

MORPHOLOGICAL SOIL DESCRIPTION FOR CLASSIFYING SOILS AND INTERPTETING THEIR GENESIS

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Morphological description of the soil profile must provide further hierarchical morphogenetic analysis and adequate diagnostic and classification of soil in any substantive-genetic taxonomic system. In a brief taxonomy-oriented description, priority should be given to soil properties having diagnostic significance; they may be different for different horizons, and those discriminating similar horizons should receive special attention. It is proposed to compile an updated field handbook for soil morphological description, supporting the recent classification system of soils of Russia.

Key words: classification system of soils of Russia, brief and comprehensive field description, horizons' identification, diagnostic significance of soil properties.

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All soil research start with a morphological, or field, profile description that may be more or less complete and/or biased; however, its common outcome is a taxonomic name of the soil. Sometimes, it is followed by a morphogenetic hierarchical analysis aimed at a deeper insight into soil genesis or soil evolution.

The conceptual background of soil morphological analysis in Russia is clearly genetic, rather comprehensive, and substantiated by voluminous and diverse data on soils in miscellaneous environments. The fundamentals of soil morphological studies were created by [S.A. Zakharov \(1927\)](#); later, [B.G. Rozanov](#) summarized information on research methods and terminology in this area that was available by 1970-ies in his manual of 1975, which remains basic until now, and is broadly used in lecture courses and in many investigations. In 1982, [E.A. Kornblum](#) with co-authors proposed a comprehensive system of soil profile description and introduced a new hierarchical level – “morphon” as part of a heterogeneous horizon. Numerical schedules for soil properties were developed by [I.S. Mikhailov \(1972\)](#) and [V.A. Rozhkov](#)

(1993) to facilitate the mathematical processing of data. A research team of the Institute of Geography (RAS), guided by Victor Targulian, tested and developed the [Brewer's](#) system of hierarchical morphological analysis for a soddy-podzolic soil near Moscow (1974).

A critical review of the system of soil morphology investigations is now needed because of increasing use of the substantive-genetic classification system on one hand, and application of advanced analytical methods, on the other hand. In the recent [classification system of soils of Russia](#) (RSC; versions of 2004 and [2008](#)), based on diagnostic horizons and genetic properties, the priority of morphological studies is obvious, whereas soil-forming agents and analytical data are weakly involved in soil identification.

Numerous requests of specialists and students to give names to their soils in the RSC system on the basis of morphological descriptions and photographs of soil pits brought some doubts concerning the quality of field descriptions – their completeness and attention to diagnostically important features. Authors' experience in this respect, gained in such consultations, teaching, and their own field practices, as well as working with papers submitted to "Pochvovedenie" journal revealed some problems limiting the exhaustive use of field data, in particular, for taxonomic purposes. Except for technical and time restrictions, the problems coming out during the morphological description of the soil profile may be qualified as subjective and objective.

The *subjective*, or personal, aspect in the description comprises either belonging of the soil scientist to a certain scientific school, or his certain prejudice –emphasizing those soil properties that correspond to his ideas on soil genesis and/or driving forces of pedogenesis, and underestimating or even neglecting the other ones. For example, a well-known dependence of gley features on waterlogging impels soil scientist to mention bluish-greenish colors in water-saturated soil mass even if they are undoubtedly absent, and to qualify such soil as gleyic (formerly, "cryptogleyic", or "with concealed gley"). Belonging to different scientific schools affects the priorities in description, namely soil-forming factors versus soil properties; hence, diagnostics and definition of genetic (diagnostic) horizons become ambiguous. For example, people sticking to "factors" use the simplified indications for soil horizons – A–B–C, so that the real difference among humus-accumulative horizons in diverse soils cannot be recorded. A similar loss of infor-

mation happens with the subsoils: they are differentiated only as B1, B2....

Objective problems concern the absence (or uncertainty) of certain rules, strict definitions and unambiguous terms for morphological descriptions. Most common are doubts in the diagnostic of pedofeatures, identification of horizons, position of their boundaries, and discrimination between diagnostic horizons and diagnostic properties; there is also a particular “taxonomic” problem: choice of soil properties and genetic horizons that should be involved in soil classification, i.e. perform the diagnostic functions.

As a consequence, the prominent volume of field work done, time and money expenses prove to be incompletely justified, samples taken for the lower levels of hierarchical analysis – not reliably positioned, taxonomic solutions – unsure, and the whole bulk of data does not contain sufficient information suitable for various purposes.

The morphological description of the soil profile must provide the following issues: adequately identify the soil and give it a name in the classification system accepted; supply the reliability of the spatial differentiation of soil ingredients at macro-, meso-, micro-, and submicro-levels; make the knowledge obtained available and useful in several research areas and applications. Presumably, the morphological description may have two versions depending on its goals: brief and comprehensive.

In the *brief (taxonomic)* version, emphasis should be put upon the recognition of diagnostic horizons and properties for the identification of the soil and possibility to name it in accordance with the rules of classification systems.

The *comprehensive (pedogenetic)* description is the first stage of the hierarchical morphogenetic analysis of the soil profile. It is time- and labor consuming, therefore, is not always reasonable to be done. It is required in the studies of soil genesis and evolution; it is indispensable for correlating and linking the results of hierarchical analysis at lower levels: “to surely know, which element of soil fabric is described at a certain magnification”. For example, in the dark-humus horizon of a chernozem, it is recommended to describe not only the abundance, shape and size of coprolites, but also the degree of their preservation and their composition because at the micro-level, properties of micro-mass and secondary carbonates may be different in old and young cop-

rolites. Another example – EL and BT morphons in the transitional BEL horizon of texturally differentiated soils: a detailed description may be helpful for revealing the time sequence and range of eluvial and illuvial phenomena. A comprehensive description is desirable for humanly modified soils (with their mixed morphons, specifically) for better substantiation of taxonomic solutions and development of diagnostic criteria.

Thus, the comprehensive genetic description should account for all properties of horizons without any preference. Much attention should be paid to the color patterns (mottling), shape and fabric of aggregates, pedofeatures and their characteristics, in particular, to their related distribution, either mutual, or referred to voids and/or morphons. There are few examples of comprehensive descriptions implemented; these are guides of scientific excursions during international events: in 1974 – soddy-podzolic soil near Moscow ([Targulian et al., 1974](#)), in 2013 – Kursk chernozem ([Guidebook..., 2013](#)).

It is worth discussing in more detail some aspects of the brief description – universal, commonly applied, and necessary for using the recent classification of soils of Russia. Of primary importance are the diagnostic horizons in terms of their identification and taxonomic functions. It should be reminded that the International soil classification system ([WRB, 2014](#)) is basing on the field guide, where the characterization of each soil property is supplied with indication of its significance for classification ([Guidelines..., 2006](#)). For example, the way to describe color using Munsell Color Charts is followed by a list of ranges for hue, value, and chroma indices, or of their combinations (at different moisture gradations), which are inherent to certain diagnostic horizons, properties, material, or qualifiers.

The following properties are obligatory in a brief horizon description: depth of the upper and lower boundary, color and moisture, particle-size composition, consistence, structure, pedofeatures (neofeatures): coatings and their material, segregations and nodules – ferruginous, carbonate and gypsic, manifestations of soil material translocations, inclusions, kind of transition to the underlying horizon and shape of the boundary. Special attention should be paid to some properties helping to identify horizons as diagnostic in the RSC. These properties are different for different horizons (Table 1), they are enumerated in both versions of the system as for diagnostic horizons,

so for genetic properties (2004 and 2008). We should like to give some comments concerning discriminative morphological elements for the groups of horizons.

For all *upper organomineral* horizons Munsell readings are required (the dark-humus horizon has the lowest values and chromas se-

Table 1. Morphological features of diagnostic horizons and genetic properties important for soil diagnostics in the classification system of soils of Russia (2004/2008)

Groups of morphological features	Soil properties of special importance for diagnostics
Depth of the upper and lower boundaries, thickness	Thickness of diagnostic horizons must not exceed 10 cm, except for W, O, E, EL...
Color: homogeneity and evenness	BFM horizon must be homogeneous and even in color. For many horizons color heterogeneity presumes occurrence of genetic properties
Color of the background	Diagnostic element for most horizons, verbal or Munsell color charts indications
Moisture	Color parameters depend on moisture content
Particle-size composition	(1) Horizons: E, BFM, BHF may be only light-textured. (2) Value of K_d factor is a criterion for BM, BI, BT horizons (3) In clayey horizons, presence of slickensides should be checked (property v, horizons V, AV)
Structure and consistence	(1) No structure in CR horizon. (2) Columnar structure in the top of ASN и BSN horizons. (3) BM horizon has any pedogenic structure. (4) V and AV horizons are wedge-like and prismatic. (5) Structure and consistence serve as criteria for some other horizons
Pedofeatures (neoformations)	Kind, shape and abundance – common diagnostic elements of a horizon or property
Translocations of material	Color heterogeneity, is diagnostic for TUR horizons and some properties (yu, y, agr, tu, @)
Inclusions	Abundance and character are diagnostic for humanly modified horizons
Transition to the lower horizon	Indicates the uncertainty of the horizon thickness measurement
Shape of horizon's boundaries	One of diagnostic criteria for P, PU, PB, PT, PTR (plow) horizons; important for BEL diagnostics and subdivision

parating it from the brownish light- and gray-humus horizons), then follows the assessment of pedofauna activity and structure: pedality, shape, size and strength of aggregates. Additionally, the gray-humus horizon has a small admixture of comminuted plant residues and whitish “uncoated” sand and silt grains. The light-humus horizon may have secondary carbonates along with the crusty-layered morphons (“akl” genetic property). These features are included in the horizons’ definitions; some of them may need corrections. Anyway, their presence or absence should be recorded in the brief field description.

The descriptions of *eluvial and transitional* horizons in texturally differentiated soils are sometimes insufficiently complete to specify subtypes of these soils, forming a genetic sequence outlined by [V.D. Tonkonogov \(2010\)](#). The EL horizon’s heterogeneity is sometimes mentioned, although not clearly enough to choose one of the alternatives for genetic properties: inserted microprofile of podzol, or iron oxides redistribution by surface-gley mechanism, or contact bleaching, or “pale phenomenon” with corresponding subtypes specification.

The introduction of two variants of BEL horizon into the RSC enables to geographically differentiate the soddy-podzolic soils (East-European and West-Siberian), supports evolutionary hypotheses and is important for the morphological analysis at the lower hierarchical levels.

To illustrate the taxonomically oriented approach to soil properties one more example is proposed – pairs of subsoil horizons with common and discriminating diagnostic characteristics (Table 2).

An important issue for soil classification in the brief description is the identification of diagnostic horizons among the other ones: transitional, or those that are not involved in soil diagnostic at the type level. Such may be thick diagnostic horizons preserving their main properties throughout the whole thickness (AU, BT, BCA), and having small differences, mostly quantitative, recorded as AU1, AU2, etc. For the type diagnostic, the transitional horizons comprising properties of both their neighbors are also not significant (AO and AY, AU and BCA); however, genetic properties being criteria for subtype specification may be recorded in them.

When discussing the procedures of soil horizons description and recognizing the diagnostic horizons, it becomes evident that some corrections should be introduced in the definitions of horizons. For example, presentation of Yakutian pale soils during the field excursion of

Table 2. Diagnostic properties of horizons that should be considered in the field description

Common properties		Subsoil horizons and discriminating properties					
		BT and BI		BHF and BFM	CR and CRM		
Increase in clay content, K_d		>1.4	<1.4				
Structure	Blocky subangular+ prismatic	Many levels	1–2 levels				
	Massive				May be weak		
	Cryogenic					Massive, cryoturbations	Fine crumb-angular
Coatings	Clay	Lay-ered + silty, on all* ped-faces	Fine, with humus, on all* pedfaces				
	Ferruginous films			Films and bridges on grains and mottles on stones	Films on stones (and peds)		
Color, “warm” hues				Decreasing downward	Even color		

*Discontinuous coatings and their occurrence on vertical pedfaces testify to the genetic property rather than to corresponding horizon.

WRB workshop in 2013 induced proposals for changes in the pale horizon (BPL) definition for the next approximation of the RSC ([Diversity of soils..., 2013](#)). Very efficient was a long-lasting on-line discussion of urban soils diagnostic, which outcome was the extensive definition of the urbic horizon – product of “collective wisdom” ([Prokofieva et al., 2014](#)) as a diagnostic horizon for “urbostratozems”.

The corrections proposed mostly concern wording and additions to make the definitions more unambiguous and the differentiating criteria more obvious. Moreover, it is suggested to enlarge the section “ad-

ditional diagnostics”, both analytical and landscape-related; they may be illustrated by corresponding examples. (1) The field diagnostic of gley horizon (G) may be supplemented by an analytical procedure, namely, test with the α,α -dipyridyl; for the alfehumus (BFH) horizon, test with sodium fluoride may be recommended. (2) In the field diagnostic of cryogenic horizon (CR), it is reasonable to control the occurrence of cryogenic microrelief and/or patterned ground. In the same time, the experience persuades us that it is not feasible to stick to strict quantitative boundaries for the parameters of diagnostic horizons, it is better to leave them flexible, i.e. permitting small deviations, that are different for different parameters and different horizons.

The above considerations, and the experience gained while working with the RSC and WRB systems show the need for an updated handbook for soil morphological description – *brief taxonomic variant* – facilitating the use of the new Russian system. This handbook should contain both descriptions (definitions) of morphological elements (essential universal and special, required for taxonomy), as well as means to discover and identify them in the field. Emphasis should be put on those diagnostic tools that are particularly important for recognition of certain horizons, and also on those that require analytical express-methods and/or account for special landscape characteristics. It seems also reasonable to consider some quantitative parameters for separating diagnostic horizons and genetic properties (type and subtype levels). The guidebook published by FAO/UNESCO ([Guidelines..., 2006](#)) and translated in Russian is written in a similar way: it is oriented at WRB system.

REFERENCES

1. R. Brewer, *Fabric and Mineral Analysis of Soils* (Wiley, New York, 1964).
2. [Classification and Diagnostic System of Russian Soils](#) (Oikumena, Smolensk, 2004) [in Russian].
3. *Guidelines for soil description* (FAO/UNESCO, Rome, 2006).
4. *Guidebook for field excursions XIIth International Symposium and Field Seminar on Paleopedology*. Eds.: I. Kovda, S. Sycheva (Institute of Geography, RAS, Moscow, 2013).
5. *Diversity of soils of cold ultra-continental climate. Guidebook-monograph for the “Mammoth” ultra-continental WRB field workshop*. Sakha (Yakutia). S. Goryachkin, D. Konyushkov, P. Krasilnikov (Eds.) (Moscow–Yakutsk, 2013).

Byulleten Pochvennogo instituta im. V.V. Dokuchaeva. 2016. Vol. 86.

6. [*Field Guide for Russian soils*](#) (V.V. Dokuchaev Soil Science Institute. Moscow, 2008) [in Russian].
7. IUSS Working Group WRB. 2015. [World reference base for soil resources 2014](#), update 2015 International soil classification system for naming soils and creating legends for soil maps. Word Soil Resources Report 106. Rome.
8. E. A. Kornblum, I. S. Mikhailov, N. A. Nogina, V. O. Targulian, (Editors). *Basic schedules of properties of morphological soil elements*. (V.V. Dokuchaev Soil Science Institute. Moscow, 1982) [in Russian].
9. I. S. Mikhailov, *Morphological description of soil* (Nauka, Moscow Publ., 1975) [in Russian].
10. T. V. Prokof'eva, M. I. Gerasimova, O. S. Bezuglova, K. A. Bakhmatova, A. A. Gol'eva, S. N. Gorbov, E. A. Zharikova, N. N. Matinyan, E. N. Nakvasina, and N. E. Sivtseva "Inclusion of Soils and Soil-Like Bodies of Urban Territories into the Russian Soil Classification System," *Eurasian Soil Science*, 47 (10), 959–967 (2014). doi: [10.1134/S1064229314100093](https://doi.org/10.1134/S1064229314100093)
11. B. G. Rozanov, *Genetic morphology of soils* (Moscow Univ. Publ., Moscow, 1975) [in Russian].
12. V. A. Rozhkov, S. V. Rozhkova, *Soil informatics* (Moscow Univ. Publ., Moscow, 1993) [in Russian].
13. V. O. Targulian, T. A. Sokolova, et al. Organization, composition and genesis of the soddy-pale-podzolic soil on mantle loam. *To the X International Congress of Soil Scientists* (Nauka, Moscow, 1974).
14. V. D. Tonkonogov, *Automorphic soil formation in tundra and taiga zones of East-European and West-Siberian Plains* (V.V. Dokuchaev Soil Science Institute, Moscow, 2010) [in Russian].
15. S. A. Zakharov, *Lecture course on soil science*. Part I. "Doctrine of soil morphology" (Gosizdat Publ., Moscow–Leningrad, 1927) [in Russian].

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