SUMMARY

MALACOFAUNA OF QUATERNARY DEPOSITS AND ENVIRONMENTAL CHANGES OF THE PODHALE BASIN DURING THE LATE VISTULIAN AND HOLOCENE

Introduction

Quaternary deposits of the Podhale Region are differentiated and usually enriched in calcium carbonate. They contain rich molluscan assemblages connected with several types of environments that developed during the Late Vistulian and the Holocene (the last 30 000 years). Changes of the environment, controlled by the climate and human activity, have been reconstructed according to the results of malacological analysis. The presented study is a contribution to scientific projects nos. 10.140.78 and 10.140.334, sponsored by the Academy of Mining and Metallurgy in Cracow.

The Podhale Basin is an area that extends between the Tatra Mts. and Beskidy Mts. It consists of the Zakopane Trough, the Gubałówka Foothills, Pieniny Klippen Belt and the Orawa-Nowy Targ Basin. The geological structure is considerably differentiated. The southern part of the region is composed of the Podhale Flysch, developed as shales and sandstones with carbonate matrix. Strongly folded Jurassic and Cretaceous limestones, marls, radiolarites and sandstones are the main geological formations of the Pieniny Klippen Belt. In the northern part of the area in question, flysch strata of the Magura Nappe are unconformably overlain by terrigenous sediments of Neogene age that fill a large intramontane basin.

Quaternary deposits are widespread. These are mainly fluviatile sediments (gravel, sand, silt and alluvial loam) forming river terraces, as well as slope deposits represented by loams and rock debris. Organogenic deposits, such as peat, calcareous tufas and travertines occur locally. Molluscan assemblages of these sediments are the subject of this study.

Material and methods

Twenty-five localities of mollusc-bearing deposits have been found during the field work (Fig. 1). Sixty-seven profiles have been selected for a detailed study. Nearly 300 samples were washed, so as to pick up all the shells of molluscs and determinable fragments of shells, as well as bones and teeth of vertebrates. The last ones were found in sixteen samples. The number of taxa varies between 1–58, and the number of specimens is 3–2620 per sample. The whole analysed material comprises 102 taxa of molluscs, 4 taxa of bivalves and 18 taxa of vertebrates. Three species of snails [*Pupilla loessica* Ložek, *Succinea oblonga elongata* Standb. and *Vallonia tenuilabris* (Braun)] are unknown in the recent Polish fauna, and one species [*Pupilla alpicola* (Charp.)] occurs only in the Podhale Basin. Molluscan spectra (MSS and MSI), introduced by Ložek (1964), were applied to the palaeoecological interpretation. Palaeoclimatic conclusions are based on geographic range of particular species, according to the method described by Sparks (1969), Kerney *et al.* (1983) and S. W. Alexandrowicz (1987a). The outlines of Quaternary malacological stratigraphy proposed by S. W. Alexandrowicz (1987a), Skąpski (1984) and other authors have been adapted and completed with the palynological and theriological data. Radiocarbon analysis made at the Silesian Technical University document the age of sediments at a few localities, as well as in palynological logs described by Obidowicz (1989, 1990, 1995) and at archaeological sites.

Shells of molluscs in Quaternary deposits of the Podhale basin

Numerous subfossil molluscs occur in sediments accumulated in different environments. Shells are preserved according to their resistance and to the kind of erosional processes. They may be found as sole components of assemblages or together with ostracodes, as well as with bones of small vertebrates. Changes of the climate and environment during the last 30 000 years can be reconstructed according to the diversity of mollusc-bearing deposits. Four types of Quaternary deposits were distinguished in the

area: slope debris, including material filling fissures and rock shelters, slope-wash and solifluction deposits, fluviatile deposits, calcareous tufas and travertines.

Slope debris

These deposits have been found on slopes of isolated calcareous tors and rocky hills of the Pieniny Klippen Belt. Sequences of mollusc-bearing deposits come from: Obłazowa Skała Hill-Rock (Ob), Korowa Skała Rock (Ko), Cisowa Skała Hill-Rock (Cs), Kramnica Hill-Rock (Kr) and Falsztyn Rocks (Fl) (Figs. 1, 2, 4, 5, 6).

L i t h o l o g y : More or less distinctly bedded loams, abounding in calcareous scree, and the fossil rendsina soils are the two main types of the described sediments. The first one occurs in eleven profiles, whereas the other one in four profiles.

Rock debris forms small fans at the foot of slopes. Fragments of limestones are angular and up to 20 cm in diameter, usually being 2–3 cm, 4–6 cm or 10–15 cm across. Particular layers contain well- or non- sorted material of different size. Loams abounding in fine-grained limestone detritus form either a matrix or intercalations devoid of rocks fragments. In most exposures, the scree containing coarse material occurs in the lower part of the profile. It becomes smaller upwards, but usually it is alternated with somewhat coarser detritus. The described deposits are yellow, yellowish-brown or red, depending on the lithological type of rocks forming the hill. The thickness of these sediments varies between 0.2–0.7 m. In most profiles it is 0.2–0.3 m. Similar deposits were found in fissures and rock-shelters.

The rendsina – type soil is developed on the surface of rocky-hills, mainly in flat parts of slopes and on rocky ledges formed of limestones. Individual soil profiles are composed of limestone rubble with dark or even black mull-humus matrix. More or less stone-free horizons occur at the top of the sequences at a few localities. This type of soil represents the initial rendsina, characterised by a very small thickness (0.1–0.2 m.).

M a l a c o f a u n a : Shells of molluscs are ubiqnitous in both types of the described deposits. The oldest fauna was found in slope detritus deposited at the foot of the rocky wall of Korowa Skała Rock (Ko-I); (Fig. 5, Table 1). The occurrence of *Vertigo arctica* (Say), *Vertigo genesii* (Gred.) and other cold-tolerant species, indicating a Late Vistulian age (Older Dryas/Alleröd), is noteworthy. Two profiles of rock detritus situated in the SE part of the Obłazowa Skała Hill Rock (Ob-II, Ob-III) contain nearly the same molluscan fauna (Fig. 4, Table 1). The occurrence of *Vertigo genesii* (Gred.), *Columella columella* (G. Mart.), besides *Arianta arbustorum* (L.) and *Semilimax kotulai* (West.) are the interesting feature of the fauna, characterised by numerous shells of *Discus ruderatus* (Fér.). In samples Ob-6 – Ob-9 shells of molluscs are accompanied by remains of rodents, such as *Lemmus lemmus* (L.), *Dicrostonyx gulielmi* (Stanford) and others (Table 3). Both molluscs and vertebrates indicate cold, continental climate. The described sediments were accumulated during the Late Vistulian, most probably during the Alleröd. Other outcrops of the deposits in question are connected with the upper part of the Middle Holocene and with Upper Holocene (Figs. 4, 5, 6; Tables 1, 2). The profiles of initial rendsina soils and a few of rock-detritus deposits, situated on southern slopes of the hills, contain poor molluscan assemblages. The open-country species [*Vallonia pulchella* (Müll.), *Vallonia costata* (Müll.)] and xerophile snails [*Cochlicopa lubricella* (Porro)] are the most typical on slopes overgrown with grass. On rocky walls *Chondrina clienta* (West.) and *Pyramidula rupestris* (Drap.) prevail. These molluscan assemblages were recognised in Cisowa Skała Hill Rock (Cs-I, II, III), Kramnica Hill Rock (Kr-I, II, III) and Falsztyn Rocks (Fl-II) (Figs. 5, 6; Table 2). Deposits accumulated on western or eastern slopes are characterised by the fauna with a considerable share of catholic and shadow-loving species: *Cochlicopa lubrica* (Müll.), *Clausilia dubia* Drap., *Euconulus fulvus* (Müll.), *Oxychilus depressus* (Sterki) (Obłazowa Skała Hill Rock (Ob-I, IV), Korowa Skała Rock (Ko-II) and Falsztyn Rocks (Fl-I)] (Figs. 4, 5, 6; Tables 1, 2). Woodland snails [*Oxychilus depressus* (Sterki), *Aegopinella pura* (Ald.)] dominate in loams enriched in rock detritus deposited on northern slope of Cisowa Skała Hill Rock (Cs-IV) (Fig. 5; Table 2). In a few samples remains of small vertebrates were found, too (Figs. 4, 5, 6; Table 3).

Slope-wash and solifluction deposits

These sediments have been found in lower parts of slopes. At a few localities slope-wash and solifluction deposits are characterised by an admixture of calcium carbonate. In these profiles shells of snails are well preserved.

Lithology: Solifluction deposits are composed of sand, silts and loams. They contain angular or somewhat rounded fragments of solid rocks of different size, ranging from 1–2 to 20 cm (up to 35 cm). These clasts are usually aligned parallel to the slope surface. Deluvial sediments, in turn, are dominated by silts, sandy-silts or sands devoid of rock fragments. Loams occur as intercalations or at the top of solifluction covers. Both these types of deposits can be regarded as one lithological unit. The thickness of the sediments described varies from one to five metres (up to nine meters). The cover was formed under purely periglacial conditions which were typical of the Vistulian and Late Glacial periods.

Slope deposits of Holocene age are developed as regoliths. Lithological properties of these sediments are depended on underlying rocks. They are composed of sands and silts with angular debris. At the Niedzica-Majerz outcrop (Nm-II) (Fig. 10) slope deposits are covered by peat.

Malacofauna: Shells of molluscs occur at three localities: Niedzica (Ns), Kosarzyska (Ks) and Niedzica-Majerz (Nm) (Figs. 1, 7, 8, 9, 10; Tables 4, 5). The oldest molluscan assemblage was recognised in two sections of solifluction-deluvial deposits at Niedzica (Ns-I, Ns-II) (Fig. 8; Table 4). The incomplete skeleton of mammoth [*Mammuthus primigenius* (Blum.)] was described from this profile by KULCZYCKI and HALICKI (1960). The molluscan assemblage found here encloses numerous shells of molluscs typical of loess or loess-like loams: *Pupilla loessica* Ložek, *Succinea oblonga elongata* Standb. and others. Similar deposits containing the same fauna at Mizerna were dated by ^{14}C method at 27 400 years BP (Gd-1917) (S. W. ALEXANDROWICZ 1988). This dating indicates the Interpleniglacial or Pleniglacial age. Younger molluscan assemblages were found in solifluction and deluvial sediments at Kosarzyska (Ks-I, Ks-II) (Fig. 7; Table 4). The fauna is dominated by cold-tolerant species: *Vallonia tenuilabris* (Standb.) and *Succinea oblonga elongata* (Standb.). In the upper part of the log Ks-II the occurrence of taxa typical of the Early Holocene [*Vertigo substriata* (Jeffr.), *Discus ruderatus* (Fér.)] was noted. The fauna indicates a Late Glacial and Early Holocene age. Stratigraphic hiatus between Ks-I and Ks-II can be connected with the Alleröd phase when solifluction processes were stopped. The fauna dominated by *Vertigo genesii* (Gred.) and bearing numerous shells of mesophile snails [*Nesovitrea hammonis* (Ström.)] was recognised in the lower part of the section at Niedzica-Majerz (Fig. 10; Table 5). It represents the Younger Dryas. A rich fauna with numerous shells of woodland snails is typical of Holocene slope-wash sediments. The occurrence of *Discus ruderatus* (Fér.), accompanied by other shadow-loving species at the site Niedzica-Majerz (Nm-I), is noteworthy (Fig. 9; Table 4). This community is connected with the Early Holocene. In the upper part of the mentioned log and in the log Ns-III (Fig. 8; Table 4) the fauna becomes more rich. Shadow-loving species prevail. The occurrence of *Discus perspectivus* (Mühlf.) and other taxa connected with the warm climate indicate a Middle Holocene age of these deposits. Peats covering slope sediments (Niedzica-Majerz Nm-II; Fig. 10; Table 5) contain a different molluscan assemblage. Mesophile and higrophile snails [*Succinea putris* (L.), *Cochlicopa lubrica* (Müll.)] are the main components of the fauna. Water molluscs [*Lymnaea truncatula* (Müll.)] and meadow species [*Vallonia pulchella* (Müll.)] complete this assemblage. The lowermost part of the peat was dated by ^{14}C method at 2670±90 years BP (Gd-4704). Both radiocarbon data and the fauna indicate a Late Holocene age.

Fluvial deposits

Fluvial deposits in the Podhale Basin form river terraces and alluvial fans. Numerous shells of molluscs have been found in a few sections of these sediments.

Lithology: Shells of molluscs were found only in low terraces of Holocene age, rising 0.5–5 m above the valley bottoms. At some localities, limestones and sandstones of Jurassic, Cretaceous or Paleogene age occur as a rock socle. Fluvial deposits are represented both by channel and overbank facies. The first of them is typical of the lower part of particular sections. It is developed as gravel with a sandy matrix. Pebbles are moderately rounded. Intercalations of coarse-grained sands were noted, as well. The overbank deposits forming the upper part of the sections are developed as fine-grained sands,

silts and muds, locally with an admixture of pebbles. At a few localities the deposits are enriched in plant remains, which were dated by the radiocarbon method. Sands, silts and muds of overbank facies contain numerous shells of molluscs.

M a l a c o f a u n a : The molluscan fauna has been found at eight localities: Rogoźnik Stream (Rg), Maruszyna (Ma), Skrzypne (Sk), Frydman (Fr), Łapszanka (Łt), Niedzica (Nt), Falsztyński Stream (Fk) and Łapsze Niżne (Łp) (Figs. 1, 11–16; Tables 6, 7, 8). The oldest assemblage was found in the lowermost part of the log Fk-I (Fig. 11; Table 6). It encloses cold-tolerant snails, such as: *Vertigo genesii* (Gred.) and *Semilimax kotulai* (West.), accompanied by woodland species, like *Discus ruderatus* (Fér.). The described sediments were accumulated during the Younger Dryas or the Preboreal Phase. The fauna typical of Early Holocene occurs in the lower interval of logs in Falsztyński Stream (Fk-I) and in Łapsze Niżne (Łp-I, II) (Figs. 11, 13, 14; Tables 6, 7). Shadow-loving species [*Discus ruderatus* (Fér.)] prevail, while mesophile and higrophile snails occur as an admixture. Shells of *Vertigo genesii* (Gred.), *Columella columella* (G.Mart) and other cold-tolerant snails have been found too. These taxa can be regarded as glacial relicts. This community resembles the „ruderatus-fauna", described by DEHM (1967) as an assemblage typical of the Early Holocene. Radiocarbon dating of sediments containing the mentioned fauna (8800±100 years BP) (Gd-5109) supports this interpretation. Higher up (middle part of profiles Fk-I, II, Łp-I, II, profile Fk-III and lower part of profiles Fk-IV, V (Figs. 11-14; Tables 6, 7)] the assemblage becomes more rich and differentiated. Woodland snails are important components of this fauna. Species typical of the Middle Holocene [*Discus perspectivus* (Müihf.), *Ruthenica filograna* (Rossm.)] are commonly noted. Sediments containing the described assemblage were dated by the radiocarbon method at 5610±130 years BP (Gd-2316). In the upper part of profiles Łp-II, Fk-III, IV, V and in the profiles from Maruszyna (Ma-I), Skrzypne (Sk-I), Rogoźnik (Rg-I, II, III), Frydman (Fr-I), Łapszanka (Łt-I) and Niedzica (Nt-I, II) (Figs. 1, 11, 14, 15, 16; Tables 6, 7, 8) the fauna is quite different. Two types of molluscan assemblages can be distinguished. The first one is characterised by the domination of shadow-loving species, connected with coniferous forests. These assemblages are found in low terraces of narrow, forested valleys. The second type contains a very poor molluscan assemblage, dominated by open-country snails. This fauna reflects the growing human impact. It is connected with sediments accumulated on the bottom of wide valleys within agriculture areas.

Calcareous tufas

The Quaternary calcareous sediments are commonly noted in the Podhale Basin. They contain more or less rich molluscan assemblages found at a few localities (Figs. 1, 17–24).

L i t h o l o g y : The exposures of mollusc-bearing Quaternary calcareous deposits are situated on the bottoms and slopes of valleys or close to springs. They are forming irregular bodies of a very differentiated structure. Five main lithological types of deposits can be distinguished: travertines – white or yellow, compact limestones, usually cavernous and porous; nodular travertines – yellowish-white calcareous sediments with angular fragments of compact travertine, reaching up to 20 cm in diameter; coarse-grained calcareous tufa – white, yellow or even brown deposits containing travertine gravel and calcareous sand; fine-grained calcareous tufa – sandy, white calcareous sediments; and calcareous silts – white, loose and unstratified deposits. The grain-size composition and content of calcium carbonate in a few samples of calcareous deposits from Podhale is presented in Tables 9 and 10 and Fig. 17. Calcareous tufas are underlain by fluvial or slope deposits. In the profile Łapsze Niżne they are intercalated and underlain by peaty silts. Peat containing fragments of travertines covers calcareous deposits in the Gliczarów site. The described calcareous deposits abound in shells of molluscs. The fauna occurs both in Late Glacial and Holocene sediments [Gliczarów (Gl), Ostrysz (Os), Groń (Gr), Łapsze Niżne (Łn), Niedzica (Nd)] and in recent ones (Mw) (Figs. 18–24).

M a l a c o f a u n a : The oldest molluscan assemblage was recognised in slope deposits underlying calcareous tufa at Gliczarów, Ostrysz and Groń (Figs. 18–21; Tables 11–13). The occurrence of *Vertigo genesii* (Gred.), *Semilimax kotulai* (West.) and other cold-tolerant species characterises this fauna as typical of the Late Glacial, probably indicating an Alleröd/Younger Dryas age of the sediments. In the lowermost part of profiles at Ostrysz, Gliczarów and Groń, a poor molluscan assemblage with the predominance of *Vertigo genesii* (Gred.) was found. This community is regarded as typical for a Younger Dryas (Figs. 18, 19, 21; Tables 11–14). Higher up, the fauna comprises numerous shells of *Discus rude-*

ratus (Fér.), accompanied by other shadow-loving species living in coniferous forests. Mesophile snails (*Vertigo substriata* (Jeffr.), *Euconulus fulvus* (Müll.)] are important components of this assemblage. A few shells of *Vertigo genesii* (Gred.) and *Semilimax kotulai* (West.) have been found, too. These species can be regarded as glacial relicts. The described fauna shows a close resemblance to the assemblage with Discus ruderatus, indicating the Early Holocene age of the sediments in question. Calcareous tufas containing the mentioned fauna was found at Gliczarów, Ostrysz and Groń sites (Figs. 18, 19, 21; Tables 11–14). At the locality Groń this interval closes the sedimentation of calcareous tufa. Differentiated assemblages, typical of the Middle Holocene, were recognised at Ostrysz, Gliczarów and Niedzica (Figs. 18, 21, 23; Tables 11–15). The main components of molluscan fauna are woodland species living in moderately warm climate: *Ruthenica filograna* (Rossm.), *Discus perspectivus* (Mülhf.) and a few others. Shadow-loving snails reach more than 50% of the assemblage. The other ecological groups of molluscs are scarcely represented. The described fauna passes upwards into the relatively poor and less differentiated community, with numerous woodland snails connected with coniferous forests. This interval, represented at Ostrysz and Gliczarów (Figs. 18, 21; Tables 11–14), indicates the deterioration of climatic conditions. The accumulation of at peat covering calcareous tufas at Gliczarów can be connected with these changes. The peat was dated by the ^{14}C method at 1730±50 years BP (Gd-1644) and 1210±180 years BP (Gd-2223) (Fig. 18). Recent calcareous tufas have been found at Ostrysz (Os-IV (Os-25), Os-VIII) and at a few other localities (Mw) (Figs. 1, 20, 21, 24; Tables 14, 15). They contain a relatively poor molluscan assemblage dominated by *Bythinella austriaca* (Frld.). A quite different molluscan fauna can be observed in calcareous tufa at Łapsze Niżne (Fig. 22; Table 14). At this locality calcareous sediments are underlain by peat, dated by the radiocarbon method at 8150±110 years BP (Gd-2792). In the whole profile, shadow-loving snails are represented by a few shells only. The tufas have been formed on the swampy bottom of the river valley. The open-country, mesophile and higrophile species prevail. In the lower part of this sequence the fauna is represented by *Vertigo substriata* (Jeffr.), *Nesovitrea hammonis* (Ström.), *Cochlicopa lubrica* (Müll.), whereas in the upper part *Pupilla muscorum* (L.), *Vallonia pulchella* (Müll.), *Vertigo angustior* Jeffr. and *Succinea putris* (L.) are main components of the assemblage. The occurrence of water molluscs living in temporary water bodies [*Lymnaea truncatula* (Müll.)] is noteworthy.

Molluscan assemblages

A few types of molluscan assemblages, recognised in the mentioned types of molluscs-bearing deposits in the Podhale Basin, can be distinguished. The stratigraphy and vertical extent of the described profiles is illustrated in Fig. 25. The succession of molluscan communities indicates environmental changes in the Podhale Basin during the last 30 000 years.

Slope debris

Mollusc-bearing deposits filling fissures and rock shelters were formed during the Late Glacial (Older Dryas and Alleröd), in the upper part of the Middle Holocene and in the Late Holocene [Fig. 25, Table 16 (C)]. Six types of snail communities can be distinguished in these sediments.

• The Semilimax kotulai and Arianta arbustorum assemblage

It is a relatively poor community, dominated by cold-tolerant species: *Vertigo genesii* (Gred.), *Columella columella* (G.Mart.) and the nominal taxa. This fauna can be regarded as typical for the uppermost part of the Older Dryas or the beginning of the Alleröd Phase. It was found in the profile Ko-I.

• The Discus ruderatus and Arianta arbustorum assemblage

Shadow-loving species of wide ecological tolerance prevail [nominal taxa, *Semilimax kotulai* (West.)] whereas a few specimens of cold-tolerant snails [*Vertigo genesii* (Gred.), *Columella columella* (G.Mart.)] have been found, too. Shells of molluscs are accompanied by remains of small vertebrates [*Dicrostonyx gulielmi* (Stamford), *Lemmus lemmus* (L.)]. Both molluscs and vertebrates indicate the Late Vistulian, most probably Alleröd age of deposits described from profiles Ob-II, Ob-III.

• The Oxychilus depressus and Aegopinella pura assemblage

It is a quite differentiated community characterised by the dominance of shadow-loving species, connected with the moderately warm climate [*Ruthenica filograna* (Rossm.), *Discus rotundatus* (Müll.)]. Open-country and mesophile species, as well as snails living on rocky walls are a supplement component of this fauna. The described assemblage corresponds with deposits laid down on the northern slopes of hills during the upper part of the Mesoholocene and Neoholocene (Ko-II, Cs-IV, Fl-I).

• The Clausilia dubia and Nesovitrea hammonis assemblage

This fauna is dominated by catholic species with an admixture of open-country snails *Vallonia pulchella* (Müll.) and woodland species [*Vitrea crystallina* (Müll.)]. It developed during the Middle and Upper Holocene (Ob-IV).

• The Pyramidula rupestris and Chondrina clienta assemblage

It is a very poor fauna containing mainly species living on rocky walls (nominal taxa), as well as shells of open-country and xerophile snails [*Vallonia pulchella* (Müll.), *Cochlicopa lubricella* (Porro)]. The assemblage is typical of southern slopes of hills and rocky walls. It was found in the initial rendsina soils and slope debris of Late Holocene age (Ob-I, Kr-I, II, III, Fl-II).

• The Vallonia pulchella and Pupilla muscorum assemblage

The fauna in question is dominated by meadow snails (nominal taxa), with an admixture of *Cochlicopa lubricella* (Porro.), *Pyramidula rupestris* (Drap.) and *Chondrina clienta* (West.). Other species are found sporadically. The mentioned community is typical of southern slopes of hills overgrown by grass. It was found in initial rendsina soils of the Upper Holocene on the Cisowa Skała Hill Rock (Cs-I, II, III).

Stratigraphic distribution of the assemblages are illustrated in Fig. 25 and Table 16 (C).

Slope-wash and solifluction deposits

These are sediments accumulated during the Late Vistulian, Late Glacial and Holocene [Fig. 25; Table 16 (S)]. Seven types of molluscan assemblages have been distinguished.

• The Pupilla loessica and Succinea oblonga elongata assemblage

It is a poor community containing cold-tolerant taxa: *Vallonia tenuilabris* (Standb.), *Clausilia dubia* Drap., besides nominal species. This malacocenose is closely similar to the „Pupilla-fauna", regarded as typical of loess. Shells of molluscs are accompanied by remains of vertebrates [*Mammuthus primigenius* (Blum.)]. Solifluction deposits, containing the same molluscan assemblage at Mizerna near Czorsztyn, were dated by the radiocarbon method at 27400±600 years BP. This dating indicates that slope sediments in the profile at Niedzica represent the last Interpleniglacial of the Vistulian Glaciation (Ns-I, II).

• The Succinea oblonga elongata and Pupilla sterri assemblage

Nominal taxa, accompanied by other cold-tolerant snails typical of loesses [*Vallonia tenuilabris* (Standb.), *Arianta arbustorum* (L.)], are the main components of the fauna. The occurrence of numerous shells of *Pupilla sterri* (Voith.) is connected with local conditions. The described assemblage, recognised in the profile Ks-I, indicates the latest Pleniglacial and Older Dryas age of these deposits.

• The Cochlicopa lubrica and Vallonia tenuilabris assemblage

It is a quite differentiated fauna containing two ecological groups of molluscs. The first of them comprises cold-tolerant snails, such as: *Vallonia tenuilabris* (Standb.) and *Arianta arbustorum* (L.), whereas the second one – catholic species of wide tolerance: *Euconulus fulvus* (Müll.) and *Cochlicopa lubrica* (Müll.). This assemblage is connected with the Late Glacial, probably with the upper part of Older Dryas or lower part of Alleröd. The fauna was found in the lower part of the profile Ks-II.

• The Vertigo genesii assemblage

This relatively poor community is dominated by the nominal taxon. A few other cold-tolerant and catholic species are important components of this assemblage. The fauna with Vertigo genesii, regarded as typical for the Younger Dryas was recognised in the lower part of the profile Nm-II.

• The Discus ruderatus assemblage

Woodland species connected with coniferous forests and the continental climate [*Discus ruderatus* (Fér.), *Eucobresia nivalis* (Dum. et Mort.)], as well as mesophile snails [*Nesovitrea hammonis* (Ström.)] are two main components of this fauna, although shadow-loving molluscs prevail. The described fauna is

similar to the Ruderatus-fauna, regarded as typical for the Lower Holocene (DEHM 1967), occurs at Niedzica (lower part of Nm-I) and Kosarzyska (upper part of Ks-II).

• The Discus perspectivus and Aegopinella minor assemblage

It is a very rich and differentiated fauna, characterised by the dominance of shadow-loving species typical of the relatively warm climate [nominal taxa, *Ruthenica filograna* (Rossm.)]. Molluscs of other ecological groups are a subordinate component of this assemblage. The fauna with Discus perspectivus is typical for the Atlantic Phase of the Holocene and was found in the profiles Nm-II, III.

• The Vertigo antivertigo and Succinea putris assemblage

The fauna occurs in peat in the upper part of profile Nm-II. Higrophile and catholic species (*Succinea putris* (L.), *Vertigo angustior* Jeffr.) prevail. Numerous shells of *Vallonia pulchella* (Müll.) have been found, too. The shadow-loving snails are represented by single specimens in a few samples. Radiocarbon dating from the lowermost part of peat (2670±90 years BP (Gd-4704) indicates the Late Holocene age of this fauna.

Stratigraphic distribution of the described assemblages is illustrated in Fig. 25 and Table 16 (S).

Fluvial deposits

Shells of molluscs occur mainly in muds and sands of overbank facies accumulated during the Holocene [Fig. 25, Table 16 (R)]. Six molluscan assemblages have been distinguished.

• The Discus ruderatus assemblage

Shadow-loving snails connected with coniferous or mixed forests [*Discus ruderatus* (Fér.), *Trichia unidentata* (Drap.)], and catholic species [*Nesovitrea hammonis* (Ström.), *Euconulus fulvus* (Müll.)] prevail. The occurrence of cold-tolerant molluscs, typical of the Late Glacial, is noteworthy. This fauna indicates an Early Holocene age of the lowermost part of profiles Fk-I and Łp-II.

• The Discus ruderatus and Aegopinella pura assemblage

This fauna is similar to that described above, but it is more rich and differentiated. Woodland snails prevail. The occurrence of species preferring moderately warm climate [*Aegopinella minor* (Stud.), *Aegopinella pura* (Ald.)] is a typical feature of this community. Shadow-loving molluscs are accompanied by mesophile ones. A few shells of *Vertigo genesii* (Gred.) and *Columella columella* (G. Mart.) have been found additionally. They can be regarded as glacial relicts. The described fauna occurs in the profile Łp-I, as well as in lower parts of profiles Łp-II and Fk-I. It is connected with the Boreal Phase of the Holocene [radiocarbon dating from Łp-II indicates the age 8800±100 years BP (Gd-5109)].

• The Discus perspectivus and Aegopinella minor assemblage

It is a very rich fauna characterised by the dominance of shadow-loving snails distributed in the moderately warm climatic zone. The community in question is typical for the Atlantic Phase of the Holocene. Plant remains found in sediments containing the mentioned assemblage was dated by C-14 method at 5610±130 years PB (Gd-2316). This fauna occurs in the profile Fk-III, in the middle part of the profile Łp-II as well as in the lower part of profiles Fk-IV and Fk-V

• The Vitrea crystallina and Vallonia pulchella assemblage

It is a relatively poor fauna devoid of snails typical of the climatic optimum of the Holocene. Shadow-loving species living in coniferous forests and open-country snails are two main components of this assemblage, found in the profile Fk-II and in the upper part of profiles Fk-IV and Łp-II. The described fauna is connected with the Subboreal Phase of the Holocene.

• The Vallonia pulchella assemblage

The community is very poor and characterised by the dominance of the nominal taxa. Single shells of catholic, higrophile and shadow-loving snails were found at a few localities. The described fauna was recognised in sections at Rogoźnik (Rg-I, II, III), Niedzica (Nt-I, II), Łapszanka (Łt-I), Frydman (Fr-I) and in the uppermost part of the profile in Łapsze Niżne (Łp-II). This community developed under the human impact within cultivated areas.

• The Vitrea crystallina and Monachoides vicina assemblage

Shadow-loving and mesophile snails [*Vitrea crystallina* (Müll.), *Nesovitrea hammonis* (Ström.), *Monachoides vicina* (Rossm.)] are the main components of the community. It developed within wooded,

narrow river valleys during the historical period. The described fauna was found in profiles at Maruszyna (Ma-I) and Skrzypne (Sk-I).

Stratigraphic distribution of the described assemblages is illustrated in Fig. 25 and Table 16 (R).

Calcareous tufas

Calcareous tufas and travertines of the Podhale Basin were accumulated during the Younger Dryas and the Holocene. These deposits contain a rich and differentiated fauna of molluscs. Nine molluscan assemblages can be distinguished [Fig. 25, Table 16 (T)].

• The Semilimax kotulai assemblage

It is a poor fauna comprising two groups of molluscs. The first one is represented by cold-tolerant snails: *Semilimax kotulai* (West.), *Vertigo genesii* (Gred.) and others. Species of wide ecological tolerance [*Nesovitrea hammonis* (Ström.), *Euconulus fulvus* (Müll.)] belong to the second group. The described assemblage was found in slope deposits underlying calcareous tufa in Ostrysz (lowermost part of the profile Os-II), as well as in Gliczarów (lowermost part of the profile Gl-IV), and can be attributed to the upper part of the Alleröd Phase.

• The Vertigo genesii assemblage

The fauna was found at Gliczarów (profiles Gl-IIIB, Gl-IIID, Gl-VI, lower part of the profile Gl-I, upper part of the profile Gl-IV), Ostrysz (lower part of profiles Os-I, III, IV, VI) and Groń (profiles Gr-II, III and lower part of the profile Gr-I). The nominal taxon, accompanied by other cold-tolerant ones [*Vertigo geyeri* Lindh., *Columella columella* (G.Mart.)], and catholic molluscs [*Nesovitrea hammonis* (Ström.), *Euconulus fulvus* (Müll.)] are the main components of this community. The assemblage occurs in the oldest calcareous tufas at Gliczarów, dated by the radiocarbon method at 10850±1800 years BP (Gl 1/83) and 10940±1830 years BP (Gl 15/83). Both the radiocarbon analysis and malacofauna indicate a Younger Dryas age of this fauna.

• The Discus ruderatus assemblage

This community is similar to the „ruderatus-fauna" of Early Holocene age in sections Gl-IIIA, Gl-IIIC, Os-II (except sample Os-3), the lower part of sections Gl-II, Gl-V, the middle part of the section Os-IV, as well as the upper part of sections Gl-I, Os-I, Os-III, Os-VI and Gr-I.

• The Nesovitrea hammonis and Vertigo substriata assemblage

This fauna is characterised by the dominance of catholic snails: *Nesovitrea hammonis* (Ström.), *Euconulus fulvus* (Müll.), open-country species [*Vallonia pulchella* (Müll.)] and higrophile molluscs [*Succinea putris* (L.)]. Woodland taxa occur as single shells. Deposits containing the described assemblage were dated by the radiocarbon method at 8150±110 years BP (Gd-2792). It indicates the Early/Middle Holocene age of this community. The fauna in question differs distinctly from the „ruderatus-fauna". It was developed within very humid, deforested environments. The mentioned assemblage was found in the lower part of profiles Łn-II, Łn-III, Łn-V and in the profile Łn-I.

• The Discus perspectivus and Aegopinella minor assemblage

This fauna was recognised both in calcareous tufa and in fluvial deposits and slope sediments. The described community is typical for the Atlantic Phase of the Holocene and was found in profiles Os-V, Nd-I, as well as in the middle part of profiles Gl-II, Gl-V and in the upper interval of the profile Os-IV.

• The Vitrea crystallina and Vallonia pulchella assemblage

Shadow-loving molluscs living in coniferous forests [*Eucobresia nivalis* (Dum. et Mort.), *Vitrea subrimata* (Reinh.)], catholic snails [*Nesovitrea hammonis* (Ström.)] and open-country species [*Vallonia pulchella* (Müll.)] are the main components of this fauna. Calcareous tufas containing the mentioned assemblage at Gliczarów are covered by peat, dated by the radiocarbon method at 1730±50 years BP (Gd-1644). This dating indicates the Subboreal age of the community. It was found in the uppermost part of the profile Gl-II.

• The Nesovitrea hammonis and Vertigo antivertigo assemblage

The fauna was found in peat covering calcareous tufas at Gliczarów and Łapsze Niżne (the upper part of profiles Gl-I, Gl-V, Łn-II, Łn-IV, Łn-V and the profile Łn-III). It is dominated by mesophile and higrophile snails. Radiocarbon datings of peat at Gliczarów [1730±50 years BP (Gd-1644) and 1210±180 years BP (Gd-2223)] indicate the Subatlantic age of this community.

• The Vitrea crystallina and Monachoides vicina assemblage

It is a quite differentiated community dominated by shadow-loving species (nominal taxa), accompanied by catholic and higrophile snails. The fauna developed during the Subatlantic Phase in wooded valleys of small streams. It was recognised in profiles Os-VII, Mw-I and Mw-IV.

• The Bythinella austriaca assemblage

The community is connected with calcareous sediments accumulated near springs. The nominal taxon dominates, reaching up to 95% of the assemblage. The fauna is typical of travertines of Subatlantic age, recognised in profiles Os-VIII, Mw-II, Mw-III, Mw-V and in the sample Os-25 (Os-IV).

Stratigraphic distribution of the described assemblages is illustrated in Fig. 25 and Table 16 (T).

Succesions of molluscan assemblages

Individual molluscan assemblages are connected with ancient habitats, changing with the evolution of climate.

The fauna of slope debris indicates the development of coniferous forests in the warmer phase of the Late Glacial (Older Dryas/Alleröd). Assemblages connected with the Lower and Middle Holocene are unknown. In the uppermost part of the Middle Holocene, as well as in the Upper Holocene the northern slopes were wooded, whereas the southern ones were covered by open habitats. The described changes are illustrated in Fig. 26(C). Communities occurring in solifluction and slope deposits reflect changes of the environment during the Late Vistulian, Late Glacial and the Holocene [Fig. 26(S)]. During the Interpleniglacial, Pleniglacial, as well as Prealleröd Phase, the subarctic tundra or steppe-tundra dominated. The occurrence of shadow-loving snails in the profile at Kosarzyska indicates a warming of the climate, connected with the beginning of the Alleröd Phase. In the Younger Dryas open-country and catholic species prevailed. Molluscan assemblages showing the dominance of woodland molluscs followed the spread of forests during the Early and Middle Holocene. In the Subboreal and Subatlantic Phases the differentiation of habitats followed. On steep slopes, shadow-loving snails were important components of the fauna, while on a flat ones open-country and mesophile species prevailed. Molluscan communities found in fluvial deposits indicate the domination of shady habitats during the Early and Middle Holocene. The growing human impact and the land occupations are expressed by the deforestation of environment. In the valleys of large rivers the fauna containing mainly open-country snails developed, whereas in narrow valleys the assemblages have been dominated by woodland species [Fig. 26(R)]. Molluscan communities connected with calcareous deposits characterise changes of the environment during the Alleröd/Younger Dryas, Younger Dryas and Holocene. In the Younger Dryas, the Podhale Basin was partly deforested. The development of shady habitats is evidenced by assemblages of woodland snails of Early and Middle Holocene age. In the Late Holocene the environment was partly or even mostly deforested [Fig. 26(T)].

Environmental changes in the Podhale Basin during the last 30 000 years are reflected by the sequence of molluscan assemblages described above. The transformation of ecosystems is illustrated in Fig. 27. The Interpleniglacial, Pleniglacial, as well as Prealleröd Phase correspond with environments of arctic or subarctic zones – the cold steppe or steppe-tundra (Fig. 27ES). The fauna of cold-tolerant snails, represented by assemblages with Pupilla loessica and Succinea oblonga elongata, as well as Succinea oblonga elongata and Pupilla sterri characterises this period. The first phase of afforestation is connected with the Alleröd Phase. At a few localities the communities containing woodland snails, typical of the coniferous forests and continental cold climate, were recognised (Fig. 27EW). During the Younger Dryas swamps and marches were developed, while the wooded areas became more reduced (Fig. 27EH). From the beginning of the Holocene, communities dominated with shadow-loving molluscs prevail. The maximum development of forests corresponds with the Atlantic Phase (Fig. 27EW). The reduction of wooded areas, connected either with climatic changes or with the human impact, appeared during the Late Holocene. The development of woodless, deforested zones corresponds with this period (Fig. 27EO).

Migration of species

The changes of molluscan assemblages, controlled both by climate and human activity can, be regarded as a result of the migration of species. During the last 30 000 years the main stages of migration are connected with the beginning of the Alleröd Phase, as well as with the Middle and Late Holocene (Fig. 28). At the termination of the Vistulian, molluscan assemblages were dominated by North European snails. Subsequently to the warming of the climate, their number decreases progressively. In deposits accumulated during the Holocene, the mentioned species occur only as glacial relicts. Since the Alleröd Phase, the Middle European snails have prevailed. The fauna was enriched in few elements, mainly woodland species typical for the coniferous forests (Fig. 28). The most important stage of the immigration falls into the climatic optimum of the Holocene. Numerous South European species arrived during that period. Most of them were decreased at the beginning of the Subboreal Phase. It was connected with climatic changes (Fig. 28). The migration connected with the human activity appears during the last 700 years. Recently, the fauna living in the Podhale Region is dominated by Middle European taxa. The palaeoclimatical structure of the fauna, as well as phases of migration are illustrated in Fig. 28.

Conclusions

Mollusc-bearing deposits of the Podhale Region are connected mainly with the Pieniny Klippen Belt. Quaternary sediments in this zone are enriched in calcium carbonate and contain rich molluscan assemblages. In other areas the fauna have been found in exceptional cases only.

Molluscan assemblages described above reflect environmental and climatic changes in the Podhale Region during the last 30 000 years. During the Interpleniglacial and Pleniglacial the fauna was dominated by cold-tolerant species, commonly noted in loess series (assemblages with Pupilla loessica and Succinea oblonga elongata, as well as with Succinea oblonga elongata and Pupilla sterri). Shells of molluscs occur in deluvial loams and solifluction deposits. The mentioned communities developed in woodless habitats, such as Arctic steppe or steppe-tundra, under the cold, periglacial climate. The content of Arctic and North European species reaches up to 90% or even more. Middle European snails occur additionally, whereas the South European ones were absent. The timber-line was about 250 m. a.s.l. The first phase of human activity in the Podhale Region is connected with the period mentioned (Fig. 29).

Sediments of the Prealleröd contain similar molluscan assemblages, progressively enriched in catholic species of wide thermal tolerance, especially in the late part of this period. The Interphase Bölling, documented by palynological analysis, is not evidenced in molluscan assemblages. The progressive warming of the climate in the upper part of the mentioned period is marked by the development of forests with Betula and Pinus, as well as by molluscan communities containing a limited number of shadow-loving snails. The North European molluscs prevail, but the occurrence of Middle European ones reaches up to 30% of the fauna. The timber-line at the termination of the Prealleöd Period was at about 500 m. a.s.l. (Fig. 29).

The Alleröd Phase was the first period of afforestation. Palynological analysis indicates the occurrence of forests with *Betula* and *Pinus*. The molluscan fauna became richer. Shadow-loving snails, mainly *Discus ruderatus* (Fér.), *Arianta arbustorum* (L.), as well as *Semilimax kotulai* (West.) are important components of the fauna, dominated by catholic species. In the optimum stage of the Alleröd Phase woodland snails prevail. The fauna became enriched in some Middle European or even South European elements. The occurrence of cold-tolerant species (*Vertigo genesii* (Gred.), *Vertigo geyeri* Lindh.) is noteworthy. The North European taxa are numerous, but the Middle European ones reach up to 40% of assemblages. Single shells of South European molluscs were found, too. The timber-line was at about 1000 m. a.s.l. (Fig. 19).

At the termination of the Alleröd Phase, the climate became more cold. That was the reason of the deforestation and the development of solifluction processes during the Younger Dryas. Molluscan assemblages were dominated by cold-tolerant snails preferring moist environments. The occurrence of shadow-loving species was reduced. The assemblage with Vertigo genesii, typical for the mentioned

period, was found in slope and fluvial deposits, as well as in calcareous tufas. It indicates a limited differentiation of habitats in the Podhale Region during the Younger Dryas. The first stage of carbonate sedimentation in Gliczarów, Ostrysz and Groń is connected with the mentioned phase. Palaeogeographical structure of the fauna is characterised by the dominance of the Middle European snails, with a considerable content of the North European ones. The South European molluscs are absent. The timber-line was lowered to 750 m. a.s.l. (Fig. 29).

At the beginning of the Holocene, a rapid warming was followed by the expansion of forests. The slope-wash and solifluction processes were replaced by chemical denudation. The molluscan fauna of the Preboreal age is characterised by the dominance of *Discus ruderatus* (Fér.) accompanied by mesophile snails. A limited number of cold-tolerant species is typical for this community. These snails can be regarded as glacial relicts. The Middle European molluscs prevail. The timber-line in the Preboreal Phase was raised to about 1000 m. a.s.l. (Fig. 29).

The progressive warming during the Boreal Phase is marked by the development of forests with *Pinus, Betula, Ulmus* and other species. Molluscan fauna dominated by *Discus ruderatus* (Fér.), was enriched by a few South European, shadow-loving snails. Catholic species were important components of the communities. At the termination of the Boreal Phase the cold-tolerant molluscs, typical for the Late Glacial, disappeared [except *Semilimax kotulai* (West.)]. The palaeogeographical structure of the assemblage is characterised by the domination of the Middle European taxa, but the South European ones comprise up to 20–25% of the community. The timber-line was at about 1400 m. a.s.l. (Fig. 29).The Atlantic Phase was a period of the maximum expansion of mixed and deciduous forests. The cessation of intense chemical denudation in the Podhale Region promoted the precipitation of calcium carbonate and the accumulation of calcareous deposits. Woodland snails, reaching up to 70–80% of the assemblages, prevailed. At the termination of the Atlantic Phase, the southern slopes of the rocky hills were deforested and overgrown by grass, as well as by xerothermic plants. In these areas molluscan assemblages contain mainly open-country and xerophile species. The palaeogeographical structure of the fauna is characterised by the dominance of the Middle European taxa with an admixture of the South European ones. The timber-line was lowered to 1800 m. a.s.l. (Fig. 29).

At the beginning of the Subboreal Phase, the cooling of the climate was noted. Molluscan assemblages became poorer and less differentiated. The limited content of the shadow-loving snails, connected with mixed forests, is a typical feature of the fauna. Woodland snails living in coniferous forests and mesophile taxa prevailed. The Subboreal Phase, as well as the beginning of the Subatlantic Phase were periods of the development of peat. The peat covers sediments containing molluscan assemblages of the Atlantic age. It can be observed at a few localities. The Middle European molluscs dominated, reaching up to 85% of the fauna. The timber-line lowers to 1700 m. a.s.l (Fig. 29).

Assemblages of the Subatlantic age correspond with the growing human impact. The development of agriculture and the main phase of deforestation is connected with the last 600–700 years. In the woodless areas, especially in wide valleys and on flat slopes, the poor fauna dominated by open-country snails developed. On steep slopes, as well as in narrow river and stream valleys, shadow-loving snails prevail. Middle European snails reach up to 90% of the assemblage (Fig. 29).

MALAKOFAUNA OSADÓW HOLOCENU W DOLINACH PRĄDNIKA I RUDAWY (POŁUDNIOWA POLSKA)

Osady holocenu odsłonięte w dolinach Prądnika i Rudawy są reprezentowane przez piaski i żwiry, mułki wapniste i torfowe, trawertyny i martwice wapienne oraz mady. Zawierają one bogate i różnorodne zespoły mięczaków, przeanalizowane w 28 profilach. Subfosylna malakofauna obejmuje 96 gatunków ślimaków i małżów. Wyróżniono 9 typów asocjacji, w tym 4 zespoły charakteryzujące osady najstarszego, dolnego, środkowego i górnego holocenu, odznaczające się obecnością takich gatunków jak: *Vertigo genesii* i *V. geyeri, Discus ruderatus, Discus perspectivus* oraz *Cecilioides acicula.* W dolinie Prądnika główną rolę odgrywa fauna z gatunkami typowymi dla środowiska otwartego z domieszką elementów mezofilnych i cieniolubnych, natomiast w dolinie Rudawy zaznacza się ilościowa przewaga asocjacji z gatunkami mezo- i higrofilnymi oraz zespołów mięczaków wodnych. W poszczególnych profilach omawiane zespoły tworzą sekwencje rozpoczynające się bądź fauną wodną bądź fauną środowisk niezacienionych, a ich kolejnymi członami są asocjacje o zróżnicowanym składzie.

Podział stratygraficzny osadów holocenu został ustalony na podstawie sukcesji malakologicznych i następstwa warstw z uwzględnieniem 18 datowań radiowęglowych. Wyróżniono także 4 poziomy gleb kopalnych o nieciągłym rozprzestrzenieniu. Zbiorczy schemat litostratygraficzny osadów budujących holoceńskie terasy obejmuje następujące ogniwa: piaski i żwiry facji korytowej przechodzące w mułki pozakorytowej facji vistulianu, mułki z wkładkami torfu, martwice wapienne i mułki dolnego i środkowego holocenu, mułki z obfitą domieszką materiału organicznego, reprezentujące fazę subborealną oraz mady mineralne górnego holocenu. W wąskich dolinach rozcinających Płaskowyż Ojcowski procesy erozji i akumulacji rozwijały się z większą intensywnością niż w szerokich dolinach, przebiegających w obrębie stref zapadliskowych. W plenivistulianie następowało nadbudowywanie den dolin przez lessy i mułki pochodzące a ich przemywania. U schyłku glacjału zaznaczyła się faza erozji, a w czasie trwania eo- i mezoholocenu narastały różnorodne osady mineralno-organiczne oraz węglanowe. Z początkiem fazy subatlantyckiej zaznaczyła się tendencja do rozcinania poprzednio utworzonych osadów, po czym w okresie historycznym (w średniowieczu) rozpoczęła się intensywna depozycja najmłodszych mad mineralnych.

Zmiany w składzie zespołów mięczaków odzwierciedlają przebieg ewolucji ekosystemów w czterech typach środowisk. Siedliska zacienione znamionowała początkowo fauna typowa dla lasów iglastych o typie tajgi, a następnie fauna lasów liściastych i mieszanych. Zespoły związane ze środowiskami otwartymi wykazywały w eo- i mezoholocenie nieznaczne zmiany, natomiast w miarę nasilania się wpływu działalności człowieka wzbogacały się one o gatunki migrujące z południa i południowego-wschodu. Znaczną stabilnością odznaczają się fauny środowisk podmokłych, w których z początkiem holocenu występowały reliktowe gatunki typowe dla klimatu zimnego. W zbiornikach wodnych asocjacje były uzależnione głównie od warunków lokalnych.

STRESZCZENIE

MALAKOFAUNA PÓŹNEGO VISTULIANU I HOLOCENU W BŁESZNIE KOŁO CZĘSTOCHOWY

Stanowisko Częstochowa – Błeszno leży na stoku doliny Warty, około 15 m powyżej jej dna. Na podłożu zbudowanym ze środkowojurajskich ciemnych iłów leży seria osadów piaszczysto-pylastych o miąższości kilkudziesięciu metrów. Wysortowanie materiału oraz charakter ziarn wskazują na jej eoliczną genezę. Ponad tymi utworami występuje martwica wapienna pylasta lub gruzłowata. W części spągowej zawiera ona znaczną domieszkę ziarn kwarcowych. Miąższość całego profilu dochodzi do 2 m. Zarówno w obrębie pokrywy piaszczysto-pylastej, jak i w martwicy wapiennej występują liczne skorupki mięczaków (fig. 1, 2A;P).

Z omawianego stanowiska pobrano 17 próbek, w których rozpoznano 57 gatunków mięczaków. Liczebność taksonów w poszczególnych próbkach waha się od 5 (w dolnej części profilu) do 46 (w części górnej). Liczebność okazów zmienia się od 112 do 2840 (fig. 2A;N). Zmienność malakofauny pozwoliła na wydzielenie trzech zespołów faunistycznych. Zespół z Vertigo parcedentata, występujący w najniższej części sekwencji (próbki 17–14), charakteryzuje się dominacją gatunków zimnolubnych, typowych dla osadów vistulianu [*Vertigo parcedentata* (Braun), *Columella columella* (G. Mart.)]. Fauna ta wskazuje na surowe warunki subarktycznej tundry o stosunkowo wilgotnym podłożu i można wiązać ją wiekowo z fazą starszego dryasu. W wyższej części profilu pojawia się zespół z *Vertigo genesii* (próbki 13–5). W asocjacji tej dominującą rolę odgrywa takson nominalny, któremu towarzyszą gatunki o dużej tolerancji ekologicznej [*Nesovitrea hammonis* (Ström.), *Euconulus fulvus* (Müll.)]. W wyższej części tego interwału pojawiają się nieliczne formy cieniolubne [*Semilimax kotulai* (West.), *Discus ruderatus* (Fér.)]. Malakocenoza o takim składzie wskazuje na chłodny klimat i podłoże o bardzo dużej wilgotności, a obserwowana zmienność w profilu pionowym świadczy o stopniowo postępującym ociepleniu. Asocjację tę można wiązać z interfazą alleröd oraz z fazą młodszego dryasu. Osady budujące najwyższą część profilu cechują się obecnością zespołu typowego dla dolnego i środkowego holocenu. Istotną rolę odgrywają w nim gatunki cieniolubne, w tym charakterystyczne dla optimum klimatycznego [*Ruthenica filograna* (Rossm.)].

Zmienność i skład malakocenoz świadczą, iż osady budujące profil w Błesznie tworzyły się w ciągu późnego glacjału oraz wczesnego i środkowego holocenu. Wytrącanie martwic rozpoczęło się prawdopodobnie w schyłku starszego dryasu lub w fazie alleröd. Omówione martwice są więc starsze od podobnych osadów opisanych z innych stanowisk na Wyżynie Małopolskiej (S. W. ALEXANDROWICZ 1983, 1984, 1987b), których tworzenie rozpoczęło się w młodszym dryasie lub w wczesnym holocenie.

MALAKOFAUNA I OSADY WĘGLANOWE W DOLINIE RZEKI PTYCZ NA WYŻYNIE MIŃSKIEJ W BIAŁORUSI

W dolinie rzeki Ptycz, w odległości około 10 km na południowy zachód od Mińska, występuje martwica wapienna podścielona i przykryta osadami organicznymi. Materiał poddany analizie malakologicznej pochodzi z profilu Ptycz-94 (ryc. 1). Profil ten ma miąższość 2,5 m i odsłania, ciemne mułki torfowe z licznymi fragmentami drzew, nad którymi leży biała, luźna martwica wapienna, przykryta ciemnymi mułkami ze szczątkami roślin (ryc. 2P). W całym profilu występują liczne skorupki ślimaków i małżów (tabela 1). W części dolnej (próbki Pt-1 – Pt-3) dominują gatunki wodne wskazujące na stały zbiornik (ryc. 2S), w niewielkim stopniu zarośnięty przez trzciny. Na taką sytuację wskazuje wartość wskaźnika Bithynia-index, wynosząca 0,08. W części wyższej (próbki Pt-4 – Pt-10) zespół mięczaków zmienia się, podkreślając stopniowe zarastanie i spłycanie zbiornika wodnego. W tym interwale fauna jest najbardziej zróżnicowana. Wartość Bithynia-index dochodzi do 0,65 wskazując na rozwój trzcin. Zespół rozpoznany w próbce najwyższej (Pt-11) znamionuje zanik otwartego zwierciadła wody i powstanie siedliska o charakterze podmokłej łąki. Zmienność i skład zespołów mięczaków obrazuje ewolucję podmokłego dna doliny z niewielkimi jeziorkami. Malakocenozy występujące w dolnej części profilu zawierają liczne skorupki *Vertigo geyeri* Lindh i *Gyraulus laevis* (Ald.) co świadczy, iż omawiany zbiornik powstał w późnym glacjale. Mułki torfowe podścielające martwicę były datowane metodą radiowęglową na 9600±50 lat BP. Sama martwica jest więc wieku holoceńskiego i tworzyła się w fazie borealnej i w młodszej części fazy atlantyckiej. Na taki wiek wskazuje obecność charakterystycznego dla początku optimum klimatycznego gatunku *Vertigo moulinsiana* (Dup.). Leżące na martwicy mułki organiczne są prawdopodobnie związane z fazą subborealną.