PRINCIPLES, STRUCTURE AND TAXONOMIC UNITS IN THE RUSSIAN AND INTERNATIONAL (WRB) SYSTEMS OF SOIL CLASSIFICATION

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Two classification systems under comparison differ in objects, terminology, hierarchical levels, and approaches to identify soils. However, they have some common features: both systems are oriented to soil properties and apply the pedogenetic concepts, on one hand; on the other hand, the results, namely, some of the soil taxonomic units are similar. The second-level units of WRB, representing the classification rather than the reference base, display a certain correlation with the subtype level in the Russian soil classification system. This level in two systems may be qualified as a really active, and it contains the most complete genetic characteristic of a soil; moreover, there is a similarity in criteria for qualifiers in WRB and genetic features (producing subtypes) in the Russian system. The difference between two classification systems is manifested in the number and essence of diagnostic horizons because they perform different functions. In the International system, they mainly serve for recognition of soils (in the key), while they directly identify genetic soil types in the Russian system.

Key words: soil properties-based systems, soil genesis, diagnostic horizons, qualifiers and genetic properties, WRB-2014.

INTRODUCTION

The World Reference Base for Soil Resources (WRB) is becoming more and more popular among soil scientists and specialists in environmental sciences, agriculture and forestry, geography, paleopedology, etc. Almost in all foreign publications concerning soils and in some Russian books and journals, soils are named in the WRB system. Moreover, the reference base acquired a new status in 2014: it became an International soil classification. These were the reasons to make an attempt of comparing this system with the recent Russian soil classification in its two versions – of 2004 and 2008 [5, 8].

The experience of correlating different versions of the Russian and International systems is rather scarce [6, 8], although it revealed many problems in this procedure and doubts in its results. A simultaneous use of both systems is in its initial stage in Russia. However, using the WRB soil names becomes expedient because of the requirements of many journals to supplement the national terminology with the worldwide one; the same is true for some soil surveys performed within the framework of environmental-control and/or soil monitoring projects. Thus, the interest to the WRB system and the need to know it is obvious.

MATERIALS AND METHODS

The last WRB version presented and officially acknowledged at the International IUSS Congress in Korea in June 2014 essentially differs of the preceding ones, including the version of 2006 published in Russian (with some corrections made in 2007) [3, 7], where brief characteristics of soils were added from another publication of FAO/UNESCO [12]. The history of the World Reference Base development has been described not once in its earlier versions as well as in the Russian translation and it is not worth describing it here; in the recent two decades, it was evolving by means of professional discussions during the special field excursions, in other words, “at the soil pit”. Such excursions were arranged in several countries. In Russia, there were excursions from St.-Petersburg to Moscow in 1996, and in Yakutia in 2013 [1]; very interesting was the tour in southern Poland (2011), where the Polish soils could be compared with their Russian analogues in the WRB philosophy [2]. In the beginning, the WRB system was regarded as a tool for correlating the national soil classifications, enabling their harmonization, or as an “umbrella”, under which soil scientists from different countries may exchange information about their soils and reach better mutual understanding.

The classification of soils of Russia, in its versions of 2004 and 2008 became popular among the soil scientists from various regions of the country, which is demonstrated by publications in “Eurasian Soil Science”, discussions on the site (forum “soils.narod.ru”), results of special workshops and programs of lecture courses in the universities.

At present, some additions and modifications are being introduced into the system; therefore, the experience of the international system may be of interest.

Both classification systems being based on the assessment of soil properties have some common features, however, the difference between the systems is essential and may be explained by the difference between the scientific schools within which frameworks they have been developed. The comparison of the systems was performed in the following aspects: principles, contribution of soil genesis (soil-forming processes), structure (hierarchical levels), and full names of soils as the outcome of the whole procedure.

RESULTS AND DISCUSSION

Among the main **principles** declared by the authors of both classification systems is the principle of substantivity, which means the priority of soil properties in the diagnostics and categorization of soils, development of discriminative rules and criteria, subdivision of soil groups into classes and other types of classification activities. Addressing to external conditions, such as soil-forming factors or pedogenetic concepts is not supported. Nevertheless, the latter statement is slightly flexible: it is changing with time and is implemented in different ways. In the Russian system, the principle of substantivity is introduced in the name of the system itself (substantive-genetic classification system), and is formulated in this way: “The soil profile being a system of interrelated genetic horizons is a basis for soil diagnostic and classification” [8, pp. 10]. The main edition (2004) starts with the definition of a horizon and discussion of the importance of genetic horizons.

It is worth reminding that the priority of soil properties is a milestone in the majority of world soil classification systems: American, French, Chinese, and is realized by means of recognizing the diagnostic horizons as main tools for soil diagnostics. The sets of horizons are supplemented by lists of diagnostic properties and diagnostic materials (Table). The examples of the latter in WRB are the following: fluvic, gypsiric, calcaric, dolomitic, sulphidic, ornithogenic, tephric. They are partially compatible with the parent materials in the Russian system in the section “Some symbols for the profile formulas of soil types and

Table. Definitions of diagnostic elements and their numbers in the Russian and WRB classification systems

Classification system	Horizons / number	Properties (features) / number	Materials (substrates) / number
Russian, 2004/2008	Subhorizontal layers differing in morphological and analytical parameters as related to their genesis / 49	Properties of horizons not violating their main diagnostic / 64	Parent materials / 11
WRB, 2014	Combinations of features corresponding to common and widely spread results of pedogenesis, which to the greatest or least extent should be visible and measurable / 39	18 (+186 qualifiers)	Essentially affect the soil-forming processes, or serve as their indicators / 17

subtypes" [5, 8]. There are now some proposals at the site and in personal discussions to enlarge and improve this part of the system in the forthcoming edition.

The priority of field identification of soils is one more common feature of two classification systems under consideration. Analytical characteristics of the soils are of minor importance. Soil diagnostics starts in the field by specifying and naming horizons in the soil pit; these are diagnostic horizons in the WRB, diagnostic or genetic in the home system. Their number is in the Russian system exceeds that in WRB (49 and 39, respectively), although the latter embraces soils of the world. Evidently, this difference is in good agreement with the difference in taxonomic functions of horizons in two systems: in the Russian system, the combination of horizons corresponds to the central taxonomic unit – genetic soil type, hence, the total pedodiversity of the country should be reflected by the combinations of many horizons. In the WRB, the presence (or absence) of a diagnostic horizon is a reason for identifying a Reference Soil Group (RSG) in the key, as well as for the definition of many qualifiers. Among the 32 RSGs, 23 Reference Soil Groups are identified with the help of diagnostic horizons, as main diagnostic criteria, 4 RSGs – by the diagnostic properties, and 4 RSGs – by diagnostic materials. (The last RSG in the key – Regosols – does not have any diagnostic elements, in other words, the absence of any above listed diagnostic horizons, properties and materials is diagnostic for them).

Diagnostic horizons in two classification systems differ by their essence and quantitative boundaries, rather than only by their number [11]. On the whole, many diagnostic horizons2 have more strict formal definitions in the WRB than in the Russian system, but they have a broader volume. Quantitative parameters are more common in the WRB definitions, including the analytical ones, whereas in the Russian system, quantitative parameters are few (content of clay, humus or organic matter, easily soluble salts), and the boundaries are flexible. For example, the criteria for mollic horizon are the following: Corg content ≥0.6%; color: value ≤3 for moist sample and ≤5 for the dry one, chroma ≤3 when moist; the color requirements are adjusted to the content of carbonates and color of the parent rock; base saturation ≥50% throughout the horizon; depth ≥10 cm if underlain by hard rock, technic material, cryic or any hard horizon (petrocalcic, petrogypsic, petroplinthic), in all other cases ≥20 cm. The criteria for the dark humus horizon, which is close to the mollic one in properties and geographical pattern, comprise the color characteristic (descriptive in 2004 version and addressing to Munsell color charts in 2008), structure with emphasis put on pedofauna activity, consistence; abundance of roots and presence of sod; additionally humus content is mentioned (about 2–3% Corg in the upper 10 cm), neutral reaction and probable presence of carbonates.

A more detailed subdivision of horizons in the Russian system may be illustrated with the example of cambic horizon in the WRB: it comprises five Russian horizons, namely, (cryo-, structural-, pale-, iron- and xerometamorphic). The definition of the cambic horizon itself is composed of several criteria, which likely correspond to the variants

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[2] Soils and horizons of intertropical areas are compared.

of the Russian metamorphic, or WRB cambic horizon. Thus, the structural criterion – “absence of rock structure in ≥ 50% of the volume of fine earth fraction” (WRB, 2014, p.22) is similar to the criteria of the structural metamorphic horizon in the Russian system. The color parameters – more red hue than that of the underlying horizon, and in former WRB versions – iron and aluminum content in the pyrophosphate extract, are applicable to the iron-metamorphic horizon. As for the pale-metamorphic horizon, it is absent in the WRB because there are no soils there that are analogues of the Yakutian cryogenic pale soils, and this was confirmed during the field excursion of 2013 in Yakutia [1].

The difference in quantitative parameters between the horizons with similar names in two systems are illustrated by the criteria for calcic and carbonate-accumulative horizons: in the former, the content of CaCO3 in the fine earth ≥15%, in the latter it is rather vague: “The content of carbonates varies in a broad range, but it is always higher than in the above-lying horizon” [8, pp. 51]. Hence, the logical volume of the carbonate-accumulative horizon is broader, and it comprises either the protocalcic qualifier, suggesting the presence of secondary carbonates ≤ 15%, or the calcic horizon.

The diagnostic elements of the next level – *genetic features* in the Russian system and *diagnostic properties* in WRB – differ in importance and functions unlike the diagnostic horizons. The assignment of genetic features is simple and definite: they unambiguously identify subtypes, simple or complex. The diagnostic features are numerous (64), and users propose to introduce new ones, which is reasonable on one hand for a more complete identification of soils, and will make the system cumbersome, on the other hand. In the version of 2004, the genetic features were strictly attached to genetic soil types, whereas in the last version (2008), an attempt was made to “liberate” them, at least partly.

The diagnostic properties, along with the diagnostic materials perform in the WRB two functions: they are introduced in the key to find the Reference Soil Group, and they are used to form the full name of a soil via qualifiers. The second function is practically the implementation of the taxonomic classification system.

In all Russian classification systems much attention was paid to **soil genesis** or soil-forming processes; thus, the central taxonomic unit was traditionally named genetic soil type since the middle of the last century. Pedogenetic concepts together with soil-forming factors were the core of the Soviet classifications of 1967 and 1977.

The main version of the Russian soil classification of 2004 declares soil genesis among the main principles. This means interpretation of the soil profile as of a system of horizons, whose properties were created by soil-forming processes, and one of the adjective characterizing the system is “profile-genetic”. Along with this very important profile approach, soil genesis is applied to a purely taxonomic procedure, which we consider to be highly significant – selection of criteria for the diagnostic elements. The definitions of diagnostic horizons and genetic features are derived of the concepts on their origin; therefore, the criteria are not strict, sometimes even diffuse, contrary to the western systems with their more formal approach to the objects classified3. Soil-forming factors are taken into account only for humanly modified soils, primarily, the arable ones, and plow horizons (agrosoils and agro-horizons, respectively) and also for urban soils (urbistratified subtypes of many soils). Moreover, as a tribute to traditions in both versions of the system, soil forming factors are mentioned as supplementary information beyond the system.

The attitude to soil-forming factors in the WRB was always rather cautious, if not negative; nevertheless, factors as mechanisms of soil formation are directly involved for the artificial soils – Anthrosols with their hortic, terric, irragric and plaggic horizons. With time, the attitude changed to the better. In the WRB versions of 1998 and 2006, the control on the choice of diagnostic criteria was assigned to soil-forming processes, which in no way could be used as criteria; in the last version, the results of pedogenesis are interpreted as horizons’ identification (Table). So, in both systems, the definitions of horizons

[3] The authors of the American Soil Taxonomy write: “Genesis itself, however, is unsuitable for direct use in soil taxonomy. Because the genesis of a soil cannot be observed or measured, pedologists may have widely differing opinions about it ([10], p.17).

comprise elements of interpretation of pedogenetic concepts, i.e. soil genesis.

The classification systems under consideration differ in terms of their **structure** – number of hierarchical levels and their arrangement. The tradition of multi-level (8) structure is preserved in the Russian system, although the upper level (trunk) is not practically used and serves for organization of the system and emphasizing its orientation to soil properties. The lower levels are related to quantitative parameters (species) and details of parent rock properties (varieties and phases), they are traditional and not disputable. Most important for the identification of soils, hence, giving them their full names, are two levels in the middle of the system: types and subtypes. Just these levels are compatible with the WRB second level.

The taxonomic system of the WRB is simple and comprises two levels. The upper level, or the reference base itself, is composed of 32 Reference Soil Groups that are correlated with soils of the national classification systems. The second level is a non-hierarchical (ordinate) classification [9]. To show the diversity of soils, 186 qualifiers are used. According to the definition, qualifiers characterize the properties of soils produced by soil-forming processes of minor importance, as well as properties important for land use. Each Reference Soil Group has its own set of qualifiers, which number strongly varies. The greatest one have Cambisols (68), the smallest – Nitisols (33). Presumably, the number of qualifiers depends on genetic homogeneity/heterogeneity of the RSG and on the volume of information available. Cambisols are identified by the cambic horizon, whose features may be recognized in many soils with a brown non-differentiated profile: brown forest soils, some podburs and soddy soils, pale soils in the regions of extra-continental climate in the cryolithozone, low-carbonate (semi)aridic soils, young tropical soils, soils on the slopes in humid and semi-humid regions; parent rocks have almost no importance. Such a great diversity of soils in so many regions requires many qualifiers. On the contrary, areas of Nitisols are few, and they are confined to mafic rocks, seasonally humid tropics, so the number of their modifications is small.

Qualifiers in the last WRB version [4] are subdivided into principal – confined to certain RSGs and arranged in accordance with their importance, and supplementary, inherent to many groups. Their sequence in the full soil name is regulated by certain rules similar to those (although rather flexible) existing in the Russian system for the subtypes [8]. Functionally, the subqualifiers in the form of prefixes indicating the position of a phenomenon in the profile, or buried soils or horizons, for example, Epi-, Endo-, Amphi-, Thapto- etc. slightly resemble some species in the Russian system.

Thus, **full names of soils** within the formal frames of two systems differ in the following ways. Soil names in WRB comprise taxa of two levels: Reference Soil Group and (sub)qualifiers covering texture and parent rock. In the Russian system, two upper levels are not mentioned in the soil name, and it starts with the type name, which is the third-level taxon followed by other lower-level elements. A certain similarity of two classifications starts at the subtype level (within soil type) in the Russian system and qualifiers of the RSG; the number of ingredients of the full names may reach 4–6 and 8–10, respectively. In this way, a complete image of a soil is formed without details concerning soil-forming and/or underlying rock and particle-size composition.

For soil names, the overall accepted scientific terms are mostly used; sometimes new terms proposed by the authors are added, for example, garbic, spolic; petrozems, urbi-stratified. Along with long-established folk names (gley, solonetz, etc.), new ones were actively introduced into the WRB, where elements of dead languages for RSG names are combined with new folk names for qualifiers. The latter are: pretic (Brazilian terra preto do Indio), murshic (Polish name for drained bogs), nechic (“white” in gamo dialect in Southern Ethiopia, suggested by J.Deckers).

CONCLUSIONS

The comparison performed revealed an obvious similarity of two systems despite their distinct formal difference. It is manifested in the approaches to the objects classified, first of all, in the priority of soil properties and of field diagnostics, involvement of pedogenetic concepts, functions of the second level in WRB and the subtype level in the Russian system. This essentially common level contains the genetic characteristic of the soil, and is realized as a RSG with several qualifiers in the WRB and type with several genetic features – subtypes in the Russian system.

In their essence and criteria, the qualifiers have much in common with the subtype genetic features, namely: incomplete fulfillment of requirements to horizons, addressing to secondary carbonate pedofeatures in the profile, to redox regimes, particularities of organic matter, colluvial phenomena, aridic pedogenesis, etc. Qualifiers for texture, rock fragments abundance and distribution in the profile are exceptions, since in the Russian system they are addressed to at the lowermost levels.

Much importance is attached to diagnostic horizons in both systems, which is rather a consequence of the attitude to the field diagnostic. There are many diagnostic horizons with more or less strict discriminative criteria; despite the difference in objects classified – soils of the world and of Russia, the number of horizons is greater in the Russian system. Functions of diagnostic horizons are different: in the Russian system, they identify soil types (set of diagnostic horizons = profile formula of a soil type); in the WRB, presence or absence of a horizon indicates a Reference Soil Group, in addition, horizons are taken into account in the definitions of some qualifiers.

In the process of WRB development by means of discussing diagnostic problems at real soil sections and classifying soils within the framework of national taxonomies, some positions of the Russian system were included. These are either elements of conceptual approaches (f.i., to subtypes and second-level qualifiers), or specifying diagnostic tools; a convincing example of the latter is the introduction of the chernic horizon for Chernozems as the most perfect variant of mollic horizon (“super-mollic”) – analogue of the Russian dark-humus horizon. As an opposite trend, the wish to decrease the flexibility of differentiating criteria in the Russian system may be noted. In any case, it is clear that the exchange of information and ideas contributes to harmonization and progress of both systems.

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