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ALTITUDINAL DIFFERENTIATION OF SOIL AND VEGETATION COVER OF THE NORTHERN MACROSLOPE OF THE ZHETYSU ALATAU (KAZAKHSTAN)[1]

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Zhetysu (Dzungarian) Alatau is a wide mountain range in the southeast of Kazakhstan, between the deserts of Turan in Kazakhstan and Central Asia, and the deserts of Dzungaria in Central Asia. The vegetation and soil cover of this region is heterogeneous due to the diversity of their formation conditions. The main ridge is combined with two parallel macroslopes, the northern and southern, with different structure of altitudinal zonation. Due to the vast amount of factual data required for analysis of the spatial patterns of the soil and vegetation cover on the ridge, and for construction of a wholesome picture of its altitudinal zones, we took a particular interest in the study of the altitudinal differentiation of the northern macroslope.

We distinguished the following zones: mountainous nival-rocky with the subbelts of glaciers, rocks and cryopetrophytic groups; mountain meadow and meadow steppe alpine; mountain meadow and meadow steppe subalpine; dark coniferous forests and meadows; small-leaved forests; mountain steppe with the subbelts of meadow, typical and desert steppes; piedmont deserts. We provide the vegetation and soil cover characteristics for each belt.

The revealed patterns of the altitudinal distribution of the soil and vegetation cover of the northern macroslope of the Zhetysu Alatau can be used to carry out a fractional botanical and geographical zonation, evaluate the ecosystem diversity and its distribution throughout the altitudes, improve efficiency of the measures for nature protection during the period of climate changes, as well as to assess the threats caused by the anthropogenic and natural impacts.

Keywords: altitudinal zonation, Zhetysu Alatau, soils, vegetation, northern macroslope.
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The Zhetysu (Dzungarian) Alatau is a ridge of mountains and intermont hollows that stretch in East West direction (Fig. 1). The conditional border between the northern and southern macroslopes is a highland hollow with the Koksu River (Kazakhstan) and Bortala River (China) (Gvozdetsky,

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Mikhailov, 1978; The Republic of Kazakhstan, 2006).

The northern macroslope includes the northern and eastern slopes of the ridge and its peripheral spurs. The northern slope has a stepped system of ridges and hollows that declines in northern direction, while the altitudes decrease in western direction.

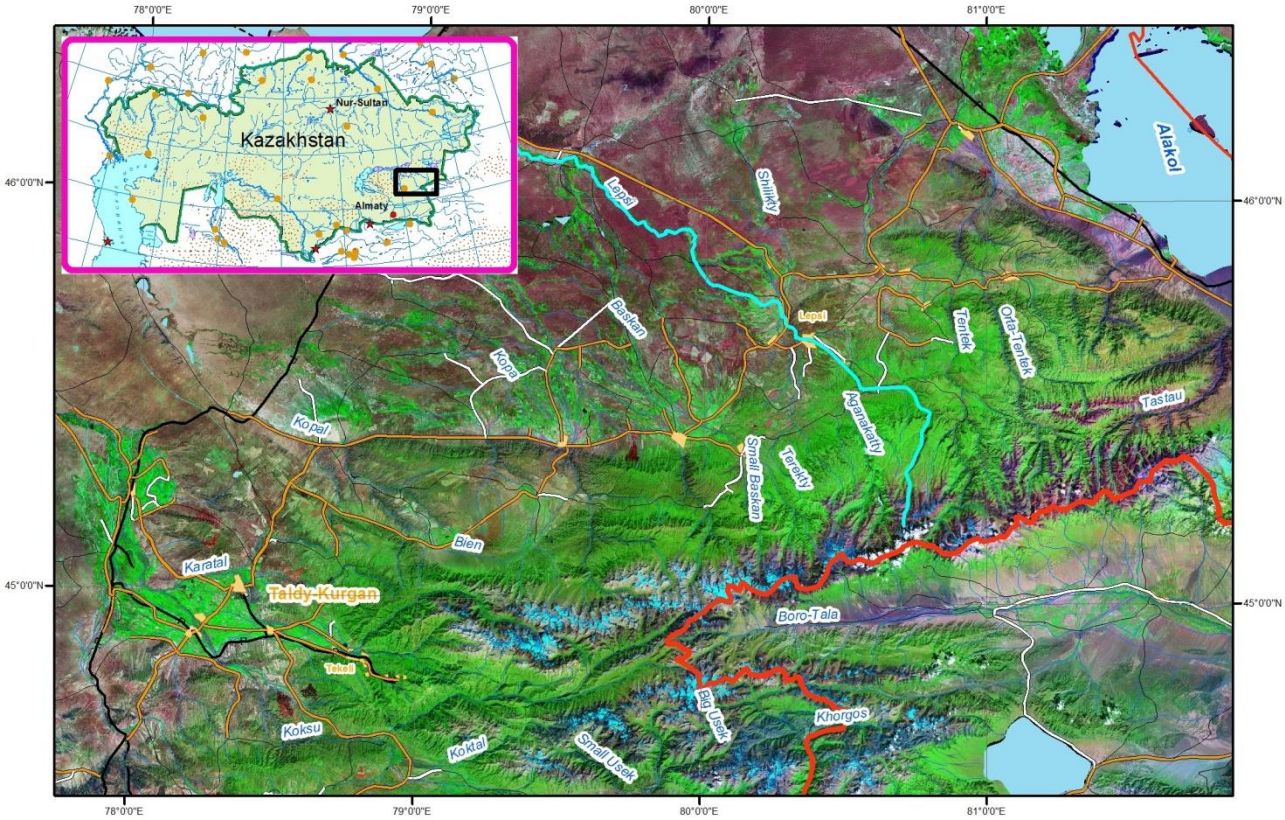

Fig. 1. Schematic map of the studied region.

The distribution of the severely dissected relief is limited, but the subdued highland relief is developed much better. It is represented with smoothed plateau-like surfaces and the glacial ones in the nival zone, occupied with glaciers and firns, over which the rocky peaks and ridges stretch (Relief of Kazakhstan ..., 1991). The residual glacial (moraine) steps are located below and merge upon the decline with the smoothed surfaces, developed within the mid-mountain relief. This relief is characterized by the two main types: smoothed, formed by the ancient leveling surfaces, and steep, formed by the dissected slopes of deep river valleys. On the border of the mid-mountain zone there is a series of extended hollows, fenced by the low, discontinuous mountains belt on the outside. The strip of foothills is represented by erosional, erosional-accumulative hilly-wavy foothill, alluvial-proluvial and deluvial-proluvial sloped flat foothill plains.

Mountain zonation depends on the climatic, geological and orographic features of the mountain system. The structure of the vertical zonation of the soil and vegetation cover is territorially heterogeneous, variable and diverse. Among the factors that determine the altitudinal borders of the vertical landscape zones, the spatial location of the ridge relative to the air masses, its height, relief and terrain dissection, slopes aspect, composition of the soil-forming and bedrock play the main role. The aridity of the territory increases from west to east and together with bioclimatic conditions determines the variation of zones and subzones along with their altitudinal boundaries. In addition, on the slopes of the southern aspect these boundaries are shifted upward in contrast with the northern aspect, which determines the variations of the altitude limits.

Altitudinal zonation of landscapes in different parts of the mountain system depends on the aspect and slopes steepness, which can be seen in the inversion processes of the soil and vegetation cover (disturbed order of altitudinal zones/belts), migration (deviation of zones boundaries), interference (attenuation or fallout of some zones; Zakharov, 1934). Continentality and climatic (latitudinal) zonation affects the formation of altitudinal zonation.

A complex systematic approach to studying the patterns of distribution and formation of vegetation cover and ecological conditions of habitats, such as relief, slopes aspects and soil type, on the northern macroslope of the Zhetysu Alatau gives us an opportunity to determine the altitudinal differentiation in a more accurate way. We used zonal type of vegetation and zonal type of soils as the main criteria to distinguish altitudinal belts.

A zone/belt is an altitudinal level in the mountains, hummocks and low mountains, with the dominance of a certain type of soil and vegetation. Each zone has a unique hydrothermal regime with a specific indicator of the ratio between heat and moisture in the heterogeneous geological structure and geomorphological forms. A subzone is a part of a bigger zone with a certain structure of the dominant plant communities, bound to different types and subtypes of soils (Lavrenko, 1964). The boundaries of belts and subbelts are the borders of the altitudinal distribution of a certain type of vegetation (Ogureeva, Bocharnikov, 2017) and soil.

The change of subzones in the vegetation cover can be diagnosed by the indicators of the plant communities structure, such as a set of life forms; dominant species composition; ratio of ecological groups of species (mesophytes, xerophytes, etc.); ratio of phytocenotic groups of species (meadow-steppe, steppe, etc.). In the soil cover this change can be diagnosed by the change in the morphogenetic soil properties in their type or subtype, hydrothermal regime and features of the soil cover structure.

On the highest parts of the main ridges the landscape belongs to a glacial-nival high-altitudinal zone, located above 3200-3300 m on the northern slope, and above 3500-3800 m on the southern slope (Sokolov et al., 1962; Pachikin, 1991; Pachikin et al., 1996, 2016). Those peaks of the main ridges of the Zhetysu Alatau that are higher than 2400 m, are occupied with highland meadows. On the slopes of northern aspect the mountain-meadow alpine and subalpine soils prevail, while the highland meadow-steppe soils prevail on the southern ones. The highland steppe soils can be found on the steep southern slopes. In the highland zone the inversion phenomena take place, causing the alpine soils to descend into the subalpine belt.

In the mid-mountains with mountain meadow-forest vegetation the meadows are bound to the mountain-meadow chernozem-like soils, and forests are spread on the mountain-forest dark soils. Together with coniferous forests the mesophytic forest meadows with mountain forest-meadow soils are widespread on the northern slopes, while the mountain meadow steppes with mountain meadow-steppe soils can be found on the southern slopes. In the mid-mountains the small-leaved forests are also common, under which the mountain-forest dark grey and mountain-forest chernozem-like soils are formed.

The mountain-steppe zone is formed in the low mountains of the dissected steep relief. The desert sagebrush-fescue-feather grass steppes dominate in the lower piedmont-low-mountain zone. The low-mountain feather grass and fescue-feather grass steppes are spread further along the altitudinal profile and turn into forb-bunch grass meadow steppes higher on it, where the merging of mountain chernozems and mountain-steppe soils, mountain dark chestnut and mountain light chestnut soils prevails.

Semi-desert and desert piedmonts are occupied with grey soils, which are replaced with the mountain chestnut soils on the front ridges and spurs in the low mountains and with mountain chernozems in the mid-mountains (Permitina, 2008; Permitina et al., 2015).

The Zhetysu Alatau has a very high botanical diversity. By its natural characteristics it stands between Tien Shan, a typical mountain system of Central Asia, and mountains of the Southern

Siberia. Its flora is thoroughly studied; its richness (2168 species) and high amount of endemics (76 species) are well-known (Goloskokov, 1985). The Altai-Siberian floral elements have a strong influence on its northern macroslope. According to R.V. Kamelin (1973), a border between the mountain Siberian and North Tien Shan floras can be drawn along the boundary between the northern and southern macroslopes. The vegetation cover of the Zhetysu Alatau was described in the classic works of N.I. Rubtsov (1946, 1948), who was the first one to determine the features of the altitudinal zonation of these slopes. The general patterns of vegetation distribution are shown on the small scale (1:2500000) "Vegetation Map of Kazakhstan and Central Asia" (1995).

By its soil-geographical zonation (Soil-geographical zonation of the USSR …, 1962; Fedorovich, 1969) the Zhetysu Alatau is considered as an element of the Northern Tien Shan mountain province. By the botanical-geographical zonation its northern macroslope belongs to the Dzungar-North Tien Shan province, North Dzungar mountain subprovince with an Trans-Ile - North Dzungar type of altitudinal zonality (Volkova, 2003). N.I. Rubtsov (1948) considered the northern slope to be a part of the Northern Dzungarian district of the Dzungarian geobotanical region. According to N.I. Rubtsov, its altitudinal belts are as follows: alpine, subalpine, forest-meadow, steppe, semi-desert and desert.

Objects and Methods of the Study

The objects of our study are the vegetation and soil covers of the northern macroslope of the Zhetysu Alatau.

The field researches were carried out in 2015 on 37 key plots between 916 m (Topolevka River) and 2136 m above sea level (Segizbay Pass), and in 2018-2019 on 83 key plots between 777 m (Bayturbau area) and 3078 m (near Upper Zhasylkol Lake). We used the traditional soil and geobotanical methods (Soil survey ..., 1959; Field geobotany, 1959-1976; Bykov, 1978). The comparative-geographical method was used for the soil studies (Rode, 1971; Zonn, 1983). It included comparison of the soils properties and factors of soil formation that determined their genesis, patterns of their spatial distribution, formation of their cover structure and structure of vertical zonation in the given mountain conditions. To diagnose and characterize the soil properties we made soil profiles within the area of distribution of certain soil types and subtypes. To describe the genetic profile we used the morphological methods (Rozanov, 2004) and clarified them on the basis of analytical data. The taxonomic determination of soil types, subtypes and varieties was carried out according to the accepted classifications (Classification and diagnostics …, 1977; Shishov et al., 2004; Identification guide …, 2008).

The field geobotanical studies included a method of landscape-ecological profiling and description of the main plant communities. The boundaries of belts, subbelts and detailed geobotanical descriptions of plant communities were recorded with GPS. Geobotanical descriptions by profiles were carried out for each type of vegetation, taking into account the diversity of communities and ecological conditions on the sample plots (100 m^2). To describe the vegetation we used the geobotanical forms that included sections to record the landscape main components (relief and soils), moisture conditions, factors that affected vegetation (natural or anthropogenic). The floristic composition of the communities was determined on the sample plots; for each species we recorder the following characteristics: height, level, abundance (O. Drude's scale), vital state (A.A. Grossheim's scale), phenological phase, general and specific projective cover, nature of distribution. The main criteria for assigning a certain community to its zone were the height above sea level, dominant types of vegetation and soils. During the study the steepness, slopes aspect, microrelief and water sources determined the diversity of communities and ecological-physiognomic vegetation categories within the belt or subbelt. We identified the plant species during the office processing of the collected material (Flora of Kazakhstan, 1956-1966; Illustrated

guide …, 1969-1972). The taxonomy of species is given according to Plantarium (2020) and The Plant List (2013).

Results and Discussion

To characterize the altitudinal zonation of the northern slope of the Zhetysu Alatau we used the literature sources and materials of the field studies that were carried out in the recent years on the basis of the complex research of the soils and vegetation cover.

High mountain nival-rocky belt (>3100 (3200) m above sea level (a.s.l.)

Subbelt of glaciers, snow fields and firns. Soil and vegetation cover are absent.

Subbelt of cryopetrophytic groups occupies the rocky ridges, trough valleys, moraines and rockslides. It is represented by the sporadic subnival species (*Waldheimia tridactylites* Kar. ex Kir., *Thylacospermum caespitosum* (Cambess.) Schischk., *Saxifraga oppositifolia* L., *S. flagellaris* Willd. ex Sternb., *Poa versicolor* Besser, *Ranunculus kamchaticus* DC, *Erysimum altaicum* C.A. Mey., *Silene uralensis* subsp. *apetala* (L.) Bocquet, *Carex nigricans* C.A. Mey., *Sibbaldia tetrandra* Bunge, *Cerastium lithospermifolium* Fisch.) that develop on the primal soil formations.

Mountain-meadow and meadow-steppe alpine belt (2700 (2750)-3100 (3200) m a.s.l.)

It is located on the steep slopes and severely dissected, high mountain, subdued relief. The soils are mountain-meadow alpine, and occupy the slopes of the northern and similar aspects, as well as smoothed surfaces of high mountain plateaus with the forming alpine meadows with low grasses. The slopes of southern and southwestern aspects are occupied with high mountain meadow-steppe alpine soils that form under the high mountain meadow steppes. Rarely, the hydromorphic high mountain meadow-bog peaty soils can be found in the deep boggy depressions.

Mountain-meadow alpine soils occupy the relatively gentle northern and northwestern slopes of the ridge. The soil-forming rocks are poorly sorted eluvial-deluvial and glacier rubbly formations. Among the mountain-meadow soils the mountain-meadow alpine turf and mountain-meadow alpine turf-peaty types are distinguished. The turf horizon is common for thin profiles. This horizon is replaced with low mineralized turf-peaty one in the turf-peaty types of soils. The humus horizon (A+B=30-50 cm) is greyish-brown, highly humid, loose and lumpy, with a significant amount of rubble and with a marl of thick rocks under it. The soils are significantly humic in the turf horizon, highly acidic, leached off the carbonates, but are not rich with bases and not saline. The medium and heavy clay loamy sediments are dominant in the grain composition.

High mountain meadow-steppe soils of the alpine zone are poorly developed, their profile is thin and filled with rocky fractions. The humus horizon merges into bedrock on the ridges and upper parts of the slopes. In the lower parts of the slopes and intermont hollows where the colluvial and deluvial matter accumulates, the profile can reach significant depth. The depth of the humus horizon (A+B) is 30-45 cm, poorly structured, light brown and highly humic, the amount of which declines with depth. Under the humus horizon the carbonate build-ups are found in the soils of the upper part of the slopes, while in the lower parts the leached soils can be found. The rubbly clay loamy sediments are prevalent in the grain composition.

On the border of the alpine and nival zones along the rocky slopes, rockslides and cliffs the low-herb kobresia-grass-forb meadows develop on the mountain-meadow alpine soils. The communities include *Kobresia capillifolia* (Decne.) C.B. Clarke, *Poa alpina* L., *Gentiana algida* Pall., *Saxifraga sibirica* L., *Aster alpinus* L., *Doronicum turkestanicum* Cavill., *Eritrichium villosum* (Ledeb.) Bunge, *Erigeron oreades* (Schrenk) Fisch. & C.A. Mey., *Swertia marginata* Schrenk, *Saussurea involucrata* Matsum. & Koidz., *Gentiana algida* Pall., *Taraxacum songoricum* Schischk., *Silene graminifolia* Otth, *Gastrolychnis brachypetala* Tolm. & Kozuh. (Dimeyeva et al., 2020; photo 1).

Photo 1. Alpine meadows with low grass (left) with participation of the Red Data Book of Kazakhstan (2014) species *Saussurea involucrata* (right) (photo by B.Sh. Kaliev).

For the western part of the ridge the meadows with *Kobresia capillifolia* and cryophytic low-herb meadows with (*Persicaria vivipara* (L.) Ronse Decr., *Primula algida* Adams, *Festuca kryloviana* Reverd., *Poa alpina*, *Viola altaica* Ker Gawl., *Gentiana algida*) are common (photo 2), forming on the mountain-meadow alpine soils with high mountain steppes (*Festuca valesiaca* Schleich. ex Gaudin, *Poa versicolor*, *Helictotrichon tianschanicum* (Roshev.) Henrard) on the high mountain meadow-steppe soils that cover the gentle slopes and moraine deposits. The pure kobresia meadows with single inclusions of other species (*Persicaria vivipara*, *Papaver nudicaule* L., *Antennaria rosea* subsp. *confinis* (Greene) R.J. Bayer, *Thalictrum alpinum* L.) cover the convex parts of slopes of the southern aspect and positive parts of meso- and microrelief. Kobresia-forb meadows (*Kobresia capillifolia*, *Primula algida*, *Swertia marginata*, *Comastoma falcatum* (Turcz.) Toyok., *Aster alpinus*, *Leontopodium ochroleucum* Beauverd, *Gagea serotina* (L.) Ker Gawl., *Androsace septentrionalis* L., *Viola kunawurensis* Royle), and sometimes with *Carex titovii* V. I. Krecz. and *Luzula multiflora* subsp. *sibirica* V. I. Krecz., *L. spicata* (L.) DC., can be found in the more humid places on the high mountain meadow-bog soils, in depressions, hollows, ravines and slopes of northern aspect.

Photo 2. Alpine meadows with Kobresia and forbs: *Kobresia capillifolia* is on the left, *Gentiana algida* on the right (photo by B.Sh. Kaliev).

The rocky-rubbly slopes of different steepness and orientation are covered with cryophytic meadows with low herbs. The prevailing species in their composition are *Sibbaldia tetrandra*, *Potentilla nivea* L., *Oxytropis lapponica* (Wachlenb.) J. Gay, *O. chionobia* Bunge, *Thylacospermum caespitosum*, *Androsace umbellata* (Lour.) Merr., *Antennaria rosea*, *Primula algida*, *Potentilla freyniana* Bornm., *Erigeron alpinus* L., *Poa alpina*, *Myosotis sylvatica* Hoffm., *Viola altaica*, *Minuartia kryloviana* Schischk. These meadows develop on the mountain-meadow alpine thin rubbly soils. The vegetation on the steep rocky slopes is sparse.

The floristic composition of the kobresia meadows in the eastern part of the high mountain zone includes *Stipa martinovskyi* Klok., *S. regeliana* Hach. In the small bogs the sedges are widespread (*Carex melanantha* C.A. Mey., *C. parva* Nees, *C. enervis* C.A. Mey., *C. canescens* L.), with *Parnassia laxmannii* Pall. ex Schult. and *Pedicularis violascens* Schrenk. *Arctous alpina* (L.) Niedenzu and *Eriophorum scheuchzeri* Hoppe are very rare. The bogged areas with high mountain meadow-bog soils are overgrown with cereals (*Poa attenuata* Trin., *P. alpigena* Lindm., *Festuca rubra* L., *Trisetum spicatum* (L.) K. Richt., *Phleum alpinum* L., *Alopecurus magellanicus* Lam.), sedges (*Carex parallela* (Laest.) Sommerf., *C. melanantha*, *C. tristis* M. Bieb., *Luzula pallescens* Sw., *L. spicata*), and *Juncus triglumis* L.

Mountain-meadow and meadow-steppe subalpine belt (2200 (2250)-2700 (2750) m a.s.l.)

It occupies the lower level of the high mountain. The relief is formed with the plateau-like peaks, steep slopes of different aspects and intermont valleys. The soil cover consists of mountain-meadow subalpine and high mountain meadow-steppe dark soils.

Mountain-meadow subalpine soils form in the lower part of the mountain-meadow zone. The soils are common for the plateau-like peaks of the ridge and the most smoothed parts of the slopes of the northern and northwestern aspects. The soil-forming rocks are eluvial-deluvial and glacier, averagely sorted rubble deposits. In the morphological profile the turf and humus horizons are prominent, have a dark grey color and granular structure. The depth of the turf horizon is 10-15 cm, the depth of the humus (A+B) is 50-65 cm. The soils are highly humic in the surface turf horizon, but the amount of humus abruptly decreases with depth. The soils are not rich with bases, are not saline, leached of carbonates; the soil solution reaction is acidic. The medium and heavy clay loamy rubbly sediments are prevalent in the grain composition.

High mountain meadow-steppe dark soils are common for the steep slopes of the southern and southwestern aspects with developed meadow-steppe vegetation and elfin juniper woods. The thin peaty humus horizon on the upper part of the slopes is dark black and positioned on the coarse deposits. The soils on the gentle slopes and smoothed watersheds have a more developed profile, turf layer and multiple horizons. The depth of the humus horizon (A+B) is only 30-35 cm, dark brown, granular-powdery and highly humic. The soil solution reaction is neutral or mildly alkaline. The heavy clay loamy sediments are prevalent in the grain composition.

In this belt the mid-herb grass-forb meadows are widespread (*Alchemilla bungei* Juz., *A. sibirica* Zamelis, *Pilosella aurantiaca* (L.) F. W. Schultz & Sch. Bip., *Rhaponticum carthamoides* (Willd.) Iljin, *Poa versicolor*, *Dactylis glomerata* L., *Papaver nudicaule*, *Lupinaster pentaphyllus* Moench, *Veronica spuria* L., *Achillea millefolium* L., *Aconitum anthora* L., *Allium obliquum* L.) on the mountain-meadow subalpine soils that sometimes alternate with communities of *Juniperus pseudosabina* Fisch. ex C.A. Mey. on the high mountain dark soils.

In the western meadows of the ridge the prevailing species are Alchemilla and Geranium (*Alchemilla sibirica* Zamelis, *Geranium saxatile* Kar. ex Kir., *G. albiflorum* Ledeb., *Pedicularis dolichorrhiza* Schrenk, *Dracocephalum imberbe* Bunge, *Astragalus alpinus* L., *Persicaria vivipara*, *Phleum phleoides* (L.) Karst., *Alopecurus pratensis* L., *Helictotrichon pubescens* (Huds.) Schult. & Schult. f.) and grass-forb (*Dactylis glomerata*, *Alopecurus pratensis* L., *Milium effusum* L., *Persicaria bistorta* (L.) Samp., *Solidago virgaurea* L., *Rhodiola rosea* L., *Dianthus kuschakewiczii*

Regel et Schmalh., *D. turkestanicus* Preobr., *Prunella vulgaris* L., *Trollius altaicus* C.A. Mey., *Heracleum dissectum* Ledeb., *Conium maculatum* L., *Galium boreale* L., *Achillea millefolium*, *Campanula glomerata* L.) meadows, forming on the mountain-meadow subalpine soils. These meadows are common for the silt slopes, mostly of the northern and eastern aspects (photo 3).

Photo 3. Subalpine mid-herb meadows (left) with the Red Data Book of Kazakhstan (2014) species (right) *Rhodiola rosea* (photo by B.Sh. Kaliev).

In the eastern part of the northern macroslope the mesophytic-forb and steppe meadows are widespread on the high mountain meadow-steppe dark soils. The phytocenoses include *Persicaria bistorta*, *Alchemilla bungei*, *Viola altaica*, *Aster alpinus*, *Erigeron azureus* Regel. ex M. Pop., *Schulzia crinita* (Pall.) Spreng., *Euphorbia alatavica* Boiss., *Galium verum* L., *Poa attenuata*, *Phleum phleoides*, *Festuca rupicola* Heuff., *Antennaria rosea*. The grass layer is dense, with no dominant species. At the lower border the mid-herb meadows with participation of *Pilosella aurantiaca*, *Alchemilla bungei*, *Poa versicolor* Besser., *Dactylis glomerata*, *Papaver croceum* L., *Veronica spuria*, *Achillea millefolium*, *Lupinaster pentaphyllus*, *Aconitum anthora*, *Allium obliquum* are formed.

In the high mountains the steppes are represented by grass associations, the main background of which is formed with *Festuca valesiaca* and *F. rupicola*, as well as *Helictotrichon tianschanicum* and *Poa pratensis*, *P. angustifolia*. The species diversity of Festuca steppes is formed with abundant forbs (*Androsace dasyphylla*, *Leontopodium leontopodioides*, *Potentilla nervosa*, *Galium verum*, *Veronica spicata*) and bunch grasses (*Koeleria gracilis*, *Stipa capillata*).

Belt of mountain dark coniferous forests and meadows (1700 (1800)-2200 (2250) m a.s.l.)

This belt is located within the mid-mountain and low mountain averagely and slightly dissected relief, as well as in the intermont valleys and mountain sloping plateaus (photo 4). In its lower part the relief is subdued due to the distribution of the loess loams. The eluvial-deluvial and deluvial rubbly clay loams are also present. The soil cover is formed with the mountain-forest dark soils and mountain meadow-forest soils.

Mountain-forest dark soils are located on the steep outer and inner slopes of the northern, northeastern and northwestern aspects. In the severely dissected relief they form a continuous belt. When the subdued relief develops, they occupy the steep slopes of river valleys. The soil-forming rocks are deluvial-eluvial deposits of varied composition. The profile has a forest litter on the surface; the horizon is peaty, brown and powdery; under it an isolated horizon is dark colored,

granular-lumpy and includes rubble. The subhorizon is rubbly, with siliceous powdering. The depth of the humus horizon (A+B) is 45-65 cm. The soils are highly humic in the litter layer, but humus decreases with depth. The soils are not rich with bases; the soil solution reaction is acidic; the heavy clay loamy sediments are prevalent in the grain composition.

Photo 4. Belt of mountain dark coniferous forests and meadows (photo by L.A. Dimeyeva).

Mountain meadow-forest soils occupy the steep slopes of the southern and western aspects and combine with mountain-forest dark, mountain meadow-steppe and mountain-steppe xeromorphic soils. The soil-forming rocks are eluvial-deluvial rubbly clay loams. The upper horizon is grey-brown, slightly pressed, granular, and merges into the pressed horizon of powdery-lumpy structure. The depth of the humus horizon (A+B) is 50-100 cm. The soils are highly humic, acidic, but are not rich with bases. The medium and heavy clay loamy sediments are prevalent in the grain composition.

The dark coniferous forests develop on the mountain-forest dark soils. In the western part of the ridge they occupy the steep western and northwestern slopes of ravines, represented by spruce forests (*Picea schrenkiana* Fisch. ex C.A. Mey.) of park-like kind; in the more humid areas they also include *Abies sibirica* Ledeb. The forests with herbs (*Rubus saxatilis* L., *Polypodium vulgare* L., *Campanula glomerata* L., *Solidago virgaurea* L., *Thalictrum minus* L., *T. simplex* L., *Dianthus superbus* L., *Polemonium caeruleum* L., *Codonopsis clematidea* (Schrenk) C.B. Clarke), herb-mosses (*Thuidium abietinum* (Hedw.) Schimp., *Aconitum leucostomum* Vorosch., *Geum urbanum* L., *Bupleurum longifolium* L., *Aegopodium podagraria* L., *Poa nemoralis* L., *Polemonium caeruleum*), mosses (*Thuidium abietinum*, *Drepanocladus uncinatus* (Hedw.) Warnst.), bushes (*Lonicera humilis* Kar. & Kir., *L. webbiana* Wall. ex DC., *L. hispida* Pall. ex Schult., *L. caerulea* L., *L. microphylla* Willd. ex Schult., *Rosa beggeriana* Schrenk ex Fisch. & C.A. *Mey.*, *R. albertii* Regel, *R. spinosissima* L., *Berberis heteropoda* Schrenk, *Cotoneaster multiflorus* Bunge, *C. melanocarpus* Fisch. ex Blytt., *Ribes meyeri* Maxim.) and forests with dead cover and sporadic bushes (*Rubus idaeus* L., *Ribes aciculare* Sm.) are also widespread there. In the upper part of the forest-meadow zone the areas with *Juniperus pseudosabina* and sporadic spruces are spread, formed on the dark soils of high mountains (photo 5).

Photo 5. *Juniperus pseudosabina* on the edge of the forest-meadow belt (photo L.A. Dimeyeva).

In the coniferous forests of the eastern part of the ridge the true spruce forests with a closed canopy are developed, mainly on the northern slopes of the ravines. The spruce forests on the northwestern and western slopes with meridional location have a well-developed undergrowth and grass layer. The spruce canopy on the steep slopes with rocky outcrops is entirely closed, with a moss cover of *Thuidium abietinum* developed under it.

The western part of the northern macroslope is covered with the typical mesophytic meadows with the prevailing *Dactylis glomerata*, *Brachypodium pinnatum* (L.) P. Beauv., *Helictotrichon pubescens*, *Aconitum septentrionale* Koelle, *Sanguisorba alpina* Bunge., *Aconogonon alpinum* (All.) Schur. These meadows are formed on the mountain meadow-forest soils. Together with the typical meadows, there grass-forb steppe meadows are widespread here, developing on the mountain meadow-steppe soils. The communities include cereals (*Phleum phleoides*, *Poa versicolor*, *Koeleria macrantha* (Ledeb.) Schult, *Festuca rupicola*) and forbs (*Origanum vulgare* L., *Achillea millefolium*, *Hypericum perforatum* L., *Thalictrum minus*, *Lupinaster pentaphyllus*, *Aconogonon alpinum*, *Phlomoides pratensis* (Kar. & Kir.) Adylov, Kamelin & Makhm., *Tanacetum vulgare* L.); the layers are well-pronounced.

The eastern meadows are represented by thick and high grasses. The most developed phytocenoses are the ones with the dominant *Dactylis glomerata* and *Calamagrostis epigejos* (L.) Roth. Usually these communities include sedges (*Carex praecox* Schreb., *C. leersii* F.W.Schultz, *C. caucasica* Stev.), legumes (*Vicia tenuifolia* Roth, *V. sepium* L., *V. cracca* L., *Medicago falcata* L., *Trifolium repens* L., *T. pratense* L., *Lathyrus pratensis* L.), as well as *Aconitum septentrionale*, *Achillea millifolium*, *Bunium setaceum* (Schrenk) H. Wolff, *Hieracium virosum* Pall., *Thalictrum minus*, *Fragaria viridis* Weston, *Origanum vulgare*. L. Some species are less abundant: *Alcea froloviana* (Litv.) Iljin, *Aquilegia karelinii* (Baker) O. Fedtsch. & B. Fedtsch., *Bupleurum longifolium*, *Crepis sibirica* L., *Delphinium elatum* L., *Geranium saxatile*, *Gentianella aurea* (L.) H. Smith, *Hypericum hirsutum* L., *Rhaponticum carthamoides* (Willd.) Iljin (photo 6).

Belt of mountain small-leaved forests (1200 (1250)-1700 (1800) m a.s.l.)

This belt is located at the lower border of the spruce forest, occupying the eroded slopes of the

northern and northeastern aspects, ancient river valleys and plateau-like peaks. The soils cover is represented by the mountain-forest dark grey soils on the northern slopes, combining and merging with mountain-forest chernozem-like soils, mountain podzolic and leached chernozems. The mountain meadow-steppe soils are common on the slopes of the southern and sometimes eastern aspects. The mountain typical chernozems are spread in the intermont valleys.

Photo 6. Mid-mountain meadows with high grass and the Red Data Book of Kazakhstan (2014) species *Rhaponticum carthamoides* (photo by L.A. Dimeyeva).

Mountain-forest dark grey soils are formed in the lower level of the mid-mountain relief, on the steep slopes of the northern aspect. They form individual massifs, sometimes making homogeneous profiles under the small-leaved forests. The soil-forming rocks are loess and eluvial-deluvial rubbly clay loams. The forest litter is prominent on the surface, the depth of the humus horizon is 40-50 cm, the horizon is dark black-grey, highly humic, The soil solution reaction is neutral or mildly acidic. The medium clay loamy sediments are prevalent in the grain composition.

Mountain-forest chernozem-like soils are formed in the low or sometimes mid-mountain relief. The soil-forming rocks are loess loams on the eluvial-deluvial rubbly deposits. The leached types are the most developed among the mountain-forest chernozem-like soils. The depth of the humus horizon is 70-80 cm, the horizon is black-grey and granular. The soils are highly humic and deeply leached of the carbonates. The medium clay loamy sediments are prevalent in the grain composition.

Mountain leached and podzolic chernozems are widespread on the gentle slopes of the northern and northwestern aspects, forming individual massifs. The soil-forming rocks are eluvial-deluvial deposits. The profile is greyish-brown or greyish-black in the upper horizon, loose or slightly pressed, finely granular. The lower horizon is paler and lumpy. In the lower part of the humus horizon of podzolic chernozems there is a developing soil powdering. The depth of the humus horizon (A+B) is 70-120 cm. The soils are highly humic. The soil solution reaction is neutral. The light clay and heavy clay loamy sediments are prevalent in the grain composition.

Mountain meadow-steppe soils are located mostly on the slopes of the southern aspects and

merge with mountain-forest and mountain forest-meadow soils. The soil-forming rocks are eluvial-deluvial clay loams. The humic-accumulative horizon of the profile is grey-brown, slightly pressed and powdery-lumpy. The subhorizon is lighter by color, pressed and less structured. The depth of the humus horizon (A+B) is 30-100 cm. The soils are highly humic, but the humus decreases with the depth. The soil solution reaction is mildly acidic, but neutral in the deeper horizons. The heavy clay loamy sediments are widespread in the grain composition.

The small-leaved forests form separate massifs and are rarely dense (photo 7). Along the slopes of the northern aspects the grass-bushes aspen, aspen-birch and birch forests are spread (*Populus tremula* L., *Betula pendula* Roth, *B. tianschanica* Rupr.), sometimes with spruce (*Picea schrenkiana*) and fir (*Abies sibirica*), with undergrowth of bushes (*Lonicera webbiana*, *Rubus idaeus*, *Ribes nigrum* L.) and layer of heliophobic herbs (*Aegopodium podagraria*, *A. alpestre* Ledeb., *Delphinium elatum*, *Anthriscus sylvestris* (L.) Hoffm., *Bupleurum aureum* Fisch. ex Hoffm., *Impatiens noli-tangere* L.) and mesophilic cereals (*Poa nemoralis*, *Dactylis glomerata*, *Brachypodium pinnatum*) that form on the mountain-forest dark grey soils. Forests with *Betula procurva* Litv. and *Populus tremula* are fragmentary, with the undergrowth of bushes (*Berberis heteropoda*, *Rosa beggeriana*). The grass cover is sparse and usually includes *Poa versicolor*, *Lathyrus humilis* (Ser.) Spreng., *L. transsilvanicus* (Spreng.) Rchb., *Codonopsis clematidea*, *Dactilis glomerata*, *Aegopodium podagraria*, *Geranium rectum* Trautv., *Bupleurum longifolium*, *Hypericum hirsutum*, *Anthriscus sylvestris*.

Photo 7. Spring aspect of mountain small-leaved forests with the Red Data Book of Kazakhstan (2014) species − *Malus sieversii* (photo by B.Sh. Kaliev).

Mountain fruit forests consist of *Malus sieversii* (Ledeb.) M. Roem. and *Sorbus tianschanica* Rupr. and form along the slopes of the northern aspects on the mountain-forest chernozem-like soils. These forests include *Populus tremula*, rarely *Betula pendula* and *B. tianschanica*, along with such bushes as *Rosa beggeriana*, *R. platyacantha* Schrenk, *Rubus idaeus*, *Lonicera microphylla* Willd. ex Schult., *Crataegus almaatensis* Pojark., *Berberis heteropoda* Schrenk, *Rhamnus cathartica* L. The herbaceous layer is represented by mixed and sod grasses: *Alopecurus pratensis*,

Dactylis glomerata, *Brachypodium pinnatum* (L.) P. Beauv., *Aegopodium podagraria*, *Polygonum songaricum* Schrenk ex Fisch. & C.A. Mey., *Aconogonon alpinum*, *Bupleurum longifolium*, *Lathyrus transsilvanicus*, *Poa nemoralis*, *Tanacetum vulgare*, *Campanula glomerata*, *Ligusticum discolor* Ledeb., *Urtica dioica* L., *Milium effusum* L., *Inula helenium* L. (Dimeyeva et al., 2020).

Steppe belt (800-1700 m a.s.l.)

This belt includes three subbelts: meadow steppes (1200 (1250)-1700 m a.s.l.), typical steppes (1000-1200 (1250) m a.s.l.), desert steppes (800-1000 m a.s.l.).

Subbelt of the meadow steppes is located in the lower part of the dark coniferous forests. Its relief is represented by the gentle slopes of the main ridge of the northern and northwestern aspects and plateau-like surfaces of some ridges and uplands. Its soils cover consists of mountain leached chernozems and mountain typical chernozems that combine with mountain-forest chernozem-like and mountain meadow-steppe soils.

Mountain typical chernozems develope on the illuvial-deluvial rubbly clay loamy deposits. The depth of the humus horizon (A+B) is 75-100 cm. The soil profile has a surface turf horizon, is granular like the humus horizon, loose or slightly pressed and greyish-black. The subhorizon has carbonate build-ups. The soils are highly humic. The soil solution reaction is slighlty acidic, close to neutral; the reaction of carbonate horizons is alkaline. The medium and heavy clay loamy sediments are prevalent in the grain composition.

The meadow steppe communities are formed with the steppe and meadow species: *Festuca valesiaca*, *Stipa zalesskii* Wilensky, *Poa versicolor*, *Phleum phleoides*, *Dactylis glomerata*; and species of *Thalictrum*, *Hedysarum*, *Galium*, *Medicago* genera. The subbelt is represented by the rich forb-feather grass (*Stipa lessingiana* Trin. & Rupr., *Poa versicolor*, *Ligusticum discolor*, *Peucedanum morisonii* Besser, *Achillea millefolium*) and forb-fescue (*Festuca valesiaca*, *Helictotrichon desertorum* (Less.) Pilg., *Achillea millefolium*, *Plantago lanceolata* L., *Phlomoides tuberosa* (L.) Moench) communities that form on the leached chernozems. The species composition includes *Stipa capillata* L., *Bothriochloa ischaemum* (L.) Keng, *Melilotus officinalis* (L.) Pall., *M. albus* Medic., *Amoria hybrida* (L.) C. Presl, *Achillea millefolium*, *Salvia deserta* Schangin, *Potentilla inclinata* Vill., *Elymus repens* (L.) Gould, *Phleum pratense* L., *Crepis sibirica*, *Alcea froloviana*, *Heracleum sphondylium* subsp. *montanum* (Schleich. ex Gaudin) Briq., *Anthriscus sylvestris*, *Verbascum orientale* (L.) All., *Bromus inermis* Leyss., *Origanum vulgare*, *Fragaria viridis*.

Subbelt of the typical steppes in the central and eastern parts of the ridge is represented by the mixed grasses and sod grasses (photo 8). Its soil cover is formed with mountain common chernozems and mountain typical chernozems that combine with mountain-steppe thermoxeromorphic and mountain meadow-steppe soils. The lower part of the piedmont plain is characterized by the dark chestnut soils that merge with mountain-steppe soils.

Mountain common chernozems occupy the slopes of the northern and eastern aspects. The soil-forming rocks are eluvial-deluvial rubble or loess loams. The type of normal chernozems is prevailing. The humus horizon is of middle depth (A+B=45-70 cm); its upper part is an isolated turf horizon. The humus-accumulative is dark grey, slightly pressed and granular; the humus-illuvial is light brown, pressed, powdery-granular or lumpy-granular. The soils are medium and low humic. The soil solution reaction is almost neutral. The middle clay loamy sediments are dominant in the grain composition.

Mountain steppe thermoxeromorphic soils are formed on the steep slopes of the southern, southeastern and southwestern aspects, merging with mountain chernozems and rarely with mountain-forest dark grey and mountain chernozem-like soils, forming on the eluvial-deluvial rubble-rock deposits. The humus horizon is of low and middle depth, the profile is poorly developed and highly rubbly-rocky. The depth of the humus horizon (A+B) is 35-50 cm. The upper horizon is dark grey, powdery-lumpy; under it the horizon is dark brown, lumpy-nut-like,

transitioning into the rubbly bedrock. The upper horizon can be low and strongly humic. The soil solution reaction changes from mildly acidic to alkaline. The soils are rich with bases. The light, medium and heavy clay loamy sediments are widespread in the grain composition.

Photo 8. Steppe with *Stipa capillata* (photo by K. Ussen).

Mountain-steppe poorly developed soils are common for the southern steep slopes and narrow plateaus of the ridges and some mountains. The soil-forming rocks belong to eluvial-deluvial formations. The profile is of low depth, poorly developed and rubbly-rocky. The depth of the humus horizon (A+B) is 35-40 cm. The upper horizon is dark grey and powdery-granular; under it the horizon is dark brown and lumpy-nut-like. The humus amounts in the upper horizon vary widely. The soil solution reaction is mildly acidic and alkaline. The light and medium clay loamy sediments are dominant in the grain composition.

Dark chestnut soils are formed on the mountain slopes (on the peripheral ridges only), distinguished as mountain soils, and in the intermont valleys, on the piedmont steeply-wavy plains, distinguished as piedmont soils. The soil-forming rocks eluvial-deluvial rubbly and loess clay loams. The upper part consists of turf horizon, under which the horizon is dark brown-grey and granular-lumpy. The following subhorizon is greyish-brown and lumpy. The depth of the humus horizon (A+B) is 45-55 cm. Its lower part includes carbonates. The upper horizon is low humic, unlike it is in the chernozems, and rich with bases. The soil solution reaction is neutral and mildly alkaline. The light and medium clay loamy sediments are dominant in the grain composition.

This subbelt is represented by the development of Festuca, mixed forb-feather grass-fescue (*Festuca valesiaca*, *Stipa caucasica* Schmalh., *S. capillata*, *S. lessingiana*, *S. kirghisorum* P. Smirn., *Koeleria macrantha*, *Poa versicolor*, *Bromus inermis*, *Sedum hybridum* L., *Hypericum perforatum*, *Origanum vulgare*, *Ziziphora clinopodioides* Lam., *Salvia dumetorum* Andrz. ex Besser, *S. nemorosa* L., *Patrinia intermedia* (Hornem.) Roem. ex Schult.) communities with ephemeroids (*Poa bulbosa* L.) and bushes (*Spiraea hypericifolia* L., *Prunus prostrata* Labill., *Cotoneaster*

melanocarpus Fisch. ex A. Blytt, *Lonicera microphylla* Willd. ex Schult.), forb-fescue-feather grass (*Stipa zalesskii*, *S. capillata*, *Festuca valesiaca*, *Helictotrichon desertorum*, *Koeleria macrantha*, *Phleum phleoides*, *Phlomoides pratensis*, *Medicago falcata*, *Salvia dumetorum*, *Galium verum*, *Thalictrum minus*, *Alcea froloviana*) steppes, formed on the common chernozems.

The upper part of the piedmont sloped plain is covered with forb-bunch grasses (*Festuca valesiaca*, *Helictotrichon desertorum*, *Stipa zalesskii*, *Koeleria macrantha*, *Phleum phleoides*, *Phlomoides pratensis*, *Salvia dumetorum*, *Medicago falcata*) steppes, partially with bushes (*Spiraea hypericifolia*, *Athraphaxis frutescens* (L.) K. Koch etc.), frequently with *Rosa platyacantha* Schrenk on the mountain leached chernozems.

The wide intermont valleys are occupied with forb-bunch grass (*Festuca valesiaca*, *Stipa capillata*, *Stipa zalesskii*, *Koeleria macrantha*, *Phleum phleoides*, *Lathyrus pratensis*, *Galium verum*, *Thalictrum minus*, *Salvia dumetorum*, *Hypericium perforatum*, *Origanum vulgare*, *Thymus serpyllum* L., *Achillea millefolium*, *Artemisia dracunculus* L.) steppe communities, developing on the mountain typical chernozems.

The mountain xeropetrophytic steppes are formed by steppe cereals (*Festuca valesiaca*, *Stipa capillata*, *Koeleria splendens* C. Presl, *Phleum phleoides*), xeropetrophytic forbs (*Ziziphora clinopodioides*, *Thymus serpyllum*, *Patrinia intermedia*, *Ajania fastigiata* (C. Winkl.) Poljak., *Hypericum scabrum* L.) and bushes (*Spiraea hypericifolia*, *Athraphaxis frutescens* etc.) on the mountain-steppe xeropetrophytic soils along the slopes of southern aspects.

The mountain-steppe, poorly developed soils are occupied with petrophytic forb-bunch grasses (*Sedum hybridum*, *Ziziphora clinopodioides* subsp. *bungeana* (Juz.) Rech. f., *Patrinia intermedia*, *Festuca valesiaca*, *Stipa caucasica*).

The dark chestnut soils are covered with fescue and feather grass-fescue dry steppes (*Festuca valesiaca*, *Stipa capillata*, *S. lessingiana*, *S. kirghisorum*, *Koeleria macrantha*, *Phleum phleoides*, *Koeleria splendens*) with the poor xerophytic (*Verbascum phoeniceum* L., *Salvia dumetorum* etc.) and xeropetrophytic (*Ziziphora clinopodioides*, *Thymus serpyllum*, *Patrinia intermedia*, *Ajania fastigiata*, *Hypericum scabrum*) forbs and *Poa bulbosa*. These communities usually include *Helictotrichon desertorum*, *Festuca rupicola*, *Phlomoides pratensis*, *Verbascum phoeniceum*, *Allium splendens* Willd. ex Schult. ex Schult. fil. and *Eremurus altaicus* (Pall.) Stev. The communities of the wide intermont valleys are abundant with forbs (*Galium verum*, *Thymus pulegioides* subsp. *pannonicus* (All.) Kerguélen, *Salvia dumetorum*, *Thalictrum minus*, *Artemisia dracunculus*, *A. austriaca* Jacq., *Lathyrus pratensis* etc.).

Subbelt of desert steppes occupies the lower part of the mountain-steppe zone and is represented by the piedmont sloped plain. Its soil cover is formed with the mountain light chestnut soils and mountain grey soils.

Light chestnut soils are common for plateaus, middle and lower parts of the piedmont plains and occupy the upper part of the piedmont semidesert zone, including the foothill sloped plain and peripheral parts of the low mountains, where they occupy the northern aspect slopes and merge with grey soils. The soil-forming rocks are eluvial-deluvial rubbly clay loams. The depth of the humus horizon (A+B) is 50-75 cm. The upper horizons are powdery-lumpy, lumpy and pressed. The lower part of the humus horizon includes carbonate build-ups. The upper horizon is low humic. The soil solution reaction is alkaline. These soils are rich with bases and are not saline. The medium clay loamy sediments are dominant in the grain composition.

Mountain common grey soils are widespread on the steep and gentle mountain slopes, on the upper and lower parts of the foothill sloping plains, lower parts of the slopes, intermont plains, upper terraces of the river valleys and narrow plateaus. The soils are represented by the north subtypes of common and light grey soils. The soil-forming rocks are eluvial-deluvial rubbly clay loams. The depth of the humus horizon (A+B) is 30-50 cm. The profile has a poor differentiation by its genetic horizons, is low humic with low amount of humus, and its carbonate-illuvial horizon is

poorly developed. The soil solution reaction is alkaline, the soils are non-saline, the medium clay loamy sediments are dominant in the grain composition.

The vegetation cover is dominated with ephemeroid-sagebrush-bunch grass communities, formed on the light chestnut soils. The desert steppes are mostly spread in the west of the macroslope. The dominant cereals are *Stipa sareptana* A. Beck., *S. capillata*, *S. lessingiana*, *S. caucasica* and *Festuca valesiaca*; the most common sagebrush is *Artemisia sublessingiana* Krasch. ex Poljakov, with a significant amount of *Poa bulbosa*. The sedge-sagebrush-fescue communities with bushes (*Festuca valesiaca*, *Artemisia sublessingiana*, *A. frigida* Willd., *Carex stenophylla* subsp. *stenophylloides* (V.I. Krecz.) T.V. Egorova, *Spiraea hypericifolia*, *Juniperus pseudosabina*), sagebrush-bindweed-feather grass (*Stipa sareptana*, *Convolvulus tragacanthoides* Turcz., *Artemisia sublessingiana*), sagebrush-bunch grass (*Stipa sareptana*, *S. lessingiana*, *S. caucasica*, *Festuca velesiaca*, *Artemisia sublessingiana*), forb-sagebrush-bunch grass (*Festuca valesiaca*, *Koeleria macrantha*, *Stipa capillata*, *Artemisia sublessingiana*, *Rhaponticoides ruthenica* (Lam.) M.V. Agab. & Greuter, *Achillea millefolium*) are spread there as well, with bushes communities (*Spiraea hypericifolia*, *Rosa platyacantha*, *Krascheninnikovia ceratoides* (L.) Gueldenst.; photo 9).

Photo 9. Combination of the sagebrush-bunch grass steppes and bushes (photo by K. Ussen).

Piedmont Desert belt (600-800 m a.s.l.)

This zone belongs to the upper part of montane plain, lower part of mountain slopes and lower belt of low mountains. Its relief is a piedmont sloped plain, assembled by the gravelly-sandy, sandy and sabulous formations, with Arkharly, Arganaty and Kyskash low mountains. Its vegetation is ephemeral (ephemeroid)-sagebrush and saltwort-sagebrush. The soil cover includes mountain grey soils, mountain brown soils and mountain grey-brown desert soils.

Mountain northern grey soils are common for the upper part of the piedmont plain, climbing up onto the spurs and lower parts of the ridge slopes. The soil-forming rocks are light clay loam and sandy loam. The grey soils are divided in common and light ones. The profile is slightly differentiated into its genetic horizons; the depth of its humus horizon is insignificant (A+B=35-

45 cm), humus composition is low. The upped horizon is pale yellow-grey, loose, layered, its bottom part is brown, slightly pressed and lumpy. The carbonate-illuvial horizon is weakly presented. The soil solution has an alkaline reaction. The soils are rich with bases and are not saline. The sabulous and loamy sediments are dominant in the grain composition.

Mountain brown desert soils are common for the lower parts of the mountains slopes. The soil-forming rocks are illuvial-deluvial formations of mountain bedrocks (sandy loams, clay loams, clays). The upper profile part fractionally includes a layer of rubble. The depth of the humus horizon (A+B) is 30-35 cm, it is brown and slightly layered. The subhorizon is dark brownish and pressed. Its humus composition is insignificant, the max carbonate amounts are in its bottom part. The soil solution has an alkaline reaction. The sabulous, light and medium loamy sediments are prevalent in the grain composition.

Mountain grey-brown desert soils are common for the piedmont plains of the eastern part of the Dzungarian Alatau ridge, forming on the binomial deluvial-proluvial deposits of clay loam and rubble. These soils are divided in common and solonetzic ones. Their surface is covered with a rubble and pebble shell, with a yellow-grey, spongy, lumpy-blocky, light clay loamy crust of 3-6 cm. Under it there is a humus brown-grey, loose, scaly-layered horizon that turns into a dark brown pressed horizon of carbonates deposit. The depth is laid with rubble (pebble) bedrocks with gypsum build-ups. The depth of the humus (A+B) horizon is 30-35 cm. The soils composition of humus is low, while the carbonates are high in the crust and carbonate-illuvial horizon. The soil solution has a strongly alkaline reaction. The medium clay loam sediments are prevalent in the grain composition.

This belt is represented by the ephemeroid-grass-sagebrush vegetation on the mountain light northern grey soils. The high piedmont plains are occupied with ephemeroid-sagebrush (*A. sublessingiana*, *Poa bulbosa*) and ephemeral-feather grass-sagebrush (*Artemisia sublessingiana*, *A. terrae-albae* Krasch., *Stipa lessingiana*, *S. sareptana*, *Eremopyrum orientale* (L.) Jaub. ex Spach., *Bromus tectorum* L.) communities with *Poa bulbosa*, *Bassia prostrata* (L.) Beck, and partially with *Krascheninnikovia ceratoides*. The sloped and poorly broken piedmont plains are occupied with the ephemeroid-sagebrush (*Artemisia sublessingiana*, *A. serotina* Bunge, *Poa bulbosa*, *Carex pachystylis* J. Gay) communities on the mountain northern common grey soils.

The rubble foothills are covered with phryganoids with *Convolvulus tragacanthoides.* The nanophyton-sagebrush-saltwort (*Salsola arbusculiformis* Drobow, *Artemisia heptapotamica* Poljakov, *Nanophyton erinaceum* (Pall.) Bunge; photo 10) and semishrub-feather grass-sagebrush (*Artemisia heptapotamica*, *Stipa caucasica*, *Krascheninnikovia ceratoides*, *Salsola arbusculiformis*) steppe deserts can be found on the mountain brown soils. For the foothill plains are the sagebrush-saltwort deserts with co-dominating *Artemisia terrae-albae* and perennial saltworts (*Salsola laricina* Pall., *Anabasis salsa* (Ledeb.) Benth. ex Volkens, *Nanophyton erinaceum*, *Suaeda physophora* Pall., *Kalidium caspicum* (L.) Ung.-Sternb.) are common, forming on the mountain grey-brown soils.

The river valleys are represented by birch (*Betula pendula*, *B. tianschanica*), poplar (*Populus laurifolia* Ledeb., *P. talassica* Kom.), willow (*Salix triandra* L.) gallery woodlands and bushes (*Salix viminalis* L., *S. kirilowiana* Stschegl., *Myricaria germanica* (L.) Desv., *Lonicera stenanta* Pojark.; photo 11), forming on the floodplain forest-meadow soils with steppe, typical and swamp meadows (*Dactylis glomerata*, *Phleum phleoides*, *Helictotrichon pubescens*, *Persicaria alpina* (All.) H. Gross, *Aconitum septentrionale*, *Elymus repens*, *Bromus inermis Medicago falcata* L., *M. lupulina* L., *Amoria hybrida*, *A. repens* (L.) C. Presl, *A. fragifera* (L.) Roskov, *Achillea millefolium*, *Origanum vulgare*, *Agrimonia asiatica* Juz., *Carex melanostachya* M. Bieb. ex Willd.) on the floodplain meadow and maedow-boggy soils, as well as grass fens (*Typha angustifolia* L., *Rumex confertus* Willd., *Mentha longifolia* (L.) Huds., *Phragmites australis* (Cav.) Trin. ex Steud.) on the boggy soils.

The foresaid patterns of the altitudinal differentiation on the basis of the complex assessment of

the soil and vegetation cover showed us a more complete picture of the altitudinal zonation of the the Zhetysu Alatau northern slope.

Photo 10. Piedmont deserts with *Salsola arbusculiformis* (photo by L.A. Dimeyeva).

The mountains of the Zhetysu Alatau are located in a desert zone, far from humid air of the oceans and seas. We compared them to the eastern slope of Caucasus, located in the desert-steppe zone, where the main ridge blocks the humid Atlantic air from the west. For the eastern ridge a continental (Dagestan) type of altitudinal zonality is common. There, aside from the arid belts of the piedmont deserts, desert steppes and arid woodlands, the broad-leaved forests are widespread, while the coniferous woods are absent (Zones and types of vegetation …, 1999; Gasanov, 2009).

Unlike the Kazakh Altai which is located in the steppe zone, there is no high mountain tundra in the mountains of the Zhetysu Alatau (Dimeyeva et al., 2012).

The northern macroslope of the Zhetysu Alatau and the mountains of the Northern Tien Shan has the same type of altitudinal zonality (Trans-Ile-North-Dzungar), but their altitudinal boundaries are different. Western Tien Shan is located in the subzone of the southern deserts, with no steppes and coniferous forests which are replaced with belts of savannoids and open juniper woodlands (Volkova, 2003; Ussen et al., 2014).

The northern macroslope of the Zhetysu Alatau differs from the southern one by the distribution of its altitudinal belts. In the higher aridity of the southern slope the small-leaved forest belt is absent, while the forest meadow belt is fragmentary (Rubtsov, 1948; Vokova, 2003; Dimeyeva, Ablaikhanov, 2014).

Conclusions

The northern macroslope of the Zhetysu Alatau has a specific structure of altitudinal distribution of vegetation and soils. It is divided in the following belts: high mountain nival-rocky with the subbelts of glaciers, snow fields, firns and cryopetrophytic groups on the primal soil formations; mountain-meadow and meadow-steppe alpine with kobresia and cryophytic meadows on the mountain-meadow alpine soils, with combination of high mountain steppes on the high

mountain meadow-steppe soils; mountain-meadow and meadow-steppe subalpine with mid-herb meadows on the mountain-meadow subalpine soils and steppe meadows on the high mountain meadow-steppe dark soils, with elfin juniper woods on the high mountain dark soils; mountain dark coniferous forests on the mountain-forest dark soils and typical mesophytic meadows on the mountain meadow-forest soils; mountain small-leaved forests on the mountain-forest dark grey soils and mountain fruit forests on the mountain-forest chernozem-like soils; steppe with the subbelts of meadow steppes, typical steppes and desert steppes on the mountain leached and common chernozems, mountain dark and light chestnut soils; piedmont ephemeroid-grass-sagebrush deserts on the mountain northern light grey soils and ephemeroid-sagebrush deserts on the mountain northern common grey soils, ephemeral-feather grass-sagebrush steppe deserts on the mountain brown soils and sagebrush-saltwort deserts on the mountain grey-brown soils.

1 2

3 4

Photo 11. Rivers of the northern macroslope of the Zhetysu Alatau: 1 – Topolevka, 2 – Koksu, 3 – Sarkand, 4 – Orta-Tenrek (photo by L.A. Dimeyeva).

The determined patterns of the altitudinal distribution of the soil and vegetation cover of the northern macroslope are the basis for the botanical and geographical zonation of the region, evaluation of its ecosystem diversity and its distribution throughout the altitudes. The various habitats have a major role in preservation of the biological richness of the mountains and improve the efficiency of the measures for nature protection during the period of climate changes.

Our studies aimed to evaluate the influence that climate changes have on the mountain systems of the Western Tian Shan, Kyrghyz Alatau and Southern Altai showed a shift in attitudinal belts (Dimeyeva et al., 2015). The attitudinal limit for the vegetation habitats in the Southern Altai has

lifted by 200-300 m (Sultanova et al., 2016) and by 100 m in the Western Tian Shan. In the Kyrghyz Alatau the shift has not been registered. However the signs of aridization have been found in every belt.

The global climate changes will make the rare and endemic species as well as the species with narrow ecological amplitude the most vulnerable. Therefore, Zhongar-Alatau National Park is hoped to have a big influence in preservation of ecosystem diversity. Created on the northern macroslope of the Zhetysu Alatau in 2010, now the Park occupies 356022 ha, stretching from west to east for 300 km. It protects the local nature systems from the threats caused by the anthropogenic and natural impacts on the environment.

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