IOP Conf. Series: Earth and Environmental Science **201** (2018) 012010 doi:10.1088/1755-1315/201/1/012010

Some aspects of soil development in small sandy catchments of ancient river valleys (a case study of Ob-Tom interfluve)

A O Konstantinov[1], E Yu Konstantinova[2], S V Loiko[3] and S P Kulizhskiy[4]

[1]Geology of Oil and Gas Research Education Center, Tyumen Industrial University, Volodarskogo Street 56, Tyumen, 625000, Russia
[2]Institute of Earth Sciences, University of Tyumen, Chervishevsky tract Street 13, Tyumen, 625008, Russia
[3] Laboratory of biodiversity and landscape ecology Tomsk State University, Lenin Avenue 36, Tomsk, 634050, Russia
[4]Institute of Biology, Tomsk State University, Lenin Avenue 36, Tomsk, 634050, Russia

E-mail: konstantinov.alexandr72@gmail.com

Abstract Aeolian sands and ancient dune fields are widely widespread in the southern part of Western Siberia. Aeolian landscapes formed in the bottom part of large ancient valleys, on the surfaces of modern fluvial terraces and near large lake systems are characterized by the unique soil cover which is determent by the sedimentalogical, mineralogical and granulometric properties of sands and very slightly dependent from local vegetation and climate. Soils of ancient inland dune landscapes located within the ancient valleys of Ob-Tom interfluve were investigated. It was shown that local topography is the main factor controlling the diversity of soils. Soils developed in dune topographical sequences differ from each other in the thickness of eluvial-illuvial horizons, content of humus and oxalate-extractable iron. Humus accumulation and podsolization process are rather poor because of the low ash content in the litter, intensive natural and anthropogenic dynamics of aeolian landscapes and adjacent soils. The fact that processes of lateral podsolization determine the processes of soil development in such landscapes has been established. All soils are characterized by a small thickness of the modern profile – 50 cm and even less for the flat surfaces of dunes. Clayey lamellaes typical for aeolian sediments are present in the bottom parts of soils profiles, located in the lower part of the dune-interdune sequence. It is rather obvious that thick cemented lamellaes are a powerful soil-geochemical barriers that largely determines the conditions for lateral and radial migration.

1. Introduction

Aeolian coversands and inland dunes are rather widespread within the territory of Western Siberia. Sandy deposits and dune fields are mainly associated with second high river terraces and ancient valleys-large rectilinear depressions, underlined by the distribution of vegetation, soils, lakes and bogs [1]. Soils within the ancient valleys are intrazonal: similar profiles are typical for such soils formed in a fairly wide range of natural zones from the middle taiga to the dry steppes of the Altai and northern Kazakhstan [2]. As well as the development of modern soil cover of ancient valleys occurs with the violation of the zonal trend and soils formed on aeolian sandy sediments show significant intra-group

IOP Conf. Series: Earth and Environmental Science **201** (2018) 012010 doi:10.1088/1755-1315/201/1/012010

variability depending on rather small changes in mineralogical and granulometric composition of sands, position in the relief and groundwater level. The main objective of this research is to determine the main properties of sandy soils formed in the areas of dune relief, depending on their landscape position.

2. Materials and methods

The study area is located within the Chernorechenskaja ancient valley at the site of its interface with the complex of modern fluvial terraces of the Tom River (Figure 1). Absolute heights decrease in the northeast direction from 165 meters above sea level near the Ob river to 115–120 m near the Tom river, the height of the sides above the varies from 20–30 m [3]. The bottom of the valley is complicated by linearly stretched ancient sand dunes, overgrown with pine forest. Brunic Arenosols form on the tops of dunes under greenish pine stands, while Endolamellic Arenosols form on the slopes under cowberry-green pine forests.

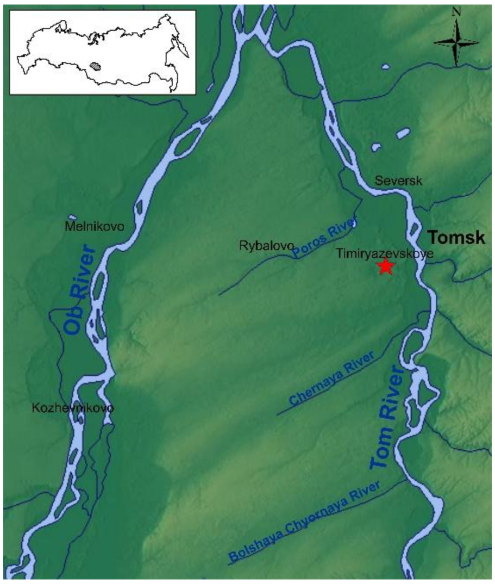

Figure 1. Ob-Tom interfluve. Asterisk shows the location of research area.

Pantolamellic Arenosols or Entic Podzols and more rarely Chromic Arenosols are confined to the less sorted silty sands of inter-dune depressions under pine forests with herbaceous and sedge-grasses [4].

The objects of the study were the soils of a closed inter dune depression: profiles 1 and 5 characterize flat surface of the dune, profiles 2 and 4 – slopes, and profile 3 – the bottom of the closed inter-gradient depression.

57 soil samples were selected from each genetic horizon along the entire thickness of the profile, the description and classification of soils were made in accordance with [5], sample preparation was carried out according to a standard procedure [6]. Organic carbon contents was determined by the Tyurin method and oxalate-soluble Fe according to Tamm using the Analytik Jena atomic absorption spectrometer of the Novaa series (Germany).

3. Results and discussion

The soil cover of the studied sequence is formed in a strong accordance with the composition of the sediments and the position in the relief (Figure 2). Brunic and Dystric Arenosols are formed on the tops of sandy dunes under greenish pine and cowberry-greenish pine forests (profiles 1 and 5), Pantolamellic and Endolamellic Arenosols develop on weakly graded sands on the slopes (profiles 2 and 4) and in the bottoms of inter-dune depressions (profile 3) under pine with pine undergrowth, rowan, stone berry, herbaceous and sedge-grasses greenish forests.

The humus profile of Arenosols formed in elevated positions (slopes and flat surfaces of dunes) is very short. Signs of humus accumulation are manifested in the form of humus incorporation in Podzol horizon (Eh) in profiles 1 and 5. Humus content sharply decreases down the soil profile and at a depth of 20–30 cm it does not practically exceed 0.2–0.3%, humus is practically absent deeper (less than 0.01%), with the exception of thick lamellaes (up to 0.2%; profiles 2, 4). At the same time high peatification degree of the litter-peat horizon is characteristic for soils of inter-ridge depressions (profile 3), which indicates a greater moisture content in comparison with upper slope positions. Unlike soils of autonomous positions and slopes, the boundaries of the horizons are even, and the transitions to the underlying horizons are gradual, the signs of turbidity of the surface horizons are poorly expressed. It can be assumed that lamellaes in the lower part of the profile serve as a waterproof layer and cause periodic water-logging, which also may affect the humus content. Thus, the content of humus in the upper part of organic horizons is 4 and 5%, (respectively for profiles 1 and 3), the thickness of the humus profile is less than 10 cm. At a depth of 30–40 cm the humus content in Bhs is only 0.3–0.5%. The increase in the content of humus in the lower part of the profile may be associated with thick lamellaes. Gley bleaching, mobilization of iron and its partial removal outside the soil profile in restorative conditions, is also observed there.

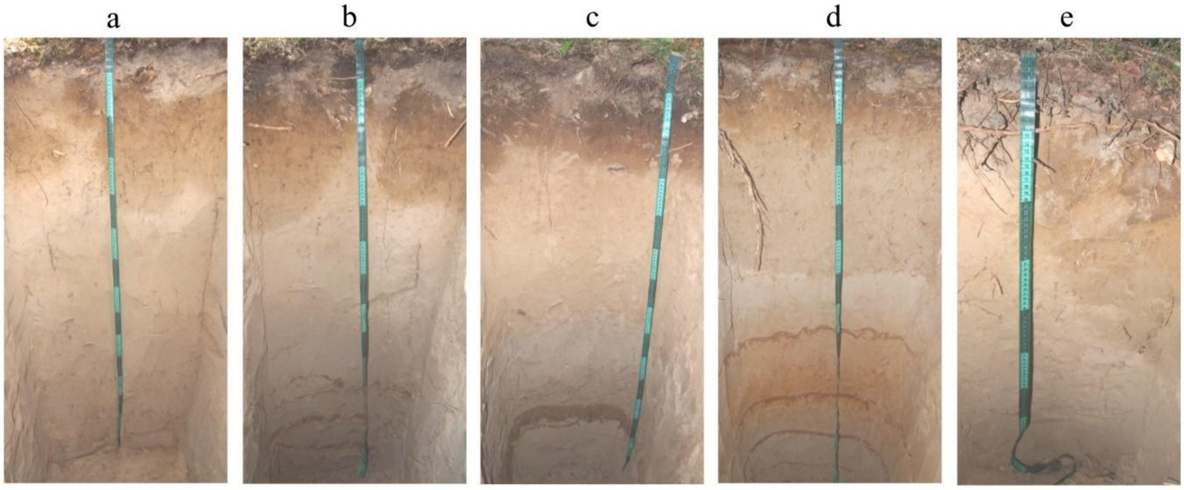

Figure 2. Soils of the research area: a – Brunic Arenosol (profile 1), b – Pantolamellic Arenosol (profile 2), c – Pantolamellic Arenosol (profile 3), d – Endolamellic Brunic Arenosol (Endostagnic) (profile 4), e –Dystric Arenosol (Endostagnic) (profile 5)

Table 1. Physicochemical characteristics of the soils

Profile	Horizon	Sample depth (cm)	Munsell color		pH	Humus (%)	Fe_o (%)
			Moist	Dry			
1	Oe-Oa	2	-	-	-	-	-
	Oa/Eh	6	2.5Y 3/2	2.5Y 5/2	5.0	4.31	0.16
	Eh	9	2.5Y 3/3	2.5Y 5/3	5.6	0.87	0.09
	Bhs	19	2.5Y 4/4	2.5Y 6/3	6.1	0.29	0.14
		30	2.5Y 5/4	2.5Y 7/3	6.2	0.18	0.06
	C1	45	2.5Y 4/3	2.5Y 7/3	5.8	0.09	0.06
		65	2.5Y 5/4	2.5Y 7/3	6.3	0.03	0.05
	C2	105	2.5Y 5/4	2.5Y 7/3	6.6	0.01	0.05
		155	2.5Y 4/3	2.5Y 6/3	6.8	0.08	0.07
2	Oe	3	-	-	-	-	-
	AB	7	2.5Y 3/2	2.5Y 4/2	4.7	4.29	0.16
		12	2.5Y 3/2	2.5Y 5/2	5.7	1.73	0.16
	Bhs	18	2.5Y 3/3	2.5Y 6/3	5.7	0.76	0.14
		30	2.5Y 4/3	2.5Y 7/3	6.3	0.30	0.19
		40	2.5Y 4/3	2.5Y 7/3	6.1	0.18	0.23
	BC	75	2.5Y 5/3	2.5Y 7/2	6.3	0.11	0.08
	C	100	2.5Y 5/3	2.5Y 7/2	6.3	0.04	0.06
		135	2.5Y 4/3	2.5Y 7/3	6.4	0.05	0.06
	Lamellae 1	134	10YR 4/4	10YR 6/3	6.5	0.01	0.11
	Lamellae 2	151	10YR 4/4	10YR 6/3	6.3	0.16	0.10
	C2	165	2.5Y 5/4	2.5Y 6/3	6.4	0.10	0.07
3	Oa	3	-	-	-	-	-

IOP Conf. Series: Earth and Environmental Science **201** (2018) 012010 doi:10.1088/1755-1315/201/1/012010

Profile	Horizon	Sample depth (cm)	Munsell color		pH	Humus (%)	Fe_o (%)
			Moist	Dry			
	AB	8	2.5Y 2/1	2.5Y 4/2	5.0	5.02	0.31
		16	2.5Y 3/2	2.5Y 4/2	5.5	4.27	0.38
	Bhs	23	10YR 2/3	10YR 5/3	5.6	1.66	0.33
	BC	45	10YR 4/4	2.5Y 6/3	5.7	0.24	0.16
	C	75	2.5Y 5/3	2.5Y 7/3	6.1	0.11	0.08
		90	2.5Y 5/3	2.5Y 7/2	6.2	0.04	0.07
		120	2.5Y 5/3	2.5Y 7/2	6.2	0.01	0.09
	Lamellae 1	132	10YR 4/3	10YR 5/3	5.9	0.22	0.27
		155	2.5Y 5/4	2.5Y 6/3	6.0	0.08	0.04
4	Oe	3	-	-	-	-	-
	AB	5.5	2.5Y 3/2	2.5Y 3/1	4.1	-	0.11
		8	2.5Y 3/2	2.5Y 5/2	4.3	4.89	0.09
	Bhs	17	2.5Y 4/4	2.5Y 6/4	5.5	0.50	0.09
	BC	35	2.5Y 4/3	2.5Y 7/3	5.8	0.20	0.03
		75	2.5Y 4/3	2.5Y 7/3	6.1	0.12	0.04
	Lamellae 1	84	10YR 4/4	10YR 6/3	6.3	0.06	0.11
	BC	95	10YR 4/4	10YR 6/4	6.3	0.02	0.08
	Lamellae 2	113	10YR 4/6	10YR 6/4	6.3	0.11	0.19
	C1	125	2.5Y 5/4	2.5Y 7/3	6.4	0.01	0.07
	Lamellae 3	132	10YR 4/4	10YR 6/3	6.1	0.21	0.13
	C2	145	2.5Y 5/4	2.5Y 7/3	6.4	0.04	0.04
5	Oi-Oe-Oa	2	-	-	-	-	-
	Oa/Eh	5	2.5Y 3/3	2.5Y 5/2	4.5	3.47	0.15
	Eh	8	2.5Y 4/2	2.5Y 5/3	5.1	0.45	0.08
	Bhs	20	2.5Y 4/3	2.5Y 7/3	5.7	0.24	0.1
	BC	55	2.5Y 5/4	2.5Y 7/3	5.9	0.07	0.05

Fe_o – oxalate extractable iron

The distribution of oxalate-soluble iron in sandy soils is an important diagnostic parameter that makes it possible to estimate the intensity of eluvial-illuvial processes and lateral migration of iron in profile formation [7]. There are several main zones of accumulation of oxalate-soluble iron in the profile; the distribution of iron in soils of autonomous positions is accumulative in nature, associated with a higher content of humus in the upper horizons. The maximum accumulation of amorphous iron compounds (profiles 1 and 5) is observed in the AB horizons - about 0.15–0.2%, and with depth it drops sharply to 0.01% in the weakly ferruginized horizon BC and C. The accumulation of oxalate-soluble iron occurs in the Bhs horizons and thick lamellaes. The maximum content of oxalate-soluble iron was observed for the Pantolamellic Arenosol (profile 3) developed in the bottom of a depression with a close groundwater level – AB (0.38), Bhs (0.33) and lamellae (0.27).

4. Conclusions

The clearly expressed confinement of each soil profile to a specific location in the relief is typical for the inland dune landscapes. Formation of soil cover occurs in accordance with the composition of sediments, the level of groundwater and its current fluctuations, the steepness and exposition of slopes. All soils are characterized by a small capacity of the modern profile – about 50 cm. Al-Fe-humus process is decisive in the formation of soils studies soils, while humus accumulation and podsolization process are poorly expressed due to the failure of sand filtration, low ash content of litter, dynamics of soil formation and manifestations of lateral migration. Flat cemented lamellaes are powerful soil-geochemical barriers that largely determines the conditions for lateral and radial migration of matter in the dune landscapes. The formation of more developed soils with a pronounced differentiation of the profile in the bottom part of interdune depressions is due to the lateral addition of matter from the entire catchment area [8-9].

Acknowledgments
The results were obtained while fulfilling the government orders from the Ministry of Education and Science of the Russian Federation (Projects Ministry of Education and Science of the Russian Federation № 5.4004.2017/4.6). PhD student A O Konstantinov was supported by the Russian Foundation for Basic Research (No. 17-35-50007 mol_nr).

References
[1] Grosvald M G 1999 *Evraziiskie gidrosfernye katastrofy i oledenenie Arktiki: Opyt geomorfologicheskogo analiza paleogidrologicheskikh sistem materika* ed V M Kotlyakov (Moscow: Nauchnyi mir) p 120 (In Russian)
[2] Gael A G and L F Smirnova 1999 *Peski i peschanye pochvy* (Moscow: GEOS) p 252 (In Russian)
[3] Maloletko A M 2008 *Evolyutsiya rechnykh sistem Zapadnoi Sibiri v mezozoe i kainozoe* (Tomsk: Tomskii gosudarstvennyi universitet) p 288 (In Russian)
[4] Dyukarev A G and N N Pologova 2011 Soils of Ob'-Tom' interfluve. *Vestnik Tomskogo gosudarstvennogo universiteta. Biologiya.* **3** (15) 16–37 (In Russian)
[5] IUSS Working Group WRB, 2014 World Reference Base for Soil Resources 2014. International SoilClassification System for Naming Soils and Creating Legends for Soil Maps. World Soil Resources Reports p 106 (Rome: FAO).
[6] Vorobeva L A 2006 *Teoriya i praktika khimicheskogo analiza pochv* (Moscow: GEOS) p 400 (In Russian)
[7] Kulizhsky S P, Loiko S V, Konstantinov A O, Kritskov I V, Istigechev G I, Lim A G and D M Kuzmina 2015 Lithological sequence of soil formation on the low terraces of the Ob and the Tom rivers in the south of Tomsk Oblast. *Int J Environ Stud* **72** 1037-46
[8] Sommer M, Halm D, Geisinger C, Andruschkewitsch I, Zarei M and K Stahr 2001 Lateral podzolization in a sandstone catchment. *Geoderma* **103** 231–47
[9] Jankowski M 2014 The evidence of lateral podzolization in sandy soils of northern Poland. *Catena* **112** 139–47