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New Late Pleistocene faunal assemblages from Podhale Basin, Western Carpathians, Poland: preliminary results

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Abstract. Interdisciplinary studies in Obłazowa Cave undertaken near its western entrance and in a new archaeological site in Cisowa Rock yielded finely layered sedimentary sequences with an abundant fossil fauna of mainly small vertebrates and scarce archaeological finds. In this paper we present a preliminary palaeoenvironmental and palaeoclimatic reconstruction of the sequences dated around MIS 2/MIS 1 boundary on the basis of small mammal assemblages. The faunal changes appear to be gradual in spite of abrupt climatic changes expected to occur at that time. The environmental and faunal results are discussed with other sequences of similar age in Poland.

Key words: fossil fauna, habitat and climate change, steppe-tundra, radiocarbon dating, Obłazowa Cave.

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I. INTRODUCTION

The Podhale Basin, also known as Orawa-Nowy Targ Basin, is located in the Western Carpathians, south Poland. Within the Polish part of the Western Carpathians KONDRACKI (2011) distinguished Central Western Carpathians which consist of Tatra and Pieniny Mountains, Pieniny Klippen Belt and Podhale (Orawa-Nowy Targ) Basin. The Quaternary faunal history of the region was relatively poorly known up to the 1980s. KOWALSKI (1959) summarized the knowledge of faunal assemblages of the Central Western Carpathians. The most spectacular discovery at that time were remains of the mammoth (*Mammuthus primigenius*) found in Niedzica (KULCZYCKI & HALICKI 1950). In the early 1980s S.W. ALEXANDROWICZ and W. P. ALEXANDROWICZ initiated extensive research on the Late Glacial and Holocene snail fauna of the region finalized by the ALEXANDROWICZ (1997) monograph. In parallel the first excavations in a small cave in the Sobczański Gully (Pieniny

Mountains) (ALEXANDROWICZ et al. 1985), Obłazowa Cave (VALDE-NOWAK 1987; VALDE-NOWAK et al. 1987; NADACHOWSKI & WOLSAN 1987) and the nearby fissure filling Obłazowa 2 (NADACHOWSKI et al. 1993) were started. From the beginning Obłazowa Cave became the most important site in the Podhale Basin from both archaeological (VALDE-NOWAK 1991; MADEYSKA 1991; VALDE-NOWAK et al. 1995) and palaeontological (NADACHOWSKI 1990, 2001; TOMEK & BOCHEŃSKI 1995; WOŁOSZYN 1995) points of view (Fig. 1). Results of excavations undertaken between 1985 and 1995 yielded a number of important archaeological findings as well as a very rich and diversified fauna of mollusks, amphibians, reptiles, birds, and small and large mammals of Late Pleistocene age (VALDE-NOWAK et al. 2003; MADEYSKA et al. 2002). Excavations were interrupted due to the danger of cave collapse and renewed in 2008, 2009, 2012 and 2013. Rescue research undertaken in 2012 yielded an unexpected discovery of a Micoquian industry, within an earlier sterile archaeological layer XVIII (VALDE-NOWAK & CIEŚLA 2014) and a new interpretation of the age of the lower part of the section on the basis of biostratigraphic markers (VALDE-NOWAK & NADACHOWSKI 2014). In 2009 a small trench was set up in the front of the probable western entrance to Obłazowa Cave (Fig. 2). Results obtained during these excavations are presented in this article. In 2013, beside intensive research in Obłazowa Cave, a new site, a rock-shelter in Cisowa Rock (Fig. 3), was studied and preliminary results are the subject of this publication.

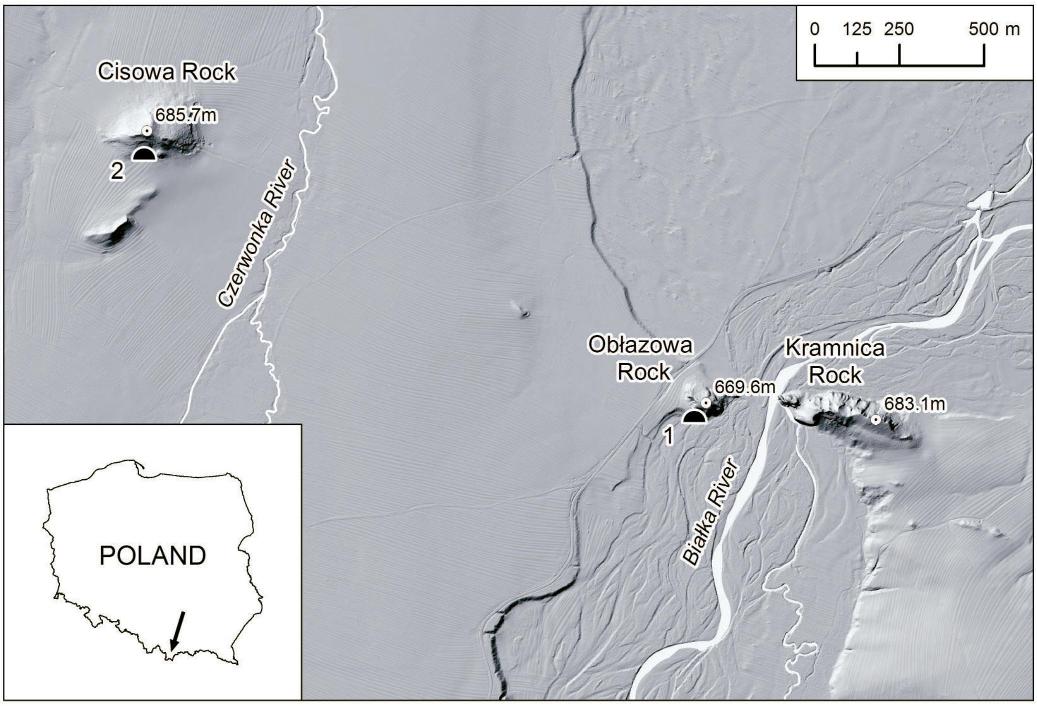

Fig. 1. Localization of Obłazowa Cave (1) and rock-shelter in Cisowa Rock (2) in the Podhale Basin, Western Carpathians.

Fig. 2. Obłazowa Cave, western entrance into the cave, filled with sediments (beginning of excavations in 2009).

Fig. 3. Cisowa Rock (south-eastern view), excavations at the base of the rock are indicated.

II. OBŁAZOWA CAVE, WESTERN ENTRANCE (WE)

During first excavations in Obłazowa Cave (1985-1995) the main (southern) entrance, in a form of the arch, was successively opened. Based on the examination of the cave's vicinity and an analysis of the arrangement of especially upper layers one can assume that there exists another entrance, westward of the present opening (VALDE-NOWAK 2003). This interpretation also explains the presence of the great volume of deposit in the inner part of the cave which constitute series F (MADEYSKA 2003), the uppermost layers I, II, III, IV, V and VI. Excavations undertaken in 2009 confirmed the assumption that at least part of the upper deposits of Obłazowa Cave were built by scree debris overwhelmed from the slopes of Obłazowa Rock.

Description of sediments and stratigraphy

A 2x2 m trench was situated next to the rocky wall directed to the west which forms an overhang. The ditch cut sediments placed close to the limestone wall, under the overhang, and partly sediments placed on the slope. A mechanical film was used to remove 5 cm thick deposits. The sediment was washed through a sieve with meshes of 0.4 mm to obtain smaller bones and teeth. The depth of the studied sediments reached ca. 60-70 cm. The following layers were distinguished (from the top to the bottom) (Fig. 4):

Layer I. Recent litter with humus and small amount of limestone rubble with particles of diameters up to 10-15 cm.

Layer II. Yellow-brown loams with significant quantities of relatively smoothed rubble and relatively rare fossil palaeontological materials.

Layer III. Brown loam of fine sharp-edged rubble and single particles with larger diameter (up to 10 cm). The sediment is divided into two parts which differ mainly in the number of fossil items. The upper part contains hundreds of small mammal and bird remains and single larger bones, in the lower part the amount of fossils is much lower. The Palaeolithic stone artifact was found in the lower part of this layer (Fig. 5).

Two radiocarbon AMS dates were obtained for layer III from the medial phalanx of the reindeer *Rangifer tarandus* (LINNAEUS, 1758) (lower part of layer III, sample 318/09) and the navicular bone of the wild horse *Equus ferus* BODDAERT, 1785 (upper part of layer III, sample 308/09) (Table I). In this paper, radiocarbon dates were calibrated with the IntCal13 curve (REIMER et al. 2013) and the values were presented with 95.4% significance level (2σ). The obtained dates were correlated with chronology of the last glaciation based on the GICC05 scale (ANDERSEN et al. 2006; SVENSSON et al. 2006).

Faunal remains

The uppermost layer I did not contain palaeontological materials and in the layer II fossils are not numerous. Therefore a preliminary analysis of fauna was based on ca. 40-50% of material collected from the layer III. This layer gathers most of the fossil material discovered in the trench up to now. The fossil items were identified to the genus and/or species level following the general criteria of vertebrate palaeontology of diagnostic elements (mainly mandibles and isolated teeth). Specific attribution of birds was based on cranial and post-cranial skeleton elements. The accumulation of small vertebrates, scarce fish

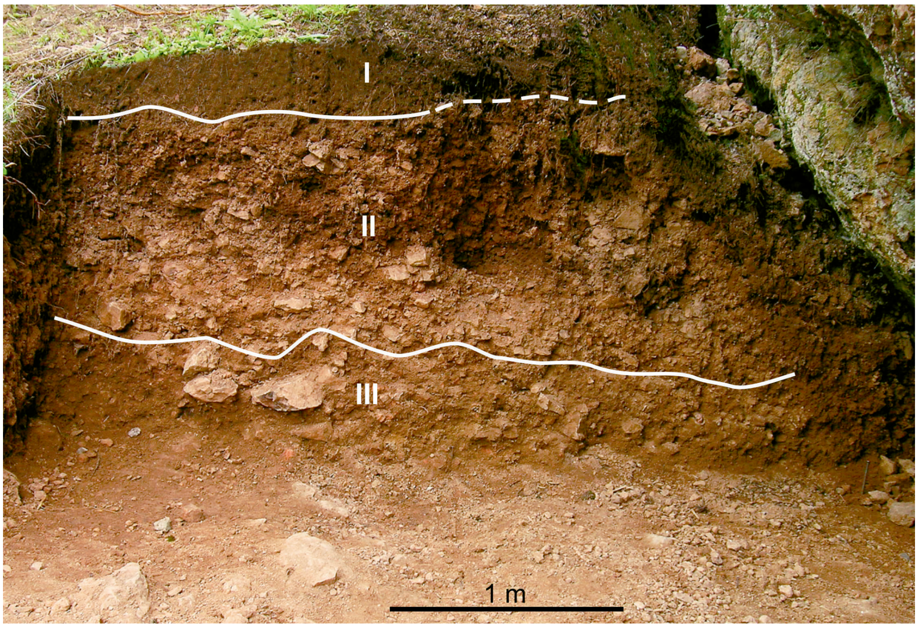

Fig. 4. Obłazowa Cave, the western entrance, geological profile in 2009 (layers I, II, III).

Fig. 5. Retouched broken blade made of red Pieniny radiolarite. Obłazowa Cave, the western entrance, layer III.

bones and relatively numerous bird remains were accumulated due to biologic agents, the birds of prey. Rare remains of amphibians were likely accumulated from *in situ* mortality, while very scarce large mammals by predation of carnivores or humans. Prior to deposition, especially remains of birds suffer some special degree of fragmentation. The remains were collected selectively, mainly leg and wing bones.

It appeared that the lower (older) and upper (younger) parts of a layer III differ in the faunal composition and percentage proportions of particular species. The assemblage is predominated by small mammal taxa represented by 12 and 10 species, respectively (Table II). Medium sized mammals belong to hare *Lepus* sp. and the steppe pika *Ochotona pusilla*, and are present in both sublayers. In spite of the taphonomic provenience of this assemblage two large mammals were found. A few bone fragments, including a complete medial phalanx of a reindeer *Rangifer tarandus* were recognized in the lower part of the layer III and a navicular bone of the wild horse *Equus ferus* in the upper part of this layer. In both lower and upper parts of the layer III two vole species, the common vole *Microtus arvalis* and the narrow-skulled vole *Microtus gregalis* prevailed, however their relative proportion change distinctly (Table II). The lower part of the layer is charac-

Table I

Radiocarbon dates for the Obłazowa Cave western entrance (WE), layer III. Ages are calibrated with the OxCal 4.2 software using the IntCal13 curve (REIMER et al. 2013)

Species/Layer	Code	^{14}C age ± BP	95.4% range cal BP	Median
Equus ferus /III (upper part)	Poz-38123	12340±80	14815-14055	14376
Rangifer tarandus /III (lower part)	Poz-3245	13210±80	16140-15614	15887

Table II

Frequency distribution of rodents (Rodentia) and insectivores (Soricomorpha) in lower and upper part of layer III of Obłazowa Cave western entrance (WE). NISP – number of identified specimens, in the case of rodents first lower molars (M_1) were counted and in the case of *Sorex* – mandibles. MNI – minimum number of individuals. Results are based on examination of about 40-50% of available palaeontological material

Taxon	Layer III (lower part)			Layer III (upper part)			Habitat preferences
	NISP	MNI	%MNI	NISP	MNI	%MNI	
Cricetus cricetus (LINNAEUS, 1758)	1	1	0.6	2	1	0.7	steppe and grassland
Dicrostonyx gulielmi (SANFORD, 1870)	20	11	7.0	6	3	2.3	well drained tundra
Lemmus lemmus (LINNAEUS, 1758)	1	1	0.6	–	–	–	swampy tundra
Microtus gregalis (PALLAS, 1779)	110	60	38.0	47	20	15.0	open grassy areas in tundra and forests
Microtus arvalis (PALLAS, 1778)	105	65	41.2	135	70	52.6	open, dryer habitats
Microtus agrestis (LINNAEUS, 1761)	4	3	1.9	12	6	4.5	damp grassland
Microtus oeconomus (PALLAS, 1776)	9	6	3.8	29	19	14.4	eurytopic, damp areas
Arvicola amphibius (LINNAEUS, 1758)	1	1	0.6	4	2	1.5	eurytopic, damp areas
Chionomys nivalis (MARTINS, 1842)	8	5	3.2	3	2	1.5	rocky areas
Clethrionomys glareolus (SCHREBER, 1780)	1	1	0.6	2	1	0.7	all kinds of woodland
Sicista cf. *betulina* (PALLAS, 1778)	1	1	0.6	–	–	–	mountain forests and meadows
Sorex araneus LINNAEUS, 1758 or/and *S. runtonensis* HINTON, 1911	5	3	1.9	16	9	6.8	damp habitats with dense vegetation
Total	266	158	100	256	133	100	

terized by almost equal frequency of both species while in the upper part *Microtus arvalis* is far more frequent (52.6%) than *M. gregalis* (15.0%). Both species inhabit open habitats: *M. arvalis* dryer biotopes and *M. gregalis* prefers open grassy areas in wet tundra. Another important difference is observed in the frequency of the root vole *Microtus oeconomus*: an increase from 3.8% to 14.4%, and less expressed in the number of the shrew *Sorex* remains – from 3.2% to 6.8%. These species inhabit damp areas, both grassland and more dense vegetation. The opposite tendency is noticed in the frequency of lemmings, typical representatives of Late Pleistocene steppe-tundra environments in Central Europe. The collared lemming *Dicrostonyx gulielmi* diminishes in number from 7.0% to 3.3% while the Norway lemming *Lemmus lemmus* occurs only sporadically (0.6%) in the lower part of layer III. Other vole species *Microtus agrestis*, *Arvicola amphibius*, and *Chionomys nivalis* and the European hamster *Cricetus cricetus* can be treated as accessory elements which in both compared assemblages do not exceed 2-4%. They are indicators of various biotopes from open and semi-open humid environments (*M. agrestis* and *A. amphibius*) to rather dry steppe and grassland (*C. cricetus*) and rocky areas (*C. nivalis*). Inhabitants of forests (*Clethrionomys glareolus* and *Sicista betulina*) are even rarer. Faunistic differences between sublayers are not visible in changes of bird assemblage. The most numerous are the willow ptarmigan *Lagopus lagopus* and rock ptarmigan *Lagopus muta*. Both are sedentary birds inhabiting taiga, forest-tundra and tundra environments and their presence suggests that the vicinity of this site was at least partly forested. The black grouse *Tetrao tetrix* found in the lower part of the layer III is primarily a forest-dwelling species, but also inhabits forest-tundra environments. The presence of a great snipe *Gallinago media*, a highly migratory species, indicates the presence of a moist to wet terrain and peatlands with scattered bushes. On the other hand, remains of the great spotted woodpecker *Dendrocopos major* indicate the presence of at least small coniferous woodlands in the vicinity of the site.

Environmental and climatic reconstruction

Radiocarbon dating obtained for the layer III served as the basis for further interpretation. The two compared faunal sub-assemblages where probably deposited in changing environmental and climatic conditions. However, full reconstruction of the past ecosystems is impossible because some species making up the fossil assemblages are not preserved in the fossil record due to taphonomic bias. The difference can be expressed by changes in the faunal composition, especially changes in relative frequencies of species typical for eurytopic habitats. The older assemblage (lower part of layer III) was probably deposited in a less diversified environment than the younger assemblage. From faunal remain it seems that first tundra (ca. 45% of species belong to this category) and other open habitats (ca. 44%) conditions prevailed in the vicinity of the cave. In the younger assemblage the percentage of tundra species diminished to only ca. 17% while other open habitat species increased their frequency (to ca. 58%). However, the main change concerns species living in more diversified biotopes (from ca. 8% do ca. 23%). This probably means an increasing mosaic of habitats, although proportions of forest species did not change. In general the humid habitat species became less frequent (change from ca. 48% to 42%) while dry habitat species increased their frequency (change from ca. 52% to ca. 58%).

Stone artifact

The artifact found in the layer III represents the basal (proximal) fragment of a bilateral retouched broken blade made of red Pieniny radiolarite (Fig. 5).

III. ROCK-SHELTER IN CISOWA ROCK

The Cisowa Rock (685 m a.s.l.) belongs to the Pieniny Klippen Belt and is a characteristic, isolated element of the Podhale landscape, placed about 1500 m from the Obłazowa Rock, between the villages Nowa Biała and Gronków (Fig. 1). The relative height is 55 m. In 2009 at the southern slope of the Cisowa Rock, just at the base of the klippe, a very small rock-shelter entirely filled with sediments was discovered (Fig. 3). At the surface of this unnamed rock-shelter several dozed bones and teeth of birds and small mammals were discovered. They all belonged to Late Pleistocene species, among them the willow ptarmigan *Lagopus lagopus* (det. T. TOMEK) and tundra rodents, the collared lemming *Dicrostonyx gulielmi* and the narrow-skulled vole *Microtus gregalis* (det. A. NADACHOWSKI). This discovery gave a direct impetus to begin an excavation at this spot. In June 2013 a regular excavation campaign was undertaken (NADACHOWSKI et al. 2015).

Description of sediments and stratigraphy

In 2013 an excavation of 5 x 5 m square meters was opened. The depth of the studied sediments reached ca. 50-60 cm. The following layers were distinguished (from top to bottom):

L a y e r I. Recent humus with larger limestone rubble of diameters up to 15-20 cm.

L a y e r I I. Yellow loams with significant quantities of relatively sharp-edged rubble and relatively numerous single larger particles and fossil material of small mammals.

L a y e r I I I. Brown clayey loam with a small amount of a fine sharp-edged rubble and numerous paleontological material of smaller vertebrates and rare remains of larger mammals. Few possibly Mesolithic artifacts were found in this layer. None radiocarbon dating was performed so far at the site.

Faunal remains

Fossil materials are present even on the surface of the sediment within the humus layer I. However, large amounts of faunal items, belonging first of all to small mammals and birds, were found in layers II and III (Table III). The fossil assemblage was dominated, like in the case of Obłazowa, by rodents which indicate birds of prey as a main source of the accumulation process. Bird remains belong to a ptarmigan *Lagopus* sp. and some Charadriiformes, which inhabit sandy or rocky margins of fast flowing rivers as well as small ponds (e.g. *Actitis hypoleucos*) or flood-plains and peatlands (e.g. *Gallinago media*). A small mammal assemblage consisting almost exclusively of rodents is characteristic for steppe-tundra environments. In the layer III a predominant species is collared lemming *Dicrostonyx gulielmi* (68%), an inhabitant of a well-drained tundra in cold climate. Development of open and dry steppe habitats is also confirmed by the presence of common vole *Microtus arvalis* (12%) and a very rare gray hamster *Cricetulus migratorius*. It seems that in the upper layer II

Table III

Frequency distribution of rodents (Rodentia) and insectivores (Soricomorpha) in layers I/II and III of Cisowa Skała. NISP – number of identified specimens, in the case of rodents first lower molars (M_1) were counted and in the case of *Sorex* – mandibles. MNI – minimum number of individuals. Results are based on examination of about 20-30% of available palaeontological material

Taxon	Layer III			Layer I/II			Habitat preferences
	NISP	MNI	%MNI	NISP	MNI	%MNI	
Cricetulus migratorius (PALLAS, 1773)	1	1	4.0	–	–	–	dry grasslands and steppes
Dicrostonyx gulielmi (SANFORD, 1870)	33	17	68.0	29	15	31.9	well drained tundra
Microtus gregalis (PALLAS, 1779)	8	4	16.0	43	23	48.9	open grassy areas in tundra and forests
Microtus arvalis (PALLAS, 1778)	4	3	12.0	13	7	15.0	open, dryer habitats
Chionomys nivalis (MARTINS, 1842)	–	–	–	2	1	2.1	rocky areas
Sorex araneus LINNAEUS, 1758 or/and *S. runtonensis* HINTON, 1911	–	–	–	1	1	2.1	damp habitats with dense vegetation
Total	46	25	100	88	47	100	

the surrounding landscape changed from dry and open to more wet with dense vegetation. This is documented by an increase of the narrow-skulled vole *Microtus gregalis* (ca. 49%) and the appearance of shrews *Sorex* while the frequency of *Dicrostonyx* decreased by half to ca. 32%.

Environmental and climatic reconstruction

The faunal composition of both studied layers III and II is characteristic for tundra steppe environments and very severe climatic conditions. It is especially true for the layer III where the collared lemming *Dicrostonyx qulielmi* distinctly predominates over other species. In the upper layer II a decrease in frequency of *Dicrostonyx* (to ca. 32%) and increase of the narrow-skulled vole *Microtus gregalis* (49%) is observed which probably means slight amelioration and dampness of the climate. Therefore the discovery of an artifact most probably from the Mesolithic is difficult to understand. The only explanation at this stage of research is that the Mesolithic people used the "Pleistocene surface" of sediments as a natural place for their activity.

IV. DISCUSSION

Both compared localities yielded information about faunal changes probably from different periods of the last glaciation. A preliminary analysis of the fauna from the rock-shelter in Cisowa Rock indicates a cold and rather dry period of e.g. LGM (Last Glacial Maximum, GS-3), the end of the Pleniglacial (GS-2a) or Younger Dryas (GS-1). However, these assumptions are highly speculative and must be regarded as preliminary due to the lack of radiometric dating. Assemblages from Obłazowa Cave (WE) were radiocarbon dated and therefore results and conclusions are more certain. The estimated radiocarbon age of the older part of layer III from Obłazowa Cave (WE) would be ca. 13,290 -13,130 years BP, or ca. 16,140-15,614 years BP after calibration (Table I). In terms of the GICC05 time scale, the lower part of the layer would thus be dated to the Greenland Stadial-2 (GS-2) chronozone, corresponding to what used to be referred to as the Oldest Dryas or Dryas 1 within the end of the Pleniglacial (BJÖRCK et al. 1998; RASMUSSEN et al. 2006; SVENSSON et al. 2006).

Of the dozen or so faunal assemblages dated in Poland to the end of the Pleniglacial (from GS-2c to GS-2a) only three – Obłazowa Cave (layers from III to V; VALDE-NOWAK et al. 2003), Krucza Skała Rock Shelter (NADACHOWSKI et al. 2009) and Wilczyce (NADACHOWSKI et al. 2014) – yielded enough faunal remains of small mammals to make possible comparisons with the fauna of Obłazowa Cave (WE). Available radiocarbon datings from the uppermost series of sediments from the chamber of the Obłazowa Cave (southern entrance) suggest that the layer IV (part) and the layer V (part) can probably be synchronized with GS-2 (b-a) (LORENC 2006, this paper Table I). The assemblage of small mammals from layer IV and V (NADACHOWSKI et al. 2003; RZEBIK-KOWALSKA 2003) is in general more diversified in comparison to the layer III (lower part) of the studied profile. On the other hand proportions of species of various habitat preferences are similar with the exception of number and eurytopic species category which is more diversified in the main profile of Obłazowa. In Krucza Skała Rock-shelter the lowermost layers I and/or 1 and perhaps 2 and/or II are age equivalents of the end of the Pleniglacial (NADACHOWSKI et al. 2009) and in Wilczyce the whole fauna can be dated to GS-2a (NADACHOWSKI et al. 2014). In general, among all compared faunas the tundra species (40-45%) prevail over other open habitat species (25-40%), while forest species are very rare (1-3%). Differences among assemblages concern mainly the number and frequency of eurytopic species (fluctuating from 8 to 30%) reflecting probably the degree of environmental mosaicity. In all studied assemblages the Norway lemming *Lemmus lemmus* is very rare or absent what seems to be a very characteristic feature of the communities dated to GS-2a.

The upper part of the layer III in Obłazowa cave (WE) is dated to the first half of the Late Glacial, around 14,815-14,055 cal BP, the period of global and abrupt warming of the climate of Bølling (GI-1e). The faunal assemblage shows some changes, particularly a decrease in frequency of tundra-dwelling species and increase of eurytopic and other open habitat species. The observed change is not so abrupt as expected. The number of species remains almost the same and only proportions of forms connected with different habitat categories are different from the lower part of the layer III, most probably due to environmental and ecological changes in the vicinity of the cave. The Bølling (GI-1e) faunal assemblages in Poland are rare. In the main Obłazowa Cave profile a part of the layer IV and layer III are most probable equivalents of the studied assemblage, however it must be confirmed by radiocarbon dating. The only available radiocarbon date from layer II yielded a younger, Allerød (GI-1c-b) date (11,260±60 BP), with range 13262-13033 cal BP (LORENC 2006). In Krucza Skała Rock-shelter layers I-III and/ or 1-3 may represent transition between Oldest Dryas (GS-2a) and Bølling (GI-1e) (NADACHOWSKI et al. 2009). The changes in faunal composition are far better expressed in comparison with Obłazowa Cave (WE). In layer 3 and III there is observed not only a decrease of tundra species but also the appearance of forest taxa (*Clethrionomys* and *Apodemus*) which were absent in older layers. In this context the small Magdalenian or perhaps tardigravettian (VALDE-NOWAK 2003) inventory from level IIIa in Obłazowa Cave should be recalled as the youngest Palaeolithic material found in the cave chamber. The above presented retouched blade made of red Pieniny radiolarite, found in a level III in the western entrance, fits well the Magdalenian flint industry known e.g. from Maszycka Cave (KOZŁOWSKI & SACHSE-KOZŁOWSKA 1993). The synchronization of the layer 3a in the chamber with the layer III in the west entrance cannot be excluded. Future research should clarify this point.

The site in Wilczyce near Sandomierz was set up in the older phase of the last cold episode (GS-2a) of the Pleniglacial, known as the Oldest Dryas or Dryas I, ca. 16,600-15,500 years ago (SCHILD 2014). The Wilczyce fauna consists of 30 species characteristic of various types of environments. These include two snail species, one amphibian species, eight or nine bird species, eight rodents, two lagomorphs, four carnivores, three ungulate mammal species and 1 elephant species (NADACHOWSKI et al. 2014). Predominant among the vertebrates are animals preferring open areas and species inhabiting steppe-tundra habitats overgrown with low brushwood or low trees. The small mammals include, most importantly, rodents characteristic of steppes overgrown with abundant and diverse flora and for tundra, the latter of the brushwood rather than the lichen variety. This category of animals includes the collared lemming *Dicrostonyx gulielmi*, narrow-skulled vole *Microtus gregalis*, common vole *Microtus arvalis* and steppe pika *Ochotona pusilla*, and the much larger marmot *Marmota*, as well as the ptarmigan *Lagopus lagopus*, all of them probably dominant species in this type of environment. Slightly drier and open habitats were inhabited by souslik *Spermophilus superciliosus* and the European hamster *Cricetus cricetus*. The nearby Opatówka valley could have been at that time overgrown with much higher shrubbery or even small trees, and this kind of environment was much better suited to the requirements of the black grouse *Tetrao tetrix*, the amphibious beaver *Castor fiber*, and the European water vole *Arvicola amphibius*. The faunal assemblage from Wilczyce is indicative of a distinctly mosaic-type environment around the site, with several plant formations characteristic for a wide variety of biotopes, ranging from the tundra and steppe to forest-tundra. A patchwork of habitats of this kind in the cold Late Pleistocene climate is most often described as steppe-tundra, a biome that does not exist in our times (HOPKINS et al. 1982; WILLIS & VAN ANDEL 2004). The distribution of plant formations in this biome depended on many paleogeographic factors; the morphology, slope exposition and angle, irrigation, soil type, etc.

The Krucza Skała Rockshelter fauna near Kroczyce in the Kraków-Częstochowa Upland is by far the youngest of all those being compared here, deposited some 2,000 years later than Wilczyce, and much more diverse, too. Of the six radiocarbon dates available for this site (NADACHOWSKI et al. 2009), one represents the cultural layer 4 (11,450±200 BP) (CYREK 1994) and another comes from the cultural layer 6 (11,210±70 BP) (NADACHOWSKI et al. 2009). Following calibration, these dates put the age of the fauna at anywhere between ca. 13,560 and ca. 13,000 years ago, placing both layers in the Allerød, or, more precisely, in the times of the GI-1b and GI-1c climatic oscillations. The fauna from

Krucza Skała is representative of the climatic warming in the Late Glacial and comprises a high number of species: 110 bird taxa (BOCHEŃSKI & TOMEK 2004) and 50 mammal species (NADACHOWSKI et al. 2009) as well as an extraordinary number of individuals, providing ample evidence that can be used to perform a comprehensive palaeoecological analysis. In archaeological layers 4 and 6 the forest species (25-30% of all the discovered species) prevail slightly over the steppe-tundra animals (ca. 20-25% of the species). The warming of the climate and changes in the vegetation cover resulted in a distinct increase over time in the number of forest-dwelling species, at the expense of those inhabiting steppe-tundra environments, with an ever greater presence of eurytopic fauna.

V. CONCLUSIONS

New excavations in Obłazowa Cave (western entrance) and the rock-shelter in Cisowa Rock supplemented the knowledge about the succession of the small vertebrate fauna in the Podhale Basin in Western Carpathians, Poland at the end of the Pleniglacial (GS-2a, the end of MIS 2) and/or very beginning of the Late Glacial (GI-1e, Bølling). An interesting feature of the analyses presented in this paper is that the change of faunal composition between the very cold end of the Pleniglacial (GS-2) and the much warmer Bølling (GI-1e) in Obłazowa Cave (WE) was not as spectacular as expected. Relatively small differences in the species composition between compared assemblages from the end of the Pleniglacial and beginning of the Late Glacial and from the other hand a shift of relative proportion of frequency between tundra-steppe and eurytopic species might suggest a slight change of environment conditions around the site in spite of probable important change of climate.

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