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South-Polish glaciations (Nidanian, Sanian) in southern Central Poland

ABSTRACT: In southern Central Poland there occur sediments and landforms indicative of a subdivision of the South-Polish (= Cracovian, Mindel) Glaciation into two separate glaciations: Nidanian (= earlier part of the Oka Glaciation, *Helme-Kaltzeit*) and Sanian (= later part of the Oka Glaciation, *Elster-Kaltzeit* s. s.), divided by the Malopolanian (= Voigsted-Warmzeit) Interglacial. The latter has been dated by FCl/P and paleomagnetic methods and documented by faunistic remains of the Kozi Grzbiet site, Holy Cross Mts. Within the Sanian Glaciation the two stadials are recognized: older (maximum) and younger (post-maximum) ones, separated by an interstadial period. During the bipartite older stadial of this glaciation the Scandinavian icesheet reached the Carpathians whereas during the younger stadial it occupied only the northern part of the studied area.

INTRODUCTION

The southern Central Poland supplies the most complete data for a subdivision of the South-Polish (= Cracovian, Mindel) Glaciation into two glaciations: Nidanian (Mindel *I*) and Sanian (Mindel *II*), separated by the Malopolanian Interglacial (*cf.* Text-figs 1 and 4). This conclusion results from the analysis of the interglacial fauna presented in the karst fillings at Kozi Grzbiet in the Holy Cross Mts (Głazek & *al.* 1976, 1977). It is noteworthy that a considerable part of the area lies outside the line of extents of the younger glaciations (*cf.* Lindner & Grzybowski 1982) and thus the glacial sediments of the South-Polish glaciations (Nidanian and Sanian) can be analyzed not only in the boreholes but also in numerous exposures. In this paper the South-Polish glaciations

of the Central Poland are discussed, the preceding interglacial, named by Różycki (1978, 1980) the Podlasian Interglacial including.

PODLASIAN INTERGLACIAL (= CROMERIAN)

This interglacial is represented in the marginal parts of the area by alluvia (20—30 m thick) in buried valleys that are incised in slope sediments of the Narewian (Günz) Glaciation, in still earlier gravels of the Połaniec Series and in pre-Quaternary sediments (Lindner 1978, 1979, 1980, 1982).

Fig. 1. Location of the investigated area
1 locality of organogenic deposits of the Podlasian Interglacial at Ceteń near Opoczno; *2* maximum icesheet extent during the Nidanian Glaciation; *3* faunistic locality of the Malopolanian Interglacial at Kozi Grzbiet in the Holy Cross Mts; *4* locality of organogenic sediments of the Malopolanian Interglacial at Jasionka near Rzeszów; *5* maximum icesheet extent during the Sanian Glaciation; *6* main ranges of the Holy Cross Mts; *7* limits of the investigated area

At Ceteń near Opoczno (*cf.* Text-figs 1 & 4) there are at least four alluvial sedimentary cycles with a gyttja insert (Makowska 1976, 1977). This complex is overlain by a pavement, formed in result of washing of glacial sediments deposited during the South-Polish glaciations. A pollen analysis of the gyttja represents a final part of the Cromerian Interglacial with three vegetation phases: the earliest one is of a birch-pine type, the middle is birch-pine with spruce, and the latest one is of a pine-birch type (Borówko-Dłużakowa 1977).

In central and southern parts of the area these alluvia are synchronous with the so-called "gravel series devoid of the Scandinavian material", found within many valleys (Czarnocki 1931, 1950; Łyczewska 1971; Lindner 1977, 1980, 1982) and usually overlying the sediments of the Narewian Glaciation and formed due to their washing.

After a chronostratigraphic subdivision of the Quaternary, proposed by Zubakov (1978), the Podlasian Interglacial should comprise an interval from 790 000 to 680 000 years B.P. whereas according to Różycki (1978) it lasted from 870 000 to 690 000 years B.P. In German Democratic Republic (*cf.* Cepek 1967) this interglacial should be related to the *Artern-Warmzeit*. In deep-sea sediments it is the equivalent of the 21st ^{18}O horizon dated for 782 000—729 000 years B.P. (Shackleton & Opdyke 1973). Wysoczański-Minkowicz (1980) named this period the Ceteń? Interglacial and dated it for 871 000—810 000 years B.P.

NIDANIAN GLACIATION

In the southern Central Poland the earliest sediments of the Nidanian Glaciation include (Lindner 1980) slope deposits, ice-dam deposits as well as loess series, overlain by a till horizon; locally they contain floristic and malacological remains (Czarnocki 1927, 1931, 1950, 1975; Poliński 1927; Łyczewska 1971, 1972; Filonowicz 1972; Walczowski 1972).

An occurrence of these sediments within the valleys, their lithologic features as well as their extent and the sedimentary cover, mainly by the oldest till (to the north of the Holy Cross Mts) and the sandy-gravel series with Scandinavian material (to the south of the Holy Cross Mts), prove their deposition in valley-dammed reservoirs. The latter were formed due to damming in the lower valley fragments by the entering icesheet tongues of the Nidanian Glaciation, described previously as the so-called Strawczyn Stadial within the earlier part of the South-Polish Glaciation (Lindner 1977). A considerable participation of loess and a loess-type malacofauna (Poliński 1927) indicates that the first icesheet advance was preceded by the loess accumulation (Text-fig. 4). The material of the latter was then incorporated, in result of washing, into the sediments that occur under the till horizon. An interfingering of the earliest sandy-silty series with colluvial flows and with glacial or fluvioglacial sediments document a deposition close to the icesheet (Lindner 1977).

A close occurrence of the icesheet is also suggested by a presence of varved clay inserts and fine pieces of Scandinavian rocks, noted within the earliest slope-lacustrine series, as well as on the basis of its occurrence up to 240—260 m a.s.l. (Czarnocki 1927, 1931, 1950, 1975; Łyczewska 1971; Filonowicz 1972; Walczowski 1972; Lindner 1977). Such a high water damming in the valley and deposition of thick ice-dam series could be done by the icesheet that entered the area not only from the north but also from the west and east.

An extent of the till that covers the earliest slope-lacustrine series and petrographic composition of the gravel-boulder till fraction mark the icesheet advance of the Nidanian Glaciation as far as the northern slope of the Holy Cross Mts (Text-fig. 1). A hypsometrical position of the earliest till in this area suggests that if the later significant neotectonic movements are excluded then the icesheet foot occurred during the Nidanian Glaciation up to 240—270 m a.s.l. Throughout the passes of the main ranges of the Holy Cross Mts (*cf.* Text-fig. 1) the glacial tongues moved several kilometres further to the south. These tongues are recognizible now by thin till horizons underlain by the earliest ice-dam and fluvioglacial sediments in the western part of the Holy Cross Mts (Lindner 1977), and also by the so-called "local till" in central and eastern parts of the Holy Cross Mts (Czarnocki 1927, 1950; Łyczewska 1971, 1972).

To the east of the area, in the Lublin Upland, the Nidanian Glaciation is probably represented by sediments of the lower glacial phase of the Serniki Stadial, South-Polish Glaciation (*cf.* Mojski 1969) whereas to the west (in the Łódź Upland) by the lowermost glacigenic horizon within the Bełchatów Graben, referred to the Lower Stadial of the South-Polish Glaciation (*cf.* Baraniecka & Sarnacka 1971).

In the European zone of the Soviet Union this part of the Nidanian Glaciation is represented by the earliest till of the Oka Glaciation (*cf.* Zubakov & Kochegura 1973) dated by a thermoluminescence method for 600 000±60 000 years B.P., and by the loesses dated for 607 000±65 000 years B.P. whereas in German Democratic Republic by the interval *Helme-Kaltzeit* = *Grundmoränen EI* (*cf.* Cepek 1967). According to Zubakov (1978) this glaciation comprises a time interval from 720 000 to 680 000 years B.P. Wysoczański-Minkowicz (1980) defines it as the pre-Nida Glaciation and dates for 810 000—748 500 years B.P. Within the deep-sea sediments the 20th ^{18}O horizon, dated for 729 000—706 000 years B.P. (*cf.* Shackleton & Opdyke 1973), seems to be of the same age.

MALOPOLANIAN INTERGLACIAL

Sandy-gravel sediments, gravels and moraine pavements at the top of the above described deposits represent in southern Central Poland

an interglacial fluvial accumulation. In most cases the interglacial fluvial sediments contain Scandinavian rocks.

In the Holy Cross Mts, these sediments fill the valleys (10—20 m deep), formed in result of erosion initiated at the end of the previous glaciation. Outside the valleys, particularly at a loessy substrate, the weathering-soil processes have developed during this interglacial and are marked now by paleosoils (Czarnocki 1975, Lindner 1977).

The faunistic site at Kozi Grzbiet in the south-western Holy Cross Mts (*cf.* Text-figs 1—4) supplied with new data for this teme interval (Kowalski 1975, 1976; Głazek, Lindner & Wysoczański-Minkowicz 1976; Głazek, Kowalski, Lindner, Młynarski, Stworzewicz, Tuchołka & Wysoczański-Minkowicz 1977; Szyndlar 1981). The cave deposits contain there (Text-fig. 2*A*) but faunistic remains, also the material (feldspars, heavy minerals) coming undoubtedly from washed fluvioglacial sediments of the Nidanian Glaciation. A rich faunistic assemblage contains numerous snails, amphibians, reptiles and mammals. Among the snails the most important are: *Helicigona banatica, Soosia diodonta, Isognomostoma personatum, Zenobiella vicina, Cochlodina laminata, C. orthostoma, Laciniaria cana, Ruthenica filograma, Clausilia cruciata, Iphigena latestriata, I. tumida* and *Acanthinula aculeata*, representative for a relatively warm and wet forest. Among the amphibians and reptiles (*cf.* Szyndlar 1981) the most common are *Natrix natrix* and *Triturus* cf. *cristatus*, the both species typical of deciduous and wet forests. At the same time there are some thermophilous genera (*Pliobatrachus* and *Elaphe*) as well as very rare steppe ones (*Pelobates*). The presence of boreal mammals (*Lemmus lemmus* and *Dicrostonyx simplicior*) proves a quite cool, steppe climate, whereas *Castor fiber, Clethrionomys* cf. *glareolus, Sus* cf. *scrofa, Alces* sp. and *Pliomys lenki* suggest a forest and wet environment.

The age of the Kozi Grzbiet locality can be defined on the ground of the overlying fluvioglacial sands of the Sanian Glaciation (Wódkowski 1971, Lindner & Kowalski 1974, Lindner 1977, Radłowska & Mycielska-Dowgiałło 1972) as well as the presence of *Pliomys lenki, Mimomys savini, Dicrostonyx simplicior, Ursus deningeri, Helicigona banatica, Pliobatrachus langhae* and probably, *Bombina* cf. *bombina* for the Late Cromerian (Głazek, Kowalski, Lindner, Młynarski, Stworzewicz, Tuchołka & Wysoczański-Minkowicz 1977). A similar conclusion is drawn from absolute datings of bones by FCl/P method as 550 — 700 000 years B. P. (Głazek, Lindner & Wysoczański-Minkowicz 1976), pointing out the so-called Cromer *II* of the Dutch workers as well as from paleomagnetic studies (Text-fig. 2*B*) of P. Tuchołka (*cf.* Głazek, Kowalski, Lindner, Młynarski, Stworzewicz, Tuchołka & Wysoczański-Minkowicz 1977) that show a positive magnetic polarization of cave sediments and so, exclude their accumulation during the optimum phase of the Cromerian Interglacial (*cf.* van Montfrans 1971). All the data prove the integlacial to be warmer than the present times.

Fluvial sediments of the Malopolanian Interglacial, noted in southern Central Poland (Lindner 1982), correspond probably in the Lublin Upland to a thick series of alluvia, deposited during the interphase of the so-called Serniki Stadial (*cf.* Mojski 1969) and to the intermorainic deposits that separate the tills of lower and upper stadials of the South-Polish Glaciation in the Bełchatów Graben (*cf.* Baraniecka & Sarnacka 1971). The upper part of the interglacial is also represented by organogenic sediments at Jasionka near Rzeszów (Dąbrowski 1967, Laskowska-Wysoczańska 1967).

In German Democratic Republic this interglacial corresponds (*cf.* Cepek 1967, Erd 1978) to the *Voigstedt-Warmzeit*, and in the Soviet Union — with the warming that separates a deposition of lower and upper tills of the Oka Glaciation (Zubakov & Kochegura 1973). After Zubakov (1978) this interglacial lasted from 680 000 to 610 000 years B. P., and according to Wysoczański-Minkowicz (1980) from 748 500 to 687 000 years B. P. In deep-sea sediments this

interglacial can be referred to the warming marked by the 19th ^{18}O horizon, dated for 706 000—688 000 years B. P. as the earliest distinct warming within the Brunhes paleomagnetic epoch (*cf.* Shackleton & Opdyke 1973, Bonifay 1980).

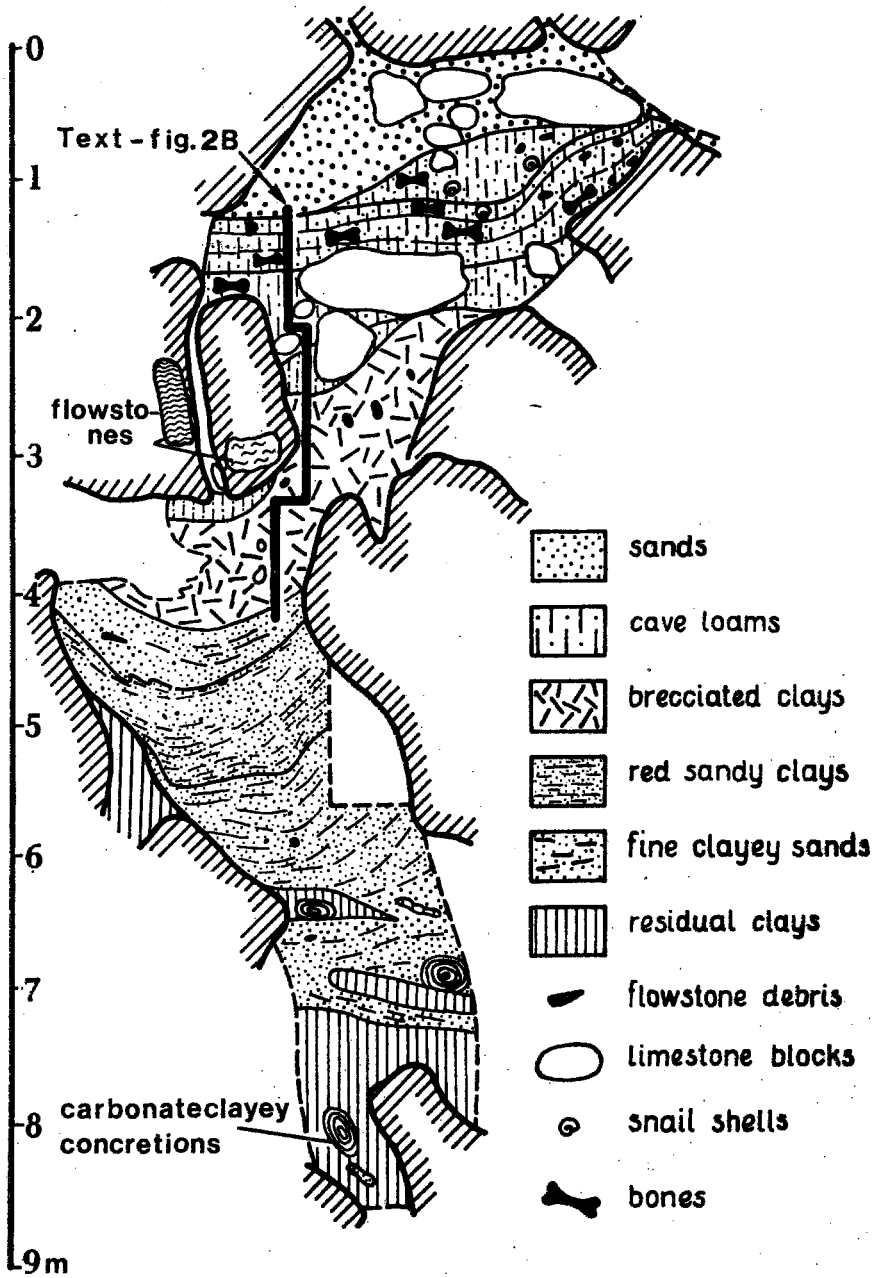


Fig. 2A. Sequence of cave sediments with fauna of the Malopolanian Interglacial at Kozi Grzbiet near Chęciny in the Holy Cross Mts (*after* Głazek & *al.* 1977)

SANIAN GLACIATION

OLDER (MAXIMUM) STADIAL

In southern Central Poland two till horizons were deposited by the icesheet of the maximum stadial of the Sanian Glaciation (Text-fig. 4). These tills are accompanied in many places by loessy, ice-dam, slope and fluvioglacial sediments (Czarnocki 1927, 1931, 1950, 1975; Łyczewska 1971; Filonowicz 1972; Hakenberg & Lindner 1971; Lindner 1971a; Lindner & Kowalski 1974; Lindner 1977). Usually, especially outside the

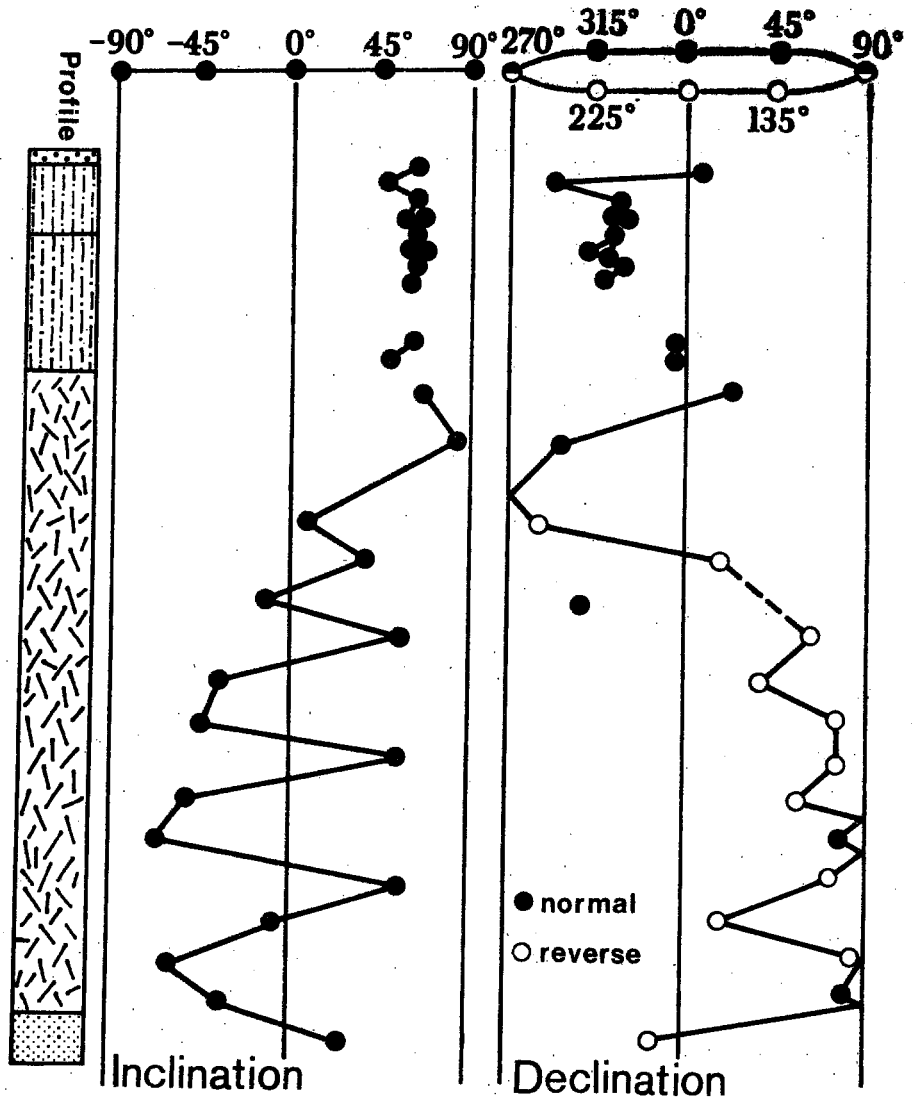


Fig. 2B. Results of paleomagnetic analyses of the profile obtained at Kozi Grzbiet (as indicated in Text-fig. 2A)

valleys, the top surface of the lower till is washed; this indicates a distinct break between deposition time of the lower and the upper till horizon. These tills seem to correspond (Hakenberg & Lindner 1971; Lindner 1971b; Lindner & Kowalski 1974; Lindner 1977, 1978) with the successive phases separated by the Kielce Interphase. This bipartity is considered wrongly by Wysoczański-Minkowicz (1980) the equivalent of "Nida and San Glaciations", lasting since 687 000 to 626 000 years B. P. Within the deep-sea sediments this tripartite interval is represented by the 18th, 17th and 16th ^{18}O horizons, dated for 688 000 to 592 000 years B. P. (*cf.* Shackleton & Opdyke 1973).

Loessy, ice-dam, slope or fluvioglacial sediments overlain by the lower till of the older stadial prove a loessy and an ice-dam accumulation, locally interfingering with slope and fluvioglacial deposits before the icesheet advance during the older phase of this stadial.

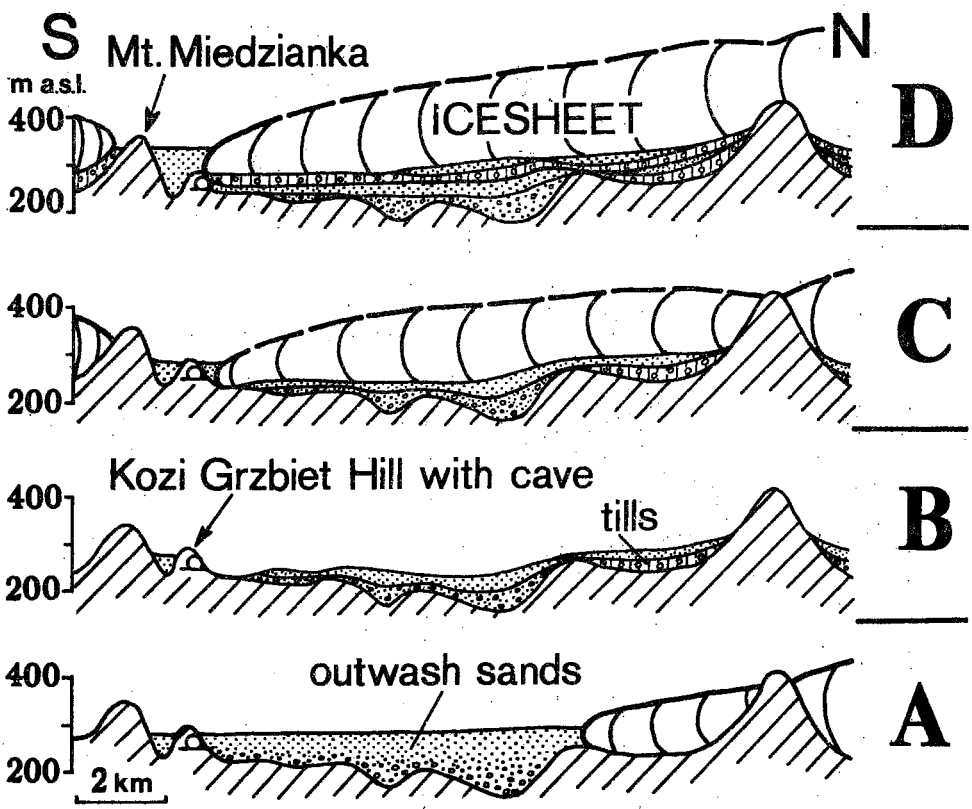


Fig. 3. Scheme of evolution of glacial and fluvioglacial deposits in the western part of the Holy Cross Mts during the South-Polish glaciations (*after* Głazek & *al.* 1977)

A — Nidanian Glaciation, **B** — Malopolanian Interglacial, **C** — older phase of the maximum stadial of the Sanian Glaciation, **D** — younger phase of the maximum stadial of the Sanian Glaciation

An extent of the lower till (2—15 m thick) proves that the icesheet of the older phase has not covered entirely the Holy Cross Mts. During its maximum expansion, not only the nunatak-like hills over 300—350 m a.s.l. high were ice-free (Text-fig. 3), but also several lower areas that were the intraglacial oases (Lindner 1977). Knowing a petrographic composition of the gravel-boulder fraction of the lower till and especially, the presence of the Tertiary and Paleozoic rocks outside their occurrence belt but within the till, supports the previous opinions (Siemiradzki 1888; Czarnocki 1931; Łyczewska 1971; Różycki 1967, 1972) on a possible encircling the Holy Cross Mts by the icesheet of the South-Polish glaciations, from the east and south-east.

During the Kielce Interphase a deglaciation caused almost the whole area to be ice-free. Only in some valleys but not entirely, the dead ices had remained, then overlain by the icesheet of the younger phase, what resulted in a single acumulative horizon of the discussed older stadial (Lindner 1977, 1978).

The petrographic composition and occurrence of till of the younger phase of the older stadial (Text-fig. 3), enabled to reconstruct the maximum icesheet extent in the western part of the Holy Cross Mts (Lindner 1977). The received data (Głazek, Kutek & Lindner 1976; Lindner 1977, 1978) supported the provious suggestions (Siemiradzki 1888; Czarnocki 1927, 1931; Łyczewska 1971; Różycki 1967, 1972) on the entrance of a glacial lobe into this area; the icesheet transported the Tertiary rocks from the south-eastern margin of the Holy Cross Mts and from their Paleozoic core.

An analysis of the icesheet movements and deglaciation of the Holy Cross Mts (*cf.* Klatka 1965; Lindner 1971b; Lindner & Braun 1974; Lindner 1977; Radłowska & Mycielska-Dowgiałło 1972, 1974) as well as the data on petrographic composition of glacial gravels (Dr. Z. Lamparski, *personal information*), the occurrence of the Scandinavian material up to 450—500 m a.s.l. (Miklaszewski 1911, Czarnocki 1931, Walczowski 1972, Łyczewska 1971) point out that during the maximum extent of the icesheet, it finally overpassed the main ranges of the Holy Cross Mts, in spite of its previous attacks from the east and west. This conclusion does not exclude, however, the possible occurrence of nunataks (*cf.* Klatka 1965), being the icesheet oases (Text-fig. 3) with a kame accumulation (Lindner 1971b, 1977; Lindner & Kowalski 1974; Radłowska & Mycielska-Dowgiałło 1972, 1974).

In the north-western part of the investigated area, the older (maximum) stadial of the Sanian Glaciation is also represented by two till horizons, the lower one of which corresponds, together with the underlying sands and silts, to the older phase whereas the upper till to the younger (maximum) phase of this stadial (Lindner 1979).

In the northern part of the area the younger erosive-denudation

processes (Mazovian Interglacial) resulted in a considerable denudation of the sediments of the South-Polish glaciations (Ruszczyńska 1961; Lindner 1971; Grzybowski 1972; Makowska 1976, 1977; Lewandowski 1977). In a vast area, these glaciations are marked by a residual pavement and in some sections only a single or two till horizons could be noted.

In the eastern part of the area a residual occurrence of glacigenic sediments, deposited during the South-Polish glaciations, makes it difficult to note a bipartity of the maximum stadial. In most cases there exists only a single, intensively destroyed till (Samsonowicz 1934; Pożaryska 1948; Radłowska 1963; Kosmowska-Suffczyńska 1966, 1972; Bielecka 1969; Kowalczyk & Puciłowska 1977).

A similar situation existed in the southern part of the area where there is usually a single till horizon of the maximum stadial of the Sanian Glaciaton (*cf.* Radłowska 1966; Łyczewska 1968, 1969, 1971; Walczowski 1972; Szajn 1978; Kwapisz 1978). Only in the zone with higher elevations there is a distinct bipartity of these tills, accentuated by inserts of sands and silty-clayey series (Hakenberg & Lindner 1971, Lindner 1977, Lindner & Ziembińska-Tworzydło 1974).

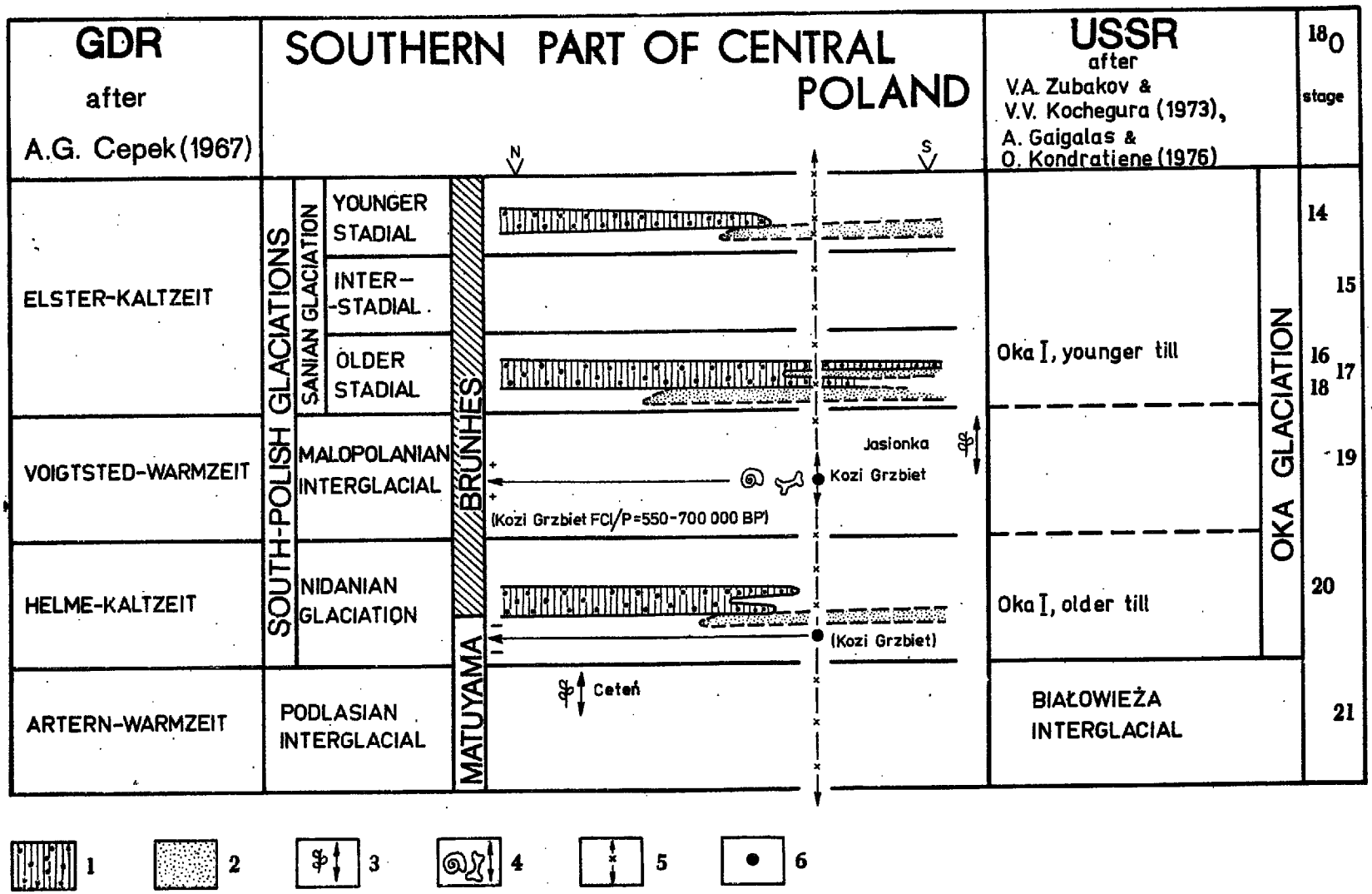
The works on the younger phase of this stadial in the Central Poland, have been mainly concentrated in the Holy Cross Mts (Radłowska & Mycielska-Dowgiałło 1972, 1974; Lindner 1977; Lindner & Braun 1974; Lindner & Kowalski 1974) and documented an areal type of the deglaciation in this area as well as its run during at least two phases.

The sediments of the maximum stadial of the Sanian Glaciation in southern Central Poland correspond probably to deposits of the upper phase of the so-called Serniki Stadial in the Lublin Upland (*cf.* Mojski 1969) and the lower till horizons noted within the Bełchatów Graben, connected also with the maximum stadial of this glaciation (*cf.* Baraniecka & Sarnacka 1971).

INTERSTADIAL

In the north-western and northern parts of the area there are fluvial sandy-gravel sediments and silts in many borehole sections, underlain by the till of the maximum stadial and representative for the post-maximum interstadial (Text-fig. 4). A stratigraphic position of these sediments is best documented by the boreholes in the Wyśmierzyce region (Jurkiewiczowa & *al.* 1973; Lindner 1979, 1982). The sediments of the Luszawa Interstadial from the Lublin Upland (*cf.* Mojski 1969) are synchronous with the deposits of the interstadial of the Sanian Glaciation. Within the deep-sea sediments this warming is recorded by the 15th ^{18}O horizon, dated for 592 000—542 000 years B. P. (*cf.* Shackleton & Opdyke 1973).

Main stratigraphic units of the earlier Middle Pleistocene



1 tills, 2 loesses, 3 localities of organogenic sediments, 4 faunistic locality, 5 chronostratigraphic extent of the Kozi Grzbiet sequence, 6 samples with absolute datings (FCl/P, *TL* and paleomagnetism *after* Głazek & *al.* 1976, 1977; ^{18}O horizons *after* Shackleton & Opdyke 1973)

YOUNGER (POST-MAXIMUM) STADIAL

An overlying of these sediments by a successive till horizon of the Sanian Glaciation and the presence of synchronous loess deposits to the south (Lindner 1979, 1982) allows eo distinguish the younger stadial of the Sanian Glaciation (Text-fig. 4).

To the north of the Lower Pilica valley, this stadial is represented by a till horizon of the Cracovian Glaciation (Ruszczyńska-Szenajch 1966). In the Lublin Upland it corresponds to the Kock Stadial (Mojski 1969) whereas in the Łódź Upland it is represented by the youngest till of the South-Polish glaciations (*cf.* Baraniecka & Sarnacka 1971). Within the deep-sea sediments this stadial corresponds probably to the 14th ^{18}O horizon, dated for 542 000—500 000 years B. P. (*cf.* Shackleton & Opdyke 1973).

In connection with the stratigraphic subdivision of the Quaternary in western Europe (Cepek 1967, van Montfrans 1971), the bipartite Sanian Glaciation corresponds to the so-called Glaciation *B* (= Elster-Kaltzeit s.s., *Grundmoränen EII*). In the European part of the Soviet Union this period is represented by the tills *b* and *c* of the Oka Glaciation, dated by the thermoluminescence method for 560 000 ± 60 000 and 483 000 ± 54 000 years B. P. (Zubakov & Kochegura 1973).

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REFERENCES

BARANIECKA M. D. & SARNACKA Z. 1971. The stratigraphy of the Quaternary and the palaeogeography of the drainage basin of the Widawka. *Biul. Inst. Geol.*, **254**, 157—270. Warszawa.

BONIFAY M. F. 1980. Relations entre les données isotopiques océaniques et l'histoire des grandes faunes européennes pliopleistocenes. *Quat. Res.*, **14**, 251—262. New York.

BORÓWKO-DŁUŻAKOWA Z. 1977. Ceteń — Pollen diagram of Ceteń sequence on the Drzewiczka River. *Przew. Symp. Teren. Czwartorzęd zachodniej części regionu świętokrzystkiego;* pp. 126—127. *Wyd. Geol.;* Warszawa.

CEPEK A. G. 1967. Stand und Probleme der Quartärstratigraphie im Norteil der DDR. *Ber. Deutsch. Ges. Geol. Wiss, A, Geol. Paläont.*, **12** (3—4), 375—404. Berlin.

CZARNOCKI J. 1927. Sur les glaciations de la partie centrale du Massif de St. Croix. *Posiedz. Nauk. P.I.G.*, **17**, 18—21. Warszawa.

— 1931. Diluvium der Święty Krzyż Gebirge. *Rocznik P.T.G. (Ann. Soc. Géol. Pologne)*, 7, 85—105. Kraków.

— 1950. Geology of the Łysa Góra Region. *Prace P.I.G.*, 1—104. Warszawa.

— 1975. Pleistocene. *Prace I. G.*, **76**, 1—155. Warszawa.

DĄBROWSKI M. J. 1967. Pollen analysis of an interstadial profile from Jasionka near Rzeszów. *Acta Geol. Polon.*, **17** (3), 509—520. Warszawa.

ERD K. 1978. Pollenstratigraphie im Gebiet der skandinavischen Vereisungen. *Schriftenr. Geol. Wiss.*, **9**, 99—119. Berlin.

FILONOWICZ P. 1972. Pleistocene deposits in the SW part of the Holy Cross Mts. *Rocznik P.T.G. (Ann. Soc. Géol. Pologne)*, **42** (1), 105—116. Kraków.

GAIGALAS A. & KONDRATIENE O. 1976. Quaternary deposits stratigraphy. *In:* The buried paleo-incisions of sub-Quaternary rocks surface of the south-east Baltic Region (*Ed.:* A. Gaigalas), 117—131. *Mokslas Publishers;* Vilnius.

GŁAZEK J., KOWALSKI K., LINDNER L., MŁYNARSKI M., STWORZEWICZ E., TUCHOŁKA P. & WYSOCZAŃSKI-MINKOWSKI T. 1977. Cave deposits at Kozi Grzbiet (Holy Cross Mts, Central Poland) with vertebrate and snail faunas of the Mindelian I/Mindelian II Interglacial and their stratigraphic correlations. *Prac. 7th Intern. Speleolog. Congr.*, pp. 211—214. Sheffield.

GŁAZEK J., KUTEK J. & LINDNER L. 1976. Boulders of Tortonian limestones in till deposits of the Sitki hill near Chęciny, Holy Cross Mts. *Przegl. Geol.*, **8** (280), 459—463. Warszawa.

GŁAZEK J., LINDNER L. & WYSOCZAŃSKI-MINKOWICZ T. 1976. Interglacial Mindel *I*/Mindel *II* in fossil-bearing karst at Kozi Grzbiet in the Holy Cross Mts. *Acta Geol. Polon.*, **26** (3), 337—393. Warszawa.

GRZYBOWSKI K. 1972. Remarks on the Pleistocene in the Pilica valley of south Sulejów. *Rocznik P.T.G. (Ann. Soc. Géol. Pologne)*, **42** (1), 143—150. Kraków.

HAKENBERG M. & LINDNER L. 1971. Quaternary deposits of the middle Nida valley. *Acta Geol. Polon.*, **21** (2), 241—264. Warszawa.

JURKIEWICZOWA I., MAMAKOWA K. & RÜHLE E. 1973. Middle Pleistocene deposits south of Wyśmierzyce near Nowe Miasto on the Pilica River. *Folia Quaternaria*, **43**, 1—26. Kraków.

KLATKA T. 1965. Geomorphology of the Holy Cross Mts. *Roczniki Gleboznawcze*, **15**, 129—162. Warszawa.

KOWALCZYK A. & PUCIŁOWSKA E. 1977. Stratigraphic position of the fossil lake series in the exposure of Łojowice near Sandomierz. *Prace Nauk. Uniw. Śląsk.*, **192** (Geologia *2*), 123—129. Katowice.

KOWALSKI K. 1975. Earliest appearance of lemmings in the Quaternary of Poland. *In:* ALBERDI A. T. & AGUIRRE E. (*Eds*), Acta *I* coloquio Internacional Sorbe Biostratigrafia Continental del Neogeno Superior y Cuaternario Inferior, Montpellier—Madrid 1974, pp. 99—104. Madrid.

— 1976. Fauna kręgowców plejstoceńskich regionu świętokrzyskiego, *Materiały II Nauk. Konf. Paleontologów*, Kielce.

KWAPISZ B. 1978. Quaternary of the Upper Mierzawa drainage basin. *Kwart. Geol.*, **22** (1), 197—211. Warszawa.

LASKOWSKA-WYSOCZAŃSKA W. 1967. The interstadial of the Cracovian Glaciation from Jasionka near Rzeszów. *Acta Geol. Polon.*, **17** (3), 495—507. Warszawa.

LEWANDOWSKI J. 1977. Sediment and transgression character of the anaglacial part of Middle-Polish Glaciation in the Opoczno region. *Prace Nauk. Uniw. Śląsk.*, **192** (Geologia *2*), 130—138. Katowice.

LINDNER L. 1971a. Pleistocene stratigraphy and palaeogeomorphology of the north-western margin of the Holy Cross Mts, Poland. *Studia Geol. Polon.*, **35**, 1—113. Warszawa.

— 1971b. Loess deposits at Oblęgorek near Kielce, Holy Cross Mts. *Acta Geol. Polon.*, **21** (2), 265—278. Warszawa.

— 1977. Pleistocene glaciations in the western part of the Holy Cross Mts, Central Poland. *Studia Geol. Polon.*, **53**, 1—163. Warszawa.

— 1978. Palaeogeomorphologic evolution of the western part of the Holy Cross region in Pleistocene. *Rocznik P. T. G. (Ann. Soc. Géol. Pologne)*, **48** (3—4), 479—508. Kraków.

— 1979. Stratigraphic position and extent of tills in the central part of the Małopolska Upland. *Biul. Geol. Uniw. Warsz.*, **23**, 59—77. Warszawa.

— 1980. An outline of chronostratigraphy of Quaternary in the Holy Cross Mts. *Kwart. Geol.*, **24** (3), 689—710. Warszawa.

— 1982. Plejstocen i holocen w Górach Świętokrzyskich. *In:* Budowa Geologiczna Polski, t. I — Stratygrafia, cz. 3 Kenozoik — Czwartorzęd (*Ed.:* J. E. Mojski). *Inst. Geol.*, Warszawa.

— & BRAUN J. J. 1974. Stratigraphie du Quaternaire et développement morphologique de la vallée de la Bobrzyczka aux environs de la grotte de Raj. *Bad. i udost. jaskini Raj*, pp. 131—142. *Wyd. Geol.*; Warszawa.

— & GRZYBOWSKI K. 1982. Middle-Polish glaciations (Odranian, Wartanian) in southern Central Poland. *Acta Geol. Polon.*, **32** (3—4), 191—206. Warszawa.

— & KOWALSKI W. R. 1974. Quaternary cover around Mt. Miedzianka in the Holy Cross Mts. *Acta Geol. Polon.*, **24** (2), 415—424. Warszawa.

— & ZIEMBIŃSKA-TWORZYDŁO M. 1974. The Eemian Interglacial deposits at Zakrucze near Małogoszcz, western part of the Holy Cross Mts. *Kwart. Geol.*, **18** (3), 636—646. Warszawa.

ŁYCZEWSKA J. 1968. L'accumulation fluvio-périglaciaire dans la partie centrale du Bassin de la Nida, Pologne Centrale. *Biul. Perygl.*, **17**, 125—147. Łódź.

— 1969. Sediments et processus Quaternaire du versant crétacé de la Basse Nida (partie méridionale de la Pologne Centrale). *Biul. Perygl.*, **18**, 195—208. Łódź.

— 1971. The Quaternary of the Holy Cross region. *Prace Inst. Geol.*, **64**, 5—108. Warszawa.

— 1972. Problems of Quaternary investigations in the Holy Cross Mts. *Rocznik P. T. G. (Ann. Soc. Géol. Pologne)*, **42** (1), 81—92. Kraków.

MAKOWSKA A. 1976. Old-Pleistocene organogenous deposits at Ceteń and their connection with the preglacial series of southern Mazovia. *Kwart. Geol.*, **20** (3), 597—624. Warszawa.

— 1977. Ceteń — Organogenic deposits of Early Pleistocene at Ceteń on the Drzewiczka River. *Przew. Symp. Teren., Cwartorzęd zachodniej części regionu świętokrzyskiego*, pp. 118—126. *Wyd. Geol.*; Warszawa.

MIKLASZEWSKI S. 1911. Les traces du glacier sur la montagne de S-te Croix. *Spraw. Tow. Nauk. Warsz.*, **4**, 388—390. Warszawa.

MOJSKI J. E. 1969. Stratigraphy of Meso-Pleistocene glacial deposits. *Kwart. Geol.*, **13** (2), 385—407. Warszawa.

van MONTFRANS H. M. 1971. Palaeomagnetic dating in the North Sea Basin, 1—113, *Princo N. V.*; Rotterdam.

POLIŃSKI W. 1927. Gasteropodes diluviaux de Kielce. *Posiedz. Nauk. P. I. G.*, **17**, 21—22. Warszawa.

POŻARYSKA K. 1948. Stratigraphy of Pleistocene of the Lower Kamienna valley. *Biul. P. I. G.*, **52**, 1—91. Warszawa.

RADŁOWSKA C. 1966. Z geomorfologii okolic Pińczowa. *In:* Studia geograficzne w powiecie pińczowskim. *Prace Geograf. Inst. Geograf. PAN*, **47**, 13—38. Warszawa.

— & MYCIELSKA-DOWGIAŁŁO E. 1972. Comments on deglaciation in W part of Święty Krzyż Mountains — near Chęciny. *Przegl. Geograf.*, **44** (4), 649—672. Warszawa.

— & — 1974. Deglaciation in the Świętokrzyskie Mts. *Geograph. Polon.*, **28**, 19—48. Warszawa.

ROŻYCKI S. Z. 1967. The Pleistocene of Middle Poland, 1—251. *Państw. Wyd. Nauk.*; Warszawa.

— 1972. Plejstocen Polski Środkowej; Wyd. 2, 1—315. *Państw. Wyd. Nauk.*; Warszawa.

— 1979. From Mochty to a synthesis of the Polish Pleistocene. *Rocznik P. T. G.* (*Ann. Soc. Géol. Pologne*), **48** (3—4), 445—478. Kraków.

— 1980. Principles of stratigraphic subdivisions of Quaternary of Poland. *Quat. Stud. Pol.*, **2**, 99—106. Warszawa—Poznań.

RUSZCZYŃSKA H. 1961. The Quaternary in the neighbourhood of Tomaszów Mazowiecki and Sulejów on the Pilica River. *Prace o Plejst. Polski Środkowej*, 101—106. Warszawa.

— 1966. Pleistocene stratigraphy and palaeogeomorphology in the Lower Pilica Region, Central Poland. *Studia Geol. Polon.*, **22**, 1—100. Warszawa.

SAMSONOWICZ J. 1934. Objaśnienia arkusza Opatów ogólnej mapy geologicznej Polski. *Państw. Inst. Geol.*; Warszawa.

SHACKLETON N. J. & OPDYKE N. D. 1973. Oxygen isotope and palaeomagnetic stratigraphy of equatorial Pacific core V28J238: Oxygen isotope temperatures and ice volumes on a 10^5 year scale. *Quaternary Res.*, **3** (1), 39—55. New York.

SIEMIRADZKI J. 1888. Compte rendu de recherches géologique éxécutées en été 1887 aux environs de Kielce et de Chęciny. *Pamiętn. Fizjograf.*, **8**, 3—18. Warszawa.

SZAJN J. 1978. Stratigraphy of Pleistocene deposits and development of river network in eastern part of the Włoszczowa basin. *Kwart. Geol.*, **22** (1), 181—195. Warszawa.

SZYNDLAR Z. 1981. Early Pleistocene reptile fauna from Kozi Grzbiet in the Holy Cross Mts. *Acta Geol. Polon.*, **31** (1—2), 81—101. Warszawa.

WALCZOWSKI A. 1972. Stratigraphy of Quaternary deposits of the SE part of the Holy Cross Mts region. *Rocznik P. T. G.* (*Ann. Soc. Géol. Pologne*), **42** (1), 125—134. Kraków.

WÓDKOWSKI A. 1971. Fragment d'une caverne á ossement de la faune pleistocéne aux environs du mont Miedzianka — Montagnes de St. Croix. *Speleologia*, **6** (1—2), 41—47. Warszawa.

WYSOCZAŃSKI-MINKOWICZ T. 1980. Dating of bone remnants as a fundamental criterion for determination of stratigraphy and chronology of the Pleistocene in Poland Guide-book of field seminar "Stratigraphy and chronology of the loesses and glacial deposits of the lower and middle Pleistocene in SE Poland", pp. 23—29. Lublin.

ZUBAKOV V. A. 1978. Pozdnikainozoiskaya lednikovaya epokha: khronologiya y peryodizatsiya. Chtenya pamyati L. S. Berga. *Nauka*; Leningrad.

— & KOCHEGURA V. V. 1973. Khronologiya noveyshego etapa geologicheskoy istoryi SSSR (ot 3 000 000 do 60 000 let). *In:* Khronologiya pleystocena i klimaticheskaya stratigrafya, pp. 39—73. *Geogr. Obskch. SSSR*; Leningrad.

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ZLODOWACENIA POŁUDNIOWOPOLSKIE W POŁUDNIOWEJ CZĘŚCI POLSKI ŚRODKOWEJ

(Streszczenie)

Przedmiotem pracy są zachowane w południowej części Polski Środkowej (patrz fig. 1) osady i formy upoważniające do podziału zlodowacenia południowopolskiego (= krakowskiego, Mindel) na dwa odrębne zlodowacenia: Nidy (= starsza część zlodowacenia Oki, *Helme-Kaltzeit*, Mindel *I*) i Sanu (= młodsza część zlodowacenia Oki, *Elster-Kaltzeit* s.s., Mindel *II*), które oddzielone są (patrz fig. 2—4) interglacjałem małopolskim (= *Voigstedt-Warmzeit*). Interglacjał ten datowany jest metodą FCl/P i paleomagnetyczną oraz dokumentowany szczątkami faunistycznymi w stanowisku krasowym Kozi Grzbiet koło Chęcin. W obrębie zlodowacenia Sanu wyróżniono dwa stadiały: maksymalny i pomaksymalny, oddzialone okresem interstadialnym. Podczas dwudzielnego stadiału maksymalnego tego zlodowacenia lądolód skandynawski pokrył cały opisywany obszar i sięgał aż po Karpaty, natomiast w czasie stadiału pomaksymalnego objął swym zasięgiem jedynie północną część obszaru.