic conglomerates (Idzików conglomerates), exposed between Waliszów and Idzików, consist of pebbles which come from several sources, namely from the Śnieżnik and Kłodzko massifs, Bardo Mts and from the older Upper Cretaceous strata, including the lower member of the Idzików Beds. Exotic rhyolites have also been found (Don & Don 1960).

The quantitative composition of the conglomerates has been determined at 6 points, and 100 pebbles were counted for each of the lower, middle and upper part of the Idzików conglomerates. The obtained results confirmed the former data (Don & Don 1960). Among the pebbles derived from the Śnieżnik Massif were identified: Gierałtów gneisses, graphitic schists, mica schists, other schists, phyllites, quartzites, Śnieżnik gneisses, and amphibolites. The total amount of pebbles derived from the Śnieżnik Massif varies from 28 to 75%; striking is a small amount (up to several per cent) of the Śnieżnik augen-gneisses which now directly border the Nysa graben from the east. A considerable quantitative share (from 8 to 45%) have the granitoids derived from the Kłodzko Massif. Exotic rhyolites also occur in large quantities in some layers; in the northern area of the Idzików conglomerates (Waliszów), they form more than half the total number of pebbles (Don & Don 1960).

The pebbles of siliceous shales and Culm greywackes, derived from the Bardo Mts[2], and redeposited Upper Cretaceous rocks occur sporadically. Among the latter the claystone pebbles from the lower member of the Idzików Beds were established many times.

The petromictic conglomerates in the vicinity of Międzylesie and Boboszów occur at the base of the upper member (cf. Fig. 6, profile *25a*; and Pl. 16, Fig. 3). They consist predominantly of pebbles derived from the Śnieżnik Massif (Gierałtów gneisses, mica schists, other schists, phyllites and quartzites). Besides, the pebbles redeposited from the lower member of the Idzików Beds as well as granitoids and quartz are present.

The mineral composition of fine- and medium-grained sandstones was determined under microscope. The grains of quartz and other stable components, feldspars, micas and rock fragments, as well as the volume of matrix and cement were counted in 9 thin sections. No essential differences were observed in mineral

[2] Maybe, also from the Kletno conglomerate of the Culm facies (cf. Kasza 1964).

composition of the Idzików and Boboszów sandstones, the framework of which consists of quartz, quartzites and cherts (44.3—64.5%), rock fragments (26.2—44.8%), feldspars (7.5—23.1%) and matrix with small admixtures of cement (usually below 10%). According to Gilbert's classification (*in* Williams, Turner & Gilbert 1955) these sandstones should be assigned to lithic arenites (cf. Figs 7 and 8).

In these sandstones, important is the abundance of biotite (up to 16%) which usually prevails over muscovite. Among feldspars plagioclases were identified most often (Turnau-Morawska *in* Pachucki 1959).

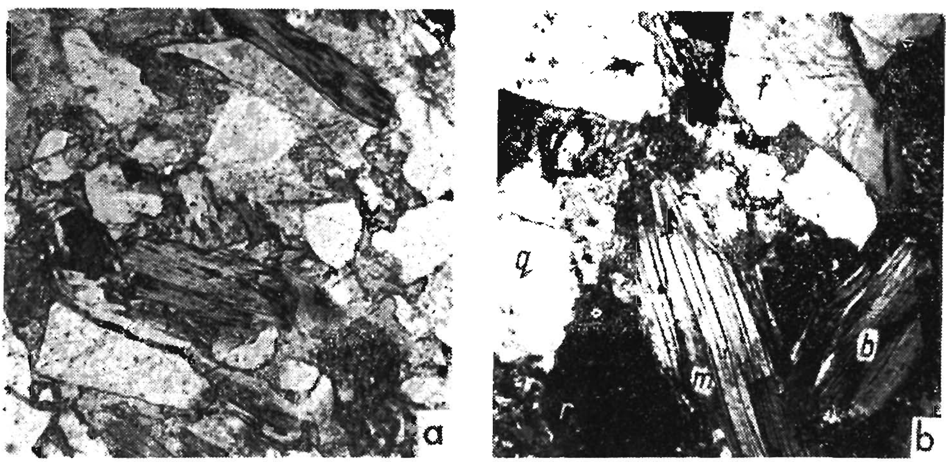


Fig. 7

Lithic arenites in the upper member of the Idzików Beds

a medium-grained lithic arenite; Idzików, outcrop *8*; ord. light, × 80
b coarse-grained lithic arenite (*q* quartz, *f* plagioclase, *m* muscovite, *b* biotite, *r* fragments of claystones derived from the lower member of the Idzików Beds); Idzików, outcrop *9*; nicols crossed, × 80

Type of bedding planes

The lower surfaces of the conglomerate layers are most often the irregular erosional contacts, while the upper contacts are gradational. On the other hand, a distinct contact between the conglomerates and the overlying sandstones is observed in the area where conglomerates and sandstones intertongue with each other (outcrops 7 and *8*). This contact is often found to be secondarily bioturbated by the shrimps (Fig. 6, profile *8*). In the area of the sandstone lithofacies, the contacts between sandstone layers differing in the bedding type are usually gradational, whereas between sandstones and intercalated layers or lenses of siltstones are sharp.

Layer properties

The sediments of the conglomerate and the sandstone lithofacies differ in their layer properties. In the first of the lithofacies, the layers are massive or, more rarely, show medium-scale cross bedding [3]. The medium-scale cross bedding is visible in the layers of pebble conglomerates, granule conglomerates and coarse-grained sandstone; foresets are usually inclined at angles 20° to 30°. The medium-scale cross bedding is most often confined to a fragment of a layer and usually is hardly visible. However, examples of well visible cross-bedded layers of the Idzików conglomerate, both medium and large-scale, are also known (Don & Don 1960). Examples of unquestionable imbrication were not recorded. The pebbles in the Idzików conglomerates do not show any preferred orientation, or their *AB* planes are inclined conformably with the inclination of the foresets (cf. Potter & Pettijohn 1963, Teisseyre 1968).

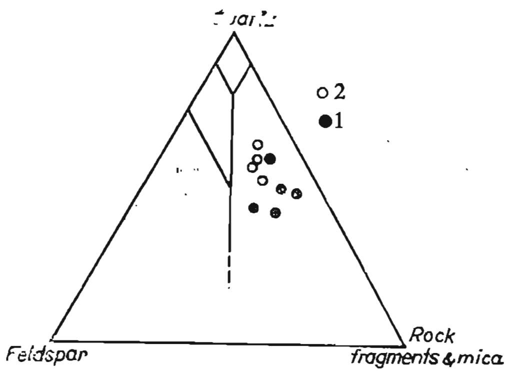


Fig. 8

Detrital framework of sandstones in the upper member of the Idzików Beds

1 from the vicinity of Idzików and Waliszów, 2 from the vicinity of Boboszów

In the second of the lithofacies, the layers are usually parallel-bedded or show medium-scale cross bedding. Gradual transitions between parallel- and cross-bedded layers are observed, and the inclination of the cross beds is usually very small. Medium-scale cross-bedded units of the Idzików sandstones, with foresets inclined at angles above 5°, are often found in the eastern part of the area. In the vicinity of Idzików and Waliszów, the cross-bedded units both tabular and trough type [4] may be observed (Pl. 12, Fig. 3). Large-scale cross-bedded units were found in the vicinity of Pisary (Pl. 16, Figs 1 and 2); their thickness exceeded 7 m. The overall thickness of these units might have been considerably larger (cf. Jerzykiewicz 1966, 1967; Collinson 1968; Rutkowski 1969). The fore-

[3] Limits for size classes of cross bedding units after Grumbt (1969).
[4] Terminology after Mc Kee & Weir (1953).

sets in large-scale units internally are parallel-bedded or massive, although small-scale intrasets (cf. Collinson 1968) are also observed.

In the Idzików sandstones, among distinctly bedded layers, there occur the layers, the original bedding of which has been completely bioturbated (Fig. 6, profile *8* and Pl. 13, Fig. 3). Almost in all such bioturbated layers, numerous remains of the shrimps were stated. The burrows do not, however, show the relief characteristic of *Ophiomorpha* (cf. Weimer & Hoyt 1964). In the completely bioturbated layers the burrows may be oriented in all directions, curved and even bifurcated, the features in which these resemble burrows of *Callianassa subterranea* Montagu (cf. Reineck & al. 1967, Fig. 12). In the layers with preserved bedding, the burrows were observed as vertical tubes filled with non-laminated sand; they begin at the upper surface of the layer, run straight or slightly curved, and pass through or bend and terminate within the layer. The burrows have an equal diameter along their length. At the Idzików quarry (outcrop *2* in Fig. 1), such vertical or slightly inclined tubes occur side by side in large numbers in distinctly bedded layers and extend to the underlying bioturbated layers where many remains of the shrimps were found.

Current direction

Medium- and large-scale cross bedding is the only common directional structure. In the vicinity of Idzików and Waliszów, the measurements of medium-scale cross bedding have been performed; the orientation of foresets (Fig. 9) is shown after correction for their tectonic inclination (cf. Potter & Pettijohn 1963). Moreover, the directions of the foreset inclination have been shown on the map (Fig. 1).

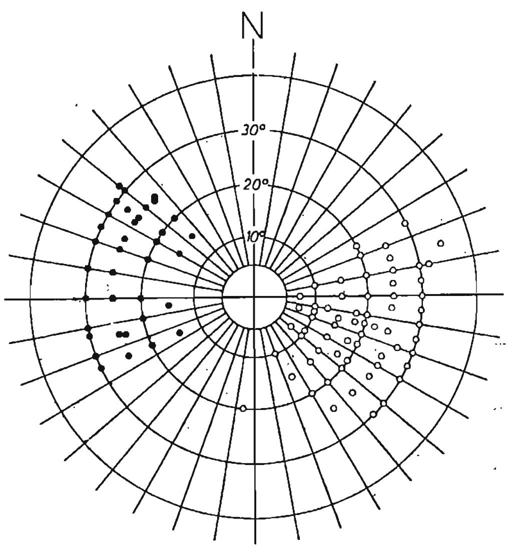


Fig. 9

Orientation of medium-scale cross bedding in the upper member of the Idzików Beds

Points of the diagram are the traces of normals to the beds (upper hemisphere projection); black points denote cross bedding in conglomerates, white points — sandstones

Within the conglomerate lithofacies, the direction was found to run to the west with northward or southward deviations. Within the sandstone lithofacies, the directions turned to the east, also with northward or southward deviations (Fig. 9). These two opposite directions were most often observed in separate but closely situated areas, although at the quarries where the Idzików conglomerates intertongue with the Idzików sandstones, these opposite directions are also visible (outcrops 7 and *8* in Fig. 1). The sandstone layers with foresets inclined in the south--eastern direction are overlaid there by conglomerate layers in which the foresets are inclined in the opposite direction (cf. Fig. 6, profile *8*). It is recorded, the oppositely inclined foresets show also the difference in angle of inclination. In the Idzików conglomerates, the foresets are inclined at larger angles (usually *c.* 25°), whereas in the Idzików sandstones they are at smaller ones (usually below 20°). Although the foresets with angles smaller than 5° were observed very frequently in the sandstones, for practical reasons these usually have been omitted for the measurements.

In the Boboszów sandstones, the measurements of the foreset orientation in the large-scale units have been performed. In the vicinity of Pisary these foresets are inclined in the southwestern direction, and in the vicinity of Międzylesie in the south (cf. Fig. 1 and Fig. 10).

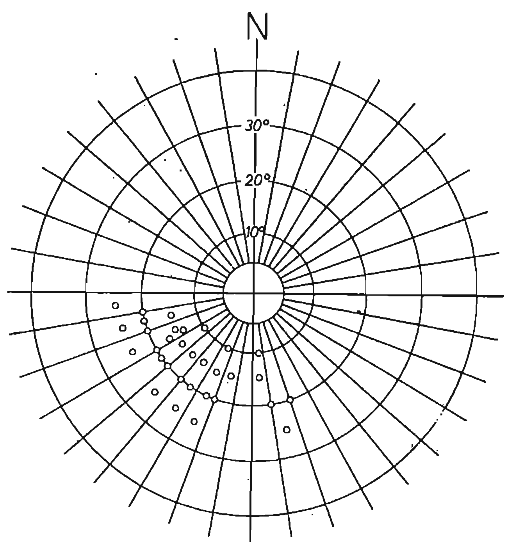


Fig. 10

Orientation of large-scale cross bedding in the upper member of the Idzików Beds in the vicinity of Boboszów

Points of the diagram are the traces of normals to the beds (upper hemisphere projection)

In one outcrop, directly above the contact between the lower and the upper member, the orientation of ripple marks and rib-and-furrow structures could be measured; the current directions agree with those indicated by the foresets (cf. Fig. 1 and Fig. 6, profile *22*).

Texture

The main textural components were determined for samples taken at 0.5 m intervals (profiles shown in Fig. 6); for pebble- and granule--conglomerates 9 sieve-size analyses were made, and grain size of the sandstones was determined in thin sections.

The deposits of the sandstone lithofacies consist of very well sorted medium- or fine-grained sandstones and siltstones. In the western part of the area (*e.g.* outcrop *6* at Stary Waliszów, cf. Fig. 1), there occur fine--grained sandstones and siltstones. In the central part, where this lithofacies intertongue with the conglomerate lithofacies, the Idzików sandstones are most often medium-grained (cf. Fig. 6, profile *8*).

The sediments of the conglomerate lithofacies consist in the first place of pebble- and granule-conglomerates, and of coarse-grained sandstones (cf. Fig. 6). Layers of medium- and fine-grained sandstones occur sporadically.

The sediments in the area of Międzylesie-Boboszów were assigned to the sandstone lithofacies on the basis of their granulometric composition. Beds of fine-grained sandstones are met mostly in this area, and only at the base there occur coarse-grained sandstones, sporadically also pinching-out beds of granule- and pebble-conglomerates (Fig. 6, profiles *22* and *25*).

Fossils and concretions

The Idzików sandstones are extremely rich in fossils, the fact already known to v. Buch (1797) who called them *"ein ganzes Museum der Vorwelt"*. Among the fossils, there were described the polychaetes, brachiopods, lamellibranchs, gastropods, nautilids, ammonites, decapods, echinoids, as well as fish teeth and remains of reptiles (Geinitz 1843, Langenhan & Grundey 1891, Sturm 1901, Pachucki 1959). Lamellibranchs and gastropods are the most frequent and form the main component of the coquinas outcropping at Idzików (Pl. 14).

The lamellibranchs are mainly represented by the genera *Ostrea, Cucullaea, Cardium, Cyprina, Tellina* and *Panope,* and gastropods by the genera *Natica, Turritella, Aporrhais* and *Fusus.* Representatives of ecologically important genera *Trochus* and *Cerithium* are also found. As may be seen, the genera characteristic of littoral zones are prevalent (cf. Hecker, Ossipova & Belskaya 1962; Bałuk & Radwański 1968). Besides the forms living in normal salinity waters, such euryhaline genera as *Tellina, Panope* and *Turritella* do occur (cf. Hecker, Ossipova & Belskaya 1962).

Of the very numerous and ecologically important fossils, the decapods have been known for a long time and assigned to various species of the shrimp *Callianassa* (cf. Langenhan & Grundey 1891, Sturm 1901); according to Mertin (1941) they all belong to *Protocallianassa antiqua* (A. Roemer). The decapod material mostly occurs as well preserved fragments of body appendages, *e.g.* at Stary Waliszów (outcrop *6*), Idzików (outcrop *8*) and between Międzylesie and Dolnik (outcrop *25*, cf. Figs 1 and 6). These appendages were mostly found in the previously discussed bioturbated layers, usually in the extension of burrows, which points to their autochthonous position (Pl. 13, Fig. 1). Allochthonous fragments of body appendages also occur in coquinas. Moreover, at Stary Waliszów (outcrop 6) the shrimp remains are abundant in concretions in fine-grained sandstones (Pl. 13, Fig. 4).

The occurrence of these decapods *in situ*, as well as their traces of activity are generally considered as indicative of high-energy littoral and shallow neritic environments (cf. Hecker, Ossipova & Belskaya 1962; Weimer & Hoyt 1964; A. Radwański 1967; Bałuk & A. Radwański 1968).

Comparison of sandstone and conglomerate lithofacies

The upper member of the Idzików Beds shows as a whole the features of shallow water deposits. Their division into lithofacies is based on the differences (Table 2) which are undoubtedly connected with the distance from the seashore situated in the east.

DEVELOPMENT OF THE SEDIMENTARY BASIN

Size of the basin

The supposition may be concluded that the sedimentary basin, embracing the area of the Nysa graben, was very vast at the time directly preceding the sedimentation of the Idzików Beds. Probably it extended from Saxony through the Bohemian Massif and the Sudetes as far as vicinity of Opole and Głubczyce. In all these areas the transitions from the Upper Turonian to the Coniacian, and in some areas also the lowermost Coniacian itself, are marked by clayey-calcareous sediments with small quantities of coarser terrigenic material (cf. Alexandrowicz 1959, Soukup 1959, Biernat 1960, Radwańska 1963, Svoboda & al. 1966, Milewicz 1967, Tröger 1969b). Such unification of facies might have been due to the sedimentation taking place in a widely extended basin (cf. Scupin

Table 2

Comparison of sandstone and conglomerate lithofacies from the upper member of the Idzików Beds

Sandstone lithofacies		Conglomerate lithofacies
Boboszów sandstones	Idzików sandstones	Idzików conglomerates
Layers with parallel or large-scale cross bedding; foresets usually inclined at *c.* 20°	Layers with parallel or medium-scale cross bedding; foresets inclined at low angles	Layers massive or medium-scale cross-bedded; foresets usually inclined at *c.* 20°
Presence of bioturbated layers containing shrimp remains	Bioturbated layers with shrimp remains common	Bioturbated layers absent
Shallow-water genera of gastropods and lamellibranchs present	Shallow-water genera of gastropods and lamellibranchs common	Shells of shallow-water genera of gastropods and lamellibranchs form coquinas
Main textural component: fine sand	Main textural component: fine and medium sand	Main textural component: granules and pebbles
Dominant current direction from NE to SW	Dominant current direction from W to E	Dominant current direction from E to W

1936, Alexandrowicz 1959), the littoral facies of which could not be still established [5].

Eastern-Sudetic part of the basin

As the presented results show, the distribution of clastic material in the basin during sedimentation of the lower member of the Idzików Beds was played mostly by subaqueous mass movements and turbidity currents. These currents were supplying the terrigenic sandy material to the pelagic environment recorded by the claystones. Directions of the turbidity currents imply the existence of a source land situated to the east (cf. Figs 1, 5, 12*A* and 13*A*).

[5] In the Saxo-Bohemian Upper Cretaceous sea, at the preceding time, known are Cenomanian and Turonian littoral deposits associated with numerous islands. In the Cenomanian and Turonian of the Sudetes, the presence of two islands: Western Sudetic and Eastern Sudetic was evidenced (Andert 1934, Scupin 1936, Jerzykiewicz 1968).

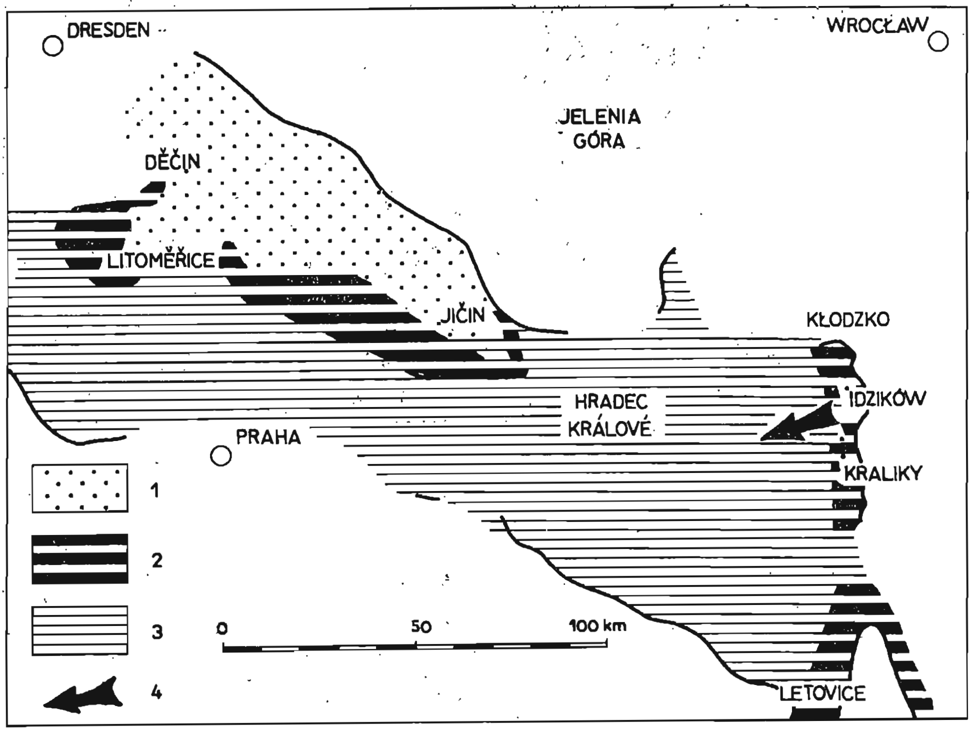


Fig. 11

Facial map of the Coniacian in Bohemia (*after* Klein *in* Svoboda & al., 1966) and in the Sudetes

1 sandy facies, *2* clayey-sandy facies, *3* clayey facies, *4* current direction in the lower member of Idzików Beds

In the first phase of sedimentation the source land was at a relatively large distance and the lithofacies of clayey flysch was developing, the features of which point to a distal source of turbidity currents (Table 1; cf. also Walker 1967). Layers of sandstones and siltstones show the properties of deep-sea turbidites (cf. Kuenen 1964). In this phase, the fore-Sudetic land was subjected to tectonic uplift. Faulting was the factor which controlled the mass movements and turbidity currents (cf. *e.g.* Williams 1962).

In the following phase, the whole analyzed part of the basin was embraced by sedimentation of proximal turbidites. The approaching of the source of turbidity currents which controlled sedimentation of the normal flysch lithofacies was presumably associated with uprising movements in the eastern part of the Śnieżnik and Kłodzko massifs (Figs 12*A* and 13*A*).

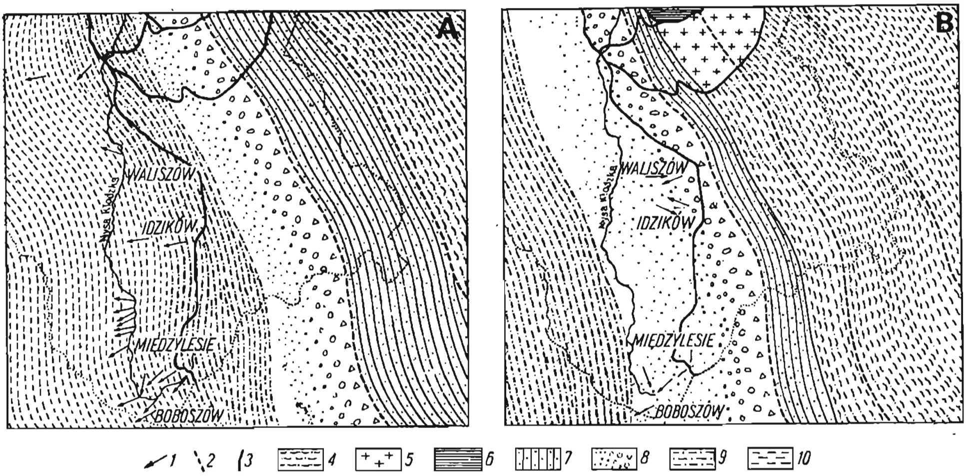


Fig. 12

Region of the Nysa graben in the time of deposition of the lower member of the Idzików Beds (*A*), and of the upper member of these Beds (*B*)

1 current directions, *2* boundaries of the present geological regions, *3* faults active during the sedimentation, *4* metamorphic rocks of the Śnieżnik Massif, *5* granitoides of the Kłodzko Massif, *6* deposits of the Bardo Mts, *7* Cenomanian and Turonian deposits, *8* Coniacian littoral facies, *9* Coniacian clayey flysch, *10* Coniacian normal flysch

Mineral composition of turbidites from the Idzików Beds allows to presume that the source land was built both of crystalline rocks and of overlying Upper Cretaceous rocks. Shallow water and littoral deposits contemporaneous with these turbidites are unknown; they probably were located in the area of the Śnieżnik and Kłodzko massifs and underwent denudation.

In the next phase, the land was enlarged and it included the central part of the Śnieżnik Massif. As a result, the shallow water zone was shifted to the area of the present Nysa graben, and sediments of the upper member were formed (Figs 12*B* and 13*B*). The occurrence of the shallow water fossils (*Protocallianassa,* some lamellibranchs and gastropods), and the sedimentary features permit a closer determination of the environmental conditions. The Idzików sandstones show parallel or low dipping cross-bedding, characteristic of the upper-flow regime (cf. Jopling 1963, 1965; Harms & Fahnestock 1965). Similarly bedded sediments are known in the first place from high-energy littoral environments: the intertonguing of sandstones and conglomerates and a bimodal paleocurrent pattern point to near-shore bars and barrier beaches (cf. Selley 1969). In such an environment the influence of fluviatile currents is still detectable (cf. Selley 1968, Fig. 6*B*) which also seem to be responsible for the formation

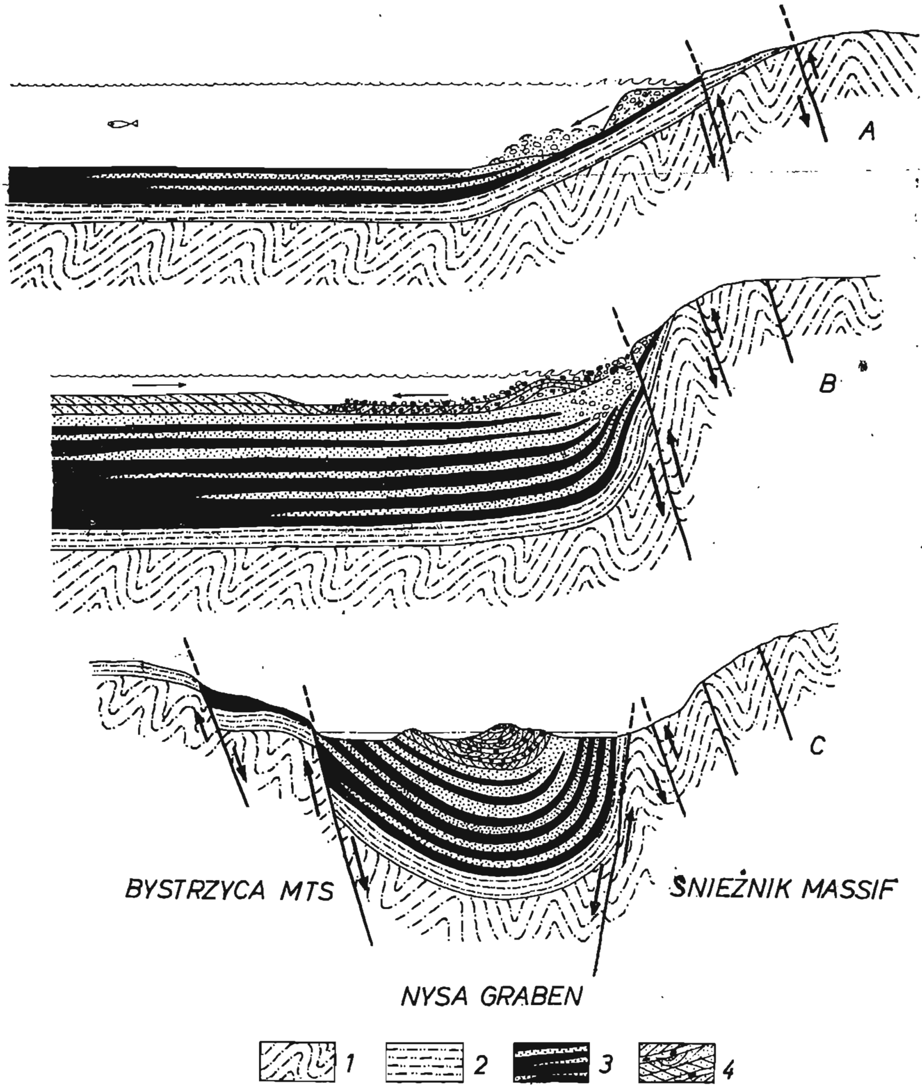


Fig. 13

Development of the Nysa graben during sedimentation of the Idzików Beds
A — Time of sedimentation of the lower member of the Idzików Beds
B — Time of sedimentation of the upper member of these Beds
C — After sedimentation of the Idzików Beds

1 metamorphic rocks of the Snieżnik Massif and Bystrzyca Mts, *2* older Upper Cretaceous deposits (Cenomanian, Turonian and „clinking shales"), *3* lower member of the Idzików Beds, *4* upper member of the Idzików Beds of the Idzików conglomerates [6]. The Boboszów sandstones, characterized by occurrence of large-scale cross bedding and absence of larger accumulations of conglomerates, were supposedly formed a little farther from the shore, in lower flow regime. The orientation of foresets of large-scale units points to the off-shore transport (cf. Figs 1, 10 and 12*B*).

The view that the Idzików conglomerates have been formed simultaneously with the tectonic uplift of the Śnieżnik Massif was previously expressed (Don & Don 1960). It was supposed that the Śnieżnik Massif was being uplifted along the eastern fault of the Nysa graben. It seems, however, that the shoreline ran a little farther at that time and the present eastern fault of the Nysa graben was still in the area of sedimentation (cf. Figs 12*B* and 13*B*). Such an opinion is confirmed *i.a.* by petrographic composition of the conglomerates consisting mainly of pebbles derived from the central and northern parts of the Śnieżnik Massif (chiefly crystalline schists) and of the Kłodzko Massif (granitoids). The Śnieżnik augen-gneisses, building that part of the Śnieżnik massif which now borders the Nysa graben in the east, occur sporadically among the pebbles in the Idzików conglomerates. It therefore appears, the western part of the Śnieżnik Massif in the time of sedimentation of the Idzików conglomerates was partly included in the sedimentary basin and partly covered by older Upper Cretaceous sediments (Figs 12*B* and 13*B*).

The Nysa graben in its present limits was formed after deposition of the upper member of the Idzików Beds (Fig. 13*C*). It should be noted, that in the uppermost part of the Idzików conglomerates, above the coquina horizon, the fossils occur sporadically and it cannot be excluded that these are already fresh-water deposits formed after regression of the sea (cf. Fig. 1 and Fig. 7, profiles *8a* and *9*).

Remaining part of the basin

Within the Coniacian deposits of the Bohemian Massif, the occurrence of flysch facies was recently recorded (Soukup 1959, Svoboda & al. 1966 [7]), which occurs as extensions of the lower member of the Idzików Beds both in the eastern part of the Bohemian Massif, and in its western part (vicinity of Litoměřice). In the latter area the flysch facies appeared later than in the Nysa graben. These sediments are considered to be

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[6] Opinion expressed by S. Radwański (1961) on a deltaic origin of these sediments cannot therefore be supported.

[7] The facies being called by these authors as a „flysch-like facies". The same term was also used by S. Radwański (1966) to designate a part of the lower member of the Idzików Beds. The present author uses the term flysch for all the discussed sediments, as these really do not differ in any respect from flysch (cf. Bouma 1962, Mc Bride 1962, Lombard 1963, Dżułyński & Walton 1965, Hubert 1967). If the flysch is understood as a facies (cf. Dżułyński & Smith 1964), it has not to be confined to orthogeosynclinal basins (cf. de Raaf 1968).

younger than the orthoquartzites building the „rock cites" between Děčin and Jičin, and area assigned to the Middle Coniacian (Soukup 1959); they are overlaid by regressive and land deposits (cf. Fig. 11).

It therefore appears that both in the eastern and western parts of the Bohemian Massif the occurrence of flysch facies is oberved directly before the regression. According to the obtained stratigraphic data, it may be affirmed that the discussed facies is not synchronic. It cannot be estimated, however, either it appeared as an episodic facies in troughs separated by internal tectonic lands (cf. Dżułyński, Książkiewicz & Kuenen 1959, Dżułyński & Ślączka 1959) or it was advancing from east to west, as a diachronic facies, in one undivided turbidite basin.

Finally, attention should be directed to the fact, that the upper part of the depositional cycle in the Sudetic and Bohemian Upper Cretaceous, generally considered as epicontinental, is similar to that observed in connection with flysch deposits in orthogeosynclinal troughs (cf. Dżułyński & Smith 1964): the flysch episode being preceded by pelagic sedimentation (clinking shales) and followed by shallow water molasse-type of sediments.

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T. JERZYKIEWICZ

FLISZOWE I LITORALNE OSADY KONIAKU ROWU NYSY

(Streszczenie)

Przedmiotem pracy jest analiza środowiska sedymentacyjnego osadów koniaku na obszarze rowu Nysy, które wykształcone są w postaci warstw idzikowskich. Analiza ta objęła przede wszystkim wykształcenie struktur i tekstur sedymentacyjnych oraz ich regionalne rozprzestrzenienie (fig. 1—2, 6, 9—10; pl. 1, 3—9, 12, 15—16), skład litologiczny osadów (fig. 3—4, 7—8) oraz ważne z ekologicznego punktu widzenia skamieniałości i ślady organiczne (pl. 2, 10—11, 13—14). Na podstawie uzyskanych wyników przedstawiono rozwój basenu sedymentacyjnego, który w okresie poprzedzającym powstanie warstw idzikowskich był zapewne rozległy i obejmował Saksonię, północne Czechy oraz Sudety sięgając na wschodzie aż po okolice Opola i Głubczyc.

W okresie powstawania *dolnych warstw idzikowskich* spokojna sedymentacja pelagiczna osadów ilastych była wielokrotnie przerywana przez sedymentację materiału piaszczystego, którego głównym czynnikiem transportu były prądy zawiesinowe (fig. 13A). W obrębie dolnych warstw idzikowskich wydzielono litofacje fliszu ilastego oraz fliszu normalnego. Osady tych facji powstały w różnej odległości od źródeł prądów zawiesinowych, które związane były z lądem obejmującym masywy Śnieżnika i Kłodzka, a położonym na E i NE od obecnego rowu Nysy (por. fig. 5 i 12). Wypiętrzające ruchy tektoniczne w obrębie rozważanego lądu obejmowały w tym czasie obszary stopniowo coraz bliższe obecnego rowu Nysy, wskutek czego facja fliszu ilastego była stopniowo (diachronicznie) zastępowana przez flisz normalny.

Rozszerzanie się strefy uskokowych ruchów tektonicznych na obszar środkowej części masywów Śnieżnika i Kłodzka towarzyszyło sedymentacji *górnych warstw idzikowskich* (fig. 12B i 13B). Wykształcenie litologiczne piaskowców i zlepieńców idzikowskich wskazuje na warunki przybrzeżne, czego dowodem jest m. in. miejscami liczne występowanie raków *Protocallianassa antiqua* (A. Roemer). Rów Nysy w swoich obecnych granicach powstał natomiast już po sedymentacji najwyższych ogniw warstw idzikowskich (vide fig. 13C).

Zwrócono uwagę na fakt, że w rozważanej części górnokredowego basenu sedymentacyjnego, a także w zachodniej części obecnego masywu czeskiego (por. fig. 11), w okresie poprzedzającym regresję morza, powstawały najpierw osady pelagiczne, potem fliszowe i wreszcie — osady płytkomorskie typu molassowego. Stwierdzone tutaj następstwo osadów jest więc analogiczne do obserwowanego w basenach ortogeosynklinalnych.

Pracownia Geologii Starych Struktur
Zakładu Nauk Geologicznych PAN
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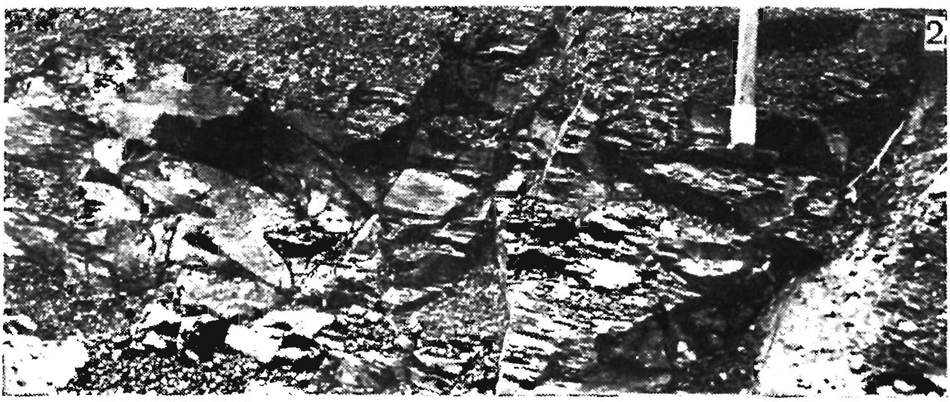
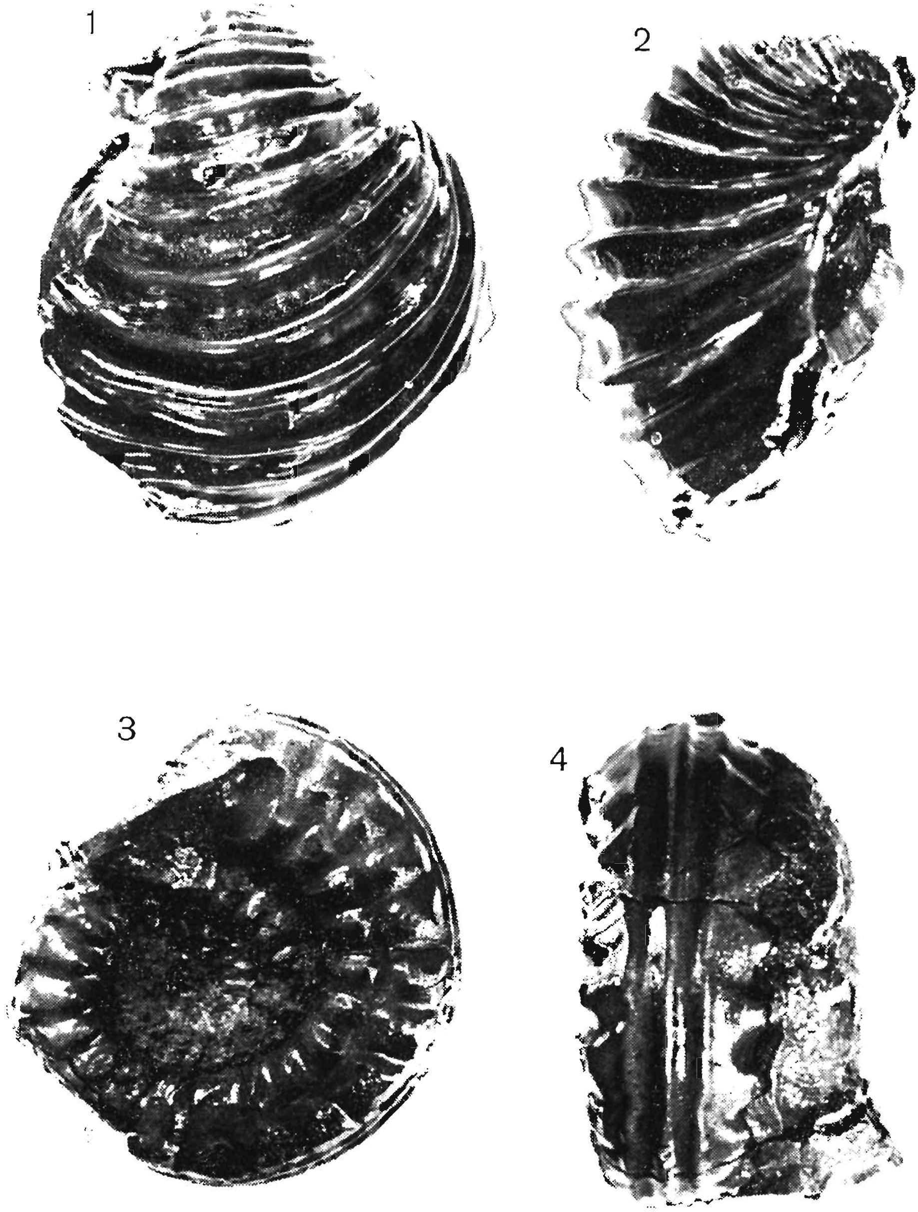
Wrocław, w listopadzie 1970 r.



Lower member of the Idzików Beds

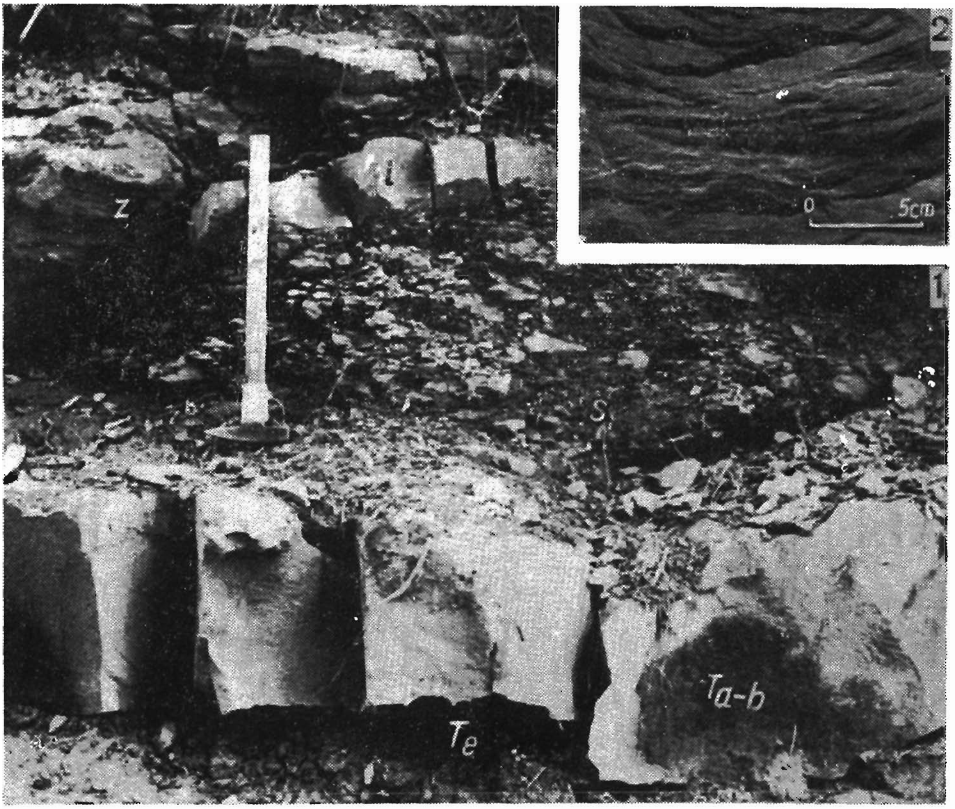
1 — Sequence type *Ta*-b and *Ta*-c composed of sandstones and siltstones alternating with pelagic claystones (*Te*). Clayey flysch; Gorzanów, outcrop *3*.
2 — Pelagic claystones. Clayey flysch; Zabłocie, *4*.
3 — Sequence type *Tb*-d composed of sandstones and siltstones occurring among pelagic claystones (*Te*). Normal flysch; Nagodzice, *16*.

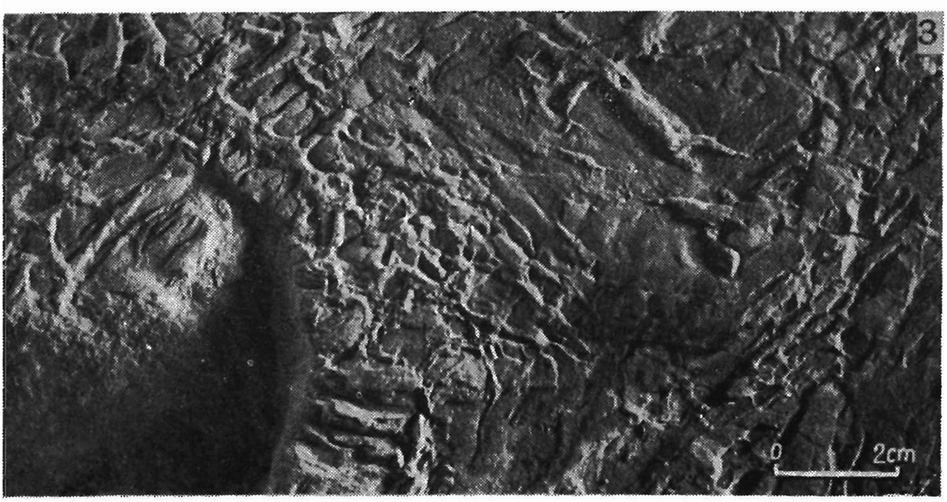


Coniacian index fossils from the lower member of the Idzików Beds

1 and 2 — *Inoceramus koeneni* C. Müller, right valve, nat. size. Clayey flysch; Krosnowice, outcrop *1*.

3 and 4 — *Peroniceras tricarinatum* (d'Orbigny), nat. size. Normal flysch; Idzików, near outcrop *10*.

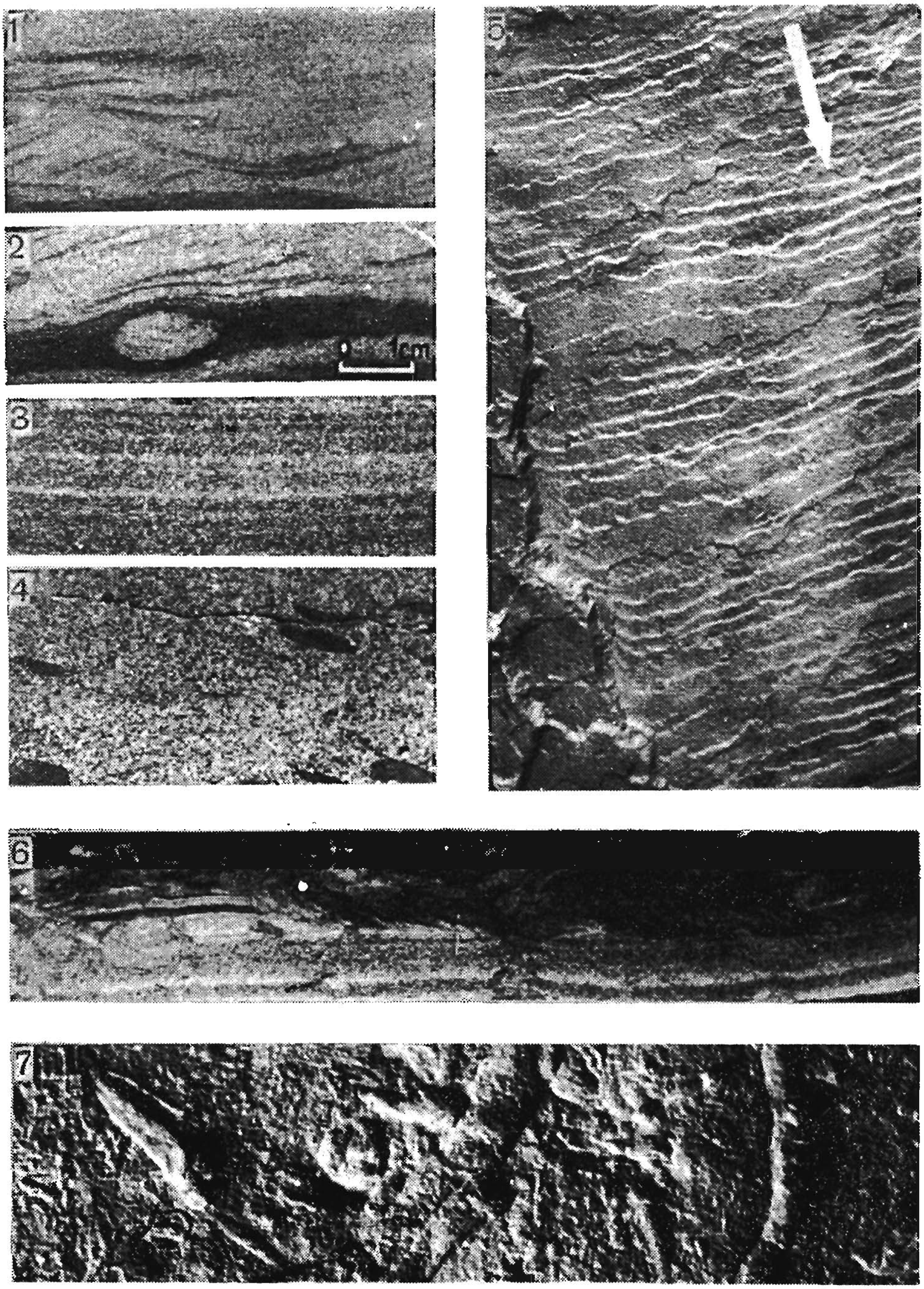




Submarine mass movements and related deformational structures in the lower member of the Idzików Beds

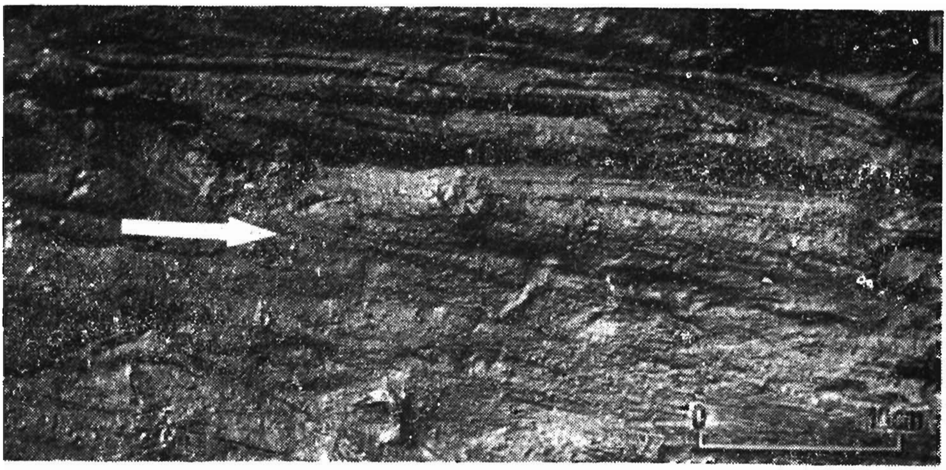
1 and 2 — Designations: *Te* pelagic claystones, *Ta-b* sequence composed of the sandstone, upper surface of which is undulated due to liquefaction of the uncompacted sediment, *S* conglomerate of slump origin, *I* sandstone injection, *Z* compactional wrinkles (enlarged in Fig. 2) on the surface of the sandstone injection. Clayey flysch; Stary Waliszów, outcrop *5*.

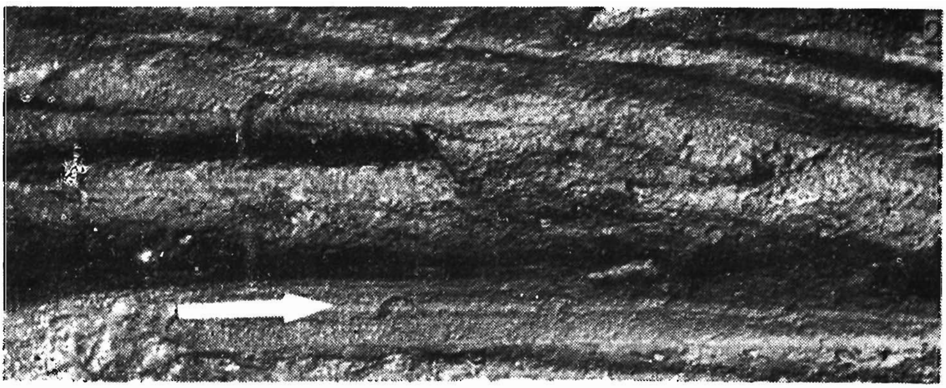
3 — Pseudo-mudcracks. Normal flysch; Nagodzice, *16*.

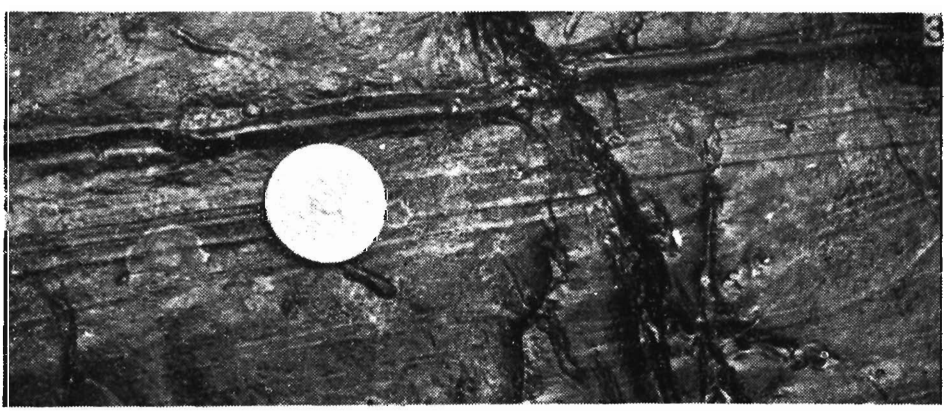


Layer properties in the lower member of the Idzików Beds

1 and 2 — Interval of current ripple lamination; in Fig. 2 a load-casted ripple mark is visible.
3 — Lower interval of parallel lamination.
4 — Graded interval; visible fragments of redeposited claystones.
5 — Cross lamination on the surface of an internal parting plane. Normal flysch; Dolnik, outcrop *18*.
6 — Feeding burrows visible in a vertical section.
7 — *?Halymenites* sp. — moulds of feeding burrows on the bottom surface of the same layer as in Fig. 6; nat. size. Normal flysch; Nagodzice, *17*.



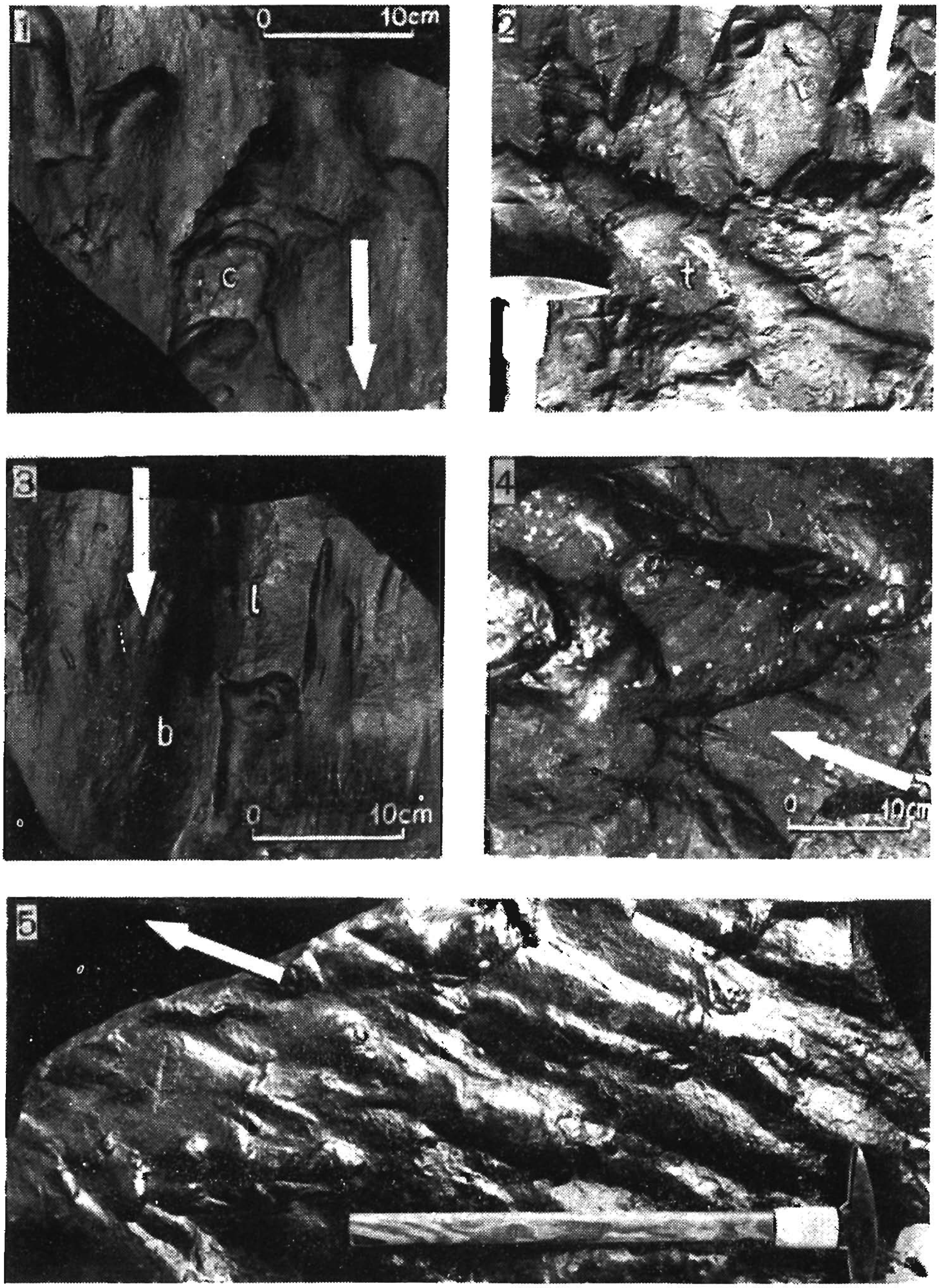




Tool moulds in the lower member of the Idzików Beds

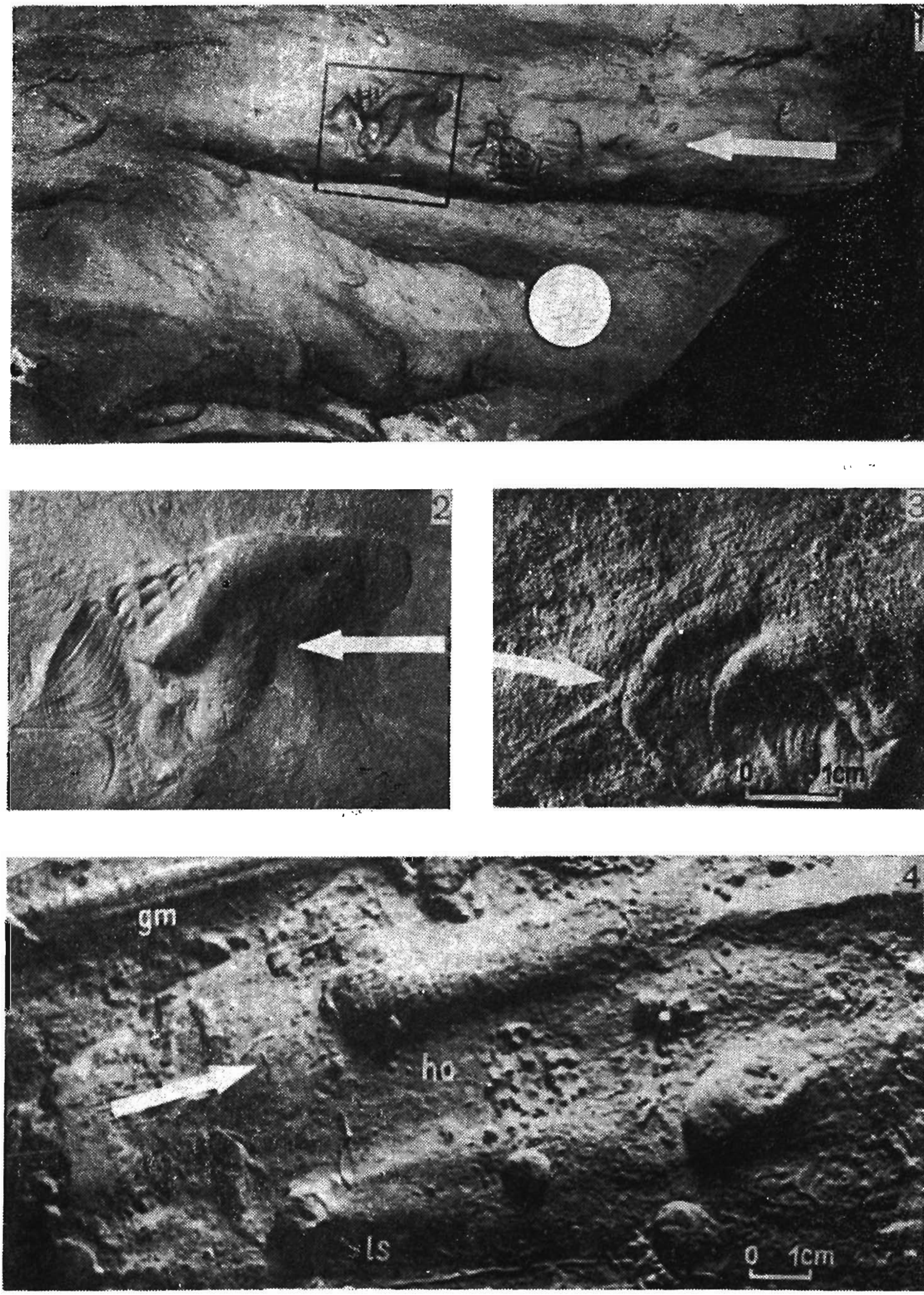
1 and 2 — Groove moulds made by claystone fragments, grains of sand and granules. Normal flysch; Boboszów, outcrop *22*.

3 — Groove moulds and striations made by tools of various dimensions. Clayey flysch; Roztoki, *13*.



Scour moulds in the lower member of the Idzików Beds

1 — Linguiform flute moulds, irregularly distributed, and a crescent mould (*c*). Clayey flysch; Krosnowice, outcrop 1.
2 — Triangular flute moulds and a transverse scour mould (*t*). Clayey flysch; Nagodzice, *15*.
3 — Linguiform (*l*) and bulbous (*b*) flute moulds. Clayey flysch; Krosnowice, *1*.
4 — Triangular flute moulds. The arrow indicates the current direction and points to a prod mould. Normal flysch; Nagodzice, *17*.
5 — Linguiform flute moulds arranged in bands crosswise to the current direction. Normal flysch; Nagodzice, *17*.

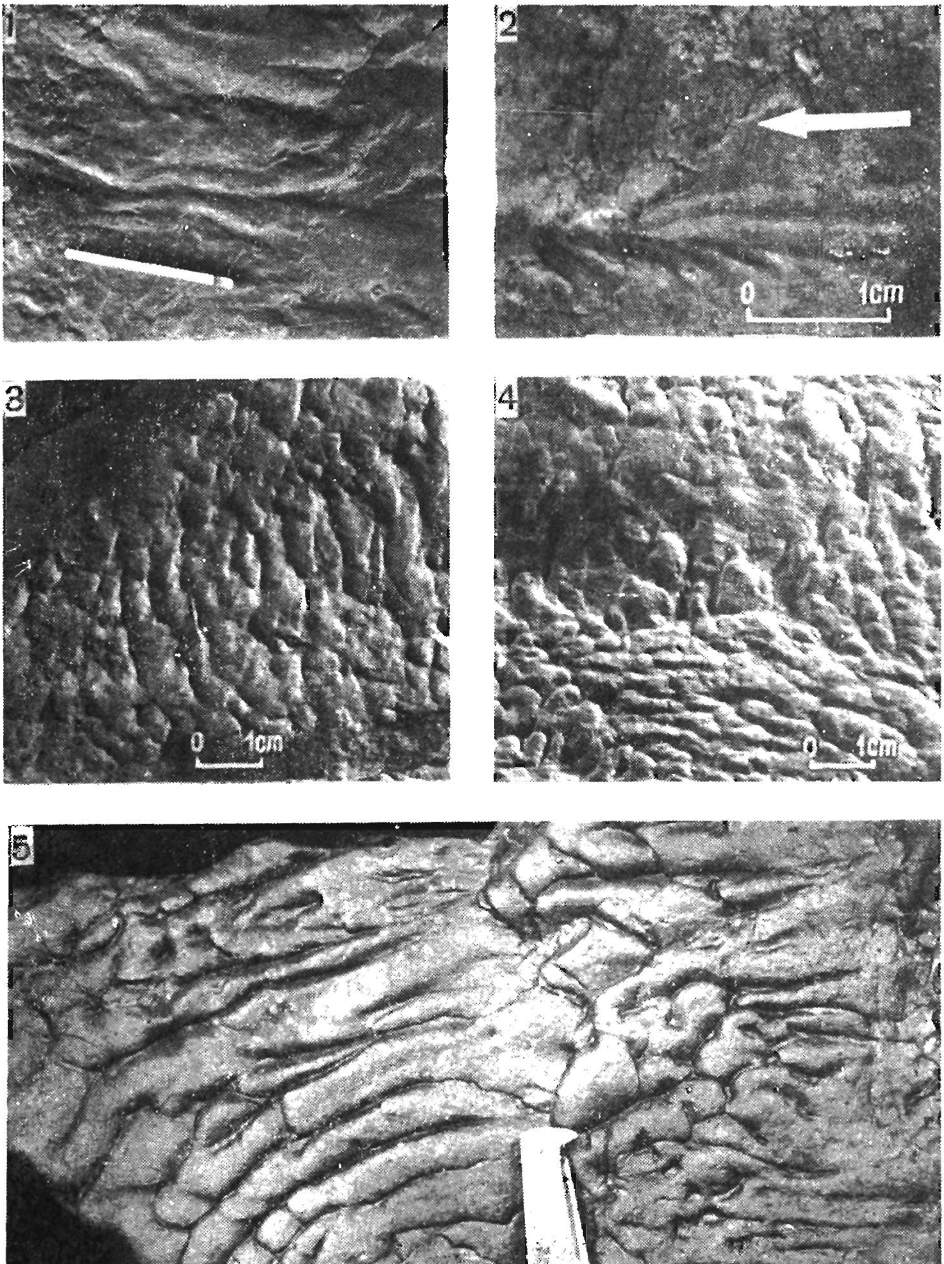


Obstacle scour moulds in the lower member of the Idzików Beds

1 and 2 — Crescent moulds formed around the shell of *Aporrhais* sp. deposited in the termination of a groove mould (Fig. 1 shows also flute moulds; framed is a fragment magnified in Fig. 2). Clayey flysch; Krosnowice, outcrop *1*.

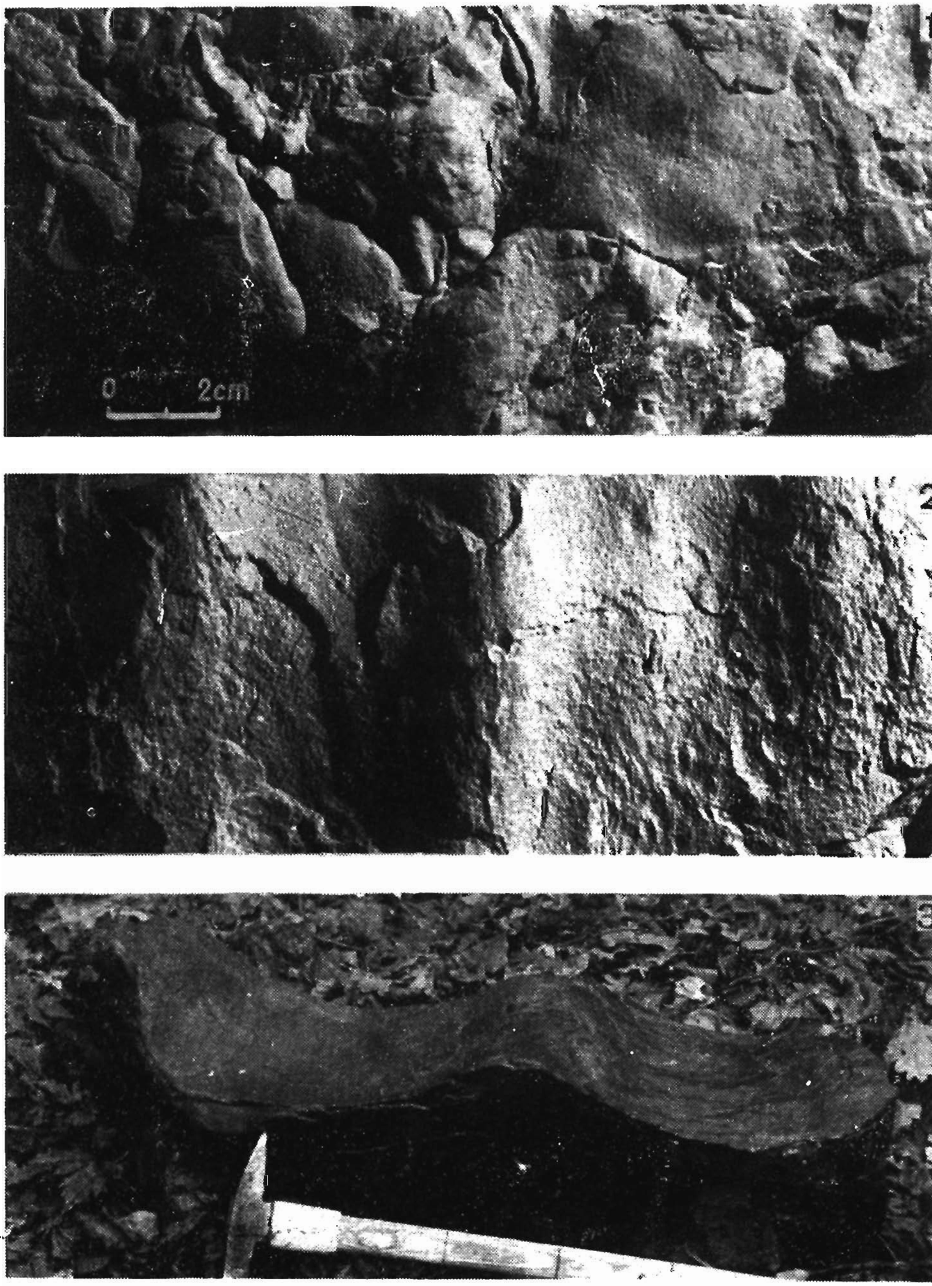
3 — Double crescent mould formed around a gastropod shell. Clayey flysch; Krosnowice, *1*.

4 — Longitudinal obstacle scour moulds (*ls*) formed behind shelter dugs of burrows; a group of small shelter dugs is also visible (*ho*). Normal flysch; Nagodzice, *16*.



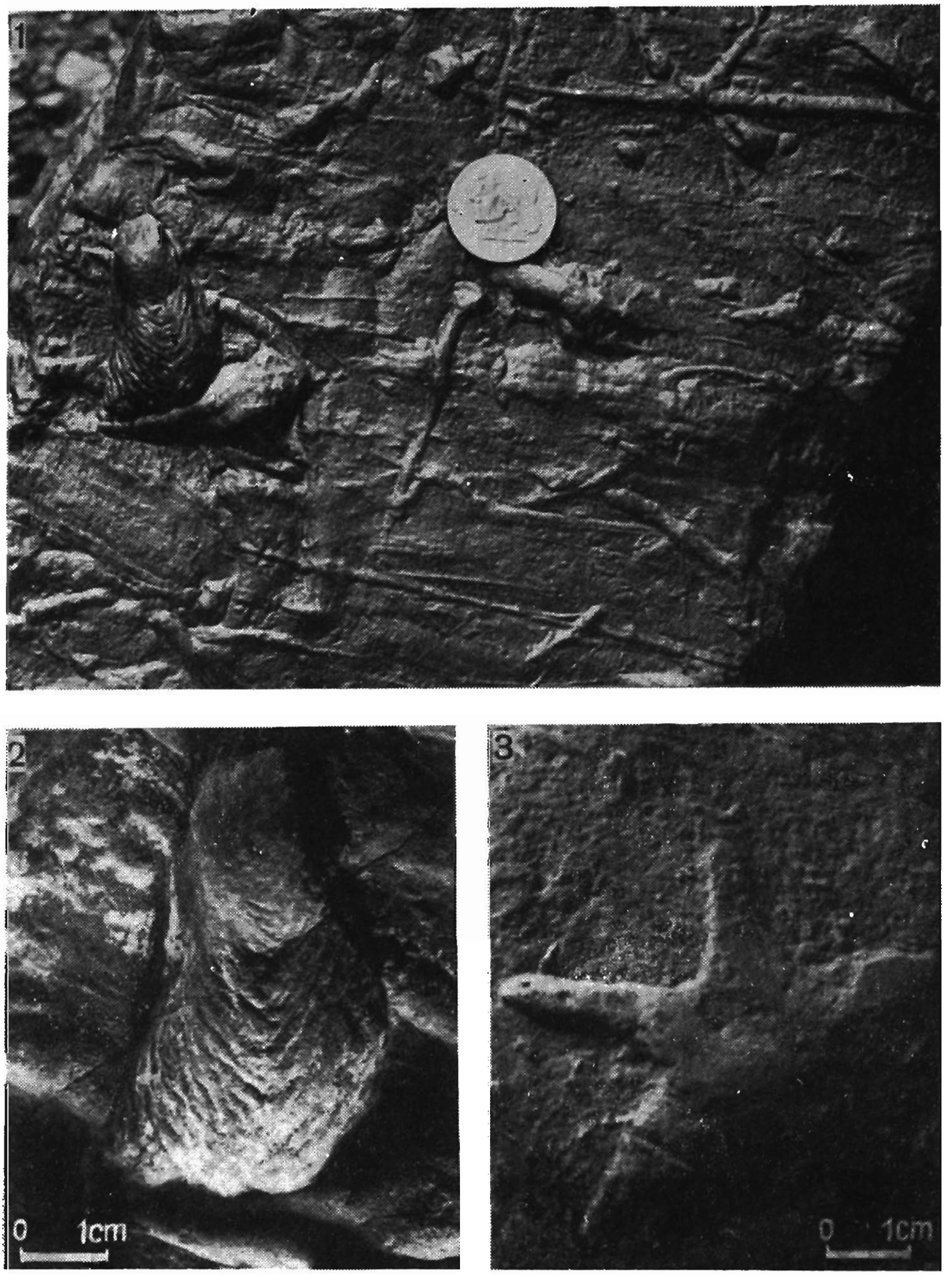
Current and current-deformed sole markings in the lower member of the Idzików Beds

1 — Small, flat flute moulds. Clayey flysch; Roztoki, outcrop *13*.
2 — Chevron mould. Normal flysch; Wilkanów, *12*.
3 and 4 — Small overlapping scaly structures and moulds of longitudinal ridges. Normal flysch; Wilkanów, *12*.
5 — Scaly structures passing into moulds of longitudinal ridges. Clayey flysch; Starków, *2*.



Deformational structures resulting from instability in density stratification in the lower member of the Idzików Beds

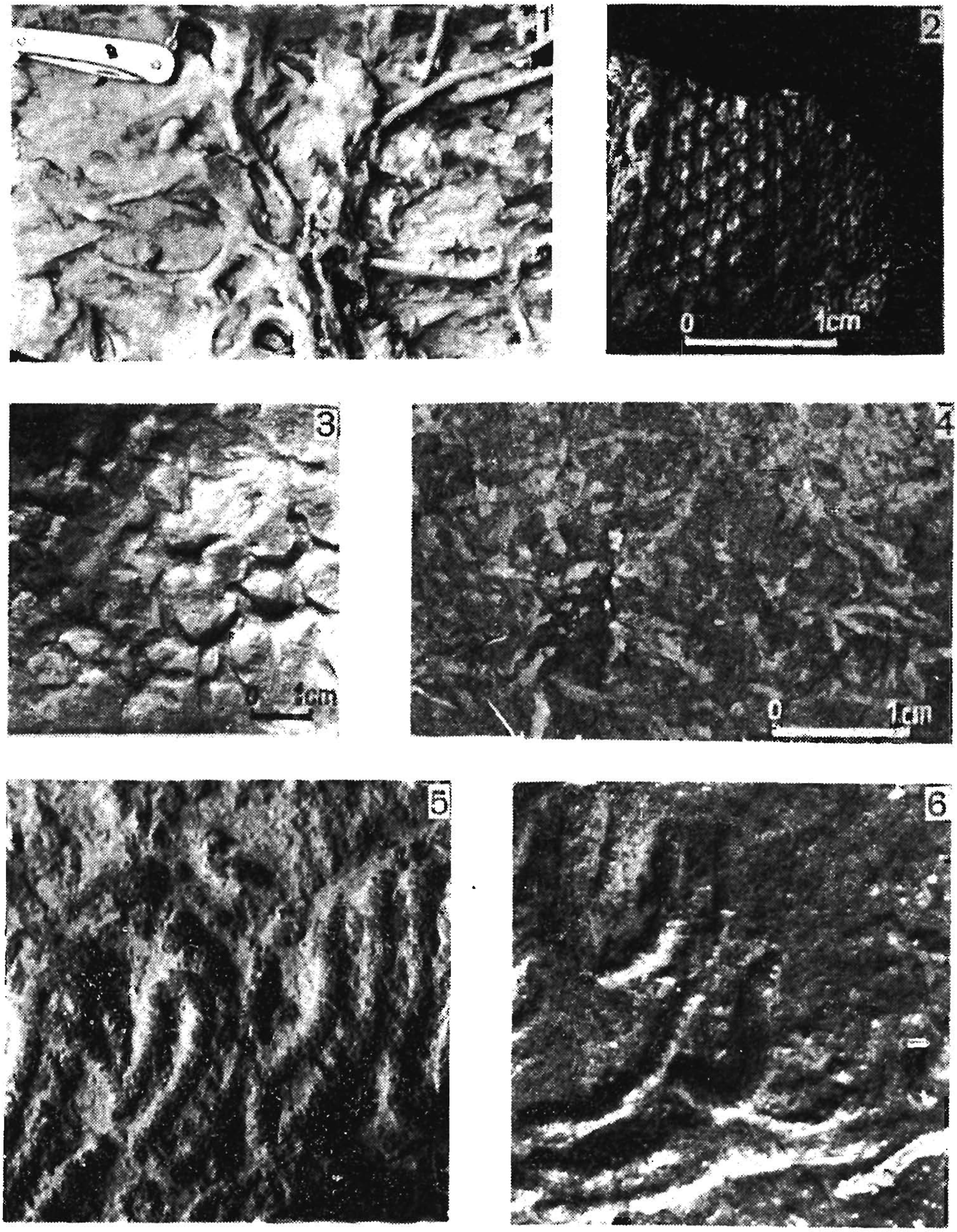
1 — Load casts on the bottom surface of a sandstone bed. Normal flysch; Nagodzice, outcrop *16*.
2 — Upper surface of an internal parting plane in the same specimen.
3 — Undulated upper surface of an internal parting plane in the sandstone bed. Clayey flysch; Krosnowice, *1*.



Biogenic structures in the lower member of the Idzików Beds

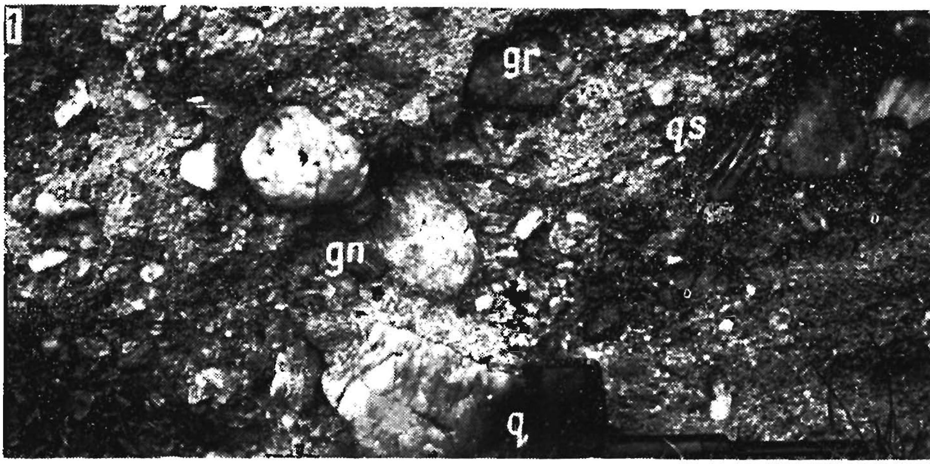
1 and 2 — Lower surface of a sandstone bed covered mainly by burrows and shelter dugs of burrows. At left, *?Gyrochorte* sp. is visible (magnified in Fig. 2). Clayey flysch; Krosnowice, outcrop *1*.

3 — *Asteriacites* sp. Clayey flysch; Krosnowice, *1*.



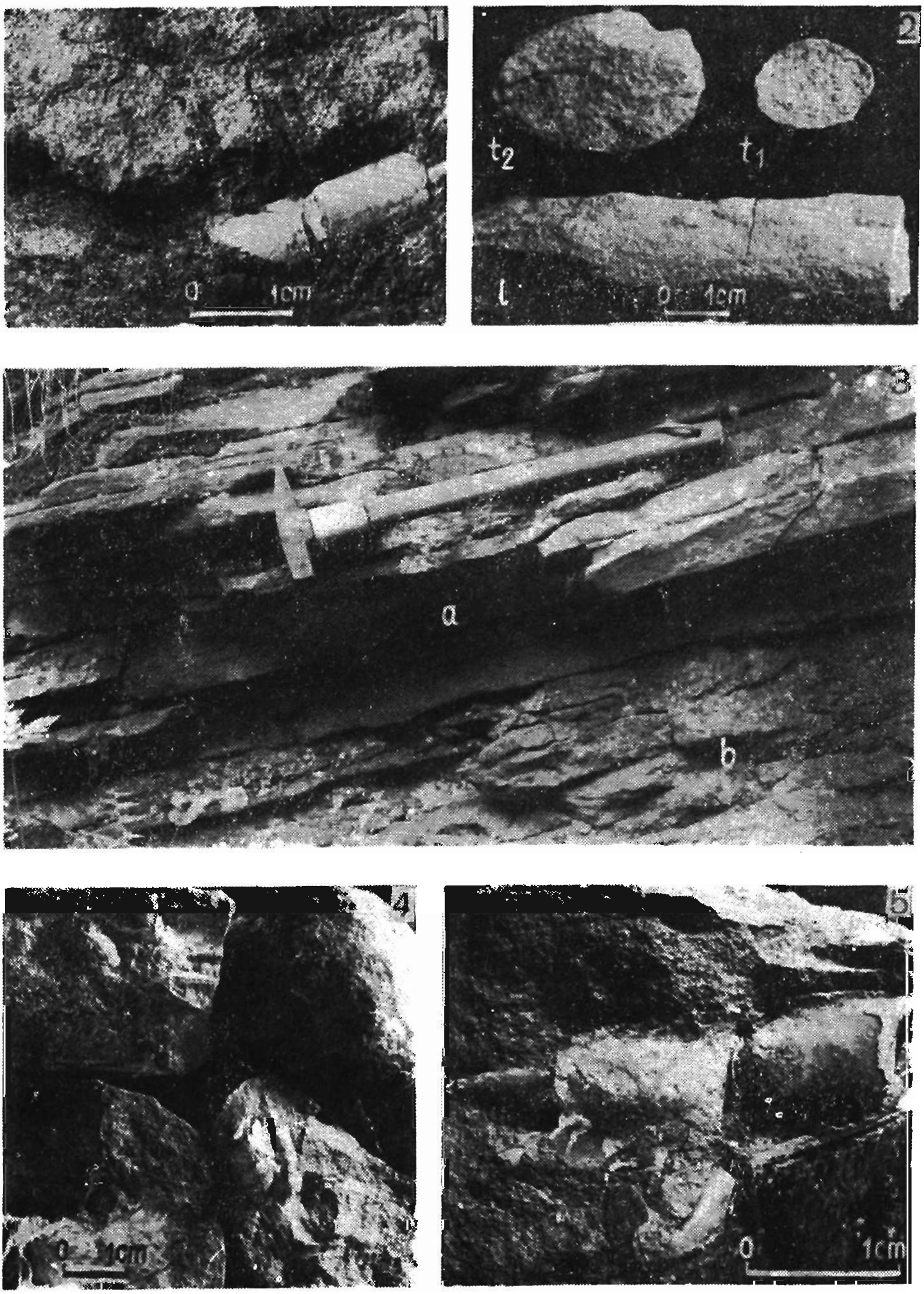
Biogenic structures in the lower member of the Idzików Beds

1 — *Phycodes* sp. Clayey flysch; Stary Waliszów, outcrop 5.
2 — *Paleodictyon* aff. *minutum* Kindelan. Clayey flysch; Krosnowice, *1*.
3 — *Paleodictyon* sp. Clayey flysch; Roztoki, *14*.
4 — *Chondrites* cf. *furcillatus* A. Roemer. Clayey flysch; Krosnowice, *1*.
5 — *Helminthoida* cf. *labyrinthica* Heer. Clayey flysch; Krosnowice, *1*.
6 — ?*Cosmoraphe* sp. Clayey flysch; Nagodzice, *15*.



Upper member of the Idzików Beds

1 — Lower surface of the conglomerate (*gr* granitoide, *gn* Gierałtów gneiss, *qs* crystalline schist, *q* quartz); Idzików, outcrop *10*.
2 — Upper part of the fine pebble conglomerate; Idzików, *9*.
3 — Medium-scale cross-bedded unit of sandstones; Idzików, *8*.



Remains and burrows of *Protocallianassa antiqua* (A. Roemer) in the upper member of the Idzików Beds

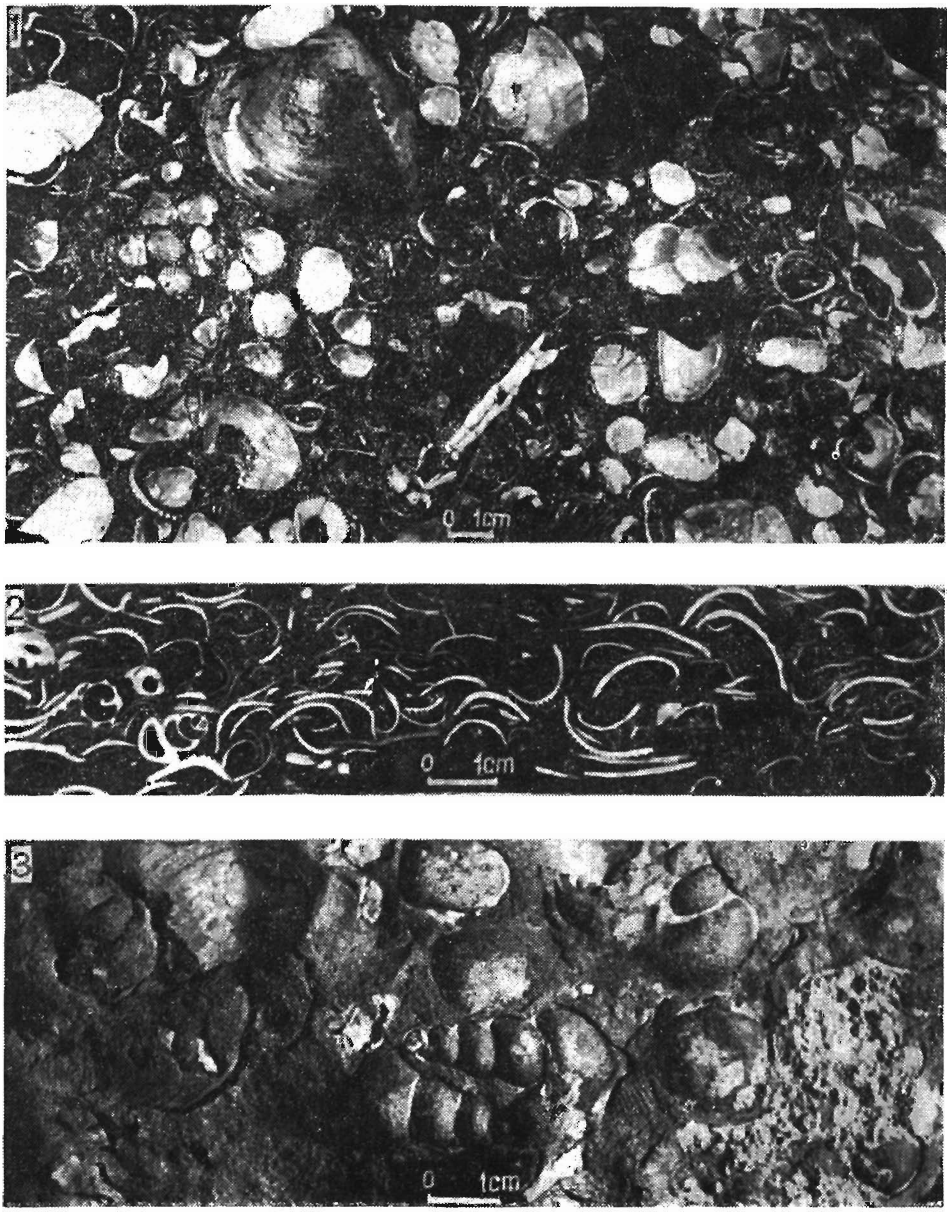
1 — Fragment of the appendage of *Protocallianassa antiqua* (A. Roemer) in a burrow. Fine-grained sandstones; Stary Waliszów, outcrop *6*.

2 — Cast of a burrow of *Protocallianassa antiqua* (A. Romer) in outer view (*l*) and cross-section (t_1); presented is also another burrow in cross-section (t_2). Medium-grained sandstone; Idzików, *8*.

3 — Sandstone beds (*a*) passing downwards into sandstones bioturbated (*b*) by *Protocallianassa antiqua* (A. Roemer). Fine-grained sandstone; Stary Waliszów, *6*.

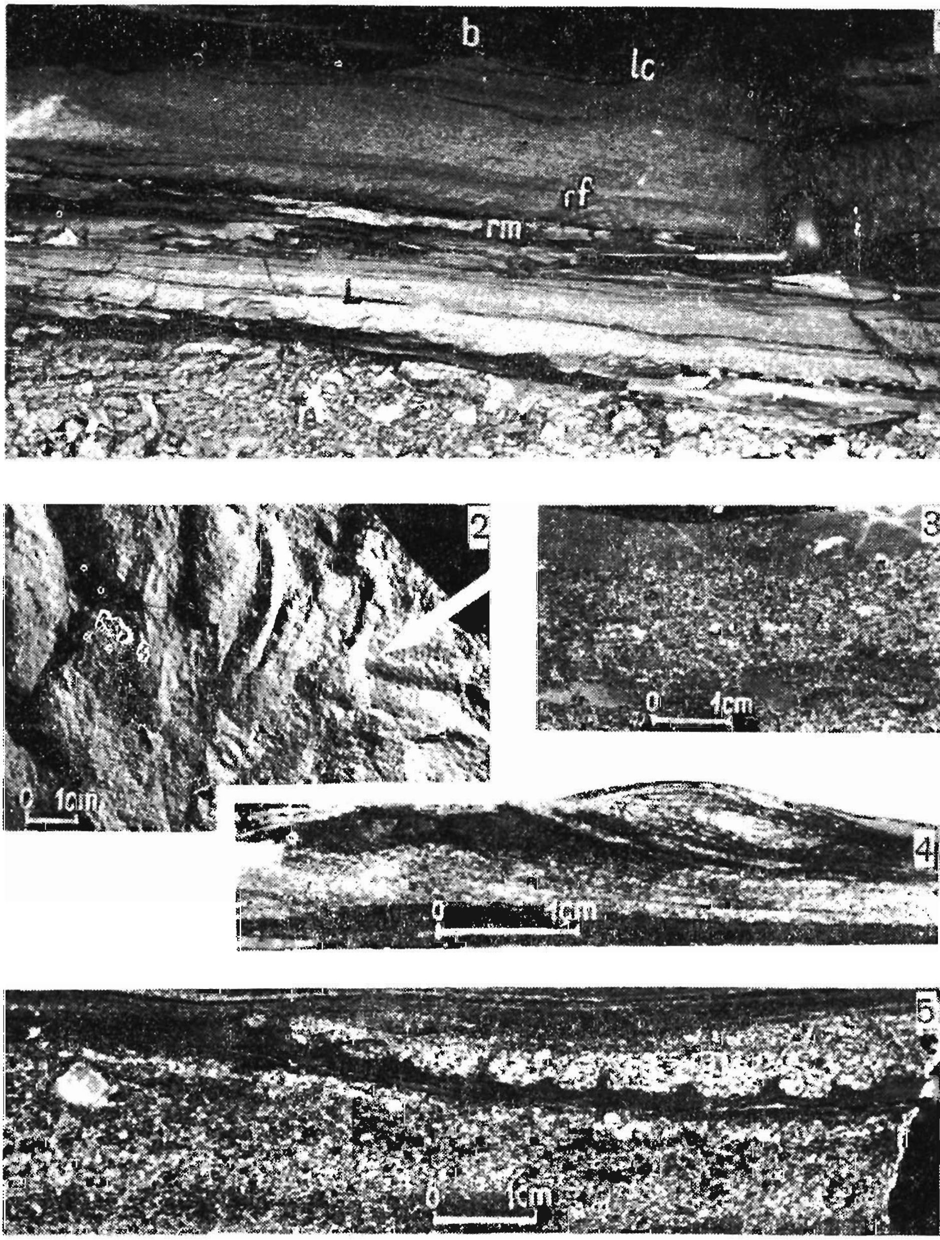
4 — Concretions formed around remains of *Protocallianassa antiqua* (A. Roemer). Fine-grained sandstone; Stary Waliszów, *6*.

5 — Fragment of the appendage of *Protocallianassa antiqua* (A. Roemer). Fine-grained sandstone; Stary Waliszów, *6*.



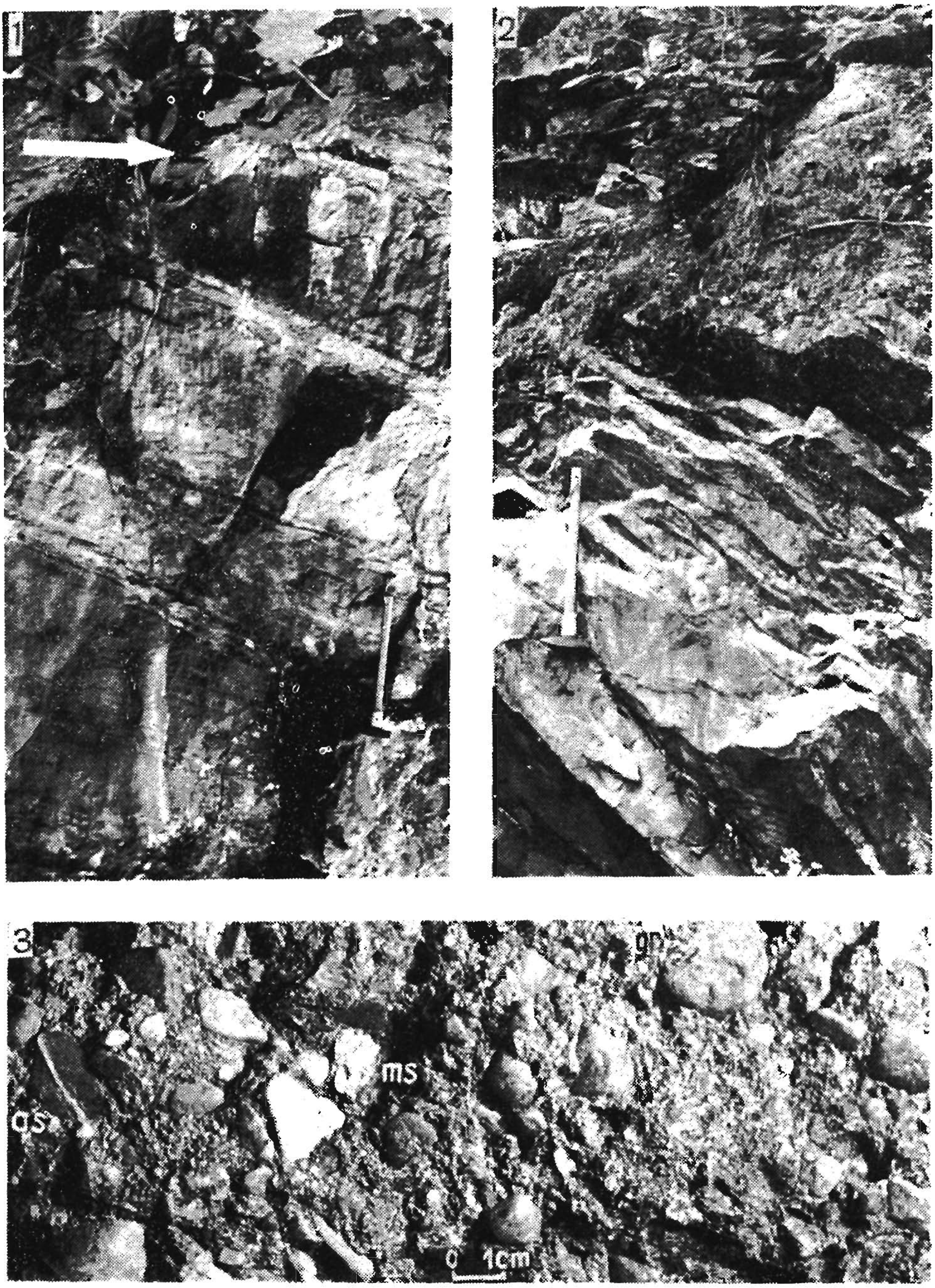
Coquinas in the upper member of the Idzików Beds

1 — Surface of the coquina bed composed mostly of the lamellibranch valves; Idzików, near outcrop *8*.
2 — Fragment of the same layer in cross-section.
3 — Weathered surface of the coquina bed composed mostly of the gastropod shells.



Contact between the lower and the upper member of the Idzików Beds; Boboszów, outcrop *22*

1 — Pelagic claystones (*Te*) in the uppermost part of the lower member and their contact with overlying sandstones and siltstones of the upper member; other designations indicate locations of the objects shown in the following figures.
2 — Upper surface of an internal parting plane showing intersection with crescentic ripple laminae, i.e. the rib-and-furrow structure (*rf*).
3 — Fragments of redeposited claystones and siltstones in the sandstone bed (*b*).
4 — Ripple-load convolution (*rm*).
5 — Laminated bed of medium-grained sandstone separated from the overlying fine-grained sandstone by a partly-loaded siltstone lamina (*lc*), the upper surface of which shows a flame structure.



Upper member of the Idzików Beds in the vicinity of Boboszów

1 — Large-scale cross-bedded unit of sandstones; Pisary, outcrop *23*.
2 — Lower part of the large-scale cross-bedded unit of sandstone; Pisary, *24*.
3 — Lower surface of the conglomerate (Gierałtów gneiss, *qs* crystalline schist, *ms* mica schist, *gr* granitoide); Międzylesie, *25*.