Spatial organization and structure of the ridge-hollow swamp complex in taiga zone of Western Siberia

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Abstract

Big Vasyuganskoye swamp located in the taiga zone of Western Siberia. It is the largest swamp in the world. Here are developed oil and gas fields, pipelines. Engineers must take into account the structural features of peatlands in the design of oil and gas production facilities. This ensures trouble-free operation of enterprises and preserve the environment for future population of the region. Particularly important are the ridge-hollow swamp complexes. The uniqueness of these complexes is that plants produce frame ecological niche in strongly acidic aqueous medium. This allows them to function in the extreme environmental conditions on the planet. The paper presents data on their spatial organization, geo-botanical description, information about life forms, mechanical and physical characteristics of peat horizons.

Keywords: ridge; hollows; swamp complex; armature; filler; spongy structure; lamellar structure; porous body

1. Introduction

Large reserves of peat are in the territory of the taiga zone of Western Siberia. Here are developed oil and gas fields, pipelines. Engineers must take into account the structural features of peatlands in the design of oil and gas production facilities. This ensures trouble-free operation of enterprises and preserve the environment for future population of the region.

Particularly important are the ridge-hollow swamp complexes. Their uniqueness lies in the natural features of life forms their biotic components that allow them to create niches and function in the most extreme environmental conditions on the planet, in a strongly acidic aqueous media (ph = 3.3-3.9). The main natural resource for them is the
climate, which supplies them photosynthetically active radiation, air and precipitation. They are the source of the mineral and water nutrition plants. Plants produce their own skeleton of the ecological niche. It allows them to gain a foothold in the body of water.

2. Spatial form of ridge-hollow swamp complexes

We examined satellite images and performed their interpretation. This allowed us to establish [1, 2] that linear complexes elongated structures are identified in the images as ridge-hollow swamp (Fig. 1). They are located, usually in the central parts of large area of raised bogs, which are at high elevations. Characteristic feature of these complexes is: lack of woody plants in depressions (hollows) and the presence of pine swamp forms on positive forms (ridges). The ridges have a convex shape, its height up to 0.5 m. The hollows are located on a flat surface heavily watered. The width of the ridges and hollows up to 100 m. Ridge (their long axes) are perpendicular slope surface. The range of slopes is 0.0004-0.0052, an average slope - 0.0015.

![Fig. 1. Ridge-hollow swamp complex: (a) aerial photograph; (b) ground-based photos. Figures: (1) ridge; (2) hollows.]

3. Mechanical properties of the swamp

Immersed in the moss roots and branches of plants create the skeleton of the swamp. Mechanical structures are the following:

• Armature. It performs the function of mechanical support and is the skeleton of the swamp. These support structures are rough orthotropic root systems of trees and branches of bushes, plagiotropnye shoots obliquely directed branches of shrubs, intertwined roots of grasses. They give the high elasticity of the whole structure. Therefore, it is able to withstand the high mechanical loads.

• Fillers. They fill the space between the reinforcing elements and rely on them. These elements are sphagnum mosses, they have no mechanical tissue.

4. The structure of ridge-hollow swamp complex

Ridge-hollow swamp complex is represented by ridges (which are formed by pine shrub-sphagnum vegetal communities) and hollows (scheuchzeria-sphagnum vegetal communities). Its characteristics are given below.
4.1. The element of swamp complex: ridge

Ridges occupy 40% of the area of the complex. Skeleton ridges is created by swamp forms of pine (*Pinus sylvestris* L. f. Litvinovii), 2.5-3 m tall, with a diameter of 2-8 cm and tree crown cover of 40% (Fig. 2a). The root system of pine trees located at the surface of the swamp, at a depth of 35 cm, due to close occurrence of swamp water. Taproot dies early, and new roots grow upward (obliquely or vertically), penetrating into the zone of favorable water, air and food regimes.

Shrub layer (with projective cover 55-65%) is represented by evergreen species, their height is about 50 cm, with a predominance of *Chamaedaphne calyculata* (L.) Moench., *Ledum palustre* L. and *Oxycoccus microcarpus* Turcz. ex Rupr. Is less abundant *Vaccinium uliginosum* L. Most of them are branched shrubs, forming swamp armature. They have a recumbent rooting stems and multiple ascending branches. Adventitious roots are penetrate to a depth of 20 cm.

Herbal tier with projective cover 30-35% is formed, mainly, *Carex gracilis* R. Br, *Rubus chamaemorus* L. and *Eriophorum vaginatum* L. These plants have long roots. Dense moss cover is filled. Absolute dominat is *Sphagnum fuscum* (Schimp.) H. Klinggr., subdominant *Sphagnum magellanicum* Brid. Mosses have a height of 20 cm, moss stalks are standing upright and tightly connected with each other. Lichens are found spots.

Thus, rigid skeleton ridges formed reinforcing elements of wood-shrub layer filled with moss. The chassis has a convex shape, towering over the marsh surface area of about 0.5 m.

From a mechanical point of view, moss cover on ridges like a spongy body, in which the pores are a system of cavities and channels between the grid of the solid phase (the leaves and stems of moss, branches of shrubs). Under a layer of live sphagnum moss is a layer of spongy structure (Fig. 2a), which has the properties of porous bodies - increased surface area, high values the getter capacity, reduced density, strength and thermal conductivity. Porosity in the spongy body is high, and depends on the ratio of the volume of pores and solid material.

Peat horizons located below the profile. They formed the remains of mosses which have undergone incomplete decomposition. In these horizons porosity gradually decreases, spongy moss structure is transformed into a plate or belt-layered structure of the peat horizon. This horizon has increased thermal insulation properties and increased calorific value.

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Fig. 2. Profiles: (a) ridge; (b) hollow

a - The ridge formed by pine shrub-sphagnum community: *Ps* - *Pinus sylvestris*; *Ch.c.* - *Chamaedaphne calyculata* + *Ledum palustre*; *C.g.* - *Carex gracilis*; *Sph.* - *Sphagnum fuscum*, *Sphagnum magellanicum*. Horizons: 1 - living mosses, 2 - porous body with sponge-like structure; 3 - peat horizon with lamellar structure.

b - The hollow formed scheuchzeria-sphagnum community: *Sp* - *Scheuchzeria palustris*; *C.l.* - *Carex limosa*; *Sph.* - *Sphagnum majus*, *Sphagnum balticum*. Horizons: 1 - living mosses; 2 - floating rhizomes Scheuchzeria with lattice structure; 3 - peat horizon.
4.2. The element of swamp complex: hollow

Hollows have a width of 5-15 m. They are watered and cover about 60% of the ridge-hollow swamp complex. Structural skeleton hollows (Fig. 2b) is a dense network of perennial rhizomes *Scheuchzeria palustris* L. and *Carex limosa* L. (projective cover up to 40-50%). These plants have a small height (20 cm) and long (up to 0.5 m), branched rhizomes. In their skeleton is shipped loose moss. Filler are sphagnum mosses: *Sphagnum majus* (Russow) C.E.O.Jensen, *Sphagnum balticum* (Russow) C.E.O.Jensen. Mosses form a loose sod capacity of about 5 cm. Such turf of moss have weak cohesion and easily deformed. Hydrological conditions are characterized by constant stagnant and excess watering.

Thus, the frame hollows reminds a lattice structure (Fig. 2b), consisting of long rhizomes *Scheuchzeria* filled with loose moss. This design provides the substrate strength and opportunity to float with rising waters swamp.

5. Conclusion

Territory petroleum province of the taiga zone of Western Siberia heavily waterlogged. Of the many wetland ecosystems in Western Siberia are particularly important ridge-hollow swamp complexes. Plants create a complex skeleton of their ecological niche that allows them to function in extreme environmental conditions.

In general, the structure of plant species forming ridge-hollow complexes can be represented as:

- Ridge:
  Armature: *Pinus sylvestris* + *Chamaedaphne calyculáta* + *Ledum palustre*;
  Fillers: *Sphagnum fuscum* + *Sphagnum magellanicum*.

- Hollow:
  Armature: *Scheuchzeria palustris* + *Carex limosa*;
  Fillers: *Sphagnum majus* + *Sphagnum balticum*.

Significance for the construction: placing pipelines on ridge-hollow complexes can disrupt their integrity due to changes in the level quagmire hollows. Understanding the mechanical structure of wetlands in areas of hydrocarbon production allows us to plan the venue product lines with minimal risk for environ.

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