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The first Polish find of Lower Paleocene crocodile *Thoracosaurus* Leidy, 1852: geological and palaeontological description

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Skeletal remains of a crocodile of the genus *Thoracosaurus* Leidy, 1852 were discovered by M. Żarski in Lower Paleocene gaizes in the neighbourhood of Kazimierz Dolny. They consist of a part of the vertebral column containing the last dorsal vertebra, the sacrum and eight caudal vertebrae. The age of the deposits was determined by means of micro- and macrofauna; they were dated as middle Danian. In the absolute chronological scale it was the period between 64.5 and 62.5 m.y. ago. The study of pelecypods and gastropods makes it possible to assume that the sea in which the crocodilian lived was a shallow basin with water temperature of about 18°C. The presence of tree trunks in the layer containing the crocodilian skeleton suggests closeness to land. The foraminifers occurring in the Greensand, the hard limestone "hardground" and the opokas were also studied.

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INTRODUCTION

The skeletal remains of the crocodile were discovered by M. Żarski in the neighbourhood of Kazimierz Dolny in 1995 during geological mapping for the preparation of the *Detailed Geological Map of Poland*, scale 1:50 000, sheet Puławy (M. Żarski, 1996). The remains were embedded in the wall of an abandoned quarry in a gorge called Kamienny Dół, in Lower Paleocene sandy gaizes overlying the "residual lag" with phosphorites *sensu* M. Machalski and I. Walaszczyk (1987) (Fig. 1).

It is the first find of crocodilian remains in Paleocene sediments in Poland. In 1845 C. Meyer described a fragment of the muzzle of a narrow-snouted Jurassic crocodile *Machimosaurus hugii* Meyer, 1845, coming from Czarnogłowy near Kamień Pomorski (J. Dzik, 1997).

The vicinity of Kazimierz Dolny has so far yielded only jaw fragments and individual teeth of mosasaurs, found in Cretaceous deposits (A. Sulimski, 1968; A. Radwański, 1985). The fragment of the crocodilian skeleton is also the first find of a representative of reptiles in Lower Paleocene sediments.

The geological and palaeontological study of the crocodilian skeleton was carried out during 1997 under the supervision of M. Żarski. Palaeontological research of the skeleton and of the macrofauna was carried out by G. Jakubowski; E. Gawor-Biedowa investigated the microfauna, whereas a stratigraphic and palaeoecological study, which will be the subject of a separate paper, was carried out by M. Machalski. Moreover, belemnites were identified by S. Cieśliński and lithological analyses were made by B. Gronkowska.

The present paper shows the geological background of the crocodilian find and comprises results of micropalaeontologi-

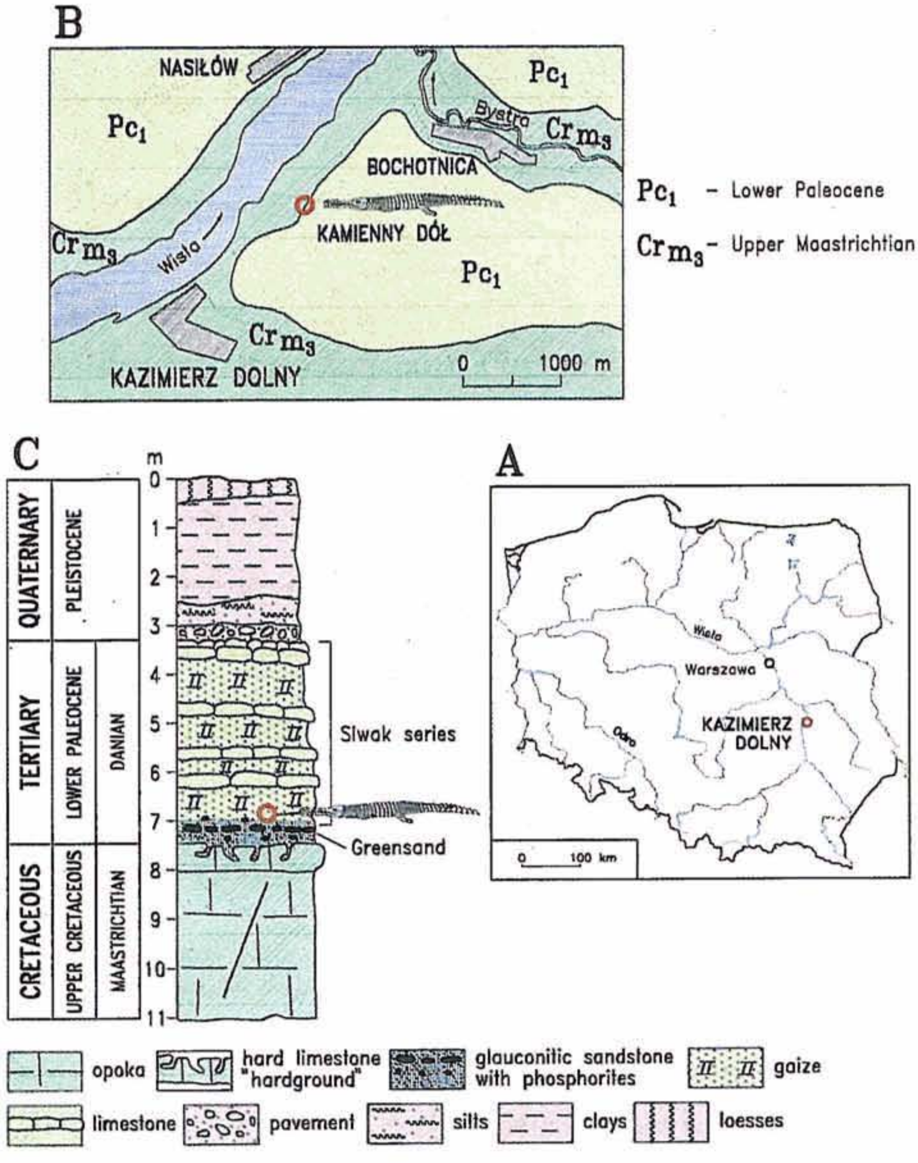

Fig. 1. Location and geological setting of crocodilian remains

A — location of Kazimierz Dolny against the map of Poland; B — uncovered geological sketch showing the location of the Kamienny Dół exposure; C — geological section of the Kamienny Dół quarry

Lokalizacja i sytuacja geologiczna znaleziska szczątków krokodyla

A — lokalizacja rejonu Kazimierza Dolnego; B — szkic geologiczny odkryty z lokalizacją odsłonięcia Kamienny Dół; C — profil geologiczny kamieniołomu Kamienny Dół

cal and macropalaeontological investigations as well as the palaeontological description of the skeleton.

The crocodilian remains are housed in the collection of the Polish Geological Institute in Warsaw, registration number Muz. PIG 1639. II (on permanent display).

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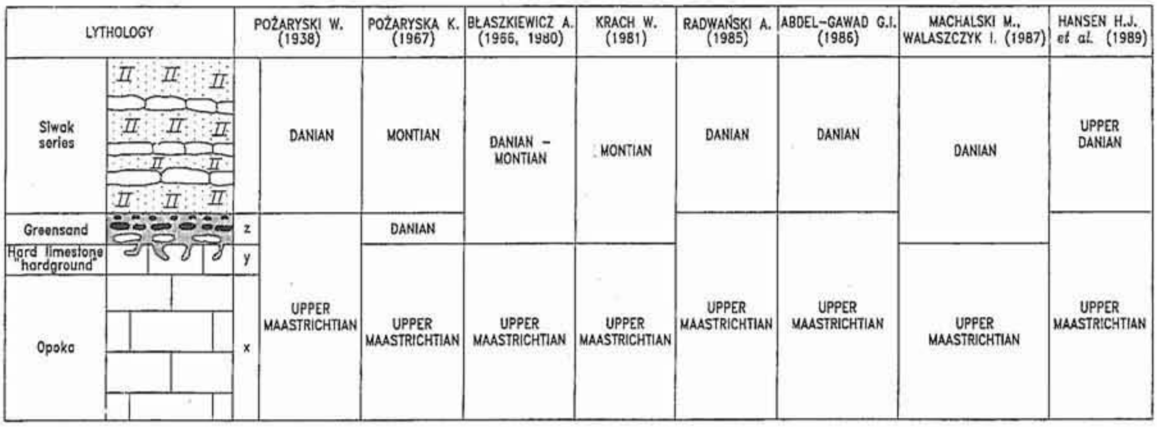

Fig. 2. Interpretations of the Cretaceous/Tertiary boundary in the Vistula Valley profile near Kazimierz Dolny according to different authors

Interpretacje granicy kreda/trzeciorzęd w profilu doliny Wisły koło Kazimierza Dolnego według różnych autorów

OUTLINE OF THE GEOLOGICAL STRUCTURE AND BRIEF SUMMARY OF PREVIOUS RESEARCH

The investigated profile is situated within the limits of the Marginal Trough — a tectonic structure formed at the turn of the Cretaceous and the Tertiary (A. M. Żelichowski, 1974). The exposure lies in the southern part of this synclinorium, called the Lublin Trough and filled with Jurassic, Cretaceous and Paleocene sediments. The total thickness of these sediments amounts to ca. 819 m (M. Żarski, 1996). The Maastrichtian sediments are ca. 250 m thick and in the vicinity of Góra Puławska ca. 60–50 m thick. The surface of the terrain is partly covered with Pleistocene deposits, whose thickness ranges from several metres up to several tens of metres. The Maastrichtian and Paleocene sediments in the vicinity of Kazimierz Dolny crop out on the surface (Fig.1). They have always been of interest to geologists. These formations have been studied by numerous investigators, for instance A. Morawiecki (1925), R. Kongiel (1935, 1950, 1962), R. Kongiel, L. Matwiejewówna (1937), L. Matwiejewówna (1935), H. Putzer (1942) and W. Pożaryski (1938, 1948, 1962, 1974, 1997). W. Pożaryski (1938) was one of the first to introduce the lithostratigraphic division of the outcropping Maastrichtian rocks. He distinguished the following strata: level "x"— comprising the upper Maastrichtian opoka series, level "y" — the hard limestone "hardground" overlying the opokas, and level "z" — the Greensand with phosphorite concretions, in the uppermost layer of which he placed the Cretaceous/Tertiary boundary (Fig. 2). The so-called Greensand is a glauconitic sandstone laying between the hard limestone "hardground" and the top of "residual lag" (the phosphorite layer).

The problem of the Cretaceous/Tertiary boundary is controversial, because the Greensand contains mixed Cretaceous and Tertiary macro- and microfauna. An important contribution to the understanding of the stratigraphic problems connected with the discussed sequence was made by K. Pożaryska (1952, 1965, 1967) and K. Pożaryska, W. Pożaryski (1951). She placed the Cretaceous/Tertiary boundary at the top of the hard limestone. The so-called Żyżyn Beds, present in nearby boreholes at Góra Puławska and at Żyżyn, representing the uppermost Maastrichtian, were not recorded by K. Pożaryska (1967) in exposures in the neighbourhood of Kazimierz Dolny. The existence of a stratigraphic hiatus comprising the uppermost Maastrichtian was also recorded by H. J. Hansen *et al.* (1989). K. Pożaryska (1967) regarded the Greensand as Danian (the Sochaczew Beds) and the overlying gaizes as Montian (the Puławy Beds). A similar opinion was put forward by W. Krach (1981) and A. Błaszkiewicz (1966, 1980). The majority of contemporary investigators regard the overlying gaizes as of Danian age (A. Radwański, 1985; G. I. Abdel-Gawad, 1986; M. Machalski, I. Walaszczyk, 1987; H. J. Hansen *et al.*, 1989) (Fig. 2). The authors of the present paper assume that the Cretaceous/Tertiary boundary runs at the top of the hard limestone (M. Machalski, M. Żarski *fide* M. Żarski *et al.*, 1997). In the last few decades a considerable amount of stratigraphic and geological research has been carried out with reference to the area under discussion (J. Liszkowski, 1970; D. Peryt, 1980; K. Wyrwicka, 1980; R. Marcinowski, A. Radwański, 1983, 1996; W. J. Kennedy, 1993; A. Radwański, 1996; M. Machalski, 1996).

Depth (m)	**Lithological profile**
	Quaternary
0.0–0.3	Loess.
0.3–2.8	Ice-dammed clays.
2.8–3.0	Silty sand.
3.0–3.2	Pavement with pebbles of Paleocene gaizes, Maastrichtian limestones and cristalline rocks of Scandinavian provenance.
	Paleocene (Danian)
3.2–3.6	Gaize rubble, grey-white.
3.6–4.7	Sandy gaize, grey.
4.7–4.9	Limestone, grey.
4.9–5.5	Sandy gaize, grey-green.
5.5–5.7	Limestone, grey.
5.7–6.1	Sandy gaize, grey-green.
6.1–6.3	Limestone, grey.
6.3–6.8	Glauconitic sandy gaize with single phosphorites, grey-green.
6.8–7.0	Sandy gaize with phosphorites, green-grey, **with remains of the crocodilian skeleton.**
7.0–7.2	Glauconitic sandstone (Greensand) with phosphorites (phosphorite layer — "residual lag"), brown-green.

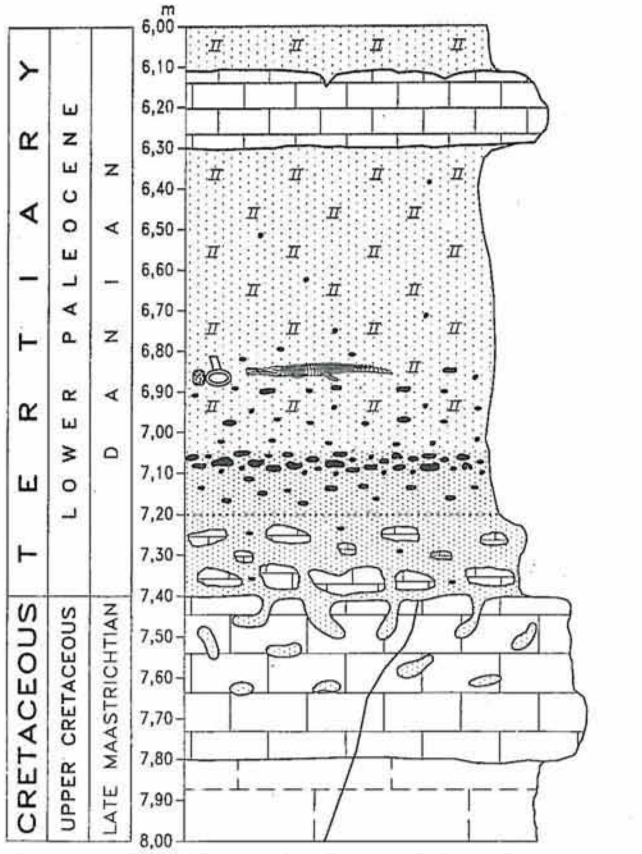

Fig. 3. Location of remains of the crocodile against the background of detailed geological section

Lokalizacja szczątków krokodyla na tle szczegółowego profilu geologicznego

7.2–7.4 Glauconitic sandstone (Greensand).

C r e t a c e o u s (Maastrichtian)

7.4–7.8 Hard limestone "hardground" with burrows filled with glauconitic sandstone, grey.

7.8–10.0 Opoka (marly — siliceous limestone), partly fractured, white-yellow-beige.

In order to determine the age of the rocks in which the crocodilian remains were present it was necessary to carry out geological research, which included a study of foraminifers, gastropods, pelecypods and cephalopods as well as lithological and sedimentological observations.

The discussed profile begins at the bottom with an opoka (Fig. 3) belonging to the *Belemnella kazimiroviensis* biostratigraphic zone (G. I. Abdel-Gawad, 1986; M. Machalski, 1996), defined by A. Błaszkiewicz (1980) as *Hoploscaphites constrictus crassus*. In the described part of the profile no detailed identification of macrofauna was made. It should be assumed that the assemblage of species present here does not differ from the macrofauna studied by G. I. Abdel-Gawad (1986) at Nasiłów and Bochotnica. The investigation of the foraminifers carried out by E. Gawor-Biedowa (*fide* M. Żarski *et al.*, 1997) testifies unequivocally to the presence of the highest part of the upper Maastrichtian. In the uppermost beds of the opoka, which contain a rich assemblage of foraminifers, taxa indicating the late Maastrichtian were recorded: *Praeglobobulimina imbricata* (Reuss), *Osangularia peracuta* (Lipnik), *Gavelinella gankinoensis* (Neckaja) and *Anomalinoides pinguis* (Jennings). The highest part of the upper Maastrichtian (the *Hoploscaphites constrictus crassus* Zone) is indicated by *Bolivina aleksandrae* Gawor-Biedowa and *B. praecrenulata* Gawor-Biedowa (E. Gawor-Biedowa, 1992). In the topmost part of the opoka a few specimens of typically Paleocene foraminifers were recorded: *Subbotina triloculinoides* (Plummer) and *Rosalina ystadiensis* (Brotzen), which were redeposited here after having been removed out of overlying Paleocene formations (Table 1).

The opokas are terminated with hard limestone "hardground" with numerous borings made by the ichnogenera *Thalassinoides, Ophiomorpha* and *Chondrites* (M. Machalski, I. Walaszczyk, 1987), filled with the overlying Greensand (Fig. 3). According to M. Machalski (*fide* M. Żarski *et al.*, 1997), the hard limestone is not the real hardground, because in this sediment the cementation processes took place in the Danian, after it had been covered by overlying deposits. In accordance with the definition of the hardground, lithification should take place before the carbonate surfaces are covered by later sediments (R. Goldring, J. Kaźmierczak, 1974).

In the hardground a limited assemblage of upper Maastrichtian species of foraminifers was recorded: *Cibicidoides involutus* (Reuss), *C. bembix* (Marsson), *Osangularia peracuta* (Lipnik), *Bolivina incrassata* Reuss, *Heterohelix moremani* (Cushman), *Gavelinella sahlstroemi* (Brotzen), *Praebulimina pusilla* (Brotzen), *P. ventricosa* (Brotzen), *Bolivinoides peterssoni* Brotzen, *Paralabamina toulmini* (Brotzen) and *Biglobigerinella abberanta* (Neckaja). They are badly damaged. Both in the top and in the bottom part of the hardground a few redeposited Paleocene species of foraminifers were recorded. The sandy material filling the burrows contains a scanty assemblage of Paleocene foraminifers: *Epistominella limburgensis* (Visser), *Cibicidoides succedens* (Brotzen) and *Pulsiphonina prima* (Plummer).

Paleocene pelecypods were also identified here by G. Jakubowski (*fide* M. Żarski *et al.*, 1997): *Nucula* (*Nucula*) *proava* Wood, 1861, *Anadara montensis* (Cossmann, 1908), *Cucullaea volgensis* Barbot de Marny, 1874, *Arcopsis* (*Arcopsis*) *limopsis* (Koenen, 1885), *Lyropecten acuteplicatus* (Alth, 1850), *Gryphaeostrea canaliculata* (Sowerby, 1812), *Astarte trigonula* Koenen, 1885, and *Crassatella krachi* Moroz, 1972.

The hard limestone is overlain with a layer of glauconitic sandstone (Greensand), 20 cm thick, containing clasts of soft and hard limestone and terminated with a lamina of glauconitic sand. The glauconitic sand may testify to a change in sedimentary conditions. There was a considerable influx of terrigenous material, connected with closeness to land. The Greensand contains Paleocene foraminifers and the clasts of limestone occurring in it contain upper Maastrichtian foraminifers. A rich assemblage of Paleocene foraminifers indicates that the Greensand is of Danian age. The most important foraminifer species are as follows: *Lamarckina rugulosa* Plummer, *Lenticulina pulavensis* (Pożaryska), *L. gryi* (Brotzen) and *Cibicidoides succedens* (Brotzen). A few specimens of redeposited Maastrichtian belemnites were also found in this layer.

The lamina of green glauconitic sand is capped with very weakly cemented Greensand, greenish-grey in colour, with very numerous and large phosphorite concretions, forming the so-called residual lag (M. Machalski, I. Walaszczyk, 1987). This layer was also termed the phosphorite layer (K. Pożaryska, 1965, 1967), with no precise definition of its boundaries given. According to the present authors, the upper boundary of the phosphorite layer is equivalent to the top of the "residual lag" (M. Machalski, M. Żarski *fide* M. Żarski *et al.*, 1997). The macrofauna present in the Greensand in the vicinity of Kazimierz Dolny was studied by M. Machalski and I. Walaszczyk (1987), who distinguished three fossil assemblages: the phosphatized Maastrichtian, the unphosphatized Maastrichtian and the Danian assemblage. The authors of the above-quoted paper observed that these assemblages occur jointly in the Greensand and attributed it to the processes of faunal condensation and mixing by burrowing organisms. The research carried by the authors of the present paper and by M. Machalski in the Kamienny Dół profile confirms the occurrence of these three assemblages and indicates additionally that phosphatized Paleocene fauna, identified by G. Jakubowski (*fide* M. Żarski *et al.*, 1997), is also present here. It comprises pelecypods *Nucula (Nucula) proava* Wood, 1861, *Cucullaea volgensis* Barbot de Marny, 1874, *Parvilucina nanna* (Cossmann, 1908), *Miltha (Recticardo) montensis* (Cossmann, 1908), *Nemocardium problematicum* (Zubkovitsch, 1960) and gastropods *Acteon kongieli* (Abdel-Gawad, 1986) and *Roxania raristriata* (Briart et Cornet, 1887). Within the "residual lag" belemnites are very common. *Belemnitella kazimiroviensis* (Skołozdrówna, 1932), *B. archangelskyi* (Jeletzky) and *B. pensaensis* (Najdin) were found here by S. Cieśliński (1997). S. Cieśliński, following R. Kongiel (1962), includes the above species in the genus *Belemnitella* and distinguishes separate taxa belonging to the *kazimiroviensis* group. The majority of contemporary investigators regard the above-mentioned belemnites as belonging to the species *Belemnella kazimiroviensis* (Skołozdrówna, 1932), (M. Machalski, M. Żarski *fide* M. Żarski *et al.*, 1997). Apart from belemnites, Maastrichtian pelecypods *Lyropecten acuteplicatus* (Alth, 1850) and *Hyotissa semiplana* (Sowerby, 1825), brachiopods *Neoliothyrina obesa* (Davidson, 1852), *Carneithyris carnea* (Sowerby, 1812) and *Cretirhynchia undulata* (Push, 1837) were recorded here as well (M. Machalski, M. Żarski *fide* M. Żarski *et al.*, 1997). Two specimens of echinoids were also found, identified as *Micraster vistulensis* (Kongiel, 1950) by M. Machalski. Paleocene fauna occurring in this layer is represented by the following taxa: *Nucula (Nucula) proava* Wood, 1861, *Lima hoperi* Mantell, *Pycnodonte vesicularis* (Lamarck), *Crassatella excelsa* Cossmann, 1908 and *Ringicula discrepans* Traub, 1938 (G. Jakubowski *fide* M. Żarski *et al.*, 1997).

The **foraminifers** occurring in the Greensand layer represent the Lower Paleocene assemblage (E. Gawor-Biedowa *fide* M. Żarski *et al.*, 1997). *Lenticulina disca* (Brotzen), *L. pulavensis* (Pożaryska), *L. rancocasensis* (Olsson), *Cibicidoides proprius* Brotzen, *C. succedens* (Brotzen), *Subbotina triloculinoides* (Plummer), *S. pseudobulloides* (Plummer), *Loxostomoides deadericki* (Cushman), *Rosalina ystadiensis* Brotzen, *Kolesnikovella cuneata* (Brotzen), *Globoconusa daubjergensis* (Brönnimann), *Polymorphina paleocenica* (Brotzen) and *Lamarckina rugulosa* Plummer should be mentioned as the most important species in this assemblage. Within this horizon there still occurs an admixture of Cretaceous foraminifers, which were not recorded higher up in the section.

The "residual lag" is overlain with a layer of greenish sandy gaize, 20 cm thick, which shows little macroscopic difference from the Greensand situated below. Relatively numerous phosphorite concretions occur in the sandy gaize, yet they are considerably smaller than those present in the Greensand. Within the layer of the sandy gaize the remains of the crocodilian skeleton were discovered (Pl. IV). The skeleton, lying in the perpendicular position in relation to the wall (approximately in the N–S direction, whereas the wall of the quarry runs in the W–E direction), was embedded in it up to the depth of ca. 1.0–1.5 m. Unfortunately, the search for the missing parts of the skeleton proved unsuccessful. The sediments in which the first parts of the skeleton were found were characterized by compactness, in contrast to the loose texture of the rock deeper in the wall, which made the process of excavating the skeleton much more difficult. The bones of the crocodile are remarkably well-preserved, with no traces of transport. The arrangement of the bones indicates their natural post-mortem position.

The investigated foraminifers from the layer in which the crocodilian remains were embedded testify unequivocally to the Paleocene age of the find (E. Gawor-Biedowa *fide* M. Żarski *et al.*, 1997). *Ceratolamarckina tuberculata* (Brotzen), *Lenticulina gryi* (Brotzen) and *Loxostomoides applinae* (Plummer) occur here, recognized by K. Pożaryska (1965) as index fossils of the Montian. The whole assemblage is very similar to the Montian assemblage described by the above author. At present the Montian is correlated with the Danian or, more precisely, with its middle part.

These sediments were regarded as Danian for instance by A. Radwański (1985), G. I. Abdel-Gawad (1986), M. Machalski, I. Walaszczyk (1987) (Fig. 3) and in an unpublished study by M. Machalski (*fide* M. Żarski *et al.*, 1997), who, following G. Bignot (1993), considers the Montian as part of the Danian.

E. Gawor-Biedowa (*fide* M. Żarski *et al.*, 1997) recorded here a few species of planktic foraminifers as well: *Subbotina triloculinoides* (Plummer), *S. pseudobulloides* (Plummer), *Globoconusa daubjergensis* (Brönnimann), which make it possible to provide a correlation with the zones distinguished in the Mediterranean area (W. A. Berggren *et. al.*, 1995). The Danian sediments from the Kamienny Dół exposure probably correlate with the *Subbotina triloculinoides-Globigerina compressa* Zone, which according to the division by W. A. Berggren *et al.* (1995) (E. Gawor-Biedowa *fide* M. Żarski *et al.*, 1997) represents the early middle Danian, whereas the Cretaceous opokas correlate with the *Praeglobobulimina im-*

Foraminifers in the sediments

Depth [m]	No. samples	Taxa																																																																				
		Cibicidoides involutus (Reuss)	*Osangularia peracuta* (Lipnik)	*Praeglobobulimina imbricata* (Reuss)	*Spiroplectammina rosula* (Ehrenberg)	*Ataxophragmium crassum* (d'Orbigny)	*Bolivina incrassata* Reuss	*Cibicidoides bembix* (Marsson)	*Gyroidinoides girardanus* (Reuss)	*Heterohelix pseudoglobulosa* Frerichs	*Heterohelix striata* (Ehrenberg)	*Pyramidina cimbrica* (Brotzen)	*Gavelinella sahlstroemi* (Brotzen)	*Praebulimina pusilla* (Brotzen)	*Gavelinella acuta* (Plummer)	*Praebulimina parvula* (Brotzen)	*Pyramidina minuta* (Marsson)	*Lenticulina rotulata* (Lamarck)	*Arenobulimina conica* Marie	*Praebulimina carseyae* (Plummer)	*Heterohelix globocarinata* (Cushman)	*Valvulineria lenticula* (Reuss)	*Bolivinoides draco* (Marsson)	*Guembelitria cenomana* (Keller)	*Ataxophragmium beisseli* (Cushman)	*Pullenia cretacea* Cushman	*Bolivinoides peterssoni* Brotzen	*Paralabamina toulmini* (Brotzen)	*Pseudouvigerina cristata* (Marsson)	*Pseudouvigerina rugosa* Brotzen	*Coryphostoma plaita* (Carsey)	*Spiroplectammina suturalis* (Kalinin)	*Gaudryina rugosa* d'Orbigny	*Tritaxia dubia* (Reuss)	*Whiteinella baltica* Douglas et Rankin	*Spiroplectammina baudouiniana* (d'Orbigny)	*Anomalinoides pinguis* (Jennings)	*Heterohelix glabrans* (Cushman)	*Bolivina decurrens* (Ehrenberg)	*Pyramidina triangularis* (Cushman et Parker)	*Rugoglobigerina rugosa* (Plummer)	*Gavelinella umbilicatula* (Vassilenko et Mjatliuk)	*Biglobigerinella abberanta* (Neckaja)	*Globigerinelloides asperus* (Ehrenberg)	*Gavelinella gankinoensis* (Neckaja)	*Gaudryina frankei* Brotzen	*Praebulimina ventricosa* (Brotzen)	*Orbignyna inflata* (Reuss)	*Gavelinella pertusa* (Marsson)	*Gavelinella lellingensis* Brotzen	*Telatynella clavata* Gawor-Biedowa	*Tappanina selmensis* (Cushman)	*Praebulimina asperoaculeata* (Brotzen)	*Gyroidinoides globosus* (Hagenow)	*Valvulinaria* sp.	*Plectina convergens* (Keller)	*Lenticulina secans* (Reuss)	*Arenobulimina sphaerica* Marie	*Bolivina alexandrae* Gawor-Biedowa	*Neoflabellina reticulata* (Reuss)	*Globotruncana rugosa* (Marie)	*Spiroplectammina navarroana* Cushman	*Arenobulimina vialovi* Woloschyna	*Nodosaria* sp.	*Dentalina* sp.	*Lagena* sp.	*Ramulina* sp.	*Guembelitria cretacea* Cushman	*Globotruncana* cf. *rugosa* (Marie)	*Eouvigerina serrata* (Chapman)
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Top of hard limestone	2							•					•		•													•																			•																							
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0,50 **	4		•				•	•			•		•	•													•									•											•																							
Bottom of hard limestone	3	•	•				•						•																														•																											
0,75 **	6	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•		•				•		•		•	•	•	•	•			•	•		•	•	•	•			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
0,80 **	5	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•		•	•			•			•	•	•	•	•	•			•	•	•	•		•	•			•	•	•	•		•			•	•		•				•	•				•	•			•	•	•
1,10 **	7	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•			•		•		•			•			•	•	•	•		•	•		•	•	•	•	•	•	•	•																									
2,00 **	8	•				•	•		•			•	•		•	•	•				•								•	•	•	•				•	•																																	
3,70 **	9	•		•	•	•	•	•	•		•		•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•																																			
5,70 **	10	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•																																																				

*above the top of hard limestone, **below the top of hard limestone

bricata Zone and the *Bolivina aleksandrae* Subzone (E. Gawor-Biedowa, 1992).

The analysis of pelecypods and gastropods made by G. Jakubowski (*fide* M. Żarski *et al.*, 1997) confirms the Lower Paleocene age of the discussed formation, which can be correlated with the Danian. The molluscan fauna present here shows differences in comparison with the stratotypical faunas from Denmark and from the Luzanovka Beds in the Ukraine (M. Machalski, M. Żarski *fide* M. Żarski *et al.*, 1997). M. Machalski attributes it to palaeoecological differences.

Among **pelecypods** the genera *Nucula, Nuculana, Cucullaea, Gryphaeostrea, Miltha, Cuspidaria, Corbicula, Crassatella* and *Pitar* are the most common. The last three genera are benthic ones. Others, like for instance *Pycnodonte, Gryphaeostrea, Nucula* and *Corbula*, are adapted to living on the soft surface of the seabed.

Table 1

of Kamienny Dół quarry

Taxa																					
Epoch	DANIAN											LATE MAASTRICHTIAN									
Biozones	S. TRILOCULINOIDES – GL. COMPRESSA											P. IMBRICATA / B. ALEKSANDRAE									
Bolivina praecrenulata Gawor-Biedowa																	•				
Cribrebella fusiformis (Gawor-Biedowa)																	•				
Subbotina triloculinoides (Plummer)	•	•	•			•	•	•	•		•				•		•				
Rosalina ystadiensis Brotzen		•		•	•	•		•									•				
Orbignyna simplex (Reuss)																	•				
Bolivinoides paleocenicus (Brotzen)																	•				
Gavelinella costulata (Marie)																	•				
Gavelinella mariae (Jones)	•			•	•	•		•	•	•	•		•								
Osangularia navarroana (Cushman)	•	•		•	•	•	•	•	•	•	•		•								
Cibicidoides commatus (Morozova)							•	•	•	•	•		•								
Pulsiphonina prima (Plummer)	•	•	•	•	•	•	•	•	•	•	•		•								
Epistominella limburgensis (Visser)	•		•	•	•	•	•	•		•	•		•								
Cibicidoides succedens (Brotzen)	•	•	•	•	•	•	•	•	•	•	•		•								
Gavelinella danica (Brotzen)	•	•	•	•	•	•	•	•	•	•	•	•	•								
Heterohelix cf. *striata* (Ehrenberg)												•									
Sitella laevis (Beissel)											•	•									
Heterohelix moremani (Cushman)											•	•									
Loxostomoides deadericki (Cushman)							•	•	•	•	•										
Ataxophragmium frankei Brotzen		•		•	•	•	•	•	•	•	•										
Polymorphina paleocenica (Brotzen)								•	•	•	•										
Guttulina communis d'Orbigny					•		•	•	•	•	•										
Globulina prisca (Reuss)											•										
Lamarckina rugulosa Plummer								•			•										
Globigerinelloides sp.											•										
Kolesnikovella cuneata (Brotzen)	•	•	•	•	•	•	•	•	•	•	•										
Karreria fallax Rzehak	•	•	•	•	•	•	•	•		•	•										
Lenticulina pulavensis (Pożaryska)		•		•				•	•		•										
Sigmomorphina soluta Brotzen								•	•	•	•										
Gyroidinoides octocamerata (Cushman et Hanna)	•		•	•	•	•	•	•			•										
Lenticulina hornerstownensis Olsson										•	•										
Lenticulina gryi (Brotzen)	•	•			•		•		•		•										
Alabamina dorsoplana (Brotzen)	•	•		•	•	•	•	•	•	•	•										
Palmula robusta Brotzen								•	•	•											
Gyroidinoides sp.										•		•									
Lenticulina bzurae (Pożaryska)										•											
Stensioeina pommerana Brotzen									•	•											
Plectina ruthenica (Reuss)									•	•											
Globorotalites lobata Brotzen										•											
Bolivinoides decoratus (Jones)									•												
Arenobulimina puschi (Reuss)									•												
Globorotalites granulatus Pożaryska et Szczechura									•												
Valvulineria laevis Brotzen								•	•												
Lenticulina disca (Brotzen)					•	•		•	•												
Lenticulina rancocasensis (Olsson)								•	•												
Stensioeina beccariiformis (White)								•													
Subbotina pseudobulloides (Plummer)	•					•	•	•													
Bolivinoides sidestrandensis Barr								•													
Astacolus cf. *trigonatus* (Plummer)								•													
Cibicidoides proprius Brotzen	•	•		•	•	•	•	•													
Orbignyna sacheri (Reuss)								•	•												
Gavelinella simplex (Brotzen)				•	•	•	•	•													
Globoconusa daubjergensis (Brönnimann)	•	•						•													
Anomalinoides nobilis Brotzen					•	•	•														
Sigmomorphina pseudoregularis (Cushman et Thomas)							•														
Saracenaria sp.							•														
Bolivina subincrassata Chalilov							•														
Bulimina rosenkrantzi Brotzen							•														
Ceratolamarckina tuberculata (Brotzen)		•		•	•	•	•														
Loxostomoides applinae (Plummer)	•	•		•	•	•															
Pullenia jarvisi Cushman						•															
Stensioeina sp.						•															
Guttulina roemeri (Reuss)						•															
Rosalina koeneni Brotzen	•	•		•	•																
Guttulina problema d'Orbigny	•	•			•																
Saracenaria hamata (Franke)					•																
Anomalinoides burlingtonensis (Jennings)	•	•	•	•	•																
Cibicidoides lectus (Vassilenko)		•																			
Frondicularia biformis Marsson		•																			
Nonionella troostae (Visser)	•																				
Bolivina oedumi Brotzen	•																				
Cymbalopora sp.	•																				

Gastropods are represented mostly by the genera *Metacerithium, Grommium, Euspira* and *Acteon* (G. Jakubowski *fide* M. Żarski *et al.*, 1997). The complete list of the pelecypod and gastropod fauna from this layer is given in Table 2. Attention should be drawn to very common occurrence of all the four species of the genus *Nucula* as well as *Lyropecten acuteplicatus* (Alth, 1850), *Crassatella excelsa* Cossmann, 1908, and to abundant presence of *Cucullaea volgensis* Barbot de Marny, 1874. Among gastropods *Grommium (Amauropsella) ciplyensis* (Vincent, 1930) and *Acteon parisiensis* (Deshayes, 1843) are the most common.

The whole faunal assemblage indicates that the environmental conditions were those of the sublittoral zone, with water depth between 30 and 80 m, normal salinity and water temperature of 17–18°C (G. Jakubowski *fide* M. Żarski *et al.*, 1997). The analysis of the gastropod assemblage confirms the

Table 2

Pelecypods and gastropods in Kamienny Dół quarry

	Species	A	B	C	D	E	F	G
	1	2	3	4	5	6	7	8
Pelecypods	*Nucula (Nucula) montensis* Cossmann, 1908				xxx	x	x	xx
	Nucula (Nucula) proava Wood, 1861	x	x	x	xxx	xx	x	x
	Nucula (Nucula) densistria Koenen, 1885				xxx	x	x	
	Nucula (Nucula) sinuatella Cossmann, 1908				xxx			
	Nuculana (Nuculana) ovoides (Koenen, 1885)				x			x
	Nuculana (Nuculana) crassistria (Koenen, 1885)							x
	Nuculana (Nuculana) biarata (Koenen, 1885)				x			x
	Nuculana (Saccella) houzeaui Glibert et Van de Poel, 1973				x			x
	Nuculana symmetrica (Koenen, 1885)						x	
	Yoldia uncifera (Vincent, 1930)				x		x	
	Anadara montensis (Cossmann, 1908)	x					x	
	Cucullaria reticularis (Netschaev, 1869)				xx		x	
	Cucullaea decussata Parkinson, 1811			x	xx			
	Cucullaea volgensis Barbot de Marny, 1874	xx	x	x	xxx	xxx	xxx	xx
	Arcopsis (Arcopsis) limopsis (Koenen, 1885)	x			x			
	Limopsis (Limopsis) minuscula Cossmann, 1908				xx	x		x
	Glycymeris (Glycymeris) corneti (Koenen, 1885)				xx			x
	Musculus vincenti (Cossmann, 1908)					x		
	Amygdalum wemmelensis (Vincent, 1900)				x	x		
	Pinna fragilis Watelet, 1868					x		
	Lyropecten acuteplicatus (Alth, 1850)	x		x	xxx	x	x	
	Lima hoperi Mantell			x				
	Lima pireti Cossmann, 1908							x
	Ctenoides holzapfeli (Hennig, 1899)				xx			
	Limatula hexagonalis (Cossmann, 1908)							x
	Pycnodonte vesicularis (Lamarck)			x	x			x
	Gryphaeostrea canaliculata (Sowerby, 1812)	x			x	x		
	Lucina lepis (Koenen, 1885)				xx	x		x
	Cavilucina duponti (Cossmann, 1908)					x		
	Parvilucina nanna (Cossmann, 1908)		x					
	Miltha (Miltha) proava (Archangelskij, 1904)				xx	x		x
	Miltha (Miltha) passelequi (Vincent, 1930)							x
	Miltha (Recticardo) montensis (Cossmann, 1908)		x		x			
	Venericardia erugata Cossmann, 1908				xx			
	Venericardia rutoti Cossmann, 1908	x			x			
	Astarte trigonula Koenen, 1885	x			xx			
	Crassatella subplana Ravn, 1939							x
	Crassatella excelsa Cossmann, 1908			x	xxx	x		x
	Crassatella montensis Cossmann, 1908					x		
	Crassatella krachi Moroz, 1972	x			x		x	x
	Parvicardium tenuitesta (Cossmann, 1908)				x			
	Trachycardium trifidum (Deshayes, 1858)				x			
	Nemocardium problematicum (Zubkovitsch, 1960)		x					
	Tellina (Peronidia) montensis Cossmann, 1908				x			
	Corbicula (Lexoptychodon) arnouldi (Michaud, 1844)			x	x	x		
	Corbicula veneriformis (Deshayes, 1860)				x	x		
	Gafrarium angelini (Koenen, 1885)				x			
	Pitar nitidula (Lamarck, 1806)					x		
	Pitar tranquilla (Deshayes, 1860)				x			
	Pitar montensis (Cossmann, 1892)				x			
	Pitar duponti (Cossmann, 1908)							x
	Pitar pireti (Cossmann, 1908)							x
	Dosiniopsis fallax (Deshayes, 1860)				x	x		
	Dosiniopsis tokodensis (Oppenheim, 1892)							x
	Sphenia haudrugata Cossmann, 1908							x
	Teredina aff. *oweni* Deshayes, 1860				x			
	Pholadomya konincki Nyst, 1843				x			
	Pholadomya moeschi Netschaev, 1894				x			
	Cuspidaria caudata (Nilsson, 1827)				x			
	Cuspidaria pulchra (Sowerby)				x			
Gastropods	*Acmaea (Tectura) simplex* (Briart et Cornet, 1887)				x			
	Tectus cf. *carinadentatus* (Briart et Cornet, 1887)						x	
	Tectus sp.					x		
	Pareuchelus lefevrei Rutot *in* Cossmann, 1915				x			

Table 2 continued

1		2	3	4	5	6	7	8
Gastropods	*Architectonica bisulcatum* (Koenen, 1885)				x	x		
	Circulus montensis (Rutot *in* Cossmann, 1915)				x			
	Sigmesalia marthae (Briart et Cornet, 1873)						x	
	Turritella (Haustator) arsenei Briart et Cornet, 1873							x
	Turritella (Haustator) circumdata Deshayes, 1864					x		
	Metacerithium hauniense (Koenen, 1885)				x			
	Coniscala johnstrupi (Mörch, 1874)							x
	Acirsa elator (Koenen, 1885)				x			
	Eucycloscala crassilabris (Koenen, 1885)				x			
	Drepanocheilus (Arrhoges) gracilis (Koenen, 1885)				x			x
	Grommium (Amauropsella) ciplyensis (Vincent, 1930)				xx			
	Ampullospira austriaca Traub, 1938				x			
	Euspira detrita (Koenen, 1865)				x			xx
	Cassidaria elongata Koenen, 1885				x			
	Columbarium heberti (Briart et Cornet, 1877)				x	x		
	Exilia crassistria (Koenen, 1885)							x
	Clavilithes hauniensis (Ravn, 1939)				x			
	Clavilithes reticulatus (Briart et Cornet, 1877)				x			
	Pseudoliva robusta Briart et Cornet, 1877							x
	Mitra omalii Briart et Cornet, 1877					x		
	Athleta (Volutispina) elevata (Sowerby, 1840)							x
	Scaphella crenistria (Koenen, 1885)					x		
	Turricula steenstrupi (Koenen, 1885)				x			
	Turricula ludmilae (Archangelskij, 1904)				x			
	Gemmula brevior (Koenen, 1885)							x
	Cochlespira koeneni (Archangelskij, 1904)				x			
	Acteon parisiensis (Deshayes, 1843)				xx			x
	Acteon kongieli (Abdel-Gawad, 1986)		x					
	Ringicula cf. *discrepans* Traub, 1938			x	x			x
	Roxania raristriata (Briart et Cornet, 1887)		xx		x	x	x	

A — burrows in hard limestone "hardground", B — phosphatized fauna in Greensand, C — 0.0–0.2 m above hard limestone "hardground", D — 0.2–0.4 m above hard limestone "hardground", E — 0.4–0.8 m above hard limestone "hardground", F — 0.8–1.0 m above hard limestone "hardground", G — 1.0–1.5 m above hard limestone "hardground"; x — 1–5 specimens; xx — 6–20 specimens; xxx — more than 20 specimens

conclusions formulated on the basis of the investigation of the pelecypod assemblage concerning the Danian age of the sediments and the environmental conditions; the microfauna does not disprove these conclusions. It is possible to assume slightly higher water temperature up to 20°C (W. Krach, 1963, 1969, 1974, 1981; G. Jakubowski, 1988). In the sandy gaize in which the crocodilian skeleton was embedded, relatively common shark teeth, a few moulds of echinoids of the genus *Echinocorys* and tree trunks suggesting closeness to land were found (M. Machalski, M. Żarski *fide* M. Żarski *et al.*, 1997).

The greenish sandy gaize in which the crocodilian remains were present is overlain with a 4 m series of gaizes and limestones called the Siwak series. The investigated foraminifers from the Siwak represent the same assemblage of species as the one discussed above, enriched with a very important early Paleocene index fossil — *Cibicidoides lectus* (Vassilenko). Consequently, this sequence represents the Lower Paleocene. Similarly, the species of pelecypods and gastropods do not differ from the ones recorded in the layer in which the crocodilian skeleton was found. However, the species diversity is smaller here. The species of pelecypods and gastropods in a sample taken from the 0.4 m layer above the crocodile bed are given in Table 2, column E. Among pelecypods *Cucullaea volgensis* Barbot de Marny, 1874 is still abundant and *Nucula (Nucula) proava* Wood, 1861 is relatively common.

In the gaize layer situated 0.8–1.0 m above the hard limestone the lowest number of molluscan species was recorded. Pelecypods include *Nucula (Nucula) montensis* Cossmann, 1908, *N. (Nucula) proava* Wood, 1861, *N. (Nucula) densistria* Koenen, 1885, *Nuculana symmetrica* (Koenen, 1885), *Cucullaea volgensis* Barbot de Marny, 1874 (abundantly), *Yoldia uncifera* (Vincent, 1930), *Lyropecten acuteplicatus* (Alth, 1850) and *Crassatella krachi* Moroz, 1972, whereas gastropods include *Tectus* cf. *carinadentatus* (Briart et Cornet, 1887), *Sigmesalia marthae* (Briart et Cornet, 1873) and *Roxania raristriata* (Briart et Cornet, 1887).

The highest examined sample, taken 1.0 up to 1.5 m above the hard limestone, shows yet another increase in the number of pelecypod taxa up to 21 and in the number of gastropod taxa up to 10 (Table 2, column G).

To recapitulate: in the investigated profile up to the level situated 1.1 m above the crocodilian find (1.5 m above the "residual lag") 60 species of pelecypods and 33 species of gastropods were identified. Of these, 13 pelecypod species: *Yoldia uncifera* (Vincent, 1930), *Anadara montensis* (Cossmann, 1908), *Musculus vincenti* (Cossmann, 1908), *Lima pireti* Cossmann, 1908, *Limatula hexagonalis* (Cossmann, 1908), *Parvilucina nanna* (Cossmann, 1908), *Venericardia erugata* Cossmann, 1908, *Crassatella subplana* Ravn, 1939, *Parvicardium tenuitesta* (Cossmann, 1908), *Trachycardium trifidum* (Deshayes, 1858), *Tellina (Peronidia) montensis*

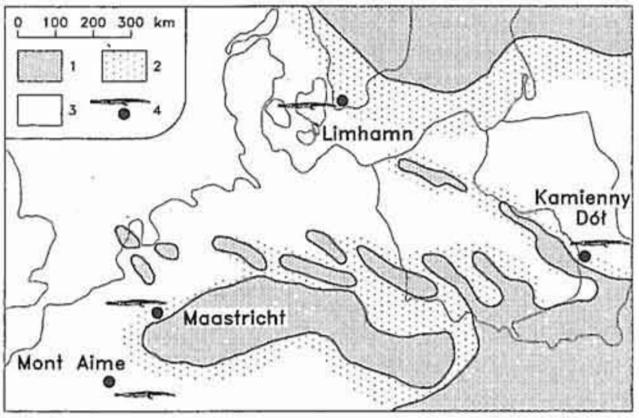

Fig. 4. Occurrences of *Thoracosaurus* crocodile finds in Europe against the palaeogeographic background of the late Maastrichtian and early Danian after M. Machalski and M. Żarski (*fide* M. Żarski *et al.*, 1997), on the basis of the map no. 32 (*fide* P. A. Ziegler, 1990)

Mont Aime (Marne Department) — P. Gervais (1859), Maastricht — E. Koken (1888), Limhamn — G. T. Troedsson (1924), Kamienny Dół — M. Żarski (1995); 1 — lands, 2 — shallow sea, 3 — deep sea, 4 — crocodile find

Znaleziska krokodyli z rodzaju *Thoracosaurus* w Europie na tle mapy paleogeograficznej z okresu późnego mastrychtu i wczesnego danu według M. Machalskiego i M. Żarskiego (*fide* M. Żarski i in., 1997) na podstawie mapy nr 32 (*fide* P. A. Ziegler, 1990)

Mont Aime (departament Marne) — P. Gervais (1859), Maastricht — E. Koken (1888), Limhamn — G. T. Troedsson (1924), Kamienny Dół — M. Żarski (1995); 1 — lądy, 2 — płytkie morza, 3 — głębokie morza, 4 — znalezisko krokodyla

Cossmann, 1908, *Pitar pireti* (Cossmann, 1908) and *Sphenia haudrugata* Cossmann, 1908, and 5 gastropod species: *Tectus* cf. *carinadentatus* (Briart et Cornet, 1887), *Tectus* sp., *Pareuchelus lefevrei* Rutot *in* Cossmann, 1915, *Circulus montensis* (Rutot *in* Cossmann, 1915) and *Sigmesalia marthae* (Briart et Cornet, 1873) were recorded in Poland for the first time.

The Paleocene sequence is overlain with Pleistocene deposits in the form of pavement, silts, clays and loess.

REVIEW OF PREVIOUS FINDS OF CROCODILES OF THE GENUS *THORACOSAURUS*

In 1852 at a meeting of the Academy of Natural Science of Philadelphia a new find of dermal scutes of a large crocodile from the Greensand formation of Mount Holly, New Jersey, was presented to the audience by J. Leidy. The demonstrated scutes were described by J. Leidy as a new genus and species *Thoracosaurus grandis* Leidy, 1852. The Greensand formation is equivalent to the Danian of Europe (G. T. Troedsson, 1924). In the following years in the sediments of the same formation many skeletal fragments of crocodiles of the genus *Thoracosaurus* were found in different states of preservation, on the basis of which the following species were described: *Thoracosaurus neocesariensis* De Kay, 1842, *T. basitruncatus* Owen, 1849, *T. obscurus* Leidy, 1865, *T. brevispinis* Cope, 1867, *T. glyptodon* Cope, 1869, *T. cordatus* Cope, 1870 and *T. pneumaticus* Cope, 1872.

Remains of two species of *Thoracosaurus* have been discovered in Europe so far. In France, in Marne Department, in rocks interpreted as deposited slightly before the Danian, the following crocodilian skeletal remains were found: almost completely preserved skull, fragments of muzzle and mandible, teeth, vertebrae and scutes belonging to one specimen as well as large fragments of two other skulls and mandibles. P. Gervais (1859) described this skeletal material as *Thoracosaurus macrorhynchus* (Blainville, 1855). In 1888 an almost complete skull of the same species was described by E. Koken from Maastricht in Holland (Fig. 4).

In the 1890s in the Limhamn quarry near Malmö two large slabs of Bryozoan limestone were found, containing the skull and other bones of a long-nosed crocodile. In 1908 another specimen was found in the same quarry, but this was more fragmentary, being only the muzzle part of a much larger individual, apparently belonging to the same species. In 1921 the preparation of both specimens was made in the Senckenberg Museum in Frankfurt am Main. In the prepared material two fragmentarily preserved specimens of crocodiles were found. The first specimen was represented by skull, mandible, teeth, 3 cervical and 2 dorsal vertebrae, 7 cervical and 4 dorsal ribs, humerus, 6 scutes and many small fragments of vertebrae, ribs, scutes and other bones. The second specimen was represented by the muzzle part and teeth. On the basis of both specimens a new species *T. scanicus* from the Danian deposits of Sweden was described by G. T. Troedsson (1924).

SYSTEMATIC DESCRIPTION

Order **Crocodilia** Gmelin, 1788
Suborder **Eusuchia** Huxley, 1875
Family **Crocodilidae** Cuvier, 1807
Subfamily **Tomistomininae** Woodward, 1932
Genus *Thoracosaurus* Leidy, 1852
Thoracosaurus sp.

VERTEBRAL COLUMN

Dorsal vertebra (Pl. I, Fig. 1a). Only the posterior part of the centrum of the last dorsal vertebra is preserved. The posterior articular surface is convex, measuring 37.0 mm in width and 26.7 mm in height.

Sacrum (Pl. I, Fig. 1b). The sacrum consists of two very crumbled vertebrae, of which only the centrum of the first vertebra is almost completely preserved. The second one is preserved fragmentarily. Several small, flat fragments of bones probably belong to the transverse processes of those vertebrae and the pelvis (Pl. I, Figs. 2, 3). The anterior articular surface of the first vertebra is concave, the posterior one is flat. The second vertebra has the anterior articular surface flat and the posterior one concave. The centra of the vertebrae are wider in the middle. The lower part of the neural canal is visible on the dorsal part of the centrum.

D i m e n s i o n s (in mm) of the first sacral vertebra:

Length of centrum	51.3
Width of centrum, anteriorly	45.8
Height of proximal articular surface	26.6
Width of proximal articular surface	37.0
Width of neural canal, anteriorly	14.5
Width of neural canal, posteriorly	9.3
Height of distal articular surface	24.8
Width of distal articular surface	34.1

C a u d a l v e r t e b r a e (Pl. I, Fig. 1c; Pl. II and III). Six almost completely preserved caudal vertebrae are preserved, probably from II-nd to VII-th (Pl. II, Fig. 2) and fragments of I-st (Pl. I, Fig. 1c) and VIII-th. The centra of the vertebrae are in the best state of preservation; the peripheral ends of spinous and transverse processes are broken. The dorsal side is covered by rock and scutes (Pl. III). After the rock had been removed from the ventral side, the centra of the vertebrae and fragmentarily preserved transverse processes became visible (Pl. II, Fig. 2). Spinous processes are visible only on the anterior and posterior parts of the specimens. The section of the vertebral column consisting of three vertebrae can be viewed laterally and in this position it can be seen that the prezygapophyses and postzygapophyses serve as connections between vertebrae. The prezygapophyses project upwards-forwards somewhat in front of the anterior end of the centrum. The postzygapophyses protrude from the posterior margin of the neural arch (Pl. II, Fig. 1). The first caudal vertebra has both the anterior and the posterior articular surface convex; the remaining vertebrae have the anterior articular surface concave and the posterior one convex.

D i m e n s i o n s (in mm) of the caudal vertebrae:

	II	III	IV	V	VI	VII
Length of centrum	58.5	58.2	55.5	55.5	50.0	45.0
Length together with articular surface	–	–	60.2	–	–	56.5
Width of centrum, anteriorly	36.5	37.6	35.0	35.8	35.7	37.6
Width of centrum, posteriorly	34.7	32.7	32.1	32.1	31.8	40.5
Height of centrum	–	–	30.8	–	–	–
Height with spinous process	–	–	102.8	–	–	–
Height of spinous process	–	–	72.0	–	–	–
Height of posterior articular surface	–	–	27.2	–	–	–
Width of posterior articular surface	–	–	38.7	–	–	–
Width of transverse process	47.7	–	–	29.6	–	–
Length of transverse process	–	–	–	63.5	–	–
Length of first transverse process — 97.6						

DERMAL ARMOUR

S c u t e s (Pl. I, Figs. 4, 5; Pl. III, Fig. 3). 12 completely preserved and 8 fragmentarily preserved bony scutes were found. Their inner surface is smooth, the exterior covered by a sculpture of deep, rounded pits. The completely preserved scutes are broader than they are long, measuring about 65 mm in width and 55 mm in length. The scutes taper slightly towards medial borders. The medial and lateral borders have suture lines, indicating that the scutes were arranged in at least four rows. The anterior and the posterior of the scutes are flattened. The outer surface of the anterior margin is smooth and serves the purpose of articulation with the posterior margin of the previous scute. Behind the anterior articular facet the well-marked groove, pitted like all the surface behind, is visible.

SOME REMARKS ON THE AFFINITIES, AGE, APPEARANCE AND MODE OF LIFE OF THE *THORACOSAURUS* FROM KAMIENNY DÓŁ

A f f i n i t i e s. The comparison of the fragment of the vertebral column and of the bony scutes discovered at Kamienny Dół with previous finds of Upper Cretaceous and Lower Paleocene crocodiles indicates that the skeletal remains from Kamienny Dół bear the greatest resemblance to *Thoracosaurus scanicus* Troedsson, 1924, described from the Danian sediments of the Limhamn quarry, the classic outcrop of Lower Paleocene deposits in Southern Sweden, especially because of the presence of a well-marked groove running behind the posterior boundary of the anterior articular facet of the scutes. According to G. T. Troedsson (1924) this feature differentiates *T. scanicus* from all the other species of the genus *Thoracosaurus*. The dimensions of the vertebrae as well as the size and sculpture of the scutes of the dermal armour make it possible to recognize the excavated remains as undoubtedly congeneric with the crocodiles belonging to the genus *Thoracosaurus*, but the absence of the skull excludes the possibility of the unequivocal identification of the Polish find with the species *T. scanicus*, the closest in terms of geography and chronology.

A g e. On the basis of micro- and macrofaunal analyses the age of the *Thoracosaurus* from Kamienny Dół can be defined as early middle Danian. In the absolute chronological scale (according to W. A. Berggren *et al.*, 1995) it was the period between 64.5 and 62.5 m.y. ago.

A p p e a r a n c e a n d m o d e o f l i f e. The analysis of the bones found at Kamienny Dół does not permit to determine the conditions in which the excavated crocodile lived. The fragment of the vertebral column without leg bones, preserved in typical marine deposits, makes it impossible to ascertain whether the animal was both aquatic and terrestrial or a marine one. Typical marine crocodiles lived during the Mesozoic era and the culmination of their development took place in the Jurassic. For instance the metriorynchid family, living in the open seas, was the most specialized of all the crocodilians. They had lost the scutes armour, converted their limbs into swimming paddles and the end of their spine was bent sharply down.

According to the literature on the subject, at the turn of the Cretaceous and the Tertiary, Europe, Africa, North America and Asia were inhabited by long-nosed crocodiles similar to modern gavials, living in coastal waters of the seas and oceans (E. Buffetaut, 1979). The specimen from Kamienny Dół can be one of such crocodiles; they may have been living on the shores of the landmass situated in the area now occupied by the Holy Cross Mountains, searching for prey in the relatively shallow early Paleocene sea.

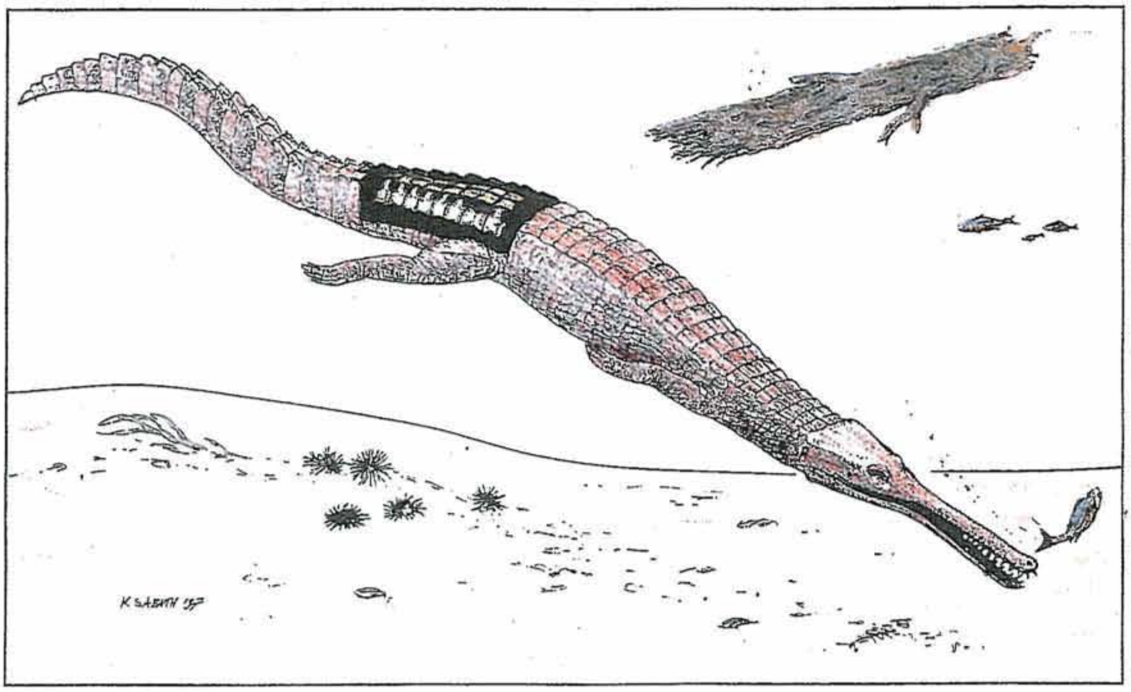

Fig. 5. Assumed appearance of the Lower Paleocene crocodile *Thoracosaurus* Leidy, 1852, as reconstructed by K. Sabath; skeleton remains marked in black

Przypuszczalny wygląd dolnopaleoceńskiego krokodyla z rodzaju *Thoracosaurus* Leidy, 1852, według rekonstrukcji K. Sabatha; kolorem czarnym zaznaczony jest fragment opisywanego szkieletu

After the death of the crocodile its carcass must have been carried into the open sea by water-currents. The decay processes and the activity of scavengers caused the body to disintegrate; its parts were gradually falling off. The head and the legs were the first to come off; the thorax disintegrated at the very end. In the area of present-day Kamienny Dół a relatively compact fragment of the spine consisting of the sacrum and the base of the tail sank to the sea-bottom. It is confirmed by unsuccessful attempts at finding the remaining parts of the skeleton. Although the layer containing the crocodilian bones had been uncovered for more that 10 m, no other skeletal remains were found except a fragmentarily preserved scute. Instead, parts of tree trunks were excavated, holed by pelecypods *Teredina* aff. *oweni* Deshayes, 1860 and brought from the land probably by the same sea-current that carried the carcass of the crocodile.

Very scanty skeletal material from Kamienny Dół makes it impossible to reconstruct the external appearance of the crocodile. However, the literature on the subject and the study of illustrations showing other thoracosaurian finds from Europe and North America (J. M. D. Leidy, 1865; F. R. S. Owen, 1849; P. Gervais, 1859; E. D. Cope, 1871; E. Koken, 1888; G. T. Troedsson, 1924) enabled K. Sabath to reconstruct the assumed semblance of the Polish *Thoracosaurus* (Fig. 5).

It was a large individual; the small preserved fragment of the vertebral column is almost 60 cm long. The comparison of the length of its vertebrae with the length of the vertebrae of other, complete crocodilian skeletons indicates that the animal from Kamienny Dół was over 6.0 m long.

Completely preserved skulls of other individuals of the genus *Thoracosaurus* bear resemblance to the skulls of modern gavials, preying on fishes and feeding on them. Short-nosed crocodiles generally prey on terrestrial animals. In the course of the evolutionary history of the Crocodilia, which has lasted for 215 m.y., several crocodilian forms resembling the *Thoracosaurus* came into being. In the Jurassic there appeared long-nosed crocodiles belonging to the family Teleosauridae, known from exposures in England, France, Germany, Asia, Africa and North and South America; they were up to 4 m long and also preyed on fishes in coastal waters. At the end of the Cretaceous the Dyrosauridae, representing the Mesosuchia, appeared in Africa; their mode of life was similar to that of the genus *Thoracosaurus*. Apart from Africa they are also known from fresh-water sediments of Asia and North and South America, where they persisted until the end of the Eocene. In the Eocene the Dyrosauridae began to be superseded by the more specialized gavials, representing the Eusuchia, at present inhabiting the great rivers of South-East Asia. There exist no modern crocodilian forms analogous to the *Thoracosaurus*; South-Asian crocodiles of the genus *Tomistoma* are the closest in external appearance, whereas the ability to spend long periods in sea-water characterizes the salt-water crocodile, *Crocodilus porosus* (Cuvier, 1807), inhabiting the Indo-Pacific region.

SUMMARY AND CONCLUSIONS

In an exposure located in a gorge called Kamienny Dół near Kazimierz Dolny skeletal remains of a crocodile of the genus *Thoracosaurus* Leidy, 1852 were discovered in sandy gaizes whose early Paleocene age was documented on the basis of foraminifers, pelecypods and gastropods. It is the first Polish crocodilian find in Danian sediments and the fourth one in Europe. The crocodilian remains, measuring about 60 cm, consist of the caudal part of the vertebral column with very well preserved vertebrae and scutes. The crocodile's habitat was presumably marine and terrestrial. The animal was probably similar in appearance to modern gavials with elongated snouts. Identified species of pelecypods and gastropods, the predominance of terrigenous material in the sediments as well as tree trunks found in the layer containing the crocodile testify to the shallowness of the sea and closeness to land. Foraminifers from the opokas, the hard limestone and the Greensand, together with gastropods and pelecypods, make it possible to place the Cretaceous/Tertiary boundary, in agreement with K. Pożaryska (1967), in the top of the hard limestone "hardground".

Translated by Tomasz Wyżyński and Gwidon Jakubowski

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PIERWSZE ZNALEZISKO DOLNOPALEOCEŃSKIEGO KROKODYLA *THORACOSAURUS* LEIDY, 1852 W POLSCE: UJĘCIE GEOLOGICZNE I PALEONTOLOGICZNE

Streszczenie

Artykuł przedstawia wyniki geologicznego i paleontologicznego opracowania profilu w Kamiennym Dole, w którym M. Żarski w 1995 r. odkrył fragment szkieletu krokodyla z rodzaju *Thoracosaurus* Leidy, 1852. Prace prowadzono w ramach tematu finansowanego przez Państwowy Instytut Geologiczny pod kierunkiem M. Żarskiego w zespole: G. Jakubowski, E. Gawor-Biedowa i M. Machalski.

Omawiane odsłonięcie znajduje się w wąwozie nie opodal Kazimierza Dolnego nad Wisłą. Profil zaczyna się opokami górnego mastrychtu kilkumetrowej miąższości (fig. 1), należącymi do poziomu biostratygraficznego *Belemnella kazimiroviensis* (*Hoploscaphites constrictus crassus*). E. Gawor-Biedowa (1992) stwierdziła w tych utworach otwornice charakterystyczne dla górnego mastrychtu: *Bolivina alexandrae* Gawor-Biedowa oraz *B. praecrenulata* Gawor-Biedowa, a także *Praeglobobulimina imbricata* (Reuss), *Osangularia peracuta* (Lipnik) i *Anomalinoides pinguis* (Jennings). Opoki przechodzą w twardy wapień, który uległ według M. Machalskiego lityfikacji dopiero w danie. Autorzy przyjęli granicę między kredą i trzeciorzędem w stropie twardego wapienia, podobnie jak K. Pożaryska (1967). W piaszczystych wypełnieniach nor po bezkręgowcach znajdujących się w twardym wapieniu występuje ubogi zespół otwornic paleoceńskich (tab. 1). W profilu zidentyfikowano także paleoceńskie małże, takie jak np. *Cucullaea volgensis* Barbot de Marny, 1874. W nadległym piaskowcu glaukonitowym, z poziomem konkrecji fosforytowych w stropie, stwierdzono typowy zespół otwornic dolnopaleoceńskich z pojedynczymi otwornicami kredowymi. Zostały tu także zidentyfikowane belemnity z grupy *Belemnella kazimiroviensis* ze szczególnym nagromadzeniem w poziomie fosforytowym. Oprócz gatunków mastrychtckich małży, ostryg, jeżowców i ramienionogów stwierdzono faunę paleoceńską. To przemieszanie gatunków kredowych i trzeciorzędowych w omawianych utworach jest przedmiotem kontrowersji. Chodzi o to, czy utwory te należy zaliczyć do mastrychtu, czy też do paleocenu.

Zarówno gatunki otwornic, jak również małżów i ślimaków jednoznacznie określają wiek skał na dolny paleocen, który można korelować z danem środkowym.

Powyżej poziomu rezydualnego z fosforytami w piaszczystych gezach znaleziono szczątki krokodyla zachowane w bardzo dobrym stanie. Jest to pierwsze znalezisko fragmentu szkieletu krokodyla z rodzaju *Thoracosaurus* w Polsce i czwarte w Europie pochodzące z osadów dolnego paleocenu z pobliża granicy kreda/trzeciorzęd. Szczątki krokodyli tego rodzaju w osadach tego samego wieku co w Europie znaleziono także w Ameryce Północnej. Badany fragment szkieletu należy do części ogonowej wraz z pokruszonymi kręgami tułowiowymi i krzyżowymi. Na uwagę zasługują charakterystyczne dla krokodyli płytki pancerza.

Opisany krokodyl prowadził morsko-lądowy tryb życia, a jego (prawdopodobnie) długi pysk charakterystyczny dla tego rodzaju przystosowany był do łowienia ryb. Znalezisko krokodyla, a także pni drzew w badanych osadach sugerują bliskość lądu. Do oznaczenia gatunkowego niezbędna jest jednak czaszka, której w opisywanym materiale nie znaleziono. Analiza ślimaków i małżów pozwala przypuszczać, że morze, w którym żył krokodyl, nie przekraczało 80 m głębokości, temperatura wody wynosiła około 18°C, a zasolenie miało charakter pełnomorski.

EXPLANATIONS OF PLATES

PLATE I

Fig. 1. Fragmentarily preserved part of vertebral column: last dorsal vertebra (a), sacrum (b), I-st caudal vertebra (c)

Fragment kręgosłupa: ostatni kręg tułowiowy (a), kość krzyżowa (b), I kręg ogonowy (c)

Figs. 2, 3. Fragments of pelvis and sacrum

Fragmenty miednicy i kości krzyżowej

Figs. 4, 5. Dorsal scutes

Płytki pancerza

PLATE II

Fig. 1. Caudal vertebrae V–VII, lateral view

Kręgi ogonowe V–VII, widok z boku

Fig. 2. Caudal vertebrae II–VII, ventral view

Kręgi ogonowe II–VII, widok od strony brzusznej

PLATE III

Figs. 1, 2. Caudal vertebrae II–VII, dorsal view

Kręgi ogonowe II–VII, widok od strony grzbietowej

Fig. 3. Dorsal scutes covering caudal vertebrae V–VII, dorsal view

Płytki pancerza przykrywające kręgi ogonowe V–VII, widok od strony grzbietowej

PLATE IV

Fig. 1. Remains of the crocodile in Paleocene gaizes in the quarry wall (in the circle)

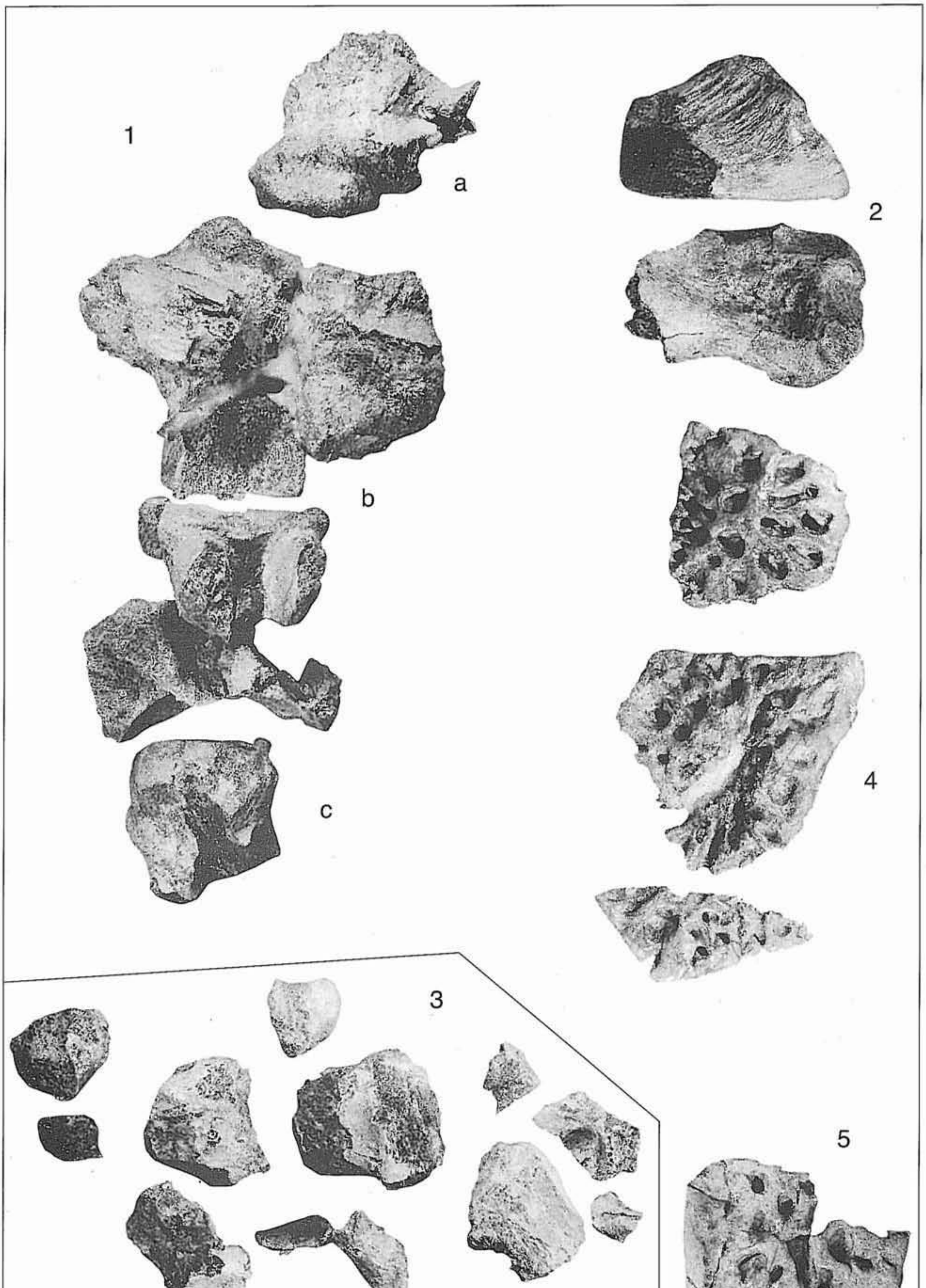
Szczątki krokodyla w paleoceńskich gezach znajdujące się w ścianie kamieniołomu (w kółku)

Fig. 2. Remains of the crocodile in the quarry wall (in the circle); upper Maastrichtian: A — opoka, B — hard limestone "hardground"; Lower Paleocene (Danian): C — Greensand with phosphorites, D — gaizes with limestones

Szczątki krokodyla w ścianie kamieniołomu (w kółku); górny mastrycht: A — opoka, B — twardy wapień (twarde dno); dolny paleocen (dan): C — piaskowiec glaukonitowy z fosforytami, D — gezy z wapieniami

Piate I, Plate II, Fig. 2 and Plate III — photo by L. Dwornik; Plate II, Fig. 1 — photo by G. Jakubowski; Plate IV — photo by M. Żarski (1995)

Geol. Quart., 1998, **42** (2)



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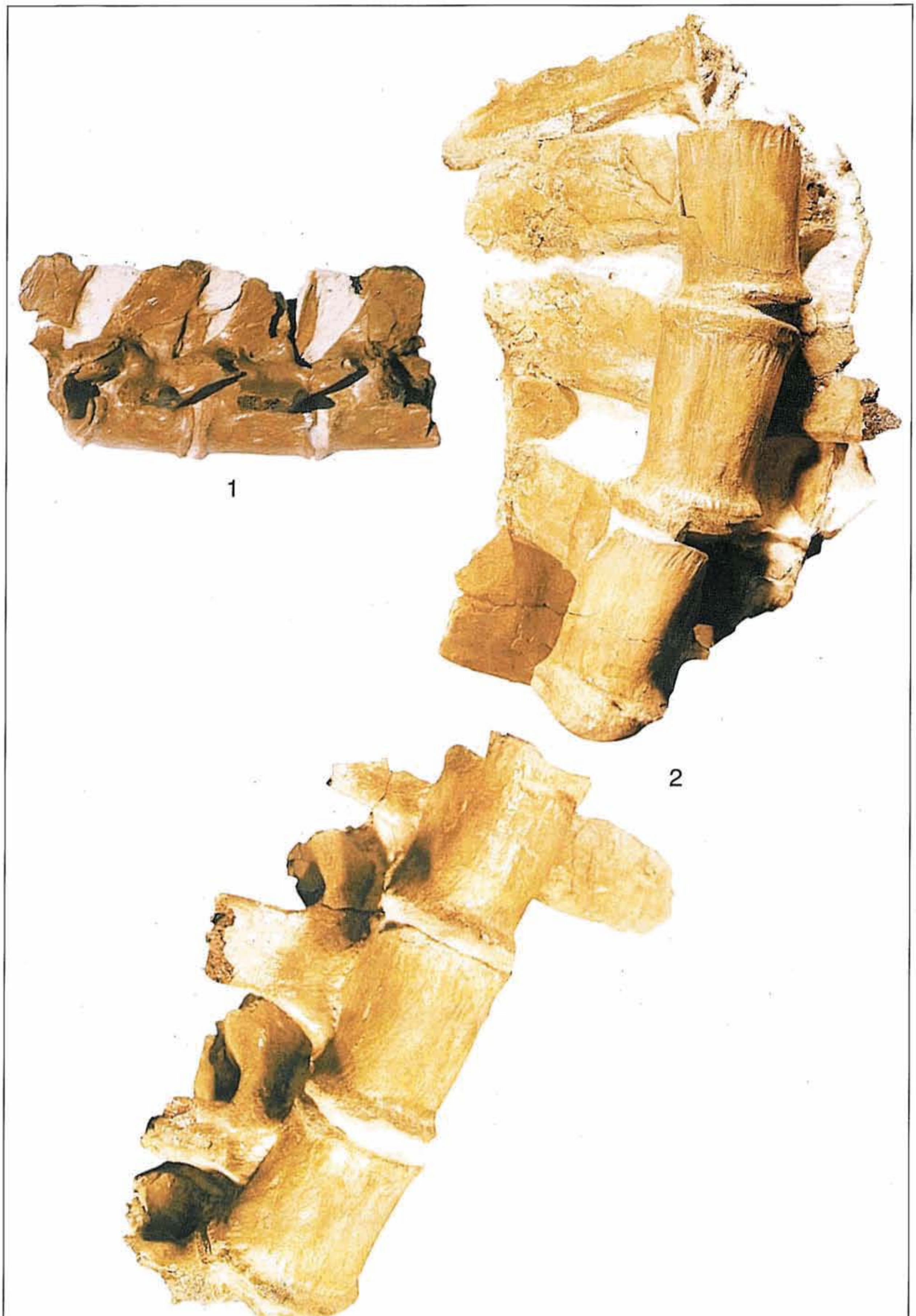

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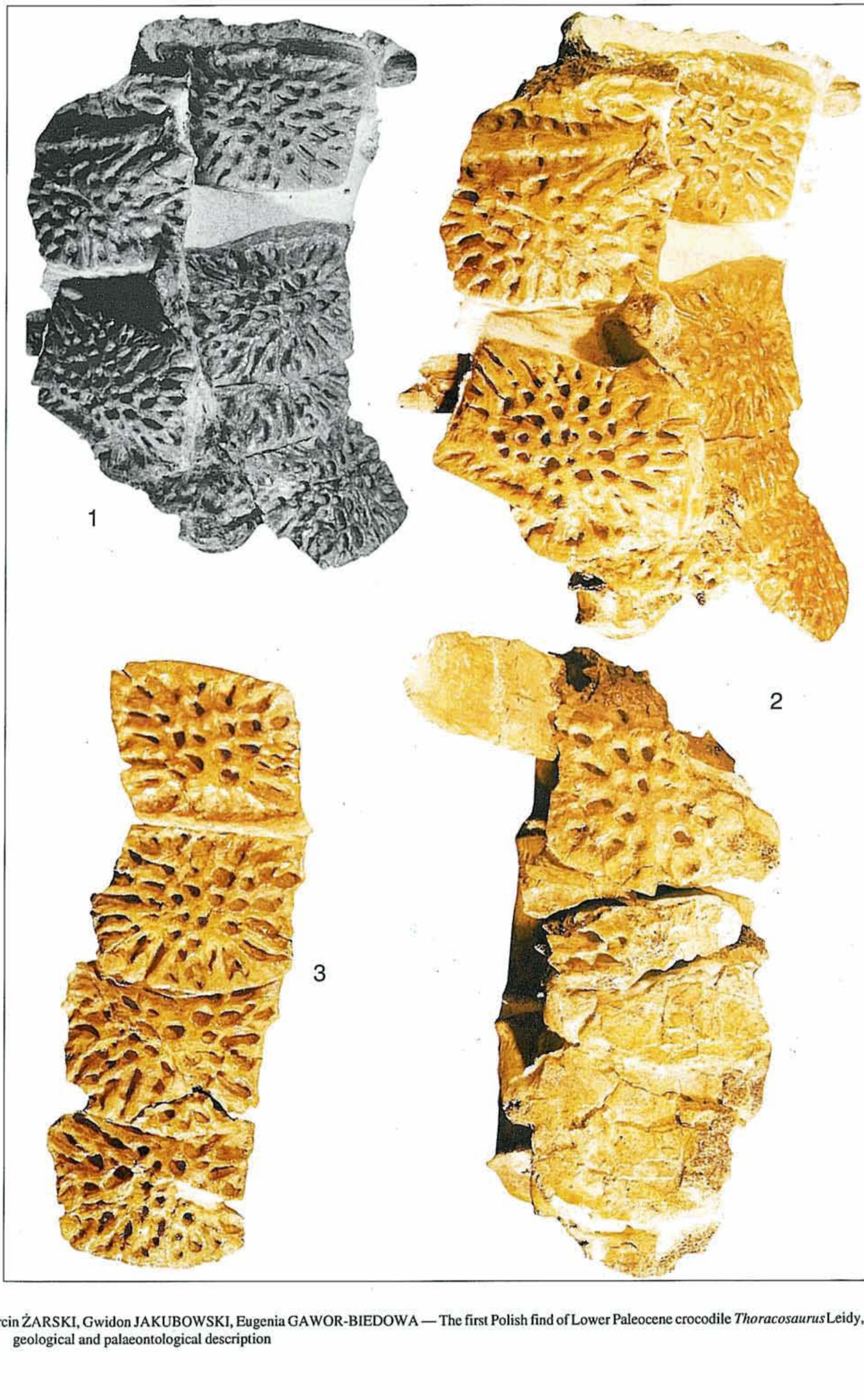
Geol. Quart., 1998, **42** (2)



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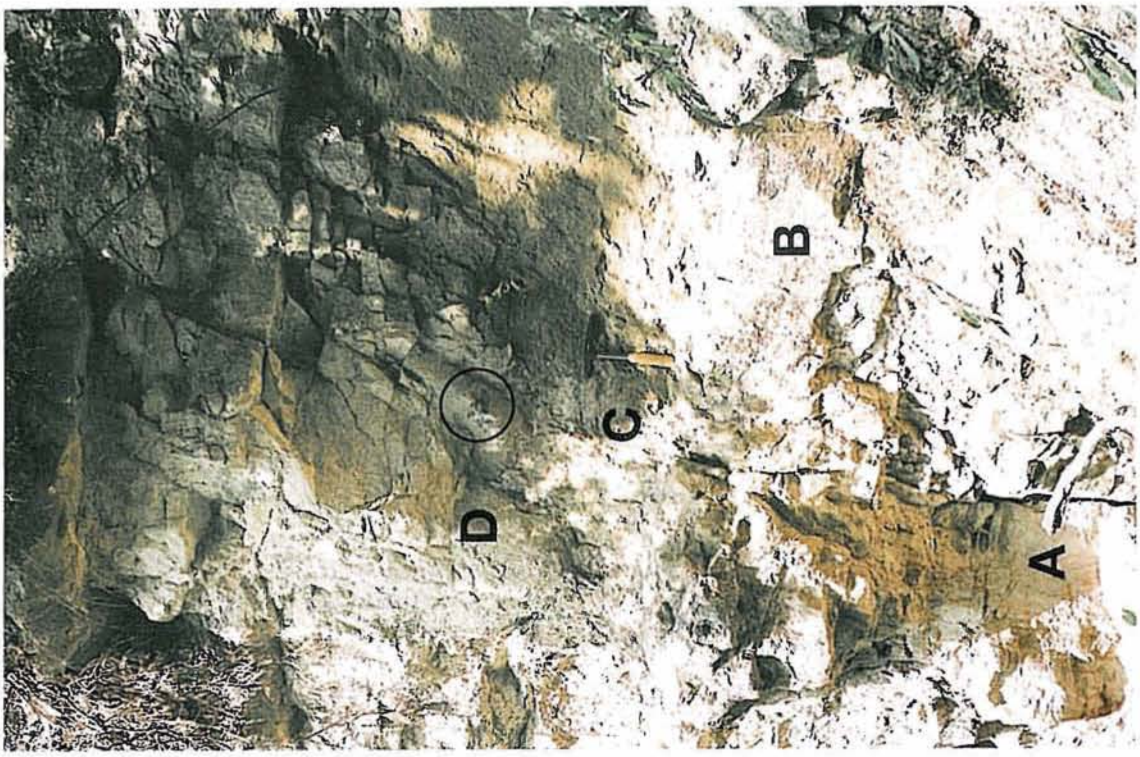

Fig. 2

Fig. 1

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