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MORPHOLOGICAL AND DYNAMIC STRUCTURE OF THE PEATY LOWLAND DEPRESSIONS TERRAIN

SUMMARY. The article analyzes the organization and operation of the peaty lowland depressions which combine the features of bogs and lowland runoff. The spatiotemporal dynamics is shown. The paper provides the recommendations to optimize the engineering structures design.

KEY WORDS. Peaty lowland depression, terrain, peat, lowland runoff, gleization.

When solving the classification and development of a descriptive text of the meso-scale environmental maps, the problem of geologic systems' spatial interaction isolation appears. The natural territorial complexes of the peaty lowland depressions (PLD) can be an example of it. They can be distinguished as a separate typological landscape complex — a type of terrain. At the same time, it is necessary to consider that the PLDs have a link with the headwaters of paleoerodible systems — "interior delta" — which are usually swamped at lower geomorphological levels and modern lowlands. From the standpoint of landscape ecology, morphology, and composition-energy interconnection, the PLDs are referred to a lowland development cycle of the geologic systems.

As a part of the lowland development cycle of the geologic systems, the PLDs are located within the paleoerodible patterns in a low runoff channel to form lowlands [1], [2]. A distinctive feature of this type of terrain is a progressive peat accumulation while maintaining a lowland development of the processes (catenas, landscape series). With respect to the study of the spatial organization, the vertical structure, that may establish a temporary structure and the PLDs functions, remains under-researched. To achieve the aim, the integrated analysis of a considerable factual material was conducted. Geological engineering, surveying, meteorological and environmental studies were under the research. It allowed establishing the relationship between the lateral and vertical structure of the PLDs.

The PLDs assignment to the lowland cycle, as opposed to the geologic systems of a blanket peatting, is caused by a dell runoff. When the PLDs reach the stage of a lowland bog through its irrigated central part, their assignment to the cycle is caused by fen peat deposits. At the same time the PLDs continue to play the role of local drains, determine a base level for their water collection, and form their own series of geologic systems.

Unlike other lowland zones, the geologic systems do not contain soil mineral ingredients and direct landscape correlations uphill (in proportion to peatting), that is against the law of universal gravitation.

The PLDs common features are the correlation of bog formation with lowland processes due to a periodic surface water runoff. An average PLD's width is from several tens up to several hundreds of meters, the length is up to 10 km. In case the length is more, the PLDs merge with other swamp masses due to a regressive peat accumulation and move to the central part of the watershed in the geologic systems of blanket peatting. In general, the PLD peat bogs along the adjoining forested sides are replaced in the center by the transition and lowland swamps.

The swamp systems of Western Siberia have been studied in the 50-80s of the twentieth century by the scientists of the State Hydrological Institute [3], Institute of Geography of The Russian Academy of Sciences (USSR) [4], Moscow State University [5] and others. The researchers of swamps consider PLDs as a runoff narrow [6], [7] or a depression narrow [8], and swamp zones are distinguished as non-classified groups of mountain areas [6] or they are classified by morphology of narrows and relief. The cotton-grass sphagnous cenosis are developed in the swamped mountain areas that lost their inlets in the north of the Russian Plain. The capacity of the peat deposit is small and averages 1.5-2.0 m. It is composed by sedge peat and sedge-hypnum peat at the eutrophic phase. The peat deposits of the swamped mountain areas which are at the oligotrophic phase contain semi-decomposed cotton grass-sphagnum on the top and complex highbog peat (in smaller amounts); a layer of sedge peat transition is below at the bottom layers of lowland. In the course of the works in the Middle Ob area the author found the opposite to that described above occurrence of peat (Fig. 2): highbog peat contains transition which in its turn contains fen peat.

The PLDs formation on the studied areas is associated with the accumulation of peat by early lowland networks or with the waterlogging of watercourse basin with the runoff inadequate for gully and advanced lowland formation.

There are a lot of PLDs in the landscape structure of the West Siberian Plain. They are especially characteristic for the drained upland plains such as Belogorsky mainland, Siberian ridges, Agan ridge.

82 PLDs are mapped over 300 km of the studied meridional oriented transect. The twin geological profiles are built for the 34 of them (along the pipelines and electric lines). The mapped PLDs belong to the three series of geologic system development: hydromorphic organogenic, hydromorphic bog and hydromorphic sinter sludging (Table 1, Fig. 1).

The hydromorphic organogenic series is formed by the relicts of paleoerosive network swamped according to the peat bog type with pit-and-mound sphagnous hummocked bogs and which are afforested with the pine of 5a-5b growth class. The series is also formed by the swale mesotrophic shallow deposited flat- hammocked grassy-moss bogs.

The series of hydromorphic suboptimum development of sinter sludging is formed by the PLDs of a low drained level with the cedar-fir-tree-birch and grass-moss forests and by the PLDs with pine-birch and grass-moss forests.

Table 1

Mapped Mountain Areas of the PLD Terrain in the Central Taiga Subzone

Series of geologic system development	Mountain area	Quantity of landscape mapping units/ quantity of twin geotechnical profiles
Hydromorphic organogenic series	PLDs with mesotrophic grass-moss bogs	22/6
	PLDs with sedge fen peats acquired by streams and small rivers with trenched courses in peat coasts	10/7
	PLDs within the drained massifs with the combination of flat and hummocked grass-moss- shruby bogs and sphagnous-wild rosemary pine forests in everglade and peaty gley soils	1/0
	PLDs with sedge fen peats	2/1
	The extended lowland depressions — relicts of paleoerosive network swamped according to the peat bog type with pit-and-mound sphagnous hummocked bogs which are afforested with the pine of 5a-5b growth class	19/7
	Swale mesotrophic shallow deposited flat- hammocked grassy-moss bogs	18/9
	Inter-bogged depressions of runoff with flat mesotrophic grassy and moss bogs	2/1
	The depressions in the headstreams of swamped lowlands with poor stand of fruticulose pine forests	1/0
Hydromorphic forest series	The relicts of a paleoerosive network of a low drained level with the cedar-fir-tree-birch and grass-moss forests	5/1
The series of hydromorphic suboptimum development of sinter sludging	The relicts of a paleoerosive network of a low drained level with pine-birch and grass-moss forests	2/2

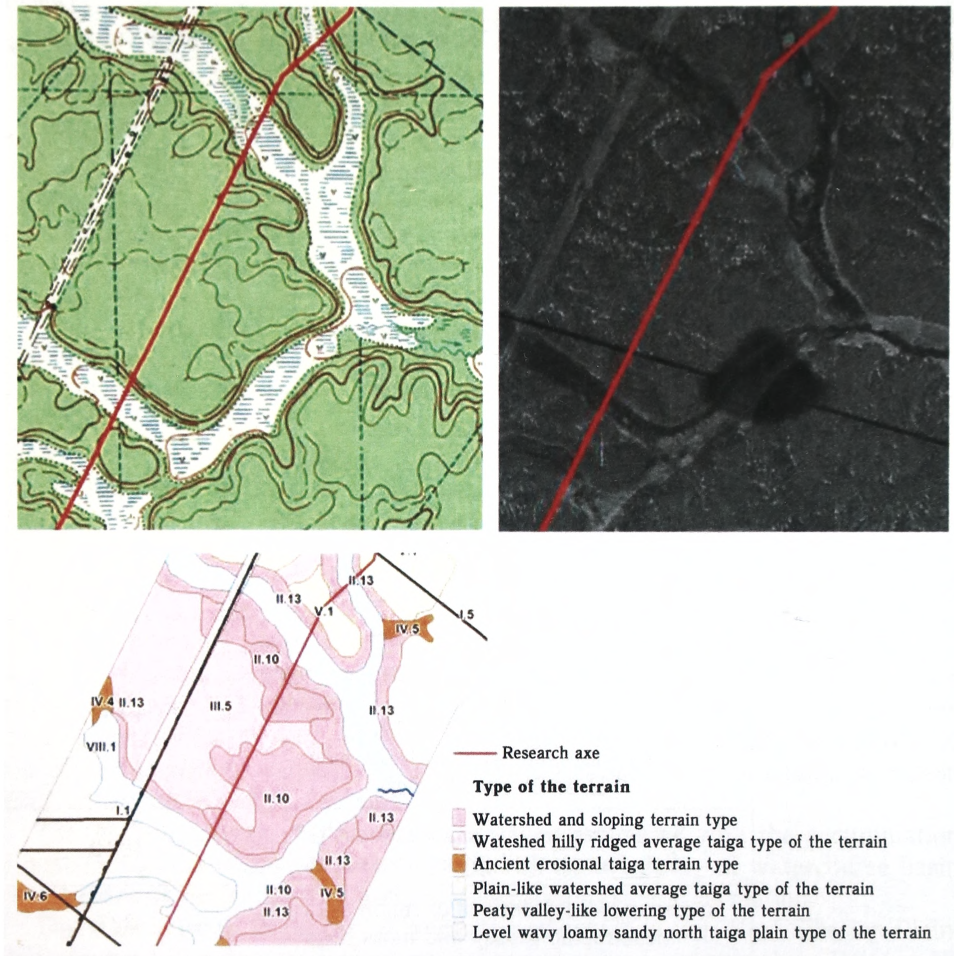


Fig. 1. A fragment of the topographic map, a satellite image and a fragment of the landscape map of the area crossed by the PLD

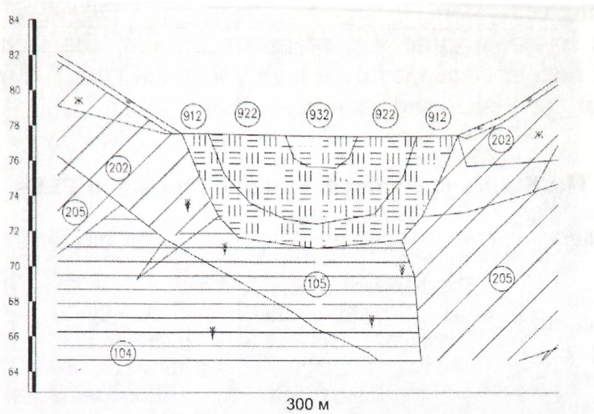
An average profile of a PLD structure is as follows (Fig. 2):

- the bottom of the lowland and peaty slopes are covered with strongly decomposed bog peat ranging from 0.3 to 1.5 meters;
- the transition peat up to 2.5 m thick overlains the bog peat;
- the low decomposed fen peat starts deposit under the conditions of sufficient depth of peat accumulation (more than 2.5 m of transition peat).

The edges and the bottom of PLDs are lined with bog peat which is overlained with the transition peat, and fen peat starts deposit when the deposit thickness in the central part rises. This reflects the link of the deposit thickness and its structure with the age of the terrain (the conditions of peat accumulation).

The ground water level corresponds to the zero point of the peat deposits, i.e. peat is in a watered condition. The absolute marks of the ground water level may be higher than zero peat deposit; in this case PLDs are the zones of ground water uploading. If the ground water level is lower than zero peat deposit then PLDs feed ground waters. This indicates a controlling environment function of PLDs. The draining qualities of lowland can be transformed into watered qualities of a bog and vice versa.

A standard seasonal freezing depth of peat soils in PLDs reduces in 0.7-1.5 times compared with the drained surfaces, and rarely reaches the foot of peat deposits deeper than 1 meter. It means that PLDs have a year-round controlling environment function.



Lithology	No	Age	Complete description of the soil
	104	laQ_{II-III}	Soft pliable clay
	105	laQ_{II-III}	Ductile pliable clay
	202	laQ_{II-III}	Hard pliable clay loam
	205	laQ_{II-III}	Viscid clay loam
	912	bQ_{IV}	Averagely/hard decomposed peat of the first type
	922	bQ_{IV}	Averagely/hard decomposed peat of the second type
	932	bQ_{IV}	Low-averagely/ decomposed peat of the first type

Borders

	Engineering and geological elements
	Ground waters level

Fig. 2. PLD average profile (according to the geological engineering survey of the author)

Waterlogging the runoff lowland correlates with the formation of taiga peat-gley soils due to hydromorphic runoff depressions (narrows and small runoff lowlands) which is increased by the depletion of base erosion slowed down by the runoff [4]. Deposited non-mineralized and humified litter of hydrophytic vegetation forms growing humus (peat) bedrock. The increase of its capacity is combined with the decrease of its decomposition. The removal of organic substances from sloping surfaces affects the humus bedrock more.

The moisture accumulated in the organic bedrock is close to the mineral composition of different wetlands with higher concentration of organic acids and less minerals than in ground or supply water (Table 2). It is followed by the change of the biocenosis which turns into a bog one. It is less demanding to the mineral composition of soil and water, which leads to a reduction in the rate of decomposition of plant litter and growth of peat bedrock.

The capacity of 70 cm peat deposits is the maximum bedrock for an active bog [7], [4]. The peat deposits which are below this layer (primarily a mineral stratum of peat-gley soils) become inert and did not actively participate in the moisture exchange and heat transfer. Thus, organic-mineral soil turns into organic one with moss bog vegetation (Table 2). The bog water becomes more important at a final stage of gley soil bedrock formation. Groundwater is no longer involved in the development of the ecosystem.

As the peat forms, a quite watery central part of the transitional peat is accumulating. It further develops into a highly watered central part of fen peat as well as a chain of open lakes and swampy hollows.

Table 2

The Stages of Geologic Systems Change in PLDs

Development stage	Moistening	Vegetation	Soils
Formation of a balance profile, attenuation of a deep erosion, thinning out of ground waters, mode of a constant hydromorphism	The dispersed runoff of surface water on the bottom, sharply contrasting with a periodic slope runoff. Slopes are drained	Mainly hydromorphic with sedge, rush, and buckbean	The taiga peat-gley
Settlement of sphagnous mosses, beginning of a bog peat deposit formation	Drain “linkage” by a peat deposit	On a peat deposit it is sphagnous-bushy, in a slope part it is rush´sedge	Peat-oligotrophic and taiga peat-gley (on the lower parts of slopes)
Accumulation of more than 1 meter peat deposit with the accumulation of transitional peat in the central part	Formation of a watered central part	Sphagnous -sedge in the watered central part	The same, peat-mesotrophic (transitional) soils are in the central part
Accumulation of more than 2 meters fen peat deposit with the accumulation in the central part	Formation of diluted peat and a secondary hydrographic network, i.e. open lakes and swampy hollows in the central part	Sphagnous -sheykhtseriy-sedge	The same, peat-eutrophic (low-lying) soils are in the central part of the peat-mesotrophic soils

The PLDs belong to the widespread geographical landscapes. Their territorial variability and the structure of the mountain areas are researched by the author in the fell lowlands on Lake Hanka drainage (Primorsky Kray), in the zone of frozen flat-hummocked bogs of Pur-Tazovskiy interfluve.

The PLD of a watered peat deposit is the core of flat-hummocked lowland bogs in the landscapes of IV-V marine terraces of Pur-Tazovskiy interfluve. The ice mound in the center of the peat lowland makes it possible to appear more plant associations of a more drained habitat type, as well as the emergence of a brook network bordering the heaving mounds. Figure 3 shows a fragment of the satellite image with impaired (south-east), and the unaffected parts (north-west) of PLD.

This redistribution plays an additional role in distinguishing the mountain area into central (frozen) and peripheral (runoff) parts in the zone of flat-hummocked bogs where the central part of the PLDs is raised by permafrost lenses.

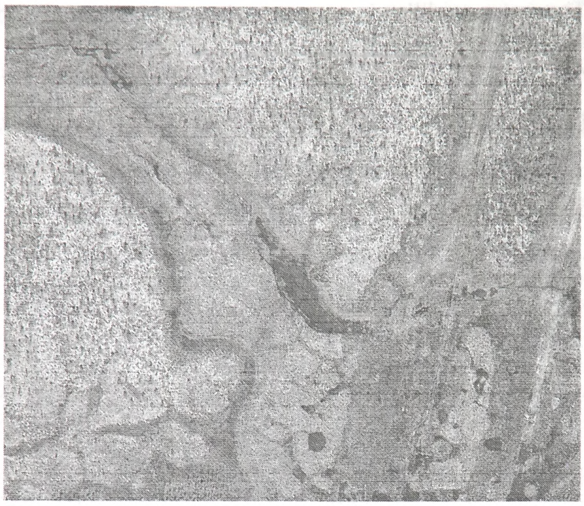


Fig. 3. A fragment of a PLD area space image

In terms of project engineering, PLDs act as a special kind of landscape and ecological environment which requires the assumption of spatial and temporal organization to ensure the stability of geotechnical systems. In this respect, the most important PLD qualities are:

• peat is the core of PLD, fractional alternating of the deposit stages development determines frequent changes of geologic systems which are sharply contrasting in geochemical environment and the dynamics of temperature;

• possible runoff blocking and underflooding determine the need to consider the qualities of peat deposits, i.e. the area of the alignment culverts should be no less than the sectional area of lowland and transitional peat;

• peat removal is necessary in road constructions and underground pipe installation to the peat depth no less than the depth of the transitional peat bottom is necessary in pipeline construction;

• considering the PLD water regulation function, it is necessary to impose environmental restrictions that are applied to the water protection zones within the zero peat deposit.

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