"GENUINE PODZOLIC SOILS" IN THE REPUBLIC OF KOMI AND THEIR POSITION IN THE RECENT SOIL CLASSIFICATION SYSTEMS

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Under consideration are typical profiles of loamy podzolic soils described in many publications on the soils of Komi Republic with respect to their diagnostics in national and international classification systems. It is argued that the podzolic soils should be preferably recognized at the type level with numerous subtypes to reflect the variations in the profile drainage conditions. In terms of the international soil classifications (FAO/WRB) the podzolic soils may be correlated with the former Podzoluvisols and recent Retisols better than with the Albeluvisols of the intermediate versions.

Keywords: typical podzolic soils, genetic properties and subtypes, Reference Soil Groups of the international classification

INTRODUCTION

In the preface written by I.P. Gerasimov to the well-known I.V. Zaboeva's monograph entitled "Soils and Land Resources of Komi ASSR" (1975) the typical podzolic soils developed in middle taiga in the North-East of European Russia were named "genuine" podzolic soils [5]. This attribute had a slightly polemic hint in that time being a response to several Russian soil scientists captivated by the ideas of lessivage and pseudogleying very popular in Western Europe [2, discussion in "Pochvovedenie" journal in 1970–1973). As a result, the taiga loamy soils with the differentiated profile were defined as pseudopodzolic, whereas the term "podzolic soils" became more and more seldom in publications. In the above preface Innokentiy Petrovich Gerasimov asked a very simple question – if podzolic soils exist at all, where could they occur if not under spruce forests in middle taiga on moraine or mantle loams under moderately continental climate and percolative water regime?

A great volume of diverse factual data collected by I.V. Zaboeva for many years and summarized in her monograph serves as substantiation of typical podzolic soils. This monograph provides not only traditional analytical soil characteristics (in many replicates), it also contains data on primary and clay minerals, particle-size and total chemical compositions of soil and the clay fraction, non-silicate forms of iron and aluminum, group and fractional composition of humus, as well as the results of observations on soil moisture and temperature regimes performed during 5 years. In view of this, it seems reasonable to discuss the taxonomic position of podzolic soils in soil classification systems with the example of soil profiles chosen by Iya Vasilievna Zaboeva as the most representative ones. It is worth emphasizing that such comprehensive information on soil types is almost unique in Russia and probably in the world.

The reasons to discuss some aspects of podzolic soils classification are explained by accumulation of information on soils and changes in genetic concepts for the last 40 years, on the one hand, and, on the other hand, by the appearance of new versions of soil classification in Russia and in the world. Two aspects are discussed in this paper: the taxonomic level of podzolic soils in different classification systems and the taxonomic position of possible modifications in the "central image" of these soils.

MATERIALS AND METHODS

The objects to discuss are the podzolic soils on homogeneous loams and on two-layered deposits. The soils on sands – podzols – referred to podzolic in old times are beyond the scope of this paper. Podzolic and similar soils are discussed basing upon the information presented in the monographs of I.V. Zaboeva (1975) and V.D. Tonkonogov (2010), "Atlas of Soils in the Republic of Komi" (2010), "Soils and Soil Cover in Pechora-Ilychskiy Natural Reserve" (2013) [1, 7, 15, 16]. In these publications, we addressed only to the problems of soil classification applying to the information on soil morphology and to analytical data when it was required by the diagnostic criteria.

The taxonomic position of podzolic soils is discussed in Russian classification systems: "old" system of 1977 (USSR), and "new" system in the versions of 2004 and 2008, and in the international ones: legends to FAO/UNESCO World Soil Map, versions of 1974 and 1988 with the soil maps compiled on their basis, and World Reference Base for Soil Resources – WRB (2006 and 2014) [3–5, 12, 14, 16].

RESULTS AND DISCUSSION

Are podzolic soils a subtype or a type? The typical profile description of the podzolic soil on silty loam under spruce forest located 3–4 km to the west of Syktyvkar was presented in publications mentioned above. The authors unanimously indicated the same features of the soil profile and its main horizons. The profile reveals a clear textural differentiation, and comprises the following horizons: the forest litter 5 cm thick; the light-colored eluvial horizon 10–15 cm thick with platy structure and few fine ferruginous segregations and nodules; the transitional horizon comprising light- and brown-colored morphons[1]. Deeper than 40–45 cm, there is a brown cutanic illuvial horizon with its common and well-known attributes. At the same time, in the profile descriptions there are some differences concerning the upper horizons, the discussion of which will be below.

In accordance with the principles of both national soil classification systems, this soil is qualified for a typical podzolic one because of its zonal location, some analytical characteristics [3] and the system of horizons [4, 5]. However, in the "new" system, this soil was recognized at the type level, whereas in the "old" one [3] it was defined as a subtype of the podzolic soil type, what is explained by the priority of horizon approach in the first case and zonal-subzonal approach in the second case. The horizon approach, i.e. "system of diagnostic horizons → soil type" is supported by the morphological descriptions permitting to identify the sequence of diagnostic horizons composing the following profile formula: 0–EL–BEL–BT–C. This profile formula enables one to separate podzolic soils from the type of soddy-podzolic soils, in which the gray-humus horizon (AY) occurs instead of the peat-litter O one (Ao symbol in [9] and [1]). This difference in the assessment of taxonomic category is in agreement with the zonal approach discussed by N.A. Nogina as early as in 1981 in the series of books on podzolic soils of the East-European Plain [11].

The taxonomic position of gley-podzolic soils is more complicated. The comprehensive studies performed by I.V. Zaboeva (1975) permit to suppose that they should be separated from typical podzolic

[1] The term was introduced by E. Kornblyum in 1980-ies for parts of horizons differing by color, texture, fabric and other morphological properties.

soils at a higher taxonomic level than the subtype level, namely, at the type level. Her monograph contains convincing arguments on the different genesis of gley-podzolic soils: they have weak profile differentiation, humus mobility causing impregnation of the eluvial part of the profile, diverse manifestations of gley in all the mineral horizons, cryoturbation features in the upper horizons. The study of the temperature regime indicated that the major part of 1.5-m-thick soil layer exists in the temperature interval from 0 to 5°C, the biologically active temperatures are observed in the 10–15-cm-thick topsoil only for a month in the warmest years. During the vegetation period, the moisture in the upper part of the profile does not practically decrease below the field water capacity. When comparing them with podzolic soils, it is possible to say that the water regime is more stagnant, and the thermal resources are considerably lower. Finally, there is a "bioclimatic" argument for raising the taxonomic level of gley-podzolic soils: the northern and extreme northern taiga – their zonal area – differs from the middle taiga not less than the middle taiga with typical podzolic soils from the southern one with soddy-podzolic soils.

In the "new" classification system, the gley-podzolic soils are also referred to the subtype level. Presumably, it would be desirable to change this situation, although it is not easy to find a diagnostic horizon to be introduced into the shell of the profile type formula: EL–BEL–BT–C. If the problem will be solved, three former subtypes of podzolic soils may be regarded as types with their specific sets of properties, horizons, processes in accordance with the soil-forming factors.

Unfortunately*, the place of podzolic soils in international classification systems* is not quite clear and is changing with time. Formerly, the ideas on soil genesis were not neglected, while the 2010-ies the rules to classify soils became more strict and formal. It is worth to note that these rules are mostly oriented to the diagnostics of definite soil profiles (in the field), and the correlation with the other classification systems is not easy and precise; moreover, the procedure of correlating soils has many limitations and its result is frequently rather wide-ranging [13]. Nevertheless, we will try to make a tentative correlation addressing the description of representative soil profiles and the maps based on the international classification systems.

In the FAO-UNESCO Soil Map of the World and in the versions of its legend, the typical podzolic soils were qualified for *Podzoluvi-*

sols – the soils with a clay-illuvial (argic) horizon and the features of podzolization, what well agreed with the idea of the “genuine” podzolic soils genesis. In the next versions, *Podzoluvisols* were excluded [5, 16]. In “Soil Atlas of Europe” [16] the areas of typical podzolic soils in Russia coincide with those occupied by *Albeluvisols* – the soils with an argic horizon and albeluvic tonguing. In WRB-2006 [7], these soils were also related to *Albeluvisols* specified by the argic horizon and albeluvic tonguing. According to WRB-2006 (it was then a reference base), and ranking the qualifiers, the soils would be named *Cutanic Stagnic Albeluvisols Dystric Alumic Loamic.* However, the problem is that the criteria of albeluvic tonguing are not always met in podzolic soils due to small size of albeluvic tongues and limited area occupied by them. For instance, in I.V. Zaboeva’s publication it was written (1975, p. 169) that the “B_1 horizon has bleached fine discontinuous sandy-clay cutans at the horizontal ped faces”, what is insufficient for albeluvic tonguing. Even these features are not always observed in all the podzolic soils in the Republic of Komi. V.D. Tonkonogov (2010, p. 179) indicated that “the bleached subvertical mottles which display no penetration into the soil textural horizon” should be considered as a fringe-like degradation pattern in podzolic soils unlike that in soddy-podzolic soils characterized by “deeply penetrating funnel-shaped tongues”.

The attention paid to the degradation zone in the soil textural profile led to the appearance of a new Reference Soil Group of *Retisols* that partially replaced *Albeluvisols* in the latest WRB version (2014). *Retisols* are soils with a “retic” diagnostic property (Lat. *rete* – network) represented by a mosaic of light and brown morphons in the upper part of the textural subsoil. The morphons are different in texture and color; as distinct from the former albeluvic tonguing diagnostic property, the vertical orientation of light-colored morphons is not obligatory. The latter should occupy not less than 10% of vertical or horizontal section within the upper (0–10 cm) part of the argic horizon. In the WRB classification system, the *Retisols* Reference Group proves to be the only possible niche for podzolic soils, most of which can be defined as *Stagnic Albic Dystric Retisol Alumic Cutanic Loamic.* Presumably, this name is better than Albeluvisols as it implies different patterns of the degradation zone, not necessarily tonguing. The *Albic* qualifier indicates the presence of the continuous bleached horizon (it was not obligatory for *Albeluvisols)*. If there are bleached tongues, the *Glossic qualifier* may be added. The other qualifiers are identical in both WRB variants and characterize adequately the well-known particular features of typical podzolic soils.

Subtypes of podzolic soils in the soil classification of Russia as reflection of local conditions. Descriptions of typical podzolic soils taken as standards differ in detail, which makes it possible to discuss the soil diagnostics at a lower taxonomic level – at the subtype level. The differences are mostly recorded in the upper part of the profile being produced by the redistribution of non-silicate iron compounds due to profile drainage. The minimal differences may be recorded between two profiles described in the monograph of I.V. Zaboeva (p. 169–171): between the horizons beneath the A_2 horizon at a depth of 12–45 cm. Pit 1 has a common A_2B transitional horizon. In pit 284, there is the A_2B horizon at a depth of 12–25 cm; it is yellowish-pale in color with non-contrasting mottles and the platy-finely blocky structure, it is underlain by the loamy B_1 horizon up to the depth of 45 cm; which we think meeting more the criteria of a transitional horizon than the illuvial one according to its properties. The diagnostics of illuvial (BT textural in Russian soil classification) horizon is beyond doubt. Soils with similar properties of the upper part of their profiles were defined by V.D. Tonkonogov as *pale-podzolic soils*, i.e. the subtype of podzolic soils. They are characterized by a weakly expressed vertical differentiation of iron oxides (pit 36-KD), and the pale color is explained by fine ferruginous coatings around the aggregates and/or mineral grains. I.V. Zaboeva's description of the A_2B horizon (pit 284) also allows us to identify the "pale" feature and to propose the profile formula with the appropriate index: O–EL–Elf–BEL–BT–C.

A more pronounced vertical differentiation of iron oxides is inherent to the *podzol microprofile* inserted in the upper part of the podzolic soil solum; it is maintained by a contrasting texture, higher acidity, or other local phenomena. In the "Atlas of Soils in the Republic of Komi" [1] the first profile of the typical podzolic soil on carbonate mantle loam (p. 121–122) displays "pale" features, and soils named as Al–Fe-humus soils there (p. 129–130) may be interpreted as podzolic soils with the podzol microprofile. According to V.D. Tonkonogov, such soils are more common in the middle and northern taiga than typical podzolic or pale-podzolic soils.

Along with the vertical differentiation of iron compounds there is another type of color pattern related to their redistribution, namely, irregular fine bleached-ocherous mottling and/or iron oxides segregations within the eluvial horizon. This kind of mottling, if clearly expressed and sometimes combined with blue-gray morphons, is qualified for surface gley, and such soils can be related to the surface-gleyic subtype of podzolic soils. However, there are two taxonomic problems. Firstly, in the majority of podzolic soils, iron mobilization with its subsequent segregation occurs in the eluvial horizons, i.e. the surface eluvial gleying is already “accounted” in the complex of soil-forming processes responsible for the formation of the eluvial EL horizon in the “new” soil classification. As is known, the podzolic and eluvial-gley processes are widely discussed in literature, and this problem is beyond the scope of this paper. To identify a surface-gleyic subtype of podzolic soils, exact quantitative criteria are required; unfortunately, they have been so far formulated insufficiently clear. Secondly, it is hard to find a reliable formal boundary between this subtype and gley-podzolic soils. Another subtype of podzolic soils may be recognized basing upon similar phenomena of iron compounds migration: these are contact-bleached soils on two-layered parent materials. The development of the deeply gleyic subtype of podzolic soils can be associated with heavy texture or late thawing of deep horizons resulting in the prolonged water logging in them. Deep gleying is also favored by “bleached tongues” as pathways for preferential flows.

It is well known, that the podzolic soils mainly occur on gently undulating or hilly moraine plains with small areas of outwash plains, hence, the mantle clays or loams, moraine loams or loamy sands and two-layered deposits are alternating. These deposits, their depth and texture, as well as slope gradients determine the difference in soil profile drainage, therefore, occurrence of several subtypes of podzolic soil (Table).

Formation of the first four subtypes in the list should be considered as a modification of processes inherent to podzolic soils. In other words, these subtypes are genetically close to their type. The two next subtypes (tongued and residual) are recognized by the degradation pattern of the BT horizon. More genetically distant are the subtypes with the second humus horizon and those associated with cryogenesis: cryometamorphic, and with permafrost, as well as top-turbated (by tree

Table. Expert evaluation of factors determining the development of podzolic soil subtypes

Genetic feature (responsible for a subtype)	Conditions for the development of subtypes						
	drainage in different parts of the profile			parent rock properties		pedoclimate	evolution
	upper	middle	lower	chemical composition	fabric		
Pale	+						
Microprofile of podzol	++				++		
Gley formation: at the surface	–	–				+	
Gley formation: at the depth			–		+	+	
Contact-bleached		+			++		
Tongued		+					+
Residual		–					
Cryometamorphic		+	+?			+	
Raw-humus	+					+	
Mucky	–					+	
Postagrogenic							+
With the second humus horizon							++
Dark-profile/Red-profile				++			
Residual-carbonate				++			

Note: 1. The number of symbols corresponds to the importance of the factor; drainage conditions mean either the removal of excessive water (+) or its stagnation (–). 2. Most common subtypes are included [9, 13].

uprooting or cryoturbation); the three latter subtypes can be identified not only in podzolic soils.

Particular properties of phytocenoses and the surface runoff distribution among the microrelief elements may contribute to the development of raw-humus features in runoff-depleted habitats and, hence, a raw-humus subtype, or a mucky subtype in case of additional moistening. Like in the other soils, the specific properties of parent material permit to recognize a number of rock-dependent subtypes (residual-carbonate, red-profile, etc.).

Thus, the type of podzolic soils has not less than 10 specific simple subtypes; the combination of diagnostic features results in identifying complex subtypes, for instance, the deep-gleyic podzolic soil with podzol microprofile and with permafrost. It is worth to note that in soil classification of 1977, the subtype of typical podzolic soils had only 4 genera.

CONCLUSION

Properties, particular features of genesis and regimes of "genuine"podzolic soils permit to move them to a higher taxonomic category than the subtype level in the "old" classification system of 1977. In the "Classification of soils of Russia" (2004, 2008) they are identified as a type according to formal horizon approach (like soddy-podzolic soils). Probably, it is feasible to find a possibility to transfer the gley-podzolic soils (subtypes in all classifications now) also to the type level.

In the "new" Russian classification system, the position of podzolic soils at the type level enlarges the possibilities to use the subtype category for adequately characterizing the intricacy of their genesis and the diversity of their properties. Some subtypes correspond to modifications in the major complex of soil forming processes produced by the combinatorics of landforms and glacial sediments (such subtypes are regarded as specific in the "Field Guide…." [13]).

In the international classification systems the former Podzoluvisols corresponded to typical podzolic soils to a considerable extent. Less successful was the later attempt to include them into Albeluvisols that were excluded from the WRB version of 2014, where podzolic soils are referred to Retisols – new Reference Group for soils with the clay-illuvial horizon (argic) and its non-tongued degradation zone (retic diagnostic property). Properties of an "averaged" podzolic soil profile may be presented by qualifiers for surface gley, continuous eluvial horizon, base unsaturation, high content of Al^{3+}, abundance of coatings and loamy texture (*Stagnic Albic Dystric Retisol Alumic Cutanic Loamic)*.

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