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Middle Pleistocene karst deposits with *Ursus spelaeus* at Draby near Działoszyn, Central Poland

ABSTRACT: The Middle Pleistocene karst bone-bearing locality Draby *3* is characterized by the sequence of deposits that fill the karst form. The sequence is divided into cave deposits (Mindel *I* — Riss *I*); glacifluvial sands (Riss *II*), filling a collapse furrow over damaged cave, and the periglacial slope deposits (Würm). The layers enriched in hydrated iron and manganese oxides are interpreted as corresponding to cool and wet kataglacial phase of the Mindel *I* and Mindel *II*. Calcareous loam corresponding to the Great (Holstein) Interglacial optimum contains bones of cave bears, *Ursus spelaeus* Rosenmüller & Heinroth, the remnants of which belonged to one adult female and two cubs. The age of the bones was determined with the fluorine-chlorine-apatite method as 320,000—440,000 years B.P., whereas great collagen loss indicates warm interglacial climate. The stratigraphic correlation of the investigated sequence is also presented.

INTRODUCTION

Recent investigations of the fossil karst in the vicinity of Działoszyn in Central Poland have revealed, besides the famous locality Węże *1* (*cf.* Samsonowicz 1934; Sulimski 1964; Głazek, Sulimski & Wysoczański-Minkowicz 1976), numerous new localities containing bone material. On the Draby Hill (E long. 18°48′34″, N lat. 51°04′54″) in the village Draby, *c.* 2 km south-east from Węże *1*, there were discovered five bone-bearing karst forms (Szynkiewicz 1975; Głazek, Sulimski, Szynkiewicz & Wysoczański-Minkowicz 1976; *cf.* also Fig. 1).

Localities Draby *1* and Draby *2* are filled with brick-red sandstones covered by coarse-crystalline flowstones. The sandstones contain remnants of *Myotis* sp., *Hypolagus* sp., *Prospalax priscus* (Nehring), and *Mimomys* cf. *stehlini* Kormos, the assemblage of which probably corresponds to the Csarnotian Stage (Głazek, Sulimski, Szynkiewicz & Wysoczański-Minkowicz 1976; *cf.* Kretzoi 1962, Tobien 1970). The localities Draby *3*, *4* and *5* were recognized as parts of one cave system filled with the same sequence of sediments (Głazek, Sulimski, Szynkiewicz & Wysoczański-Minkowicz 1976). As the most complete section of sediments and the richest paleontological material were found in the locality Draby *3*, this will be described here as the type.

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GEOLOGICAL SETTING

The Draby Hill (222.5 m a.s.l.) is built up of biohermal limestone (*Felsenkalk*) and bedded limestones with flints of Middle Oxfordian age (*Bifurcatus* Zone). These flat-lying limestones are broken by numerous small faults. The hill stands c. 15 m higher than a denuded surface of outwash sands (c. 205—215 m a.s.l.) deposited during the Warta (Warthe, Riss *II*) Glaciation and occurs c. 2 km south of the morainic belt which marks the maximal extent of this glaciation (*cf.* Text-fig. 1; Różycki 1961, 1972; Krzemiński 1974).

The area of Draby was probably covered twice by the Scandinavian icesheet, viz. during maximal stadials of the Cracovian *II* (Mindel *II*, Elster *II*) and Middle Polish Glaciations (Riss *I*, Saale; *cf.* Różycki 1961, 1972; Krzemiński 1974).

Preglacial morphology of the area is very diversified as the glacial deposits between the limestone hills reach a thickness of c. 30 m.

Limestone buttes form the top part at the Draby Hill, where also exists a small cave, the Ewy Cave (*cf.* Fig, 1; and Szynkiewicz 1976). Generally, at the top part of the hill the limestones crop out on the surface and reveal karst sculpture of the rounded solution runnels (soil lapies) type, whereas on the slopes the original surface of limestones is covered by c. 2 m of rock rubble.

All the bone-bearing karst localities occur on the slopes below the rubble cover (*cf.* Figs 1 and 2). These localities represent narrow karst depressions developed along tectonic fractures, and they are completely filled with sediments which are covered by limestone rubble, and Recent soil.

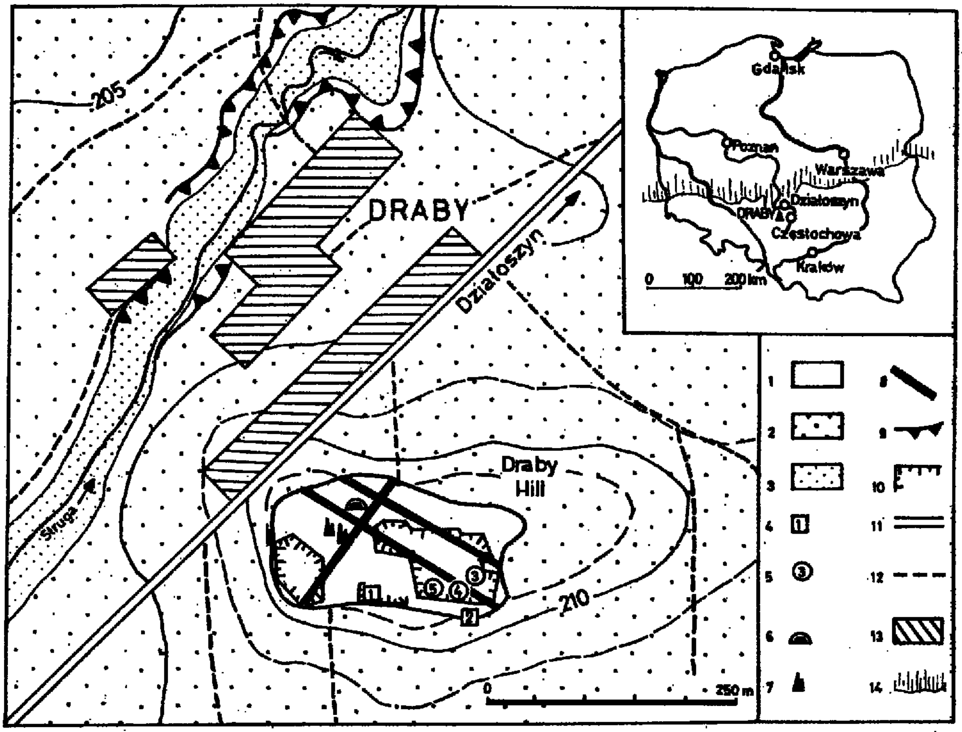

Fig. 1. Geological situation of the fossil karst at Draby; inset shows its position in Poland (marked is the southern extent of the Warta Stadial)

1 Oxfordian limestones, *2* glacifluvial sands of the Warta Stadial, *3* Holocene alluvia, *4* Upper Pliocene (?Csarnotian) karst localities (Draby *1* and Draby *2*), *5* Middle Pleistocene (Holstein, Great Interglacial) karst localities (Draby *3*, *4* and *5*), *6* the Ewy Cave, *7* limestone buttes, *8* faults, *9* erosional escarpments, *10* quarry escarpments, *11* road, *12* cart-roads, *13* buildings, *14* southern extent of the Warta icesheet

SEQUENCE OF DEPOSITS

The locality Draby *3* occurs in the south-eastern part of the quarry at the height 215 m a.s.l. The sequence of sediments that fills and covers the karst form comprises several successive layers, numbered in ascending order (Fig. 2 and Pl. 1).

Thick bedded limestones with flints (layer *1* in Fig. 2 and Pl. 1), that contain the karst form are strongly corroded. The top part of these limestones (surrounding the layer *9*) is frost shattered and corroded in separate blocks among which sands (resembling the layer *9*) penetrate all fissures (Fig. 2, Pl. 1).

Layer *2* consists of flint rubble representing a washed residuum of surrounding limestones. Flint debris are covered by black encrustations of hydrated oxides of iron and manganese.

Layer *3* consists of brown-black ferruginous pelite with nodules (*Bohnerze*) The chemical analysis reveals over 50% of Fe_2O_3 and only 10% of $CaCO_3$. A remarkable high content of MnO_2 is *c.* 4% (*cf.* Fig. 3), while Mn/Fe ratio is *c.* 1 : 15. The undissolved matter that contains only clay and flint particles, reaches 20%.

Layer 4 consists of laminated clays passing upwards into silts and sands. The layer may be divided into the lower, clayey-silty (*4a*) and the upper, sandy sublayer (*4b*). Laminated clays and silts are greenish-gray at the bottom, while at the top they become yellowish-gray and contain corroded limestone debris and white concretions of pelitic carbonate ("lublinite"). Changes in chemical composition of clayey-

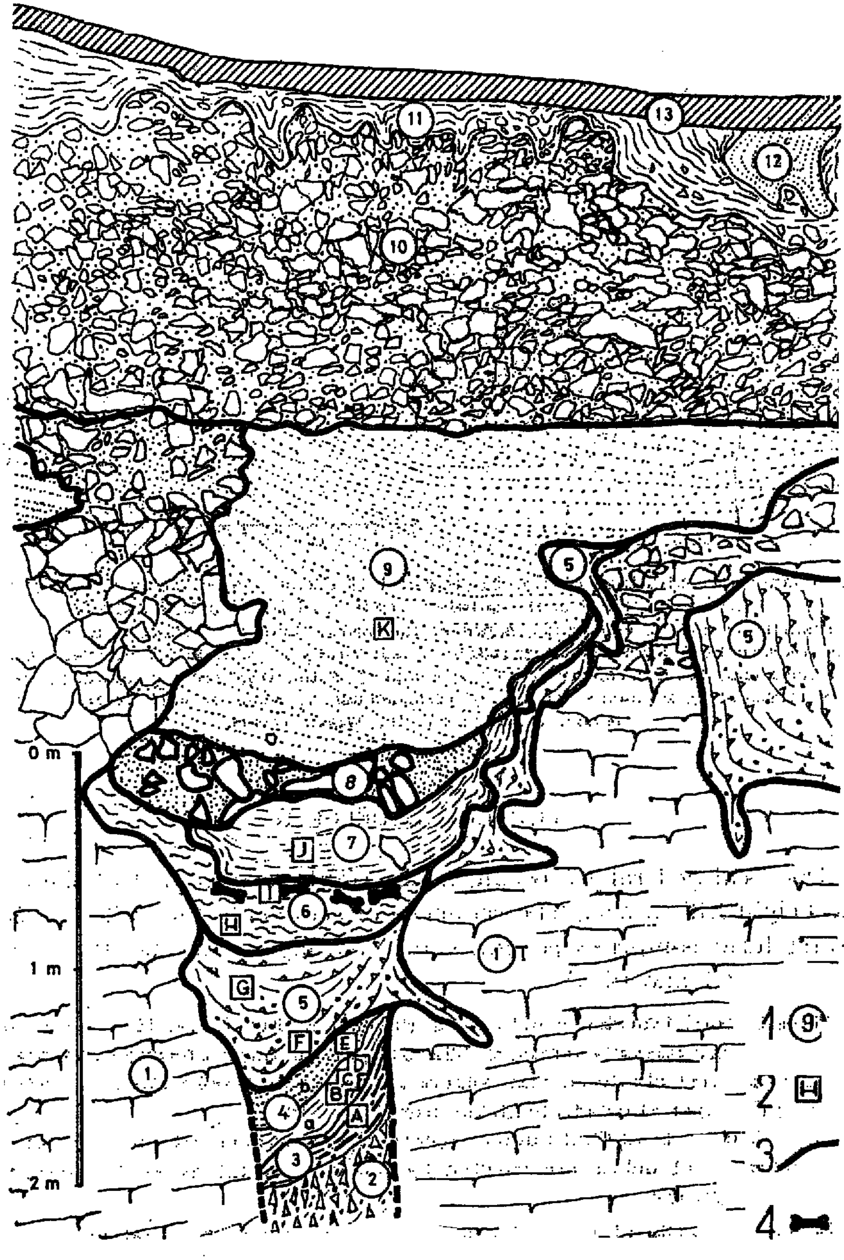

Fig. 2. Karst form at the locality Draby 3

1 numbers of layers (1—13) described in the text (*cf.* also Pl. 1), 2 location of analysed samples (A—K, *cf.* Text-fig. 3), 3 erosional boundaries of layers, 4 bones of *Ursus spelaeus*

-silty deposits are illustrated by samples *B*—*D* (Fig. 3). Remarkable are a high content of $CaCO_3$ in the middle of the sublayer *4a* (sample *C*) and the presence of sand-grade particles in insoluble matter of their upper part (sample *D*). The upper sublayer (*4b*) is composed of yellow layered fine- and medium-grained sands that contain some feldspar grains. Lack of calcium carbonate is a characteristic feature of this sublayer.

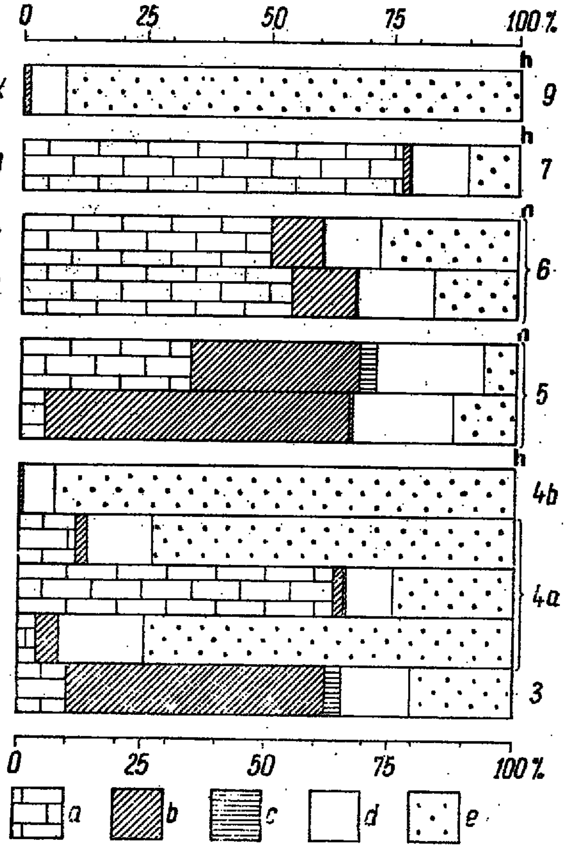

Fig. 3. Chemical composition of sediments in the locality Draby 3
A—*K* analysed samples (*cf.* Text-fig. 2), *3*—*9* numbers of layers (*cf.* Text-fig. 2 and Pl. 1), *h* hiatuses between layers
Content of components (in weight per cent): *a* — $CaCO_3$, *b* — Fe_2O_3, *c* — MnO_2, *d* — another soluble, *e* — insoluble

Layer *5* consists of dark brown pelitic loams with black ferruginous concretions (*Bohnerze*) and corroded limestone debris. The layer contains 35—60% of Fe_2O_3, 1.5—3.5% of MnO_2 and 5—35% of $CaCO_3$ (*cf.* Fig. 3: samples *F* and *G*). Insoluble compounds of this layer consist of fine sand, flint detritus and some clay matter. The Mn/Fe ratio changes from 1 : 55 in the lower part (sample *F*) to 1 : 11 in the upper part of this layer.

Layer *6*, composed of brownish-yellow pelitic carbonate loam, contains in its topmost part numerous bones of *Ursus spelaeus*. Any other vertebrates are missing. This loam is partly cemented with calcite and it contains angular debris of flints and smoothed (corroded) limestone debris. Chemical analyses (*cf.* Fig. 3) reveal 50—55% of $CaCO_3$, 10—13% of Fe_2O_3 and traces of MnO_2, while insoluble compounds reach 15—30% and consist of quartz sand and some clay. The X-ray diffraction analysis and *DTA* reveals dominant calcite, quartz, goethite, and some clay minerals (probably smectite group).

The bone material of *Ursus spelaeus* consists of numerous fragments of bear skulls and postcranial skeleton. The bones are broken *post mortem* in the sediment; they reveal no traces of rounding as well as no traces of gnawing by carnivores or rodents. All the bones are fragile, brown-yellow in colour, whereas the enamel is hard and dark coloured. The bones strongly react with HCl; the pores in their spongy parts are empty.

Layer *7* consists of yellowish-white carbonate pelite with corroded limestone debris. Chemical analysis reveals over 75% of $CaCO_3$, while clayey insoluble compounds reach only 10% (*cf.* Fig. 3).

Layer *8* consists of limestone blocks and flint debris (*cf.* Fig. 2 and Pl. 1). The limestone blocks are commonly coated with black crust (up to 3 mm in thickness) of hydrated iron and manganese oxides. The matrix of this layer consists of sandy loam.

Layer *9* is composed of yellowish cross-bedded varigrained sand with gravels. The sands contain numerous Scandinavian crystalline rock fragments, as well as some feldspar grains and biotite. Lack of calcium carbonate is also a feature of these sands (*cf.* Figs 2—3 and Pl. 1).

Layer *10* consists of angular limestone rubble that contains Scandinavian crystalline boulders, flint debris and sandy matrix cemented with white pelitic carbonate (lublinite).

Layer *11* (light-brown sandy loams), and layer 12 (light-coloured sands) are encountered only in soil lapies developed in limestone rubble below Recent humic layer (*13* in Fig. 2 and Pl. 1).

The sequence of deposits at the locality Draby *4* consists only of equivalents of the layers *5, 6, 8—13*, while in the locality Draby *5* the sequence comprises only the equivalents of layers *3, 4a, 5—13* (cf. Głazek, Sulimski, Szynkiewicz & Wysoczański-Minkowicz 1976). In the equivalents of the bone-bearing layer *6* in the localities Draby *4* and *5* were found some bone fragments that probably also belong to the cave bears.

INTERPRETATION OF THE SEQUENCE

In the described sequence some evident hiatuses occur which are connected with erosion of older formations and with either widening or destruction of the karst form (*cf.* Fig. 2). More pronounced erosional gaps are present between layers *1—2, 4b—5*, and *9—10*. In other localities, some of these gaps are more marked, being responsible for the absence of layer *7* at Draby *4*, and layer *4b* at Draby *5*.

The erosional gaps discussed are attributable to climatic changes during the Quaternary. Sharp erosional boundaries between some layers suggest that strong erosion of older deposits took place.

The complete lack of calcium carbonate in layers *2*, *4b* and *9* proves that these layers were deposited in wet and cool climate when soluble carbonate was completely washed out of the karstified massif. The layers containing more calcium carbonate (*e.g.* layers *4a*, *5*, *6* and *7*) mark more arid and warmer periods when a considerable quantity of carbonate precipitated.

The Quaternary changes of the intensity of karst corrosion in the region were discussed by Markowicz-Łohinowicz (1969) who showed that the maximal intensity took place under wet and cool kataglacial conditions and during wet interglacial phases, while the corrosion was less intensive during arid interglacial phases, and it ceased almost completely during cold pleniglacial phases.

Of the recognized components of the deposits, calcium carbonate, clay minerals, hydrated iron and manganese oxides may be treated entirely or partly as derived from karstified limestones, whereas sands should be regarded as derived from glacial deposits. In consequence, the sandy layers may be interpreted as deposited during glaciation periods.

Dark layers (No. *3* and *5*), composed mostly of iron oxides, and having the Mn/Fe ratio 1 : 11—1 : 55, may be related to such present-day precipitates as those found in fresh water deposits of Nova Scotia, Canada (Harriss & Troup 1970) and Dalecarlia (Ljunggren 1953), that is in wet and cool climate with pine forest vegetation. Under such conditions, an acid and oxidating milieu caused not only strong removal of carbonates but also of iron and manganese compounds. The latter were removed from soil and subsequently precipitated in the subsoil where water acidity was sufficiently lowered.

Rubble layer (No. *10*) may be interpreted as a periglacial slope deposit with its carbonate cement being probably precipitated as a result of the freezing out from solution (congélation of Ek & Pissart 1965).

PALEONTOLOGICAL DESCRIPTION

Family **Ursidae** Gray, 1825
Genus *URSUS* Linnaeus, 1758
Ursus spelaeus Rosenmüller & Heinroth, 1794
(Pl. 2, Figs 1—10)

Material. — Forty samples (*No. 1—40*) represent different skull fragments and teeth of an adult and of two juvenile individuals; one sample of clay with a cast of brain section (*No. 41*). All samples are held in the Institute of Geology, University of Warsaw.

Measurements. — The dimensions of the bear dentition are given and compared (Table 1) with the variability range of *Ursus spelaeus* remains described from the Pleistocene localities of Europe (Schlosser 1909; Kormos 1914; Soergel 1926, 1940; Ehrenberg 1928; Rode 1933, 1935; Motti 1935; Heller 1939, 1956; Zapfe 1946; Herak 1947; Erdbrink 1953; Hütter 1955; Malez 1958, 1959; Kurtén 1959).

Table 1

Comparison of dentition of *Ursus spelaeus* Rosenmüller & Heinroth from Draby 3 with the variability range of the species

Measured character		Variability range /in mm/	Draby 3 /in mm/
Upper canine	Length	81.2–132.7	107.0
	Medio-lateral diameter	13.0–32.3	18.0
	Antero-posterior diameter	20.3–40.0	25.0
Distance between internal walls of M^{1-1}		55.0–68.0	66.0
	Length of P^4–M^2	80.0–106.0	87.5
	Length of P_4–M_3	75.0–106.5	81.0
P^4	Length	16.0–24.0	16.0
	Width	11.0–19.0	13.5
M^1	Length	22.3–33.2	27.0–28.0
	Anterior width	15.0–23.7	15.0–19.5
	Posterior width	17.0–21.7	18.5–20.0
M^2	Length	34.9–61.2	40.0–44.0
	Anterior width	17.0–27.5	18.0–23.0
	Posterior width	14.0–22.0	15.0–18.0
P_4	Length	13.0–16.5	13.0
	Width	6.7–10.7	7.0
M_1	Length	24.0–35.0	26.5–28.0
	Anterior width	9.0–17.0	9.0
	Posterior width	11.5–16.5	12.0–13.0
M_2	Length	24.6–36.7	26.0–28.0
	Anterior width	13.0–23.4	13.0–15.0
	Posterior width	12.7–20.9	15.0
M_3	Length	19.0–35.0	24.0–27.0
	Anterior width	15.0–24.0	17.0–18.0
	Posterior width	14.0–23.0	14.0–15.0

Description. — Specimen *No. 1* (Pl. 2, Fig. 8) is a well preserved palatal fragment with P^4—M^2 *in situ*, alveoli of I^{1-3} (on both sides), right alveolar part of P^3, left P^3 alveolus and medial alveolar walls of both canines. The left alveolus of P^3 with a diameter of 5 mm is distant *c.* 1.5 mm from the anterior alveolus of P^4. The right P^4 is incomplete, but metacone and deuterocone are well developed. The posterior cusp is distinctly displaced backwards. The paracone is broken but its basis shows that the cusp was large and somewhat larger than the preceding. The tooth has the same structure as P^4 of *Ursus spelaeus* from the Kupići cave (*cf.* Malez 1959, Pl. 1, Fig. 1). The M^1, considered as a diagnostic tooth (Kurtén 1959, p. 89), has distinct speleoid characters: anterior lobe is wider than the posterior one, the crown is of brachyodont type with angular outline, mesostyle well developed, paracone (11.0 mm) higher than metacone (10.0 mm). The dimensions of this tooth are smaller than average dimensions of M^1 of mature individuals of *U. spelaeus*. The only untypical feature is lower parastyle. The M^2 is somewhat worn, but the complicated structure of the mastication surface is well visible. The dimensions of this tooth in comparison with M^2 in the typical representative of *U. spelaeus* are somewhat smaller but have the same crown structure as M^2 in the cave bear from the Veternice and Kupići caves (*cf.* Malez 1958, Pl. 3, Figs 19, 22; 1959, Pl. 1 and Pl. 6, Fig. 3).

Specimen *No. 3* — left maxillar fragment with M^{1-2} *in situ* (Pl. 2, Fig. 9) is a part of the same skull as the specimen *No. 1*, but the teeth show stronger lateral wear of the mastication surface.

Specimen *No. 8* (Pl. 2, Fig. 7) is perfectly preserved left upper canine, exactly fitting into the medial alveolar walls of the specimen *No. 1*. This tooth, except for its delicate structure and smaller dimensions, does not depart morphologically from the upper canine of *U. spelaeus*.

A small right I^1 with worn crown (*No. 9*); crown fragment of left P^4 with well preserved metacone and deuterocone (*No. 15*); complete little-worn left M_1 (*No. 17*; Pl. 2, Fig. 3); left M_2 with damaged roots and distinctly worn crown (*No. 20*; Pl. 2, Fig. 4); worn right M_3 with fused roots (*No. 22*; Pl. 2, Fig. 5); fragment of I_1 with strongly worn crown (*No. 23*); apical part of the crown of the right upper canine of similar dimensions as specimen *No. 8* (*No. 24*); posterior palatal part (*No. 2*); right roofing part of the auditory bulla (*No. 31*); two parietal fragments (*No. 32*); posterior part of right border of internal choanae (*No. 33*); left squamosal process (*No. 34*); occipital fragment with sagital and occipital crests (*No. 35*); fragment of right occipital condyle (*No. 36*); posterior basal part of right jugal arch (*No. 37*); anterior section of left jugal arch (*No. 38*) and occipital bone fragment (*No. 39*) without doubt belong to the skull *No. 1*. To the same individual belong some of skull fragments (*Nos 25, 40, 41*) and some of metacarpal bones (*No. 26*), as well as some phalangs (*No. 28*).

All these skull fragments and isolated teeth do not show distinct deviations from the normal structure of typical *U. spelaeus*; their dimensions fall near the lower limits of the variability range of adult individuals (*cf.* Table 1).

Two pisiform bones (*No. 27*), both left (Pl. 2, Fig. 10) and right, as it appears from their dimensions, proportion of distal swelling and ulnar surface character, may be assigned to a female (*cf.* Kurtén 1966).

Central part of the left mandible with M_2 *in situ*, posterior part of M_1 alveolus and lingual alveolar wall of M_3 (*No. 4*; Pl. 2, Fig. 1) after its dimensions and perfectly preserved complicate sculpture of M_2 crown, belongs to a juvenile, to which also unworn left M_3 (*No. 21*; Pl. 2, Fig. 6) and well preserved left M_1 (*No. 18*) are to be assigned.

Horizontal mandibular ramus without teeth of the left mandible (*No. 5*) does not differ in dimensions from the specimen *No. 4*; it belongs to another juvenile.

Two lower canines, right (*No. 7*) and damaged left (*No. 6*); fragment of left I_3 with damaged crown (*No. 10*); left M^2 (*No. 12*); two fragments of M^2 talon (*No. 11*) with a smooth mastication surface; fragment of right M_2 (*No. 14*); left milk tooth DP_4 (*No. 16*; Pl. 2, Fig. 2); anterior section of right M_1 with characteristic trigonid structure (*No. 13*), left M_1 fragment without roots (*No. 19*); palatal fragments (*Nos. 25* and *29*); as well as parts of phalangs (*No. 28*) and metacarpals (*No. 26*) belong to the juveniles represented by the mandibles (*Nos. 4 and 5*), as it is evidenced by their dimensions and unworn crowns.

Discussion. — The dimensions and structure of teeth, skull elements, mandibles, and especially of diagnostic teeth M^1 and M_2 indicate that the presented bear remains should be assigned to *Ursus spelaeus* Rosenmüller & Heinroth, 1794. The remains belonging to a mature individual, as it appears from their delicate structure and smaller dimensions (Table 3), considered as a manifestation of the sex dimorphism (Kurtén 1955, 1958), should be attributed to a young, but adult female.

The presence of P^3 alveoli in the specimen *No. 1* (Pl. 2, Fig. 8) and P_1 alveolus in the specimen *No. 5* is noteworthy, as additional premolars were noted in mandibles and maxillies of the Pleistocene bears, both *U. spelaeus* and *U. arctos* (Schlosser 1909; Kormos 1914; Ehrenberg 1928, *in:* Abel & Kyrle 1931; Mottl 1933, 1935; Rode 1933, 1935; Thenius 1956; Malez 1957, 1958, 1959; Kurtén 1957, 1959) but interpretations of that feature has differed markedly. Some of the authors believed that the additional premolars are indicative of the extant species *U. arctos*, while in *U. spelaeus* a distinct reduction of anterior premolars occurs (Rode 1933, Kurtén 1959). But a clear majority of investigators (Schlosser 1909; Kormos 1914; Mottl 1933, 1935; Malez 1959) regarded the presence of additional premolars as an atavistic character, more frequently encountered in the females of *U. spelaeus*. Probably, the reduction of the premolars may have become faster in *U. spelaeus* than in *U. arctos*. The additional premolars in almost full arrangement have appeared in young individuals of both sexes of *U. spelaeus*, but in the ontogenetic development of the males these teeth come out earlier than in the females. Probably these teeth could remain all the life of some female individuals, in which only P^2 and P_2 were submitted to the complete reduction.

The unequal wear of M^{1-2} (*Nos. 1 and 3*) proves defective occlusion and stronger development of the left temporal muscle (*cf.* Kurtén 1959, p. 77) in the female from Draby 3.

In the material collected any bones of an adult male are lacking; all the bones hitherto found show the presence of a young adult female and two, one-year-old, probably her own cubs.

AGE OF THE BONE-BEARING LAYER

The occurrence of bones in one part of the bone-bearing layer, a similar state of their preservation and a lack of the rounding traces on bone fragment, and a similar chemical composition of bones, give evidence that the bone material is syngenetic with the bone-containing sediment.

As it appears from the palaeontological analysis, the bone material represents only an adult female of the cave bear, *Ursus spelaeus* Rosenmüller & Heinroth, associated with the two cubs. According to Kurtén (1957, 1959), the speciation of *U. spelaeus* occurred during the Mindel (Elster) Glaciation, while the extinction of the species took place during the Würm decline. If the factor leading to speciation was probably an isolation and environmental pressure during the very severe Mindel Glaciation (*cf.* Kurtén 1957) on western population of *U. deningeri* v. Reichenau, the speciation had to happen during the maximal Mindel *II* (Elster *II*, Cracovian *II*) Glaciation when the icesheet reached the Carpathians. During the Kozi Grzbiet Interglacial (= Mindel *I*/Mindel *II*), only *U. deningeri* lived (*cf.* Głazek, Lindner & Wysoczański-Minkowicz 1976). Consequently, the *spelaeus* Ontozone may be defined as Mindel *II* — Late Würm.

The small size of the adult female as well as the presence of P^3 alveoles may also suggest that it was a primitive form that resembled its smaller ancestor, *U. deningeri* v. Reichenau. Moreover, the small size of the adult individuals is a prominent feature of the interglacial cave bears (*cf.* Kurtén 1959).

The age of the bones was determined by fluorine-chlorine-apatite and collagen methods (*cf.* Wysoczański-Minkowicz 1969, Różycki & Wysoczański 1969) which have already been applied to Pleistocene and Neogene bone materials from different karst localities (*cf.* Różycki & Wysoczański 1969; Wysoczański-Minkowicz 1969; Głazek, Sulimski & Wysoczański-Minkowicz 1976; Głazek, Lindner & Wysoczański-Minkowicz 1976). The age values as well as the chemical results, obtained for samples from Draby *3*, are given in Table 2; the age coefficient FCl/P ranges between 0.92 and 1.03, and it points to the period between 320.000—440,000 years B. P.

The collagene loss coefficient (*cf.* Wysoczański-Minkowicz 1969) for samples from Draby *3* ranges between 9.0—9.8 and points to warm interglacial conditions.

The different premises lead therefore to the conclusion that the bone-bearing layer represents the hitherto unsatisfactorily documented

Table 2

Dating of bones of *Ursus spelaeus* with the fluorine-chlorine-apatite and collagene methods; locality Draby 3

Characteristics	Kind of bone fragment		
	cranium roof		limb bone
	Laboratory No. of sample		
	F425P	F426P	F427P
F /weight %/	0.92	1.03	1.32
Cl /weight %/	0.015	0.015	0.011
P_2O_5 /weight %/	38.9	38.9	38.2
$\frac{\% F}{\% P_2O_5} 10^2$	2.37	2.65	3.46
$\frac{\% Cl}{\% P_2O_5} 10^2$	0.39	0.39	0.29
$\frac{\% F \% Cl}{/\% P_2O_5/^2} 10^5$	0.92	1.03	0.97
Burning loss in weight % at 800°C for 1 hr	9.3	10.0	9.4
Collagene loss coefficient	9.8	9.0	9.6

interglacial period between the Mindel and Riss Glaciations (Great, Holstein, Hoxnian, or Likhvin Interglacial). The site Draby 3 is the first locality in Poland where *Ursus spelaeus* was found in a sequence of this interglacial; moreover, it seems to be the first locality in Poland where vertebrate remnants of the Great Interglacial were found. The species *U. spelaeus* of this interglacial is known from only a few localities in western Europe — Happenloch, Steinheim, Swanscombe (*cf.* Kurtén 1959). The site Draby is also the oldest occurrence of *U. spelaeus* in Poland, as well as probably the easternmost site of this species in Europe during the Holstein Interglacial.

DEVELOPMENT OF THE KARST FORM

The investigated sequence allows us to recognize the development of karst and the sedimentary events during a period of Quaternary time.

The origin of the flint rubble layer (*No. 2*) is contemporaneous with the origin of a narrow karst fissure; it probably was deposited during the decline of the Cracovian *I* (Mindel *I*) Glaciation. The ferruginous layer (*No. 3*) presumably corresponds to the subsequent cool (boreal) phase, whereas the next layer (*No. 4a*) of calcareous clays may indicate the optimal phase of the Kozi Grzbiet (Mindel *I*/Mindel *II*) Interglacial (*cf.* Głazek, Lindner & Wysoczański-Minkowicz 1976). The subsequent sandy layer (*No. 4b*) was deposited during the glaciation, the most probably Cracovian *II* (Mindel *II*, Elsterian *II*); in this layer however only an older part of the glaciation is represented because erosion connected with the kataglacial phase destroyed older sediments and caused important enlargement of the karst fissure into the cave accessible to large animals.

The set of layers *5—7* was deposited in the cave and it represents an interglacial sequence belonging to the Great (Holstein) Interglacial. This set resembles cave loams commonly encountered in Quaternary fillings of the caves in the Central Polish Uplands, and interpreted as the deposits of warmer periods (*cf.* Madeyska-Niklewska 1969; Głazek, Lindner & Wysoczański-Minkowicz 1976). The ferruginous layer (*No.* 5) was probably deposited in wet and cool climate after the older optimal phase of the Great Interglacial; to this phase may also be attributed a slight erosion between layers *5* and *6*. The bone-bearing layer (*No. 6*) represents the next optimal phase of this Interglacial, while subsequent erosion may be correlated with a wet and slightly cooler phase dividing the latest two optima of the Great Interglacial. The calcareous layer (*No.* 7) represents probably a younger optimum of this Interglacial.

The layer *8* consisting of sandy loam with limestone blocks covered with ferruginous crusts is bordered by sharp erosional contacts both at the bottom as well as at the top. The origin of this layer may be related to a roof collapse of the cave. Prior to this collapse, erosion in the anaglacial phase of the Middle Poland (Riss *I*, Saale) Glaciation took place. During the pleniglacial phase, when the icesheet covered the area and reached the Moravian Gate about 200 km southward of Draby, the cave was probably preserved in permafrost beneath the 300—400 m thick icesheet. During the succeeding kataglacial phase and the Lublin Interglacial (*cf.* Środoń 1969) in the neighbouring area the vigorous erosion dominated (Krzemiński 1974). This erosion was probably responsible for the corrosion of limestones and the cave collapse.

In the time of the following Glaciation (Warta, Riss *II*), the advancing icesheet was stopped somewhat to the north and the whole area around Draby (*cf.* Fig. 1) was covered with outwash sands, except for the more elevated limestone hills. These outwash sands (layer *9*) filled all depressions in limestones, including the collapse furrow over the destroyed cave.

The Eemian Interglacial, being a period dominantly of erosion, is recorded in the sequence as an erosional gap between older deposits and rubble layer (*No 10*). This layer covers the slopes of limestone hills in the vicinity, and creeps downslope on the denuded surface of outwash sands. Such rubble layers of the Würm are common in Middle Poland and represent periglacial slope deposits (Różycki 1961, 1972). The Holocene karstification and soil forming processes are recorded in the soil lapies (layers *Nos. 11—13*).

Correlation of deposits filling the Draby 3 karst form with some climatostratigraphic schemes of the Quaternary deposits in Poland and neighbouring countries

POLAND								D. D. R.		CZECHOSLOVAKIA	SOVIET UNION	
DRABY 3					Różycki 1961, 1972			Cepek 1967		Červený Kopec – Kukla 1969	Zubakov & Kochegura 1973	
Layer No	Lithology (cf. Fig. 2)	Interpretation										
13, 12, 11		Holocene			Holocene			Holocene		Interglacial Soil – A1	Holocene	
10		Würm Glaciation			Baltic glaciation			Weichsel – Kaltzeit (Grundmoränen, W1, W2)		Loesses – B2, B3	Valdai Glaciation	
10		Eemian Interglacial			Eemian Interglacial			Eem – Warmzeit		Soil – B2 Interglacial Soil – B1	Mikulino Interglacial	
9		Recession Substages	Warthian Glaciation	Riss II	Glacial Substage Bugo-Narew interst.		Middle Poland Glaciation	[erosion ?]	Saale – Kaltzeit	Loesses – C3 Soil – C2	Lake silts Sand and gravels	Moskva Glaciation
9		Warta Glac. Subst.			Warta Glac. Subst.			Lausitzer – Kaltzeit (Grundmoräne – S3)		Loess – C2	Moskva tills	
8		Lublin Interglacial	Skaerumhede		Pilica Interstadial			Rügen – Warmzeit		Soil – C2 Interglacial Soils – C1	Odintsovo Interglacial	
8		Middle Poland Glaciation	Riss I		Radomka Glac. Subst. Miłaszyn Interstad. Glacial Substage			Flaming – Kaltzeit – S2 Treene(?) – Warmzeit Saale – Kaltzeit – S1		Loess – D3 Soil – D2 Loess – D2	Dnepr, younger till Dnepr, older till	Dnepr Glacial.
7		Interglacial Optimum III	Great Interglacial		Olszewice warm Substage	Great Interglacial		Dömnitz – Warmzeit	Holstein – Warmzeit	Soil – D2 333.000 – 323.000 Y.B.P.	Interglacial Optimum III TL: 325.000 – 315.000 Y.B.P.	Likhvin Interglacial
6		Cool Substage			2nd post-optimal cool Substage					Loessloam – D1 342.000 – 333.000 Y.B.P.	Cool Substage TL: ~ 330.000 Y.B.P.	
6		Intergl. Opt. II FCIJP: 440.000–320.000 Y.B.P. Coll.: Warm Subst.			Syrniki warm Substage					Interglacial Soil – D1 370.000 – 360.000 Y.B.P.	Interglacial Optimum II TL: 400.000 – 335.000 Y.B.P.	
5		Cool Substage			1st post-optimal cool Substage			Fuhne – Kaltzeit		Loess – E3 Soil – E3 Loess – E2	Cool Substage TL: ~ 420.000 Y.B.P.	
5		Interglacial Optimum I			Sulejów optimum			Holstein – Warmzeit		Interglacial Soils – E1, E2 ~ 485.000 Y.B.P.	Interglacial Optimum I TL: ~ 459.000 Y.B.P.	
4b		Recession Substages	Cracovian II Glaciation	Mindel II	2nd and 3rd Glacial Substages	Cracovian Glaciation		[erosion ?]	Elster – Kaltzeit	Loess – F3	Oka s.s. till	Oka s.l. Glaciation
4b		Przemyśl Glac. Subst. (max.)			Przemyśl Glac. Subst. (max.)			Elster – Kaltzeit (Grundmoräne – E II)		Soil – F3 Loess – F2	Oka I younger till	
4a, 3		Kozi Grzbiet Interglacial	Westerhoven		Interstadial			Voigtstedt – Warmzeit		Interglacial Soil – F1	Interglacial soil (Lubensk)	
2		Cracovian I Glaciation	Mindel I		Glacial Substage			Helme – Kaltzeit (Grundmoräne – E I)		Loess – G3	Oka I older till	

The sediments are hachured as in Text-fig. 2 but not to scale; *h* — hiatuses; brackets point to the present author's interpretation

The stratigraphic interpretation of the Draby *3* sequence, and its correlation with Quaternary schemes in neighbouring coutries (Table 3), presents some modifications of the scheme elaborated by Różycki (1961, 1972) for Middle Poland. The accepted scheme includes the Lublin Interglacial of Środoń (1969), and the Kozi Grzbiet Interglacial (*cf.* Głazek, Lindner & Wysoczański-Minkowicz 1976). Such modifications are in accordance with Cepek's (1967) scheme for the Quaternary of DDR, Kukla's (*in:* Demek & Kukla 1969) stratigraphy of loesses in Czechoslovakia, and stratigraphic division of the Quaternary in glaciated areas of the European part of the USSR elaborated recently by Zubakov & Kochegura (1973).

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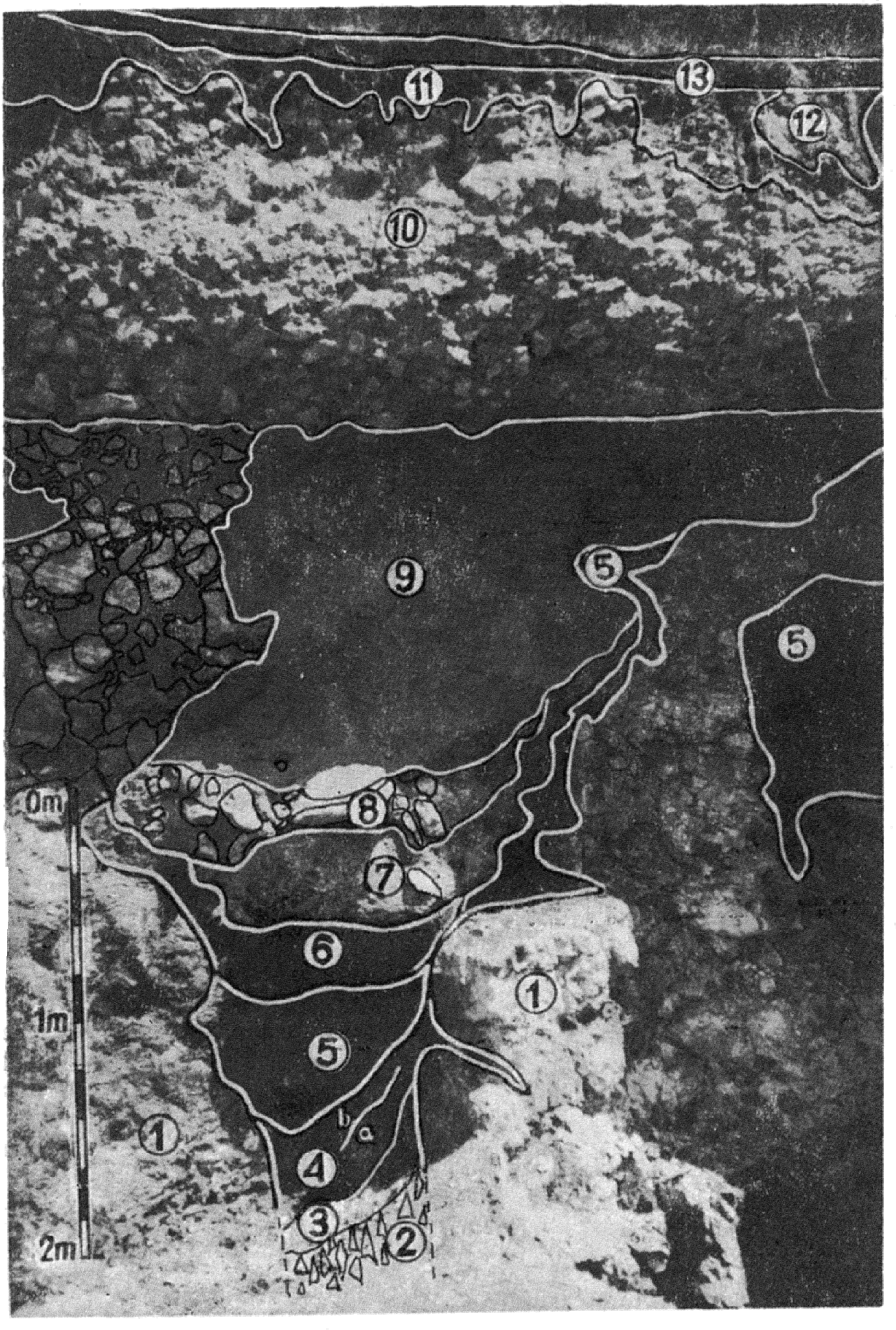
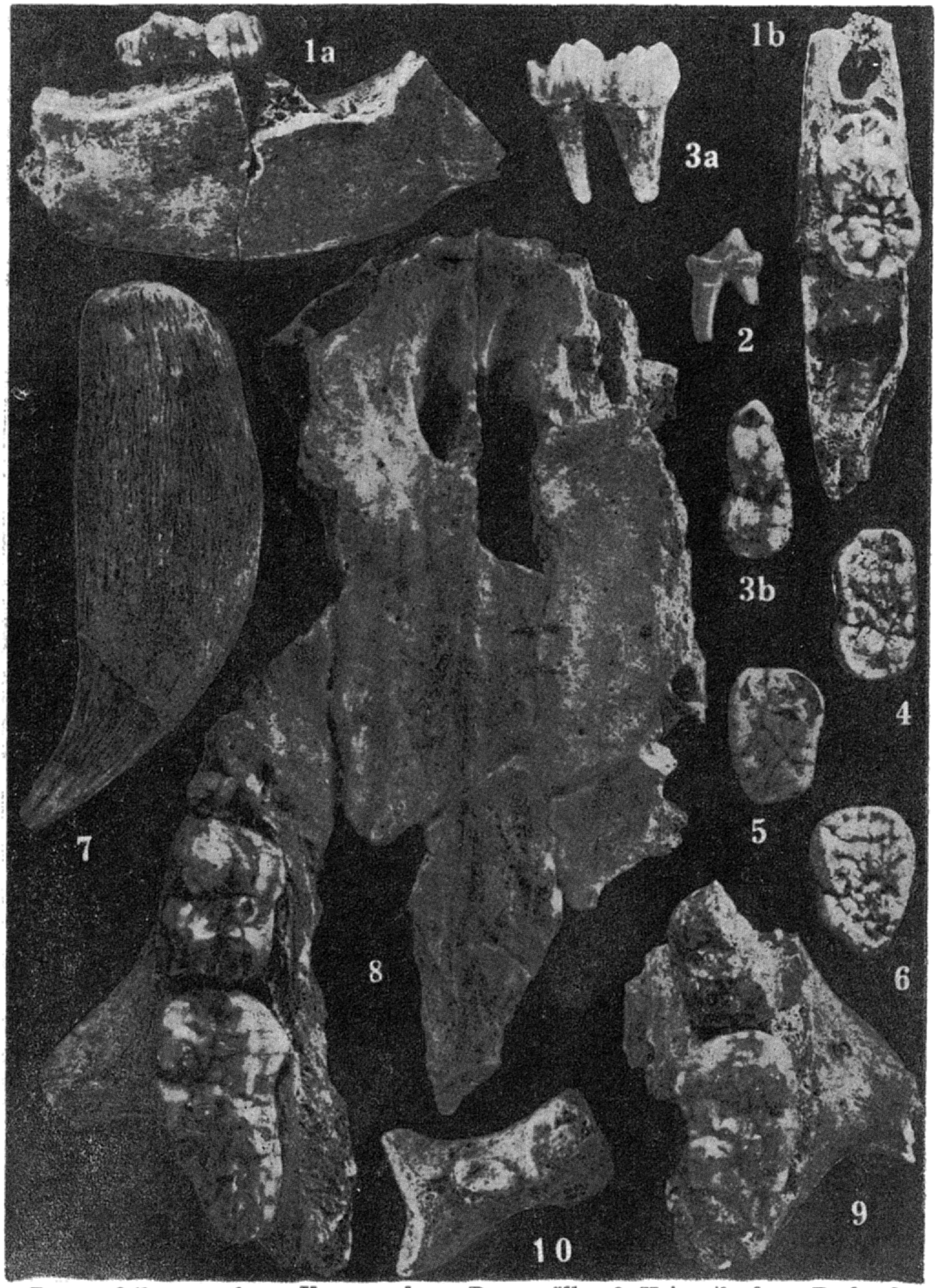


General view of the locality Draby *3* during excavation in the summer of 1974; photo taken by A. Szynkiewicz

1–13 numbers of layers described in the text (*cf.* Text-fig. 2)



Bones of the cave bear, *Ursus spelaeus* Rosenmüller & Heinroth, from Draby *3*
1 Central part of left mandible with M_2 (juvenile form): *a* lingual, *b* occlusal view (*No. 4*); **2** Left DP_4, lingual side (*No. 16*); **3** Left M_1: *a* lateral view, *b* occlusal view (*No. 17*); **4** Left M_2, occlusal view (*No. 20*); **5** Right M_3, occlusal view (*No. 22*); **6** Left M_3, occlusal view (*No. 21*); **7** Left upper canine, lingual view (*No. 8*); **8** Palatal part of the skull with right P^4—M^2 and alveoli of both left and right I^{1-3} and *C* (alveolus of left P^3 and medial walls of left P^4 are visible), ventral view (*No. 1*); **9** Fragment of the left maxilla with M^{1-2}, ventral view (*No. 3*); **10** Left pisiform bone, ulnar view

All figures × c 0.8; taken by B. Drozd, M. Sc.

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ŚRODKOWOPLEJSTOCEŃSKIE OSADY JASKINIOWE ZE SZCZĄTKAMI *URSUS SPELAEUS* ROSENMÜLLER & HEINROTH W DRABACH KOŁO DZIAŁOSZYNA

(Streszczenie)

Przedmiotem pracy jest opis środkowoplejstoceńskiego stanowiska krasowego Draby 3 koło Działoszyna (fig. 1) zawierającego szczątki kostne. W sekwencji osadów wypełniających formę krasową (fig. 2 i pl. 1) wydzielono osady złożone w jaskini (*2—7* na fig. 2 i pl. 1) w okresie od schyłku zlodowacenia krakowskiego starszego (Mindel *I*) do anaglacjalnej fazy zlodowacenia środkowopolskiego (Riss *I*), warstwę bloków wapiennych (*8* na fig. 2 i pl. 1) powstałą w wyniku zawalenia się stropu jaskini podczas deglacjacji zlodowacenia środkowopolskiego (Riss *I*), warstwę piasków fluwioglacjalnych (*9* na fig. 2 i pl. 1) wypełniającą bruzdę zawaliskową nad zniszczoną jaskinią z okresu zlodowacenia warciańskiego (Riss *II*) oraz warstwę peryglacjalnego rumoszu zboczowego (*10* na fig. 2 i pl. 1) z okresu zlodowacenia bałtyckiego (Würm); w tej ostatniej warstwie rozwinięte są formy krasowe typu lapiazu glebowego wieku holoceńskiego (*11—13* na fig. 2 i pl. 1). Przedstawiono zmiany składu chemicznego osadów (fig. 3) w zależności od warunków klimatycznych. Warstwy złożone głównie z uwodnionych tlenków żelaza i manganu (*3* i *5* na fig. 2 i p.l. 1) zinterpretowano jako osady odpowiadające chłodnym i wilgotym okresom kataglacjalnym starszego i młodszego zlodowacenia krakowskiego.

Znalezione w warstwie 6 (optimum wielkiego interglacjału) szczątki niedźwiedzia jaskiniowego, *Ursus spelaeus* Rosenmüller & Heinroth, należały do dorosłej samicy i dwóch małych niedźwiadków (por. tab. 1 oraz pl. 2). Jest to najstarsze stanowisko niedźwiedzia jaskiniowego na obszarze Polski i jedno z najstarszych w Europie, a prawdopodobnie także — najdalej na wschód wysunięte występowanie tego gatunku z okresu wielkiego interglacjału (por. Kurtén 1957, 1959).

Przedstawiono stratygrafię zbadanych osadów i skorelowano ją ze schematami klimato-stratygraficznymi czwartorzędu dla obszaru Polski i krajów ościennych (tab. 3). W korelacji tej uwzględniono (por. Środoń 1969) istnienie interglacjału lubelskiego (= odincowskiego) oddzielającego zlodowacenie środkowopolskie od warciańskiego oraz istnienie interglacjału Koziego Grzbietu — Jasionki (= Kromer *II*) oddzielającego starsze zlodowacenie krakowskie od młodszego — maksymalnego zlodowacenia krakowskiego (por. Głazek, Lindner & Wysoczański-Minkowicz 1976).