

LITHOLOGY AND STRATIGRAPHY OF THE QUATERNARY  
FORMATIONS OF THE SOUTH-WESTERN PART OF THE WŁODAWA  
ELEVATION (LUBLIN POLESIE)

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**A b s t r a c t.** The Włodawa Elevation, a sub region of the Lublin Polesie constitutes a clear elevation built in its core of tertiary deposits, enclosed in lithologically and stratigraphically varied Quaternary deposits strongly disturbed by glaciotectionic processes. The area investigated was glaciated five times during the Narewian, Sanian 1, Sanian 2, Liwiecian and Odranian glaciations, which is evidenced by the lithological character and the age of the sediments, as dated by thermoluminescent and palynological methods.

**K e y w o r d s:** The Włodawa Elevation, Quaternary formations, thermoluminescent dates, Quaternary stratigraphy

INTRODUCTION

The Włodawa Elevation is the most hypsometrically diversified regional unit of the Lublin Polesie, constituting a clear parallel elevation stretching from Sosnowica in the west to the Bug in the east. The total length of the ridge is about 34 km, and its width varies from 2 to 10 km. The heights within this sub-region reach 197,5 m above sea level, and relative ones reach 40 m.

The results of geological research conducted for a number of sheets of the Detailed Geological Map of Poland, scale 1:50 000, allow a fairly thorough definition of the geological composition of the area. Those interested in the history of the research of this region may find more information in earlier works on this subject [2-6,9-12].

### THE SEDIMENTS OF THE UNDERQUATERNARY BED

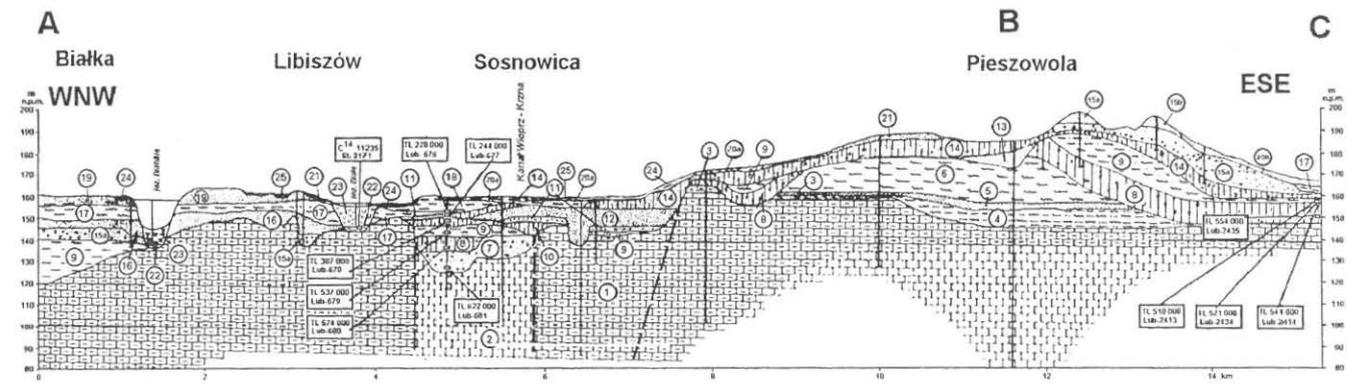
The underquaternary bed of the Włodawa Elevation consists of a Cretaceous bed in parallel elevation, strongly split up tectonically and by karsic processes which took place in the Tertiary period. Cretaceous rocks developed in the form of marls, white chalk and marly limestone. The biggest tectonic dislocation, predisposed by the presence of older tectonic fractures in the bed (Hannas Fall), stretches from the fossil valley of the Wieprz, through Piaseczno and Orzechów Nowy, Sosnowica and further on to Kodeniec, where it changes direction from NE-SW to NE. Other vast tectonic depressions join this depression, cutting the Włodawa Elevation crosswise near Turno and Hola, as well as Horostyta and Kołacze (Fig. 1). In those crosswise falling zones, sediments of thick detached blocks from the Pleistocene age, strongly disturbed by glaciotectionic processes were preserved. They consist of Cretaceous-Oligocene sediments, divided by Scandinavian erratic material [12].

Tertiary rocks occur only on a limited surface of upper-Cretaceous rocks. These are upper-Eocene loams, with iron concretions, covered by thick sediments of the Oligocene period, occasionally building culminations of the upper forms of underquaternary relief (area of Górki, Wołoskowola, Turno and Hola). From the lithological point of view, the Oligocene sediments are mainly glauconite sands, medium- and fine-grained, grey dusty sands with conglomerates of sandstone and loamy silt with boulders of grey sandstone. Miocene deposits are mainly sands and light grey loamy silts with a large dust fraction share (60-87%!). These are lacustrine deposits.

### EO- AND MESO-PLEISTOCENE DEPOSITS

The oldest Pleistocene formations are pre-glacial (Eopleistocene) weathered clays with local rock and vein quartz gravel, and sands, preserved on the Włodawa Elevation only occasionally. They are of deluvial-colluvial genesis [3,7]. These oldest deposits occur in larger condensation in the vicinity of the Włodawa Elevation in Żmiarki.

Glacial deposits of the oldest glaciation the Narewian, were found in Żmiarki, where they lie on pre-glacial sediments. These are sands with Scandinavian material, as well as varved silts and boulder clay which was dated with TL method to  $771 \pm 115$  ka BP (Lub-684) in Żmiarki and to  $822 \pm 183$  ka BP (Lub-683) in the town of Horostyta.



**Fig. 1.** Geological section across the south-western Włodawa Elevation. Cretaceous, Maestrichtian: 1 - marl, 2 - writing chalk. Tertiary, Oligocene: 3 - glauconite sands, 4 - clayey silts. Pleistocene, Sanian 1 Glaciation: 7 - glaciofluvial sands with gravels, 8 - till, Ferdynandowian Interglacial: 9 - lacustrine-fluvial sands, Liwiecian Glaciation: 10 - till, 11 - sands with gravels, Zbójnian Interglacial: 12 - fluvial sands, 13 - lacustrine-fluvial sands, Odranian Glaciation: 14 - till, 15a - sands with gravels, 15b - kame sands, Lublinian Interglacial: 16 - fluvial sands, 17 - lacustrine silts, Wartanian Glaciation: 18 - fluvioperiglacial silts, 19 - fluvioperiglacial sands, Wartanian and Vistulian Glaciations (together): 20a - lacustrine sands and silts, 20b - deluvial sands, Vistulian Glaciation: 21 - aeolian sands, 22 - peats. Holocene: 23 - gytjtjas, 24 - peaty muds, 25 - allochthonous peats

Podlasiian Interglacial (=Augustowian) did not leave any traces in the form of deposits; erosion and denudation dominated at that time.

The oldest sediments of southern-Polish Glaciations in this area are the water-glacial formations of the Sanian 1<sup>1</sup> Glaciation TL dated to  $622 \pm 93$  ka BP (Lub-681) in Sosnowica, where they lie in the bed of a depression of tectonic origin. For boulder clays of this glaciation a number of TL dates were obtained, varying from 540 to 574 ka BP ([12], Tabela 2), which, together with petrographic features of this formation allowed them to be stratigraphically assigned to the Sanian 1 Glaciation.

Sediments of the Ferdynandovian Interglacial period were found in a clear stratigraphic position in boring in Sosnowica, where lacustrine silts were found. They were investigated palynologically [13,14], and dated with by the TL method to  $537 \pm 80$  ka BP (Lub-679). The sediments of this age occur in larger amounts on the northern foreground of the Włodawa Elevation in the area of Podedwórze as well as Radcze and Paszenki.

The Sanian 2 Glaciation, fully extending to the Carpathians, is represented by water-glacial sands of the descending phase of the glaciation and boulder clays dated with the TL method in Orzechów Stary to  $474 \pm 71$  ka BP (Lub-2418), where they lie on Ferdynandovian silts, and in Lasek Bruski, where boulder clay was assigned a TL date of  $447 \pm 67$  ka BP (Lub-2428). Glacial deposits of this type also occur in Brus (TL date = 417 ka BP). The tills of this age have a clearly reduced thickness – by erosion processes, denudation and exaration in the period of the following younger glaciations.

The Mazovian Interglacial period is mainly evidenced by traces of erosion and denudation. The traces of this interglacial period are mainly fluvial sands and lacustrine deposits occurring in the Radcze area on the northern foreground of the Włodawa Elevation, where they were dated with TL method to:  $397 \pm 59$  ka BP (Lub-689) and  $429 \pm 64$  ka BP (Lub-699). On the basis of the results of expert palynological research, it can be determined that at that time vast, open landscapes dominated and the climate was moderate.

The Liviecian Glaciations period left clear marks of glacial and water-glacial sediments on the Włodawa Elevation, which is important for determining the extent of this glacier. Tills were found in the sections of Radcze, Sosnowica, Lasek Bruski, Horostyta and other places. These sediments were dated with the TL method to 387 to 391 ka BP [12]. They were also identified stratigraphically on

<sup>1</sup>In the description the stratigraphic division of the Quaternary is used after L. Lindner [15]

the basis of petrographic indicators. The Liviecian Glaciation is also represented by silts and periglacial loams.

The Zbójnian Interglacial period was characterised by a great increase of erosion and denudation, which is evidenced by erosion forms reaching 35 m in depth. From this period mainly fluvial sediments were preserved (Kołacze, Starzyzna, Szczęśniki, Lasek Bruski) as well as lacustrine sediments (Brus, Brus Nowy).

Sediments from Odranian Glaciation occur commonly and usually constitute an areas surface. The largest areas are occupied by water-glacial formations from the ascending and descending phases of the glaciation. On the morainic clays there is often glacial sand and gravel, which is quite common in the southern part of the Włodawa Elevation near Pieszowola, Marianka, Lasek Bruski, Podgórze, where they constitute hillocks. Kame deposits are numerous, especially in the highest positions, where they constitute clear morphological forms in the area of Turno, Marianka, Czołoma and other. Some of these forms were previously considered to be hillocks of frontal moraines. Tills of the Odra Glaciation have a very characteristic petrographic composition, where local rocks play only a subordinate role to the rocks of Scandinavian origin. The age of the tills was dated with the TL method to the range of 244 to 273 ka BP [12].

The Lublinian (Lubawian) Interglacial period is represented by fluvial sands, lacustrine loamy silts and low peats. The largest dispersion of deposits of this age was found not only in the north-western part of the Włodawa Elevation near Kodeniec, but also in Sosnowica and Lake Białka; In older works they were identified with deposits of the Eemian epoch, i.e. the last interglacial period. These sediments were dated with TL method to within  $228 \pm 34$  ka BP (Lub-676) in Sosnowica and  $237 \pm 37$  ka BP (Lub-70) in Marianka [1,9].

The Wartanian Glaciation left sediments of periglacial and fluvial-periglacial origin on the Włodawa Elevation. Deposits of this age are common near the Sosnowickie Lakes, where they lie on Odranian deposits.

Interglacial deposits of Eemian epoch are limited in extent; these are lacustrine-flood water silts and fluvial sands.

#### NEO-PLEISTOCENE SEDIMENTS

The Vistulian Glaciation is represented by sand and silt, covering vast surfaces of lake terraces, separated from older surfaces of the same genesis with a clear hypsometric step. There are numerous patches of loess-like formations, small in

thickness, and peat, the TL age of which in the bottom of Lake Białe was defined with the  $^{14}\text{C}$  method to  $11235 \pm 140$  years BP (St.-3137) [16].

Eolian sands, occurring often in the form dunes, e.g., near Górkki, Czołoma and the area of Lake Czarne Sosnowickie, originate from the decline of the last glaciation and the early phase of the Holocene Period.

In the lowest positions there are sediments of the Holocene Period. These are mainly organic-mineral aggradations, deluvial deposits and peats.

### CONCLUSIONS

1. Tertiary deposits occur in the Włodawa Elevation and its direct vicinity in a mosaic way and only in a limited area. This is contrary to previously held views which favoured widespread occurrence of those formations.

2. Among Miocene deposits, silt with a very high, 60-70% content of dust are worthy of notice. These are probably lacustrine deposits, which, however, can sometimes be genetically interpreted as Eolian formations.

3. The stratigraphic diversification of the Quaternary deposits of the Włodawa Elevation is apparently dependent upon the relief of Sub-Quaternary under-soil. The deposits preserved in depressions and tectonic troughs are stratigraphically more complete than those on elevations.

4. In the area studied there occur glacial deposits of five glaciations: the Narevian (Nidanian?), Sanian 1, Sanian 2, Liviecian and Odranian. Older glacial deposits have a visibly reduced thickness, or they are residual in character.

5. The discovery of glacial deposits of the Liviecian Glaciation is an important contribution to the study of the maximum extent of this glaciation in South-East Poland.

6. No glacial deposits of the Wartanian Glaciation have been found on the Włodawa Elevation, but periglacial and fluvioperiglacial deposits of this glaciation occur there.

7. The interglacial periods in the area studied were characterised by a strong erosion and denudation. Mainly fluvial and lacustrine deposits from these periods have been preserved.

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LITOLOGIA I STRATYGRAFIA UTWORÓW CZWARTORZĘDOWYCH  
POŁUDNIOWO-ZACHODNIEJ CZĘŚCI GARBU WŁODAWSKIEGO  
(POLESIE LUBELSKIE)

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**S t r e s z c z e n i e.** Garb Włodawski, subregion Polesia Lubelskiego stanowi wyraźne wyniesienie zbudowane w jądrze z osadów trzeciorzędowych, otulonych zróżnicowanymi pod względem litologicznym i stratygraficznym osadami czwartorzędowymi silnie zaburzonymi przez procesy glaciektoniczne. Badany obszar był pięciokrotnie zlodowacony podczas glacjałów Narevian, Sanian 1, Sanian 2, Liwiecian oraz Odranian, o czym świadczy charakter litologiczny i wiek osadów datowanymi metodami termoluminiscencyjną oraz palinologiczną.

**S ł o w a k l u c z o w e:** Garb Włodawski, utwory czwartorzędowe, daty termoluminiscencyjne, stratygrafia czwartorzędu