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Genetic Characteristics of Brown Forest Soils on the Middle Urals

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Abstract: Feature of mountain soil formation is that the soils on the mountain slopes are formed in different bioclimatic and orogeomorfological conditions. The purpose of research is to study genetic properties of the brown forest soils in the Middle Urals. Features of the morphological structure: truncated profile (35-75 cm), weakly expressed in the differentiation of the soil profile into individual Horizons, detritus (20-65%), loamy fine earth, the signs of podzolization in the soil profile is not found. Feature granulometric size distribution of the soil - a gradual increase in weight on the profile into Sandy Loam to Silty Clay and Clay, the dominant factions are either big Silt or Sand. Soils are characterized by a very acidic environment and high hydrolytic acidity. The soils are enriched in organic matter and humus profile characterized by prolixity. Group composition humus shows mobility, high degree of humification of organic substances to fulvic acids. Gross composition shows that the processes of soil formation on Mount, North Basegi aren't leading to a distinctly different profile. Coefficients of geochemical accumulation, subsurface weathering, eluviation, oxidation calculated and helped define the features of the gross composition of soils. Character of distribution in profile and correlation of forms of iron help to diagnose physical processes of weathering and soil formation (burozemic pedogenesis et al.); signs Podzolization not revealed. Weathering and soil formation processes that occur with varying intensity, creating a diversity of soil cover and the spatial heterogeneity of soils, even within the same type. Thus, in the mountains of the Middle Urals brown forest soils form a number of subtypes: raw organic (900 m) - ferruginized (655 m) - metamorphosed (590 m) - clay-illuvial (577 m) - eluvial (565 m) - clay-illuvial (315 m).

Keywords: Brown Forest Soils, Properties, Genetic Horizons, Soil Profile, Soil Formation, Weathering Processes

1. Introduction

Mountain areas represent about 20 % of Earth's land area (excluding the areas covered by ice). The largest area is occupied by mountainous taiga zone (one-third), and mountain forest and brown soil zones (almost one quarter) [1-8]. In Russia, mountain areas occupy 34 % of the total area. Problems in studying of mountain soils are associated with many factors. These include soil-forming processes and constant weathering, special climate and vegetation. It is also natural that soils differ in different mountains depending on their location, height, composition of the material, etc. [4, 5, 9-18].

Scientists have established that brown forest soils are formed under broad-leaved forests in the warm-temperate and humid areas of subboreal belt [19-24]. It took a number of years for this type of soil to be recognized, yet only in the southern mountains of the Crimea and the Caucasus, and at the Far East. It was believed that the mountain brown forest soils are common in the Caucasus, the Crimea, the Carpathians and the Sikhote-Alin [20, 25, 26]. Brown forest soils have always been of great interest for researchers, causing numerous disputes and differences of opinions regarding their distribution and formation. It took some time for soil scientists come to a consensus on the type of brown forest soils, so the matter remained unclear for a long time [27-32].

Active studies of the genesis of brown forest soils in different mountain systems in Russia began in the middle of 50s-60s of 20 centuries [33-39]. A considerable number of papers on forest soils showed that the area of the brown forest soils is much broader than it was believed to be. As a result of development of soil studies in Siberia, the question arose if some forest soils of the Urals, Sayan and Baikal can be classified as brown forest soils. Brown forest soils have been allocated under the dark-coniferous forests, not only in the Caucasus and the Carpathians, but also in more continental areas, such as the Altai and Kuznetsk Alatau and the Urals

[40-42]. The assumption on the distribution of brown forest soils in colder regions of Russia was confirmed later.

Thus, the brown forest soils have no clear affinity to any particular type of vegetation, as they develop both under broadleaved and mixed coniferous-broad leaved forests, and even under coniferous forests. Knowledge of the brown forest soils was generalized. Due to numerous studies, brown soils have been allocated almost everywhere, even in colder climatic conditions. As a result, brown forest soils and brown soils are now considered the most common type of forest soils.

Rozanov B.G. [4] described the almost ubiquitous brown-colored soils, poorly differentiated on the horizons, having different types in different bioclimatic zones, located on the slopes of humid, sub-humid and subarid areas of the world, as one of the features of the soil covering of mountain systems of the world. Mountain brown soil is the main form of soil-forming in humid mountain slopes regardless of the climatic characteristics of the mountains. The scientist indicated that the presence of brown soils in the mountains is a definite historical stage in the development of the soil maintained for a long period in conditions of mountain slope soil-forming. Thus, similarity of mountain soils is noted in mountains worldwide in senile soils, and the diversity increases in mature soils.

On the background of large-scale studies of mountain ecosystems, the studies of Subpolar, Northern, and Middle Urals soils began to appear [43-57]. There are opinions that in the Middle Urals, under the middle-taiga forests, the formation of brown forest soils having its own characteristics is possible.

The purpose of the research is to study the genetic characteristics of brown forest soils in the Middle Urals.

2. Material and Method

The object of research is the brown forest soils of North Basegi, which is a part of the Basegi crest overlying in the West of the Urals watershed and is located between 58°50' and 60° N. Basegi is a meridionally elongated range of three mountains: North Basegi (951.9 m), Middle Basegi (994.7 m), and South Basegi (851 m). The ridge is a part of "Basegi" State Natural Reserve. The lowest point in the reserve is located in the mouth of the Korostelevka river on the altitude of314 m. The territory of the reserve is a part of the Urals mountain band, which is composed of metamorphic rocks [58]. The territory belongs to the field of ridge-remnant low mountains of the Middle Urals [59]. The climate is cold and wet with features of continental (precipitation of 496 mm to 1,071 mm; the average temperature of the coldest month, January, is -17,9 ° C, and the warmest, July, +13,3 ° C). By zonal distribution of vegetation cover, the territory is located in the middle taiga subzone of the boreal forest zone.

In the Middle Urals, there are mountain-forest belt, subgoltsy (subalpine) belt, and mountain-tundra (alpine) belt [60]. In the mountain-forest belt to a height of 450-600 m above sea level the cover is dark coniferous taiga with a sufficiently dense grass cover. Subalpine belt comprises three sub-belts (park open forest, subalpine meadows, and crooked forest). Park open forest belt (sparse, with the small closeness of undergrowth and tall grasses) is gradually transformed to the crooked forest with altitude increasing. Subalpine meadows are located at the same altitude as the crooked forest, often mixing with it. Meadow communities are common almost up to rocky places. At an altitude of 800 m or more, rocky, suffruticous, and grass-moss tundra is found.

In 2010-2012 soil cross sections on North Basegi Mountain were made in different altitudes and vegetation zones, namely in mountain forest, park open forest, under the sub-alpine meadows, in a crooked forest, and mountain tundra belts. In total, 12 soil cross sections were made for the study of morphological characters of soils on the slopes of different exposures. Soil samples were collected throughout the profile from genetic soil horizons.

The following parameters were evaluated at samples: gritty consistency, granulometric texture with pipette method, version of N.A. Kaczynski (with the pyrophosphate method of soil preparation for the analysis), accelerated gross analysis, exchange acidity with potential measurement method, hydrolytic acidity with Kappen method, total exchangeable bases by Kappen-Gilkovits, group composition of humus in mineral soils by M.M. Kononova and N.P. Belchikova [61], content of organic substances by the method of Turin in Antonova's modification [62]. Analytical studies were performed at the Department of Soil Science of the Perm State Agricultural Academy, and in the laboratory of soils physical chemistry of Soil Institute named after V.V. Dockuchaev. The following indicators were defined: total iron content by "Respect" XRF analyzer, the content of non-silicate and amorphous iron by methods of Tamm and Mer-Jackson with atomic-absorption ending. Based on acquiring data, the iron content in the silicate compounds (Fe_c) and crystallized compounds ($Fe_{окр}$) as well as Shvertmann ratio (the ratio of $Fe_{окр}/Fe_{нс}$) were calculated [63].

Russian soil classification as of the year 2004 was used [64].

Statistical analysis was performed in the "Data Analysis" software in Microsoft Excel and the STATISTICA 6.0 software.

3. Results and Discussion

Original physiographic position of the "Basegi" Reserve in the Middle Urals and a variety of environmental conditions influencing the formation of soil cover determine the presence of a broad range of soils, represented mainly by brown soils. The spatial distribution of the soils is subject to the laws related to the mountain nature of the area: exposure and slope angles, altitude, and composition of biocenosis. The main factors of classification differentiation of the soil cover are soil position in the landscape, vegetation diversity, and the nature of deposits.

The pedogenesis processes are closely related to the dynamics and functioning of the landscape. Brown forest soils of North Basegi are formed at different altitudinal positions and in different vegetation belts (table 1). Changes in vegetation formations can cause adifferent combination of different (by orientation) soil-forming processes: sod, alfehumus, gley, and cryogenic.

Table 1. *Conditions of formation of brown forest soils in the North Basegi Mountain*

№ of the cross section, Altitude, m asl	Belt, sub-belt	Exposure, graient	Relief form	Vegetation
№ 30, 900	Goltsy-subgoltsy	South, 30°	Drained steep part at the top of the mountain slope	Birch crooked forest with blueberry and green moss
№ 32, 655	Crooked forest	Southeast, 20°	Drained open forest gentle part in the middle of the slope	Birch crooked forest with large fern and groups of meadows
№ 17, 590	Park open forest	East, 5°	Drained gentle part at the middle of the mountain slope	Spruce and fir forest with large fern
№ 27, 590	Park open forest	South, 5°	Poorly drained gentle part in the intermountain	Birch and fir aconitic forest
№ 15, 577	Mountain-forest	East,5°	Poorly drained gentle part at the middle of the mountain slope	Spruce and fir aconitic forest
№ 19, 565	Mountain-forest	West,5°	Drained gentle part	Spruce and fir forest with large fern
№ 26, 315	Mountain-forest	North-west, 3°	Drained flat surface at the foot of the mountain	Birch forest with meadowsweet and mixed herbs (riverbank)

In the upper part of the southern slope of the studied mountain range, at an altitude of 800-900 m, in subalpine vegetation, a complex of brown (Cambisoils, FAO/UNESCO) earth has been formed, which is completely not typical of this high-altitude belt. In a small hollow in the crooked forest belt with bistort cover in a periodic waterlogging, ferruginated brown soils have been formed (c. 8, *AY-BM-BM$_f$-CLM*). Raw-organic dark-humus brown soils (c. 30, *H$_{ao}$-AU$_1$-AU$_2$-BM-CLM*) have been formed on a drained steep part of the hill terraces under the birch crooked forest with blueberry and green moss communities. The soils are 60 to 70 cm deep. The alternation of forest and meadow landscapes is probably due to the migration of the forest belt during the late Pleistocene and Holocene up and down the slope, which has already been noted in other mountain systems [65].

Conditions suitable for forming brown soils can mostly be found in the park open forest belt at an altitude of 500 m. At the bottom of the southern slope (closed intermountain saddle, altitude of 590 m) under the birch and fir aconitic forest in a higher humidification due to significant surface and lateral runoff, gleyey ferruginated brown soils are formed (c. 27, *AY$_{an}$-AY$_g$-BM$_g$-CLM$_{f,g}$*). A characteristic feature of the soil is the presence of the clearest signs of gleying in the profile, namely the rusty patches, compact constitution, long-term water saturation.

On the east macroslope, brown soils were discovered at the bottom of the slope at an altitude of 577-580 m. These are poorly drained flat areas (gradient 5°), occupied by spruce and fir aconitic forests on raw-organic eluviated brown soils (c. 16, *AO-AY$_{el}$-BM$_1$-BM$_2$-CLM*) and dark humus clay-illuviated brown soils (c. 15, *AU-BM-BM$_i$-CLM*). Above 590 m, aconitic associations are replaced by large ferns which are also located on dark humus brown soils (c. 17, *AU-BM-BM$_i$-CLM*). Thickness of the brown soil profile varies from 54 to 70 cm, naturally decreasing with area altitude increasing (r= -0.9). There is also a positive correlation between humus layer and absolute altitude (r = 0.8).

The next series of genetically conjugated soils is located on the western slope at the same relief altitude (557-590 m) with similar vegetation. Under the aconite, the short-profile dark humus eluviated brown soils have been formed (c. 19, *AU-BM$_{el}$-BM-CLM*; c. 21, *AY$_{el}$-AU-BM-CLM*) as well as dark-profile brown soils (p. 20, *AU-BM$_u$-BM*); under the large fern communities, a more deep dark humus eluviated brown soils are formed (p. 22, *AU-BM$_{el}$-BM-CLM*). There was an inverse mean correlation between the average depth of the *BM* horizon (r = -0,6) and the total depth of soil profiles (r = -0,5) and the area altitude.

On the shady northern slope at the bottom of the mountain slope (400-430 m) on a gentle slope section of 3° gradient under spruce forest with sorrel and small fern, eluviated brown soils have been formed (c. 9, *AY-BM$_1$-BM$_2$-BM$_{el}$-CLM* and c. 10, *AO-AY-AY$_{el}$-BM$_{el}$-BM- CLM*). Brown soils profile depth is 70-104 cm, moist, the structural and metamorphic horizon is lighter at a depth of 30-70 cm. At 300 m from the Usva river (altitude above sea level of 315 m), where drainage conditions are improving locally, vegetation gives way to a birch forest with meadow-sweet and mixed herbs, the clay-illuviated brown soils with a depth of 67 cm is formed (c. 26, *AY-BM$_1$-BM$_2$-BM$_i$*). It should be noted that increasing of absolute altitude is followed by increasing of thickness of structural metamorphic horizon *BM* (r = 0.9) in the soils, and the correlation with the total thickness of the profile is practically absent.

Subgoltsy belt soils profile thickness varies significantly depending on the slope angle and slope exposure, as at the slopes of different exposure an unequal distribution of heat and moisture is created, and it results in a different degree of erosion and soil-forming processes. These differences affect the structure of the soils profile. So, on the shady slopes of the northern and eastern exposure brown soils are formed, the thickness of which varies from 45-50 cm to 100-110 cm. On the slopes of the southern and western exposure, more rubbly and short (no more than 30-45 cm) soils are formed. Thickness of individual horizons also varies significantly: top humus 2 to 7 cm, humus horizon 3 to 16 cm. Humus horizon color varies from black and dark gray through shades of gray to dark brown and gray-black. There is a relationship between the position of the soil on the slope (altitude) and sod thickness (r = 0,5).

In the mountain-forest belt, brown soils of different subtypes occupy a dominant position both under deciduous and coniferous forests. They occupy middle parts of the gentle slopes with an absolute altitude of 315-500 m (c. 26, 9, 10). The morphological appearance of brown soils in mountain and forest belt is similar to that of brown soils under the park vegetation. Thus, the general morphological characteristics of mountain brown forest soils are the following: truncated profile, mild differentiation in separate horizons, high rubbility (20-65%). No morfological signs of podzolity were found in the soils profile despite the presence of fir and spruce forests and acid forest litter.

Granulometric texture of the fine soils is loamy and varies from medium loamy to clayey. The soils feature is the gradual increment in weight of granulometric texture (by physical clay content), and the dominant factions are either large silt or sand. Distribution of elementary particles in the soil profile indicates soils poligenecity, which is manifested in the presence of the barrier, on which there is a sharp decline or a sharp increase in granulometric particles content.

Morphologically and analytically, the following basic processes of common geochemical features typical of soil-forming and weathering in cold humid areas are clearly distinguished for the brown forest soils of the Middle Urals – ferrugination and aluminizing of the thickness of soil and eluvium combined with desilication of the soil profile, which are fixated by different types of differentiation of lithophile elements in the process of pedogenesis; staging of accumulation and the contrast in the profile distribution profile-forming elements (iron, aluminum, silicon) (table 2).

Table 2. *The bulk composition of the oxides in the brown forest soils on the North Basegi mountain*

Cut	Depth, cm	Horizon	SiO_2	Al_2O_3	Fe_2O_3	K_2O	Na_2O	CaO	MgO	TiO_2	MnO	P_2O_5
30	13-23	AU_1	68.67	11.45	3.40	1.74	0.62	0.18	0.41	1.16	0.02	0.29
	23-32	AU_2	66.18	12.41	5.09	1.82	0.52	0.25	0.71	1.04	0.03	0.23
	32-50	BM	69.69	13.28	4.11	1.77	0.68	0.29	1.30	0.94	0.04	0.11
	50-75	CLM	74.28	13.64	3.84	1.81	1.12	0.31	1.45	0.91	0.04	0.10
32	5-9	AY_1	61.33	14.67	8.02	2.67	0.59	0.16	0.96	1.68	0.10	0.61
	9-22	AY_2	61.51	15.34	8.23	2.66	0.38	0.17	0.82	1.55	0.10	0.43
	22-37	AYf	61.7	16.24	8.53	2.7	0.33	0.18	1.16	1.53	0.12	0.38
	37-58	BM	63.56	16.05	8.19	2.60	0.62	0.18	1.21	1.49	0.09	0.32
	58...	CLM	65.11	16.84	8.01	2.69	0.66	0.22	1.49	1.48	0.09	0.25
27	4-12	AYan	63.10	16.11	6.14	2.29	1.14	1.11	1.99	1.33	0.04	0.50
	12-26	AYg	66.03	15.52	6.65	2.41	0.82	0.99	1.99	1.49	0.06	0.31
	26-57	BMg	66.74	13.98	7.13	2.32	2.49	1.16	2.63	1.56	0.09	0.18
	57...	CLMf,g	66.38	15.07	7.59	2.45	1.77	1.20	2.52	1.38	0.08	0.14
17	4-13	AU	58.82	13.70	5.82	2.08	0.16	0.36	1.13	1.09	0.10	0.72
	13-23	AUm	59.38	14.37	6.40	2.17	0.45	0.30	1.46	1.09	0.08	0.49
	23-32	BM_1	67.66	14.91	5.69	2.29	0.74	0.38	1.58	1.11	0.06	0.16
	32-46	BM_2	69.56	14.57	5.41	2.28	0.19	0.40	1.63	1.05	0.05	0.06
	46...	CLM	68.57	15.56	5.62	2.41	0.86	0.39	1.86	1.07	0.06	0.12
15	10-14	AU	71.45	12.51	5.02	2.06	1.01	0.51	1.04	1.13	0.15	0.17
	14-21	BM	69.64	14.51	5.98	2.08	1.03	0.43	1.76	1.13	0.05	0.07
	21-43	BMi	67.55	15.59	6.39	2.15	0.98	0.42	2.03	1.10	0.06	0.06
	43-70	CLM	69.77	14.28	6.13	2.16	0.78	0.42	1.59	1.06	0.06	0.02
19	6-15	AU	46.31	7.874	7.81	1.30	1.10	0.30	0.84	1.09	0.06	0.17
	15-30	BMel	64.71	15.63	7.63	2.25	1.03	0.58	2.16	1.64	0.07	0.30
	30-72	BM	65.92	14.95	7.32	2.22	1.32	0.67	2.49	1.52	0.07	0.11
	72…	CLM	65.58	15.16	7.59	2.43	1.59	1.24	2.52	1.43	0.10	0.19
26	5-22	AU	65.62	14.66	5.60	2.17	1.09	0.42	1.66	1.02	0.10	0.16
	22-33	AY	65.23	15.88	5.88	2.14	0.66	0.36	1.37	1.05	0.08	0.16
	33-57	BM	69.68	14.29	5.59	2.13	0.81	0.39	1.65	1.06	0.07	0.05
	57...	BMi	71.40	14.50	5.45	2.27	0.98	0.43	1.51	1.06	0.07	0.03

For brown forest soils formed in a mountain-tundra belt (cross section 30), the seasonal permafrost plays a significant profile-forming role as hydrothermal factor and geochemical barrier.

Types of distribution of various oxides in soils vary depending on the role in soil formation. Thus, distribution of SiO_2, Al_2O_3, Fe_2O_3 is mildly differentiated throughout the profile, and only in some soils, it is closer to the eluvial-illuvial type with various manifestations of eluviality and illuviality. Accumulative eluvial-illuvial distribution characterized by accumulation on the surface was noted for CaO, while MgO is mainly characterized by progressive eluvial and eluvial-illuvial types of distribution. TiO_2 distribution in the soils is not differentiated. Regressively or uniformly accumulative distribution is noted for phosphorus oxide and sulfur. These substances distribution subtypes are of accumulative type of distribution that characterizes profiles with a maximum accumulation of substances from the surface with a gradual decrease of their content with depth. To determine the relationship between type of substances distribution and the altitude, correlation coefficients were calculated. Based on these, it can be said that the correlation between the types of substances distribution and the altitude is low ($r <0,3$).

Based on data on the content of macroelements, their ratio was calculated, and various geochemical factors were defined that allow detection of changes in soil properties and determination of their geochemical characteristics. Detailed characterization of geochemical factors illustrating the process of soil-forming is presented in [57]. Geochemical factors show that soils are poligenetic and intergenerational judging by time of exposure and manifestation of various paedogenesis processes in their properties, which indicates a change in the conditions while forming these soil profiles.

The ratio of the various forms of iron compounds in the profile, and even within the same horizon, performs diagnostic role for the detection of elementary processes of soil formation, which can be controlled by accumulation or redistribution of different forms of iron [39].

Thus, in the brown soils at an altitude of 900 m asl the iron content through the profile is differential and is < 5 %. In crooked forest brown soils the maximum iron content is noted, that is more than 8 % with a maximum in the middle of the profile. In the brown soils of mountain-forest belt, the iron content is also more than Clark's and varies from 5.02 to 7.81 %.

The group composition of iron compounds shows that in brown soils at different altitudes ratios of iron compound forms may vary. In brown soils, the content of non-silicate iron is less (27-40 %) than silicate (49-80 %), especially in soils on the slopes of the southern and western exposure.

The ratio of amorphous and crystallized iron in the brown soils is also interesting. Thus, in the brown forest dark humus soils in the mountain forest belt and the transition sub-belt of park open forest (cross sections 15, 17, 19) there are more crystallized forms of iron compounds than amorphous. In brown forest clayey illuviated soil (crosssection 26) in the lower border of the mountain-forest belt, the content of amorphous iron is slightly higher than that of crystallized, with a maximum in structural and metamorphic profile horizons.

In brown soil profile in crooked forest and mountain tundra, there is an alternation in the prevalence of crystallized and amorphous forms of iron compounds. Chemogenic differentiation processes manifested in the soil profile indicate a change in ecological and landscape conditions at altitudes above 500 m asl. Influenced by various factors, the main soil-forming processes can be transformed, flow with different intensity and superimpose each other, thereby defining various modifications of the structure and properties of diagnostic horizons.

The results of the bulk composition allow to diagnose the following processes in the studied soils by the 2004 classification: humus accumulation, decilitization, argillization, pedogenic weathering, chemogenic differentiation, lessivage, metomorfization, ferrugination, illuviation.

The content of organic matter in humus horizons of soils ranges from 3.2 to 4.1 % per the weight of the soil. With the depth increment, wamount of organic substance gradually decreases (Table 3).

The soils have a very strong acidic reaction which depends on altitude and varies from 3.01 to 3.97. The soils are characterized by a rather high value of hydrolytic acidity (Ng) (in the upper horizons it varies between 10.3-25.2 mEq/100 g). The highest Ng rates are found in organogenic accumulative horizons. Hydrolytic acidity decreases down through the profile. There was noted a clear spatial pattern in the distribution of the magnitude of the potential acidity: the highest values have been observed in soils of north-western and western slopes, as well as at the top of the North Basegi. No regularities in change of acidity depending on altitudinal belts were identified. It has been established that the soils are depleted in exchangeable bases (0.5 to 22.3 mEq/100 g of soil). There is a gradual decrease in the cation exchange capacity down through the profile, and in some soils the content of exchangeable cations increases in the rock and the transitional horizon.

Based on the analysis of group composition of humus in brown forest soils of North Basegi (Table 4), it should be noted that humus in the soil is very mobile, since more than a half of humic substances goes into pyrophosphate extraction. Humic substances in brown soils of park open forests and mountain-forest belt have the highest solubility (95.79 and 78.62 %, respectively).

Table 3. *Physical and chemical properties of brown forest soils on the Middle Urals*

Cut	Slope exposure	Altitude at sea level, m	Depth, cm	Horizon	pH_{KCl}	pH_{H2O}	Organic matter, %	S	Hr	T	V,%
								mg-ekv/100 g of soil			
30	West	900	13-23	AU_1	3.01	4.07	4.1	2.7	20.7	23.4	6.4
			23-32	AU_2	3.45	4.16	3.8	0.7	22.2	22.9	1.7
			32-50	BM	3.91	4.48	1.5	0.5	13.3	13.8	1.2
			50-75	CLM	3.95	4.58	1.6	1.9	12.4	14.3	4.5
32	South–East	691	5-9	AY_1	3.50	4.01	4.0	2.5	16.2	18.7	6.0
			9-22	AY_2	3.77	4.18	2.6	1.1	13.9	15	2.6
			22-37	AYf	3.80	4.48	2.3	2.7	13.2	15.9	6.4
			37-58	BM	3.84	4.60	1.5	1.5	13.2	14.7	3.6
			58...	CLM	3.97	4.80	0.4	1.7	11.0	12.7	4.0
27	South	590	4-12	AYan	3.80	5.09	3.7	17.8	10.3	28.1	42.4
			12-26	AYg	3.71	5.39	1.8	15.3	9.7	25	36.4
			26-57	BMg	3.83	5.60	0.2	16.9	3.8	20.7	40.2
			57...	CLMf,g	3.84	5.67	0.1	22.3	3.8	26.1	53.1
15	East	577	10-14	AU	3.44	4.63	3.5	8.5	15.0	23.5	20.2
			14-21	BM	3.47	4.81	1.6	-	17.3	17.3	-
			21-43	BMi	3.54	4.92	0.8	6.6	19.8	26.4	15.7

Cut	Slope exposure	Altitude at sea level, m	Depth, cm	Horizon	pH_{KCl}	pH_{H2O}	Organic matter, %	S	Hr	T	V,%
								mg-ekv/100 g of soil			
			43-70	CLM	3.72	5.14	1.0	5.4	14.1	19.5	12.9
19	West	565	6-15	AU	3.32	4.10	3.2	5.0	18.0	23	11.9
			15-30	BMel	3.83	4.47	1.5	–	14.2	14.2	–
			30-72	BM	3.78	4.61	0.9	2.5	13.2	15.7	6.0
			72…	CLM	3.94	5.66	0.2	21.9	3.6	25.5	52.1
26	North–West	315	5-22	AU	3.33	4.66	3.5	–	25.2	25.2	–
			22-33	AY	3.37	3.85	2.7	0.2	25.2	25.4	0.8
			33-57	BM	3.54	4.66	0.6	–	20.4	20.4	–
			57...	BMi	3.48	4.83	0.5	2.5	17.5	20	6.0

Table 4. *Group composition of humus in the humus horizons of brown forest soils of North Basegi (%)*

Altitude sub-zone	Altitude asl, m	Cut	C_{total}	$C_{extract}$	$C_{humic\ acid}$	C_{fulvic}	NR	C_{humic}:C_{fulvic}	Degree of humification
Crooked forest	900	30	3.85	1.95 50.65	0.13 3.40	1.82 47.27	1.90 49.35	0.1	51
	691	32	3.63	1.94 53.44	0.37 10.20	1.57 43.25	11.69 46.56	0.2	53
Park open forest	590	17	3.80	3.64 95.79	0.66 17.30	2.98 78.42	0.82 4.21	0.2	96
Mountain-forest	565	19	2.81	2.11 75.09	0.37 13.10	1.74 61.92	0.70 24.91	0.2	75
	315	26	2.76	2.17 78.62	0.69 25.00	1.48 53.62	0.59 21.38	0.5	79

Note: NR – nonhydrolyzable residue

C_{humic}:C_{fulvic} ratios reflect the structural features of humic acids, which allow us to estimate the degree of hydrolyzability of humic acids and the properties of the humic acid itself, its looseness [66].

In the brown forest soils of the Middle Urals, humic acids are rather loose (C_{humic}:C_{fulvic} varies between 0.1 and 0.5) and able to hydrolysis, that means that they are not very persistent and therefore easy passing to solution. These indicators show that the degree of hydrolyzability of mountain soils is high, and the possibility of the formation of double bonds is very low. It is believed that fulvic acids are the split product of humic acids, i.e. fulvic acids are the derivants of the humic acids. The degree of humification calculated by the formula [66] gives a clearer picture of humification of plant residues. About half of the incoming plant residues are humified in the soils, with a greater extent in a mountain forest belt. Nonhydrolyzable residue characterizes conservative, stable part of humus. Nonhydrolyzable residue content in soils ranges from very low (4.2 %) to medium. This once again confirms the high mobility of humic substances.

Thus, the features of the humus condition of brown forest soils are recency and immaturity of humic substances, staying at the first stage of humification, which manifests in the predominance of fulvic acids in the humus and the high proportion of soluble humic substances ($C_{extract}$.).

4. Conclusions

Physical and geographical conditions of the Middle Urals cause the following genetic characteristics of brown forest soils.

1. Formation at an altitude of 315-900 m above sea level under different plant biocenoses on well-drained parts of the slopes.
2. Soils profile is poorly differentiated into genetic horizons.
3. Granulometric varieties of soil are loamy and clayey.
4. Distribution of the gross forms of oxides in the soil profile depends on a combination of processes in soils, regardless of an area altitude. The high content of *Ti, Si, S, P*, as well as *Al* and *Fe* was also revealed within the whole soils profile not having anthropogenic nature.
5. The bulk composition reveals the homogeneity of all soil horizons, suggesting the lack of podzolization processes; high content of total iron (6 % average for all soils) followed by a predominance of silicate compounds in the composition allows to diagnose brown soil forming process.
6. Brown forest soils in the Middle Urals have a very acidic environment and actively manifest all forms of soil acidity.
7. Characteristics of group composition of humus showed that mountain soils of the Middle Urals have the following specific features: significant spatial variation of parameters of qualitative composition of humus; stretched humus profile; acidic and immature nature of humic substances; there was also noted the impact of altitude and slope exposure to conditions of humus formation.
8. Based on diversified studies of the properties of brown forest soils, there has been made an assumption of soils polygeneticity and the presence of paleohorizons in the profile, which indicates a change in environmental conditions during the formation of mountain soils in the Middle Urals.

Integrity of mountain ecosystems allows us to observe the development of soil in time and space and find a whole range of transition conditions and stages of soil formation in a small area. Soils located below the slope are constantly interact and contact with soils of overlying high-altitude belt and adjacent areas through gravitational movement of weathering products. Simultaneousness of processes of soil formation, weathering and denudation, having varying intensity, cause the diversity of soil cover so that even within a single altitude belt a spatial heterogeneity of soils can be observed. Spatial heterogeneity and evolution of the soils in the mountains is evident even within a soil type.

By the nature of the main and associated processes, brown soils at hypsometric levels of the Northern Basegi mountain form the next evolutionary series and are divided into the following subtypes: raw-organic dark humus brown soils (900 m), ferruginated brown soils (800, 655 m), ferruginated gleyey brown soils, metamorphosed dark humus brown soils (590 m), clayey illuviated dark humus brown soils (577 m), eluviated dark humus brown soils (565 m), eluviated brown soils (430, 400 m), raw-organic humic brown soils (383 m), clayey illuviated brown soils (315 m).

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References

[1] Kovda V.A. Similarities and differences in the history of the soils of the continents // Trans. 8th Int. Congr. Soil Science. Bucharest, 1964. vol. 1.

[2] FAO/UNESCO Soil Map of the World, 1:5,000,000. UNESCO, Paris, 1971-1975.

[3] Buol S.W., Hole F.D., Cracken R.J. Soil genesis and classification // The Lowa State Univ. Press, Amer. 1973.

[4] Rozanov B.G. The soil cover of the globe. M.: MGU, 1977. 248 p.

[5] Urushadze T.F. Some aspects of the soil formation in the mountainous regions // Soil science. 1979. № 1. P. 131-143.

[6] Soil Taxonomy. A Basic system of Soil Classification for Making and Interpreting Soil Surveys. Second edition. USDA. Washington D. C. 1999. 869 p.

[7] World Reference Base for Soil Resources 2006. A framework for international classification, correlation and communication. Food and Agricultural Organization of the United Nations. Rome. 2006. 128 p.

[8] http://polyera.ru/geografiya-pochv/1119-pochvennye-zony-gornyh-territoriy-chast-8.html

[9] Baumler R., Zech W., Heuberger H., Weber-Diefenbach K. Investigations on the intensity of weathering jf soils developed from glacial and fluvioglacial deposits and their relationship with the history of the landscape in the Mt. Everest region // Geoderma, 1991. 48. P. 223-243.

[10] Grosswald M.G., Kuhle M., Fastook J.L. Wurm Glaciation of Lake Issyk-Kul Area, Nian Shan Mts.: A Case Stady in Glacial History of Central Asia // GeoJournal. 1994. 33.2/3. P. 273-310.

[11] Brooks P.D., Schmidt S.K., Williams M.W. Winter production of CO_2 and N_2O from alpine tundra: environmental controls and relationship to inter-system C and N fiuxes // Gecologia. 1997. Vol.110. N. 3. P. 403-413.

[12] Farley R.A., Fitter A.H. Temporal and spatial variation in soil resources in a deciduous woodland // Journal of Ecology. 1999. Vol. 87. № 4. P. 688-696.

[13] Lee B. D., Sears S. K., Graham R. C., Amrhein C., and Vali H. Secondary mineral genesis from chlorite and serpentine in an ultramafic soil toposeqnence // *Soil Science Society of America Journal*, 2003, vol. 67, no. 4, P. 1309-1317.

[14] Wilkinson M.T. et al. Soil production in heath and forest Blue Mountains, Australia: influence of lithology and palaeoclimate // Earth Surface Processes And Landforms, 2005. 30: P. 923-934.

[15] Humphreys G.S., Wilkinson M.T. The soil production function: A brief history and its rediscovery // Geoderma 139. 2007. P. 73-78.

[16] Heimsath A.M., Hancock G.R. and Fink D. The 'humped' soil production function: Eroding Arnhem Land, Australia // Earth Surface Processes & Landforms, 34: 2009. P. 1674-1684.

[17] Fu G., Shen Z., Zhang X., Yu C., Zhou Y. and Yang P. Response of ecosystem respiration to experimental warming and clipping at daily time scale in an alpine meadow of Tibet // *Journal of Mountain Science*, 2013. vol. 10, P. 455-463.

[18] Yanhong L., Huimei W., Wenjie W., Lei Y., Yuangang Z. Ectomycorrhizal Influence on Particle Size, Surface Structure, Mineral Crystallinity, Functional Groups, and Elemental Composition of Soil Colloids from Different Soil Origins // The Scientific World Journal Volume, 2013. P. 1-13. http://dx.doi.org/10.1155/2013/698752

[19] Rammann E. Soil and climatic zones of Europe // Soil science. 1901. N 1. p. 5-18.

[20] Prasolov L.I. Mountain-forest soils of the Caucasus // Tr. Soil institute. 1947. T. 25. P. 5-28.

[21] Antipov-Karataev I.N. On the brown forest and brown soils // Soil science. 1947. № 12. P. 697-703.

[22] Liverovskii J.A., Kornblum E.A. Zonation of soils in submontane areas // Publishing house of USSR Academy of Sciences. Ser. geograph. 1960. № 3. P. 34-41.

[23] Stefanovits P. Broun forest soils of Hungary // Academiai Kiado, Budapest, 1971.

[24] Urushadze T.F. Soils of Georgia mountain forests. Tbilisi: Mentsiereba, 1987. 243 p.

[25] Zakharov S.A. Soils of mountain regions of the USSR // Soil science. 1937. № 6 P. 810-848.

[26] Zakharov S.A. On some controversial issues of mountain soil science // Soil Science. 1948. № 6. P. 347-356.

[27] Zonn S.V. Mountain forest soils of the Northwest Caucasus. M.: Publishing House of USSR Academy of Sciences, 1950. 333 p.

[28] Friedland V.M. Brown forest soils of the Caucasus // Soil science. 1953. № 12. P. 28-44.

[29] Retzer J.L. Soil formation and classification of forested mountain lands in the United States // Soil Science, 1963. vol. 96. N. 1.

[30] Stase H. a.o. A handbook of Australian soils. – Adelaide. 1968.

[31] Prehtel L.V. Silvicultural properties of brown forest and brown sod soils // FESU Scientific notes. 1969. T. 20. P. 62-79.

[32] Ohtsuka T., Hirota M., Zhang X. et al. Soil organic carbon pools in alpine to nival zones along an altitudinal gradient (4400–5300 m) on the Tibetan Plateau. // Polar Science, 2008. vol. 2. №.4. P. 277-285.

[33] Petrov B.F. Soils of Southern Sakhalin // Soil science. 1947. № 11. P. 641-651.

[34] Glazovskaya M.A. Soils of mountain regions of Kazakhstan // Publishing house of Academy of Sciences of the Kazakh SSR, soil science series. 1949. Issue 14. № 52. P. 191-220.

[35] Gradoboev N.D. Soils of larch forests of Siberia (Altai, Kuznetsk Alatau and Tuva) // Works on Siberia Forestry. 1955. Issue 2. – Novosibirsk.

[36] Ivanov G.I. Soils of mountain coniferous and deciduous forests of South Primorye // Komarovski readings. Vladivostok, 1957. Issue 6. P. 55-87.

[37] Gerasimov I.P. Brown forest soils in the USSR, European countries and the USA // Soil science. 1959. № 7. P. 61-68.

[38] Karpachevskii L.O. Some features of the soil forming in Kamchatka // Soil science. 1965. № 11. P. 1-10.

[39] Zonn S.V. Features of allitic soil-forming on the islands of Primorye and the Far East // Studying and development of the natural environment. M.: Science, 1976. P. 125-137.

[40] Firsova V.P., Gorjacheva T.A., Prokopovich E.V. Comparative characteristic of properties of mountain soils of the Middle Urals // Soil science. № 5. 1963. P. 16-25.

[41] Firsova V.P. On the problem of the distribution and properties of brown forest soils in the Urals // The collection Forest and soil: Tr. of All-Union Scientific Conference. Krasnoyarsk, 1968. P. 200-203.

[42] Firsova V.P. The soils of the taiga zone of the Urals and Trans-Urals. M.: Science, 1977. 175 p.

[43] Ivanova E.N. Mountain forest soils of the Middle Urals // Proceedings of the Soil Institute of the USSR Academy of Sciences, 1949. T. 30. P. 168-193.

[44] Mikhailova R.P. Micromorphological and chemical properties of brown raw-organic soils of central mountainous zone of the Middle Urals // Soil science. 1976. № 5. P. 18-28.

[45] Firsova V.P. Brown mountain forest soils of the Urals // Soil science. 1991. № 4. P. 47-58.

[46] Karpachevsky M.L., Shevchenko E.M. The ratio of lithogenic and cenogenetic factors in the formation of brown forest soils of the Middle Urals // Soil science. 1997. № 1 P. 22-30.

[47] Semikolennykh A.A., Bovkunov A.D., Aleynikov A.A. Soils and soil cover of the taiga belt of the Northern Urals (the Pechora river headwaters) // Soil science. 2013. № 8. P. 911-923.

[48] Rusanova G.V., Kuhri P. Soil on the border of the forest and alpine tundra of the Polar Urals // Soil science. 2001. № 4. P. 409-417.

[49] Dymov A.A., Zhangurov E.V. Morphological and genetic features of soilf of the Enganepe ridge (Polar Urals) // Soil science. 2011. № 5. P. 515-524.

[50] Dymov A.A., Dubrovsky Y.A., Gabov D.N. Pyrogenic change in illuvial ferruginous podzols (middle taiga, Komi Republic) // Soil science. 2014. № 2. P. 144-154.

[51] Dymov A.A., Zhangurov E.V. Diversity and genetic characteristics of soils of the Polar Urals // Perm Agricultural Gazette. 2014. № 3 (7). P. 45-51.

[52] Samofalova I., Luzyanina O., Maulina E., Kulkova L. Features soil mountain-taiga zone the middle urals // Igdir university jurnal of the institure of science and technology. 2(2EK: A): 2012. P.93-100.

[53] Samofalova I.A., Luzyanina O.A. Ecological and genetic characteristics of soils of mountain forest zone in the Middle Urals // Proceedings of the Samara Scientific Center of the Russian Academy of Sciences. 2013. T. 15. № 3(4). P. 1426-1431.

[54] Samofalova I.A., Luzyanina O.A., Kondratieff M.A., Mamontov, N.V. The elemental composition of soils in undisturbed ecosystems in the Middle Urals // Bulletin of the Altai State Agrarian University. 2014. № 5 (115). P. 67-74.

[55] Samofalova I.A., Luzyanina O.A. Sokolova N.V. Morphological and genetic features of soils in the subalpine zone (Middle Urals) // Actual problems of the humanitarian and the natural sciences. 2014. № 1 (60). Pt. I. P. 24-28.

[56] Samofalova I.A., Luzyanina O.A. "Basegi" reserve soils and their classification // Perm Agricultural Gazette. 2014. № 1 (5). P. 50-60.

[57] Samofalova I. Geochemical features of the elemental composition of soils in undisturbed ecosystems in the Middle Urals (for example the Reserve "Basegi") // French Journal of Scientific and Educational Research. No.2. (12), July-December, 2014. Vol. III. "Paris University Press". 2014. P. 156-170.

[58] Sofronitsky P.A. Geological outline // Proceedings of the fifth meeting on the chemical water geography and hydrogeochemistry of Perm region. PSU, Perm wepartment of geographical Society of the USSR, Institute of Karst and Speleology. Issue 4 (5). Perm, 1967. P. 26-41.

[59] Voskresensky S.S., Leontiev O.K., Spiridonov A.I. [et al.]. Geomorphological zoning of the USSR and adjacent areas: tutorial. M.: Higher School, 1980. 343 p.

[60] Gorchakovskii P.L. The flora of the alpine Urals. M.: "Science", 1975. P. 13-67.

[61] Theory and practice of chemical analysis of soils. / Ed. by L.A. Vorobeva. M.: GEOS, 2006. – P.344.

[62] Antonova Z.P., Skalaban V.D., Suchilkina L.G. Determination of humus in soils // Soil Science. 1984. № 11. P. 130-133.

[63] Schwertmann U. Relations between iron oxides, soil color, and soil formation // Soil color. SSSA Special Publication no 31. Madison, USA, 1993. P. 51-69.

[64] Classification and diagnosis of soils of USSR / comp. V.V. Egorov, V.M. Friedland. M.: Kolos, 1977. 225 p.

[65] Samofalova I.A., Luzyanina O.A. Mountain soils of the Middle Urals (for example, SNR "Basegi"). Perm State Agricultural Academy. Perm: Publishing House of HPE Perm State Agricultural Academy, 2014. 154 p.

[66] Orlov D.S., Sadovniko L.K. Soils chemistry. M.: Higher School, 2005. 558 p.