Министерство сельского хозяйства Российской Федерации
ФГБОУ ВО «Красноярский государственный аграрный университет»

В.В. Чупрова, О.В. Мартынова

Почвы Сибири: вопросы и ответы

*Учебно-методическое пособие
на английском языке*

Красноярск 2016

ББК 40.3(253)
Ч 92

Рецензент
И.В. Борисова, кандидат географических наук, доцент кафедры экологии и природопользования Сибирского федерального университета

Ч 92 **Чупрова, В.В.** Почвы Сибири: вопросы и ответы: учеб.-метод. пособие на английском языке / В.В. Чупрова, О.В. Мартынова; Краснояр. гос. аграр. ун-т. – Красноярск, 2016. – 27 с.

В издании приводятся вопросы и ответы по условиям формирования и состоянию функционирования почв и почвенного покрова Сибири в пределах Красноярского края. Рассматриваются в форме вопросов и ответов особенности почвообразования и возможности использования почв, распространенных в полярном, бореальном и суббореальном поясе Средней Сибири. Предложенные вопросы и ответы к ним на английском языке позволяют более углубленно изучать курс «Почвы Сибири» и использовать эти знания на международных конференциях и семинарах.

Предназначено для магистров, обучающихся по направлению подготовки 35.04.03 (110100.68) «Агрохимия и агропочвоведение», и для аспирантов – по направлению подготовки 06.06.01 «Биологические науки», профиль «Почвоведение».

ББК 40.3(253)

Печатается по решению редакционно-издательского совета Красноярского государственного аграрного университета

CONTENTS

INTRODUCTION

Soils of Siberia are studied by masters of the specialty 110100.68 «Agrochemistry and agropedology», postgraduates of specialty «Pedology» This science is very important for them. The specialists should know genesis of these soils and possibilities of their using. The area of the Krasnoyarsk region is 236670,9 hectares or 14 percent of the territory of Russia. Soil cover of the Krasnoyarsk region varies very much. Four soil zones and a lot of soil provinces are divided here. The variability of ecological conditions on its territory determines specific features of regional soil cover.

It is important to note that cryogenic factor is the most significant among other factors of soil genesis in Siberia. Many scientists researched specific features of regional soils and described them in their scientific works. Masters and postgraduates should study these books. The role of soil as the most important component of biosphere is shown in the list of recommended books.

Methodical book includes questions and answers about the genesis and evaluation of soils, their contents, properties and geography. All texts are written in English. We hope that studying of Siberian soils in English will be useful and interesting for masters and postgraduates.

1. Questions to the topics

1.1. Soil resources of the Krasnoyarsk region

1. Where is the Krasnoyarsk region situated?
2. What is the area of our region?
3. What is its proportion of the area of Russia?
4. How many lands of agricultural using are there in the Krasnoyarsk region?
5. What is the territory of arable lands in our region?
6. Name the causes of arable lands reducing in the Krasnoyarsk region.
7. When was the maximum arable lands reducing observed?
8. What is the area of arable lands in the taiga?
9. Name the territory of arable lands in the forest steppe of our region.
10. What is the area of arable lands in the steppes of the Krasnoyarsk region?
11. What crops are grown in the Krasnoyarsk region?
12. What is the wheat productivity in our region?
13. Name geographical landscapes on the area of the Krasnoyarsk region.
14. Name causes of soil genesis variability on the area the Krasnoyarsk region.
15. Where is the horizontal soil zoning observed in our region?
16. Where is the vertical soil zoning observed in our region?
17. Name types of lands and soils degradations in the Krasnoyarsk region.
18. Name the most important cause of soil degradation in the modern period of time.
19. What do you understand under rational using of soil resources?
20. What do you understand under sustainable development of agricultural areas?

1.2. Soil-geographical regionalization of the Krasnoyarsk region

21. What geographical areas are divided in the Krasnoyarsk region?
22. What soil-bioclimatic regions are divided in the Krasnoyarsk region?
23. What soil-geographical zones are divided in the Krasnoyarsk region?
24. What soil-geographical subzones are divided in the Krasnoyarsk region?
25. How many soil provinces are there on the territory of our region?
26. Why is regionalization of our region so difficult?

1.3. Conditions and features of pedogenic processes in the Krasnoyarsk region

1.3.1. Arctic area

27. Name the arctic zone.
28. How much is the precipitation in the arctic zone?
29. How long is the stable snow cover?
30. Name the plants of the arctic zone.
31. Name the subarctic zone.
32. How much is the precipitation in the arctic zone?
33. Describe the plants of the subarctic zone.
34. Name the main feature of climate in the arctic area.
35. Name parent materials in the arctic area.
36. Name cryogenic processes in the arctic area.
37. Name evident characteristics of soil genesis in the arctic area.
38. Name primary soil processes in the arctic area.
39. Name soils of the arctic area.
40. What are the symbols of pedogenic horizons in gley soils?
41. Name particle-size distribution and chemical contents of gley soils.
42. What are the symbols of pedogenic horizons in cryic brunisoils?
43. Name particle-size distribution and chemical contents of cryic brunisoils.
44. What are the symbols of pedogenic horizons in cryosoils?
45. Name particle-size distribution and chemical contents of cryosoils.
46. What are anthropogenic effects on the content and soil properties in the arctic area?

1.3.2. Boreal area

47. Name the territory of the boreal area.
48. How much is the precipitation in the arctic zone?
49. Name the type of water regime in soils of the boreal area.
50. Name the plants of the boreal area.
51. Name bio-climatic zones in the boreal area.
52. Is permafrost observed on the territory of the boreal area?
53. Name parent materials in the boreal area.

54. Name features of soil genesis in the boreal area.
55. What soil groups are divided in the boreal area?
56. Name primary soil processes in the boreal area.
57.Name main soil types in the boreal area.
58. Write genetic profile in gley podzolic soils.
59. What soil neoformations are observed in the horizon A_2 of gley podzolic soils?
60. What soil neoformations are observed in the horizon B of gley podzolic soils?
61. Name the features and causes of gleization in gley podzolic soils.
62. Characterize fertility of gley podzolic soils.
63. Name distinguished features of particle sized soils (grain sized soils).
64. Can you see particle sized soils (grain sized soils) in other regions of Russia or of the world?
65. Name subtypes of podzolic soils in the central taiga of the boreal area.
66. What are the symbols of pedogenic horizons in humic illuvial podzols?
67. What soil neoformations are observed in the horizon Bh of humic elluvial podzols?
68. What are the symbols of pedogenic horizons in elluvial ivou podzols?
69. What soil neoformations are observed in the horizon Bfe of elluvial ivou podzols?
70. Characterize productive capacity of podzols.
71. Why are there soddy podzolic soils in the southern taiga of the boreal area?
72. Write genesis profile of soddy podzolic soils.
73. What soil neoformations are observed in profile of soddy podzolic soils?
74. Name particle-size distribution and chemical content of soddy podzolic soils.
75. What is pH of these soils?
76. What is the fertility of these soils?

1.3.3. Subboreal area

77. Where is the subboreal area situated?
78. Name zones in the subboreal area.
79. What is the climate in the subboreal area?

80. How much is the precipitation in the arctic zone?
81. Characterize the relief in the subboreal area.
82. Name parent materials in the subboreal area.
83. Name the type of water regime in soils in forest steppe of the subboreal area.
84. Name the plants in forest steppe and steppe of the subboreal area.
85. What soils are dominated in the subboreal area?
86. Write genesis profile of gray forest soil.
87. What soil neoformations are observed in the horizon A_1 of gray forest soil?
88. What soil neoformations are observed in the horizon A_1A_2 of gray forest soil?
89. Name soil structure and neoformations in horizon B of gray forest soil.
90. Name particle-size distribution and chemical contents of gray forest soil.
91 .Name primary soil processes in the gray forest soil.
92. Write genesis profile of black soils.
93. Name subtypes of black soils.
94 Describe genesis profile of dark brown soils.
95. What soil neoformations are observed in the horizon A of black soil?
96. What soil neoformations are observed in the horizon Bea of dark brown soil?
97. Name distinguished features of black soils.
98. Name main properties of black soils.
99. Characterize productive capacity of black soils.
100. How are black soils used?

2. Answers to the questions

2.1. Soil resources of the Krasnoyarsk region

1. The Krasnoyarsk region is situated in the central Siberia. It stretches along the Enisey from the Arctic Ocean to the republic of Tyva. Its area includes the western part of Central Siberian plateau, the peninsula Taymyr, the eastern part of Western Siberian plain and the central part of the Altay-Sayans.
2. The area of the Krasnoyarsk region is 236 million hectares.

3. The proportion is about 14 percent of the total area of Russia.
4. There are 39, 9 million hectares of agricultural lands in our region.
5. The area of arable lands in our region is about 3 million hectares.
6. There are two causes. The first one is the change of land ownership. The second one is the economic decline in agrocomplex of our country.
7. The maximum reducing of arable lands in our region was observed in 2004.
8. Arable lands in the taiga occupy little area, only 5 percent of total arable area.
9. Arable lands in the forest steppe occupy 89 percent of the total arable area.
10. Arable lands area in the steppe is as small as in the taiga, only 6 percent of the total arable area.
11. Such crops as wheat, oat, potato, cabbage, beetroot, carrot and others are grown in our region.
12. Productivity of wheat is 2-2, 5 tons per hectare.
13. They are tundra, taiga, forest steppe and steppe.
14. The causes of variety are: a wide range of bioms from tundra to steppe; mountainous and flat relief; continental climate; permafrost and seasonal frost; variety of parent materials.
15. The horizontal zoning is observed in the mountains.
16. The vertical zoning is observed on the plains.
17. They are erosion, deflation, repacking, dehumification and soil pollution.
18. The main reason of soil degradation is soil deflation.
19. They are regulation of soil fertility, using of fertilizers and crop rotation.
20. Sustainable development of agricultural areas is the ability of agroecological systems to keep their structure and stable functioning by anthropogenic effects.

2.2. Soil-geographical regionalization of the Krasnoyarsk region

21. They are the arctic, boreal and subboreal areas.
22. On the area of the Krasnoyarsk region 5 soil-bioclimatic regions are divided. They are the Eurasian-arctic region of arctic soils and cryosoils; the west Siberian forest region of podzolic soils; the east Siberian region of

organic soils; the central forest steppe and steppe region of black soils; the Altay-Sayan mountain region of mountain forest soils.

23. Four soil-geographical zones are divided on the territory of our region. They are arctic and arctic tundra soils; arctic gley, cryic brunisoils and cryogenic soils; podzolic, gray forest and dark gray soils, black soils; dark brown soils.

24. Eight soil-geographical subzones are divided on the area of our region.

25. Thirteen soil provinces on the plains and nineteen provinces in the mountains are divided on the area of the Krasnoyarsk region.

26. The area of the Krasnoyarsk region is very variegated in ecological conditions of pedogenesis. There are plains, mountains, tundra, taiga, steppe, different parent materials and soils here.

2.3. Conditions and features of pedogenic processes in the Krasnoyarsk region

2.3.1. Arctic area

27. The arctic zone includes the archipelago of the North Earth (Severnaya Zemlya), mountains of the Byrranga and the North-Taymyr arctic desert.

28. The precipitation in the arctic zone is 200 mm in a year.

29. Steady snow cover lasts for nine months.

30. The plants of the arctic zone are mosses, lichens, blue green algaes.

31. The subarctic zone is situated to the south of the arctic zone to the borders of taiga.

32. The precipitation in the subarctic zone is 220-500 mm in a year.

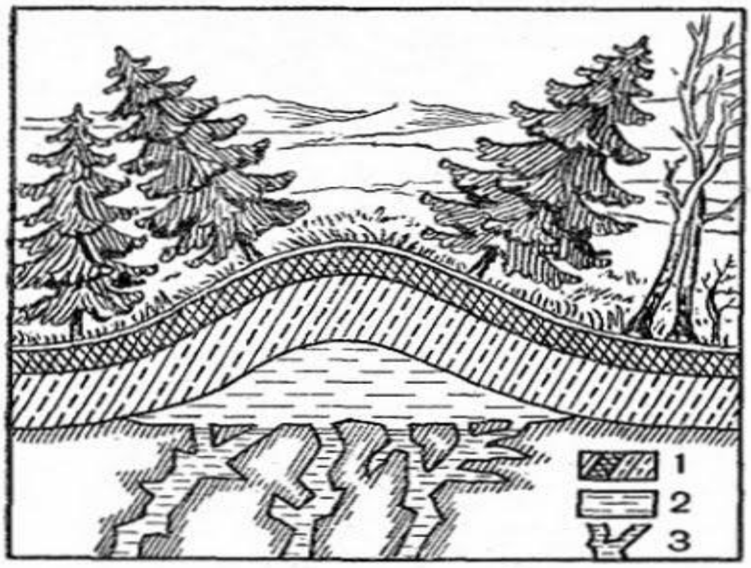
33. The plants of the subarctic zone are mosses and sparse larch forest.

34. Permafrost is the evident feature of climate in the arctic area.

35. They are elluvial-deluvial and glacial genesis. They have loamy, sandy or clay particle size distribution.

36. They are frost weathering, solifluction and thermokarst.

37. The main features of pedogenesis in the arctic area are comprehensiveness of soil cover, cryogenic processes and weak biological activity (fig. 1):



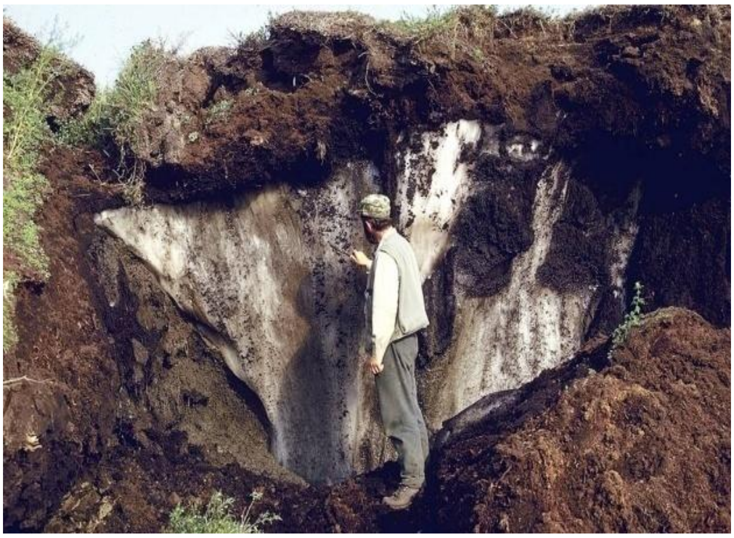


Figure 1 – Cryogenic processes

38. The primary soil processes in the arctic area are gleization, peat accumulation, podzolization, salinization, calcium carbonate formation, cryoturbation.
39. Soils of the arctic area are gley tundra, arctic cryogley, arctic sod, bog cryogenic, bog tundra, cryomorphic and cryoturbic, cryic brunnisoils.
40. The symbols of pedogenic horizons in gley tundra are Ao-A_1-Bq-G.
41. Gley tundra soils have low power profile, loamy particle size distribution, acidic or neutral pH, 1,5-10 percent of humus. The accumulation of movable humus and R_2O_3 is observed in them.
42. The symbols of pedogenic horizons in cryic brunisoils are O-BHF-C or O-BHF-G-CG.
43. Particle size distribution and chemical content of cryic brunisoils (tables 1, 2).

Table 1 – Particle size distribution of grain sized soils and cryic brunisoils (Karpenko, 2015)

Layer	Hori-zon	Depth, cm	The contents of fractions, %;mm							Particle size dis-tribution
			1–0,25	0,25–0,05	0,05–0,01	0,01–0,005	0,005–0,001	<0,001	<0,01	
The floodplain terrace of the river Kygym. Particle sized soils (grain sized soils)										
15	Bm,h	4–12	7,4	38,4	33,1	6,3	7,2	7,6	21,1	Light loam
	Bm	12–56	11,9	41,3	31,6	4,0	5,7	5,5	15,2	Sandy loam
	BC	56–73	27,8	36,6	20,8	4,6	4,8	5,4	14,8	″
	C	73–85	31,4	31,4	21,6	3,9	6,0	5,7	15,6	″
The average slope of the plateau. Cryic brunisoils										
19	Bh,f	6–13	9,4	30,7	33,3	5,9	10,7	10,0	26,6	Light loam
	Bh	13–22	22,5	32,7	27,5	4,2	9,0	4,1	17,3	Sandy loam
	BC	22–30	21,6	34,6	25,3	6,0	7,7	4,8	18,5	″

Table 2 – Some physic-chemical parameters of particle size soils and cryic bruni soils (Karpenko, 2015)

Hori-zon	Depth of samp-ling, cm	pH		Humus, per cent	Hydrolytic acidity	Exchangeable cations				Exchangeable cations According to Sokolov			Degree of saturation, per cent %
		wat.	salt.			Ca^{2+}	Mg^{2+}	H^{+}	total	H^{+}	Al^{3+}	total	
					mg·equ per 100 g of soil								
Layer № 15. Particle sized soils													
Ov	0–2	4,1	3,8	55,9*	28,4	15,7	2,9	13,2	31,8	0,03	1,2	1,23	53
Oms	2–4	4,0	3,7	37,6*	19,2	11,6	3,4	11,2	26,2	0,02	1,3	1,32	58
Bm,h	4–12	4,8	3,9	8,0	13,6	10,2	4,1	2,8	17,1	0,03	1,2	1,23	56
Bm	12–30	5,0	4,6	5,5	10,2	12,8	3,4	1,8	18,0	0,03	0,5	0,53	64
Bm	30–56	5,3	4,8	4,1	5,7	14,8	3,3	2,4	20,5	0,02	0,9	0,92	78
BC	56–73	6,2	5,5	3,1	2,3	18,1	3,0	1,1	22,2	0,02	0,8	0,82	91
C	73–85	6,8	5,8	1,8	1,8	19,1	2,9	0,1	22,1	0,03	0,7	0,73	92
Layer № 19. Cryic bruni soils													
Ov	0–2	4,5	3,2	74,5*	35,6	16,4	6,3	17,2	39,9	Not defined			53
Oms	2–6	4,7	3,6	48,9*	24,1	11,8	4,9	15,8	32,5	–	2,4	2,4	57
Bh,f	6–13	5,1	4,1	7,8	13,2	6,2	4,0	5,6	15,8	–	2,8	2,8	54
Bh	13–22	5,3	4,6	6,3	6,3	7,3	3,6	2,2	13,1	–	1,6	1,6	67
BC	22–30	5,9	4,8	2,1	3,0	6,6	3,0	0,8	10,4	–	1,8	1,8	78
Layer № 24. Cryic brunisoils													
Ov	0–1	4,1	3,7	52,8*	22,8	14,0	3,5	13,4	30,9	0,03	1,2	1,23	57
Oms	1–3	5,0	4,4	20,6*	17,1	17,4	2,8	12,3	32,5	–	0,4	0,45	65
Bh	3–8	4,5	3,8	5,8	8,7	16,5	3,8	2,2	22,5	0,02	0,4	0,42	72
BC	8–15	4,9	4,0	3,2	3,2	14,2	3,2	1,9	19,3	0,02	0,4	0,42	72
C	15–20	5,2	4,6	0,5	1,5	12,8	3,4	1,8	18,0	0,03	0,2	0,23	92

44. The symbols of pedogenic horizons in cryomorphic are O_{1qd}-(O_{2qd})-A_1O (A_1OB_d,tix; $A_1OB_{g,d,tix}$)-$B_{d,tix}$ ($B_{gd,tix}$).
45. Particle size distribution and chemical content of cryomorphic (tables 3, 4).

Table 3 – Particle size distribution of cryomorphic (Krasnoshchyokov, 2001)

Horizon	Depth of sampling, cm	1-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001	<0,01
Layer 11. Cryomorphic								
AB	9-13	0	13	44	10	14	19	43
Btx	15-25	0	13	46	9	16	16	41
mBCtx	40-50	0	6	47	7	20	20	47
Layer 11-05. Cryomorphic								
Bd	20-30	0	19	44	7	10	20	37
mC	35-45	0	12	47	7	13	21	41

Table 4 – Some physic-chemical parameters of cryomorphic (Krasnoshchyokov, 2001)

Hori-zon	Depth of samp-ling, cm	pH		Hu-mus, %	Hydrolyt-ic acidity	Exchangeable ca-tions			Degree of satu-ration , %
						Ca^{2+}	Mg^{2+}	H^+	
		wat.	salt.		mg·equ per 100 g of soil				
Layer 11. Cryomorphic									
O	0-3	4,3	3,7	95,3	51,4	20,0	8,7	14,2	35,8
ATH	3-9	4,2	3,4	64,6	57,5	33,1	11,1	19,3	43,4
AB	9-13	4,9	5,6	7,7	15,8	18,3	7,6	6,5	62,1
Btix	15-25	6,2	5,0	2,1	5,2	22,8	9,2	0,5	86,0
mBCtix	40-50	6,9	5,0	1,1	2,3	26,0	10,9	0,1	94,1
Layer 11-05. Cryomorphic									
O	0-3	5,1	4,5	89,3	138,0	43,8	16,3	2,4	30,3
AT	3-20	5,5	4,7	85,1	132,0	44,7	14.1	1,1	30,8
Bd	20-30	6,5	5,4	6,5	3,1	22,5	9,5	0,2	91,2
mC	35-45	6,7	5,5	4,4	2,3	22,6	9,2	0,2	93,3

46. As results of anthropogenic effects we can observe intensification of solifluction and thermokarst, displacement of genetic horizons, pollution of the JSC «Norilsk nickel».

2.3.2. Boreal area

47. The boreal area is situated to the south of the arctic area. Its area includes the Enisey part of west Siberian plain and right bank terraces of the Enisey.
48. The precipitation in the boreal area is 400-600 mm in a year.
49. The types of water regime in soils of the boreal area are flushing and permafrost.
50. The plants of boreal area are larch, spruce, fir, cedar, birch, pine, aspen.
51. Bio-climatic zones in the boreal area are the northern taiga, the central taiga and the southern taiga.
52. Permafrost is observed.
53. They are products of weathering and denudation.
54. Soil genesis in the boreal area is influenced by cold, wet, continental climate, forest and taiga plants, loamy and sandy parent materials, permafrost and seasonal frost. The evident features of soil genesis are predominance of semihydromorphic and hydromorphic soils; podzolization; illuviation of humus and R_2O_3; increase of biological activity in soils of the southern taiga; reduction of soil comprehensiveness and cryogenic processes in the direction from the northern to the southern taiga; formation of brown forest soils in the central and the southern taiga.
55. They are soils of the northern, the central and the southern taiga.
56. The primary soil processes in the boreal area are mat formation; humus and peat accumulation; podzolization; gleization; formation of brown forest soils.
57. Soils of the boreal area are gley podzols,humic illuvial podzols, cryic brunisols, cryosoils, moor soils, soddy podzols, particle sized soils.
58. Genetic profile of gley podzolic soils is O-ELq-BEL-BT-C or Ao-AoA_1-A_2-A_2Bq-B-C (fig. 2).

Figure 2 – Gley podzolic soil

59. Such soil neoformations as oxides of Si and oxides of Fe are observed in the horizon A_2 (ELq) of gley podzolic. The horizon A_2 is elluvial.
60. Such soil neoformation as oxides of Fe and cutanes from organic mineralogical substances are observed in the horizon B of gley podzolic soils. This horizon is illuvial.
61. Causes of gley formation are waterlogging and lack of oxygen. The change of reductive and oxidative pedogenic conditions is the result of waterlogging. For this reason, these soils are heterogeneous in colour and are characterized by brownish spots and bluish or greenish ones due to gleization.
62. The fertility of gley podzolic soils is low. They cannot be used for agriculture.
63. The particle sized (grain sized) soils were first allocated by Yu. I. Ershov on the plateau Putoran. Their distinguished features are peaty mat; illuvial-metamorphic horizon Bos, m, h; spherical structural units; no signs of podzolization.

64. We can see the particle sized soils in other regions of Russia and around the world. These soils are not introduced in the Russian and world classifications.
65. The subtypes of podzols in the central taiga of the boreal area are podzolic, podzolic humic illuvial, podzolic ferrous illuvial soils (fig. 3).

Figure 3 – Podzol humic ferrous illuvial

66. The symbols of pedogenic horizons in humic illuvial podzols are Ao-AoA$_1$-A$_2$-Bh-C or O-EL-BEL-BH-C.
67. Such soil neoformations as humus and other organic substances are observed in the horizon Bh or BH of podzolic humic illuvial soils.
68. The symbols of pedogenic horizons in podzolic ferrous illuvial soils are Ao-aoA$_1$-A$_2$-Bfe-C or O-EL- BEL-BF-C.
69. Such soil neoformation as concretions oxides of Fe are observed in the horizon Bfe or BF of podzolic ferrous illuvial soils. This horizon has red, yellow or red brown colour (tables 5, 6).
70. The fertility of podzols is low.

Table 5 – Chemical content of podzolic ferrous illuvial soils (Bezkorovaynaya, Tarasov, Ivanova et al., 2007)

Index of horizon	Depth, cm	Depth, cm	pH		Hr	EKO	V,%	Mobile, mg/kg	
			H_2O	KCl	Mg-eguivalent/100 gr			P_2O_5	K_2O
Sym plain, central taiga (60° N, 89° E)									
O	0-5	78,7	3,63	2,80	14,49	-	-	250,0	163,0
E	5-10	0,31	4,59	3,69	1,34	4,41	69,6	5,5	9,0
B_{f1}	10-20	0,52	4,91	4,05	1,71	5,06	66,2		
B_{f1}	20-30	0,45	5,33	4,46	1,89	5,72	67,0		

Table 6 – Chemical content of podzolic soil (Bugakov, Chuprova, 1995)

Index of horizon	Depth, cm	Depth, cm	Shaft		Mg-eguivalent/100 gr		pH		<0,01 mm
			N	P_2O_5	EKO	Hr	KCl	H_2O	
Podzolic, Eniseysk									
AYEL	0-17	0,67	0,05	0,11	3,2	3,8	4,5	5,0	14
EL	28-38	0,25		0,09	4,0	1,9	4,2	4,8	11
BEL	54-64	0,30		0,21	12,4	2,3	5,4	5,9	19
Gley brown podzolic soil, v. Bartat									
AY	4-13	4,83	0,26	0,16	10,0	4,4	4,9	5,4	15
EL	13-28	0,26		0,07	1,6	1,6	4,2	4,8	10
BEL	43-58	0,33		0,12	2,3	2,3	5,5	6,0	20
BT	60-70	0,40		0,12	3,4	2,5	5,7	6,0	22

71. Plants of the southern taiga are more varied than plants of the northern taiga. There are coniferous-deciduous forest and various wood grasses here. Phytomass of grasses is 10-20 tons per hectare, where roots are dominated. It promotes the development of the sod pedogenesis. However, podzolization is kept in the condition of coniferous-deciduous forest and flushing water regime.

Sod process- the pedogenic process characterized by the accumulation of ash elements and mull type of humus. The following process is one of the important pedogenic processes characterizes the soil genesis in steppe, prairie and some other landscapes.

Podzolization-the sum of elementary pedogenic processes resulting in the genesis of podzols.

72. The symbols of pedogenic horizons in the soddy podzolic soils are Ao-AoA_1-A_1-A_2-B-C or O-AY-EL-BEL-BT-C.

73. Such soil neoformations as humus, oxides of Si, oxides of Fe and cutanes from organic mineralogical substances are observed in the profile of soddy podzolic soils.

74. Particle-size distribution and chemical content of soddy podzolic soils (see table. 6).

75. These soils have acidic pH.

76. The fertility of soddy podzolic soils is higher than that one of podzolic soils. They are used for agriculture.

2.3.3. Subboreal area

77. The subboreal area is situated to the south of the boreal area, in the south of the Krasnoyarsk region.

78. The bio-climatic zones in the subboreal area are forest-steppe and steppe.

79. The climate of the subboreal area is sharply continental.

80. The precipitation in this area is 350-450 mm in a year.

81. The subboreal area has mountain-basin relief. The Krasnoyarsk, Kansk, Achinsk-Bogotol and Chulym-Enisey basins are distinguished here. They are separated from each other by hills.

82. They are brown clay and lessivage loam. They contain calcium carbonates.

83. The types of water regime in soils of the subboreal area are periodically flushing and non-leaching.

84. The plants in the forest-steppe are herbal sparse forests of birch, aspen, seldom of pine. The plants of steppe are cereals and fescue grasses feather. The most part of natural areas is replaced by agrocenosis.

85. Such soils as gray forest and black soil are dominated here. But we can observe other types of soils. For example, alluvial and alluvial meadow soils. They are presented in the river valleys.

86. The symbols of pedogenic horizons in gray forest soil are Ao-A_1-A_1A_2-B-C or O-AY-AEL-BEL-BT-C.

87. Such soil neoformations as humus and oxides of Si are observed in the horizon A_1 (AY) of gray forest soil.

88. Such soil neoformation as oxides of Si and humus are observed in the horizon A_1A_2 (AEL) of gray forest soil. It contains more oxides of Si and less humus than horizon A_1 (AY).
89. Soil structure in the horizon B (BT) is nutty and prismatic. Such soil neoformation as cutanes from organic-mineral substances and concretions of oxides of Fe^{+3} are observed in the horizon B (BT) of gray forest soil. This horizon is thick and brown in colour.
90. Particle-size distribution and chemical content of gray forest soils.

Table 7 – Subboreal area

Index of horizon	Depth, cm	Humus, %	Mg-eguivalent/100 gr				pH_{KCL}	%	
			Ca^{++}	Mg^{++}	Hr	EKO		<0,001	<0,01
Light gray forest soil, Kozulka district									
A_1	3-12	3,41	16,8	3,2	3,2		5,6	28,2	49,7
A_1A_2	14-22	1,14	9,1	0,9	2,4		5,4	24,2	50,2
B_1	30-40	0,64	10,1	1,5	3,6		4,8	31,6	56,1
B_2	65-75						4,8	39,3	60,4
Gray forest soil, Kazachinskoe district									
A_1	0-15	5,90	25,6	4,2	4,2		6,1	15,8	47,3
A_1A_2	17-27	2,48	14,4	3,5	4,2		6,2	24,0	62,4
A_2B	27-34	1,40	15,6	4,2	3,5		5,9	37,4	65,7
B	39-49	0,83					5,6	36,4	54,1
Dark gray forest soil, Kozulka district									
A_1	6-16	8,64	36,1	3,5	2,4		6,4	14,2	38,7
A_1A_2	21-31	3,67	24,2	2,6	3,3		6,2	14,3	40,3
A_2B	38-48	2,33	18,3	3,1	2,1		6,5	21,9	50,3
B	90-100						6,8	25,1	61,1

91. The primary soil processes in gray forest soil are humus accumulation, eluvialization and illuvialization.
92. The genetic profile of black soils (chernozem) is A-AB-B_1-Bn-Ck or AU-BI-Cca (table 7).

Figure 4 – Humus accumulation in black soils: A (AU)-AB (AUBI)

93. Subtypes of black soil are dark gray soil and dark brown soil.
94. The genetic profile of dark brown soil is A-AB-Bk-Ck or AU-BCAmc-BCAq-Ccaq.
95. Such soil neoformation as humus is observed in the horizon A (AU) of black soil.
96. Such soil neoformations as concretions of calcium carbonates are observed in the horizon B (BCA) of black soil.
97. Distinguished feature of black soil pedogenesis is humus accumulation.
98. Chemical contents of black soil (agrochernozem luvic) in the training farm «Minderlinskoye» (table 8).

Table 8 – Chemical contents of black soil (agrochernozem luvic) in the training farm «Minderlinskoye»

Index of horizon	Depth, cm	Humus, %	Mg-eguivalent/100 gr			pH_{KCL}	V, %	Content of nutrients, mg/kg		
			S	Hr	EKO			N-NO_3	P_2O_5	K_2O
A	0-26	6,5	17,2	0,1	17,4	6.0	99	15	253	263
A	26-65	5,0	19,7	0,8	20,5	5,9	96	14	134	223
AB	65-86	3,8	22,7	1,4	24,1	6,3	94	13	193	208
B	86-107	1,6	16,9	2,1	19,0	6,2	89	9	123	163
$B_к$	107-150	1,3	8,9	1,5	10,4	6,2	93	7	93	178

99. The fertility of black soils is high. They are characterized by large supply of humus and nutrients, neutral pH and good physical properties. It is the most fertile soil on the Earth. It is important to remember that V.V. Dokuchaev considered black soils to be the kings of soils.

100. Black soils are used as arable lands. Various agricultural plants are grown on them. The main one is wheat. Its productivity in the Krasnoyarsk region is 2-4 tons per hectare.

CONCLUSION

The Arctic is experiencing the highest rates of warming compared with other world regions that will likely have great impacts on high-latitude ecosystems The large and potentially volatile carbon pools stored in Arctic soils have the potential for large emissions of greenhouse gases in the form of both CO_2 and CH_4 under warmer and potentially drier conditions, resulting in a positive feedback to global warming. Further, climatic changes may impact vegetation development and affect water and energy exchange in tundra ecosystems, with consequences for permafrost thaw depth and concomitant soil carbon release to the atmosphere. The response of soil organic matter decomposition to increasing temperature is a critical aspect of ecosystem responses to global change. It has been suggested that a warmer and drier climate in Arctic regions might increase the decomposition rate and, hence, release more CO_2 to the atmosphere than at present.

Besides expected changes within the soil itself, changes on the vegetation development are observed and expected for future warming. Plant species composition may greatly affect rates of soil processes, including decomposition. In general, species within a growth form (graminoids, evergreen shrubs, deciduous shrubs, and mosses) are more similar in their effects on decomposition than species belonging to different growth forms, with graminoid litter having the fastest rate and litter of deciduous shrubs and mosses having the slowest rates. Gough et al. found that soil pH was significantly correlated with plant species richness and density at larger spatial scales.

Abiotic soil factors have a strong influence on vegetation development, since plant growth in tundra regions is typically limited by temperature and nutrient availability. Without knowledge of the present chemical composition of the soil it is not possible to estimate how and with which magnitude vegetation changes will take place, thus limiting our understanding of climate-vegetation-permafrost feedbacks. Arctic vegetation is expected to be more shrub dominated with rising temperatures which may positively feedback to summer atmospheric heating by decreasing the surface albedo. On the other hand, an increase in shrub cover may concomitantly also lead to summer soil cooling and decreasing permafrost thaw by shading the soil surface, thus potentially slowing down soil carbon turnover. More knowledge on the relationships between soil properties and vegetation composition is however required to accurately predict the consequences of climate-induced vegetation shifts for soil carbon pools in the Arctic.

The presented results show that reflectance spectroscopy can be used for fast quantification of multiple soil properties in the Siberian tundra, although drying of the soil samples is required before measuring reflectance. As such, it can be a useful tool to achieve a higher sampling density for soil properties in tundra ecosystems, where logistics limit the collection and chemical analysis of a large number of samples. In situ reflectance spectroscopy can be used to determine total C. Soil properties show large variation over short distances, requiring intensive sampling to achieve good regional estimates of, for example, carbon stocks. To allow good estimates of carbon stocks in the area, it is important to increase maximum sampling depth and determine bulk density for each sample. Because of the relation between vegetation species and soil properties, plant species composition can be used to give a qualitative indication about the soil properties below the surface.

We hope that the following questions and answers about Siberian soils will be interesting for masters and postgraduates. Studying this material in English will help to prepare for master exams and to promote in communication with foreign colleagues.

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Почвы Сибири: вопросы и ответы

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Чупрова Валентина Владимировна

Мартынова Ольга Валерьевна

Редактор Л.Э. Трибис

Санитарно-эпидемиологическое заключение № 24.49.04.953.П. 000381.09.03 от 25.09.2003 г.
Подписано в печать 21.01.2016. Формат 60x90/16. Бумага тип. № 1.
Печать – ризограф. Усл. печ. л. 2,0. Тираж 108 экз. Заказ №
Редакционно-издательский центр Красноярского государственного аграрного университета
660017, Красноярск, ул. Ленина, 117