PALEOGEOGRAPHIC CONDITIONS AND SOIL-FORMING ROCKS OF THE ADJACENT TERRITORY OF THE CENTRAL FERGANA RESERVOIR

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Abstract:
This article analyzes the paleogeographic conditions of the adjacent territories of the Central Fergana Reservoir and the complex genesis of the parent rocks. It is shown that the ancient aeolian relief of the area and subsequent sedimentation processes in the lacustrine-proluvial plain formed deposits with a layered structure and sharply differing lithological characteristics. As a result of geochemical processes associated with changes in the groundwater regime, the "arzyk" and "shokh" layers, rich in gypsum ($CaSO_4 \cdot 2H_2O$) and carbonates ($CaCO_3$), are formed in the lower part of the soil profile. It is scientifically substantiated that this ancient lithogenetic legacy is the main factor determining the current complex meliorative state and the tendency towards salinization and waterlogging of the region's soils.

Keywords: paleogeography, parent rocks, lithogenesis, aeolian relief, "arzyk" and "shokh" layers, secondary salinization, Central Fergana.

Introduction:

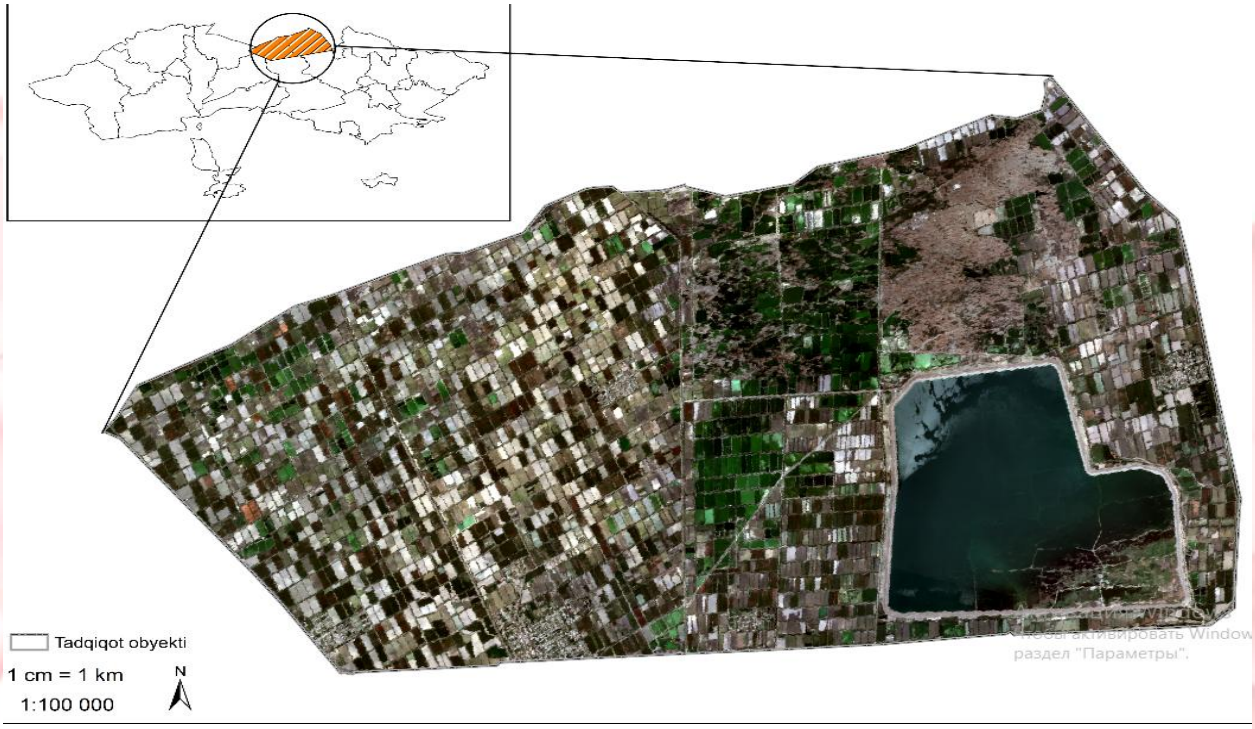
A thorough and objective assessment of the current soil-reclamation status and genetic characteristics of the study area requires a fundamental analysis of its paleogeographic evolution, particularly the Quaternary landscapes and the lithogenesis of the parent rocks.

Existing paleogeographic reconstructions and historical-geological data indicate that the study area once possessed a complex aeolian morphostructure, formed in the conditions of an ancient arid (arid) landscape. This landscape consisted primarily of mobile and semi-fixed dune-ridge systems, as well as widespread flat sandy massifs [3]. Hydromorphic conditions prevailed in the inter-eolian depressions (basins) of the relief, where solonchak-takyr complexes, salt marshes, and temporary lakes with shallow groundwater were widespread. These conditions, due to high evaporation, led to the accumulation of mineralized groundwater rising by capillary action on the surface, leading to the intensive accumulation of readily soluble salts and gypsum. These processes resulted in the formation of a complex of parent rocks with

markedly different lithologies: well-sorted and washed aeolian sands on one side, and layers of heavy mechanical composition, gypsum-laden, and highly saline on the other.
In subsequent periods, particularly with the introduction of large-scale irrigation and agriculture, the natural topography of the area underwent significant anthropogenic transformation. Although many sandy ridges were leveled and ancient lowlands were covered with soil, the "genetic memory" of the ancient topography remained. Its traces are evident today in the form of well-preserved dunes in the northern part of the reservoir and, most importantly, in the form of isolated relict sand dunes found among the irrigated areas. These residual landforms cause the marked heterogeneity of the modern soil cover. Soils formed on the site of ancient sand dunes have a light texture and are characterized by low water-holding capacity and a high permeability coefficient, whereas soils on the site of ancient inter-eolian depressions have a heavy loamy composition, low water permeability, and are prone to secondary salinization and waterlogging. Therefore, the modern soil cover of the territory should be considered a complex palimpsest (multilayered record) of natural paleogeographic heritage and strong anthropogenic transformation, which must be taken into account when planning agro-reclamation measures and sustainable land use [1].
Historical sources also confirm this position. As noted by the renowned orientalist V.V. Bartold, citing Arabic chronicles, in the 14th-15th centuries, the territory of Central Fergana was a system of interconnected lakes, dense reed beds, and swamps [2]. Later, research conducted in the 1930s and 1940s also confirms the past existence of extensive swamp and lake landscapes on these lands [Pankov, Rozanov, Maksudov]. Consequently, the territory developed for a long time in hydromorphic (excessively wet) conditions. The lithogenesis and soil formation processes of the lacustrine-proluvial plain, which occupies a central position in the geomorphological structure of the Fergana Valley and serves as the terminal sediment accumulation basin, are particularly complex. Geologically, this area represents the lowest hypsometric stage of the valley and served as the terminal center for virtually all surface runoff originating in the surrounding adyrs and mountain ranges. As a result, water and sediment masses from several sources accumulated here:

1. Natural streams: High-energy proluvial and alluvial flows of mountain rivers, as well as periodic mudflows and flood waters.

2. Anthropogenic flows: Irrigation, drainage, and wastewater from agricultural fields in the oases are rich in suspended particles and dissolved salts.
As a result of these processes, the grain size distribution of sediments accumulated in the basins varies extremely widely and includes all fractions—from coarse sand and fine gravel to silt, clay, and the most highly dispersed colloidal particles.



The history of the geological development of the region, particularly in relation to Holocene climate fluctuations, gave the process of sedimentogenesis a cyclical nature. During hydromorphic (wet) phases, increased climate humidity and melting glaciers in the mountains led to a sharp increase in river runoff. During these periods, primarily light-textured rocks—sand and light sandy loam—were deposited on the plain, forming thick layers. Conversely, during automorphic or semi-hydromorphic (arid) phases, river runoff weakened, the surface area of reservoirs shrank, and they often turned into shallow, intermittent lakes. Under conditions of low energy, stagnant water, and intense evaporation, the finest, finely dispersed materials (siltstone, clay) precipitated, forming layers of heavy texture.

These periodic changes led to the formation of a distinctly layered lithological structure in the soil profile. This polygenetic layering directly influences the hydrophysical properties of modern soils. Sandy layers are highly permeable, while clay layers act as a virtually impermeable "hydrostatic screen." This hinders vertical filtration, leading to the formation of high groundwater tables under the influence of irrigation and, consequently, creates the basis for the development of negative reclamation processes such as swamping and secondary salinization. Therefore, for an accurate assessment of the agricultural potential of the territory and the optimization of reclamation measures, a thorough study of this lithological and stratigraphic heterogeneity of the soil profile is of great scientific and practical importance.

The parent and underlying rocks of soils formed in lacustrine-proluvial plains consist primarily of lacustrine and bog sediments formed underwater (in subaqueous conditions). These sediments subsequently underwent significant changes during early diagenesis. As N.V. Logvinenko [9] notes, the water contained in sediments contains dissolved substances in ionic form, colloids, and gases. Subsequently, under normal atmospheric conditions, at low temperature and pressure, early diagenesis processes develop. These include:

- • **Physical changes:** compaction of sediments, dehydration (drying), crack formation and aggregation.
- • **Biochemical changes:** decomposition of organic matter (mineralization and humification) and synthesis of new organic compounds.
- • **Chemical changes:** processes of oxidation, reduction and cementation.

The periodic alternation of dry and wet climatic phases in the region, as well as seasonal fluctuations in water levels (spring rise and autumn fall), led to sharp dehydration and cracking of sediments. Gypsum crystals accumulated in these cracks due to capillary solutions. Geochemical processes proceeded along the following lines:

• Dissolution of primary minerals and recrystallization of secondary minerals.
• Reduction of iron (Fe) and manganese (Mn) under oxygen-deficient conditions.
• Formation of sulfides (FeS, PbS, etc.) with the participation of hydrogen sulfide (H2S).
• Precipitation of iron and manganese carbonates.

Soil formation processes in the region are closely linked not only to sedimentological factors but also to complex geochemical changes of subsequent periods. In particular, shifts in oxidation-reduction conditions caused by periodic fluctuations in groundwater levels radically altered the chemical composition of the soil.

During hydromorphic phases, that is, when the soil profile was saturated with water and oxygen deficiency arose (anaerobic conditions), intense reduction processes occurred. Under these conditions, sulfate-reducing bacteria were activated, reducing sulfate ions (SO42−) to hydrogen sulfide (H2S). Simultaneously, iron and manganese, as elements with variable valence, converted from their poorly soluble compounds with a high oxidation state (Fe3+, Mn4+) to highly mobile, low-valence forms (Fe2+, Mn2+) and entered the solution. Anaerobic decomposition of organic matter enriched the soil solution with carbon dioxide (CO2). In contrast, during automorphic or semi-hydromorphic (drier) phases, when the groundwater level dropped and air entered the soil profile, oxidative processes predominated. During this period, the soil solution concentrated due to capillary rise or evaporation. As a result, calcium ions (Ca2+) and sulfate ions (SO42−) accumulated in the solution underwent chemical precipitation, transforming into a solid phase as the mineral gypsum (CaSO4·2H2O). Also, as a result of the interaction of calcium ions and bicarbonates, calcium carbonate (CaCO3) precipitated, binding soil particles together.

Conclusion: It was as a result of these periodic geochemical cycles that illuvial-metamorphic horizons consisting of intense accumulations of gypsum and carbonates formed in the lower part of the soil profile, usually in the zone of seasonal groundwater fluctuations. These dense, cemented layers, with virtually zero permeability, formed, known in local agricultural practices as "arzyk" (gypsum layer) and "shokh" (carbonate-gypsum layer). These lithogenetic barriers are currently the main factor determining the hydromeliorative regime of the region's soils. They sharply limit vertical water exchange, promote the formation of high-pressure perched water, and create the fundamental basis for the development of secondary salinization processes.

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