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FEATURES OF THE ECOLOGICAL-GEOLOGICAL SYSTEM OF THE TUFF MASSIF OF THE PAUZHETSKY GEOTHERMAL REGION (KAMCHATKA)

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Abstract

The purpose of the study is to fully characterize the ecological-geological system (EGS) of the tuff massif of the Pauzhetsky geothermal region, compiled on the basis of the author's own field research (six field seasons) and published literature data. Features of the lithotope: an outcrop of andesite-dacitic tuffs of the Upper Pauzhetian subformation was studied. The rocks are divided into groups: 1) silty tuffs: density 1.40-1.57 g/cm^3, porosity 42.2-48.2%, uniaxial compressive strength 8-11 MPa; 2) fine psephitic tuffs are dense (ρ = 1.59-1.80 g/cm^3), porous (33.8-42.7%); 3) pumice tuffs are characterized by the lowest density (ρ=0.98-1.35 g/cm^3) and the highest porosity (n=49.8-63.5%). Features of the edaphotope: on the tuffs under consideration, volcanic layered ocher soils are developed; have a low density (0.6-0.8 g/cm^3). Features of the phytocenosis: forest and dwarf altitudinal zones occur. Features of the zoocoenosis: invertebrates include extensive complexes of arachnids, the diversity of the animal world is represented by species of mammals characteristic of Kamchatka. The EGS formed on the tuff massif of the Pauzhetsky geothermal region is a complex formation. The most important features of the EGS are mainly determined by its lithogenic base - rocks soils (andesite-dacite tuffs), which have specific properties.

Key words

ecological-geological system, Kamchatka, tuffs, Pauzhetsky geothermal region, andesite-dacitic

1 Introduction

A general classification of ecological-geological systems (EGS) was developed and first published in 2022 (Korolev, Trofimov, 2022). It identified the ecological and geological systems of rock massifs. And, if publications devoted to the EGS of dispersed soil massifs already exist (Korolev, Grigorieva, 2022), then for rocky soils there are very few such publications. The purpose of the study is to fully characterize the EGS of the tuff massif of the Pauzhetsky geothermal region (Kamchatka), compiled on the basis of the author's own field research (six field seasons) and published literature data.

2 Methods

Laboratory determination of composition, structure and physical properties. The mineral composition of the studied volcano-clastic rocks was determined in thin sections using a polarizing microscope, spot chemical analyzes of minerals and study the morphology of the pore space using a scanning electron microscope. To determine the composition of minerals a quantitative X-ray analysis is conducted. Chemical analysis of rocks is determined by X-ray crystal diffraction spectrometer. To study the physical and physico-mechanical properties of rock samples required preparations using stone-cutting machine to obtain rectangular parallelepipeds and also were polished. After preparation following properties are measured: bulk and mineral density, total porosity, open porosity, water absorption, propagation velocities of elastic waves (longitudinal and transverse), magnetic susceptibility, uniaxial

compression strength and tensile. The total porosity was determined by the ratio of the mineral density (ρ_s) and the bulk density of the rocks in the air-dry state (p) using the formula: $n=(\rho_s-p)/\rho_s$. All measurements are performed according to standard methods described in conventional textbooks and manuals.

3 Results

Let us consider the main features of the ecological-geological system of the tuff massif of the Pauzhetka geothermal region (Kamchatka) (Fig. 1, 2, 3), which is located in the south of Kamchatka in the Pauzhetka River valley within the internal zone of the Kuril-Kamchatka island arc and belongs to the southern segment of the East Kamchatka volcanic belt.

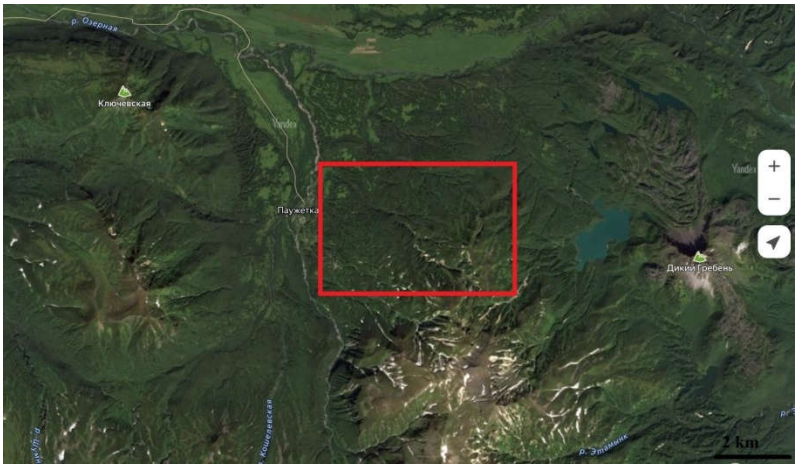

Figure 1. Scheme of the location of the ecological-geological system of the tuff massif of the Pauzhetsky geothermal region (https://yandex.ru/maps)

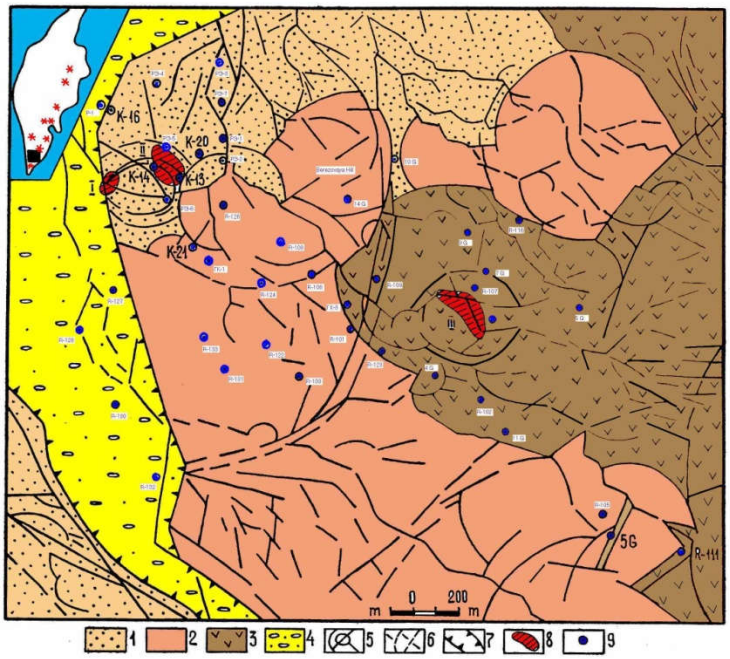

Figure 2. Schematic geological map of the Pauzhetka geothermal field (from The Structure of the Hydrothermal System, 1993). 1 - tuffs and tuffites of andesite-dacitic composition of the Upper Pauzhetka subsuite; 2 - lavas and extrusive bodies of dacite composition of Middle-Upper Quaternary age; 3 - andesite-basalts of Middle-Upper Quaternary age; 4 - modern alluvial deposits; 5-6 - tectonic structures: 5 - ring and their elements, 6 - "linear" and their elements; 7 - boundaries of the Pauzhetka Upper Quaternary graben; 8 - thermal fields: I - South, II - Upper, III - East; 9 - wells

Figure 3. General view of the ecological-geological system of the tuff massif of the Pauzhetsky geothermal region

Meteorological, hydrological and hydrogeological conditions. The climate is subarctic. The warmest month is August with an average temperature of 12.3 °C. The coldest month is January, with an average daily temperature of -6.3 °C. The average annual precipitation is 2056.1 mm. The minimum precipitation occurs in June, the maximum amount falls from October to December, most of it in the form of snow (Samkova, 2009b). Pauzhetka River (length 24 km, basin area 148 km²) originates on the slope of Kambalny volcano. It flows into the Ozernaya River on the left at a distance of 27 kilometers from its mouth. The width of the river in the middle reaches is 10 meters, the depth is 0.6 meters, the current speed is 2.5 m/s. Many streams flow into Pauzhetka, the largest of which is Lednikovy. The Pauzhetka thermal field in the Pauzhetka River valley has been studied in detail using exploratory drilling. Two pressure water-bearing complexes have been uncovered, confined to deposits of psephitic tuffs of the Pauzhetka suite (upper) and Paleogene-Neogene polymictic sandstones (lower). The upper water-bearing complex, with a thickness of 150-260 m, is isolated from groundwater by relatively impermeable siltstone tuffs. The area of the artesian slope, outlined by the distribution of psephitic tuffs in the western part of the Kambalny Ridge structure, is about 40 km^2; the underground flow rate is at least 400 l/s (Structure of the hydrothermal system, 1993). According to the chemical composition, the waters of both horizons are chloride, sodium, and siliceous with a mineralization of 2.7–3.4 g/l (Belousov, Sugrobov, Sugrobova, 1976).

Features of the lithotope. Complete sections of the Pauzhetsky Formation are exposed by wells drilled at the Pauzhetsky springs and in the bedrock outcrops of the northern part of the Kambalny Range (Belousov, 1978). The upper 450 m of the sequence are represented by dacite and rhyolite tuffs of various granulometric compositions. On the right side of the stream, outside the zone of influence of hydrotherms, an outcrop of tuffs of the Upper Pauzhet subformation (N_2-Q_1pau_3) was studied. The exposed side of the stream represents a sequence of interlayered andesite-dacitic tuffs from fine to coarse clastics. According to their properties, the rocks are divided into three groups: 1) silty tuffs: density from 1.40 to 1.57 g/cm^3, density of the solid component 2.70-2.72 g/cm^3, porosity from 42.2% to 48.2 %, open porosity from 31.2 to 40.3%, hygroscopic humidity 0.7-3.6%, water absorption 20.5-27.1%, longitudinal wave speed 2.00-2.40 km/s, magnetic susceptibility 2.9-11.4*10^{-3} SI, uniaxial compressive strength 8-11 MPa; 2) fine psephitic tuffs are dense (ρ = 1.59-1.80 g/cm^3), density of the solid component is 2.72-2.78 g/cm^3, porous (33.8-42.7%); 3) pumice tuffs are characterized by the lowest density (ρ=0.98-1.35 g/cm^3) and the highest porosity (n=49.8-63.5%) (Shanina, 2013), which is associated with the presence of pumice fragments.

Features of the edaphotope. On the considered tuffs of the Pauzhetsky geothermal region, volcanic layered ocher soils are developed (Samkova, 2009a), have a low density (0.6-0.8 g/cm^3), crumbly, with high water permeability and a predominance of free humic acids and those associated with mobile sesquioxides humic acids and fulvic acids. Humus type is fulvate (0.7-0.9), humus content 15-20%. The presence of allophan and aluminum hydroxides determines the high sorption capacity. The edaphotope soils of the tuff massif of the Pauzhetsky geothermal region on aerial pyroclastic substrates are distributed outside the thermal fields.

Features of phytocenosis. The phytocenosis of the considered EGS of the tuff massif of the Pauzhetsky geothermal region contains forest and dwarf altitudinal belts. Forest vegetation is represented by stone birch forests on the slopes of the Kambalny Range (105-315 m above sea level). The elfin elfin belt (100 - 900 m above sea level) is composed of communities of alder and cedar elfin trees. Meadow vegetation is represented by large-grass hygromesophytic (shelomaynik) meadows, reed meadows, forb mesophytic and hygromesophytic meadows, subalpine meadows (in the dwarf belt) (Samkova, 2009b). The predominant plant communities are wormwood-geranium, wormwood-cinquefoil and burnet (Samkova, 2009a). Vascular plants include 112 species and subspecies belonging to 91 genera and 38 families (Samkova, 2009b). There are plants included in the Red Book of Russia - large-flowered slipper, rough bluegrass, Asian grasshopper, as well as rare plants of the Far East - Kamchatka lyubka, Daurian lily (Volcanoes of Kamchatka..., 2011).

Features of zoocenosis. The composition of the zoocenosis of the considered EGS of the tuff massif of the Pauzhetsky geothermal region is represented by both invertebrates and vertebrates. Among invertebrates, there are extensive complexes of arachnids of the families Clubionidae, Linyphiidae, Theridiidae, Tetragnathidae, Araneidae, Philodromidae, Eutichiuridae, Dictynidae, Thomisidae (Nenasheva, 2020) and insects (Fig. 4). Among insects, the species composition of caddisflies (Trichoptera) is especially representative, 10 species (Lobkova, Vshivkova, 2015). Insects of other orders are also numerous: hymenoptera, especially bees, dipterans, especially hoverflies, as well as bloodsucking (Tabanidae, Culicidae, Simulliidae, etc.) and butterflies. Predators predominate among beetles. There are also numerous vertebrate animals—birds and mammals—that live permanently or temporarily on the territory of the Pauzhetsky geothermal region. The diversity of the animal world is represented by mammal species characteristic of Kamchatka: brown bear, fox, sable, wolverine. The bird fauna includes 170 species, including the rare Buzzard subspecies Buteo lagopus kamtschatkensis (Lobkov, 2012), of which 34 are nesting (The trails of Southern Kamchatka, 2020).

Figure 4. Strelchatka caterpillar (Acronicta alni), Pauzhetsky geothermal region (Kamchatka)

4 Conclusion

The ecological-geological system formed on the tuff massif of the Pauzhetsky geothermal region is a complex formation. The most important features of the EGS are mainly determined by its lithogenic base - rocky soils (andesite-dacite tuffs), which have specific properties. The composition and properties of the lithotope largely determine the properties of the edaphotope and the species composition of phytocenoses and have less influence on the zoocenosis.

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