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Investigation of the physico-mechanical properties of cohesive soils in deluvial-proluvial (QII-III) and alluvial (QIII-IV) deposits of the Alakol Depression

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Abstract. When conducting engineering and geological surveys, one of the main tasks is to determine the physical and mechanical properties of soils. The physical properties of soils are necessary for accurate soil classification, while the mechanical properties are essential for calculating the stability of foundations, as well as the foundations of buildings and structures. This article presents the results of a study on the physico-mechanical properties of cohesive soils in deluvial-proluvial and alluvial deposits of the Alakol depression. Modern geological processes and phenomena in this region are mainly influenced by human engineering and economic activities, particularly land reclamation and construction. Until the 1960s, the development of certain UCPs (Unified Classification Points) was sporadic. The erosion activity of water flows was primarily observed during spring floods and heavy rains, leading to the washout and collapse of riverbanks. Deflation was evident in the Aeolian reworking of alluvial-lacustrine deposits, resulting in the formation of blow basins, sand dunes, wind ripples, and other microrelief features. Additionally, salinization and waterlogging led to the widespread development of salt marshes and puffin formations in areas with shallow groundwater levels.

Keywords: *absolute marks, depression, complex, alluvial, deluvial, physical and mechanical properties.*

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1. Introduction

The natural boundaries of the region include Lake Balkhash to the north, the Tarbagatai Ranges to the northeast, the Chu-Ili Mountains to the southwest, and the spurs of the Dzungarian Mountains to the south. The absolute elevation of the plain surface varies from 600 m in the south to 340 m in the north.

Most of the region is covered with extensive sandy massifs. In the west, deeply dissected Taukum sands dominate, while the center is characterized by the Saryesik-Atyrau and Muyunkum sands. To the east, the Mokkum and Zhamanzhal sands are prevalent, and between Lake Balkhash and Lake Sasykkol lie the Karakum and Sarykum sands. All sand massifs exhibit narrow, elongated ridges aligned with seasonally alternating northwesterly and northeasterly winds. The elevations of dunes and sand ridges range from 3 to 30 m, reaching up to 50 m in the Taukum massifs (Figure 1).

The valley of the Ili River, the largest river in the region, is situated between the Taukum and Saryesik-Atyrau sands. The modern and Late Quaternary river deltas of the Ili River (covering an area of 8 000 km²) are dissected by a dense network of meandering channels and dry branches known as bakanas, some of which are partially covered with sand. The entire region is composed of a thick (up to 2 000 m) sequence of loose, weakly lithified Cenozoic deposits [1, 2].

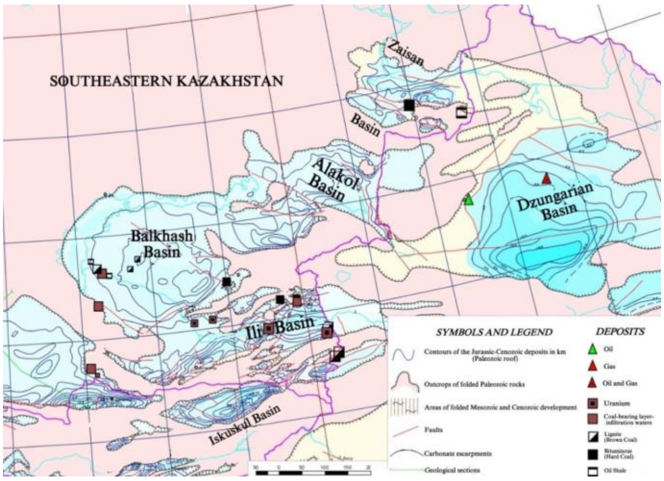

Figure 1. Map of the Alakol depression

The formation of the Alakol depression in the Upper Triassic period was accompanied by the accumulation of a terrigenous coal-bearing formation (TT3-JJ1), consisting of interbedded sandstones, conglomerates, and siltstones with coal interlayers. During the Paleogene-Neogene period, lacustrine and lacustrine-alluvial sediments of the terrigenous red-colored formation were deposited under hot, arid climatic conditions. These include montmorillonite-rich, red-colored

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carbonate clays, pinkish-gray Eocene marls, and light-toned bentonite clays, which are overlain by brick-red sandy clays with lenses and interlayers of red-colored clay sands (P3-N1). These deposits occur at significant depths and are, therefore, poorly studied from an engineering and geological perspective.

2. Materials and methods

Under conditions of intensified mountain-building tectonic movements in the border areas of the region, Pliocene-Quaternary red-colored molassic formations were deposited alongside the subsidence of depressions. The geotechnical assessment of Quaternary deposits is based on geological-genetic complexes and their geomorphological association with the corresponding geotechnical zones.

Within the basement plains on the Paleozoic folded foundation of the region's northeastern part, cover eluvial-deluvial and deluvial-proluvial accumulations have developed. These are distinguished as stratigraphic-genetic complexes of Quaternary eluvial-deluvial and deluvial-proluvial deposits (pl.1). The modulus of deformation of loams ranges from 17.6 to 50 MPa, while the degree of corrosion varies from 1.5 to 2.3 g/m² (the uniform corrosion rate of carbon steel is 2.55 mm/year) [3]. The physical and mechanical properties of cohesive soils in deluvial-proluvial (QII-III) and alluvial (QIII-IV) deposits of the Alakol Depression are summarized in Table 1.

Rocks of the alluvial-proluvial and alluvial complexes are mainly distributed on submountain inclined accumulative plains. Quaternary alluvial-proluvial deposits form sediment cones and fans at the base of mountains. The structure of these cones distinctly exhibits two accumulative cycles, beginning with gravel-pebble deposits containing individual boulders and sand-clay aggregates, and ending with variously grained sands and dense loams containing small pebbles and gravel. The thickness of the Lower Quaternary deposits ranges from 5 to 20 m, while Middle and Upper Quaternary deposits reach thicknesses of 80 to 140 m. The properties of cohesive soils in these complexes are presented in Table 2.

Table 1. Physical and mechanical properties of cohesive soils in deluvial-proluvial (QII-III) and alluvial (QIII-IV) deposits of the Alakol Depression

Indicators	Loam	Loam	Loam		Loam	
	dp Q_{II-III}	dp Q_{II-III}	aQ_{III}	aQ_{IV}	aQ_{III}	aQ_{IV}
Particle density, g/cm^3	2.68-2.75 2.72 (15)	2.70-2.74 2.72 (36)	2.66-2.75 2.71 (29)	2.70-2.82 2.72 (35)	2.65-2.72 2.68 (63)	2.66-2.73 2.69 (31)
Density, g/cm^3	1.49-1.88 1.67 (15)	1.41-1.93 1.68 (36)	1.40-2.10 1.75 (28)	1.34-2.03 1.74 (35)	1.43-2.01 1.71 (63)	1.30-2.19 1.67 (31)
Skeletal density, g/cm^3	1.32-1.64 1.48 (15)	1.28-1.59 1.48 (36)	1.37-1.65 1.50 (12)	1.30-1.85 1.49 (35)	1.31-1.71 1.52 (63)	1.20-1.85 1.51 (31)
Porosity, %	40.3-51.5 45.8 (15)	41.8-59.2 45.5 (36)	-	34.4-52.3 47.6 (25)	-	42.7-54.3 48.4 (6)
Porosity coefficient, %	0.66-1.06 0.85 (15)	0.72-1.12 0.84 (36)	0.56-0.98 0.76 (28)	0.47-1.098 0.81 (35)	0.495-1.061 0.75 (63)	0.438-0.921 0.66 (25)
Yield point humidity, %	22-31 26 (15)	18.5-25 23.1 (36)	22-38 26.7 (30)	15.7-41 28 (14)	17-33 23 (63)	17-30 24.3 (31)
Plasticity number, %	7-11.7 8.9 (15)	3.2-6.9 5.6 (15)	5-17 9.4 (30)	5-16 11 (14)	1-7 4.6 (63)	1-7 4.8 (31)
Internal friction angle, degree: at natural humidity	17-30 24 (7)	19-29 26 (11)	-	12-46 28 (13)	-	22-45 36 (15)
Adhesion at natural humidity, 10^5 Pa	0.15-0.8 0.5 (7)	0.2-0.9 0.7 (11)	-	0.3-2.1 1.09 (13)	-	0.03-0.88 0.43 (15)
Relative drawdown coefficient at P = 0.3 MPa	0.017-0.11 0.07 (7)	0.006-0.113 0.04 (27)	0.002-0.1 0.033 (9)	-	-	-

Table 2. Physical and mechanical properties of cohesive soils in the quaternary alluvial-proluvial deposits

Indicators	Sandy loam			Sandy loam		
	apQ	apQ_{II-III}	apQ_{III-IV}	apQ	apQ_{II-III}	apQ_{III-IV}
Particle density, g/cm^3	2.65-2.73 2.88 (89)	2.65-2.73 2.88 (44)	2.68-2.74 2.72 (18)	2.6-2.81 2.71 (65)	2.68-2.82 2.72 (62)	2.70-2.75 2.73 (9)
Density, g/cm^3	1.36-2.09 1.75 (89)	1.41-1.93 1.67 (44)	1.25-1.99 1.64 (18)	1.17-2.09 1.64 (62)	1.40-2.01 1.55 (62)	1.54-1.76 1.61 (9)
Skeleton density, g/cm^3	1.38-1.77 1.55 (72)	1.28-1.75 1.49 (44)	1.28-1.75 1.54 (15)	1.07-1.77 1.46 (34)	1.31-1.72 1.49 (62)	-
Porosity coefficient	0.29-0.98 0.70 (89)	0.59-1.13 0.84 (44)	0.58- 1.17 0.76 (18)	0.29-1.38 0.79 (63)	0.58-1.05 0.87 (62)	0.63-0.85 0.75 (9)
Yield point humidity, %	16-30 23 (89)	18.5-26.8 23 (38)	21-25 22.5 (10)	22-51 27 (65)	19.6-25.9 23.5 (10)	22.6-30.7 27.7 (9)
Plasticity number, %	1-7 4.6 (90)	3.2-6.9 5.6 (38)	2.2-6.6 5.1 (10)	7-17.3 9.1 (65)	12.1-18.8 17.1 (10)	9.0-11.7 10.7 (9)
Internal friction angle, degree: at natural humidity	20-37 26 (27)	14-46 26 (16)	14-46 28 (8)	21-48 27 (14)	11-46 28 (18)	-
when soaking with water	-	11-17 16 (5)	11-17 15.8 (5)	-	11-37 18 (44)	-
Coupling, 10^5 Pa: at natural humidity	0.08-2.7 0.37 (36)	0.2-1.9 0.86 (16)	0.7-1.9 1.03 (5)	0.10-3.8 0.64 (40)	0.4-1.7 0.98 (18)	-
hen soaking with water	-	0.3-0.9 0.5 (5)	--	-	0.1-0.7 0.43 (44)	-
Module deformations, MPa	3.9-19 12 (3)	--	-	2.6-10 5.9 (9)	--	-
Relative drawdown coefficient at P = 0.3 MPa	0.001-0.150 0.045 (11)	0.006-0.113 0.04 (27)	0.001-0.06 0.02 (3)	0.002-0.20 0.065 (9)	--	-

Loamy alluvial-proluvial deposits exhibit subsidence characteristics [4]. The amount of subsidence varies as follows: apQII loam thickness ranges from 5.4 to 72.8 cm, apQII-III from 16.5 to 16.8 cm, and apQIII-IV up to 5 cm. The most subsident deposits are the Lower and Middle Quaternary alluvial-proluvial loams of ancient sediment cones.

Channel facies are represented by gravel-pebble deposits with a sand aggregate, frequent interlayers, and lenses of different-grained sands. The clastic material is well-rounded and differentiated by strike and section. Boulders and gravel-pebble deposits with a sand-clay aggregate form the base of the section. Sand and gravel formations with lenses and interlayers of different-grained sands and loamy rocks usually lie above. Near the surface, coarse-grained rocks are overlain by gray loams and sandy loams.

The soil properties are very similar, despite testing being carried out in different river valleys of the northern and northeastern slopes of the Dzungarian Alatau. The loams of the first above-floodplain terraces (aQIII) are saline in some areas, and the soils exhibit increased corrosivity. Single determinations showed a degree of corrosion of 2.2-12 g/m² (the corrosion rate of carbon steel is 2.5-13.3 mm/year). Loam is slightly shrunken in some areas, and its subsidence under household loads is less than 5 cm [5].

The characterization of engineering and geological conditions and map construction is based on the principle of geological-genetic (formation) analysis. The territory is divided into geological bodies-the primary objects of mapping. These bodies represent parts of geological formations, including stratigraphic-genetic and lithological-facies complexes of rocks and their characteristic combinations. The sediments were studied for the depth of development of lithified rocks capable of supporting structural loads. Neogene clay deposits were taken as a regional water barrier.

3. Results and discussion

Quaternary deposits are widespread from the surface throughout the entire research area, where most hazardous geological processes occur. Based on the conducted studies, the following first-to-surface stratigraphic-genetic complexes were identified within the study area. These differ in genesis, geological age, and lithology.

Stratigraphic-genetic complex of modern alluvial deposits (aQIV). Deposits of this complex are confined to floodplains and low terraces (up to 5 m) of nearly all major rivers in the region. They also form the extensive deltas of the Yrgaity, Terekty, Takyu, and Chindaly rivers, among others. Riverbed and floodplain terrace deposits are composed of loam and sandy loam with gravel and small pebbles, boulder-pebble aggregates with sand-gravel inclusions, and low-power lenses of different-grained sands and clays (Table 3).

Boulders ranging in size from 30-40 cm to 1.0-1.5 m in diameter are observed in the beds and floodplains of mountain rivers. All detrital material is well-rounded. In contrast, the flat part of the area is characterized by finer-grained alluvial deposits, primarily sandy-clay material with gravel and small, well-rounded pebbles. The thickness of alluvial deposits in mountain valleys reaches 10-12 m, whereas, within the flat plain, it does not exceed 3-5 m [6].

According to previous studies, groundwater is encountered at depths of 2-5 m, occasionally reaching 10-15 m. The water is fresh, with a mineralization of 0.1-0.2 g/dm³. Due to the limited development area, this complex is considered unsuitable for construction purposes.

Table 3. Physical and mechanical properties of gravel-pebble deposits with sand aggregate (aQIV)

N	Physical and mechanical properties	Minimum value	Maximum value	Arithmetic mean
1.	Soil density, g/cm³			
2.	Volume density of soil, g /cm³:			
	Loose	1.10	2.18	1.67
	Compacted	1.12	1.94	1.63
3.	Clay fraction, %			0.73
4.	Dust fraction, %			2.16
5.	Sand fraction, %			31.68
6.	Gravel fraction, %			65.43
7.	Natural humidity, %	0.60	4.20	1.93
8.	Filtration coefficient, m /day	30.70	77.40	77.40
9.	Natural slope angle, deg:			
	dry	37.0	53.0	46.47
	underwater	35.0	49.0	42.87

Figure 2 shows a typical granulometric composition graph for gravel-pebble deposits with sand aggregate. The filtration coefficient, determined using the Boldyrev method in experimental pit infusions, ranges from 9.18 to 31.10 m/day.

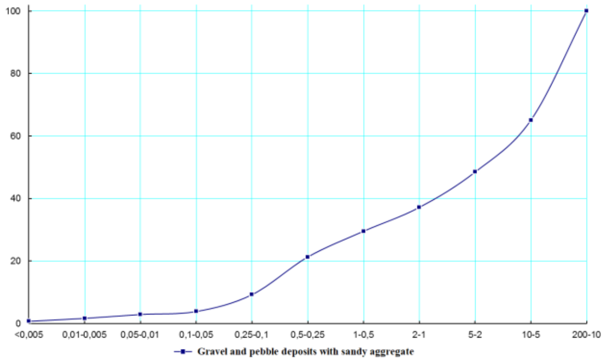

Figure 2. Integral curve of the granulometric composition of modern alluvial deposits

Coarse-grained sand is rarely found as interlayers. Two samples were taken (w-5/1, 0 and 2.0 m). The composition of these deposits includes 63.6-78.0% sand and 22.0-36.4% gravel. The compacted soil's volume weight ranges from 1.57 to 1.60 g/cm³, while the soil skeleton's density is 1.74-1.89 g/cm³. Natural moisture content varies between 1.0–1.2%. The natural slope angle is 40-42° for dry ground and 39-42° under water [7,8]. Loam is widely developed in the area, overlying boulder and pebble deposits.

Figure 3 presents a typical graph illustrating the granulometric composition of loam. Additionally, five monoliths were extracted from these loams (M-6/2.0 m, M-7/2.5 m, M-8/2.0 m, M-9/2.5 m, and M-10/1.0 m).

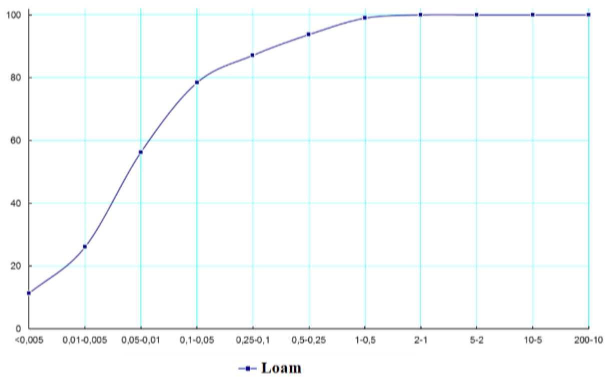

Figure 3. Granulometric Composition of Gravel-Pebble Deposits with Sand Aggregate

The soil density is 2.70 g/cm³. The volume weight of dense soils ranges from 1.43 to 1.54 g/cm³, whereas loose soils range from 1.34 to 1.47 g/cm³. Natural moisture content varies between 5.0% and 13.5% (Table 4).

Table 4. Physical and mechanical properties of loam aQ$_{IV}$

N	Physical and mechanical properties	Minimum value	Maximum value	Arithmetic mean
1.	Soil density, g/cm^3	2.70	2.70	2.70
2.	Volume density of soil, g/cm^3:			
	Loose	0.65	1.65	1.26
	Compacted	0.82	1.69	1.36
3.	Clay fraction, %			11.29
4.	Dust fraction, %			44.98
5.	Sand fraction, %			55.02
6.	Gravel fraction, %			-7
7.	Natural humidity, %	2.90	26.80	9.91
8.	Yield point	22.20	46.40	35.54
9.	Rolling border	15.20	29.30	21.84
10.	Plasticity index	7.0	17.70	10.70
11.	Turnover rate	-1.46	-0.48	-1.12
12.	Water saturation coefficient	0.15	0.36	0.24
13.	Filtration coefficient, m /day	0.04	0.08	0.06

According to compression test results, these loams are classified as medium compressible, with a compressibility coefficient (m_0) of 0.015-0.068 kg/cm³. The soil is highly compacted, with a skeleton density of 1.35-1.47 g/cm³. The yield index ranges from 0.48 to 1.64, indicating solid and plastic properties, while the total deformation modulus reaches 24.1-123.2 kg/cm³. The soil's porosity ranges from 45.6% to 50.3%, and the natural state porosity coefficient (e) is 0.713-1.015.

Stratigraphic-genetic complex of modern lake sediments (lQIV). This complex is prevalent along the southern coasts of Lakes Alakol and Zhalanashkol. The lake plain is generally flat and smoothed, with a slight (<1°) slope toward the northeast. Lake deposits consist of dense loams, clays, clay loams, and sands, interspersed with well-rounded pebbles and gravel, with a thickness varying from 1-3 m to 6 m.

According to previous studies, underground water is found at depths of 0.5-1.5 m, with a significant portion of the surface swampy. The water quality is fresh, with a salinity of 0.2-0.5 g/cm³. Gravel and pebble deposits with a loamy aggregate have developed from the surface (Figure 4).

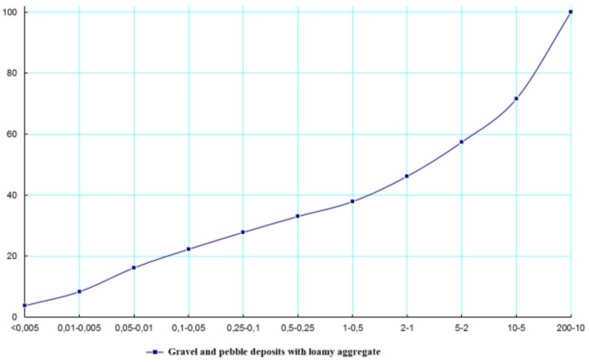

Figure 4. Integral curve of the granulometric composition of modern lake sediments

Experimental data from pit infusions using the Boldyrev method indicate a filtration coefficient ranging from 9.18 to 31.10 m/day (Table 5).

Table 5. Physical and mechanical properties of gravel-pebble deposits with loam aggregate (lQIV)

N	Physical and mechanical properties	Minimum value	Maximum value	Arithmetic mean
1.	Soil density, g / cm^3	-	-	-
2.	Volume density of soil, g /cm^3: Loose/compacted	-	-	-
3.	Clay fraction, %			3.77
4.	Dust fraction, %			12.40
5.	Sand fraction, %			30.0
6.	Gravel fraction, %			53.83
7.	Natural humidity, %	9.00	33.30	18.53
8.	Filtration coefficient, m /day	-	-	-
9.	Natural slope angle, deg: Dry/Underwater	-	-	-
10.	Yield point*(for placeholder)	18.30	29.20	23.40
11.	Rolling border*(for place-holder)	11.60	21.30	16.03
12.	Plasticity number*(for aggre-gate)	6.70	7.90	7.37

Figure 5 shows a typical graph of the granulometric composition of loams.

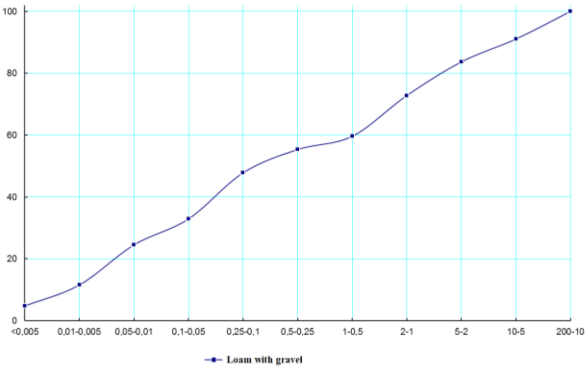

Figure 5. Integral curve of the granulometric composition of modern lake sediments

Stratigraphic-genetic complex of upper quaternary alluvial-proluvial deposits (apQIII). This complex extends across the foothill plain and the Alakol depression as a continuous cover. According to prior studies, deposit thickness varies from 8-20 m to 80-155 m and consists of boulder and gravel-pebble deposits interspersed with sand and loam (Table 6).

Table 6. Physical and mechanical properties of loam with gravel lQ$_{IV}$

N	Physical and mechanical properties	Minimum value	Maximum value	Arithmetic mean
1.	Soil density, g/cm^3	-	-	-
2.	Volume density of soil, g/cm^3: Loose/compacted	-	-	-
3.	Clay fraction, %			4.75
4.	Dust fraction, %			19.74
5.	Sand fraction, %			45.35
6.	Gravel fraction, %			30.16
7.	Natural humidity, %	13.30	30.80	23.43
8.	Yield point	18.50	40.00	27.50
9.	Rolling border	12.10	22.80	18.58
10.	Plasticity number	6.40	17.20	8.92
11.	Flow rate	0.47	1.21	0.82
12.	Water saturation coefficient	-	-	-
13.	Filtration coefficient, m /day	-	-	-

Fieldwork indicates that underground water in this area is mainly non-pressurized or low-pressure, with a pressure range of 1.7-5.0 m, and is encountered in wells at depths of 5-8 m to 11-25 m. Loam with gravel appears from the surface, occurring as interlayers throughout the section, alternating with sand, clay, and silt [11, 12].

This region, part of Kazakhstan's largest drainless basin, includes three artesian groundwater basins. Underground water associated with terrigenous coal-bearing (T3-J1J1) and terrigenous red-colored (K-N11) formations exists locally at great depths and does not significantly impact the region's engineering-geological conditions.

The Neogene pressure waters sometimes emerge through clay «windows», interacting with overlying aquifers. Local groundwater is found in eluvial-deluvial and deluvial-proluvial deposits [13, 14]. The boulder-gravel deposits contain fresh water, which transitions to gravel-sand and loam as the distance from foothills increases. Aquifer stratification results in pressurized lower horizons, with water-bearing interlayers reaching thicknesses of 180 m in foothill zones, but reducing to ≤50 m in depressions.

In the direction of the center of depressions, it decreases sharply and usually does not exceed 50 m. The depth of groundwater near the mountains reaches 100 m. Towards the center of the depression, it gradually decreases, and at the border with the lacustrine-alluvial plain, water wedges in the form of springs and hollows are noted [15].

4. Conclusions

The capacity of water supply points in the Alakolsky basin is 2.5-50 dm³/s. The flow rates of self-spilling wells reach 50 dm³/s. The waters are mainly sodium and calcium bicarbonate, with mineralization not exceeding 0.7 g/dm³. Sediments of stratigraphic-genetic complexes associated with accumulative hummocky-ridge and flat concave plains are linked to groundwater with a level depth (depending on the relief) ranging from 0 to 20 m or more. The mineralization and chemical composition of groundwater are highly diverse. As the groundwater flows toward the center of the depressions, an increase in water salinity is observed, ranging from 1 to 10 g/dm³. Accordingly, the composition changes from calcium bicarbonate to magnesium-sodium sulfate-chloride.

Groundwater, mostly occurring at shallow depths (1-5 m), is associated with alluvial deposits. In floodplains and river deltas, the groundwater level depth is no more than 1 m. The thickness of alluvial aquifers does not exceed 30 m. The water content of rocks varies widely. Flow rates of tenths of a liter per second prevail, and only in the upper reaches of rivers, where the water-bearing rocks are pebbles, do well flow rates reach 3 dm³/s. The mineralization of the waters reaches 5-10 g/dm³ and, in some cases, even 50 g/dm³. The composition of the water is sulfate and sodium chloride [16, 17].

The natural regime of groundwater is characterized by smooth, shallow-amplitude (0.5-1.0 m) fluctuations in levels throughout the year, with weakly expressed spring maxima and summer minima. The main autumn-winter maximum is due to the filtration flow of irrigation and wastewater from irrigated areas. The level rise is 1.8-2.2 m, and in areas of rice crop rotations, it reaches 5 m. An irrigation-type groundwater regime has developed over a large area.

Modern geological processes and phenomena in the region are mainly associated with human engineering and economic activities, particularly land reclamation construction. Until the 1960s, the development of a number of DGPs was episodic. The erosive activity of water flows was observed only during spring floods and heavy rains, leading to bank erosion and collapse. Deflation was evident in the eolian processing of alluvial-lacustrine sediments, resulting in the formation of blow basins, sand dunes, wind ripples, and other microrelief forms [18, 19]. Salinization and waterlogging occurred in the form of extensive development of salt marshes, sores, and puffs in areas with a shallow groundwater level.

Abrasion was intensely observed on the southern and eastern shores of Lake Alakol. The southern shore of the lake (near the village of Koktum) has moved more than 200 m over 20 years. As a result of the washout and collapse of the coastal ledge, part of the village was destroyed. The shoreline of the lake has advanced very close to the railway track. The activation of abrasion processes is caused by frequently recurring hurricane winds and an increase in the lake's water area. According to measurements from 1862 and 1931, the lake's size increased in length and width by 5 km. Even more intensive growth of the water area was established by the 1951 measurements. Over 20 years, the lake's length increased by 15 km, its width by 5 km, and its depth significantly as well [20].

Author contributions

Conceptualization: M.M.A., M.R.Z.; Data curation: M.M.A., E.S.A.; Formal analysis: M.R.Z., E.S.A., E.M.K.; Funding acquisition: M.M.A., M.R.Z.; Investigation: E.S.A., E.M.K.; Methodology: M.M.A., M.R.Z.; Project administration: M.M.A., M.R.Z.; Resources: E.S.A., E.M.K.; Software: E.S.A., E.M.K.; Supervision: M.R.A., E.S.A.; Validation: M.M., E.S.; Visualization: E.S., E.M.; Writing – original draft: M.M.A., M.R.Z.; Writing – review & editing: E.S.A., E.M.K. All authors have read and agreed to the published version of the manuscript.

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Conflicts of interests

The authors declare no conflict of interest.

Data availability statement

The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

References

[1] Sanatbekov, M.E., Zholtaev, G., Tileuberdi, N., Auelkhan, E.S. & Imansakipova, Z.B. (2024). Study of geodynamic and hydrogeological criteria for assessing the hydrocarbon potential of the alakol depression. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, (4), 5-10. https://doi.org/10.33271/nvngu/2024-4/005

[2] Alzhigitova, M.M., Zapparov, M.R. & Mirlas, V.M. (2021). Impact of anthropogenic activity on the condition of lake Alakol. *Engineering Journal of Satbayev University*, *143*(2), 44-51. https://doi.org/10.51301/vest.su.2021.i2.06

[3] Alzhigitova, M.M., Zapparov, M.R. (2020). Engineering and hydrogeological features of the Alakol depression. *Engineering Journal of Satbayev University*, *142*(6), 33-41. https://doi.org/10.51301/vest.su.2020.v142.i6.06

[4] Baibatsha, A.B., Kurkina, L.A. (2003). General Engineering Geology. Almaty, Scientific and Publishing Center «Gylym»

[5] Barinov, A.V. (2003). Emergency Situations of Natural Character and Protection from Them. Moscow: Publishing House «Vlados-Press».

[6] Tarikhazer, S.A., Karimova, E.J. & Kuchinskaya, I.Y. (2022). Quantitative assessment of mudflow risk in the Greater Caucasus of Azerbaijan (on the example of the northeastern slope). *Journal of Geology, Geography and Geoecology*, *31*(4), 722-735. https://doi.org/10.15421/112268

[7] Valeyev, A., Karatayev, M., Abitbayeva, A., Uxukbayeva, S., Bektursynova, A. & Sharapkhanova, Z. (2019). Monitoring Coastline Dynamics of Alakol Lake in Kazakhstan Using Remote Sensing Data. *Geosciences*, *9*(9), 404. https://doi.org/10.3390/geosciences9090404

[8] Zaripov, A.S. & Luchnikov, A.I. (2021). Investigation of the dynamics of bank failure of the Kama and Votkinskoye reservoirs as a result of abrasion using aerial photography materials. *Georisk*, *15*(1), 58-66. https://doi.org/10.25296/1997-8669-2021-15-1-58-66

[9] Khalykov, E.E., Ly, Y.F., Abitbaeva, A.D., Togys, M.M. & Valeev, A.G. (2021). Determination of the dynamics of reworking the shore escarpment of Lake Alakol using a laser scanner. *Geography and Water Resources*, (4), 23-34.

[10] Valeev, A.G., Akiyanova, F.J. & Sagintaev, J. (2020). Modern relief-forming processes of the shore zone of lake alakol. *Hydrometeorology and ecology*, *2*(97), 125-145.

[11] Chaklikov, A.Y., Korobkin, V.V., Ismailov, A.A., Buslov, M.M., Tulemissova, Z.S. (2024). Specifics of the Geological Structure of the Alakol Basin and the Choice of Drilling Well Design. *Kazakhstan Journal for Oil & Gas Industry*, *6*(1), 18-34. https://doi.org/10.54859/kjogi108695

[12] Zhiyembayeva, J.A., Zhanakova, R.K., Sarybayev, M.A., Nurtay, G. & Yelzhanov, E.A. (2024). Investigation of hazardous geologic processes at the Kaskelen-Talgar polygon by geodetic methods. *Bulletin of Kazgasa*, *1*(91), 108-121. https://doi.org/10.51488/1680-080X/2024.1-08

[13] Kozhnazarov, A.D. (2004). Engineering Geodynamics. Almaty: KazNTU

[14] Maltseva, K.A. & Maltsev, A.V. (2023, October). Efficiency of application of geophysical methods of soil investigation of landslide massifs. *XLIX Samara Regional Student Scientific Conference*, *1*(S), 155-156

[15] Gulkayyr, T. & Rakhmedinov, E.E. (2023). Large landslides in active structures of southwestern tien shan (batken oblast). *Bulletin of the Institute of Seismology of the National Academy of Sciences of the Kyrgyz Republic*, (1), 21

[16] Zakirova, D.A., Satybaev, A.D. & Satybaldiev, B.S. (2024). Analysis of Causes of the origin of the sinkhole movement process (on the example of Nookat district of Osh oblast). *Bulletin of Science and Practice*, *10*(9), 80-89. https://doi.org/10.33619/2414-2948/106/08

[17] Semyachkov, A.I., Pochechun, V.A. & Semyachkov, K.A. (2023). Hydrogeoecological conditions of technogenic groundwater in waste disposal sites. *Notes of the Mining Institute*, (260), 168-179. https://doi.org/10.31897/PMI.2023.24

[18] Bielova, N., Mykytyn, T. & Dolynko, N. (2023). Monitoring of Modern Exogenous Processes in Precarpathia. *17th International Conference Monitoring of Geological Processes and Ecological Condition of the Environment*, (1), 1-5. https://doi.org/10.3997/2214-4609.2023520165

[19] Hablovskyi, B., Hablovska, N., Shtohryn, L., Kasiyanchuk, D. & Kononenko, M. (2023). The Long-Term Prediction of Landslide Processes within the Precarpathian Depression of the Cernivtsi Region of Ukraine. *Journal of Ecological Engineering*, *24*(7). http://doi.org/10.12911/22998993/164753

[20] Cascini, L., Scoppettuolo, M.R. & Babilio, E. (2022). Forecasting the landslide evolution: from theory to practice. *Landslides*, *19*(12), 2839-2851. https://doi.org/10.1007/s10346-022-01934-3

Алакөл ойпатының делювиалды-пролювиалды (Q_{II-III}) және аллювиалды (Q_{III-IV}) шөгінділер кешендерінің байланысқан топырақтарының физика-механикалық қасиеттерін зерттеу

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Аңдатпа. Инженерлік-геологиялық зерттеулер жүргізу кезінде ең маңызды міндеттердің бірі топырақтың физика-механикалық қасиеттерін анықтау болып табылады. Топырақтың физикалық қасиеттері Топырақтың атауын дәл анықтау үшін қажет, механикалық қасиеттері Іргетастардың, ғимараттар мен құрылыстардың негіздерінің тұрақтылығын есептеу үшін қажет мақалада Алакөл ойпатының делювиалды-пролювиалды және аллювиалды шөгінділер кешендерінің біртұтас топырақтарының физикалық-механикалық қасиеттері келтірілген. Аймақ аумағындағы қазіргі геологиялық процестер мен құбылыстар негізінен адамның инженерлік-шаруашылық қызметімен, атап айтқанда мелиорациялық құрылыспен байланысты. 60-шы жылдарға дейін бірқатар КГП-дың дамуы эпизодтық сипатта болды. Су ағындарының эрозиялық белсенділігі тек көктемгі су тасқыны кезінде және жағалаулардың шайылуы мен құлауында жаңбыр жауған кезде пайда болды. Дефляция аллювиалды көл шөгінділерін эолдық өңдеуде үрлеу бассейндерін, құмды қопсытқыштарды, жел толқындарын және микрорельефтің басқа түрлерін қалыптастыруда көрінді. Тұздану және батпақтану жер асты сулары деңгейінің таяз жатқан жерлерінде тұзды батпақтардың, қопсытқыштар мен қопсытқыштардың кең дамуы түрінде болды. Түйінді сөздер: абсолютті белгілер, ойпат, кешен, аллювиалды, делювиалды, физика-механикалық қасиеттері.

Негізгі сөздер: *абсолютті белгілер, ойпат, кешен, аллювиалды, делювиалды, физика-механикалық қасиеттер.*

Изучение физико-механических свойств связных грунтов комплексов делювиально-пролювиальных (Q_{II-III}) и аллювиальных (Q_{III-IV}) отложений Алакольской впадины

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Аннотация. При проведении инженерно-геологических изысканий одной из главнейших задач является определение физико-механических свойств грунтов. Физические свойства грунтов необходимы для точного определения наименования грунта, механические свойства необходимы для расчета устойчивости фундаментов, оснований зданий и сооружений. В статье представлены результаты физико-механические свойства связных грунтов комплексов делювиально-пролювиальных и аллювиальных отложений Алакольской впадины. Современные геологические процессы и явления на территории региона связаны преимущественно с инженерно-хозяйственной деятельностью человека и, в частности, с мелиоративным строительством. До 60-х годов развитие ряда ОГП носило эпизодический характер. Эрозионная деятельность водных потоков проявлялась только в период весенних половодий и выпадения ливневых дождей в подмыве и обрушении берегов. Дефляция проявлялась в эоловой переработке аллювиально-озерных отложений с образованием котловин выдувания, песчаных барханов, ветровой ряби и других форм микрорельефа. Засоление и заболачивание происходило в форме широкого развития солончаков, соров и пухляков на участках неглубокого залегания уровня грунтовых вод.

Ключевые слова: *абсолютные отметки, впадина, комплекс, аллювиальный, делювиальный, физико-механические свойства.*

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