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Institute of Geology, Warsaw University, Al. Żwirki i Wigury 93, 02-089 Warszawa, Poland

Jerzy NITYCHORUK

Glacial Deposits in the Tarnów Plateau (S Poland) and the Problem of Dunajec Outflow During the San 2 (= Elsterian II) Glaciation

Osady glacjalne na Płaskowyżu Tarnowskim i problem odpływu wód Dunajca w okresie zlodowacenia San 2 (=Elsterian II)

ABSTRACT

As the result of interpretation of geological situation and determination of petrographic composition of Quaternary deposits in the NW part of the Tarnów Plateau, new data on a outflow of the Dunajec river waters during the South Polish glaciation has been presented. TL dating of tills occurring in this area permitted to ascribe them to the San 2 (= Elsterian II) glaciation.

INTRODUCTION

Quaternary deposits of the Tarnów Plateau are poorly understood, despite numerous drillings for oil and gas. It is caused by a small number of outcrops, very generalized description of cores of deep boreholes, and the absence of hydrogeological drillings. Thus, the opportunity to correlate results of field investigations with studies of cores obtained during drilling for clastic raw materials by the enterprise "Hydrogeo" from Kraków, stimulated detailed investigations of geological situation and the age of the deposits of the South Polish glaciation in this region.

Field works concerned detailed description of sections of Tertiary and Quaternary deposits in numerous outcrops. A petrographic analysis of

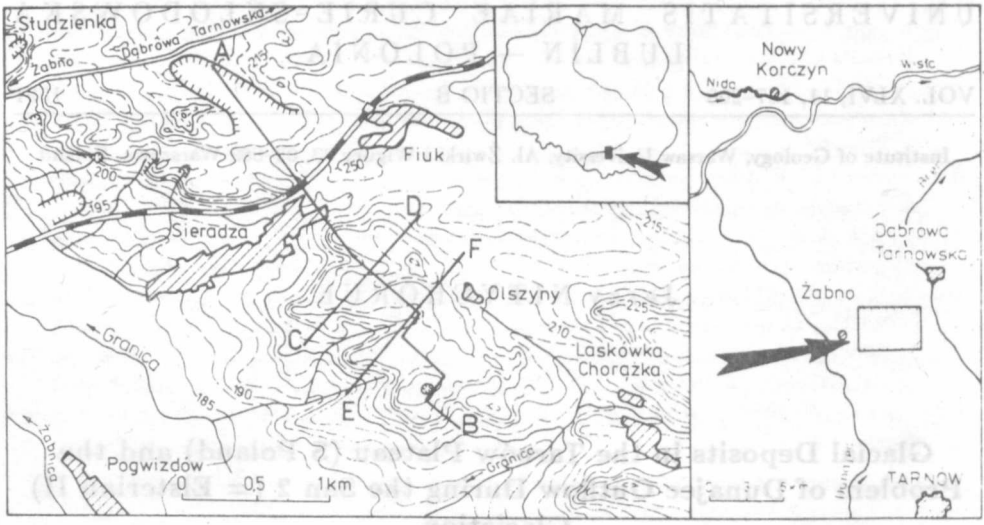

Fig. 1. Location of the investigated area within the NW part of the Tarnów Plateau; lines (A–B; C–D; E–F) of geological cross-sections marked

4 gravel samples (for fraction 0.8–64 mm, counting 300 pebbles in each sample), collected in the Fiuk-Sieradza and Olszyny gravel-pits (Fig. 1), has also been carried. Five samples of Quaternary deposits were TL dated (in the TL Laboratory, Department of Physical Geography, University Maria Curie-Skłodowska in Lublin, by Dr. J. Butrym). Borehole data were correlated on geological cross-sections.

A detailed study includes a part of Plateau, between the Dunajec valley (from Żabno area) and the Breń river valley, below Dąbrowa Tarnowska (Fig. 1). This area has no separate geological description, thus the results have been related to the results of studies of Quaternary deposits in the Sandomierz Basin.

PREVIOUS INVESTIGATIONS

The first important geological description of the area was presented in the Geological Atlas of Galicja (M. Łomnicki 1903), where stratigraphical section of Quaternary deposits in relation to river terraces had been presented. Also S. Pawłowski (1920) had studied river terraces of the Wisłoka and Mleczka rivers, recognizing one glaciation event first, and next (S. Pawłowski 1925) two glaciation events in this area. K. Konior (1946) prepared a geological map of the area, where moraine

deposits, fluvioglacial horizons and accumulation terraces of the Dunajec river have been marked; he also supported the idea about one glaciation event there. Similar study of Quaternary deposits has been presented by H. Kozikowski (1963) for the Carpathian foreland between Brzeźnica and Dunajec.

M. Klimaszewski (1948, 1967) papers are a considerable contribution to the knowledge of Quaternary stratigraphy in the Western Carpathians. He distinguished three accumulation horizons, different in age, in the valleys of the Carpathian rivers: they were correlated with the following glaciations: Cracovian (= Elsterian), Middle Polish (= Saalian) and Baltic (= Vistulian). This idea was further supported and supplemented by Starkel (1957). Different ideas about the age of the Middle Polish glaciation terrace of the Dunajec have been presented by A. Jahn (1957) and A. Środoń (1965), who ascribed it to the Baltic glaciation. They also divided the last glaciation into younger and older parts, basing it on lithological differentiation of that terrace deposits and occurrence there organogenic sediments. Investigations carried out by W. Laskowska-Wysoczańska (1967) in the eastern part of the Sandomierz Basin have proved, suggested earlier by S. Pawłowski (1925), bipartition of the Cracovian glaciation. This was further supported by the studies of J. Buraczyński and J. Wojtanowicz (1968), carried out in northern part of the Sandomierz Basin and concerning the development of the Vistula and San river valleys. Of considerable importance, for a knowledge of Quaternary stratigraphy and paleogeography of the Sandomierz Basin, are the synthetic papers by W. Laskowska-Wysoczańska (1971) and L. Starkel (1972, 1984).

One should mention studies by W. Zuchiewicz (1983, 1984) carried out in adjacent areas Carpathian parts of the Dunajec valley. They note the tectonic movements of the Carpathians during Quaternary and distinguish accumulation horizons of the Dunajec, resulting on the attempt to determine their age. The most recent stratigraphical studies of Quaternary deposits concern the Holy Cross Mountains, Nida Depression and Miechów Upland (L. Lindner 1988a, b), which form the northern edge of the Sandomierz Basin. L. Lindner (1988b) prešents the extent of the San 1 (= Elsterian I) inland ice, which was smaller than the extent of the younger, San 2 (= Elsterian II) inland ice. The ice sheeet of the San 1, covered the entire Nida Depression together with northern part of the Sandomierz Basin, beginning from the Dunajec mouth. Dating of tills of this glaciation, obtained by B. Kwapisz and J. Szajn (1987), supports the idea.

GEOMORPHOLOGY AND GEOLOGY OF THE INVESTIGATED AREA

The north-western part of the Tarnów Plateau, between the valley of Dunajec, and the Breń river, which flows toward the north, morainic plateau exists displaying relative relief up to 33 m (200–230 m a.s.l.). Dominant morphological feature of that area is a longitudinal belt of hills running from NW to SE, sometime cut by perpendicular tributaries of the Dunajec and Breń. In the edge of the plateau, 20 m high there, separating it from the Dunajec valley, crops out so called Krakowiec Clay of the Tertiary age. They form a bedrock of Quaternary deposits in this area (H. Jurkiewicz and J. Woiński 1979). The top of Krakowiec Clays occurs at the altitude of 196 to 220 m, and the covering Quaternary deposits which are up to 20 m thick are masking its diversified character. Lithological composition of Quaternary sediments, built mainly by clays, sands, glacial and glaciofluvial gravels, indicates that landscape forming processes were not dependent on a character and distribution of deposits. In the western part, at a foot of the plateau edge, there is a flat (180 m a.s.l.) surface about 4 km wide, forming a rightbank part of the Dunajec valley, which culminates at 190 m a.s.l. The zone of dunes corresponds to the margin of the middle terrace of the Dunajec. The erosional socle of this terrace (162 m a.s.l.) is located 10 m higher, in the investigated area, than the socle of a younger ("rendzina") terrace (174 m a.s.l.). The origin of older gravel cover of the upper terrace, according to T. Sokołowski (1981), should be related with the Middle Polish glaciation, while the origin of younger gravel cover, with the period of the Vistulian glaciation. The age of erosion which formed the "rendzina" terrace is determined by L. Starkel (1977) as the late Vistulian, then the main stage of its accumulation as Holocene.

The Dunajec valley displays poorly differentiated relief while infilling deposits are masking culminations and deep erosional incisions occurring within erosional socle. Culminations are formed here by erosional monadnock of Tertiary clays (see T. Sokołowski 1981) hidden under thin cover of river deposits. It thus permits their exploitation in clay-pits (Żabno, Radłów). The deep incisions in the Quaternary deposits bedrock, the nearest one running from Zdrochec to Otwinów (48 m beneath the terrace surface, while alluvia of the terrace are only 5–10 m thick), occur also between the Raba and Dunajec rivers (see E. Jawor et al. 1974, T. Sokołowski 1981). They are infilled with sandy-gravel deposits and it is rather difficult to follow their extent along a larger distance.

South and west from the investigated area, the hummocky morainic plateau occur, composed of tills and sands with gravels of glacial accumula-

tion (H. Jurkiewicz and J. Woiński 1979), which is separated by a gentle margin from the Vistula valley in the north.

DESCRIPTION OF THE INVESTIGATED SECTIONS

Well outcropped, 20 m thick complex of Quaternary deposits, has been described from the Fiuk-Sieradza gravel-pit (Figs. 1 and 2). The section starts with 20 cm thick layer of pebbles, resting on the Miocene Krakowiec Clays (201 m a.s.l.). A layer of homogeneous medium grained sand, laying above, contains single gravels and balls of Tertiary clays, dozen centimeters in diameter. A sample for TL dating has been collected from the lower part of these sands which is dated 586±87 ka (Lub—1719). Another sample has been collected from a 30 cm thick gravel interlayer (Fig. 2) for determination of petrographic composition. Gravels in that sample are characterized by high content of quartz and sandstone pebbles; they contain also flints, Scandinavian rocks, cherts and lydites (Fig. 3). High resistance of the gravels, as well as their roundness, indicate long transportation, during which it could be collected already sorted material.

Higher, above the sands, 2 m thick zone of older varved clays occurs, TL dated 558±83 ka (Lub—1718). Above the clays there are sands with gravels and pebbles occurring in two horizons up to 20 cm thick (Fig. 2). A sample from the lower gravel horizon shows the petrographic composition very similar to the lowest gravels (Figs. 2, 3). The sands are clearly cross-stratified, what allowed determination of the transport direction from NE to SW. In a higher part of the section there is a second, younger horizon of varved clays. TL age is 520±78 ka (Lub—1717) for these clays. Above the clays and thin layer of sands, there is a till with pavement in the upper part. Two TL dates received for the bottom and the top of the till are 518±77 ka (Lub—1716) and 490±73 ka (Lub—1715) respectively. The till is covered with 0.4 m thick layer of silty-sands with gravels (Fig. 2).

The next gravel-pit, smaller than others, occurs toward SSW from the Olszyny village. The section cropping there out is 6 m thick and starts with a layer of till (thickness unknown), covered with a 4.5 m thick complex of medium grained sands; they contain single gravels (Fig. 2). At the depth 4.0 to 5.0 m within the sands, occur two intercalations of gravels with pebbles (up to 20 cm in diameter), separated by a 10 cm thick layer of medium grained sands. Two samples of pebbles contain Carpathian sandstones and quartzites with considerable share of nonresistant opokas, gaizes and limestones from the Holy Cross Mts regions. There are also Scandinavian

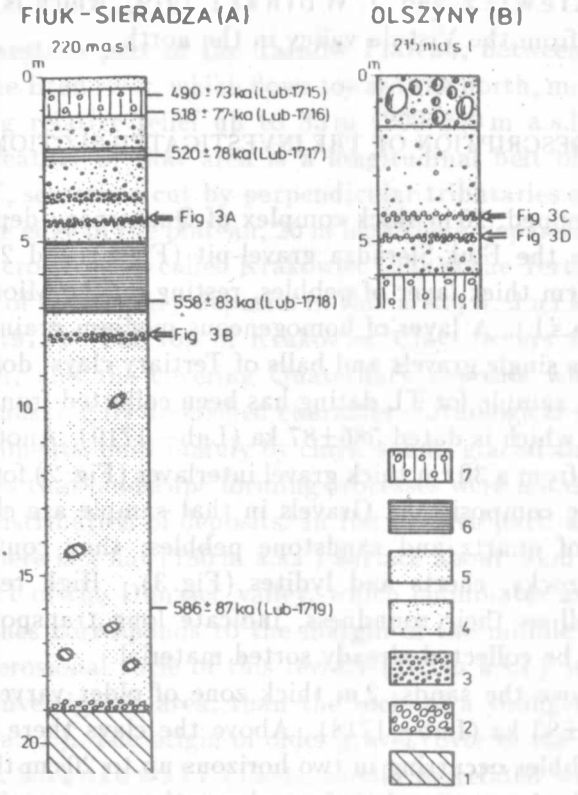

Fig. 2. Lithological sections and TL age of Quaternary deposits cropping out in the Fiuk-Sieradza and Olszyny gravel-pits

1 — Quaternary bedrock: Krakowiec Clays (Miocene); 2 — boulders; 3 — gravels; 4 — medium grained sand; 5 — fine grained sand; 6 — varved clays; 7 — till

material, quartz, granitic and quarzitic rocks from the Tatra Mts, as well as flints, lydites and cherts (Figs. 2 and 3). Above the sands there is a 1.5 m thick horizon of silty sands containing gravels, pebbles and erratic boulders (1.3 m in diameter). Similar lithological profile is cropping out in the Studzienka village (Fig. 1).

A sandy-gravel complex occurring in the Fiuk-Sieradza gravel-pit displays no sedimentary discontinuities, what is indicated by a very similar petrographic composition of gravel layers occurring in the upper and lower parts of the section (Figs. 2, 3). The content of Scandinavian material as well as direction of transportation to SW, indicate that it represents glacifluvial material deposited in front of a glacier transgressing over the Sandomierz Basin. Tills covering the above mentioned deposits have TL

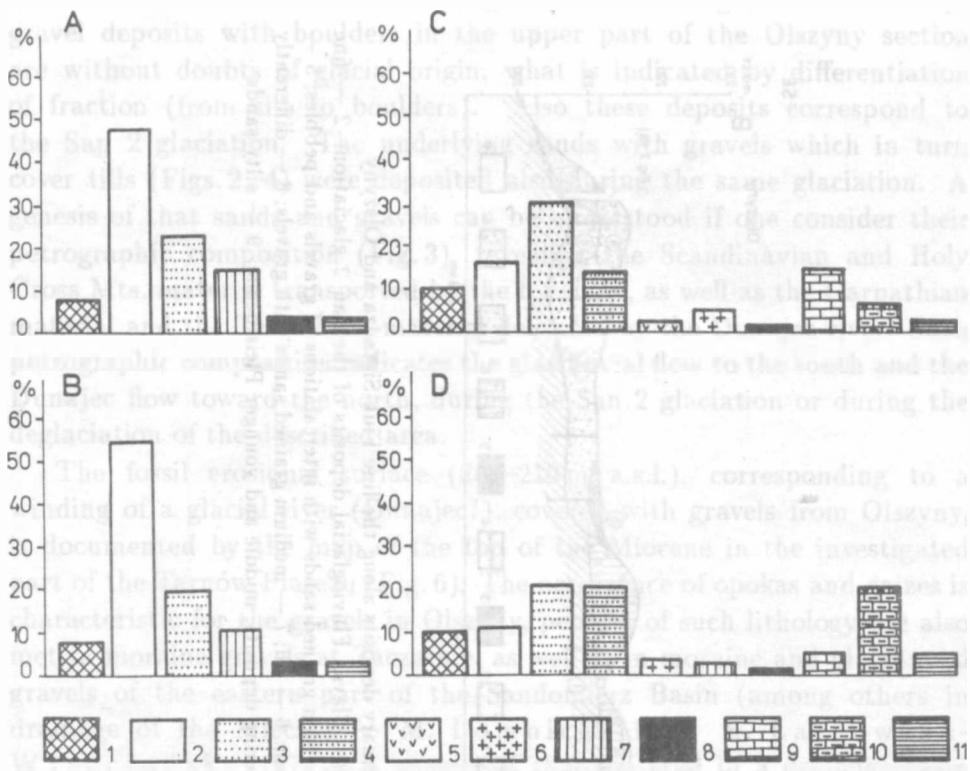

Fig. 3. Petrographic composition of gravels from the Fiuk-Sieradza gravel-pit (A and B) and Olszyny (C and D)
1 — Scandinavian rocks; 2 — quartz; 3 and 4 — quartzites and carbonate sandstones; 5 — Triassic quartzites; 6 — granitic rocks; 7 — flintstones; 8 — cherts and lydites; 9 — limestones; 10 — opokas and gaizes; 11 — undetermined rocks

age 518–490 ka, what corresponds with the TL dates received for tills from Giedlarowa (J. Wojtanowicz 1985), tills in the Niebylec (J. Butrym and T. Gerlach 1985), Krukienice and Dubanowice (J. Butrym et al. 1988), as well as those from the Kolosy section near Wiślica (L. Lindner 1988b). The tills of that age are ascribed by L. Lindner (1988b) to the San 2 glaciation. Homogeneous petrographic composition of the underlying glacifluvial deposits in the Fiuk-Sieradza, and TL age of the lower part of these deposits 586–558 ka seem to indicate — taking into consideration the error of the TL dating method — that they could belong to the San 2 glaciation.

As it follows from the geological cross section, the till underlying sandy-gravel deposits at Olszyny (Figs. 4, 5) should be correlated with

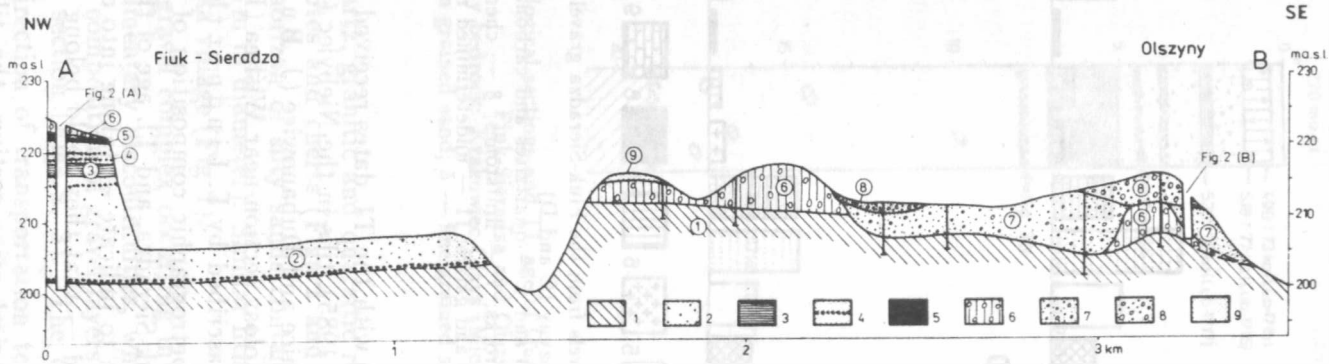

Fig. 4. Geological cross-section (A–B) of Quaternary deposits along the line Fiuk-Sieradza and Olszyny
Bedrock of Quaternary deposits (Miocene): 1 — Krakowiec Clays. Fluvioglacial deposits of the San 2 glaciation: 2 — fine grained sands and gravels; 3 — older varved clays; 4 — medium grained sands with intercalations of gravels and pebbles; 5 — younger varved clays. Glacial deposits of the San 2 glaciation: 6 — till; 7 — medium grained sands with gravels; 8 — differently grained sands with gravels, gravels and boulders. Covering deposits, middle and younger Pleistocene: 9 — silty sands

the till in the Fiuk-Sieradza, belongs to the San 2 glaciation. Sandy-gravel deposits with boulders in the upper part of the Olszyny section are without doubts of glacial origin, what is indicated by differentiation of fraction (from silt to boulders). Also these deposits correspond to the San 2 glaciation. The underlying sands with gravels which in turn cover tills (Figs. 2, 4) were deposited also during the same glaciation. A genesis of that sands and gravels can be understood if one consider their petrographic composition (Fig. 3), revealing the Scandinavian and Holy Cross Mts. material transported by the ice sheet, as well as the Carpathian material and the Tatra Mts. material delivered by the Dunajec river. Such petrographic composition indicates the glacifluvial flow to the south and the Dunajec flow toward the north, during the San 2 glaciation or during the deglaciation of the described area.

The fossil erosional surface (208–210 m a.s.l.), corresponding to a winding of a glacial river (Dunajec?), covered with gravels from Olszyny, is documented by the map of the top of the Miocene in the investigated part of the Tarnów Plateau (Fig. 6). The occurrence of opokas and gaizes is characteristic for the gravels in Olszyny, pebbles of such lithology are also met in moraine gravels at Zaczarnie, as well as in moraine and glacifluvial gravels of the eastern part of the Sandomierz Basin (among others in drainage of the Mleczka — M. Łomnicki 1903, H. Laskowska-Wysoczańska 1971). A genesis of that material in a drainage-basin of the Mleczka is the subject of controversy. M. Łomnicki (1903) supposed that they were deliverd by the ice sheet from the Lublin Upland, while H. Laskowska-Wysoczańska (1971) relates their origin with Cretaceous deposits from the Rzeszów-Przemyśl folds. It seems, however, that in the case of opokas and gaizes in the gravels from Olszyny, such problem does not exists, as that type of rocks are not known in the Carpathian part of the Dunajec. The large distance between Olszyny and the Carpathians (20 km), makes also transportation of poorly resistant material over such distance improbably. Thus, one should regard it as a material delivered by the ice sheet.

PALEOGEOGRAPHIC CONCLUSIONS AND FINAL REMARKS

The oldest Quaternary deposits in the investigated area crop out in the Fiuk-Sieradza, where they infill erosional trough in the Miocene clays running from NE to SW (Figs. 4, 6). These are deposits which originated before the San 2 glaciation, what is indicated by the petrographic

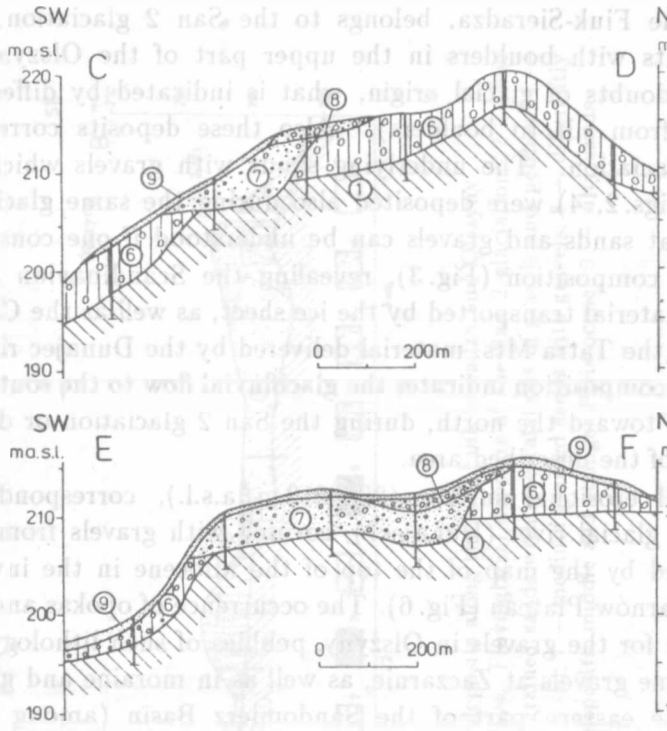

Fig. 5. Geological cross-sections (C–D, E–F) of Quaternary deposits in the Olszyny area (explanations see Fig. 4)

composition and TL dating (Figs. 2, 3). High resistance of a gravel material occurring in them indicates its remote source. That material was delivered by approaching front of the ice sheet destroying old Quaternary gravels from interfluve areas (L. S t a r k e l 1972). In the east that ice sheet was damming the flow of water to E, toward the Dniestr catchment also to the Black See, and forced the flow toward SW (Fig. 6A). Quarzites and the Carpathian sandstones occurring in gravels at the Fiuk-Sieradza, are derived from the deposits accumulated by the Vistula or Raba. Lack of a material, derived from the Tatra Mts, indicate that the flows of the Dunajec toward the north, before the San 2 glaciation, are improbable.

Transgressing onto the Tarnów Plateau, the ice sheet of the San 2 glaciation exarated non resistant Krakowiec Clays, thus forming differentiated relief. It is the cause of so high location of the upper part of glacifluvial deposits in the Fiuk-Sieradza gravel-pit, in relation to the surrounding Tertiary bedrock (Figs. 4, 6A). Ice-sheet transgressing further to S met an obstacle formed by the edge of the Carpathians, what caused most prob-

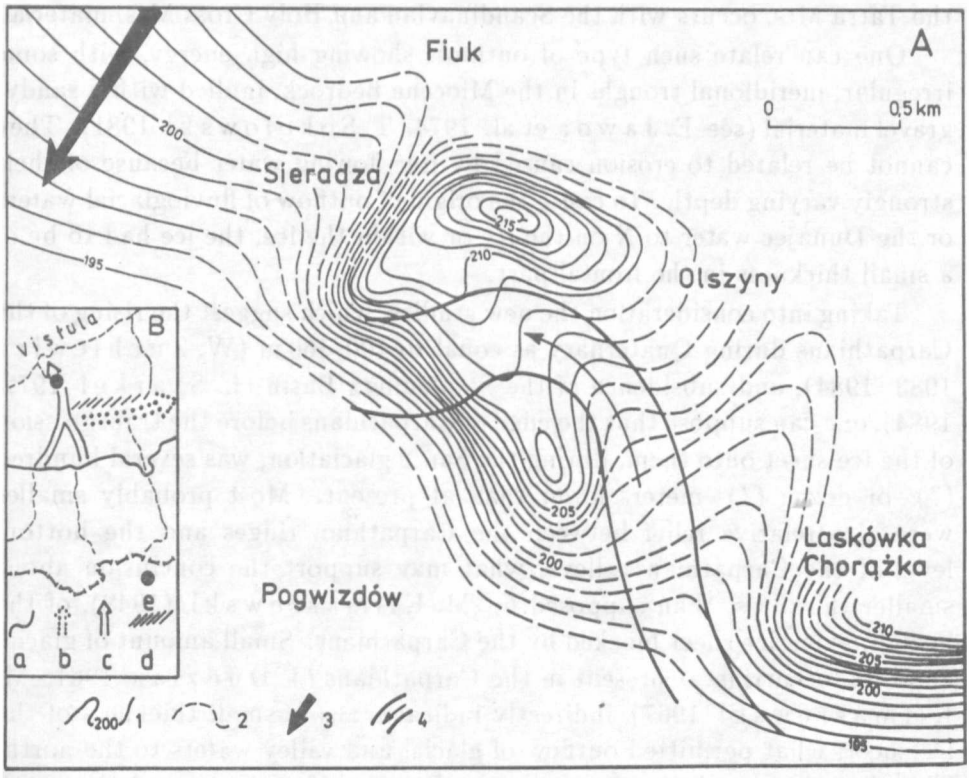

Fig. 6. The upper surface of the Miocene deposits in the NW part of the Tarnów Plateau (A) and paleogeographical situation of the investigated area during the San 2 glaciation (B)

1 — contour lines of the top surface of Miocene deposits (sure); 2 — contour lines of the top surface of the Miocene deposits (interpolated); 3 — direction of fluvioglacial flow related to the San 2 glaciation; 4 — direction of flow and extent of the Dunajec deposits during the San 2 glaciation; a — extent of the San 2 glaciation; b — Forecarpathian ice-marginal valley; c — direction of the Dunajec flow during the San 2 glaciation; d — increased thickness of glacial deposit in the Jaźwiny-Lisia Góra environs; e — investigated area

ably its halt, expressed by a increase in the thickness of glacial deposit in the Jaźwiny-Lisia Góra environs (Fig. 6B). Even then outflow of the Dunajec was taking place toward the E by the Forecarpathian ice-marginal valley (W. Laskowska-Wysoczańska 1971, L. Starkel 1972, 1984). Transgression of the ice sheet into Carpathian valleys caused damming of the Dunajec and glacifluvial waters, their flood over the ice or outflow by glacial crevases toward the north. It is confirmed by a petrographic composition of the gravel-sandy complex from Olszyny, where the material derived from

the Tatra Mts. occurs with the Scandinavian and Holy Cross Mts. material.

One can relate such type of outflow, showing high energy, with some irregular, meridional troughs in the Miocene bedrock, infilled with a sandy-gravel material (see E. Jawor et al. 1974, T. Sokołowski 1981). They cannot be related to erosion caused by free-flowing water because of their strongly varying depth. To cause the origin of outflow of fluvioglacial waters or the Dunajec water to N on the ice or within the ice, the ice had to be of a small thickness in the frontal part.

Taking into consideration the new studies, which suggest the rising of the Carpathians during Quaternary as equal to 100–160 m (W. Zuchiewicz 1983, 1984), and subsidence of the Sandomierz Basin (L. Starkel 1972, 1984), one can suppose that the edge of Carpathians before the transgression of the ice sheet onto them, during the San 2 glaciation, was several hundred (?) or dozen (?) meters lower than at present. Most probably smaller were also relative relief between the Carpathian ridges and the bottom level of the Carpathian valleys, what may support the conclusion about smaller thickness, than supposed by M. Klimaszewski (1948), of the Scandinavian ice sheet blocked by the Carpathians. Small amount of glacial deposits, occurring at present in the Carpathians (J. Dudziak 1961, M. Klimaszewski 1967), indirectly indicates also a small thickness of the ice sheet, what permitted outflow of glacial and valley waters to the north. This direction has been chosen by the Dunajec, flowing toward the north after the San 2 glaciation.

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STRESZCZENIE

W wyniku badań geologicznych prowadzonych w NW części Płaskowyżu Tarnowskiego (ryc. 1) wyróżniono dwie różnowiekowe serie piaszczysto-żwirowe odsłaniające się w żwirowniach Fiuk-Sieradza i Olszyny (ryc. 2). Datowania TL 5 próbek ze żwirowni Fiuk-Sieradza oraz analiza składu petrograficznego żwirów obu serii (ryc. 3) pozwoliły zaliczyć żwiry z Fiuk-Sieradza do okresu poprzedzającego zlodowacenie San 2, a glinę zwałową na nich leżącą do tego zlodowacenia. Natomiast skład petrograficzny i pozycja międzymorenowych żwirów z Olszyn (ryc. 4, 5) są dowodem na przepływ wód Dunajca i fluwioglacjalnych na N w trakcie zlodowacenia San 2 (ryc. 6).*

* Opracowanie wykonane częściowo w okresie pobierania stypendium im. Krzysztofa Beresa, przyznanego autorowi przez Zarząd Główny Polskiego Towarzystwa Geologicznego.

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Adresse:

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