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DEVELOPMENT OF RIVER VALLEYS IN LITHUANIA

Abstract: Fluvial landforms in Lithuania are closely related to the deglaciation, melting and retreat of the last Scandinavian ice sheet (Nemunas glaciation). This is confirmed primarily by the geomorphology of modern river valleys, which formed gradually as the ice sheet retreated and ice-blocked lakes were drained, a process, which started approximately 15000 years ago. In order to differentiate the base from the alluvium, the author uses the spectrogram method.

Key words: river valleys, Lithuania.

1. Deglaciation

Within the scope of the IGCP Project 158, data on geological/geomorphologic structures of river valleys in the South Peribaltic area has been collected. Fluvial landforms of Lithuania are closely related to the deglaciation, melting and retreat of the Last Scandinavian Ice Sheet (Nemunas glaciation). Studies in the geomorphologic structure have shown that modern river valleys are 15000 years old. They were formed behind the retreating ice sheet, as the ice-dammed lakes were drained. The river valleys with the maximum number of terraces located in southeastern Lithuania were formed in the frontal parts of the Gruda (Brandenburg, Bologoe) and the Baltic (Pomeranian, Vepsovo) ice sheets. The presence of 7-13 terraces above the floodplain is therefore typical (Dvareckas 1990).

Moving northwards and following the retreating glacier, the number of terraces in the river valleys decreases, e. g. five terraces in the central part of Lithuania (the south-central Lithuanian phase) and three or four terraces in the northern and western portions of Lithuania (the north Lithuanian phase). Thus the number of terrace indicates, to a certain extent, the age of the river valleys. It should also be mentioned that as the height of the terrace base increases northwards, the alluvium thickness decreases from 5 to 1 m. This can be linked to the dynamics of deglaciation varying with various climatic conditions (Fig. 1).

2. Ice-marginal valley

The structure and development of the valleys of the Zeimena, Neris, Merkys and some parts of the Nemunas are rather intricate. Previously it had been presumed that the Neris valley is a head section of a large ice-marginal valley, stretching southwards from the vicinity of Svencioneliai as far as Warsaw and Berlin (Basalykas 1958, 1962). Now the views of Lithuanian researchers have changed radically (Dvareckas 1989, 1990). So, the Southeastern Lithuanian Sand Plain is regarded as a

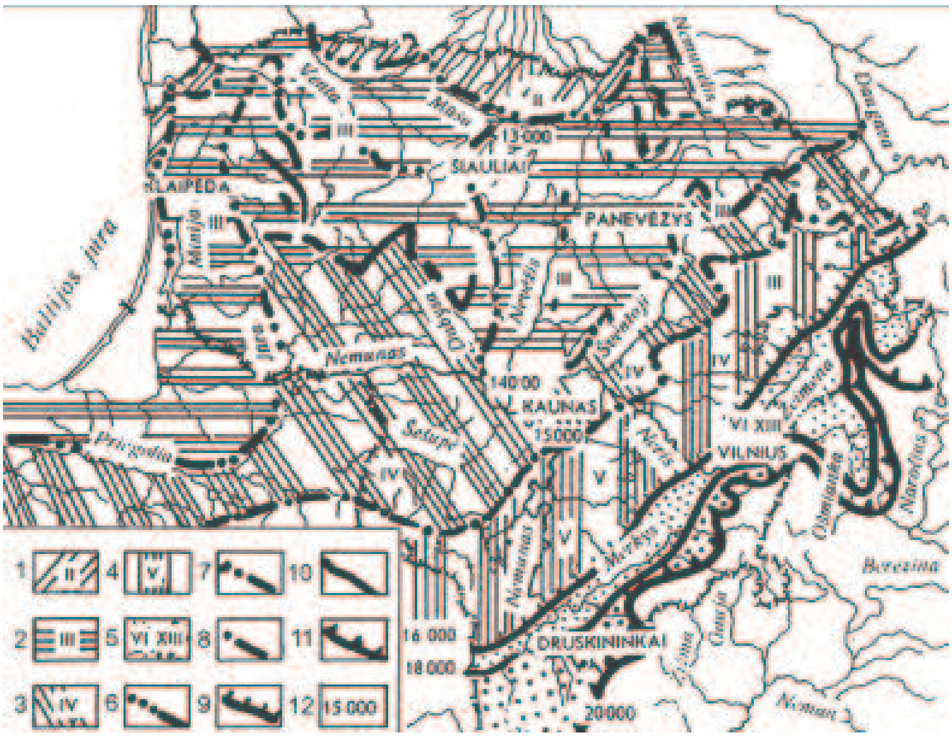


Fig.1. Distribution of river valley terraces and the relationship between them and deglaciation of the area of Lithuania: 1-5 - areas with the prevailing number of terraces, 6 - North- Lithuanian Phase, 7 - Middle-Lithuanian Phase, 8 - South-Lithuanian Phase, 9 - Baltic Stage, 10 - Ziogeliai Phase, 11 - Gruda Stage, 12 - age.

Ryc. 1. Rozmieszczenie teras w dolinach rzecznych i ich związek z deglacjacją w obszarze Litwy: 1-5 - obszary z przeważającą liczbą teras, 6 - faza północnolitewska, 7 - faza środkowolitewska, 8 - faza południowolitewska, 9 - stadium bałtyckie, 10 - faza Ziogeliai, 11 - stadium Gruda, 12 - wiek.

fluvioglacial plain. The principal agents of its formation are thought to be the cascading of ice-dammed lakes during various stages of the ice-sheet retreat. Water ran through the gap from the upper periglacial lakes (220 m above the present sea level) to the lower lying lakes (135 m), a base level of the Late Glacial. The upper terraces in the ice marginal valley of the Neris correspond to the level of the former periglacial lakes.

Therefore, the Lithuanian part of the Vilnius-Berlin ice-marginal valley is considered to consist of 9 interconnected lakes: the Middle Zeimena Lake, the Lower Zeimena Lake, the Middle Neris Lake, the Vilnius Lake, the Middle Merkys Lake, the Ula Lake, the Katra Lake, the Verseka Lake and the Druskininkai Lake.

At present, in the place of these periglacial lakes, there are shallow lakes and the present river valleys. A lacustrine stage existed in the upper reaches of the Zeimena, Skroblus, Ula, Derezva, Taurupis, Ratnycele and many other rivers.

3. Base and alluvium

The boundaries between the alluvium and the base for recent river valleys in Lithuania have been determined. The prevailing types of the bases are as follows: (1) Pleistocene boulder-loam and loam-sand belonging to various glacial periods, (2) fluvioglacial horizontal and cross-bedded sand, sand-gravel and gravel-pebble deposits, (3) limnoglacial varved clay, silt and sand, (4) interglacial and interstadial river, lake and mire sand, silt clay and organogenic deposits, (5) epigenetic conglomerates of the Quaternary age, (6) pre-Quaternary solid rocks (dolomite, limestone, gypsum, etc.).

Special attention has been paid to the texture and structure of the river terrace bases. It is rather difficult to distinguish the base from the alluvium, especially in the catchment area of the Zeimena, where stratified fluvioglacial deposits are uniformly distributed over the substratum. In order to differentiate them, terrace spectrograms are applied (Fig. 2).

Eight characteristic exposures (1-8) are presented in the spectrogram. A spectrum shows the lithological composition of the deposits in the exposures, the absolute heights of the river water level and the relative heights of the terrace sections above the present river level. A bold line of the arc represents the width of the site where the section was studied. This enables one to illustrate the height of a terrace more accurately, as well as the structure, texture, thickness and colour of the alluvium.

4. Neris River

Upper terraces in the Neris catchment are of a heterogeneous nature. The alluvium characterised by two facies, channel and floodplain, is 3-5 m thick. The deposits in the upper and middle terraces contain the increased amounts (when compared to those of the lower terraces) of clay particles (hydromica), and ice-wedge casts are present there. Clay minerals are washed out of a moraine and re-deposited by glacier meltwater.

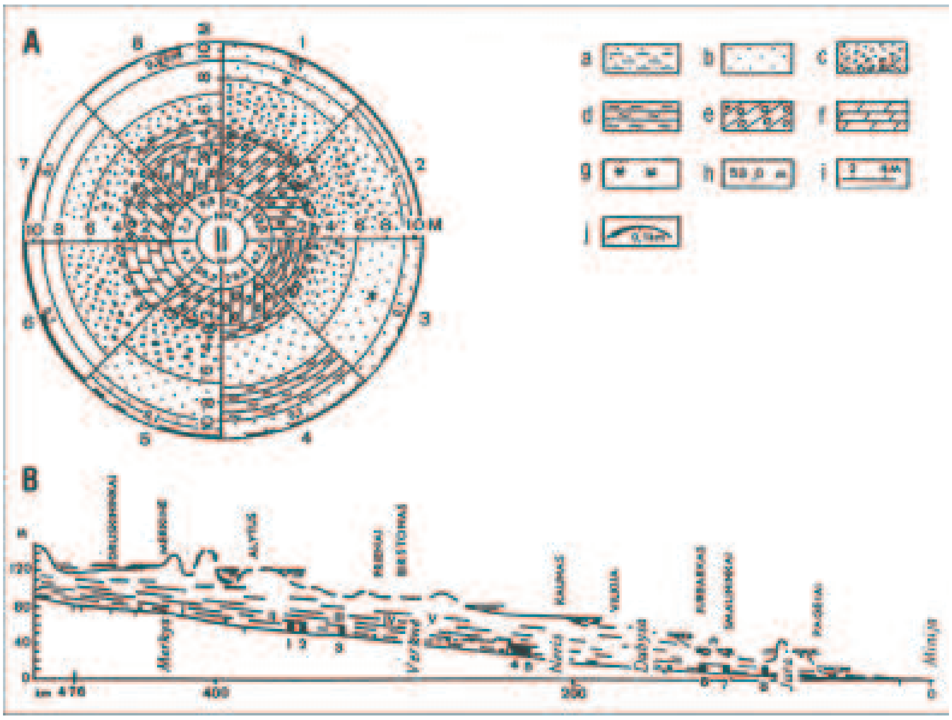


Fig.2. A typical spectrogramme for the terrace II deposits (A) and the stream profile (B) of the Nemunas River: 1-8 - exposures (1-2 - on the right bank, 1 km downstream from Nemaniunai, 3 - right bank, 4 km downstream from Balbieriskis, 4 - left bank, in front of the mouth of the Rukla River, 5 - left bank, 9 km upstream from Petrašiunai, 6 - right bank at Jurbarkas, 7 - right bank at Smalininkai, 8 - right bank, 3 km upstream from the mouth of the Sesupe River, a - aleuritic sand, b - sand, c - gravel, pebbles, boulders, d - varved clay, e - morainic loam and sandy loam, f - marl, g - ironization degree, h - absolute height of river shoreline, i - relative heights of terrace profiles above the present river level, j - width of a terrace.

Ryc. 2. Typowe spektrogramy dla osadów II terasy (A) i profil koryta (B) Niemna: 1 -8 - odsłonięcia (1-2 - na prawym brzegu 1 km poniżej Nemaniunai, 3 - na prawym brzegu 4 km poniżej Balbrieriskis, 4 - na lewym brzegu przed ujściem rzeki Rukla, 5 - na lewym brzegu 9 km powyżej Petrasiunai, 6 - na prawym brzegu w Jurbarkas, 7 - na prawym brzegu w Smalininkai, 8 - na prawym brzegu 3 km powyżej ujścia rzeki Sesupe, a - pył, b - piasek, c - żwiry, kamienie, głazy, d - iły warwowe, e - glina morenowa i glina piaszczysta, f - margiel, g - stopień zażelazienia, h - bezwzględna wysokość brzegów rzeki, i - wysokość względna profilów terasowych nad obecny poziom rzeki, j - szerokość terasy.

During the third advance of the Nemunas glaciation (the Balt stage), meltwater began to flow down the overburdened valley, thereby producing the highest terraces

(XIII-VII). The reactivation of this valley began and proceeded during the Late Glacial after water broke through the Baltic Ridge. In the initial phase, the nearby and high periglacial lakes served as a base level. Fragments of their shores have been found as terraces at 102-85 m.

Terraces VI and V (30 and 25 m above the floodplain) were formed following the dissection and lateral shift.

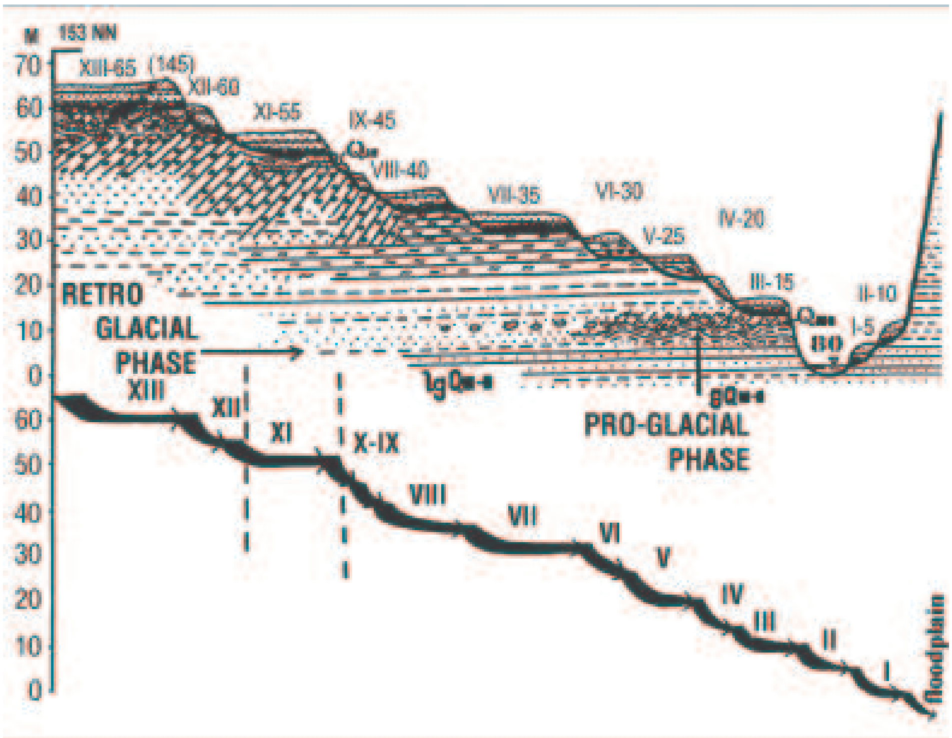
During the northwestward retreat, low and remote periglacial lakes were formed. Fragments of their shores are found in the lower reaches of the Nemunas at 40 and 16-20 m. Terraces IV (20 m) and III (15 m) along the reactivated valley are related to that time (SE Lithuanian stage, Baltic deglaciation). They are connected to a very dense network of ancient erosion landforms, e.g. the hilly area in Vilnius City.

Terrace III at 11-17 m can be traced in all valleys of the South Peribaltic area with alluvium rich in clay minerals, transported by landslides due to solifluction during Bolling (c. 13.000 BP). The mean grain size (Ma) of the alluvium is 5.291 mm, while the degree of sorting is 0.678 (Dvareckas et al. 1976). The terraces are slightly inclined towards the river channel. Ice-wedge casts in the upper parts of the terrace alluvium are often found in the place of former ice wedges and veins (to 3 m long). They are filled with sand from the floodplain, and related, alluvium (mostly to the former oxbow lakes). The alluvial character shows that the climate was still cold during the formation of this terrace (III), and permafrost and scarce tundra vegetation were the prevailing forms.

It should be mentioned that terraces V and IV were formed during the Oldest Dryas, whereas terrace III is related to Bolling and Older Dryas. This is based on geomorphologic data analysed applying spectrograms.

When the second (II) terrace was formed at 6-13 m, the Baltic Ice Lake had been the base level of erosion for a long time. Recently, the terraces II and III have been considered the widest in the valleys and their development has proved the most controversial. A detailed study (Dvareckas 1989, 1990) has shown that this terrace (II) coincides with the base level and that it is not accumulative as previously assumed. The floodplain alluvium of this terrace is rich in limonite attributed to the climatic amelioration (Allerod). The mean grain size is 4.133 mm, the sorting degree is 0.694. Macroscopically, the Late Glacial deposits are distinguished by their yellowish grey colour, which serves as a diagnostic feature in differentiating accumulative terrace deposits from base deposits composed of sand and interglacial lake sediments. A characteristic feature of the second terrace is the presence of dunes. It was formed during Allerod and Younger Dryas.

A radical change in climatic conditions during the Holocene has led to the slowing down of the geomorphologic processes. Only a narrow terrace I was formed (3-5 m above floodplain). The floodplain alluvium of this terrace consists of highly humus loamy sand or sand. The channel alluvium (gravel and pebble) is well washed and pure. The mean grain size is 3.431 mm, and the sorting degree is 0.723. This terrace contains numerous oxbow lakes (e. g. along the rivers of Sventoji, Zeimena and Minija) close to the river channels.



XIII XII XI X-IX VIII VII VI V IV III II I F
EROSIONAL-SOKLE DOUBLE SINGLE SUIT TERRACES
COKÓŁ EROZYJNY PODWÓJNE POJEDYNCZE ZESPOŁY TERAS
ALLUVIUM
ALUWIA

Limonite humusial
horizon
limonitowy humusowy
horyzont

GLACIAL-FEEDING SATURATED WITH LOAM PARTICLES
ZASILANIE LODOWCOWE NASYCONE CZĄSTKAMI ILASTYMI
OLDEST DRYAS BOLLING ALLEROD HOLOCENE
NAJSTARSZY DRYAS BOLLING ALLEROD HOLOCEN
OLDER YOUNGER
DRYAS DRYAS
STARSZY MŁODSZY
DRYAS DRYAS

AVERAGE COMPOSITION CRUSHED MATERIAL
OF ALLUVIUM IN MM Ma-MM 5,291 4,133 3,431
ŚREDNI SKŁAD ROZDROBNIONEGO MATERIAŁU
5,291 4,133 3,431

SORTING RATE 0,678 0,694 0,723
STOPIEŃ WYSORTOWANIA
16000 YEARS 13000 10500
16000 LAT
12000 3000
floodplain

5. Oxbow Lakes

Pollen data and radiocarbon dating of the oxbow lake deposit have been analysed. The oxbow lakes are mostly crescent-shaped, although other forms are also possible. These lakes are subdivided into two groups differing in sedimentation conditions.

The first group consists of oxbow lakes, which underwent five phases of development from near-river lakes to mires. Detailed results concerning these phases are already available (Gaigalas et al. 1987). As a rule, there are sand and sand loam deposits and, in particular, mineralised peat deposits without detrial sapropel. The second group of oxbow lakes underwent development from a lake phase to a mire and is alimented by groundwater.

On the first terrace of the Neris River, the oxbow lake deposits were formed during the second half of the Boreal period. There is numerous carbon datings (from 6000 to 3760 BP) obtained from various sites in Vilnius and other places (Gaigalas et al. 1991). Oxbow lake deposits in the floodplains of the Lithuanian rivers are considerably younger than those on the terraces (from 3000 to 270 BP).

Sometimes archaeological remnants are found in the lake-mire deposits, helping to interpret pollen and radiocarbon data. In the area adjacent to the inflow of the Vilnia River into the Neris (at the lower Castle), about 60 radiocarbon datings (from several hundred years to 6140-210 BP) have been obtained. This enabled us to reconstruct the basic development stages of the oxbow lake. Shells of the following freshwater molluscs dominate the oxbow lake alluvia: BITHYNIA, VALVATA, SPHAERIUM etc.

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Fig.3. Scheme of Lithuanian valley structure with the curve of paleodynamical phases (A) and the development periods of the terraces (B): a - aleuritic sand, b - sand, c - gravel, pebbles, boulders, d - varved clay, e - morainic loam and sandy loam.

Ryc. 3. Schemat struktury dolin Litwy z krzywa faz paleodynamicznych (A) i okresy rozwoju teras (B): a - pył, b - piasek, c - żwiry, kamienie, głazy, d - iły warwowe, e - glina morenowa i glina piaszczysta.

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Rozwój dolin rzecznych na Litwie

Doliny rzeczne Litwy zaczęły się formować około 16 000 lat temu. Początek ich rozwoju był ściśle związany z przebiegiem deglacjacji podczas ostatniego zlodowacenia plejstoceńskiego. Najstarsze doliny, z największą liczba poziomów terasowych (7-13), powstały w południowo-wschodniej Litwie, na przedpolu czoła lądolodu w okresie jego maksymalnego zasięgu. W miarę jego cofania ku północy rozwijały się doliny Litwy centralnej i północnej, w których liczba teras nie przekracza 3-4. Rozcinanie den dolinnych było związane ze zmianami bazy erozyjnej, wyznaczonej poziomem jezior zastoiskowych, tworzących się na coraz niższych poziomach przed czołem ustępującego lądolodu. Terasy odpowiadają kolejnym stadiom recesji glacjalnej i etapom przelewania się wód rzecznych drogą licznych przełomów z wyżej położonych zbiorników jeziornych do niższych. W obrębie pradoliny wileńskiej istniało dziewięć jezior, położonych na różnej wysokości, powiązanych odcinkami przełomowymi dolin rzecznych. Rozcięcie najwyższych poziomów terasowych wynosi 85-102 m.

Wszystkie terasy rzeczne są skalno-osadowe. Ich cokoły wycięte są w osadach plejstoceńskich: glacjalnych, fluwioglacjalnych i limnoglacjajnych lub przedczwartorzędowym podłożu skalnym. Pokrywy aluwialne, o miąższości 3-5 m, złożone są z osadów facji korytowej (żwir) i powodziowej (piasek). Osady wyższych teras zawierają dużą ilość cząstek ilastych, pochodzących z przemycia utworów morenowych. Powszechne są w nich (do terasy III włącznie) kliny mrozowe, świadczące o surowych warunkach klimatycznych w okresie akumulacji. Natomiast wzbogacenie w limonit aluwiów II terasy, powstałej w okresie allerödu i młodszego dryasu oraz występujące na jej powierzchni wydmy wskazują na ocieplenie w końcowej fazie późnego glacjału.

Zmiana warunków klimatycznych w holocenie doprowadziła do zwolnienia tempa procesów fluwialnych. W holocenie poza równią zalewową, powstała tylko jedna - I terasa o wys.3-5 m. Na jej powierzchni występują liczne starorzecza, wypełnione osadami torfowymi. Według wyników datowań C^{14} tworzyły się one od 6 tys lat BP. Występowanie starorzeczy świadczy o tendencjach do wyprostowywania i pogłębiania koryt rzecznych.

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