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MANIFESTATIONS OF NATURAL AND MAN-MADE GEODYNAMIC PROCESSES AND RISKS ON THE TERRITORY OF THE CHECHEN REPUBLIC

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Abstract

The paper attempts to consider geological processes occurring in the upper layers of the Earth, which either simplify or complicate the native relief. In this case, the territory subject to exogenous processes is likened to a nonequilibrium, open thermodynamic system. For successful application of the synergetic approach to natural phenomena, a comprehensive study of the degree of influence of each of the factors acting on the system under consideration on the processes occurring in it is required. Therefore, this paper focuses on the dynamics of the development of exogenous processes in the south-eastern part of the Chechen Republic, subject to exogenous processes. It is shown that these processes are cyclical in nature and cause great harm to the economy and population of the region. Geodynamic processes arising during long-term development of oil and gas fields are also considered. This work can be considered as a preparatory stage for the study of these phenomena based on the synergetic approach. It is expected that these studies can become the basis for systematization, theoretical generalization of the results obtained and the development of methods for predicting natural processes.

Keywords: landslide processes, geological risks, slope erosion

I. Introduction

In recent years, many scientific fields have often used a synergetic approach, which takes into account the collective action of a number of factors on a nonequilibrium system. The essence of the synergetic paradigm is the presence of such properties of the system as nonlinearity, openness, dissipativity. To successfully use this direction, objective data on the nature and degree of influence of each of the acting factors on the system are needed. A synergetic effect in relation to exogenous processes can consist, firstly, in the simultaneous action of several forces or factors on the process under study. It can manifest itself the more, the greater the relationship between the elements of the system. For example, the presence of a slope with a soft soil covering, under which a relatively smooth, impermeable rock is concentrated; heavy precipitation penetrating the boundary between soft soil and impermeable rocks, etc. Secondly, the system must have various options for possible development that cannot be predicted in advance. Such expected processes include landslides, mudflows, avalanches, floods. Depending on specific conditions, these processes can have varying degrees of intensity.

II. Methods

The work is based on methods of system analysis and generalization of available materials using a synergetic approach. The basis for the work were stock, archival materials and published literary sources on the subject of the study, both domestic and foreign. The territory of the Chechen Republic is located within the Eastern Caucasus, which is characterized by specific features that create favorable conditions for the development of dangerous natural and man-made geodynamic processes - a thick layer of clay rocks, strong development of erosional dissection and folded forms, the activity of modern movements of the earth's crust, anthropogenic impact, etc.

Various types of exogenous processes are developed in the territory under consideration. Landslides and mudflows are especially active in the mountainous part, the intensity of which depends, first of all, on the lithological composition and properties of the rocks that make up the earth's crust of a particular territory. In some areas, one of the key factors is also anthropogenic activity: laying of communication lines, deforestation of slopes, laying and widening of roads, etc. A number of scientific articles are devoted to landslide processes in the territory of the Chechen Republic [1, 6]. This work focuses on the synergism of their manifestation.

Synergism of exogenous processes, as noted above, can consist of the synchronous manifestation of landslides, mudflows and floods in appropriate conditions. The material for the mudflow is the lithomass from the landslide area.

Synergy consists in the fact that heavy rains lead to a rise in the water level in rivers and, accordingly, to the erosion of banks composed of easily eroded rocks.

An example of landslides most typical for low-mountain forest-steppe landscapes is the landslide near the village of Belgatoy. It begins at approximately an altitude of 766 meters (below the old mosque) and ends on an alluvial fan superimposed on a river terrace that steeply drops off to the river bed.

The Belgatoy landslide develops on Neogene deposits represented by interbedded sandy argillites with multiple aquifers. They are exposed as the landslide deepens, forming a temporary watercourse in the thalweg part of the erosion-landslide cirque, which, passing the alluvial cone in the lower part, cuts into the depth of up to 5 meters.

III. Results

The dynamics of landslide processes over the past 10 years (2011-2021) shows that landslide and erosion-landslide processes remain active. This is noticeable, first of all, in the remaining unsodded areas in the erosion-landslide cirque.

In general, the integration of the Belgatoy landscape-landslide complex into the landscape structure strongly depends on the geomorphological features and moisture conditions of this territory. Currently, due to anthropogenic activity, the relief, soil and ground moisture conditions have been significantly transformed. The construction of multi-storey buildings, bridges and roads in the 60s of the 20th century, the intensification of agriculture contributed to the activation of landslides, the apogee of which was the catastrophic landslides of 1989 [3, 5]. Another area of active landslide processes is the Benoy-Sayasan-Zandak area of the eastern Black Mountains, where Sarmatian deposits composed of clay rocks come to the surface. That is, the dependence of the occurrence of landslides on the material composition of the rocks that make up the area is clearly visible.

Since the early 1960s, landslide processes have repeatedly intensified in the mountainous part of the Chechen Republic, causing enormous damage to many settlements located there. In this regard, the problems of predicting landslide processes and developing effective methods to combat them, taking into account the specific features caused by many factors that are tied to the studied area, are relevant. An example of effective measures taken to combat landslides in the

village of Khochi-Ara, Nozhai-Yurtovsky District, are the events, the essence of which was as follows: a trench 1-1.5 m deep was dug across the mountain slope at an angle of 20-250, the bottom and lower wall of which were lined with polyethylene film. It promotes the flow of water along the drainage ditch. A special drainage pipe was placed on the film, which was covered with crushed stone from above. In turn, this entire system was wrapped in a special material and covered with earth. Landslide processes are also prevented by a concrete barrier along the road, poured as a foundation for the fence. Over the past 8 years since the completion of these works, no manifestations of landslides have been detected.

Another example confirming the effectiveness of the proposed anti-landslide system: in the village of Benoy-Vedeno, Nozhai-Yurtovsky district, landslides began, which were approaching a recently built house every year. According to our recommendation, a protective system was built, which consists of drainage and a concrete wall. It has been working normally for two years, but further monitoring is required. An important factor is the fall of heavy precipitation, which could provoke landslides.

In general, the territory of the Chechen Republic is divided into mudflow-hazardous areas of 4 categories according to the activity of mudflows [4] (Figure 1).

Figure 1: *Complex natural landslide in low mountain forest landscapes (Goy-chu river gorge)*

The formation of an oil-producing complex together with the section of the geological environment covered by it can be considered as a complex open natural-technogenic system caused by the synergy of a number of factors. There are many examples of the manifestation of dangerous geodynamic processes during long-term exploitation of oil and gas fields (technogenic seismicity, subsidence of the daylight surface, etc.). The problem of technogenic seismicity during the development of mineral deposits is relevant for many countries with developed oil production. Technogenic processes (such as various types of flooding, induced seismicity) cause significant damage to structures and complicate the process of developing new territories [10].

Technogenic seismicity is characteristic of some developed hydrocarbon fields of the Tersko-Sunzhenskaya oil and gas region , in particular, for the Starogroznenskoye and Gudermesskoye oil fields. Within the Starogroznenskoye field, earthquakes of low intensity associated with its development were noted in 1938, 1963, 1971, and at Gudermesskoye – in 1950, 1955, 2008. The relationship between seismic activity and the dynamics of oil production from these fields indicates the active development of geodynamic processes.

IV. Discussion

Thus, the paper attempts to consider geological processes in the Chechen Republic from the point of view of a synergetic approach. The main factors influencing the intensity of geological processes are identified. It is shown that the synergism of landslide and mudflow processes in the territory under consideration consists of the simultaneous and joint action of various factors, which at the same time increase the intensity of their occurrence [3,9]. Manifestations of mudflow and landslide processes in the territory of the Chechen Republic are quite active. When they occur, great damage is caused to landscapes and infrastructure of mountainous areas. Communications of settlements, inter-settlement and inter-district highways are exposed to such danger (Figure 2). The synergism of dangerous geodynamic processes (landslides, voids, subsidence of the earth's surface, man-made seismicity) in the development of hydrocarbon deposits consists in the fact that the formation of these processes occurs through the collective action of many factors and conditions, which are based on geomechanical processes [7,11]. When developing oil and gas fields, the moment of occurrence of dangerous geodynamic processes corresponds to the so-called "bifurcation" point.

In our opinion, further studies of the considered and similar exogenous processes in the aspect of synergism can lead to practically important results. On this basis, various theoretical generalizations are possible, which, in turn, can contribute to the development of methods for predicting these processes.

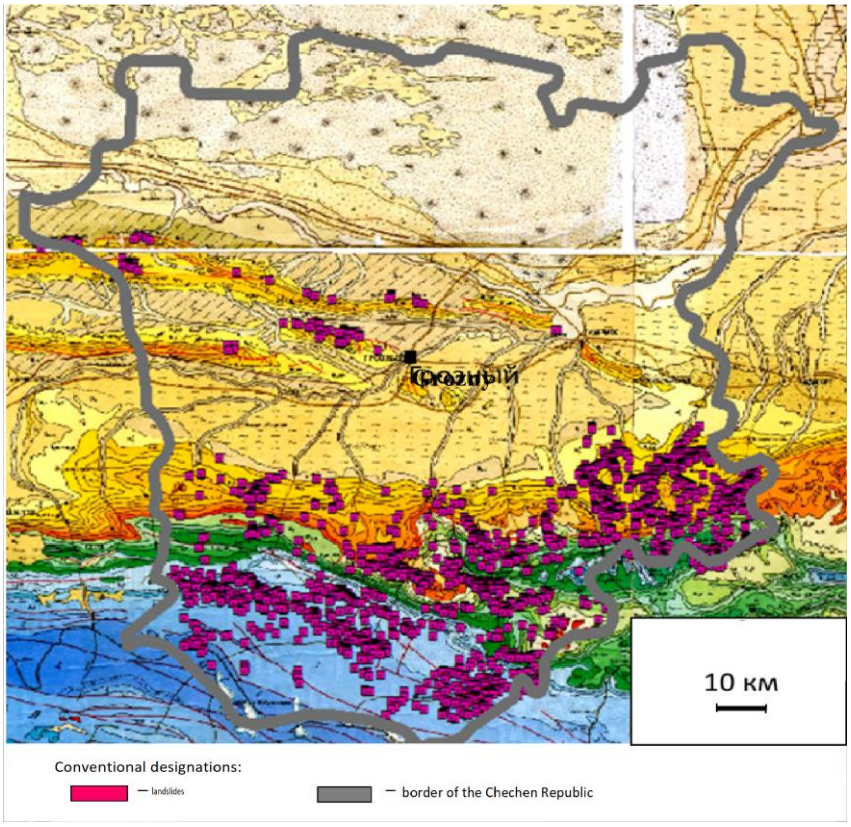

Figure 2: *Spatial distribution of landslides based on the geological map of the Chechen Republic*

The geological structure of the mountainous part of the Chechen Republic is characterized by the participation of a wide range of sedimentary rocks from the Lower Jurassic to the Quaternary period. Moreover, the older rocks are in the south, and are replaced by younger ones as one moves north. The highlands are represented by Lower and Middle Jurassic deposits of flysch rocks, consisting of interbedded siltstones, sandstones and argillites. To the north, in the midlands, the

flysch deposits are replaced by a complex of carbonate deposits from the Upper Jurassic to the Lower Cretaceous, consisting of limestones, partially dolomitized, as well as clays and marls. Upper Cretaceous rocks are represented, as a rule, by limestones and marls. To the north of the Upper Cretaceous rocks, there is a belt of Paleogene-Neogene clayey deposits, representing a low-mountain belt. In the lowest part, there are Maikop clays, and higher up, there are Karagan-Chokrak deposits, which, in addition to clays, contain sandstones. Even higher up are the Sarmatian and Akchagyl-Apsheron clayey deposits [2, 8]. The same rocks – from the Maikop to the Akchagyl-Apsheron stages – also make up the Forward Ranges. Between the Forward Ranges and the Black Mountains, Quaternary deposits are widespread, represented by pebbles and sands with clay interlayers (Figure 3).

According to their susceptibility to landslide formation, four main types of rocks are distinguished within the study area: Paleogene-Neogene clays, Cretaceous-Jurassic calcareous rocks, Jurassic siltstones and sandstones, and Jurassic argillites and sandstones.

Figure 3: *Landslide processes near the Nozhai-Yurt - Sayasan highway*

In the southern highland part of the territory, Lower Jurassic argillites predominate, which are close in composition to clays. Therefore, they often serve as an aquiclude, facilitating the development of landslide processes and corresponding relief forms. To the north, a narrow strip of Middle Jurassic siltstones stretches, more dusty, sandy. They are a fertile substrate for soils, in particular, in the Galanchozh intermountain basin, which is considered the historical core of the Chechen settlement, as well as in the Itum-Kalinskaya and Sharoy-Argunskaya intermountain basins. In the northernmost part of the studied territory, Upper Jurassic and Lower Cretaceous rocks are widespread, represented by chalk. They form the Pastbishchny Ridge. Carbonate soils, karst, and partly also gypsum karst are developed in these areas. Significant areas in the northernmost part of the territory are occupied by Paleogene-Neogene clay deposits.

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