acta geologica polonica

Vol. 31, No. 3-4 Warszawa 1981

JERZY GŁAZEK, ŁUKASZ KARWOWSKI, GRZEGORZ RACKI & TOMASZ WRZOŁEK

The early Devonian continental/marine succession at Chęciny in the Holy Cross Mts, and its paleogeographic and tectonic significance

ABSTRACT: The early Devonian transgressive deposits at Chęciny in the Holy Cross Mts, which rest on a weathered surface of Lower Cambrian claystones, are represented by diverse terrigenous rocks containing scarce marine fossils in their higher part. The lower part represents a local waste, redeposited under continental conditions. The thin development of the transgressive terrigenous sequence (8 m) points to slow subsidence and a rapid advance of marine conditions. These deposits are overlain by carbonate-terrigenous (chiefly dolomitic) rocks containing a diversified open-marine fauna. The paleogeography of the early Devonian is discussed. Evidence is presented for a swell, trending E-W, in the southern part of the Holy Cross area; also for the presence of an epicontinental basin filled with Lower Devonian deposits over 1 km thick in the northern periphery of that area. It is concluded that there is little evidence for the concept of Caledonian geosyncline in southern Central Poland.

INTRODUCTION

The Cambrian and early Devonian deposits of the Chęciny anticline in the Holy Cross Mts, Central Poland (Text-figs 1—2) due to lack of natural outcrops are poorly known.

The early Devonian of the Chęciny anticline was first recognized by Gürich (1896) and Sobolev (1909), and subsequently more data were given by Czarnocki (1919, 1936, 1938, 1948) and Filonowicz (1968, 1973b). Formerly studied sections occur mostly near Brzeziny, SE of Chęciny (Text-figs 1 and 7) where exposed are "Emsian" sandstones, and Eifelian limestones and marly dolomites with rich fauna (*Dąbrowa Horizon* of Gürich 1896). In the NW parts of the anticline the coeval strata are locally known (*e.g.* "Emsian" sandstones near Skiby, W of Chęciny).

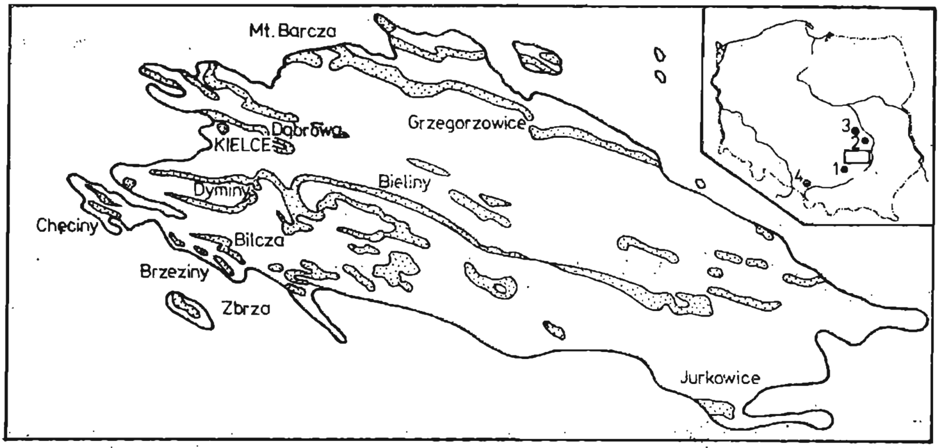


Fig. 1. Sketch map of outcrops of the early Devonian clastics (*stippled*) within the boundary (*thick solid line*) of the Paleozoic core of the Holy Cross Mts (*modified after* Kowalczewski 1971). Inset shows the Holy Cross area (*rectangled*) and discussed boreholes: **1** — Jaronowice IG-1, **2** — Ciepielów IG-1, **3** — Pionki-4, **4** — Goczałkowice IG-1

Poor registration of "Emsian" sandstones and "Eifelian" dolomites in the western part of the Chęciny anticline has commonly been interpreted as a result of tectonic reductions along the Cambrian/Devonian contact (Czarnocki 1936, 1948; Kutek & Głazek 1972; Hakenberg 1974) and/or erosional hiatuses (Czarnocki 1936, Kowalczewski 1971, Filonowicz 1973b).

In this paper new data on the early Devonian deposits are presented, the observations of which were carried in the sewage cuttings in 1978, and in the the water-piping cuttings in 1977, excavated in the western outskirts of Chęciny (Text-fig. 2). These field observations were made by the authors helped by the students of the Silesian and Warsaw Universities.

The mineralogical investigations presented in this report were made up by Ł. Karwowski, whereas paleontological, stratigraphical and ecological remarks were written by G. Racki and T. Wrzołek; paleogeographical and tectonic speculations were given by J. Głazek.

Acknowledgements. Docent A. Stasińska kindly identified the coelenterates, Dr. E. Tomczykowa the trilobites, Dr. L. Karczewski the pelecypods, Dr. E. Głuchowski the crinoid columnals, and Professor G. Biernat consulted the brachiopod determinations, which is here gratefully acknowledged. Thanks are also due to M. Racka, M. Sc., A. Mikołajczyk, M. Sc., D. Jankowska, M. Sc., J. Pukowski, S. Stolarczyk and T. Zydorowicz, M. Sc., for field assistence; D. Lis for taking some photos; and L. Wawro and W. Roszczynko for drawing figures. The Authors are especially indebted to Dr. S. Rudowski who read the sedimentological part of the manuscript and made helpful suggestions.

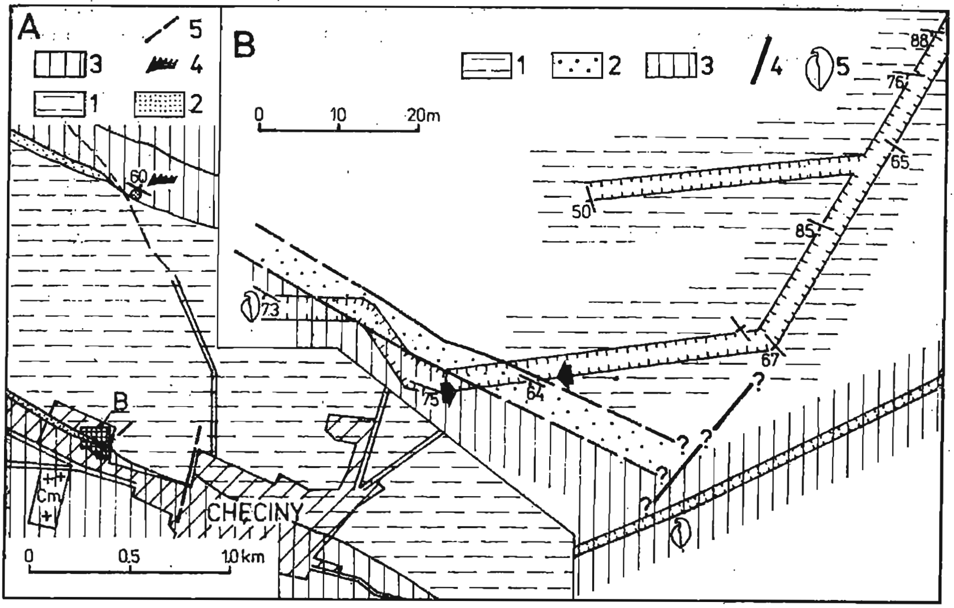


Fig. 2. Location of the studied exposures at Chęciny

A — Geological sketch map (*modified after* Czarnocki 1948): *1* Lower Cambrian deposits, *2* early Devonian clastics, *3* late Devonian carbonates, *4* *Icriodus* locality on the northern limb of Chęciny anticline, *5* faults

B — Geological sketch of trenches; wider — sewage cuttings (1978), narrower — water-piping cuttings (1977); arrowed is the part presented in Text-fig. 4; *1* Lower Cambrian claystones, *2* early Devonian clastics, *3* Eifelian dolomites, *4* supposed fault, *5* fossiliferous sites

DESCRIPTION OF THE SECTION

The excavated profile in the cuttings at Chęciny has been divided into 7 unformal lithostratigraphic units (Text-fig. 3), two of them being treated as the Cambrian substrate while the five younger attributed to the Devonian (Text-figs 3—5).

CAMBRIAN

UNIT A: In the most part of the outcrops (Text-figs 2—3) more than 100 m of olive-gray, fissured and poorly stratified claystone were observed (Pl. 1, Figs 1, 3). Intercalations of siltstones and fine-grained quartz sandstones in distinct beds up to 10 cm rarely occur (Pl. 1, Fig. 2); layer surfaces are often covered by sericite, and bioglyphs were also observed. Claystones are sometimes laminated (Pl. 2, Fig. 1) what is underlined by fraction differentiation of clay minerals. The latter show low degree of order and are represented mainly by illite, kaolinite and hydromuscovite (*1* in Text-fig. 6); small admixture of detrital quartz and postpyrite aggregates of iron hydroxides are also noted. These rocks belong to the Czarna Shale Formation (Orłowski 1975) and represent the Lower Cambrian (Czarnocki 1948).

UNIT **B**: Brownish-violet claystones, sharply limited from the underlying olive-gray claystones by the color change. Violet spots penetrate the substrate along fissures 2 m down. Bedding is unvisible; unchanged parts of the unit are bright-green, and in places yellow spots were observed. The mineral composition of this unit displays no major differences with the underlying strata (*2* in Text-fig. 6). Occurrence of goethite (up to 7% of Fe_2O_3) is significant and it causes

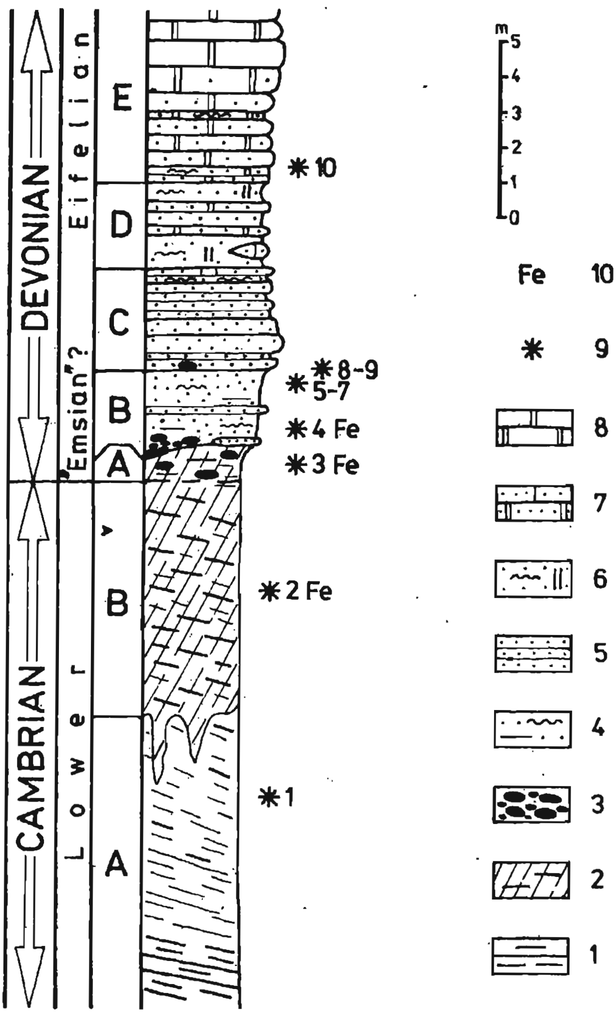
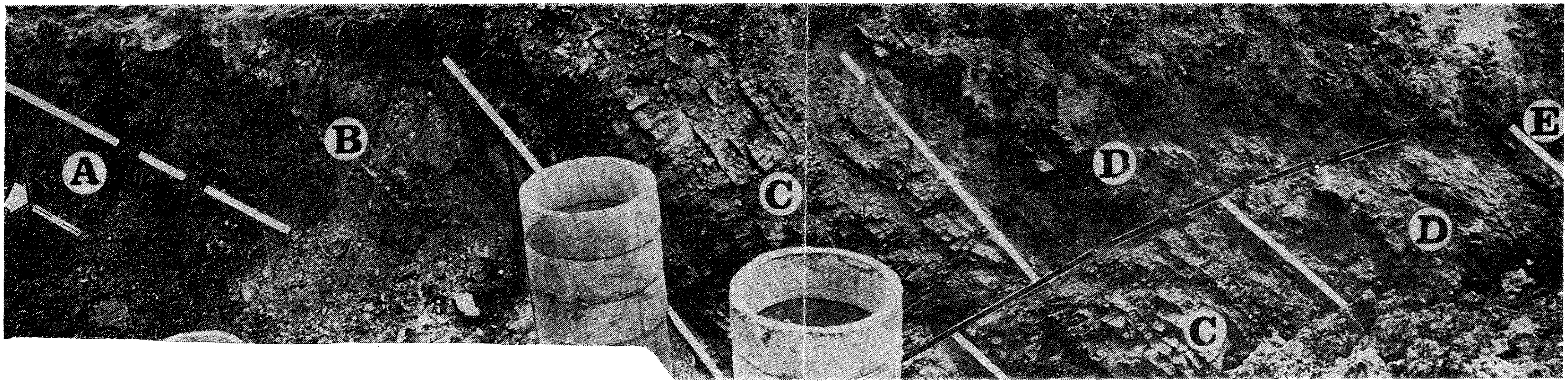


Fig. 3. General stratigraphic column of the studied trenches at Chęciny
LOWER CAMBRIAN: *1* olive-gray and green claystones, *2* violet-brownish claystones (weathered *in situ*); EARLY DEVONIAN (*cf.* Text-fig. 5): *3* conglomerates, pebbles, rock fragments, *4* clayey sandstones, *5* sandstones, *6* carbonate sandstones, *7* sandy dolomites, *8* dolomites; OTHERS: *9* location of samples for **X**-ray study (numbers as in Text-fig. 6), *10* samples with high concentration (> 5 weight %) of Fe_2O_3; *A-E* lithostratigraphic units discussed in the text



Fragment of the southern wall of the southern sewage trench at Chęciny (*cf.* Text-fig. 2*B*); arrowed is the supposed Cambrian/Devonian boundary
A-**E** — early Devonian lithostratigraphic units described in the text (*cf.* Text-figs 3 and 5); small fault through the sequence is visible

the color of the unit. Thickness is about 7 m. The unit may be treated as *in situ* weathered Cambrian claystones.

DEVONIAN

UNIT **A**: The topmost part of the brownish-violet claystones, about 1 m thick exhibits indistinct parallel bedding (Text-figs 4—5). Fragments of sandstones and siltstones up to 3 cm in diameter have been found. Kaolinite, illite, quartz and goethite are the main mineral components. The clay minerals show relatively high degree of order (*3* in Text-fig. 6). This unit represents probably a redeposited waste of the underlying Cambrian deposits.

UNIT **B**: Silty sandstones, with sandstone and coglomerate interbeddings, and sandy-clayey matrix. The thin bed of bright-green sandstone with fragment of violet claystones rests directly on the underlying deposits; laterally it passes into a thicker lens of cross-bedded conglomerate and sandstone (Text-fig. 5; Pl. 2, Fig. 3) with imbricated pebbles. Clay minerals and iron hydroxides dominate in rock matrix and the former show very low degree of order (*4* in Text-fig. 6). Some grains of K-Na feldspars, muscovite, as well as rounded zircon and tourmaline are seen in thin section. First organic remain, a fragment of a ribbed shell, was found in this part of section. Sandy-silty deposits with indistinct bedding and irregular jointing prevail in the higher parts of this unit; they are mottled, brownish-violet and bright-green or grayish, to the top also yellow and cherry. Locally silty claystones occur (in the lower part parallel-bedded; *see* Pl. 2, Fig. 3) as well as thin layers of compact sandstones. In the upper part of the unit organic remains were found: a crinoid columnal and a fragment of ?hexactinellid sponge (Pl. 4, Figs 1—2). Thickness is 2.4 up to 3 m.

UNIT **C**: Fine-grained sandstones, chiefly thin- to middle-layered, bright-colored. Of the fossils only sporadical *Planolites* bioglyphs were stated. Indistinct cross-bedding and lamination were rarely seen. Some layers are most soft, dark--cherry with ferruginous spots and laminae. Quartz grains with regeneration rims were only rarely seen. Beds of mostly cherry sandy-siltstones (up to 1.2 m in thickness) were observed, as well as lateral change of hard sandstones into loose mudy-sandy rocks. Towards the top, the thickness of beds distinctly diminishes. These rocks are composed of fine quartz (up to 0.6 mm), poorly sorted and rounded. Common are zircon and tourmaline. Thickness is 2.9 m, laterally growing up to more than ?3.5 m.

UNIT **D**: Sandy carbonates, yellowish or bright-violet, indistinctly bedded with intercalations of siltstones displaying lower carbonate content. Two layers and a lense enriched in carbonates were stated. In low-carbonate layers the clayey--ferruginous matrix dominated, while higher-carbonate layers contain chiefly dolomicrite matrix. In lower part calcite dominates (Text-fig. 5). Thickness is 2.6 m.

UNIT **E**: Fossiliferous dolomites, distinctly bedded. Their layer thickness, as well as crystalinity are increasing to the top. In the lower part of the unit high terrigenous admixture (mainly sandy quartz, but illite and kaolinite are also common; *10* in Text-fig. 6) and yellow-grayish color appears. To the top, colors are more gray and faunal remains (almost exclusively crinoids) are more numerous. In the lowermost part, in some more terrigenous laminae concentrations of

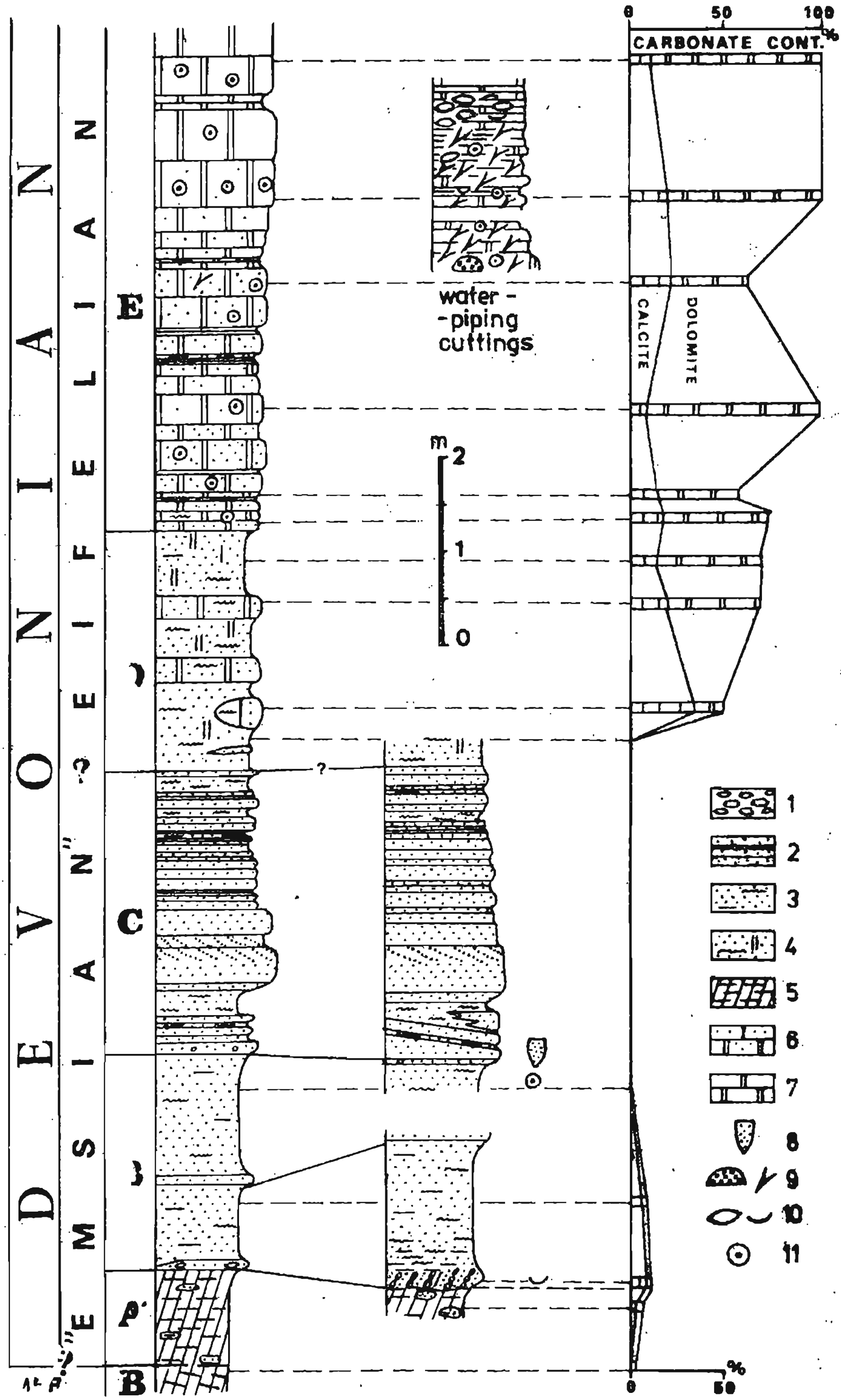


Fig. 5. Detailed column of early Devonian deposits exposed at Chęciny; carbonate content (weight %) is presented on the associated graph (at right)
1 conglomerates, *2* sandstones, *3* clayey sandstones, *4* carbonate sandstones, *5* violet-brownish claystones, *6* sandy carbonates, *7* dolomites, *8* sponges, *9* coelenterates (branched and massive), *10* brachiopods, *11* crinoids

haevy minerals (chiefly zircon) are also stated. Strong dolomitization of bioclasts is observed and frequently only relics of primary structures may be stated. The calcite relics are visible in matrix in the lower part of the unit, while in the upper part only inside the bioclasts. The replacement of calcite skeletal fragments by chalcedony is also common. Observed thickness is 12.5 m.

More numerous and strongly diversified macrofaunal remains were found in grayish-yellow or greenish dolomicrites (Pl. 3, Figs 2—3; Pl. 4, Figs 3—4), intercalated with some barren beds, speckled by ?bioturbations. They were observed in the westernmost part of the sewage cuttings (Texts-fig. 2) and may be treated as lateral equivalent of the above-decribed dolomite unit. Similar deposits (chiefly tabulate- and brachiopod dolomicrites — Text-fig. 4; Pl. 3, Figs 1, 4) were also stated in water-piping cutting (Text-fig. 2).

STRATIGRAPHIC INTERPRETATION

Numerous fossils were gathered from the dolomite unit (Pl. 3). In spite of generally poor state of preservation, the following groups were recognized:

COELENTERATA: ?*Pachypora* sp. (abundant), *Chaetetes barrandi* Nicholson, ?*Heliolites* sp. (identified by Docent A. Stasińska);

BRACHIOPODA: "*Athyris concentrica*" (v. Buch) [?*Atrythyris*], *Chonetes angustestriata* Gürich (both abundant), rare thick-ribbed spiriferids *Chimaerothyris dombrowiensis* (Gürich) and atrypids;

CRINOIDEA: ?*Hexacrinites humilicarinatus* Yeltischeva (most numerous), *Cupressocrinites gracilis* Goldfuss, *Kabanicrinus lobatus* Yeltischeva & Stukalina (identified by Dr. E. Głuchowski);

PELECYPODA: *Posidonia* cf. *venusta* (Muenster), *Mytilarca* sp., *Pterinopecten* sp., *Leptodesma* sp., *Palaeoneilo* sp., *Pterinea* sp. (identified by Dr. L. Karczewski);

TRILOBITA: *Dechenella* sp. (most numerous), *Phacops* cf. *schlotheimi* Bronn, *Proetus (Proetus)* sp. (identified by Dr. E. Tomczykowa);

associated with rugose corals, bryozoans, nautiloids, gastropods, ostracodes, fishes, and conodonts.

The investigated assemblage (chiefly brachiopods and tabulates) is similar to the hitherto still poorly known fauna of the Dąbrowa Horizon, especially from the environs of Zbrza and Brzeziny (*cf.* Gürich 1896; Sobolev 1909; Filonowicz 1968, 1973b) and borehole Jaronowice (Jaworowski & *al.* 1967). The assemblage shows also some affinities to coeval fossiliferous Grzegorzewice Beds of the northern Holy Cross Mts (*cf.* Sobolev 1909, Pajchlowa 1957, Głuchowski 1981). The listed pelecypods and the trilobite *Proetus* are for the first time cited from the Holy Cross Eifelian.

Early Eifelian (Lower Couvinian) age of the Dąbrowa Horizon at Jurkowice (and in boreholes drilled NW of Kielce. Text-fig. 1) has been confirmed by conodonts (Szulczewski, Romanek *in*: Narkiewicz & *al.* 1981). The conodont *Icriodus* was also found in the similar with the herein described deposits of the northern limb of the Chęciny anticline (gray-violet dolomites with crinoids, brachiopods and tabulates at the Zelejowa Hill; *cf.* Text-fig. 2). It points to much wider than previously believed geographical range of the fossiliferous early Eifelian deposits in the Holy Cross Mts.

Poorly preserved fossils from the terrigenous unit *B* and *C* do not permit any precise stratigraphical statements. Similar sequences from the south Holy Cross Mts were traditionally (but without paleontologic documentation) described as the "Upper Emsian" (*e.g.* Czarnocki 1936; Kowalczewski 1971; Filonowicz 1968, 1973b). It should be noted that no marine fossils were known from the terrigenous Devonian of this part of the Holy Cross Mts (*e.g.* Kowalczewski 1971). This sequence is continuosly grading into carbonate series and lithostratigraphic boundary is placed over last distinct sandstone bed (Text-fig. 5). It seems probable that the top of terrigenous deposits belongs to the Lower Eifelian (*cf.* Kowalczewski 1971), and this very age may be ascribed to whole studied sequence.

The rapid color change and disappearing of bedding in Cambrian claystones, as well as presence of fragments of violet claystones in the overlying unit *B* suggest that the claystone series is connected with weathering processes developed on the Cambrian substrate. The boundary with the terrestrial Devonian slope deposits is to be placed just below the occurrence of first sandstone fragments that indicate redeposition. This is also confirmed by the degree of order of clay minerals which is generally much lower in unquestioned Devonian deposits (units *B-E*). The highest degree of order was stated in unit *A* (*3* in Text-fig. 6). and may be explained by an outwash of the finest clay particles during resedimentation.

Similar mottled deposits with sandy or conglomeratic intercalations below the sandstone unit (*cf.* Text-fig. 8) are known from the eastern part of the Chęciny anticline (Brzeziny-Bilcza area; *cf.* Filonowicz 1968, 1973b) and from borehole Jaronowice (Jaworowski & *al.* 1967). In the section studied, the lower part of unit *B* shows locally gravel lenses, considered as equivalent of the transgressive Bieliny Conglomerates of "Upper Emsian" age ("Eifelian sensu lato" of Kowalczewski 1971). There is no sign of the existence of older, pre-Devonian deposits in the section, although eastward of the area, at Brzeziny (Text-fig. 7), the Ordovician and Silurian (graptolite shales including) are preserved (Czarnocki 1938, 1948; Filonowicz 1963, 1968, 1973b; Tomczyk & Turnau-Morawska 1964).

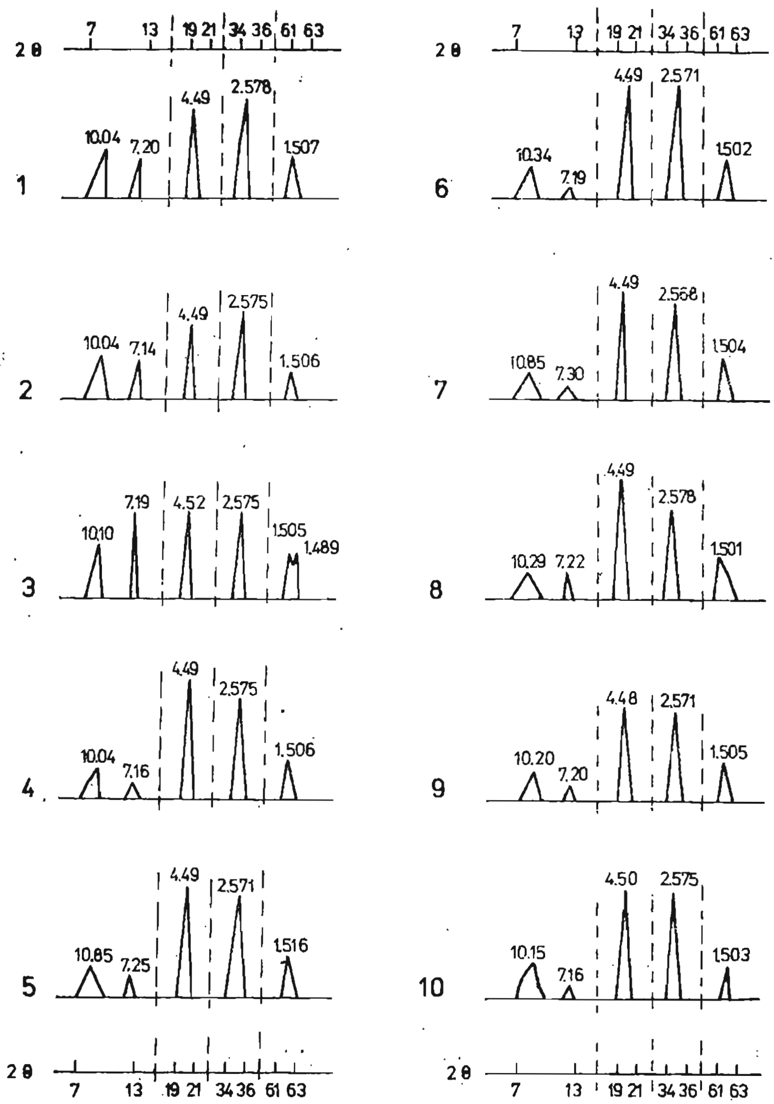


Fig. 6. Degree of order of clay minerals (X-ray, Cu, Kα) in the studied section at Chęciny; for sample location *see* Text-fig. 3

ENVIRONMENTAL REMARKS

Prior to the deposition of the Early Devonian unit *A* the erosion of all older deposits had exposed the top of Lower Cambrian deposits to strong continental weathering with high redox potential evidenced by concentration of Fe^{3+} (goethite) in weathering *in situ* claystones. The slope redeposition of weathering mantle (unit *A*) took place under conditions of hot arid climate proved by impregnation of rock fragments with iron hydroxides. Reworking of the older waste, as well as of nearby exposed Cambrian rocks and fragments of allochthonous quartz pebbles found at the base of unit *B* indicates an environment with rapid changes of energy and probably strong evaporation (carbonate rims on pebbles already impregnated with iron compounds) in continental desert environment of the Old Red type. The fragments of organic remains suggest nearshore conditions at the beginning of sedimentation of the unit *B*. Similar, but more stabilized depositional setting may be ascribed to the unit *C*, seemingly intertidal. Further development of transgression and the restricted lagoonal environment is more probable during terrigenous-carbonate sedimentation of unit *D*. Small thicknes of the studied terrigenous sequence points to slow subsidence of the Chęciny area.

Differentiated shallow-marine environment with more favorable life conditions has followed during deposition of unit *E*. This habitat may be ascribed to the transition from restricted lagoon to more open-marine carbonate sedimentation, when different communities have developed, the most important of which are: (*1*) "*Athyris*" monospecific (?) brachiopod populations, and (*2*) more diversified, *Chonetes*-dominated one (containing also some pelecypods, trilobites), colonizing soft, partly bioturbated bottom. The latter paleocommunity is similar to some of those from the Grzegorzowice Beds (*e.g.*. series *VIII* of Pajchlowa 1957). Similar synecologic differentiation was not described from the Holy Cross Devonian, but was stated in the Givetian Honseler Beds of the Rheinisches Schiefergebirge; for instance, Cinar (1978) reported from his type *H* sediment the *Athyris*-banks, *Thamnopora*-banks and barren intercalations with fine bioturbations.

The presence of diversified, open-marine fauna, and high calcite content in the passage carbonate-terrigenous unit point to chiefly secondary dolomitization of primary lime-terrigenous sediments (*cf.* Narkiewicz 1979). The coeval non-dolomitized equivalents of some lithologies (*e.g.* tabulate- and "*Athyris*"-limestones) are known from the other localities of this part of the Holy Cross area (Gürich 1896; Sobolev 1909; Czarnocki 1919; Jaworowski & *al.* 1967; Filonowicz 1968, 1973b). Nevertheless, some layers with fauna could be deposited in conditions of abnormal salinity.

PALEOGEOGRAPHIC AND TECTONIC REMARKS

The described section presents the first record of sedimentary contact between Lower Cambrian claystones and transgressive early Devonian deposits, as well as the first full profile of these deposits in the vicinity of Chęciny. Very poor surface outcrops of early Devonian deposits in this area were interpreted by tectonic reduction along the limbs of Chęciny anticline and/or by tectonic reduction together with sedimentary reduction and direct sedimentation of dolomitic Eifelian or Givetian on the Cambrian substrate (Czarnocki 1936, 1948; Kowalczewski 1971). In many places along the limbs of the Chęciny anticline are known tectonic contacts between the Cambrian and younger deposits, *e.g.* Triassic and Zechstein at Zajączków (Kutek & Głazek 1972, Kowalski 1975, Gągol & *al.* 1976), Zechstein near Radkowice and Brzeziny (Czarnocki 1938, 1948; Filonowicz 1968, 1973b), different Devonian strata elsewhere (Czarnocki 1938, 1948, 1952; Filonowicz 1968, 1973b; Kutek & Głazek 1972; Hakenberg 1974; Gągol & *al.* 1976; Głazek & Kutek 1976). Similar contacts are also known between younger deposits *e.g.* Triassic or Zechstein and Devonian (Czarnocki 1927, 1938, 1948; Filonowicz 1968, 1973b; Kutek & Głazek 1972; Kowalski 1975; Gągol & *al.* 1976).

The origin and age of these contacts have long been under discussion, and some authors (*e.g.* Hakenberg 1974) treated them as exclusively Variscan, while the others stressed their Laramide age (Gągol & *al.* 1976). The most popular remains the view of Czarnocki (1948) that these contacts are of Variscan age but strongly remodelled during the Laramide movements.

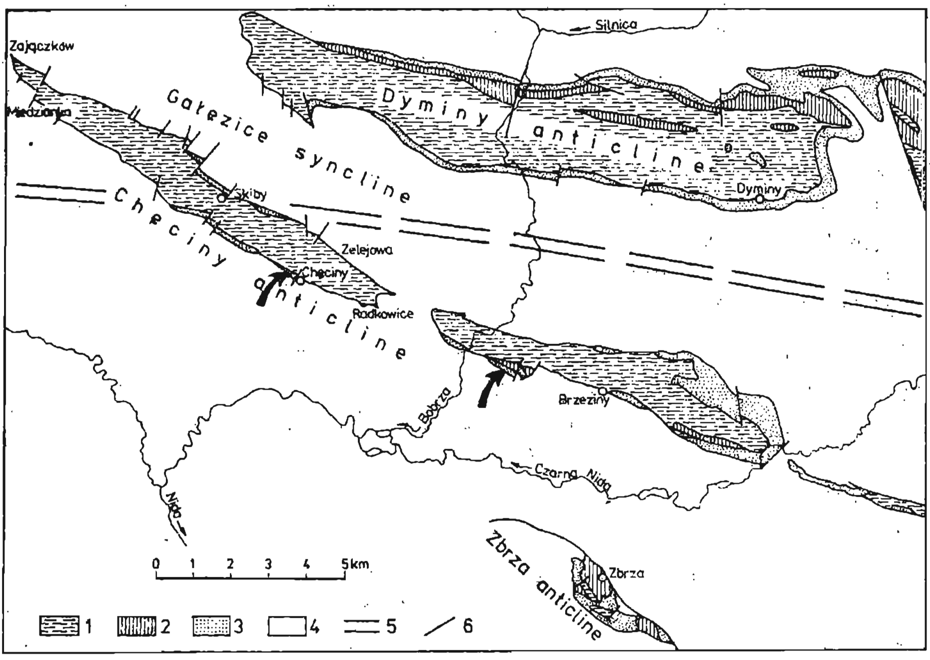


Fig. 7. Outline of the Caledonian structure in SW part of the Holy Cross Mts (compiled and modified after: Czarnocki 1938, 1948; Filonowicz 1965, 1973a; Hakenberg 1974); arrowed are new-discovered occurrence sites of early Devonian clastics

1 Lower Cambrian, 2 Ordovician and Silurian, 3 early Devonian clastics, 4 younger deposits, 5 supposed axis of the Caledonian swell (Chęciny-Dyminy Swell), 6 faults

Thin early Devonian clastics instead of their complete tectonic reduction between the carbonate Devonian and Silurian deposits were found also in the test-pit at Brzeziny (dug out in 1978 by J. Pułkowski, S. Stolarczyk and T. Zydorowicz; arrowed in Text-fig. 7).

Thus, the tectonic deformations of the Chęciny area need further detailed study, and the presence of tectonic contacts should be tested everywhere along the limbs of the Chęciny anticline.

The early Caledonian (before late Tremadocian), late Caledonian (before Emsian), Variscan (before Zechstein), early Cimmerian (before Bathonian), late Cimmerian (before Albian) and Laramide (before Upper Eocene) movements were stated in the area studied, but their consequences were not properly evaluated till present. Some authors have stressed the Caledonian deformations (*e.g.* Znosko 1963, 1965, 1974; Kowalczewski 1978), the others the Variscan (Czarnocki 1919, 1948, 1957; Filonowicz 1968, 1973b; Hakenberg 1974) or the Laramide ones (Kutek & Głazek 1972, Głazek & Kutek 1976, Gągol & *al.* 1976). The here recognized section allows a discussion on the significance of late Caledonian (pre-Middle Devonian) movements in the Holy Cross area.

At first, it should be stressed that in the southern part of the Holy Cross area and south of it, the late Precambrian and Cambrian deposits were uplifted and eroded before the Ordovician transgression, the deposits of which rest directly on the late Precambrian south of the Holy Cross Mountains (Jaworowski & *al.* 1967, Pożaryski & Tomczyk 1968, Deczkowski & Tomczyk 1969, Jurkiewicz 1975), on the Lower Cambrian in the area studied, on the Middle and Upper Cambrian in the central and northern Holy Cross Mountains (Czarnocki 1919, 1938, 1948). These movements had the character of regional uplift with its axis south of the Holy Cross Mountains.

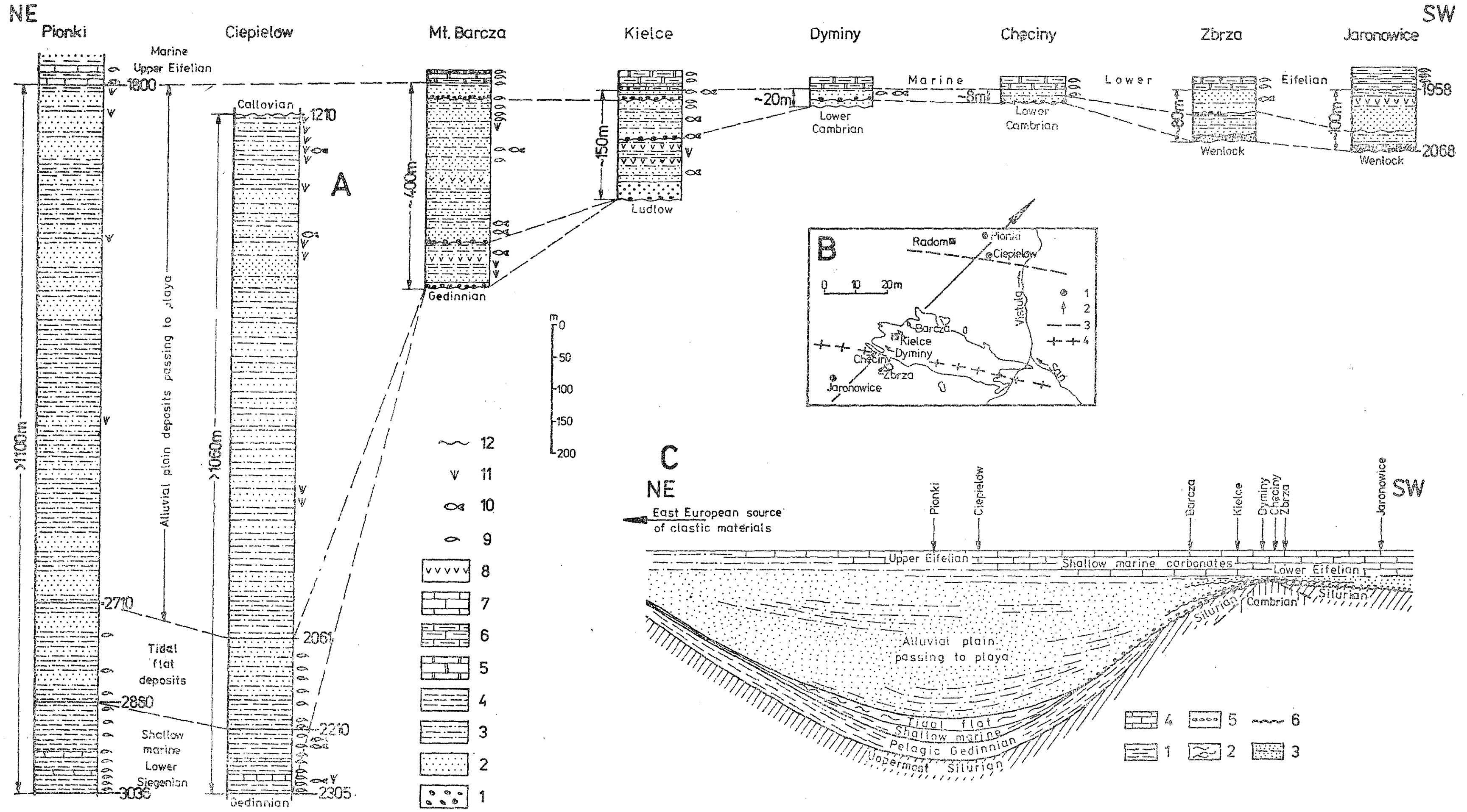
During the Ordovician the whole area underwent transgression and was covered by a condensed sequence of glauconitic sandstones and limestones, and later on by pelagic graptolite shales passing upwards to the Silurian and even to the Gedinnian (in the northern part of Holy Cross area).

Successive pre-Middle Devonian movements and erosion removed completely the Ordovician and Silurian deposits on the elevated antiforms (swells). The distribution of Ordovician, Silurian and Cambrian deposits suggests that the axis of the eroded late-Caledonian antiform may be restored as E-W, obliquely to the younger Chęciny anticline (Text-fig. 7). Similar conclusion was given by H. Tomczyk (*in:* Sokołowski 1970) after his study of the Silurian sequence.

During the early Devonian the whole area was gradually covered with terrigenous deposits, continental at the beginning and passing upwards through lagoonal into open-marine carbonate deposits. The differentiation of thickness and facies in the early Devonian reflects the morphology of inundated land (Text-fig. 8), and the axial part of elevated swell in the vicinity of Chęciny has been covered with the thinest detrital deposits.

The lower detrital units *B* and *C* might have been deposited contemporaneously with the beginning of carbonate sedimentation in less ele-

Early Devonian deposits in the Holy Cross area



A — Key profiles of the early Devonian: *1* conglomerates, *2* sandstones, *3* siltstones, *4* claystones and clays, *5* dolostones, *6* marls, *7* limestones, *8* tuffites; *9* marine and lagoonal invertebrates, *10* placoderms, *11* plants; *12* erosional breaks
B — Location map of the compiled profiles: *1* boreholes, *2* outcrop areas, *3* axis of subsidence, *4* axis of swell; the line of section (Fig. 8C) is indicated by a long arrow

C — Diagrammatic section through the early Devonian basin in the Holy Cross area, to show the general facies pattern; exaggerated are sections with very low thickness, diminished are sections with the thickest deposits: *1* clayey-silty deposits, *2* sandy-silty tidal flat deposits, *3* sandy-silty deposits, *4* carbonates, *5* conglomerates or gravel-sandy deposits; *6* erosional breaks vated areas. The early Devonian subsidence of slightly differentiated land exceeds the terrigenic supply, and the marine onlap took place in the southern part of the Holy Cross area. The symmetric paleogeographic scheme of the Holy Cross area with the northern zone (north of Kielce) of the strongest subsidence, the central zone of the minimal subsidence, and the southern one subsiding more than the former (Gürich 1896, Sobolev 1909, Szulczewski 1977) is confirmed by the new data. The axis of the early Devonian antiform was slightly shifted to the north in the late Devonian (*cf.* Szulczewski 1971, 1977) due to synsedimentary submarine faulting (Szulczewski 1973).

This paleogeographic interpretation can be used for the broad area due to borehole data (Jaworowski & *al.* 1967, Żelichowski 1969, Sokołowski 1970, Senkowicz 1973, Niemczycka 1974, Łobanowski & Przybyłowicz 1979). North of the Holy Cross Mts, the pelagic Silurian graptolite shales pass directly into similar Gedinnian deposits (H. Tomczyk, E. Tomczyk *in*: Niemczycka 1974) and then in shallow marine Lower Siegenian covered with tidal flat deposits (Łobanowski & Przybyłowicz 1979). Subsequently these latter deposits pass into alluvial flat and playa deposits (Old Red) originated in arid climate. In the Holy Cross Mts thin sandy and carbonate deposits with Uppermost Emsian-Lower Eifelian conodonts *Icriodus* ex gr. *corniger* covered the Old Red deposits, but north of the Holy Cross area the carbonate sedimentation began in the Upper Eifelian (Upper Couvinian) evidenced by *Euryspirifer supraspeciosus* (Lotze) in borehole Pionki-4 (Łobanowski & Przybyłowicz 1979).

Generally, the above interpretation differs distinctly from that offered by Łobanowski & Przybyłowicz (1979) by a direct connection of the Holy Cross area with the intracontinental furrow lying north without any continental barrier separating them. The difference of clastic material between the Barcza region (strongly matured) and Pionki-4 borehole (derived from crystalline rocks) may be easily explained (*see* Text-fig. 8): the NE slope of basin was fed by the source lying NE where crystalline basement of the East European platform was eroded, whereas the Holy Cross area was fed by the local source built up to old Paleozoic rocks (Chęciny-Dyminy Swell). For this reason the clastic material in the Barcza region is well sorted and rounded, and the heavy minerals are dominated by chemostable components (zircon, tourmaline and rutile; *cf.* Łobanowski 1971). Similar compositions were stated by present investigations in the Chęciny region. Łobanowski (1971) when studying the cross-lamination, imbrication and lineation of grains observed in thin sections, suggested the transport both from the north and south of Barcza. The above premisses are not however sufficient because in the alluvial flat with lakes passing upward to lagoonal and shallow marine conditions every direction of transport may appear as resulted from local waving and current propagation even opposite to the regional transport (*see* Rudowski 1982).

The carbonate sedimentation began over the inundated swell probably nearly at the same time and earlier (Lower Eifelian)than in the opposite slope of the sedimentary basin supplied with clastic material from the still persisted NE source, where the carbonates appeared in the Upper Eifelian or even in the Givetian further to NE. Upon this inundated swell the carbonate platform originated in the younger Devonian (*cf.* Sobolev 1909; Szulczewski 1971, 1973) after short lagoonal episode, while the lagoonal sedimentation with anhydrite was stated here and there to NE of this platform in the late Devonian (*cf.* Miłaczewski & Radlicz 1974).

The studied section shows that between Lower Cambrian and early Devonian deposits there occurs low angular unconformity (*cf.* Text-fig. 2). Similar phenomenon was stated in Jaronowice borehole (Jaworowski & *al.* 1967). In the studied section there are no signs of the découlement between Cambrian and Devonian deposits, and only small transverse faults were stated in the cuttings (Text-figs 2, 4, and 7).

It seems that the whole area was covered by Devonian clastics but in the western part of the Chęciny anticline, where the clastics were the thinest, a slight découlement caused tectonic contacts between Cambrian claystones and Devonian carbonates (Zajączków, Miedzianka area). The age of these découlement seems to be rather Laramide than Variscan (*cf.* Gągol & *al.* 1976), and they originated within early Paleozoic deposits due to differences in their tectonic competence. Such disharmonic folding and diapiric protrusion of clayey Cambrian deposits throughout younger competent rocks was caused by Laramide activation of a deep fracture zone, viz. the Rzeszów-Poznań lineament (*cf.* Pożaryski 1971, Gągol & *al.* 1976), and it took place beneath the thick Mesozoic cover (more than 3 km, *cf.* Kutek & Głazek 1972). Under such conditions, the clayey deposits may creep up from the depth twice greater than salt deposits usually require. These phenomena took place in the substrate of deep intraplatform trough (aulacogene) during the Laramide movements, thus not during the Variscan ones commonly believed earlier. The Laramide diapiric protrusions explain well the disorder of dips in Cambrian clayey deposits and some Ordovician-Silurian deposits, without any help of a geosynclinal Caledonian tectogenesis believed by some authors (*cf.* Znosko 1963, 1965, 1974; Kowalczewski 1971, 1978; Jurkiewicz 1975; Ziegler 1978). From the evidence presented here it is clear that there can no longer by any support for the concept of a Circum-Fennosarmatian Caledonian geosyncline either in the southern Holy Cross area or further to the south-west where the Cambrian is absent, the Ordovician is condensed and the Silurian thin.

Similarly, the late Caledonian tectogenesis is improbable due to the persitence of general facies pattern since the Ordovician through the late Devonian (Szulczewski 1977). The Circum-Fennosarmatian Caledonides in the southern Central Poland are improbable also due to the fact that the Precambrian crystalline basement is covered by flat lying Lower Cambrian in Upper Silesia (Goczałkowice borehole, *see* Text-fig. 1; *cf.* Kotas 1973, Orłowski 1975b) and in the substrate of the North Carpathians (Ślączka 1976). Currently it is evident that in southern Central Poland there is no place for any early Paleozoic geosyncline between the stable part of the ancient East European platform and the Variscan geosyncline of the Sudetes (*cf.* Szulczewski 1977). In all these areas only the discontinuous epicontinental sedimentation and slight Caledonian epeirogenic movements in the outer zone (mobile margin) of the Precambrian platform are recognizable. Seemingly, the Caledonian folded "Lubliniec-Zawiercie-Kraków-Rzeszotary zone" (Znosko 1974, p. 38) represents only an intracratonic (intraplatform) fracture zone (Cracow--Myszków lineament of Bogacz 1980).

Institute of Geology
of the Warsaw University,
Al. Żwirki i Wigury 93,
02-089 Warszawa, Poland
(J. Głazek)

Institute of Geology
of the Silesian University,
ul. Mielczarskiego,
41-200 Sosnowiec, Poland
(Ł. Karwowski, G. Racki, T. Wrzołek)

REFERENCES

BOGACZ K. 1980. Tectonics of the Palaeozoic rocks of the Dębnik region. *Rocz. Pol. Tow. Geol.*, **50** (2), 183—208. Kraków.

ÇINAR C. 1978. Marine Flachwasserfazies in den Honseler Schichten (Givet-Stufe, Lüdenscheider Mulde, Rechtsrheinisches Schiefergebirge). *Göttinger Arb. Geol. Paläont.*, **20**, 1—77. Göttingen.

CZARNOCKI J. 1919. Sratigraphy and tectonics of the Holy Cross Mts [*in Polish*]. *Prace Tow. Nauk. Warsz.*, **28**, 1—172. Warszawa.

— 1927. Compte-rendu des recherches exécutées en 1926 et la structure du Mesozoïque de la région de Chęciny [*in Polish*]. *Pos. Nauk. Państw. Inst. Geol.*, **17**, 4—14. Warszawa.

— 1936. Überblick der Stratigraphie und Paläogeographie des Unterdevons im Polnischen Mittelgebrige. *Spraw. Państw. Inst. Geol.*, **8** (4), 124—200. Warszawa.

— 1938. Carte Géologique Générale de la Pologne. Feuille **4**, Kielce. *Państw. Inst. Geol.*; Warszawa.

— 1948. Guide pour 20 Réunion de la Société Géologique de Pologne dans le Montagnes de St. Croix en août 1947. [*in Polish*]. *Rocz. Pol. Tow. Geol.*, **17**, 237—299. Kraków.

— 1952. Holy Cross marbles [*in Polish*]. *Biul. Państw. Inst. Geol.*, **80**, 27—52 Warszawa.

— 1957. Tectonics of the Święty Krzyż Mountains. *Prace Inst. Geol.*, **18**, 1—137. Warszawa.

DECZKOWSKI Z. & TOMCZYK H. 1969. Geological structure of the Zbrza anticline in the south-western part of the Góry Świętokrzyskie. *Biul. Inst. Geol.* **236**, 143—175. Warszawa.

FILONOWICZ P. 1963. Lower Silurian in the Chęciny anticline [*in Polish*]. *Kwart. Geol.*, **7** (4), 735—736. Warszawa.

— 1965. Sheet Morawica. Detailed Geological Map of Poland. *Wyd. Geol;* Warszawa.

— 1968. Explanations of sheet Morawica; Detailed Geological Map of Poland [*in Polish*]. *Wyd. Geol.;* Warszawa.

— 1973a. Explanations of sheet Kielce; Detailed Geological Map of Poland [*in Polish*]. *Wyd. Geol.;* Warszawa.

— 1973b. Geology of the SW-part of the Holy Cross Mts [*in Polish*]. Unpublished Ph. D. Thesis. *Inst. Geol.;* Warszawa.

GĄGOL J., GŁAZEK J., JURKIEWICZ H., KOWALSKI W. R. & ROMANEK A. 1976. Problem IIIb — Tectonics, lithology and mineral raw materials of early Mesozoic and its relation to Variscan basement [*in Polish*]. [*In:*] Przewodnik 48 Zjazdu Pol. Tow. Geol., pp. 228—254. *Wyd. Geol.;* Warszawa.

GŁAZEK J. & KUTEK J. 1976. Post-Variscan geotectonic development of the Holy Cross area [*in Polish*]. [*In:*] Przewodnik 48 Zjazdu Pol. Tow. Geol., pp. 14—51. *Wyd. Geol.;* Warszawa.

GŁUCHOWSKI E. 1981. Stratigraphic significance of Paleozoic crinoid columnals from Poland. *Zesz. Nauk. AGH, Geol.*, **7** (2). Kraków.

GÜRICH G. 1896. Das Paläozoicum im polnischen Mittelgebirge. *Zap. St. Pet. Miner. Obshtch.*, **2** (32), 1—539. St. Petersburg.

HAKENBERG M. 1974. Explanations of sheet Chęciny; Detailed Geological Map of Poland [*in Polish*]. *Wyd. Geol.;* Warszawa.

JAWOROWSKI K., JURKIEWICZ H. & KOWALCZEWSKI Z. 1967. Sinian and Palaeozoic in the borehole Jaronowice IG-1. *Kwart. Geol.*, **11** (1), 21—36. Warszawa

JURKIEWICZ H. 1975. The geological structure of the basement of the Mesozoic in the central part of the Miechów Trough. *Biul. Inst. Geol.*, **283**, 5—100. Warszawa

KOTAS A. 1973. Occurrence of Cambrian formations in the substratum of the Upper Silesia Coal Basin [*in Polish*]. *Przegl. Geol.*, **21** (1), 37. Warszawa.

KOWALCZEWSKI Z. 1971. Main geological problems of the Lower Devonian in the Świętokrzyskie Mts. *Kwart. Geol.*, **15** (2), 263—283. Warszawa.

— 1978. An outline of tectonic development of Pre-Permian basement of the Góry Świętokrzyskie. [*In:*] PIĄTKOWSKI T. S. & WAGNER R. (*Eds.*) Guide of Excursions, Symp. Central Europ. Permian, pt. 2, 5—7. Wyd. Geol.; Warszawa.

KOWALSKI W. R. 1975. Tectonics of western end of Chęciny anticline and surrounding structures of Mesozoic margins of the Holy Cross Mts. *Rocz. Pol. Tow. Geol.*, **45** (1), 45—61. Kraków.

KUTEK J. & GŁAZEK J. 1972. The Holy Cross area, Central Poland, in the Alpine cycle. *Acta Geol. Polon.*, **22** (4), 603—654. Warszawa.

ŁOBANOWSKI H. 1971. The Lower Devonian in the western part of the Klonów Belt (Holy Cross Mts); Part I — Upper Emsian. *Acta Geol. Polon.*, **21** (4), 629—685. Warszawa.

— & PRZYBYŁOWICZ T. 1979. Tidal-flat and flood-plain deposits in the Lower Devonian of the western Lublin Uplands (after the boreholes Pionki-1 and Pionki-4). *Acta Geol. Polon.*, **29** (4), 383—407. Warszawa.

MIŁACZEWSKI L. & RADLICZ K. 1974. Dewon. [*In*:] ŁASZKIEWICZ A. (*Ed.*) Rocks of the Precambrian Platform in Poland, pt. 2, Sedimentary cover. *Prace Inst. Geol.*, **74**, 83—98. Warszawa.

NARKIEWICZ M. 1979. Problem of dolomite genesis in the Middle Devonian of the Holy Cross Mts. [*in Polish*]. *Kwart. Geol.*, **22** (4), 903—904. Warszawa

NIEMCZYCKA T. (*Ed.*) 1974. Borehole Ciepielów IG-1 [*in Polish*]. *Profile Głęb. Otworów Wiertn. Inst. Geol.*, **34**, 1—117. Warszawa.

ORŁOWSKI S. 1975a. Cambrian and Upper Precambrian lithostratigraphic units of the Holy Cross Mts. *Acta Geol. Polon.*, **25** (3), 431—448. Warszawa.

— 1975b. Lower Cambrian trilobites from Upper Silesia (Goczałkowice borehole). *Acta Geol. Polon.*, **25** (3), 377—383. Warszawa.

PAJCHLOWA M. 1957. The Devonian in the Grzegorzowice-Skały section. *Biul. Inst. Geol.*, **122**, 145—254. Warszawa.

POŻARYSKI W. 1971. The tectonics of the Radomsko elevation. *Rocz. Pol. Tow. Geol.*, **14** (1), 169—179. Kraków.

— & TOMCZYK H. 1968. Assyntian orogen in south-east Poland. *Biul. Inst. Geol.* **237**, 13—27. Warszawa.

RUDOWSKI S. 1982. Sedimentary environment of the barred coast on the tidalless sea., Southern Baltic, Poland. *Studia Geol. Polon.*, in press.

SENKOWICZ K. 1973. Geology and structures of the Pionki-Zwoleń region (NW part of the Lublin area). *Acta Geol. Polon.*, **23** (4), 645—700. Warszawa.

SOBOLEV D. 1909. Middle Devonian of the Kielce-Sandomierz Chain [*in Russian*]. *Mat. Geol. Ross.*, **24**, 41—536. St. Petersburg.

SOKOŁOWSKI S. (*Ed.*) 1970. Geology of Poland, vol. 5, Stratigraphy, pt. 1, Pre-Cambrian and Palaeozoic. 651 pp. *Wyd. Geol.*; Warszawa.

SZULCZEWSKI M. 1971. Upper Devonian conodonts, stratigraphy and facial development in the Holy Cross Mts. *Acta Geol. Polon.*, **21** (1), 1—129. Warszawa.

— 1973. Famennian-Tournaisian neptunian dykes and their conodont fauna from Dalnia in the Holy Cross Mts. *Acta Geol. Polon.*, **23** (1), 15—58. Warszawa.

— 1977. Main facial regions in the Paleozoic of the Holy Cross Mts. *Przegl. Geol.*, **25** (8—9), 428—432. Warszawa.

ŚLĄCZKA A. 1976. New data on the structure of the basement of the Carpathians south of Wadowice. *Rocz. Pol. Tow. Geol.*, **46** (3), 337—350. Kraków.

TOMCZYK H. & TURNAU-MORAWSKA M. 1964. Stratigraphy and petrography of the Ordovician in Brzeziny near Morawica (Holy Cross Mts., Central Poland). *Acta Geol. Polon.*, **14** (4), 501—546. Warszawa.

ZIEGLER P. A. 1978. North-Western Europe: tectonics and basin development. *Geol. Mijnbouw*, **57** (4), 589—626. Den Haag.

ZNOSKO J. 1963. Tectonic problems of the outer Carpathian part of Poland. *Prace Inst. Geol.*, **30** (4), 71—99. Warszawa.

— 1965. The problem of Caledonides and the border of Pre-Cambrian platform in Poland. *Biul. Inst. Geol.*, **188**, 5—72. Warszawa.

— 1974. Outline of the tectonics of Poland and the problems of the Vistulicum and Variscicum against the tectonics of Europe. *Biul. Inst. Geol.*, 274, 7—47. Warszawa.

ŻAKOWA H. (*Ed.*) 1981. Guide-book of the 53 Meeting of the Geological Society of Poland [*in Polish*]. *Wyd. Geol.*; Warszawa.

ŻELICHOWSKI A. M. (*Ed.*) 1969. Geological structure of the Lublin area [*in Polish*]. *Prace Geostrukturalne Inst. Geol.*; Warszawa.

J. GŁAZEK, Ł. KARWOWSKI, G. RACKI i T. WRZOŁEK

LĄDOWO-MORSKA SEKWENCJA WCZESNODEWOŃSKICH OSADÓW W CHĘCINACH, ORAZ WYNIKAJĄCE Z NIEJ KONSEKWENCJE PALEOGEOGRAFICZNE I TEKTONICZNE

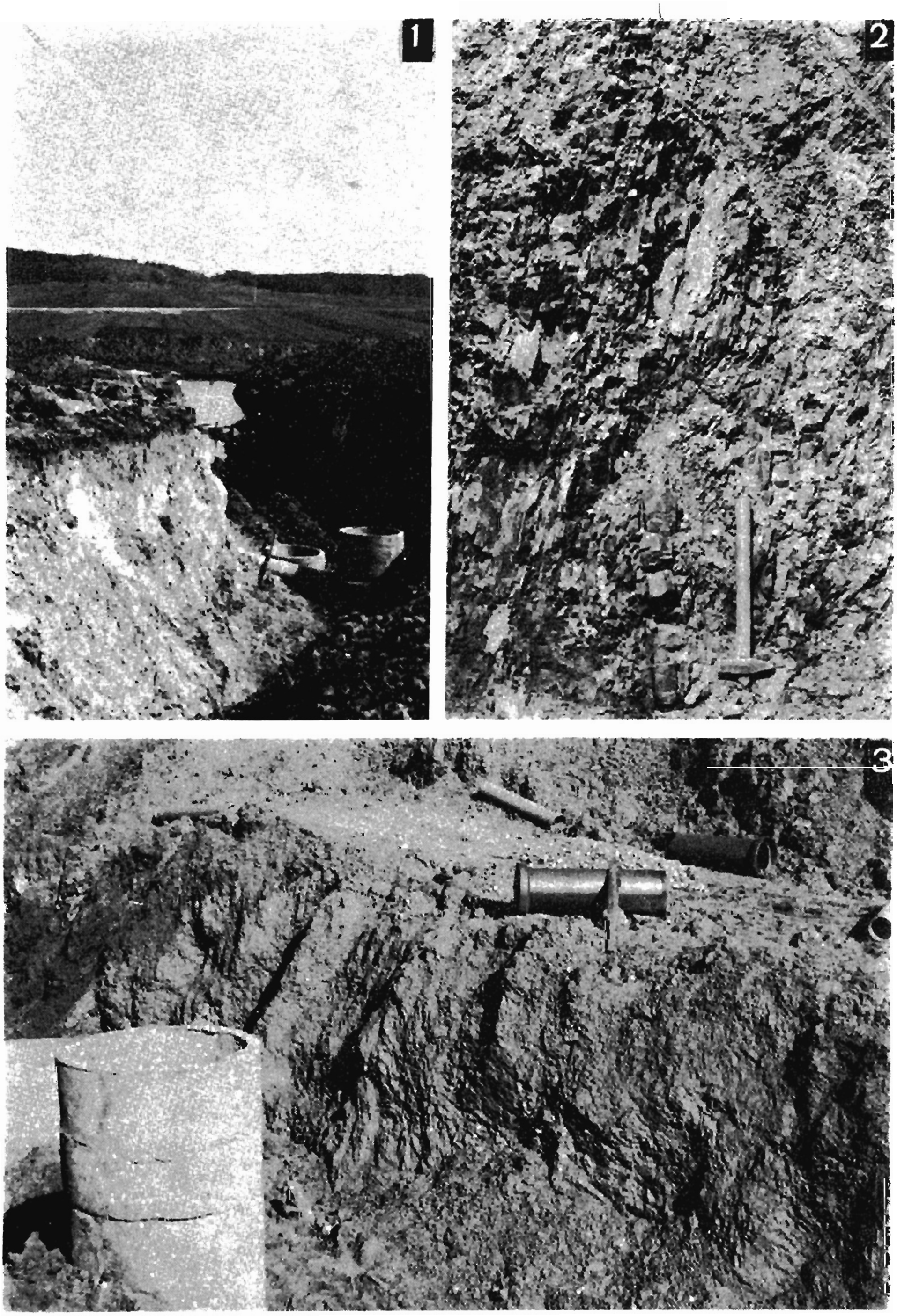
(Streszczenie)

Kontakt osadów kambryjskich i wczesnodewońskich antykliny chęcińskiej w Górach Świętokrzyskich (Fig. 1) uznawany był dotychczas za tektoniczny (Czarnocki 1938, 1948; Kutek & Głazek 1972; Hakenberg 1974).

W latach 1977—78 na zachodnim skraju Chęcin we wkopach kanalizacyjnych odsłonięto sedymentacyjny kontakt osadów kambryjskich z klastycznymi osadami wczesnego dewonu (fig. 2—6; pl. 1—4). Na zwietrzałych iłowcach dolnokambryjskich leży zwietrzelina przemieszczona i nieco przemyta w warunkach lądowych (1 m), a następnie osady klastyczne (8 m) przechodzące ku górze w margliste dolomity z bogatą fauną dolnego eiflu. Osady piaszczyste przykrywające przemieszczoną zwietrzelinę zawierają rzadkie szczątki fauny morskiej i stanowią przybrzeżne osady transgredującego morza dewońskiego. Podobne piaskowce wczesnodewońskie znaleziono też we wkopie badawczym na zachodnim skraju Brzezin (fig. 7).

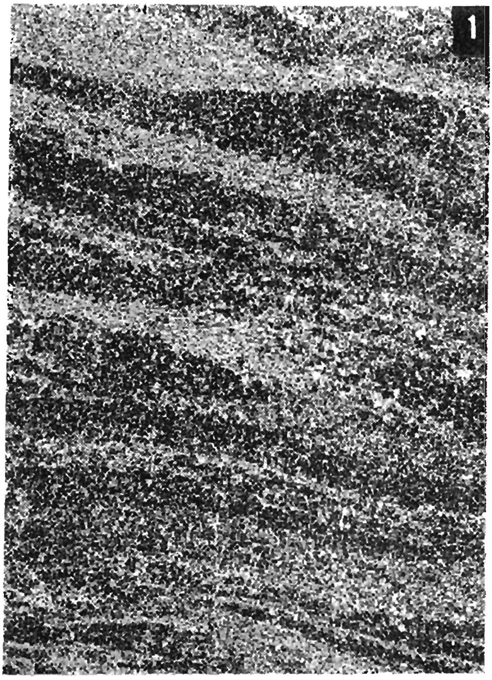
Coraz liczniejsze stanowiska wczesnodewońskich osadów klastycznych w antyklinie chęcińskiej wskazują, że odkłucie tektoniczne osadów dewonu i kambru nie jest tutaj regułą, a występuje ono lokalnie, podobnie jak kontakty tektoniczne iłowców kambru z młodszymi osadami paleozoicznymi i triasowymi. Prawdopodobnie odkłucia te powstały podczas ruchów laramijskich (Gągol & *al.* 1976). pod pokrywą osadów permsko-mezozoicznych o miąższości przekraczającej 3 km (Kutek & Głazek 1972), w wyniku diapirowego przebijania kompetentnych utworów przez ilaste wzdłuż strefy głębokiego rozłamu (lineament Rzeszów-Poznań).

Rozważono paleogeografię dolnego dewonu obszaru świętokrzyskiego wykazując, że w południowej jego części istniał wał o kierunku W-E ograniczający epikontynentalny basen old redu znajdujący się na północnym skraju rejonu świętokrzyskiego. Wał ten wypiętrzony w wyniku epejrogenicznych ruchów kaledońskich (Fig. 7) został najpóźniej pokryty klastycznymi osadami dewonu (Fig 8). Przekroczenie tego wału przez morze spowodowało szybkie rozprzestrzenie osadów węglanowych w całym obszarze świętokrzyskim. Na podstawie wykształcenia osadów staropaleozoicznych zakwestionowano istnienie geosynkliny kaledońskiej w rejonie świętokrzyskim. Ruchy kaledońskie zaznaczające się w tym obszarze nie miały charakteru geosynklinalnej tektogenezy, lecz epiplatformowych ruchów pionowych.



Lower Cambrian deposits exposed in sewage cuttings at Chęciny

1 — Eastern trench with claystones; 2 — Intercalations of fine-grained quartzites in claystones; 3 — Claystones in the southern trench



1 — Cross-laminated claystone; Lower Cambrian, sewage cuttings; × 5 (negative print)

2 — Clayey-ferrous-carbonate conglomerate with claystone and sandstone pebbles; lowermost part of unit *B*, ?Upper Emsian; sewage cuttings, southern trench; × 3 (negative print; *white* — pebbles impregnated with iron compounds, *black* — carbonate rims)

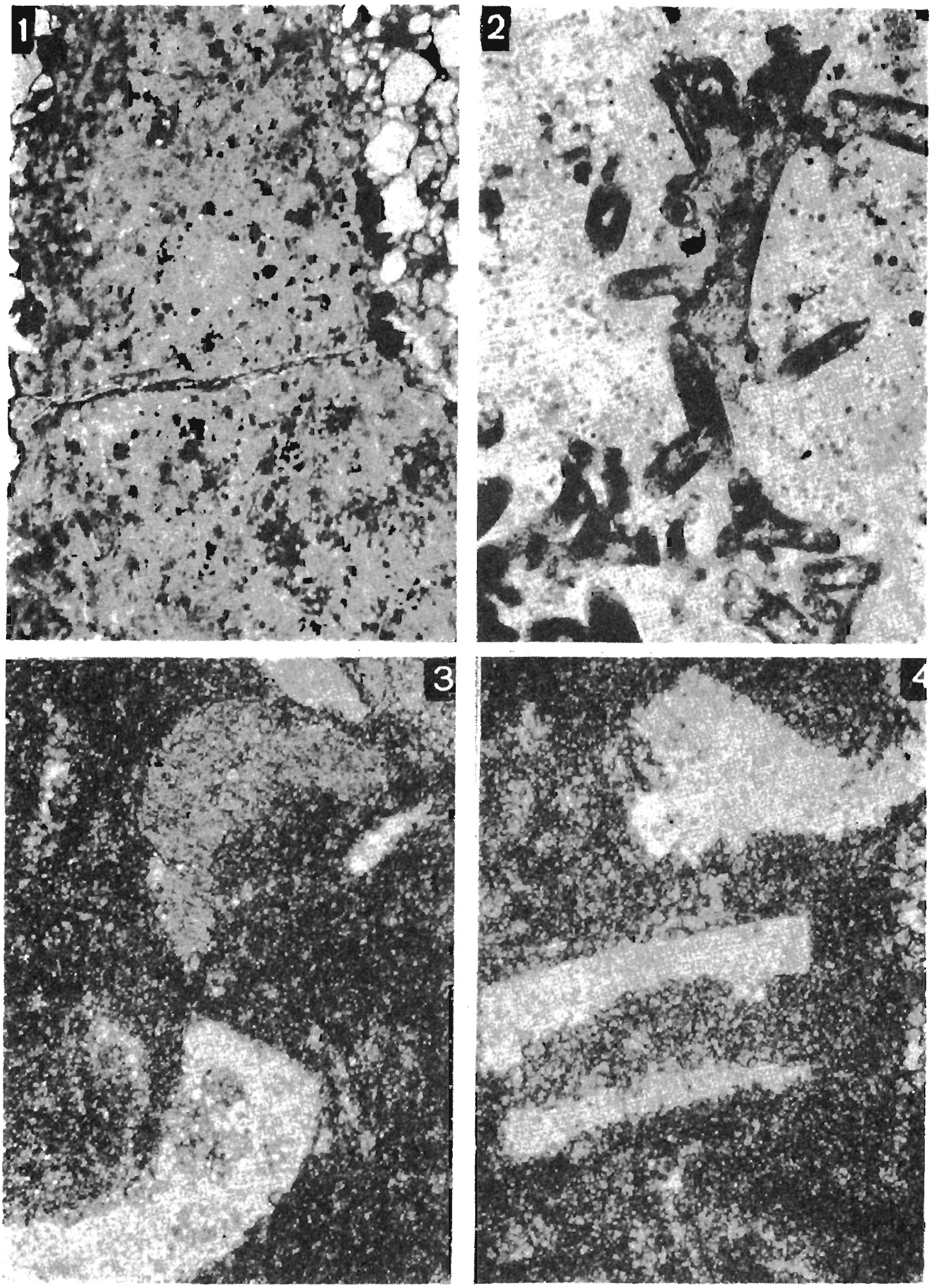
3 — Cross-bedded sandstone (light lamina) with conglomeratic intercalations (*dark*) covered by horizontally-laminated claystone; location as above; nat. size

Eifelian fossiliferous dolomits (unit *E*) at Chęciny

1 — "*Athyris*"-bearing dolomite; note ferrous films on brachiopod moulds; water-piping cuttings; nat. size

2-3 — *Chonetes*-bearing dolomite; note spiriferid shell (*S*) and trilobite fragment (*T*); sewage cuttings, western end of southern trench; nat. size.

1 — Coral-bearing dolomite (coral branches obscured by dolomitization); water-piping cuttings; nat. size



1 — Fragment of siliceous sponge in ferrous sandstone (unit *B*, top layer); sewage cuttings, southern trench; × 40

2 — Spicules (?triaxones) with ferrous filling in chalcedony-opal skeleton of sponge; same specimen as in Fig. 1, taken × 400

3-4 — Crinoid remains (pinnules, arm plates, columnals), and shell fragments in dolomicrites (unit *E*); sewage cuttings, western end of southern trench; × 40