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The stratigraphy of Palaeolithic sites of the Cracow Upland

ABSTRACT: The palaeoclimatical interpretation of the sedimentary sequence, and the analysis of fossil fauna according to the assemblages differentiation connected with the environment conditions, allow to establish the stratigraphy of Palaeolithic cave sites of the Cracow Upland. The stratigraphy of the loess sites was based on the interpretation of the aeolian sediments sequence and of fossil soils and deformation structures. In both types of sites the archaeological materials of the Middle and Upper Palaeolithic were used as dating element supplemented by scarce age determinations (thermoluminescence and radiocarbon methods). Within the investigated profiles, the last cold period (Vistulian), the last interglacial (Eemian) and the decline of the Penultimate Glaciation are recognizable. Within the Vistulian sedimentary sequence, five lithostratigraphical units and five rodent assemblage zones are established.

INTRODUCTION

The subject of this paper is to discuss the correlation of sedimentary sequences from caves and from open site profiles as well as their stratigraphical interpretation.

About 20 cave sites were investigated (*see* Text-fig. 1 and Pls 1—5) but only some of them were interesting from stratigraphical point of view. The stratigraphical subdivision is based on palaeoclimatic and palaeoenvironment sequence reconstructed using lithological and faunistic methods.

The stratigraphy of loess sites is based on lithological and palaeopedological criteria. The correlation of these two types of sites was made on the background of archaeological materials, age determinations, but

first of all sedimentation, deformation and soil formation sequences (Text-fig. 2). The main principle of this stratigraphic interpretation is the succession of palaeoclimatical changes recognized by the use of different methods.

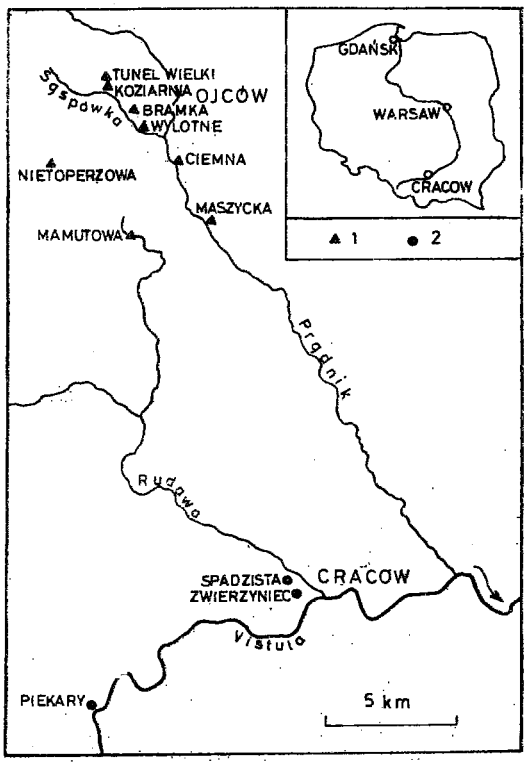


Fig. 1
Location of the main Palaeolithic sites of the Cracow Upland
1 cave sites, *2* open sites

The stratigraphy of the Upper Pleistocene, particularly of the Vistulian in glaciated regions is based mainly on the sequence of tills (Mojski 1980, Makowska 1980, Drozdowski 1980). Different criteria were used in the extraglacial regions, *e.g.* the development of loess and of fossil soils (*e.g.* Jersak 1973, Maruszczak 1980). In the other regions ,different authors used either the Dutch nomenclature (Hammen & *al.* 1967) or similar terms: Early Glacial, Early Vistulian, Pleniglacial, Pleni-Vistulian with subdivision into smaller units. The main criterion of this stratigraphy is the reconstruction of palaeoclimatical conditions, succession of erosion and accumulation processes in rivers and palaeobotanical data (Starkel 1977, 1980; Kozarski 1980). The limits of particular stratigraphic units of different authors differs according to the diachronic character of the phenomena used as stratigraphical criteria (Galon 1982).

The climatostratigraphic units employed by the author (left side of the Text-fig. 3) are useful for palaeoenvironmental and stratigraphical

interpretation of the Polish archaeological sites. As a chronostratigraphic framework, the geoclimatochrones defined by Wysoczański-Minkowicz (1982) were used as the most objective units calculated according to the solar radiation changes (*II* in Text-fig. 3). The fundamental units are thermo- and kalidostadials (*TS, KS*) grouped into thermo- and kalidomegastadials (*TMS, KMS*).

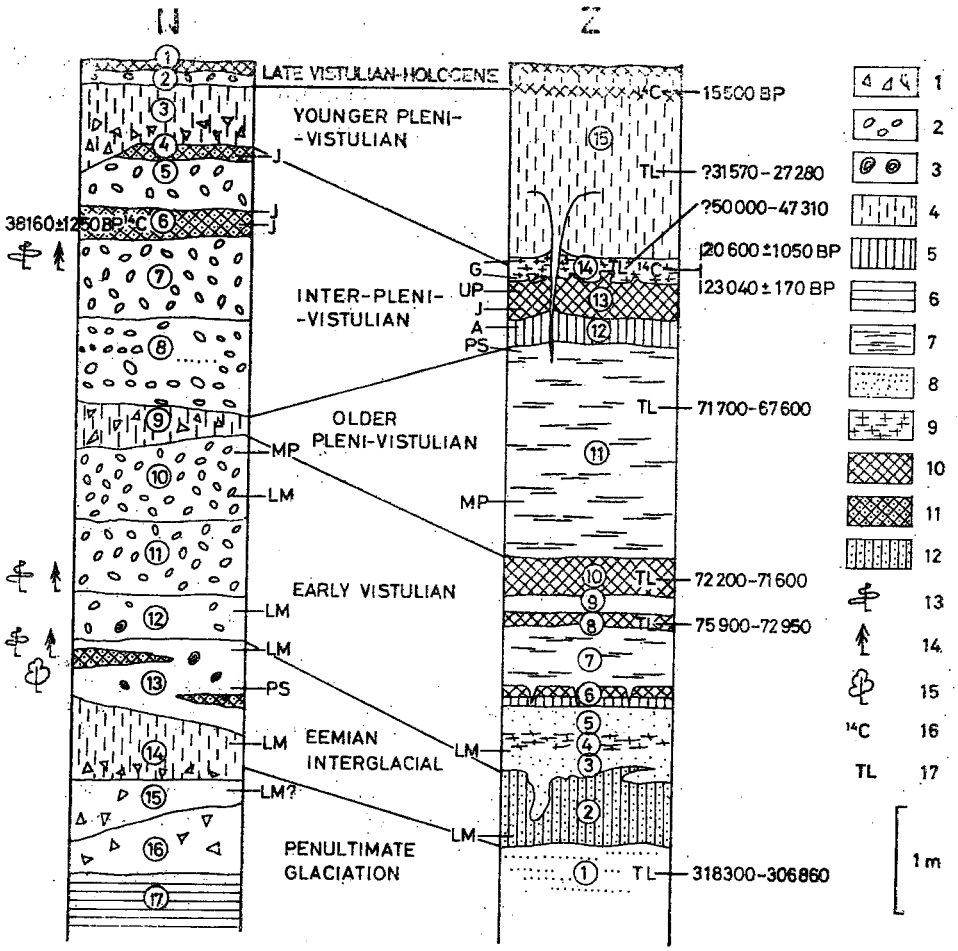


Fig. 2. Correlation of the Nietoperzowa Cave (**N**) and Zwierzyniec (**Z**) profiles; circled are the numbers of layers after the monographic descriptions (Madeyska 1969a, Chmielewski & *al.* 1977)

1 angular limestone rubble, *2* rounded limstone rubble, *3* limestone rubble strongly chemically weathered, *4* loess, *5* loamy loess, *6* clays, *7* laminated silts, *8* laminated and non-laminated sands, *9* horizon of gleification, *10* humus horizon, *11* cultural layer, *12* B_t horizon of the lessivé soil, *13—15* presence of charcoals (13 — *Pinus*, 14 — *Larix* vel *Picea*, 15 — *Fraxinus*), *16* samples taken for 14C dating (in the column *Z*, the samples are taken from the Spadzista site), *17* samples taken for thermoluminescence dating

Archeological cultures according to Chmielewski's (1975) classification: **LM** — Levallois-Mousterian, **PS** — Preseletian, **MP** — Micoquo-Prondnikian, **A** — Aurignacian, **J** — Jerzmanowician, **UP** — other Upper Palaeolithic materials, **G** — East Gravettian

The climatostratigraphical units are of different rank: the Older, Inter- and Younger Pleni-Vistulian relate to particular megastadials, and Early Vistulian to the two megastadials in the Wysoczański-Minkowicz's scheme. According to Różycki's (1972) stratigraphical subdivision and his interpretation of the Nietoperzowa Cave profile (*I* in Text-fig. 3), the Older and Younger Pleni-Vistulian relate to stadials (GIV-2, GIV max), but the Inter-Pleni-Vistulian relate to three units of this rank (GIV-2/1, GIV-1 and GIV-1/max). The early Vistulian can be correlated with two kalidostadials (J III/IV + 1 and J III/IV + 2) of the postoptimal part of the last interglacial. Correlations with palaeobotanically defined interstadials like Moershoofd or Hengelo are in any case hipothetical.

LITHOSTRATIGRAPHY OF CAVE SEDIMENTS

Lithological analysis was the main basis for the palaeoclimatic interpretation, environmental reconstruction and stratigraphy of cave and rock-shelter sedimentary sequences from the Cracow Upland (Madeyska 1969a, 1971, 1972, 1979, 1982).

The Nietoperzowa (*Bat*) Cave (*see* Pl. 5, Fig. 1, and *N* in Text-fig. 2) is stratigraphically the most important site because it yields the most complete sequence of the Upper Pleistocene sediments, whilst the other sites supplied only additional data on some finer stratigraphic units (*cf.* Chmielewski 1961, 1975; Madeyska 1969a, 1981; Różycki 1972).

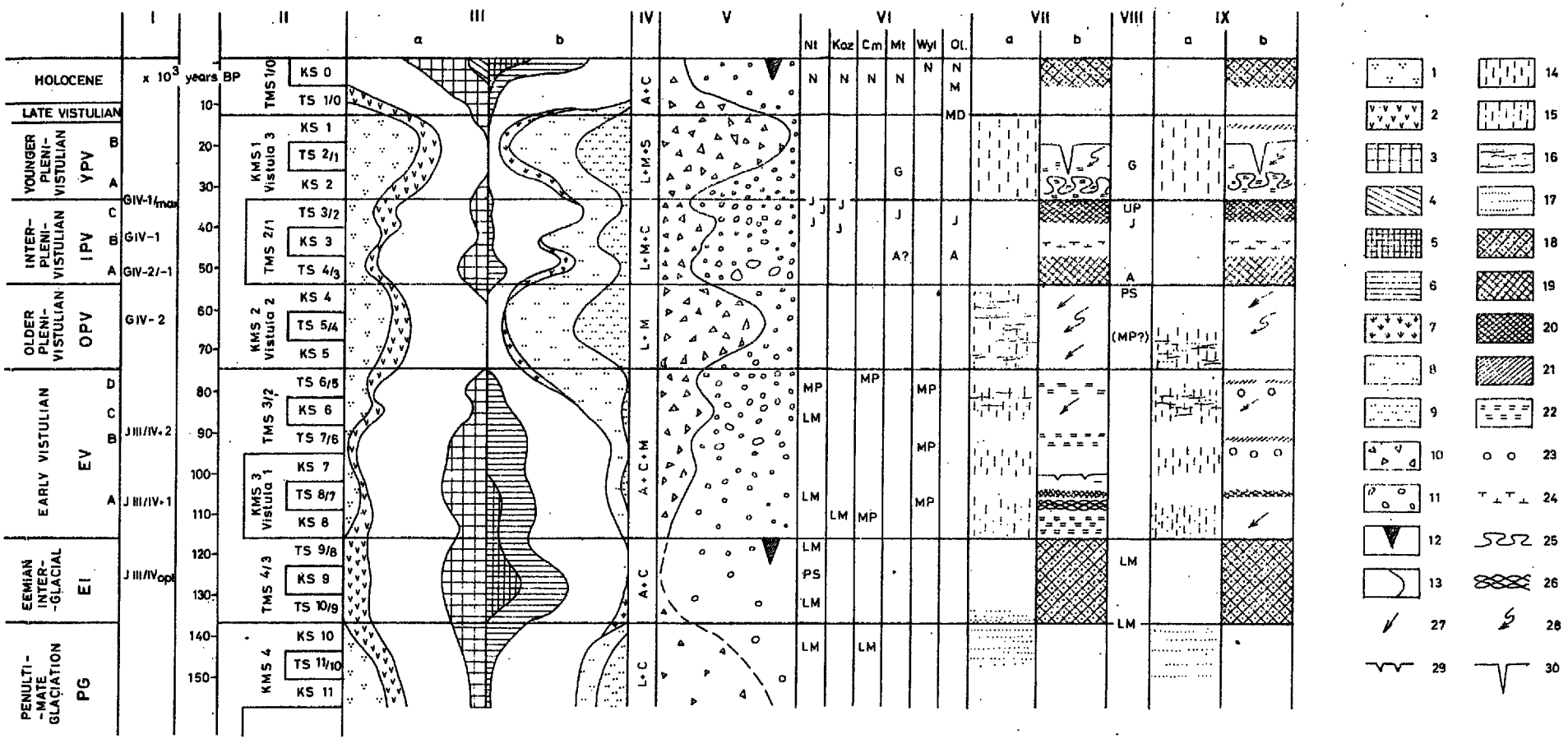
The variability of limestone rubble roundness coefficient (V in Text-fig. 3) is shown as a curve composed of the data from the Nietoperzowa Cave deposits, supplemented by those from other cave sites, *e.g.* for the Early Vistulian from Tunel-Wielki cave, for the younger part of the profile from the Koziarnia Cave (Pl. 5, Fig. 2), for the youngest part from the Bramka Rock-Shelter (Pl. 4). With the broken line in the lowest part of the profile the approximate roundness coefficient is shown because of the impossibility of accurate measuring in this part of the profile for strong chemical weathering of the limestone rubble.

The angular shape of limestone particles in the lowest part of the sequence testifies the cold climatic conditions during its sedimentation. The chemical weathering was connected with the later warm period. The fine material in this part of the sequence is loessic in type. Basing on the both features, these sediments are dated as the decline of the Penultimate Glaciation. They are covered by interglacial series characterized by the highest degree of chemical weathering among the whole sequence. In this horizon, inside a niche of the cave wall, was found a stalactite column originated probably at the interglacial time.

Between the interglacial and Holocene layers, two horizons of angular, fresh, crioclastic rubble are present, being thick in the entrance part of the Nietoperzowa Cave and thinner in its inner part. Analogical horizons of crioclastic rubble appear also in several other sites.

Within the Early Vistulian sediments of the Nietoperzowa, Koziarnia, and Tunel Wielki caves (*cf.* Chmielewski & *al.* 1967; Madeyska 1969a, 1981, 1982) it is possible to distinguish 2 or 3 oscillations of stronger traces of chemical weathering. Lithological criteria are not however sufficient for a precise correlation of particular oscillations with the Early Vistulian interstadials.

Geological, faunistic and archeological data for the discussed Palaeolithic sites of the Cracow Upland



I — Stratigraphic units, *after* Różycki (1972); **II** — Geoclimatochrones, *after* Wysoczański-Minkowicz (1982)

III — Percentage composition of mammalian fauna from the cave sites according to ecological requirements: a — percentage of mammalian species in ecological groups, b — percentage of rodent individuals in the same ecological groups: 1 tundra element, 2 steppe element, 3 forest element, 4 domesticated mammals, 5 *Apodemus silvaticus* and *Apodemus* sp. separated from the group of forest rodents, 6 remaining forest rodents, 7 steppe rodents, 8 tundra rodents, 9 *Dicrostonyx torquatus* and *Lemmus lemmus* separated from the group of tundra rodents; the emptyfields show the eurytopic elements

IV — Rodent Assemblage Zones; **V** — main lithological features of cave sediments; *10* angular limestone rubble, *11* rounded limestone rubble (density of hachure shows the limestone rubble amount), *12* horizons with speleothems, *13* roundness coefficient changes for limestone particles

VI — Culture horizons in the cave sites; **Nt** — Nietoperzowa Cave, **Koz** —Koziarnia Cave, **Cm** — Ciemna Cave, **Mt** Mamutowa Cave, **Wyl** — Wylotne Rock-Shelter, **Ot.** — other caves and rock-shelters; Archaeological cultures: **N** — Neolithic, **M** — Mesolithic, **MD** — Magdalenian; remaining explanations the same as for Text-fig. 2.

VII and **IX** — Succession of: **a** — sedimentation: **b** — pedogenetic, deformationand slope processes in the lower (*VII*) and the upper (*IX*) part of the Zwierzyniec site: *14* aeolian sedimentation of loess, *15* aeolin sedimentation of sandy loess, *16*slope sedimentation, *17* water sedimentation of sands, *18* formation of lesssivé forest soli, *19* formation of arctic brown soil, *20* formation of tundra gley soil, *21* formation of initial humus soil, *22* process of gleification, *23* arsing of "krotovinas", *24* frost weathering, *25* deformation processes of the "diapir" type, *26* formationof the ground-ice structures, *27* slope — washing processes, *28* solifluction, *29* development of desiccation fissures, *30* formation of frost wedges; **VIII** — Culturalhorizons in the Zwierzyniec and Spadzista sites; for designations of the cultures see Text-fig. 2

The Inter-Pleni-Vistulian series is characterized by chemical weathering lesser than the Early Vistulian series, and the presence of one cold oscillation that divides the series into two parts. In rock-shelters the redeposition of sediments took often place during the Inter-Pleni-Vistulian, and it is expressed by washing of loess-like silts into the shelter as well as by removing of sediments out off the entrance part of the shelters (Madeyska 1972). The similar process resulted in outwashing of deposits from the entrance part of the Nietoperzowa Cave, which is now visible as an erosion surface covered by the Upper Pleni-Vistulian loess with angular limestone rubble.

Late Vistulian and Holocene deposits are quite thin in the inner parts of the caves, and thicker in their outer parts, where they often form loose limestone debris (Madeyska 1982). The uppermost parts of cave fillings are usually cemented by carbonates.

LITHOSTRATIGRAPHY OF LOESS SITES

The Palaeolithic loess sites are known from a few places in the Cracow Upland (Kozłowski 1969; Chmielewski & *al.* 1977; Madeyska 1979, 1981; and *Upper Palaeolithic site...* 1972, 1974). Their stratigraphy is recognizable with the reference to soil formation sequences, ice wedges pseudomorphoses and other periglacial structures, as well as to the palaeomagnetic investigations (Jersak 1969, 1973; Mojski 1969; Tuchołka 1977; Maruszczak 1980).

The series of loess sediments at Zwierzyniec (*see* Pl. 6 and Z in Text-fig. 2) is preceded by lessivé forest soil with important B_t horizon similar to the common type of soils dated as the last interglacial (Konecka-Betley 1976, Jersak 1976, Maruszczak 1976). The differentiated set of aeolian and slope loess-like sediments with post ground-ice structures and humus intercalations (layers *3-10* at Zwierzyniec in Text-fig. 2) is correlated with the Early Vistulian.

Layer *7* at Zwierzyniec is correlated with the younger lowest loess (*LMn*) of Maruszczak (1980), and the humus horizons — with the interstadial soil Gi/LMn. Altogether with the lessivé soil, they correspond to the Nietulisko pedocomplex of Jersak (1973). Silts and sands of aeolian and slope sedimentation (layer *11*) correspond to the younger lower loess of Maruszczak (*LMd*). In many loess profiles this horizon is characterized by evidences of sedimentation under wet conditions on the contrary to the upper, typically aeolian loess (layer *15*) corresponding to the younger upper loess (*LMg*) of Maruszczak (1980). The bipartite soil complex (layers *12—13*), together with the inner frost weathering horizon which is correlated with Inter-Pleni-Vistulian, corresponds with two interstadial soil horizons (Gi/LMd and Gi/LMs) separated by the younger middle loess (*LMs*). The Younger-Pleni-Vistulian typical aeolian loess (layer *15*) has only in its lowest part the sympthoms of sedimentation under wet conditions resulting in its strong gleification (layer *14*).

The radiocarbon datings in the Zwierzyniec profile come from the stratigraphically corresponding layers of the neighbouring site Spadzista, whilst several thermoluminescence age determinations were kindly supplied by Dr. M. Prószyński and W. Stańska-Prószyńska. The two youngest dates obtained (*see* Text-fig. 3) are questionable, especially when compared with the datings from the analogous profile exposed at Wąchock in the Holy Cross Mts (*cf.* Lindner & Madeyska 1980).

FAUNISTIC CRITERIA OF THE CAVE FILLINGS STRATIGRAPHY

A rich fossil fauna in cave fillings consists of the mammals (among which the most important are the rodents), birds, reptiles, amphibians

and mollusks (*cf.* Kowalski 1961, 1962, 1966; Chmielewski & *al.* 1967; Stworzewicz 1973, 1982; Bocheński 1974, 1982; Nadachowski 1976, 1982). The composition of mammal assemblages was studied in order to reconstruct the environmental changes in the Upper Pleistocene (Madeyska 1981).

During the interpretation of faunistic data one has to conscious that any assemblage of the fauna contained in cave sediments differs seriously from the life community (Kowalski 1962, Madeyska 1981). Nevertheless, the quantitative differences are observable between particular species and groups of different ecological requirements (*III* in Text-fig. 3, and Text-figs 4—5). Basing on this material several rodent assemblage zones, bioecostratigraphical in their character, are distinguishable within the cave sites of the Cracow Upland:

L + C zone of lemmings and other tundra rodents with small admixture of *Clethrionomys glareolus*, corresponding to the decline of the Penultimate Glaciation;

A + C zone of silvan elements represented by *Apodemus* sp. and *Clethrionomys glareolus*, corresponding to the Eemian Interglacial;

A + C + M zone of occurrence of silvan species, in the beginning with *Apodemus* sp., with an increasing amount of tundra species, mainly *Microtus gregalis* and small admixture of lemmings, corresponding to the Early Vistulian;

L + M zone of almost exclusively tundra species, mainly lemmings, corresponding to the Older Pleni-Vistulian;

L + M + C zone of occurrence of *Microtus gregalis* and *Lemmus lemmus* with *Clethrionomys glareolus* and steppe species, corresponding to the Inter-Pleni-Vistulian;

L + M + S zone of almost exclusively tundra species with numerous lemmings and scarce steppe elements, corresponding to the Younger Pleni-Vistulian;

A + C zone of silvan elements, increasing in number when the tundra forms disappear, corresponding to the Late Vistulian and to the Holocene.

The above zones express much finer stratigraphic subdivision as compared with the biostratigraphical units distinguished within the whole mammalian fauna by Kretzoi (*cf.* Kretzoi & Pécsi 1979), by Tobien (1970) or by Feifar (1976), as well as climatozones offered by Chaline (1978), and elaborated basing on the migration of particular species.

ARCHAEOLOGICAL CRITERIA OF THE PALAEOLITHIC SITES STRATIGRAPHY

The geological and palaeontological investigations as well as the absolute age determinations of Palaeolithic sites show important acceleration in the evolution of culture units. Whilst the Lower Palaeolithic cultures endured much the same for hundreds of thousands years, the Middle Palaeolithic ones for tens of thousands, and the Upper Palaeolithic even shorter. The conclusion is that archaeological materials give important data for the stratigraphy of the Upper Pleistocene, because

the evolution of culture untis was quicker than the evolution of the biological creatures.

The complex investigation of Palaeolithic sites gives the designation of geological age of the majority of culture units, which now can be used as dating element in stratigraphy. One have to take, however, into consideration the possibility of big differences in the duration of cultural units in distant regions, especially with regard to climatic conditions.

The following review of Polish Palaeolithic materials is prepared basing on the literature (Chmielewski 1975, Kozłowski & Kozłowski 1977, Madeyska 1981).

The Lower Palaeolithic materials, Acheulean and Clactonian in type, were found in single implements or poor assemblages, very often on secondary bed. According to their stratigraphical position one could ascertain that the human occupation on the territory of Poland started in the Masovian (Holstein) Interglacial.

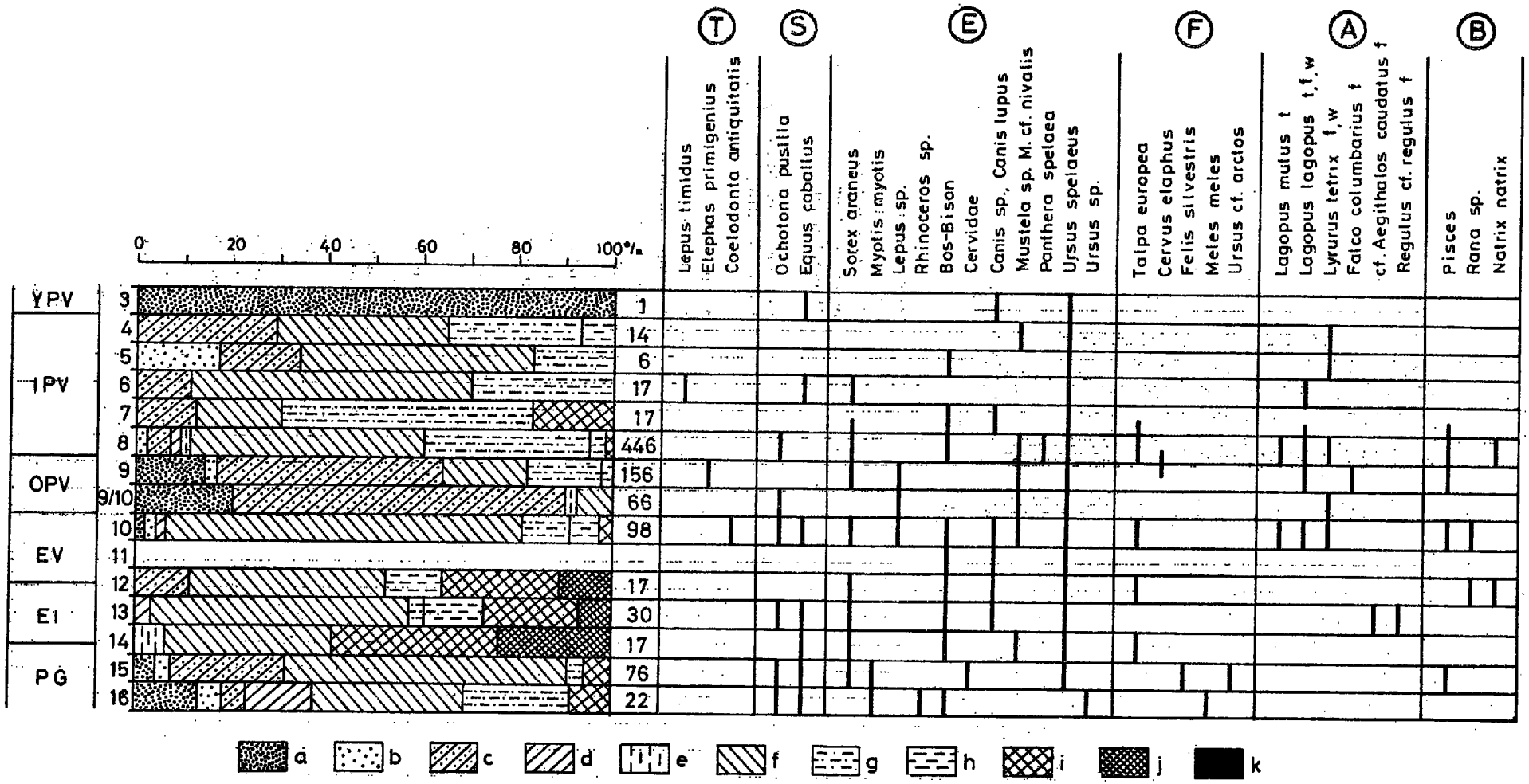
The problem of the beginning of human occupation following the retreat of the Penultimate Glaciation cames to be interresting. Firstly Krukowski (1939—1948) signalized the possibility of existence of cultural materials in sediments dated to the decline of Riss Glaciation, but only Zwierzyniec site and Nietoperzowa Cave throw light on the matter.

Two assemblages characterized by levalloisian technique were found in layers *15* and *14* of the Nietoperzowa Cave (Chmielewski 1961). The assemblage of 34 artifacts from layer *14* is similar to the assemblages from Zwierzyniec (Chmielewski 1975). The lithological composition of layers *15* and *14* evidences sedimentation under cold conditions with traces of amelioration (upper part of layer *14*). The fauna of layer *15* contains tundra species with lemmings, not so numerous as in layer *16*. Besides them, the elements of silvan fauna appear, increasing in number in layer *14*, where they are associated with steppe forms. These horizons correspond to the rodent assemblage zone *L+C* and older part of zone *A+C*, it means to the decline of the Penultimate Glaciation and the beginning of the Eemian Interglacial.

In similar stratigraphical position, in loess beneath the loam layer of the last interglacial, Krukowski (1939—1948) found in the Ciemna Cave two scanty assemblages of artifacts with levalloisian technique.

A few Levallois-Mousterian assemblages were discovered at Zwierzyniec (Chmielewski & *al.* 1977). The oldest one, 48 flint artifacts was found in stratified sands altered by the soil processes, in the lower part of the illuvial horizon of lessivé interglacial soil, whilst the younger materials in the upper part of the soil. The oldest assemblage comes from the time before the end of river sedimentation. These sands are correlated with gravels and sands of the so-called middle terrace of the Vistula, recognized in the eastern part of the city of Cracow (Klimaszewski 1952, Kleczkowski 1964, Tyczyńska 1968, Kozłowski 1969). The age recognition of this terrace and of the Prądnik and Dłubnia alluvial fans related to that terrace is difficult because of a thick cover of aeolian and slope sediments dated palaeobotanically and with radiocarbon method to the Pleniglacial (Mamakowa & Środoń 1977). According to hipsometrical data, the sands of Zwierzyniec correspond to the upper part of the Prądnik fan dated by mentioned authors for different stages of the Middle-Polish (Penultimate) Glaciation. The development of the interglacial soil at Zwierzyniec was contemporaneous with the erosional cutting of the upper part of the Prądnik fan. Early Vistulian aeolian and slope sedimentation at Zwierzyniec corresponds to the younger part of the Prądnik fan composed of limestone debris and loams of slope sedimentation.

Composition of fauna in the Nietoperzowa Cave sediments

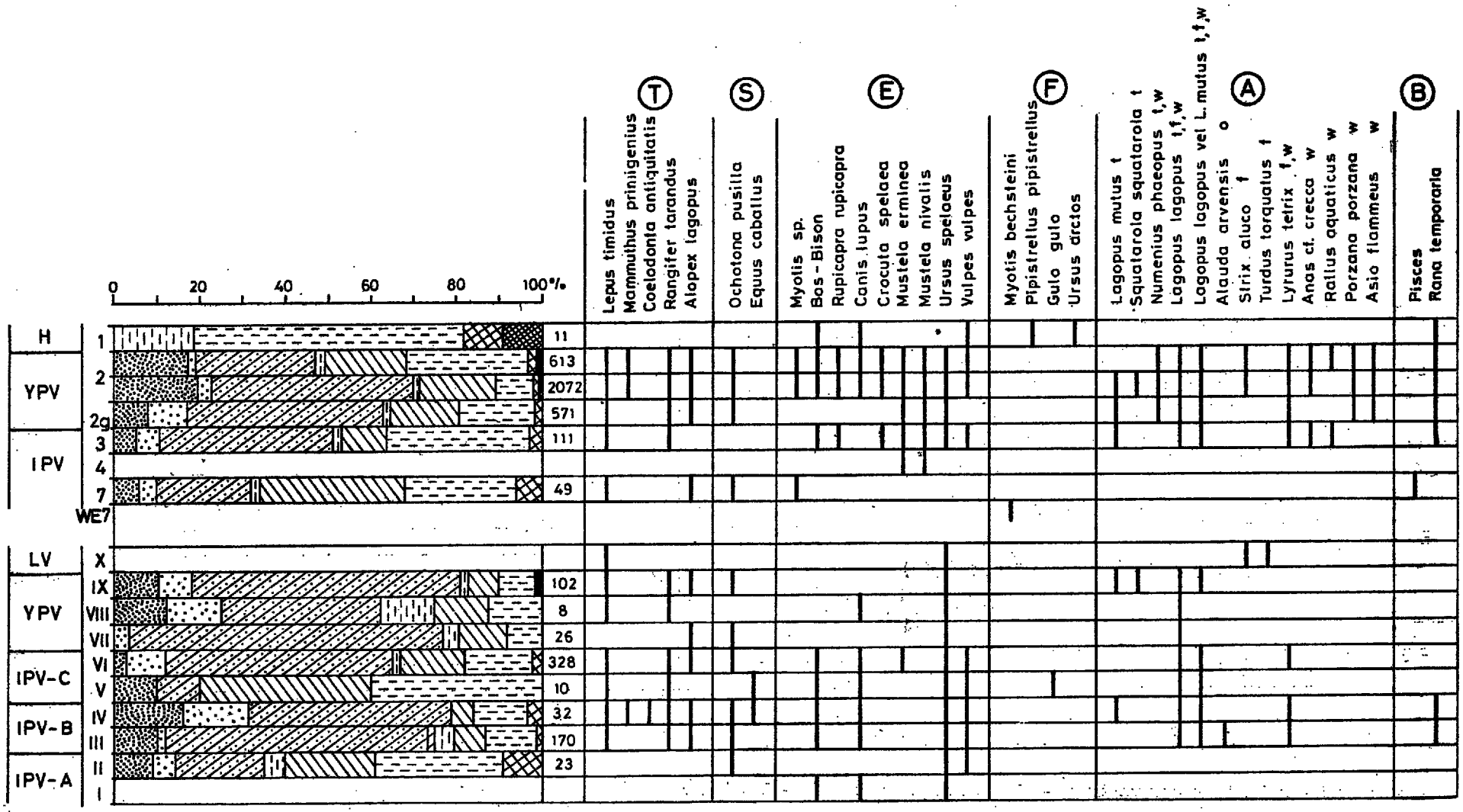


Rodents of tundra and cold environments: **a** — *Dicrostonyx torquatus*, **b** — *Lemmus lemmus*, **c** — *Microtus gregalis*, **d** — *Microtus nivalis*; **e** — Rodents of steppe environment: *Citellus citelloides*, *C.* ex gr. *major*, *C. superciliosus*, *Cricetus*, *Lagurus lagurus*, *Cricetulus* (cf.) *migratorius*; **f** — *Microtus arvalis/agrestis*; Rodents *living at water environment*: **g** — *Microtus oeconomus*, **h** — *Arvicola terrestris*; Forest rodents: **i** — *Clethrionomys glareolus*, **j** — *Apodemus* sp. and *Apodemus sylvaticus*, **k** — *Sicista betulina*

Other vertebrates: **T** — tundra mammals, **S** — steppe mammals, **E** — wide distributed mammals, **F** — forest mammals; **A** — birds (letters show the breeding habitats: *t* tundra, *o* open areas, *f* forests, *w* water-marsh); **B** fishes, amphibians and reptiles

Numbers at the left side show the layers, numbers in the middle — quantity of rodent individuals; all data *after* Kowalski (1961) and Bocheński (1974)

Composition of fauna in the Mamutowa Cave sediments



The upper part of the diagram shows the data from the section situated at the cave entrance, the lower one — from the section inside the cave; for explanations see Text-fig. 4

All data *after* Nadachowski (1976) and Bocheński (1974); several bird species found in layer *2* are ommited

The oldest Levallois-Mousterian assemblage from Zwierzyniec has, according to Chmielewski (*in* Chmielewski & *al.* 1977), an analoague in the Piekary *IIA* site (*cf.* Morawski 1975). This site (*cf.* Krukowski 1939—1948) is located on the headland close to the present-day Vistula river bed. The river gravels of Carpathian rocks with small admixture o cristalline rocks were deposited here on Jurassic rocky limestones at the altitude of 220 m a.s.l. On the surface of these gravels as well as in the overlying sands, the archaeological flint artifacts with levalloisian technique were discovered, partly on secondary bed. These materials, called by Krukowski as the Piekary industry, have recently been suggested by Kozłowski & Kozłowski (1977) as being of "Early Riss" age. Morawski (1975) as well as Chmielewski & *al.* (1977) dated these materials to the decline of the Middle-Polish Glaciation. The Carpathian gravels are probably the residuum of the Middle-Polish terrace (*cf.* Alexandrowicz 1960) corresponding to the above discussed terrace from the eastern part of Cracow and from Zwierzyniec. In such a case, the stratigraphical position of archaeological materials would be similar to that from Zwierzyniec, it means that the human occupation of the Levallois-Mousterian culture started during the decline of the Penultimate Glaciation.

As another culture of the Mousterian complex, the South-East Charentain was distinguished from the Raj Cave in the Holy Cross Mts (*Studies...* 1972) dated as the younger part of the Early Vistulian.

A distinct group of the Middle Palaeolithic materials consists of industries with hand-axes. Among them, Kozłowski & Kozłowski (1977) distinguished assemblages of the Bockstein, of the Ciemna and of the Wylotne type. These three groups Chmielewski (1969, 1975) jointed into one Micoquo-Prondnikian culture that shows its evolution observable in the proportion differences between particular types of implements, reaching a dozens of percent during the whole Early Vistulian. All the assemblages of this culture are younger than the last interglacial, the youngest one from the Cimna Cave is contemporaneous with the beginning of loess sedimentation of the Older Pleni-Vistulian (Madeyska 1969b).

Besides these Middle Palaeolithic cultures, poor assemblages with leaf points known from Poland are interpreted by Chmielewski (1975) as Preseletian; Kozłowski & Kozłowski (1977) point to their connection with the Muselievo-Samuilitza culture known from the Balcan Penninsula. One assemblage o this type was found in the declining part of the Eemian Interglacial sediments in the Nietoperzowa Cave, another one in slope sediments of the Older Pleni-Vistulian at Zwierzyniec (Chmielewski 1975, Chmielewski & *al.* 1977).

Among above mentioned Middle Palaeolithic cultures two are important from stratigraphical point of view — the Levallois-Mousterian and Micoquo-Prondnikian (according to Chmielewski's definition) because of their occurrence in several sites in stratigraphical position comparatively well defined.

The persistence of Middle Palaeolithic cultures in Poland terminates with the beginning of the first coldness maximum, it means Older Pleni-Vistulian (rodent assemblage zone $L + M$) when a gap in human occupation becomes apparent.

The next period of occupation falls to the Inter-Pleni-Vistulian. Of this age several tens of sites are known, but few only have good stratigraphical framework. In the Polish archeological literature various kinds of cultural subdivision of the Upper Palaeolithic results from different understanding of cultural development rules, expansion of cultural units, connections between particular occupation groups and interpretation of diverse lithic assemblages differentiation (Kozłowski 1980, Dolukhanov & *al.* 1979).

Chmielewski (1975) and Schild (1975) include to the Upper Palaeolithic all the archaeological materials of the Inter-Pleni-Vistulian and of the beginning of

the Younger Pleni-Vistulian. Younger materials, started since the Magdalenian, which are separated from the former ones by the Younger Pleni-Vistulian break in occupation, are included to the Late Palaeolithic. Kozłowski (1980) and Kozłowski & Kozłowski (1977, 1979) divided the Upper Palaeolithic into three phases of development and included the Magdalenian complex into the youngest one.

The Jerzmanowician culture was defined by Chmielewski (1961) basing on three assemblages from the Nietoperzowa Cave and poor materials from the Koziarnia and Mamutowa caves, Puchacza-Skała Rock-Shelter (*VI* in Text-fig. 3) and from Zwierzyniec. The oldest assemblage in the Nietoperzowa Cave was found in the layer dated lithostratigraphically to the cold oscillation *(B)* inside the Inter--Pleni-Vistulian. The charcoals from this layer were dated using radiocarbon method for 38 160 ± 1250 BP (Gro 2181). Two younger assemblages from the Nietoperzowa Cave and the materials from the layer *VI* of the Mamutowa Cave are dated as the Inter-Pleni-Vistulian C. Professor W. Chmielewski (*oral information*, 1979) considers that the assemblage from Zwierzyniec is older from the above mentioned ones. It is thought that Jerzmanowician developed during the Inter--Pleni-Vistulian *B* and *C*, but its Inter-Pleni-Vistulian *A* age still remains probable.

The wide distribution of Aurignacian materials in Europe and their important differentiation show that it could not be a homogenous culture unit. Kozłowski (1966, 1981), and Sachse-Kozłowska (1978) distinguish several regional cultures of Aurignacian tradition, while Chmielewski (1975) supposes that typical assemblage of the Aurignacian implements makes an intercultural value adopted by people of different cultures.

At the Zwierzyniec site, the Aurignacian materials occur in the soil horizon of the Inter-Pleni-Vistulian *A*. At the Spadzista site, this assemblage is dated by Kozłowski (1980) for the "interphase Arcy — Stillfred *B*".

In the famous site Góra Puławska in Central Poland, the Aurignacian materials were found in soil and loess-like silts lying beneath loesses covered by sands of the Vistula river terrace (Sawicki 1954); this soil can be correlated with the Inter-Pleni-Vistulian as a whole.

The stratigraphical situation of other Aurignacian assemblages (Mamutowa Cave, Piekary) is not clear.

A distinct group of the Upper Palaeolithic assemblages was called by Chmielewski (1975) as the East Gravettian, and by Kozłowski (1980) as the Backed Points cultures. Three units of that group were distinguished in Poland: Kostienkian-Avdeevo, Pavlovian, and the assemblage from the Mamutowa Cave.

Stratigraphical position of the Kostienkian-Avdeevo culture (*Upper Palaeolithic...* 1974) was stated at the Spadzista site. The materials were found above the Inter-Pleni-Vistulian soils, in the so-called solifluction layer originated during the beginning of the Younger Pleni-Vistulian loess sedimentation which took place under wet conditions and are correlated with the layer of gleified, laminated loess (layer 14) at Zwierzyniec.

Two radiocarbon dates were obtained from the Spadzista site: for kollagen of mammoth bones 20 600 ± 1050 BP (Ly 631), and for burned bones and charcoal 23 040 ± 170 BP (Grn 6636). These data show that the development of this culture took place at the beginning of the Younger Plein-Vistulian. Kozłowski (1977) dates it to the interstadial Tursac, defined in France.

An assemblage with back-point was found in the Mamutowa Cave in the lower part of the layer 2 composed of limestone rubble and loess, dated to the Younger Pleni-Vistulian.

The Pavlovian culture assemblage from Wójcice (Ginter 1966) originated probably at the same time.

During the Inter-Pleni-Vistulian, the Szeletian culture existed on the territory of Poland, as well as the recently defined Zwierzyniec culture (Kozłowski & Sachse-Kozłowska 1980). Precise dating of these two cultures is not possible.

The Magdalenian culture represented in the Cracow Upland by the assemblage from the Maszycka Cave, and by several poor materials from another cave and from open sites, appeared on this territory during the decline of the Younger Pleni-Vistulian. It expanded to the north and occupied, like the other Late Palaeolithic cultures, primarily the Middle European Lowlands.

FINAL REMARKS

The cave and loess Palaeolithic sites situated in the Cracow Upland and along the Vistula valley offer a well-outlined picture of palaeoecological changes during the Upper Pleistocene. The correlation of these sites profiles is founded on the comparison of the sequence of these changes reconstructed using lithological, palaeopedological and palaeozoological methods and supplemented by prehistoric data (Text-fig. 6). The

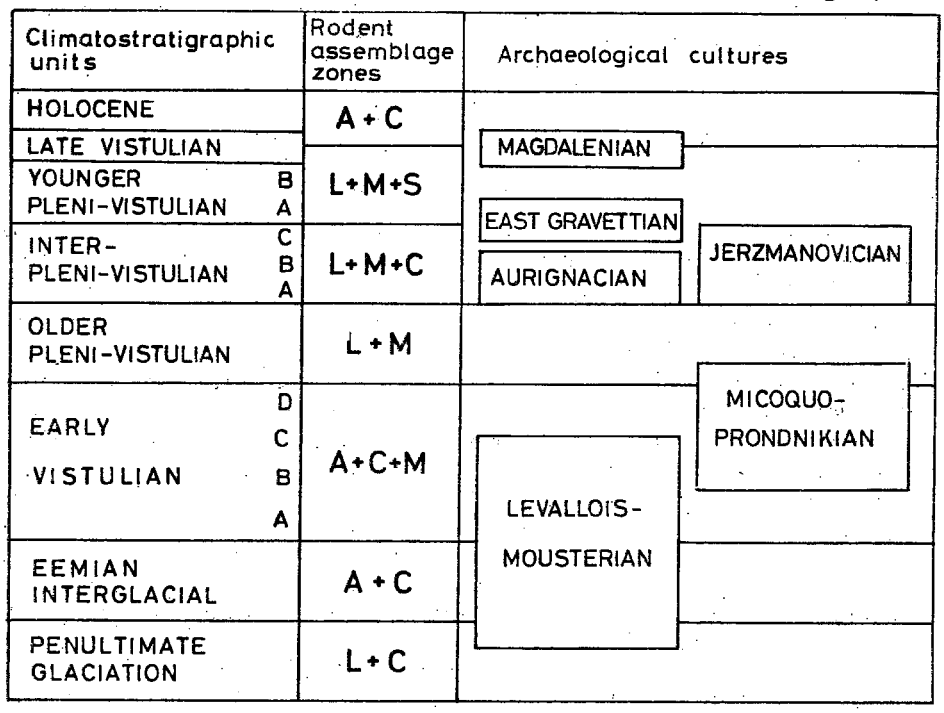


Fig. 6. Correlation of the Upper Pleistocene and Holocene climatostratigraphical, faunistic, and archaeological subdivisions

profiles of these two types of sites complement each other, because the warmer periods (Early Vistulian, Inter-Pleni-Vistulian) are represented by compartively thick series of cave deposits, whilst colder ones are better represented by series of loess in open sites.

The distinguished climatostratigraphic units have good documentary evidence, but the correlation of smaller units with those distinguished palaeobotanically is hipothetical.

In the Early Vistulian sediments of the Nietoperzowa Cave two warmer oscillations are distinguished (Early Vistulian *B* and *D*) after the Eemian Interglacial, whilst in the Tunel-Wielki Cave three horizons were observed which are corelated with the warmings. At the Zwierzyniec site, in the slope-aeolian sediments of this time, three humus horizons are present, but their stratigraphical rank is probably smaller. Probably the Early Vistulian *B* corresponds to the Brørup and Early Vistulian *D* — to Odderade interstadial (Hammen & *al.* 1971).

Basing on the big caves profiles as well as complicated structure of the fossil soil complex at Zwierzyniec, a long duration in time of the Inter-Pleni-Vistulian is assumed. In the loess stratigraphy of Maruszczak (1980), this period corresponds to two fossil soils (Gi/LMd and Gi/ /LMs) and the middle younger loess. It correponds as well to the Interpleniglacial distinguished by Starkel (1980) in the Carpathians, and to the Middle Pleni-Vistulian in the Wielkopolska Lowland after Kozarski (1980). It is also possible to correlate this period with the Middle Pleniglacial in Holland (Kolstrup & Wijmstra 1977), composed of the interstadials of Moershoofd, Hengelo (= Inter-Pleni-Vistulian *A*) and Denekamp (= Inter-Pleni-Vistulian *C*). Similarly long period was defined by West (1978) as interstadial complex Upton Warren for the Great Britain and by Zarrina (1982) as Middle Valdai stratigraphic horizon for the glacialed region of the European part of the USSR. The Scandinavian intermorainic interstadials Peräpohjola and Jämtland (Tobolski 1975) probably correspond to the Inter-Pleni-Vistulian *A*.

Camparing with profiles of the Lower Vistula river it is supposed that the interstadial Gniew (Makowska 1980) corresponds to the Inter--Pleni-Vistulian *A* and subinterstadial Grudziądz to the Inter-Pleni-Vistulian *C*. In the stratigraphical scheme presented by Mojski (1980) and Drozdowski (1980) the whole Inter-Pleni-Vistulian corresponds to the Grudziądz interstadial.

The older part of the Younger Pleni-Vistulian (*A*) was distinguished in the profiles of Zwierzyniec and Spadzista basing on the features of loess indicative of the sedimentation under wet conditions with distinct presence of vegetation documented by the organic substance contents. According to the radiocarbon datings for the Spadzista site (20—23 thousands years BP), this horizon would be correlated with the moss-peat and sandy mud layer of Konin-Maliniec *II* (Kozarski 1980) dated to a little bit more than 22 thousands years BP, and deposited shortly before the transgression of the Vistulian icesheet in the Wielkopolska Lowland.

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REFERENCES

ALEXANDROWICZ S. W. 1960. Geological structure of the vicinity of Tyniec (Cracow region). *Biul. IG*, **152**, 5—93. Warszawa.

BOCHEŃSKI Z. 1974. The birds of the Late Quaternary of Poland; 197 pp. *PWN;* Warszawa.

— 1982 (*in press*). Fossil birds from the caves of the Sąspowska valley.

CHALINE J. 1978. Biogeography and climatic fluctuations in the Quaternary on the basis of the rodent fauna. *Acta Zool. Cracov.*, **23**, 153—174. Kraków.

CHMIELEWSKI W. 1961. Civilisation de Jerzmanowice, 92 pp. *IHKM PAN;* Wrocław-Warszawa-Kraków.

— 1969. Ensembles Micoquo-Prondnikiens en Europe Central. *Geogr. Polon.*, **17**, 371—386. Warszawa.

— 1975. Paleolit środkowy i górny. *In:* Prahistoria Ziem Polskich, vol. **1**, pp. 9—158. Wrocław-Warszawa-Kraków-Gdańsk.

— , KONECKA-BETLEY K. & MADEYSKA T. 1977. Palaeolithic site Cracow-Zwierzyniec *I* in the light of investigations in 1972—1974. *Biul. IG*, **305**, 13—30. Warszawa.

— KOWALSKI K., MADEYSKA-NIKLEWSKA T. & SYCH L. 1967. Studies on the deposits of Koziarnia Cave at Sąspów in the Olkusz district. *Folia Quatern.*, **26**, 1—69. Kraków.

DOLUKHANOV P. M., KOZŁOWSKI J. K. & KOZŁOWSKI S. K. 1980. Multivariete analysis of Upper Palaeolithic and Mesolithic stone assemblages. 103 pp. *PWN;* Warszawa-Kraków.

DROZDOWSKI E. 1980. Chronostratigraphy of the Vistulian Glaciation on the Lower Vistula region. *Quatern. Stud. Poland*, **2**, 13—20. Warszawa-Poznań.

FEIFAR O. 1976. Plio-Pleistocene mammal sequences. *In:* Report 3 on the session in Bellingham *IGCP* Project 73(1)24, Quaternary Glaciations in the Northern Hemisphere, pp. 352—366. Prague.

GALON R. 1982. On the stratigraphy and chronology of the Last Glaciation (Vistulian) in Poland. *Quatern. Stud. Poland*, **3**, 37—48. Warszawa-Poznań.

GINTER B. 1966. Station du Paléolithique à Wójcice, district Grodków. *Materiały Archeol.*, **7**, 59—70. Kraków.

HAMMEN VAN DER T., MAARLEVELD G. C., VOGEL J. C. & ZAGWIJN W. H. 1967. Stratigraphy, climatic succession and radiocarbon dating of the Last Glacial in the Netherlands. *Geol. Mijnb.*, **46**, 79—95. Amsterdam.

— , WIJMSTRA T. A. & ZAGWIJN W. H. 1971. The floral record of the Late Cenozoic of Europe. *In:* K. K. TUREKIAN (*Ed.*). The Late Cenozoic Glacial Ages, pp. 391—424. New Haven — London.

JERSAK J. 1969. La stratigraphie de loess en Pologne concernant plus particulièrement de dernier étage froid. *Biul. Perygl.*, **20**, 99—133. Łódź.

— 1973. Lithology and stratigraphy of the loess in the southern Polish Uplands. *Acta Geogr. Lodz.*, **32**, 1—125. Łódź.

— 1976. Nature of fossil soils and their paleogeographic and stratigraphic implications. *Biul. IG*, **297**, 21—38. Warszawa.

KLECZKOWSKI A. 1964. The geology and ground waters of the high Vistula terrace east from Cracow. *Rocz. PTG* (*Ann. Soc. Géol. Pologne*), **34** (1—2), 191—224. Kraków.

KLIMASZEWSKI M. 1952. The forms of the Pleistocene regelation in the Cracow region. *Biul. PIG*, **66**, 115—134. Warszawa.

KOLSTRUP E. & WIJMSTRA T. A. 1977. A palynological investigation of the Moershoofd, Hengelo and Denekamp interstadials in the Netherlands. *Geol. Mijnb.*, **56**, 85—102. Amsterdam.

KONECKA-BETLEY K. 1976. Diagnostic horizons of the intra-loess fossil soils of south-eastern Poland. *Biul. IG*, **297**, 121—130. Warszawa.

KOWALSKI K. 1961. Pleistocene rodents from Nietoperzowa Cave in Poland. *Folia Quatern.*, **5**, 1—22. Kraków.

— 1962. Paleozoological dating of cave deposits. *Folia Quatern.*, **8**, 1—11. Kraków.

— 1966. Stratigraphic importance of rodents in the studies on European Quaternary. *Folia Quatern.*, **22**, 1—16. Kraków.

KOZARSKI S. 1980. An outline of Vistulian stratigraphy and chronology of the Great Poland Lowland. *Quatern. Stud. Poland*, **2**, 21—36. Warszawa-Poznań.

KOZŁOWSKI J. K. 1966. Remarques sur l'Aurignacien en Pologne. *Folia Quatern.*, **24**, 1—31. Kraków.

— 1969. Problems of geochronology of the Palaeolithic in the Cracov section of the Vistula valley. *Folia Quatern.*, **31**, 1—66. Kraków.

— 1977. Prehistoric settlement in the northern part of Central Europe in the light of the palaeogeogrpahical conditions prevailing during the earlier phase of the Würm Pleniglacial. *Folia Quattern.*, **49**, 5—14. Kraków.

— 1980. Sur l'interpretation des unités taxonomiques du Paléolithique Supérieur. Coll. Intern. l'Aurignacien et le Gravettien (Périgordien) dans leur cadre écologique, 123—138. Nitra.

— & KOZŁOWSKI S. K. 1977. Stone age in Poland; 384 pp. *PWN*; Warszawa.

— & — 1979. Upper Palaeolithic and Mesolithic in Europe. Taxonomy and Palaeohistory. *PAN Oddz. w Krakowie, Prace Kom. Archeol.*, **18**, 180 pp. Wrocław-Warszawa-Kraków-Gdańsk.

KOZŁOWSKI S. K. & SACHSE-KOZŁOWSKA E. 1981. Le „Zwierzyniecien", une nouvelle entité taxonomiue avec pointes à dos dans le Paléolithique supérieur ancien de l'Europe centrale. Coll. Intern. l'Aurignacien et le Gravettien (Périgordien) dans leur cadre écologiue. Supplément, 35—44. Kraków.

KRETZOI M. & PÉCSI M. 1979. Pliocene and Pleistocene development and chronology of the Pannonian Basin. *Acta Geol. Sci. Hungar.*, **22**, 3—33. Budapest.

KRUKOWSKI S. 1939—1948. Paleolit. *In:* Encyklopedia Polska, vol. **4**, 1—117. PAU. Kraków.

LINDNER L. & MADEYSKA T. 1980. Loess profile at Wąchock on Kamienna river and an attempt at its correlation with the site Zwierzyniec in Kraków. Guide-book of field seminar: Stratigraphy and chronology of the loesses and glacial deposits of the lower and Middle Pleistocene in SE Poland, 55—58. Lublin.

MADEYSKA (NIKLEWSKA) T. 1969a. Upper Pleistocene deposits in caves of the Cracow Upland. *Acta Geol. Polon.*, **19** (2), 341—392. Warszawa.

— 1969b. Situation stratigraphique des ensembles microquo-prondnikiens. *Geogr. Polon.*, **17**, 387—393. Warszawa.

— 1971. Methods used in researches on the Upper Pleistocene sediments of the Cracow Upland caves. *Światowit*, **32**, 5—25. Warszawa.

— (MADEYSKA T.) 1972. Lithological series of sediments in the caves of Cracow Upland, with reference to the archeological data. *Speleologia*, **7**, (1—2), 7—24. Warszawa.

— 1979. The environment of Middle and Upper Palaeolithic cultures in Poland. *Quatern Stud. Pcland*, **1**, 15—28. Warszawa-Poznań.

— 1981. Le milieu naturel de l'Homme du Paléolithique moyen et supérieur en Pologne à la lumière des recherches géologiques. *Studia Geol. Polon.*, **69**, 1—125. Warszawa.

— 1982 (*in press*). Sediments of caves and rock-shelters of Sąspowska valley.

MAKOWSKA A. 1980. Late Eemian with preglacial and glacial part of Vistulian Glaciation in the Lower Vistula region. *Quatern. Stud. Poland*, **2**, 37—56. Warszawa-Poznań.

MAMAKOWA K. & ŚRODOŃ A. 1977. On the Pleniglacial flora from Nowa Huta and Quaternary deposits of the Vistula valley near Cracov. *Rocz. PTG (Ann. Soc. Géol. Pologne)*, **47** (4), 485—511. Kraków.

MARUSZCZAK H. 1976. Loess stratigraphy of South-Eastern Poland. *Biul. IG*, **297**. 135—167. Warszawa.

— 1980. Stratigraphy and chronology of the Vistulian loesses in Poland. *Quatern. Stud. Poland*, **2**, 57—76. Warszawa-Poznań.

MOJSKI J. E. 1969. La stratigraphie de loess de la dernière période glaciaire. *Biul. Perygl.*, **20**, 153—178. Łódź.

— 1980. Vistulian Stratigraphy in the glaciated area of the Polish Lowlands. *Quatern. Stud. Poland*, **2**, 76—98. Warszawa-Poznań.

MORAWSKI W. 1975. Middle Palaeolithic flint assemblages from the Piekary IIa site. *Światowit*, **34**, 139—146. Warszawa.

NADACHOWSKI A. 1976. Fossil fauna of the deposits of Mamutowa Cave in Wierzchowie near Cracow (Poland). *Folia Quatern.*, **48**, 17—36. Kraków.

— 1982 (*in press*). Fossil fauna (Amphibia, Reptilia, Mammalia) from the deposits of caves in the Sąspowska valley.

RÓŻYCKI S. Z. 1972. Plejstocen Polski Środkowej na tle przeszłości w górnym trzeciorzędzie, 314 pp. *PWN;* Warszawa.

SACHSE-KOZŁOWSKA E. 1978. Polish Aurignacian assemblages. *Folia Quatern.*, **50**, 1—37. Kraków.

SAWICKI L. 1954. Stratigraphy of the wave-cut alluvial terrace o the pre-Vistula at Góra Puławska. *Acta Geol. Polon.*, **4** (3), 391—422. Warszawa.

SCHILD R. 1975. Późny paleolit. *In:* Prahistoria Ziem Polskich, vol. **1**, 159—338. Wrocław-Warszawa-Kraków-Gdańsk.

STARKEL L. 1977. The paleogeography of mid- and east Europe during the last cold stage, with west European comparisons. *Phil. Trans. R. Soc. Lond.*, **280**, 351—372. London.

— 1980. Stratigraphy and chronology of the Vistulian in the Polish Carpathian and in the Subcarpathian Basins. *Quatern. Stud. Poland*, **2**, 121—135. Warszawa-Poznań.

STWORZEWICZ E. 1973. The fossil land snails (Gastropoda) of rock-shelter above Niedostępna Cave in the Ojców region. *Acta Zool. Cracov.*, **18** (12), 301—310. Kraków.

— 1982 (*in press*). Fossil Mollusca from the cave deposits in the Sąspowska valley.

TOBIEN H. 1970. Biostratigraphy of the Mammalian faunas at the Pliocene-Pleistocene boundary in the Middle and Western Europe. *Palaecgeogr., Plalaeoclimat., Palaeoecol.*, **8**, 77—93. Amasterdam.

TOBOLSKI K. 1975. The vegetation of northern Finland during the last glaciation (Vistulian) and in the early Holocene (Flandrian). *Folia Quatern.*, **45**, 1—41. Kraków.

TUCHOŁKA P. 1977. Magnetic polarity events in Polish loess profiles. *Biul. IG*, **305**, 117—123. Warszawa.

TYCZYŃSKA M. 1968. Geomorphological evolution of the city of Cracow. *Zesz. Nauk. UJ*, **73**, 1—70. Kraków.

WEST R. G. 1978. Pleistocene geology and biology with especial reference to the British Isles. 377 pp. *Longman;* London-New York.

WYSOCZAŃSKI-MINKOWICZ T. 1982. Climatochronostratigraphic subdivision of the last cool period (Vistulian). *Quatern. Stud. Poland*, **3**, 129—146. Warszawa-Poznań.

ZARRINA E. P. 1982. Stratigraphy and chronology of the Upper Pleistocene in the glacial region of the European Part of the USSR. *Quatern. Stud. Poland*, **3**, 147—155. Warszawa-Poznań.

[Studies on Raj cave near Kielce (Poland) and its deposits. 1972. *Folia Quatern.*, **41**, 1—148. Kraków.]

[Upper Palaeolithic site with dwellings of mammoth bones — Cracow, Spadzista street *B*. 1974. *Folia Quatern.*, **44**, 110 pp. Kraków.]

[Upper Palaeolithic site Cracow — Spadzista street C (investigation in 1970—1973). 1975. *Folia Quatern.*, **45**, 43—71. Kraków.]

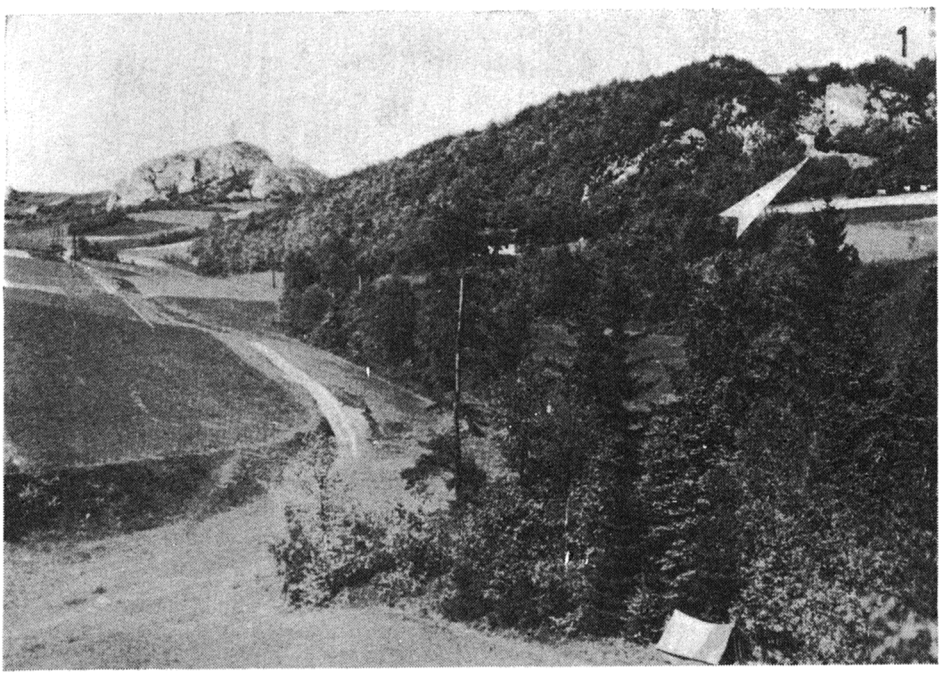
T. MADEYSKA

STRATYGRAFIA STANOWISK PALEOLITYCZNYCH WYŻYNY KRAKOWSKIEJ

(Streszczenie)

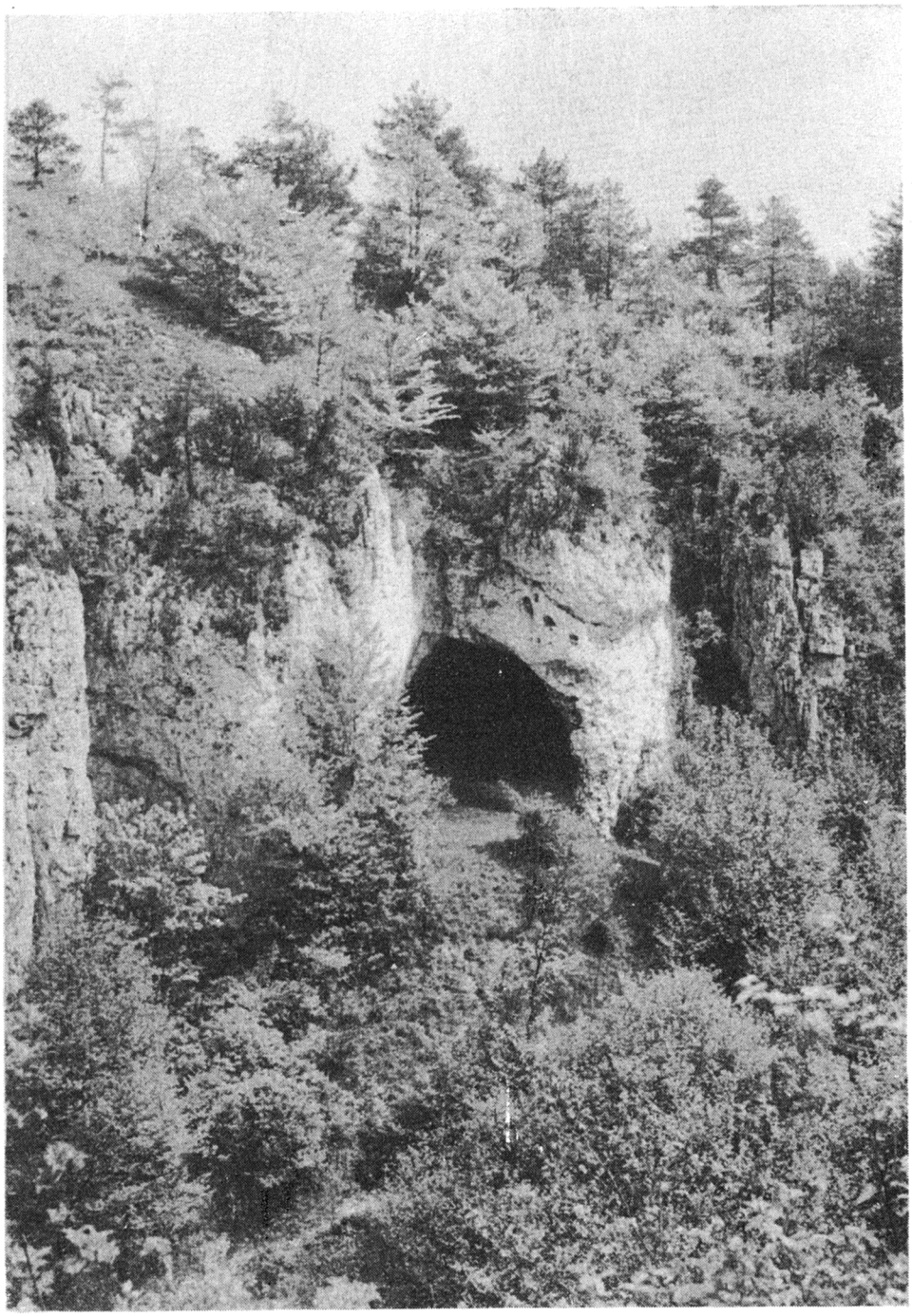
Przedmiotem pracy jest analiza stratygraficzna stanowisk paleolitycznych na obszarze Wyżyny Krakowskiej (*patrz* fig. 1—6 oraz pl. 1—6). Stratygrafia stanowisk jaskiniowych opiera się tutaj na rekonstrukcji zmian klimatycznych i środowiskowych (Madeyska 1981), oraz na analizie szczątków kręgowców, rozpatrywanych pod kątem wymagań ekologicznych ich zespołów. Stratygrafia stanowisk lessowych opiera się natomiast na analizie następstwa osadów eolicznych i stokowych, gleb kopalnych oraz struktur deformacyjnych. Korelacja profili stanowisk obu tych typów opiera się na sukcesji zmian klimatycznych, analizie materiałów archeologicznych środkowego i górnego paleolitu, oraz na nielicznych datowaniach radiowęglowych i termoluminescencyjnych (*patrz* fig. 2).

Wśród fauny znalezionej w badanych stanowiskach paleolitycznych szczególne znaczenie mają gryzonie. Na podstawie zmienności ich zespołów wydzielono „bioekozony" odpowiadające jednostkom klimatostratygraficznym górnego plejstocenu i holocenu (*patrz* fig. 6): **L + C** — zona lemingów i innych gryzoni tundrowych z małym udziałem *Clethrionomys glareolus;* **A + C** — zona gatunków leśnych z *Apodemus* sp. i *Clethrionomys glareolus;* **A + C + M** — zona współwystępowania gatunków leśnych, początkowo także *Apodemus* sp., ze wzrastającą ilością gatunków tundrowych, głównie *Microtus gregalis* i znikomą ilością lemingów; **L + M** — zona prawie wyłącznie gatunków tundrowych, z dużym udziałem lemingów; **L + M + C** — zona współwystępowania gatunków tundrowych, głównie *Microtus gregalis* i *Lemmus lemmus,* z małą ilością *Clethrionomys glareolus* i gryzoni stepowych; **L + M + S** — zona prawie wyłącznie gatunków tundrowych, z dużym udziałem lemingów oraz nielicznym udziałem gryzoni stepowych; **A + C** — zona wzrostu ilości gatunków gryzoni leśnych kosztem szybko zanikających form tundrowych.

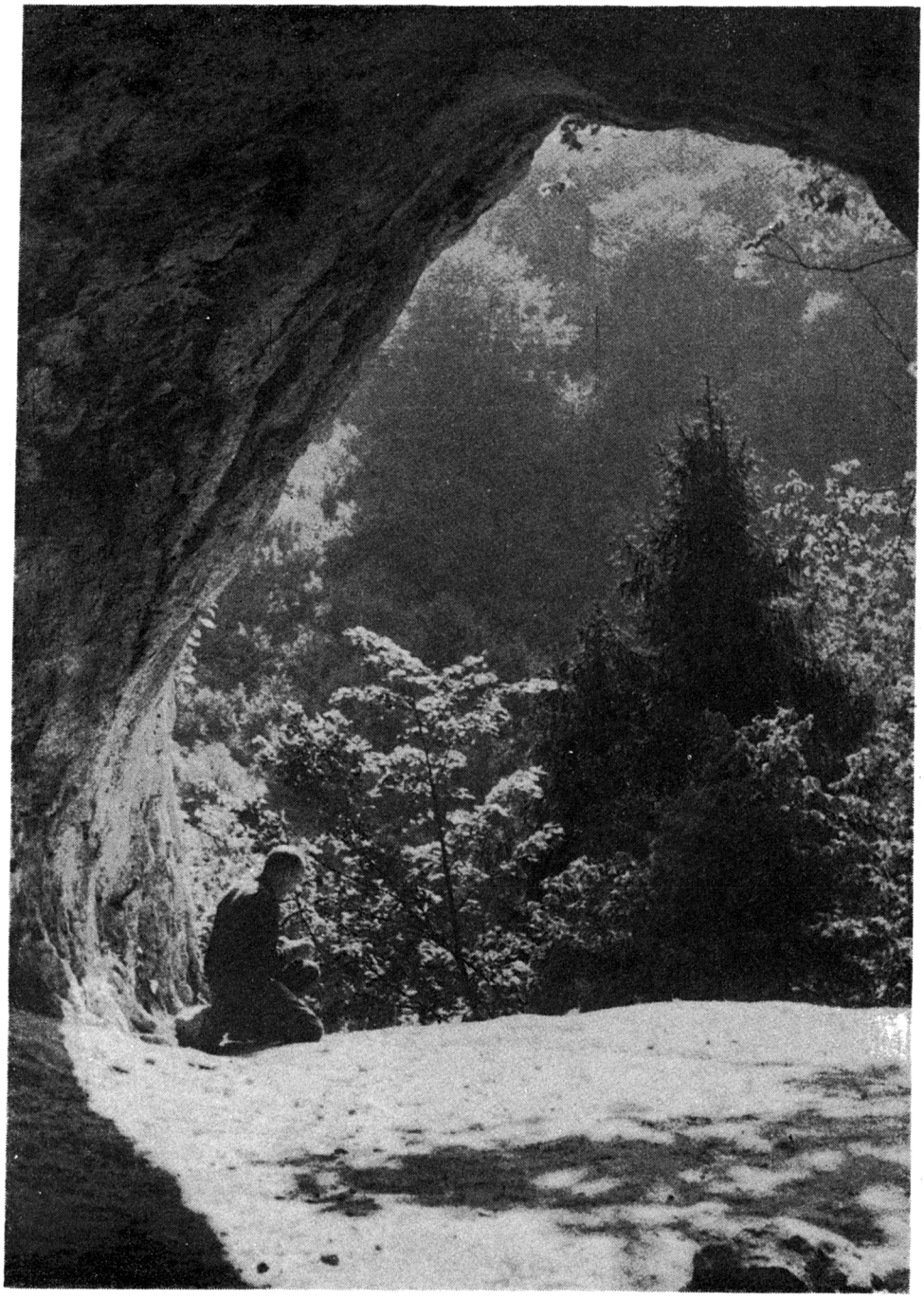


1 — Upper part of the Będkowska Valley with the entrance to the Nietoperzowa Cave (arrowed)

2 — Koziarnia Valley with several cave entrances exposed along its slopes (arrowed is the Koziarnia Cave; *cf.* Pl. 2)

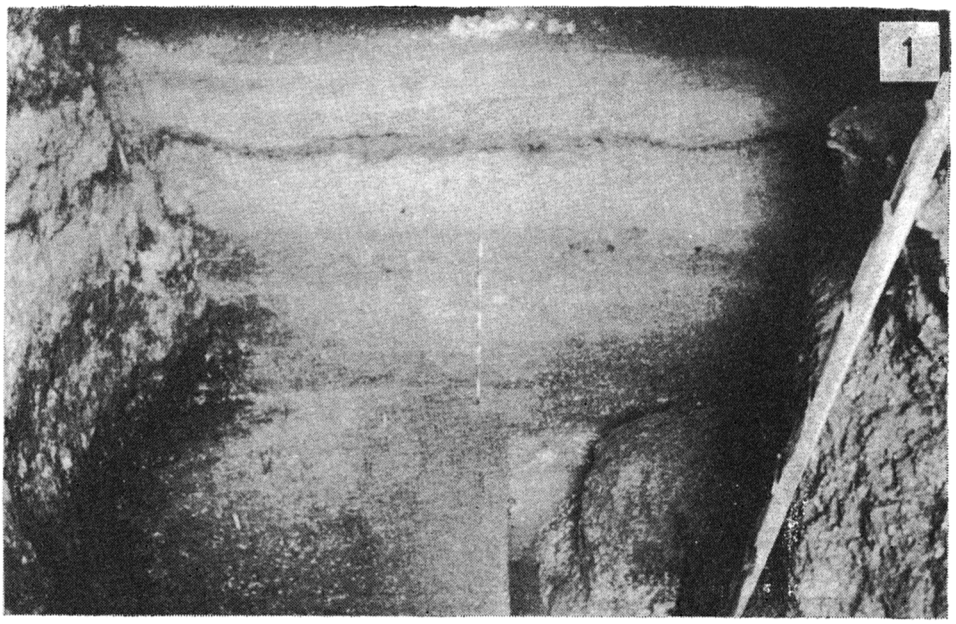


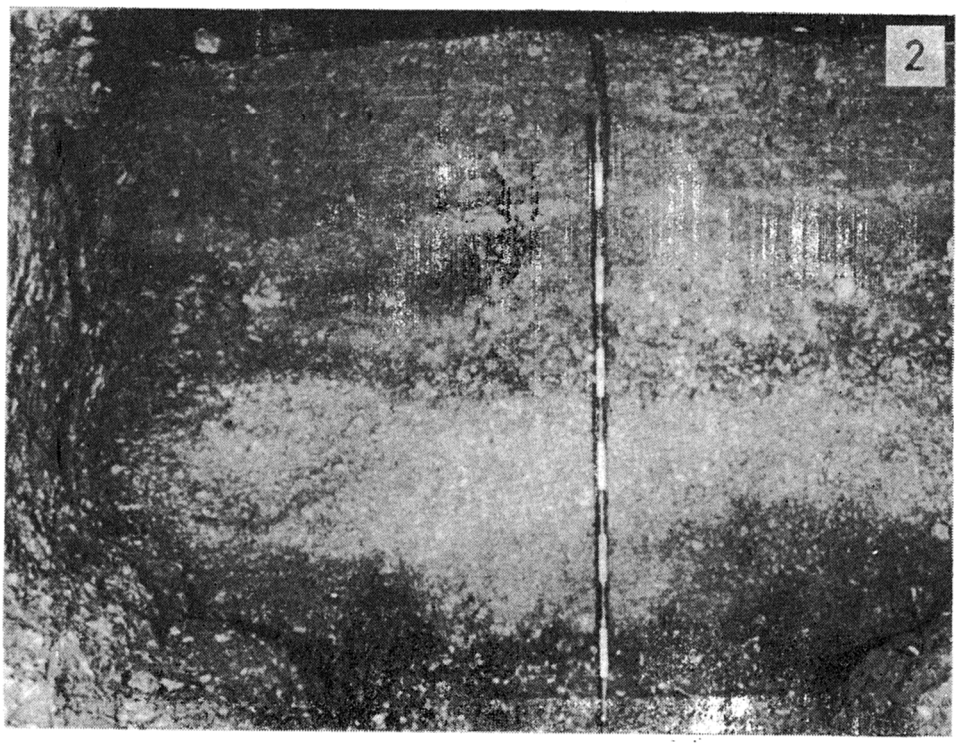
Opening of the Koziarnia Cave (*cf.* Pl. 1, Fig. 2)



West-faced opening of the Wylotne Rock-Shelter

Two fragments of a destroyed cave situated in the south-faced slope of the Sąspowska Valley; one of the fragments (Fig. 2) is called the Bramka Rock-Shelter





1 — Sequence of the Nietoperzowa Cave sediments
2 — Sequence of the Koziarnia Cave sediments

1 — General view of the Zwierzyniec site

2 — Fragment of the Early Vistulian sequence at the Zwierzyniec site