ABOUT THE STATE SOIL MAP AT 1: 1 000 000 SCALE FOR THE TERRITORY OF KAMCHATKA

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A semi-centennial history of compiling the State Soil Map for the territory of Kamchatka Peninsula is described; the reasons for its correcting are shown including new data about soils and regularities in the soil development at the territory of this peninsula, the particular ash distribution in the region, available satellite images of high resolution. The map was compiled in traditional paper version by using multizonal LANDSTAT images, the geological maps at 1:1 000 000 and 1: 5 000 000 scales, a hypsometric map at 1: 1 000 000 scale, the published materials about soils, vegetation cover and the soil-ash mantle. In general, Kamchatka and its separate regions have been so far examined insufficiently and the compilation of the State Soil Map assumed an expert character being based upon a comprehensive analysis of different available information on soils. As an example the boggy West-Kamchatskaya (Pre-Okhotomorskaya) lowland is considered. A list of soils demonstrating on this map is given to show 26 soils, 4 gradations according to the particle-size distribution and 2 gradations according to the lithologic-mineralogical composition of compacted soil-forming bedrocks and their genesis.

Keywords: lowland, expert mapping, satellite images, high bogs, list of mapped soils

INTRODUCTION

It is well known that Zaboeva Iya Vasilievna is unusually fertile in her work. But we can say for sure that she manifested a profound interest to soil geography and its visualization on soil maps not only at the territory of the Republic of Komi but also on the State Soil Map at 1:1 000 000 scale. She was very active and spent much time in field and laboratory to compile these maps. The given paper contains a comprehensive analysis of some sheets for the territory of Kamchatka Pen-

insula and a short history of their compilation to be devoted with deep respect to Prof. Dr. I.V. Zaboeva.

A SHORT HISTORY OF THE PROBLEM

The soil map for the territory of Kamchatka has being compiled during 50 years. In the 1960s the first version of the sheet N-5 (Petropavlovsk Kamchatskiy) was prepared using the data of field and stationary studies obtained by specialists of the V.V. Dokuchaev Soil Science Institute (I.A. Sokolov, V.O. Targulian, V.D. Tonkonogov, N.I. Belousova, Z.A. Prokhorova) in the composition of Kamchatka complex expedition of the USSR Academy of Sciences. These studies have been carried out under the guidance of Prof. Dr. Ye. N. Ivanova as the head of the department of soil genesis, geography and classification in the above Institute. Her remarks to the map legend and the explanatory text are carefully kept in the archive of this department.

The author's version of this sheet was scientifically edited (Ye.M. Naumov) and approved by the editorial board of the State Soil Map (G.V. Dobrovolskiy), however, it hasn't been prepared for publication. Nevertheless, it is difficult to overestimate the importance of these studies. (1) The main regularities in the development of boreal and tundra soils under conditions of the recent volcanism have been first determined and shown on the map. (2) The present-day volcanic activity was first recognized as a factor responsible for the soil formation. (3) A new conception suggested for the first time allowed elaborating the soil classification at the territory of Kamchatka as well as a list of soils to be shown on the State Soil Map.

The studies were continued in the 1970s. Having used the conception suggested by I.A. Sokolov the sheets 0-57 (Palana), 0-58 (Ust-Kamchatsk), N-56 (Kamchatka, the western see shore) and M-57 (Lopatka cape) have been compiled by N.I. Belousova, but they haven't be published as well.

In the last decade of the XX - the early XXI centuries these studies started again (cartographers A.G. Urazova and N.A. Shestakova) as based upon a new Program of the State Soil Map accepted in 1986. According to this Program the nomenclature and indexation of volcanic soils were changed, a list of soils to be shown on the State Soil Map revealed changes, the data about the particle-size distribution of soils and parent materials were included into the map content. A serious edi-

torial work was required but due to historical events in the country it hasn't been implemented.

A new stage in this work was connected with the information assimilated in literature sources to describe the soils of Kamchatka, their properties and classification, soil formation and regularities in soil geography [2, 7, 8, 9, 29, 30, 31, 5, 36]. The data about peculiar features of the soil development, diagnostics and the age of soil-ash mantle [19, 1, 24] as well as the vegetation cover in the peninsula [4] and satellite images were available to introduce amendments into the map, what was made within 2009-2011. However, the Sokolov's conception remained to show the role of the volcanic activity in the soil formation process and in regularities of spatial distribution of volcanic soils.

A list of soils in Kamchatka included into the legend of the State Soil Map in the 1990s was subjected to changes due to the following reasons.

1. The version of the State Soil Map (SSM-90) was created according to the Program (1986) and the soil classification published in1977. However, this Program revealed numerous changes in compliance with the legend of the Soil Map of the RSFSR at 1:2 500 000 scale (1988). The new "Soil Classification of Russia" (2004) finds a wide application and Kamchatka sheets of the map contain the synonymic names of soils presented in both classification systems.

2. The SSM-90 showed only 7 contours of volcanic soils in Kamchatka, whereas the latest version of this map contains 8 contours including the volcanic peaty-humus soils developed under alder forests that occupy large areas being confined to more "warm" positions, gentle slopes and the substrata which are coarse to a lesser extent. By this reason, within the zone of moderate ash showers under alder forests the peaty-humus soils are developed while the formation of dry peaty soils is observed under cedar forests.

3. For the last 25 years the description of new soil types and new trends in the soil formation conditioned by peculiar environmental conditions appeared in literature, what made it necessary to show them on the soil map of this peninsula.

It is worthy of note that the soils of hydrothermal fields ($B^{ГТП}$) were recognized by Goldfarb in 2005. They occupy relatively small areas in regions of the recent volcanism accompanying by hydrothermal and fumarole activity.

Table 1. A list of volcanic soils presented in the State Soil Map at 1:2 500 000 scale and in different versions of this map at a scale of 1: 1 000 000

On the map at 1 : 2 500 000 scale		Intensity of ash showers and vegetation type	On SSM-90	On SSM-2013 as compared to SSM-90	
				former	new
Volcanic dry peaty soils	B^{cr}	Intensive and average ash showers, cedar forests	Without changes	No changes	
Volcanic layered-ocherous soils	B^{cx}	Moderately intensive ash showers under forest vegetation	»	»	
Volcanic ocherous including podzolized soils	B^{x}	Moderate ash showers, grass birch forests	»	»	
Volcanic light-ocherous including podzolized soils	B^{xc}	Moderate ash showers, grass white birch forests	»	»	
Volcanic layered-ashy soils	$B^{сп}$	Intensive ash showers, coniferous and birch forests	Soil name and index were changed: volcanic layered coarse-humus soils = $B^{гр}$	»	
Volcanic illuvial-humus tundra soils	$B^{иг}_{т}$	Moderate ash showers, tundra	Soil name and index were changed: peaty and humus-ocherous volcanic = $B_{т}^{x}$	No changes	

On the map at 1 : 2 500 000 scale		Intensity of ash showers and vegetation type	On SSM-90	On SSM-2013 as compared to SSM-90	
				former	new
Volcanic podzolic-ocherous soils	$B^{пх}$	Slightly expressed ash showers, grass birch forests	Soil index was changed = $B^{хо}$	»	
Volcanic peaty-humus soils	$B^{тп}$	Intensive and moderate ash showers, alder forests	absent		$B^{тп}$
The soils that are absent on the map at 1 : 2 500 000 scale					
Volcanic peat soils of fen bogs	$T_н^с$	Different intensity of ash showers	absent		$T_н^с$
Volcanic peat soils of high bogs	$T_в^с$	Different intensity of ash showers	»		$T_в^в$
Soils of hydrothermal fields	$B^{гтп}$	Different intensity of ash showers	»		$B^{гтп}$
Dry peat soils	$T_с$	Ash is absent	»		$T_с$

4. In the Kuril islands, where the highly humid oceanic climate is characterized by low summer temperatures and constant mists, the dry peaty soils have been described in detail. The thickness of “dry” peat accumulation is higher than a half-meter in these soils. Probably, such an intensive process is characteristic for island landscapes [27, 33]. The identical soils haven’t been described in Kamchatka but they are shown on the map thanks to similar environmental conditions in regions of southern Kamchatka situated near the oceanic and sea shores.

5. In the last decades the areas of different ash showers have being specified [1, 19, 24, 5, 36, 18]; it permitted to show on the map the peat and peaty layered-volcanic soils of high and fen bogs character-

ized by the presence of ashy layers with different thickness and a higher ash content of the peat-humus mass.

6. According to V.L. Komarov [12] the peat bogs in Kamchatka represent a complex of associations; transferring or permeating each other, they are not isolated in space. By this reason the soils of transitional bogs have been excluded from the list of soils shown on the State Soil Map.

Thus, a list of soils demonstrating in sheets of Kamchatka (M-57, N-56, N-57, N-58, O-56, O-57, O-58) is the following:

volcanic (synlithogenic) soils

$В^{х}$ – volcanic ocherous
$В^{хс}$ – volcanic light-ocherous
$В^{сх}$ – volcanic layered-ocherous
$В^{хо}$ – volcanic podzolic-ocherous
$В^{ст}$ – volcanic layered dry-peaty
$В^{гр}$ – volcanic coarse-humus layered
$В_{т}^{х}$ – volcanic peaty-ocherous and humus-ocherous
$В_{т}^{с}$ – volcanic layered tundra
$Т_{в}^{с}$ – volcanic peat and peaty-layered soils of high bogs (oligotrophic)
$Т_{н}^{с}$ – volcanic peat and peaty-layered soils of fen bogs (eurotrophic)
$В^{гтп}$ – volcanic soils of hydrothermal fields (they are recognized only as accompanying soils)

unvolcanic (postlithogenic) soils

$ПБ^{х}$– ocherous podburs
$ПБ^{ст}$ – dry peaty podburs
$ПБ^{т}$ – dark-colored podburs
ПБ – podburs
$По^{х}$ – ocherous podzols
$По^{ст}$ – dry peaty podzols
Пог – gley podzols
По – podzols
Тс – dry peat (oceanic)
$Г^{т}$ – peat-gley
$Г^{гр}$ – coarse humus gley
$Т_{в}$ – peat of high bogs (oligotrophic)
$Т_{н}$ – peat of fen bogs (eutrophic)
$А^{т}$ – alluvial peat
А – alluvial soils

In general, in sheets of Kamchatka there are 26 soil names, among them only 11 names are associated with the specific of the volcanic soil formation, what is explained by the fact that the soil cover of Kamchatka has being so far examined insufficiently. The map demonstrates also the outcrops and sands of marine and river alluvium (spits and beaches).

In electronic version of the map t*he soil-forming deposits, the particle-size distribution, the lithologic-mineralogical composition of bedrock*s are shown in a separate layer. Bearing in mind the specific properties of tephra conditioned by their porous (vesicular) form [32, 13], the volcanic and nonvolcanic genesis (alluvial, eluvial or the other one) of the soil-forming deposits is shown as well. However, in case of tephra redeposition by water flows its porous form becomes destroyed and mixed with usual loose bedrocks.

There are 4 gradations of the particle-size distribution in loose bedrocks and 2 gradations in natural deposits:

(1) sands and loamy sands (including volcanic redeposited ones);

(2) pebble and gravelly sands;

(3) volcanic sands, loamy sands and ashes (aerial);

(4) volcanic fine-and medium loamy sands (aerial);

(5) magmatic, metamorphic acid rocks and compact sedimentary deposits;

(6) basic and medium magmatic and metamorphic bedrocks.

THE ROLE PLAYED BY THE SOIL FORMATION FACTORS IN SOIL GEOGRAPHY

In Kamchatka the geography of the soil cover is mainly determined by two factors: (1) the present explosive volcanic activity and (2) the meridionally expressed form of the peninsula what has a great influence on the factors responsible for the soil formation. Let us consider the role of the above factors in detail.

In Russia the Kamchatka Peninsula and Kuril islands are the only place, where the volcanic activity is considered as a factor responsible for the soil formation. Its effects include the periodical input of pyroclastic materials and the other products of the volcanic activity to the soil surface. This phenomenon occurs with different intensity and leads to accumulation of fresh mineral materials at the soil surface, to the formation of the buried soil profile or polygenetic profiles composing of several layers.

Table 2. Distribution of volcanic soils within the bioclimatic zones depending on the intensity of ash showers

Bioclimatic zone or altitudinal belt	Intensity of ash showers		
	intensive	moderate	weakened and slightly expressed
Tundra	$В^{с}_{т}$	$В^{х}_{т}$	$По^{х}ПБ^{х}В_{т}^{х}$
Cedar forest	$В^{ст}$	$В^{ст}В^{х}_{т}$	$По\ ПБВ_{т}^{х}$
Alder forest	$В^{тп}$	$В^{тп}В^{х}_{т}$	$ПоПБВ^{тп}$
Forest	$В^{гр}В^{сх}$	$В^{сх}В^{х}В^{хс}$	$В^{хо}$

There is a wide scope of soils with “normal” profiles that display no changes and destruction and soils with numerous layered profiles. I.A. Sokolov (1973) was the first to identify the zones of different intensity in the explosive volcanic activity including the zones of intensive, moderate, weakened and slightly expressed ash showers (Table 2). The latitudinal changes in bioclimatic processes of the soil formation are decreasing with increasing the intensity of the volcanic activity being depressed in the zone of intensive ash showers. The meridionally stretched peninsula and the macroforms of its relief transform climatic parameters and particularly the “wind rose” having the influence on many ash showers that are stretched from southwest to northeast. The effect exerted by the cold Pacific Ocean and Okhotsk Sea serves as a level of zonal (latitudinal) regularities in the soil cover and landscapes but forms the “specific zonality”, where the landscapes are changed from littoral tundra to the belt of alder and birch forests. In mountains it is possible to observe the same set of vegetation formations: birch and sometimes larch forests – cedar or alder forest – mountain moss- and lichen-shrubby tundra is changed by alpine meadows – alpine belt. The “normal” vertical zonality is destroyed by inversion of zones in mountain depressions and river valleys.

The soil cover of the Kamchatka Peninsula has been so far uneven studied The Kamchatka river valley, Nalychevskaya depression and the Avachi river valley with adjacent regions of Eastern lowland have been studied in detail. The other regions including the southern part of this peninsula (Lat.52°N), the Western plain from the sea shore to the piedmont of Sredinniy ridge, Sredinny ridge proper, Paradolsky depression and adjacent northern areas have been studied insufficiently

being provided with scanty and sometimes discrepant information [21, 15, 37, 36, 32, 16]. We analyzed comprehensively the soils and the soil cover of these regions using the satellite images, geological and hypsometric maps at 1: 1 000 00 scale, climatic data as well as the published materials about soils and vegetation.

IDENTIFICATION AND CORRECTION OF SOIL CONTOURS

All the sheets of Kamchatka on the State Soil Map were compiled in traditional paper version using multizonal satellite images obtained by LANDSTAT, the hypsometric map at 1:1 000 000 scale, the geological map of the same scale and the map of minerals at a scale of 1: 500 000. The West-Kamchatskaya plain is considered as an example of expert small-scale mapping of this territory.

The West-Kamchatskaya plain is stretching from the Golygina river in the south (Lat. 52°N) to the Palana river (Lat. 59°N) in the north being almost 1000 km long and 20 to 100-120 km wide. The plain and its western part (Pre-Okhotomorskaya lowland) in particular are water-bogged; high bogs are dominant occupying the flat interfluve [12, 15, 16, 34, 20]. When comparing the published materials and the obtained satellite images, it seemed possible to interpret the landscape structure and the soil cover at the mapped territory. For instance, the high bogs enriched with water are shown as black-colored in satellite images, whereas the fen bogs (valley bogs) are brightly green (Fig.1).

In the southern part of this peninsula from the Golygina river (Lat. 52°N) to the Krutogorovaya river (Lat. 55°N) widespread are trembling bogs with numerous (probably relic) thermokarst lakes, “mochars” and a set of water flows entered the river valleys. The water-logging makes up 80%, but the bog edges are dry and have a sharply expressed transition into the valley landscapes [12, 15, 16, 34, 20]. The satellite images demonstrate a strip of bogs that is discontinued by large rivers from the Sredinniy ridge into separate quasi-trianglers, thus reflecting the intensive erosion and drainage activity of rivers, thus discontinuing a strip of trembling bogs [15].

The peat stratum is rather thick and covered by a small group of birch trees in the landscape. In satellite images it is shown by brightly green spots against the black-colored background. In the soil cover such landscape changes are interpreted as a combination of peat soils of high bogs with peat-gley soils and sometimes gley podzols and even

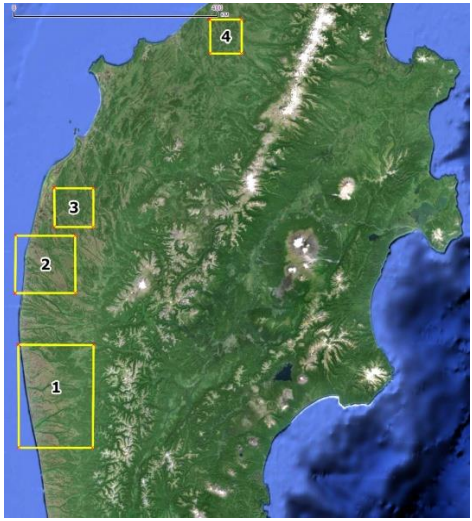

Fig. 1 Satellite image Google Satellite © 2004 TerraMetrica. The location scheme of test areas.

light-ocherous soils [32, 7, 36]. Bearing in mind the fact that this territory is situated within the zone of slightly expressed ash showers [32, 5] it is possible to observe the peat-ashy layered soils of high bogs (T8c) that are shown as accompanying soils on the map.

The large massifs of high bogs (Fig. 3) at the territory under consideration sharply differ from river valleys [12, 16]. In satellite images they are clearly expressed and permit to specify the boundaries of soil contours and the elementary soil area of high bogs or their combination with gley podzols in dependence on the satellite image pattern.

According to botanic and landscape descriptions the great river valleys are well drained being covered by wood vegetation with separate areas of tall grass meadows and sedge-grass bogs. They are derived from sandy and pebble alluvium. The soil cover of these valleys is shown as different combinations of alluvial peat and alluvial soddy soils and peat soils of fen bogs, included into the list of soils represented on the State Soil Map.

To the north from the Krutogorovaya river to Khairyuzova (test area 3) the landscapes are well drained. According to Komarov (1940) the bogs are covered by hillocks composing of cup moss and sedge.

Fig. 2. Test area 1. High bogs in the southern part of Pre-Okhotomorskaya lowland (from the Golygina river in the south to the Krutogorovaya river in the north).

Fig. 3. The test area 1a. A large high bog (the north-western fragment of the test area 1, the interfluve between Kolpakova and Krutogorovaya rivers).

In satellite images they are loose, the boundaries are indistinct, their total area is decreased, but the drainage of the territory covered by them reveals an increase. The soil cover is mainly represented by gley peaty-humus soils combined with high peatlands, podzolic-gley and ocherous-podzolic soils. Northwards the Tigil river the high bogs are completely disappearing, what is clearly reflected on the hypsometric map and satellite images. The peat soils of high bogs are prevailed there. In the eastern part of this territory confined to Oligocene-Miocene argillites, tuffstones and conglomerates the landscapes assume a tundra character (test area 4 in Fig.1, Fig.6). Widespread are sphagnum and sedge-sphagnum shrubs on the peat layer of 0.5 m in thickness. The podzolic-gley soils combined with several peaty soils of high bogs are developed here. At the elevated and erosion-dissected territories derived from intrusive and tuffogenic deposits the moss-lichen and moss-shrubby cedar forests are met [16]. In the development of the soil cover the processes of dry peat accumulation are dominant in combination with the Al-humus process. As a result, predominated are the dry-peaty ocherous podzols, dry-peaty and ocherous podburs; on coarse substrata the shallow dry-peaty soils are developed, the peaty horizon of which is 15-25 cm thick.

Fig. 4. The test area 2. Separate massifs of high bogs in Icha and Sopochnaya river valleys.

Fig. 5. The test area 3. The relatively small massifs of high bogs in the interfluve of Moroshechnaya and Belogolovaya rivers.

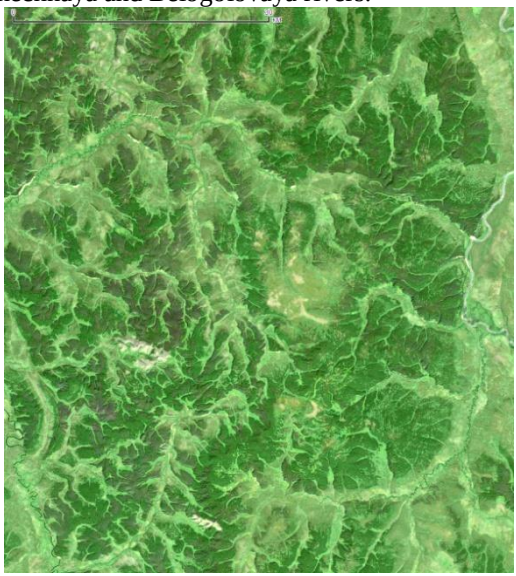

Fig. 6. The test area 4. The sphagnum-shrubby and sphagnum-lichen “tundra” covered by shallow peaty soils of high bogs in the interfluve of Tigil and Amanina rivers.

The landscapes in river valleys are clearly identified on the hypsometric map, their satellite image allows specifying the boundaries of some areas covered by alluvial peaty soils or alluvial soils combined with peat soils of fen bogs.

CONCLUSION

Under consideration are the main landscapes of the Western (Pre-Okhotomorskaya) lowland in the Kamchatka Peninsula, that has been so far studied insufficiently. The satellite images obtained by LANDSTAT were used to compile the latest version of the State Soil Map and permitted to specify the boundaries of high bogs as well as the areas covered by high bogs in combination with hydromorphic soils. The regions differed by the drainage degree were also identified in the course of this study. The information is given to show the changes in the evolution of the soil cover. The changes in areas covered by high bogs, their size, form, boundaries allow speaking about the drainage processes and decrease in the area of high bogs taking place now at the territory of Pre-Okhotomorskaya lowland in Kamchatka.

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