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The assessment of hazard of geological processes depending on the ground conditions at Berezniki (Permsky kray, Russia)

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ABSTRACT: In article described a methodology to assess the geological hazard depending on the natural structure of territories. The offered assessment is based on comparison between soil conditions and top surface series represented by quarternary soils, with typical factors of danger, within a limited site which is located in the Permsky kray, Russia. The danger is expressed through various occurrences (cavities, subsidence and so on). The result of the analysis is to ranking the degree of stability of layers. Methods assessment of dangers occurrence of natural geological processes is based on comparison of cartographical models studying of factors danger and geology-lithologic structure.

1 THE COMPONENTS FOR STUDY DANGEROUS GEOLOGICAL PROCESSES

There is huge number of methods for assessment of dangerous geological processes development.

Figure 1. Location of Berezniki on the territory of Permskiy krai.

One of the components of its study is research of soils conditions of near-surface cover rocks.

Thus, zoning of the territory depending on degree of hazard of geological processes can be realized through a comparison with soil thickness.

Soil conditions are considered from a position of division of soil thickness on separate layers, depending on the origin, species and the variety of soils and evaluation of physical and mechanical properties of these layers.

Such approach is proposed for study area of Berezniki (Permsky kray, Russia). On this territory are actively developing erosion, abrasion, slope and karst-suffusion processes and are widely developed weak soils (Fig. 1).

The territory of the city is too large. In this paper author consider the reference area which is located on the left bank of the Kamskoe Reservoir in 1.5 km west of the habitable area of the city. Within the studying area widely developed dangerous geological processes, listed above.

2 ENGINEERING-GEOLOGICAL CONDITIONS

Soil conditions of the quaternary sediments were studied in detail at the early stages of research. Therefore, within the study area were collected and classified data of engineering and geological surveys and studies over the past 60 years. As a result of systematization the materials was formed a catalog that includes more than 1 100 boreholes, 2 087 soil samples and 159 water samples. According to these data have been analysed engineering-geological conditions of the site.

For the first time the division of soil thickness on engineering-geological layers was executed in 1977. Based on results of these works, author extend and expand earlier offered classification (Trubchaninov 1977).

Within the studied territory danger of emergence of adverse geological processes is expressed through such factors of danger as gullies and cavities (formed as a result of dumping of technical drains in soil in the conditions of faulty drainage system of drains of technical drains in the sewerage) technogenic accidents on communications and pipelines; precipitation of a terrestrial surface and deformation of construction designs of buildings and the constructions, established on the benchmark (geodetic monitoring in 10 years); the anomalies of a wave field established by results of geophysical researches.

3 ENGINEERING-GEOLOGICAL LAYERS

According to drilling operations, field tests of soil thickness and laboratory researches of tests of soil geological lithological the profile of the studied territory is subdivided into a number of engineering-geological layers. At allocation of layers their spatial arrangement in the form of a uniform geological body wasn't considered. Therefore the same layer can be developed in any part of the studied territory within various depth intervals. Allocation of layers is carried out depending on an origin, species and the variety of soils, and also their condition and properties. In total 18 layers are allocated. Two from which are presented by artificial soil, seven—plastic soil of various origin, six—sandy and greatly-clastic alluvial soil, two—eluvial argillous and greatly-clastic soil with clay filler, one—rocky soil.

On surface deposited the artificial bulk and inwashed soil (layers 1, 2).

Layers 3–9 are presented by disperse plastic soils (clayey, organic and organo-mineral). They deposited on territory flood plain under a layer of artificial soils. Below these sediments the sandy horizon begins.

Sandy horizon (layers 10–14) distributed throughout the study area. The size of sand increases with depth. The total thickness of sand varies from 1.0 to 16.0 m, average—8.0–10.0 m.

The alluvial greatly-clastic soils (layer 15) and eluvial loamy and greatly-clastic deposits with clay filler (layers 16, 17) are developed under deposits of the sandy horizon. It is products of destruction of basement rock. Their development has sporadic character in the profile.

Basement rocks are represented alternation of gray marl with sandstone, limestone and mudstone (layer 18). Deposits of the marl are dominated. The depth of the basement rock at the site varies within 14.0–21.0 m. It is drilled up to the depth—0.5–6.0 m (Shilova 2012).

Complex statistical processing of properties of soil within the allocated engineering-geological layers is carried out. Statistical processing is executed taking into account all samples which belong to studied layers. Samples choose irrespective of time and seasonality of sampling. Limits of variability of the main physical and mechanical characteristics of the soil basis are defined.

4 TYPES OF ENGINEERING-GEOLOGICAL STRUCTURE

It is noticeable that as a result of systematic and sub-sequent analysis of engineering and geological data at the study of site was classified geological structure of subsurface portion of the massif. Inside the proposed classification is an alternation in the section of various engineering and geological layers. 6 types of geological structure were allocated. The first four of these are isolated additionally subtypes (Fig. 2). Extension of geological structure types within the study area is shown in Figure 3. Within the study area are represented the first four types of engineering-geological composition. Types 5 and 6 appear in the profile of 200 m east of the study area. The aim of the study was the identification and evaluation of adverse sections of the study area.

Areas with type 1 profile characterized by a predominance of sandy and greatly-clastic alluvial

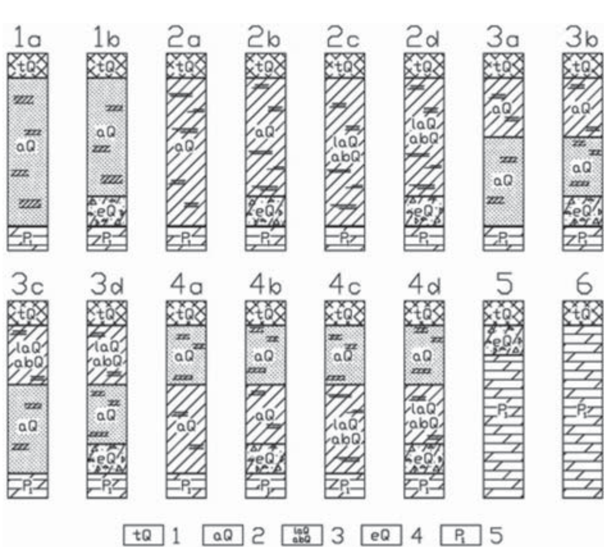

Figure 2. Types of geological structure: 1—anthropogenic deposits; 2—alluvial deposits; 3—lacustrine-alluvial and alluvial-biogenic deposits; 4—eluvial deposits; 5—deposits of P_1 age.

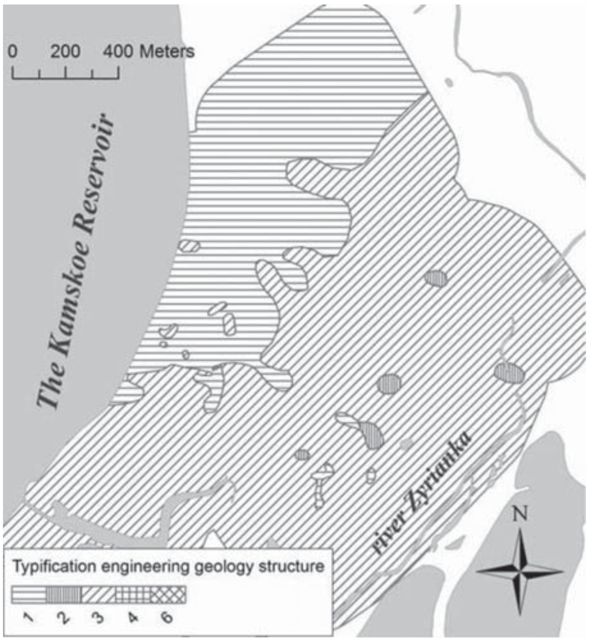

Figure 3. Scheme of location of geological structure types on investigated territory.

deposits with minor inclusions in thickness clay layers and are distributed mainly in the floodplain and in the coastal strip p. Kama. Area dissemination of 1 type profile composes 988.5 m^2. 2 type of geological structure presented by mainly clay soil and developed slightly. It is distributed local spots in the southern and south-eastern part of the study area (23.4 m^2). The largest area occupied of land with 3 the type of the profile (2241.6 m^2), which are confined to the old riverbed Zyryanka. These areas are characterized a layerwise replacement argillaceous deposits by a arenaceous. 4 type profile, characterized of inversion bedding of arenaceous and argillaceous soil. It is developed extremely rarely (0.4 km^2). Small spot areas of development are met within the territories characterized by 3 types of geological structure.

It should be noted that area with 3 and 4 types of geological structure of the worst in the construction and in development dangerous geological processes (suffusion, subsidence, swelling, weak bedding). Within the area them of development is fixed most of the technogenic disasters and the uneven accelerated subsidence of soil (Shilova & Kataev 2012).

5 HAZARD ASSESSMENT

Comparison of areas of individual layers development with location of the problematic buildings and structures, places of fixation of industrial accidents, anomalies of the wave field and sites of the earth surface subsidence has revealed the most unstable engineering-geological layers.

At the first stage, author constructed an auxiliary card with drawing isoline distance from unstable areas. These contours delineate zones of 50 m. One of the main objectives of the study was assessment and calculation the number of samples of different soils that fell within the areas remoteness. In the course of such a method is defined within any of the engineering-geological layers are most active geological processes, which manifest factors hazards. Number of sampling is the basis for calculation.

Identify that the most unstable are soils it is alluvial and lake-marsh loam and clay, and loam and clay with I_L flow index in the range 0.50–0.75 and I_L 0.75–1.00; as well as alluvial sands small and medium-size, medium-density saturated with water. This category also includes technogenetics made soil.

Engineering-geological layers which are steady, are composed of alluvial sand small and medium size and solid build and of sand with inclusions of gravel and pebble. In this category there are the layers presented by weakened organo-mineral soils (silt), and alluvial loams and clay with an indicator of fluidity of I_L in the range of 0.75–1.00 and $I_L > 1.00$. It is explained by the area of development of these layers, and also conventionality of the chosen methodical approach to establish such relations. The thickness of wave-built soil (layer 1), developed in the south-eastern part of the site is also relatively stable.

Comparison of physical and mechanical properties of the most stable and unstable engineering-geological layers generally indicates the correctness of their separation. The normative values of the basic physical and mechanical properties are determined by the aggregate of layers in each of the categories of sustainability. The accurate tendency to improvement of construction properties and increase of bearing capacity of soils is established. These soils are steady.

Based on the marked unstable layers, whose development in the surface of the area is an indicator of risk, author select the most dangerous site within the study area.

Methodical computation to the assessment of the dangers occurrence of natural geological processes is based on the cartographic comparison studying factors hazards and geology-lithology structure. First, natural hazards assessment is performed including wells. Second, within each of investigated wells is allocated the presence or absence of unstable layers and evaluate depth of each of them. Finally, the criterion of danger is the ratio of the total depth of the unstable layers within each individual wells to depth traversed

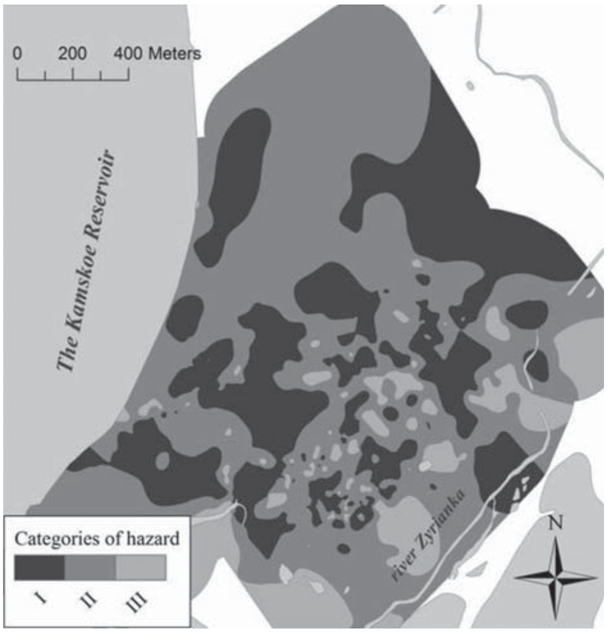

Figure 4. Scheme of location of geological structure types on investigated territory.

Table 1. Distribution of square depending on the category of hazards.

Categories of hazards	Square m^2	%
I. Dangerous	879.0	27.0
II. Temperedly dangerous	1851.3	56.9
III. Temperedly dangerous	523.8	16.1
TOTAL	3254.1	100.0

by the wells soil interval. Thus, this approach to an assessment of danger is the quantitative analysis.

Of allocation categories of the hazard produced by the principle of equal interval. Total allocated 3 categories of hazards: I—dangerous ($H > 0.7$), II—temperedly dangerous ($H = 0.2\ldots0.7$) and III—almost harmless ($H < 0.2$) (Fig. 4).

The distribution of areas used of different categories of natural hazards is shown in Table 1.

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