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Late Tertiary alluvial gravels of the Korytnica Basin (Holy Cross Mountains, Central Poland)

ABSTRACT: Origin of the gravels overlying the Korytnica Clays and exposed in the central part of the Korytnica Basin (Holy Cross Mountains, Central Poland) is discussed and reinterpreted. Clastic material of these gravels was delivered by a river from the waste of Mesozoic rocks and older Miocene deposits remained after the Middle Miocene regression. The gravel lithosome is regarded as an erosional outlier of a greater alluvial fan deposited during a relatively longer span of time since the regression of the Middle Miocene sea (Upper Badenian or Lower Sarmatian) till the preglacial part of the Pleistocene.

INTRODUCTION

This paper presents a reinterpretation of the nature of gravels exposed between the villages Chomentów and Karsy (*see* Text-figs 1—2) within the Korytnica Basin, being a small part of the Korytnica Bay developed during the Middle Miocene (Badenian) trangression onto the southern slopes of the Holy Cross Mountains, Central Poland (*see* RADWAŃSKI 1969; BAŁUK & RADWAŃSKI 1977, 1979, 1984; SZYMANKO & WÓJCIK 1982). The origin of these gravels has previously been discussed by many authors (KOWALEWSKI 1930, RADWAŃSKI 1969, RUTKOWSKI 1976, SZYMANKO & WÓJCIK 1982, GUTOWSKI 1983) but still remained unclear. A complicated geological situation and a lack of good exposures showing relations between the several Middle Miocene (Badenian) members and the overlying gravels cause that these sediments should be studied in a context of facies development in a regional scale. The geotectonic control of sedimentary processes close to the Holy Cross shores can be a base of such consideration. Simultaneously, a detailed sedimentological analysis of the gravels is an important paleogeographical and environmental indicator.

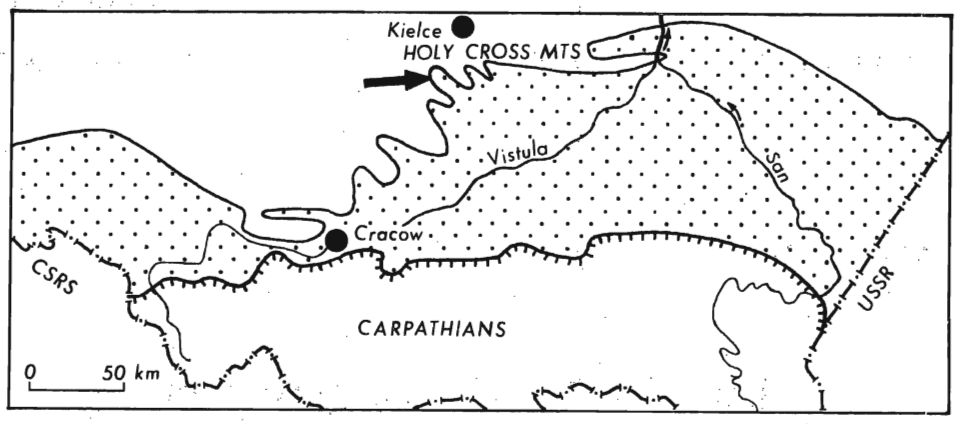

Fig. 1. Extent of the Middle Miocene (Badenian) deposits in the Fore-Carpathian Depression (*stippled*); arrowed is the Korytnica Basin (*after* RADWAŃSKI 1977b)

SEDIMENTARY CHARACTERISTICS OF THE GRAVELS

The investigated gravels form a 3 km long and 1—5 m thick lithosome in the central part of the Korytnica Basin (*see* Text-fig. 2 and Pls 1—2) and are composed mostly of Jurassic limestone pebbles and of Badenian rhodoid detritus. The Jurassic pebbles greater than 10 cm in diameter, bored by diverse rock-borers, are rare in that loose sediment, particularly as exposed near Karsy (*see* Pl. 2). Clastic material is quite well sorted and rounded. Granulometric analysis (Text-fig. 3) shows a noticeable contribution of quartz material and pieces of flints and diverse clastic rocks. Among these, one can recognize marly sandstones, most probably of Badenian age (*cf.* GUTOWSKI 1984), sandstones with glauconite and conglomerates similar to those of Albian/Cenomanian age exposed near Staniewice and Korytnica (*cf.* HAKENBERG 1969). All Badenian organic remains, mainly rhodoids, fragments of calcitic shells of oysters and scallops, are very destroyed and, undoubtedly, they were transported before deposition for a relatively long distance. Only foraminifers, *i. e.* anomalinids and elphidiids, are recognizable among microfaunal elements.

A small spot of loose gravels, found 1.5 km SE from Karsy, interfingers with well cemented conglomerates and sandstones of identical petrographic composition, in which such sedimentary structures as horizontal and cross lamination have been recorded. Observations over the cropland and geophysical data (SZYMANKO & WÓJCIK 1982) indicate that the gravels overlie discordantly all the members of the Badenian sequence, *i. e.* marly sands (at Jawor and Chomentów) or the Korytnica Clays (at Karsy and Jawor; *see* Text-fig. 2*B* and Pl. 1, Figs 1—2). The

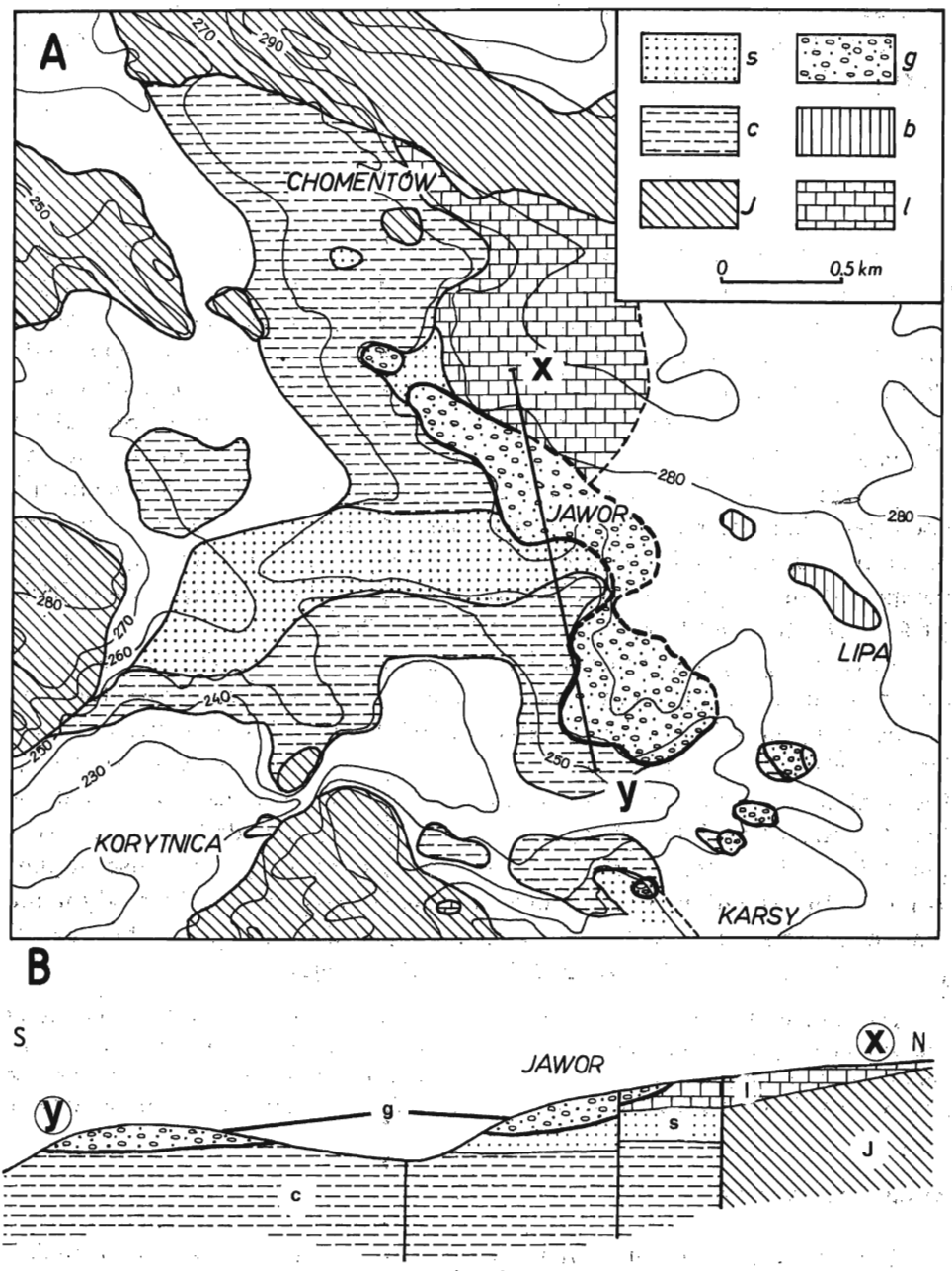

Fig. 2

A — Geological sketch-map of the Korytnica Basin (*from* GUTOWSKI 1984)

J — Jurassic substrate, **c** — Korytnica Clays, **s** — marly sands, **l** — red-algal limestones, **b** — sandy red-algal deposits with bentonites.

Pleistocene glacial deposits and Holocene are blank

B — Idealized cross-section through the central part of the Korytnica Basin, to show relation of the Late Tertiary alluvial gravels to the Middle Miocene (Badenian) sequence; lithology the same as in the map

Pleistocene deposits, identified due to their content of Scandinavian erratic material, cover the discussed gravels, particularly near Karsy (Text-fig. 2*A* and Pl. 1, Figs 1—2).

PALEOENVIRONMENTAL ANALYSIS

Since the investigations carried out by KOWALEWSKI (1930), the gravels were referred to as of Sarmatian age because of their lithologic similarity to psefitic deposits called the "detrital Sarmatian" lying along the southern margin of the Holy Cross Mountains (*cf.* RUTKOWSKI 1976). By turn, the complex study of littoral structures developed during the Middle Miocene (Badenian) transgression (RADWAŃSKI 1969) allowed to postulate that the gravels originated from abrasion of the hypothethical Jawor Ridge which isolated the Korytnica Basin from the open sea. The presence of such a barrier resulted in specific conditions prevailing during sedimentation of the Korytnica Clays and in the development of an unique organic world within the basin (RADWAŃSKI 1969; BAŁUK & RADWAŃSKI 1977, 1979, 1984).

However, geophysical data showed a lack of any ridge of the Jurassic basement which could separate the Korytnica Basin from the rest of the Korytnica Bay (SZYMANKO & WÓJCIK 1982). According to the latter statement, the gravels occurring near Jawor have been treated as the sediment of the same age as the red-algal limestones from Chomentów (*cf.* RADWAŃSKI 1977a), and resulting from a hydrodynamic transport of clastic material from adjacent littoral zones. It was also supposed that the isolation of the Korytnica Basin was only of hydrodynamic nature, stressed by the tendency to lowering the bottom in the central part of the basin (SZYMANKO & WÓJCIK 1982).

The author, basing on his recent investigations, suggests another concept of the gravel origin. In fact, this problem would be resolved if one can answer the following questions: (*i*) where the gravel material originated from, (*ii*) how to characterize its depositional environment, and (*iii*) what is the age of these gravels.

ALIMENTARY AREA

A lack of any hypothethical ridge in the Jurassic basement makes the gravels unusual in comparison with the deposits resulting from abrasion of the rocky shores situated along the Korytnica Basin (localities *I, II, III, IV* at Korytnica and *I, II* at Chomentów *see* RADWAŃSKI 1969, and locality *VI* near Karsy *see* GUTOWSKI & MACHALSKI 1984). Single cobbles and pebbles could have been rolled off the abrasion zones to the central part of the basin during sedimentation of marly sands

and red-algal limestones (*see* RADWAŃSKI 1977a, GUTOWSKI 1984, GUTOWSKI & MACHALSKI 1984). Such a fact can be explained by a temporary storm activity. However, so great accumulation of psefitic material in the center of the basin gives an evidence of exceptionally high hydrodynamic conditions. Large cobbles and pebbles of local ba-

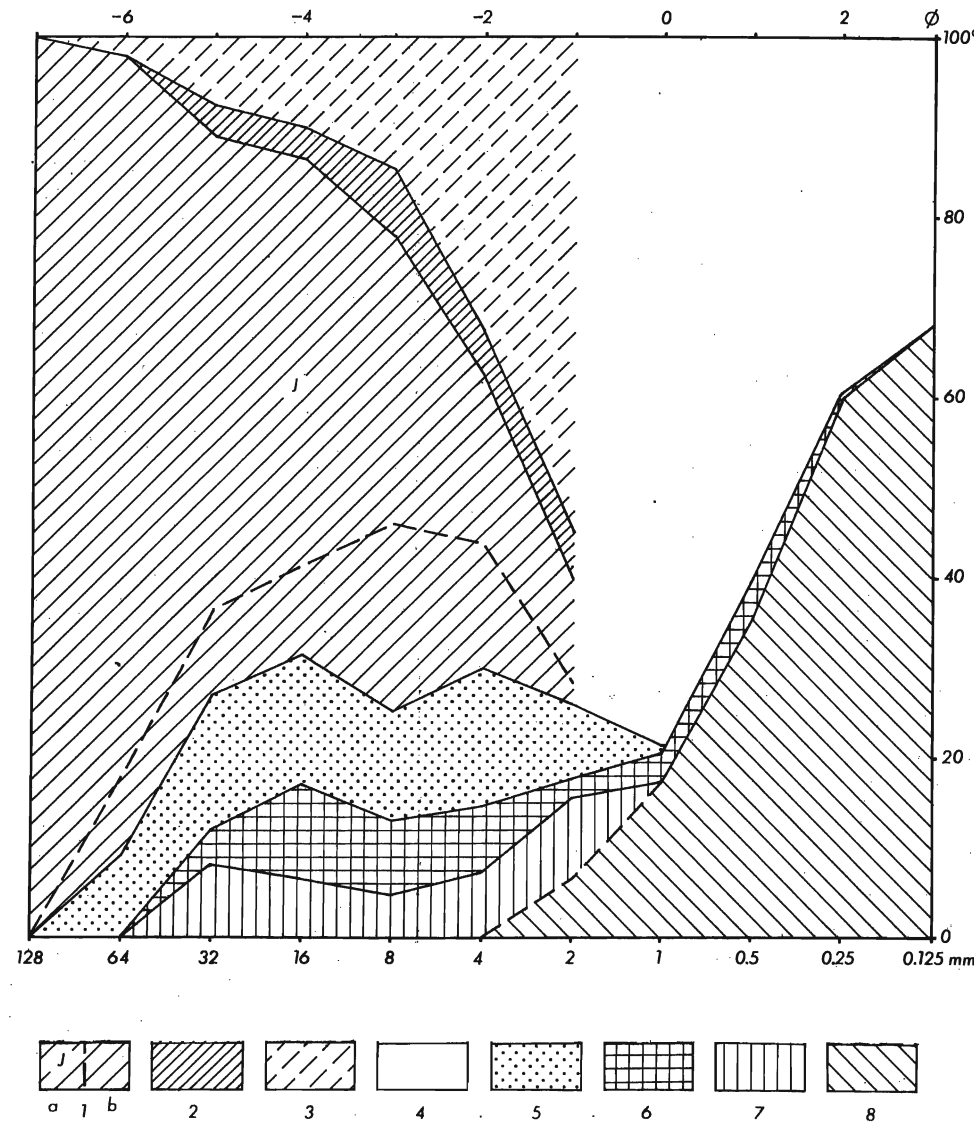

Fig. 3. Petrographic composition of the Late Tertiary alluvial gravels

1 — limestones of Upper Jurassic (*a*) and other (*b*) age; **2** — calcitic shell remains of Badenian age; **3** — red-algal detritus of Badenian age; **4** — unrecognizable carbonate material; **5** — sandstones, commonly with glauconite, and conglomerates (Albian/Cenomanian), as well as marly sandstones (Badenian); **6** — grey-blackish flints (mostly Upper Jurassic); **7** — other flints, silty rocks and vein quartz; **8** — quartz grains

sement, densely bored by various rock-borers, are in all mentioned littoral localities inherent in the Korytnica Clays, oyster shellbed or red-algal limestone. The borings there are very well preserved and often include the moulds of their bivalve producers (RADWAŃSKI 1969, BAŁUK & RADWAŃSKI 1977, GUTOWSKI & MACHALSKI 1984). On the other hand, the discussed gravels are relatively well sorted. The bored pebbles are here rather rare and the borings are always strongly abraded.

A significant content of the gravels is taken by quartz material, flints and sandstones (Text-fig. 3), whereas the Mesozoic substrate of the Korytnica Basin consists of limestone members of uppermost Oxfordian and Kimmeridgian age (*cf.* KUTEK 1968). Some of gray-blackish flints might originate from the "banded limestones" member (*see* KUTEK 1962, 1968), the nearest exposure of which is situated NW from Niziny (*see* Text-fig. 4). However, proportion of such resistant components as flints and quartz to the limestone pieces in several fractions indicates relatively long transport and/or sorting. Moreover, sandstones with glauconite and conglomerates of Albian/Cenomanian age are recognizable among the rock pieces and some of white and pink flints are dissimilar to any of those known from the Upper Jurassic substrate. Fragments of the marly sandstones were delivered from the Badenian sedimentary sequence, the same as the pebbles overgrown by coralline red algae (*cf.* RADWAŃSKI 1969).

All the above presented facts suggest an allochthonous nature of the gravels and, on the other hand, a conclusion that they are younger than all the Badenian members of the Korytnica Basin. A supposed alimentary area of the terrigenous material was located in a Neogene valley (*see* LINDNER 1977, Text-fig. 7) running from the zone built up of the Keuper clays through dislocated zones of the Małogoszcz region to subsequent denivelation composed of unresistant Albian and Cenomanian fine-clastic rocks (*cf.* HAKENBERG 1969) and, eventually, to the axial part of the Sobków anticline, which consists of the Upper Jurassic limestones (KUTEK 1968). The clastic material could have been transported this way from the waste of the Mesozoic clastic rocks by a river called the pre-Wierna River (LINDNER 1977).

SEDIMENTARY ENVIRONMENT AND AGE

Deposition of the gravel material expresses an intensification of erosion and transport after sedimentation of the Korytnica Clays and marly sands in the Korytnica Basin (*cf.* RADWAŃSKI 1969, BAŁUK & RADWAŃSKI 1977, GUTOWSKI 1984). If one looks for a process res-

ponsible for a large-scale erosion and transport to the south in the Miocene history of the Holy Cross Mountains one must consider the facies interrelation between the gravels of the Korytnica Basin and the deposits called the "detrital Sarmatian" (*cf.* RADWAŃSKI 1973, RUTKOWSKI 1976). The latter sediments originated as a result of an intense isostatic uplift of the Holy Cross area compensed by a lowering of the Carpathian Foredeep (*cf.* KUTEK & GŁAZEK 1972, RADWAŃSKI 1973) and created a large accumulation platform along the offshores of the regressing sea (RADWAŃSKI 1973). Older Miocene sediments, remained in an emerged zone, were reworked and redeposited to the south. This caused a presence of red-algal material, mixed organic elements and pebbles bored by rock-borers within that sedimentary complex. That episode is expressed in the foreland of Korytnica Bay by the sedimenta-

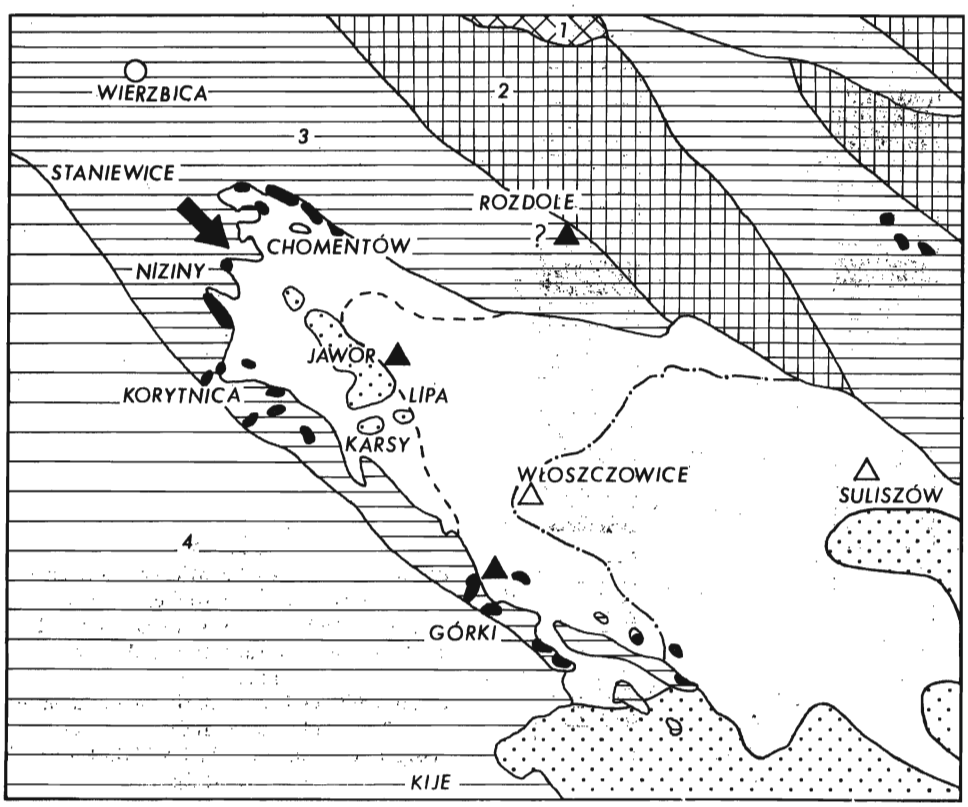

Fig. 4. Geological sketch-map of the Korytnica Bay

Pre-Miocene substrate: 1 — Paleozoic, 2 — Triassic; 3 — Jurassic, 4 — Cretaceous

Middle Miocene (Badenian): transgressive stage deposits with preserved littoral structures (*black spots*); regressive stage: localities of the sediments with bentonites (*black triangles*) and their extent (*dashed line*), clays originated under higher salinity conditions (*white triangle*) and their extent (*spotted line*)

Late Tertiary alluvial gravels are stippled; arrowed is the direction of their transport

tion of gravels, often cross-bedded, and sands yielding specific fanual elements. The ecology of benthic, bivalve-dominated communities indicates lower salinity conditions there (STUDENCKA & STUDENCKI 1980). Recently, a model of barier shore sedimentation is postulated for the latter deposits (CZAPOWSKI 1984). Paleogeographical setting of the Korytnica Basin needs, however, a detailed discussion.

The Korytnica Bay was developed in a subsequent, long and relatively narrow pre-Miocene valley between the rocky Jurassic ridges (RADWAŃSKI 1969, BAŁUK & RADWAŃSKI 1977). During the Badenian transgression that valley was covered by shallow water (depth of 0—20 m) in which red-algal and/or sandy deposits (ten to twenty meters thick) were deposited. More thick sediments, mainly clays, were accumulated in somewhat deeper conditions (down to about 60 m) only in small denivelations like the Korytnica Basin and another one in the

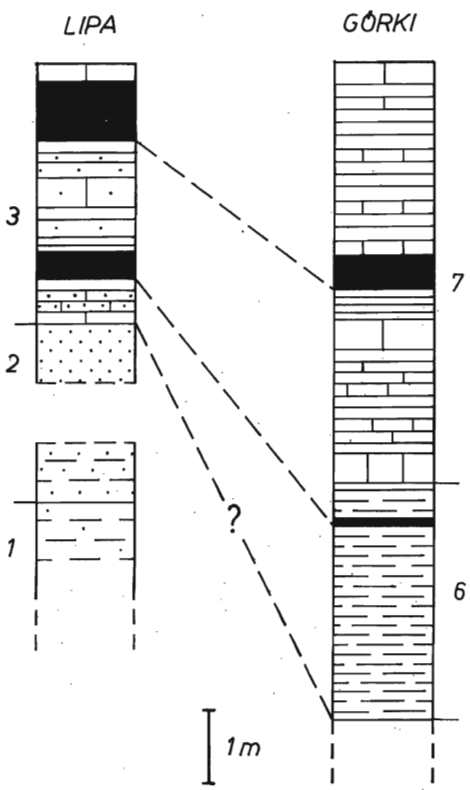

Fig. 5
Profiles of the Middle Miocene (Badenian) deposits with bentonites (*black*)
Locality LIPA: **1** — Korytnica Clays, **2** — marly sands and sandstones, **3** — red-algal limestones
Locality GÓRKI: **6** — marly clays and marls, **7** — sandy marls and sandstones
Assignations as *in* ALEXANDROWICZ (1979, Text-fig. 3)

vicinity of Suliszów (*cf.* KOWALEWSKI 1927, 1930; RADWAŃSKI 1969; SZYMANKO & WÓJCIK 1982). A comparison of thickness and lateral extent of the deposits with bentonites, originated ofter the sedimentation of the Korytnica Clays and overlying marly sands and red-algal limestones, shows a well-marked regularity (*see* Text-figs 4—5). Two

bentonite members can be treated as good key horizons correlatable with two tuffogenic units recognized in other localities along the SW margin of the Holy Cross Mountains (ALEXANDROWICZ & PARACHONIAK 1956, FIJAŁKOWSKA & FIJAŁKOWSKI 1966). The youngest Miocene sediments in the Korytnica Bay, *i. e.* clays known from the boreholes Włoszczowice and Suliszów, correspond to those representing a period of an increasing salinity just below the Gypsum Member in the Połaniec depression (*see* RADWAŃSKI 1969, ALEXANDROWICZ 1979).

The presented space relationships between several Badenian members could result from later erosion, but an increasing to the SE thickness of the sediments with bentonites (Text-fig. 5) suggests rather a real regressional facies succession. Taking into account these facts, it is evident that the Korytnica Bay has successively become shallower and shallower and, eventually, excluded from the marine sedimentation in a response to the isostatic uplift of the Holy Cross land (RADWAŃSKI 1969, 1973). Therefore, evaporation and accumulation of the Gypsum Member took place only in the Połaniec depression, the NW end of which is located nearby the Kije-Suliszów area (*see* Text-figs 4—6 *and* SZYMANKO & WÓJCIK 1982). The latter area is also recorded by NW extent of the marine gravel-sandy deposits (Text-fig. 4) overlying the

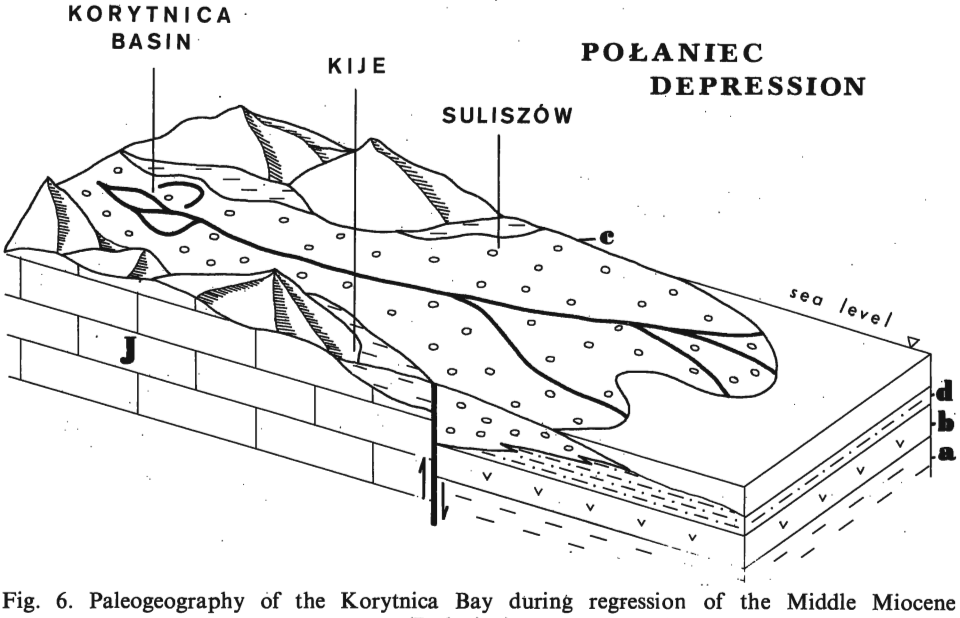

Fig. 6. Paleogeography of the Korytnica Bay during regression of the Middle Miocene (Badenian) sea

J — Jurassic basement

Middle Miocene (Badenian): **a** — transgressive deposits, including the Korytnica Clays, **b** — Gypsum Member

c — investigated alluvial gravels of Late Tertiary age, **d** — fine-grained marine clastics, coeval with the investigated gravels

Gypsum Member. This consideration indicates that the conditions prevailing during deposition of the discussed gravels within the Korytnica Basin were terrestrial.

The present-day occurrence of these gravels overlying diverse members of the Badenian sequence (*see* Text-fig. 2*B*) can be well explained by fluviatile erosion. The discussed area constituted probably a small kettle between the subsequent Jurassic ridges in which river sediments could be accumulated and later preserved during Pleistocene and/or Holocene geomorphological processes. On the other hand, the tendency to lowering of the central part of the Korytnica Basin (SZYMANKO & WÓJCIK 1982) continued during the sedimentation of the gravels and resulted in their relatively great thickness. The gravel lithosome can be defined as an erosional outlier resisted after a much larger alluvial fan.

REGIONAL REMARKS

The fluviatile gravels of the Korytnica Basin are most probably a stratigraphic equivalent of marine deposits developed in the foreland of the Korytnica Bay and assigned to the Upper Badenian and/or Lower Sarmatian (*cf.* discussion *in* RADWAŃSKI 1973, RUTKOWSKI 1976, SZCZECHURA 1982, CZAPOWSKI 1984). However, it must be stressed that similar river erosion, transport and redeposition of psefitic material took place in the Korytnica Basin after the time of regression of the Middle Miocene sea from the Carpathian Foredeep (Upper Badenian or Lower Sarmatian ?). These processes were connected with the Pliocene/preglacial river valleys, the action of which resulted in the denivelations which attained up to 150 m in the Holy Cross Mountains (LINDNER 1977). Simultaneously, the rivers formed an alluvial plain in the foreland of the Holy Cross Mountains. Taking this into account all the loose gravels overlying the gravel-sandy marine regressive deposits in the Połaniec Depression originated during that long span of time.

Consequently, it is thought that the term "detrital Sarmatian", as used in Polish literature is a designation of clastic deposits being, in fact, not homogenous in origin, and originated in the basin of the regressing sea and, later, under the terrestrial regime until the first Scandinavian icesheet reached the area in the Pleistocene.

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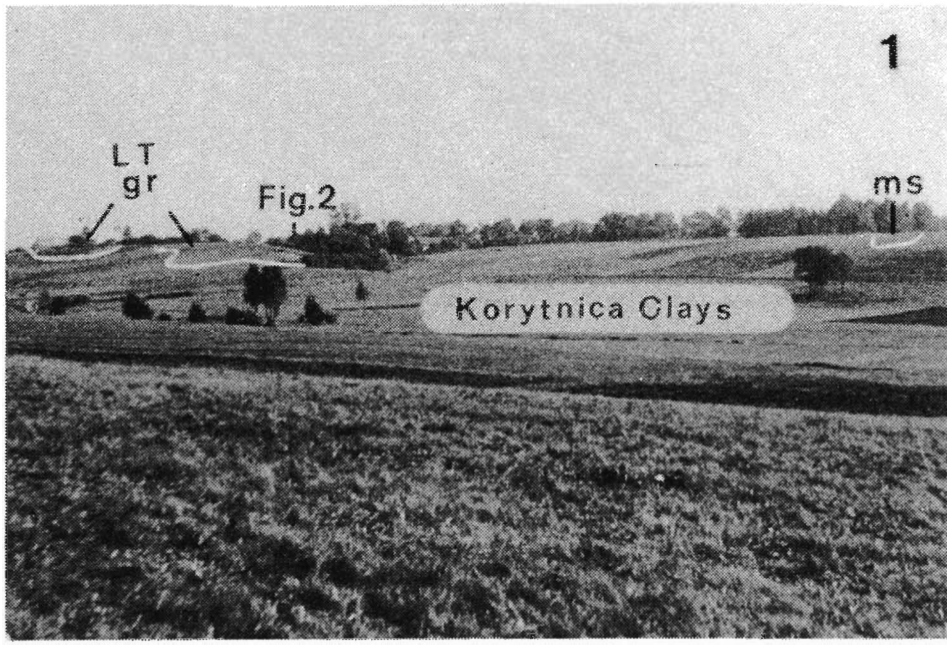
PÓŹNOTRZECIORZĘDOWE ŻWIRY RZECZNE W BASENIE KORYTNICY

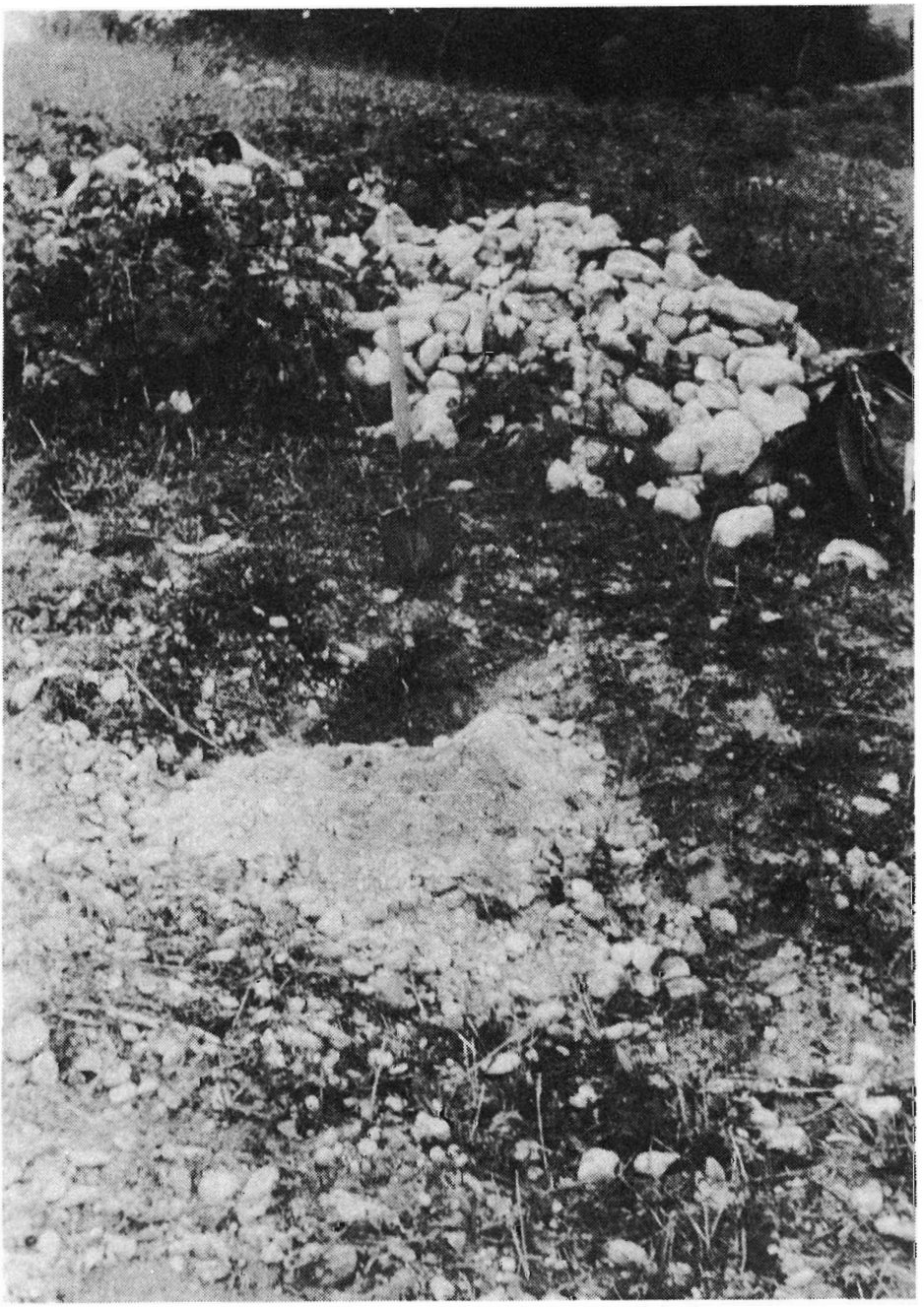
(Streszczenie)

Przedmiotem pracy jest analiza żwirów odsłaniających się pomiędzy Chomentowem a Karsami w centralnej części basenu Korytnicy (*patrz* fig. 1—2 oraz pl. 1—2). Żwiry te zawierają urozmaicony materiał allochtoniczny, a w porównaniu z badeńskimi osadami abrazyjnymi rozciągającymi się wokół basenu, charakteryzują się stosunkowo wysokim stopniem selekcji i obróbki materiału (*patrz* fig. 3). Analiza przebiegu regresji morza badeńskiego, zarówno w Zatoce Korytnickiej (*patrz* fig. 4—5) jak i na całym obrzeżeniu Gór Świętokrzyskich, prowadzi do wniosku, że badane żwiry są młodsze od wszystkich osadów badenu w basenie Korytnicy. Uważać je należy za fragment stożka aluwialnego, zachowany po erozji czwartorzędowej (fig. 6). Rozważane procesy rzecznego transportu i sedymentacji odbywać się mogły, zarówno na obszarze Zatoki Korytnickiej jak i na terenie sąsiadującej od południa niecki połanieckiej, w szerokim zakresie czasowym od regresji morza badenu (górny baden — dolny sarmat) aż do preglacjału włącznie. Z okresu tego pochodzą zapewne żwiry rejonu Chmielnika przykrywające regresywne osady miocenu. W świetle przedstawionej analizy rysuje się pogląd, iż termin „*sarmat detrytyczny*", powszechnie używany jako określenie rozmaitych osadów żwirowych na południowym obrzeżeniu Gór Świętokrzyskich, odnosi się w rzeczywistości do osadów genetycznie bardzo niejednorodnych oraz różniących się wiekiem w dość szerokim przedziale czasowym (górny baden — preglacjał).



1 — General view of the SE margin of the Korytnica Basin near Karsy; indicated are occurrence zones of the Korytnica Clays, **ms** — marly sands, both of Middle Miocene (Badenian) age; **LTgr** — Late Tertiary alluvial gravels

2 — Close-up view of Late Tertiary alluvial gravels exposed near Karsy



Exposure of Late Tertiary alluvial gravels near Karsy (*see* Pl. 1, Fig. 2)