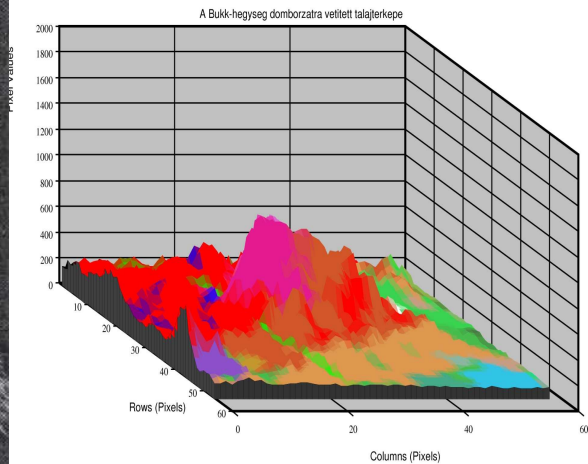


# Bridging the Centuries 1909-2009 Budapest

Celebration of the legacy of agrogeology  
and the 100 years of advances in soil sciences

## From the Dokuchaev School to numerical soil classifications



Program and abstracts

18. September, 2009  
Budapest, Hungary

## **18. September, 2009**

**Venue: Szent István University, Gödöllő (1<sup>st</sup> floor, Rector's Hall)**

Bus transportation will be organized from Hotel Andrassy to Gödöllő and back.

**08:00** Departure from Budapest

**08:45** Registration

### **Program**

Keynote speakers (Richard Arnold, Otto Spaargaren and Alex McBratney) will have 30 minutes, other speakers will have 20 minutes for the presentations. The discussions will be after 2 or 3 speakers discussing similar topics. The relatively long coffee breaks and the lunch arrangement will allow further discussions. The poster authors will have a chance to explain their posters if they wish to do so.

**09:00** Richard Arnold: Believe in Icebergs: principles and conflicts in soil classification

**09:30** Peter Schad: Soil classification: past – present – future

**09:55** Pavel Krasilnikov: Soil classification: The end of the history?

**10.15** Discussion

**10:30** **Coffee break**

**11.00** Otto Spaargaren, Peter Schad, Erika Michéli: Small-scale mapping with WRB

**11:30** Einar Eberhardt, Dana Pietsch: Classifying soils according to WRB with national soil legacy data

**11:50** Endre Dobos: The WRB qualifiers as melting pots for digital soil mapping

**12:10** Discussion

**12:30** **Lunch break**

**14:00** Alex McBratney, Budiman Minasny, Raphael Viscarra Rossel: Numerical soil classification: a missed, but not a lost opportunity

**14:30** Darrel Shultze and Philip Owsen: Visualizing Soil Landscapes

**14:50** Rainer Baritz, Dietmar Zirlwagen, Eric Van Ranst: The role of pedogenetic map units to

predict landscape-level soil properties - is a paradigm changing?

**15:10** Discussion

**15:30** **Coffee break**

**16:00** Gergely Tóth and Ciro Gardi: Classification of European soils by their functional abilities

**16:20** Jonathan Hempel, Alfred Hartemink, Robert McMillan: Global Soilmap.net project and the

North American Node

**16:40** Discussion

## **17:00 POSTERS**

### **Posters and computer demonstration:**

- 1.** István Sisák, Csaba Hausner, Ferenc Máté: Deriving high precision soil texture data for a study area in Hungary
- 2.** Florence Carré and Martin Jacobson: Soil profile distance measures and classifications
- 3.** István Waltner and Vince Láng: One hundred years of evolution of soil classification in Hungary
- 4.** József Szabó, Erika Michéli, László Pásztor, Endre Dobos, Zsófia Bakacsi, Miklós Dombos: Elaboration of the OSIRIS framework for new, cost-effective soil survey and monitoring programs in Hungary
- 5.** Irén Puskás, Andrea Farsang: Classification of soils in Szeged and its vicinity into WRB (2006)
- 6.** Zoltán Borcsik, Andrea Farsang, Irén Puskás: The comparison of humic substances and its grouping in Hungary and in European countries
- 7.** Erika Michéli, Márta Fuchs, Tamás Szegi: The major soils of Hungary in the WRB

## Believe in Icebergs: principles and conflicts in soil classification

Dick ARNOLD

Icebergs are important to pedologists because they have much in common with soil classifications. We see the tip and usually forget that 90% or more lies beneath the surface. Our legacy involves hundreds of schemes – a fantastic storehouse of knowledge – and valuable if we examine how they used the principles of soil classification.

I no longer consider these differences as conflicts, rather they are more like paradoxes – seemingly contradictory, but in reality satisfying their own understanding and application of principles. Principles for the most part are well known: purpose, domain, objects, structure, categorization (rationale), diagnostics, and viability. The first three I refer to as driving forces; the next three as organization, and the last is continuity. Concepts related to each principle will be pointed out and you can imagine why and how the differences have been considered as conflicts. For example, if a system intends to provide direct pragmatic interpretations for a specific use, or multiple uses versus one that intends to show relationships among entities based mainly on pedogenetic concepts there likely will be definitional differences throughout the remaining principles.

As we attempt to reach consensus it may be useful to recall the three-legged stool of learning-teaching: we need to learn how people learn, then learn how and when to teach, and then teach effectively so that others may learn. The vast knowledge of our icebergs cautions us to be careful, be clear, be ambitious yet humble. Are we ready to go universal?

## Soil Classification: Past - Present - Future

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Soil classification as a science started in the 19<sup>th</sup> century. In the midst of the 20<sup>th</sup> century, two different approaches have been outlined in classical publications. The classification approach by Cline (1949) requires “framing classes by grouping individuals that are alike in *selected characteristics*” to serve “a *specific objective*”. The systematics approach by Kubiena (1948) classifies soils “based on *the entire set of its characteristics* to understand their mutual relationship and *natural coherence*”.

Many national soil classification systems use the systematics approach, especially in Europe. The United States followed the classification approach and, based on the idea of diagnostics outlined by Guy Smith (1952), published Soil Taxonomy (ST, 1975).

The merits of Soil Taxonomy are:

- precise, quantitative and *consistent* definitions
- suitability for both, soil *classification* and soil *mapping*

The weak points of Soil Taxonomy are:

- neglect of important soil features on higher and intermediate levels
- definitions using fairly arbitrary limit values
- complicated and individual keys for every unit

In the 70ies, FAO and Unesco published the Soil Map of the World and under the leadership of Rudi Dudal elaborated a Legend which was also used as a soil classification system. Many definitions of ST served as archetypes for the FAO system. In the 80ies, a working group of the International Soil Science Society (ISSS), led by Ernst Schlichting, prepared the International Reference Base for Soil Classification (IRB) which combined elements of the FAO system with some principles of a systematics.

Based on FAO and IRB, the World Reference Base for Soil Resources (WRB) was published in 1998 and endorsed as official correlations system of the ISSS. It had only two hierarchical levels: the upper level with the Reference Soil Groups (RSGs), and the lower level whose units are constructed by adding a set of qualifiers to the name of the RSG. Many qualifiers are relevant for management. With that system, WRB overcomes most of the weak points of ST. On the other hand, WRB 1998 had many imprecise or inconsistent definitions and could not easily be used for basic soil maps. The second edition of WRB (2006) is now characterized by (mostly) precise and consistent definitions. And the “Guidelines for constructing small-scale map legends using the WRB” (2009, not yet published) are promising to make WRB suitable for designing basic soil maps. In the meantime, attempts for an automatic computer-based WRB classification of soils on the basis of field and laboratory data are underway.

Are with that all the present demands on a soil classification satisfied?

Key words: classification, systematics, Soil Taxonomy (ST), FAO-Unesco Soil Map of the World, World Reference Base for Soil Resources (WRB)

## Soil classification: the end of the history?

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For a long time soil classification was in the centre of interest of pedologists. In 50-70's of the 20<sup>th</sup> century the discussions on soil classification attracted the attention of all the soil scientists. Currently soil classification has moved from the nucleus to the margin of the attention of soil science community as environmental issues of terrestrial ecosystems have gained prominence. In the last decades developments in digital mapping now facilitate combining various information layers, somewhat replacing traditional soil classification based maps. Even in soil genesis and soil geography studies researchers commonly speak in terms of pedogenetic processes and particular soil characteristics rather than the use of formal soil names. For many purposes mathematical ad-hoc classifications work better than more general basic classifications. Does it mean that soil classification is "dead and buried"? If there is future for soil classification, or it will disappear completely? Should it be in the focus of the interest of the scientific community, or will be developed and used by small marginal groups of researchers?

To answer these questions we should remember the functions of classification in natural sciences in general and in soil science in particular. These functions are: arrangement of our knowledge about the Universe, development of common language for the communication among the specialists, presentation of soil information in a compact form (e.g. for mapping) and simplification of education. The development of technology produced novel methods of visualization of soil information. The GIS-based soil maps include several layers with soil properties, important for the users, instead of extensive soil names, which need explanation. Definitely the use of digital soil maps is a big challenge in soil geography that reduces the importance of classification for practical soil mapping. However, the other functions of soil classification cannot be replaced by high technology. Soil classification is a mirror of our knowledge about the soil, and the structure of soil classification depends on our current system of concepts and ideas about soil genesis, geography and functioning. Then, the communication among the scientific community requires common language. We use names in our everyday activity, and we need them in science. To a great extent the existence of specific terminology determines the identity of science. Without soil classification all the pedology may be reduced to chemistry, physics and biology. Finally, the education on any level requires simple systems of presentation of information. If we teach the students on the basis of independence of soil properties, they would be easily confused and lost in the chaos of soils. Classification permits simple and structured explanation of soil phenomena.

We believe, that soil classification is not dead. However, it seems natural that its significance for soil science community decreased. Like in the ontogenesis of human being, the classification occupies the central place in science on the initial stages of its development.

Key words: theory of classification, soil mapping, soil education, history and philosophy of science

## Small-scale mapping using the World Reference Base for Soil Resources

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When classifying soils, the World Reference Base for Soil Resources (WRB) is capable of indicating most of the soil's properties; in most cases the result is a quite satisfactory and informative soil name. However, when generalization is required, e.g. in mapping, important information may not show, depending on how the generalization is carried out. Although WRB was not primarily designed to serve mapping purposes, it is increasingly used for that. Therefore, guidelines are needed how to construct map unit and map legend names.

In the WRB publication it is suggested to use for small-scale maps the prefix qualifiers only and for large-scale maps additional suffix qualifiers. If this approach is taken with the current configuration of the qualifiers, important information on certain soil characteristics may not be revealed on small-scale maps. For example, the occurrence of clay skins (Cutanic) is recognized very high at prefix level, and, when generalizing, Luvisols (and related soils) become Cutanic Luvisols or Cutanic other soils, which for temperate and subtropical regions does not give a satisfactory differentiation. Similarly, Rhodic in Ferralsols and Nitisols, and Xanthic in Ferralsols, important qualifiers to indicate their environmental setting and geological relationship, are suffix qualifiers, which may only show up on large-scale maps. The Ferric characteristic, important to assess the structural stability of soils, will not show up in small-scale soil maps if the current suggestion in the WRB publication is followed.

Guidelines have been developed to construct map units (or soil typological units) and map legends for scales of 1:250 000 and smaller. These guidelines, which are still for discussion and testing only, are based on the following considerations:

- The soil units and their ranking in the FAO-UNESCO Legend and Revised Legend of the Soil Map of the World (SMW);
- The occurrence and significance of soil properties in other classification systems;
- The relevance of differentiating characteristics for the soil's environmental and management functions;
- The availability of soil information (legacy and modern);
- The mappability of soil characteristics at scales of 1:250 000 and smaller.

For each Reference Soil Group lists are compiled of main map unit qualifiers and optional map unit qualifiers. The main map unit qualifiers are ranked and have to be used in the given order. The optional map unit qualifiers are listed alphabetically and may be added according to the need of the user. Several examples will be given.

Key words: World Reference Base for Soil Resources (WRB), small-scale soil maps, soil map legends

## **Classifying soils according to WRB with national soil legacy data - obstacles and approaches for automated solutions**

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The World Reference Base for Soil Resources (WRB) provides a soil classification for international use. Existing data on soils mostly were obtained by using national soil description guidelines and soil classification systems. For international cooperation, a correlation with WRB is needed. This poses problems that originate from the divergence between how soil scientists traditionally approach soil profiles and how soil profile data are normally obtained, structured and stored in databases on the one hand, and how profiles are investigated for classification according to WRB on the other.

Typical soil data that can be found in databases describe profiles and their genetic horizons. Described genetic horizons follow one after another, they do not overlap and there are no gaps in the sequence. They are identified by their properties and designated with a letter and/or number code (in FAO 2006 named master horizons and subordinate characteristics). Genetic soil classification systems classify the soil with presence and absence, thickness and depth as well as vertical order of genetic horizons which were identified by their features and properties. WRB essentially only looks for diagnostics, e. g. diagnostic horizons that may overlap or may be somewhat distant from each other. The number of required diagnostics depends on the order of the soils in the WRB key and the qualifiers that can be applied with each reference soil group. Further problems arise when national legacy data are confronted with definitions that, e. g., involve weighted means of single parameters, such as substance contents, that do not fit with national content classes, or if transitions between layers shall have defined properties that cannot be precisely checked with typical horizon descriptions, e. g. the change of clay content over a specified vertical range.

The general idea of our project is to develop algorithms which can be used to correlate a multitude of existing national soil data with WRB. Ideally, such a system connects to diverse regional databases, so that a wide variety of users has access to such a correlation system. Analyzing the existing WRB procedures and nomenclature, we identify typical problems with the example of soil data obtained according to the German soil survey guideline. Instead of translating German genetic soil types into WRB nomenclature, we present algorithms for the determination of WRB diagnostics, reference soil groups and qualifiers with both descriptive and, if available, analytical soil data. Cross-references to the FAO *Guidelines for soil description* will show that some of the problems of our national system apply in the same way.

Key words: World Reference Base for Soil Resources (WRB), diagnostics and qualifiers, German soil description and classification, soil databases, soil data harmonization

## **The WRB qualifiers as melting pots for digital soil mapping**

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Many countries completed large scale (1:5,000 – 1: 25,000) soil surveys decades ago, and have since used their thematic and geographic information to derive thematic soil property layers of the same or smaller scale (1:100,000 and smaller). The new layers are often simply aggregates of the original soil polygons and inherit the same geographic relationships that were delineated in the original data source. In reality, this approach does not use all information of the input data. Instead of aggregating existing maps, the original, non-interpreted field survey point data can be gathered and used for deriving new property layers. However, the great variability of input data always limits the correlation work. The related variables are often difficult to translate to a common one due to the non-matching class limits. Therefore, WRB qualifiers were selected as melting pot variables for describing the soil properties. The paper aims to summarize a soil database development project using legacy data for a transboundary area, representing two different systems of data collection, storage and management. Recent and archived soil profile data have been collected, including monitoring sites, soil nutrient status campaign data for different periods, and recorded soil profiles from previous soil mapping activities. These data sources have been transformed to have a common theoretical basis using commonly accepted pedotransfer rules and an integrated profile database has been formed. It was used to interpolate soil information and develop soil property maps and layers representing the WRB diagnostic properties and horizons. The creation of the property layers was based on statistical/geostatistical interpolations of the soil profile database using DEM derivatives, SPOT and Landsat satellite images as covariates to provide information for the natural setting of the area. The interpolated values for the numeric variables were estimated using regression kriging, while the classified variables were calculated using the maximum likelihood classification algorithm. It was concluded, that the development of WRB diagnostic criteria database is feasible using raw data of different origin and a set of harmonization and digital soil mapping tools.

**Key words:** World Reference Base for Soil Resources (WRB), diagnostics and qualifiers, soil properties, soil databases, digital soil mapping

## **Numerical soil classification: a missed, but not a lost, opportunity**

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The idea of numerical classification comes from the 1770s – the so-called Adansonian approach (Michel Adanson, French botanist, 1727-1806). This notion came into reality in the 1950's and 1960's with the advent of digital computers and numerical analysis. This movement was largely led by biologists.

Soil scientists were involved in the early stages of numerical taxonomy and many experiments with numerical soil classification were completed. However these were generally local studies of limited scope.

The jump to national and international studies was not made, largely, we believe, because of the lack of good national and global soil databases in the 1970's and '80's.

Today, we have such databases, much faster computers, and better pedometric methods such as continuous classification (with fuzzy k-means with extragrades), so the possibility of global numerical classification is good. But, is it too late? Many would argue that the era of soil classification is past. We believe that there is still a great need for improved and new ways of ordering soil information. There are some choices to be made however. Do we create classes of soil horizons and/or profiles? Do we use all soil properties to define and allocate soil classes? Do we create such classes *ab initio* or do we start with centroids of pre-defined classes (e.g., WRB diagnostic horizons or Soil Taxonomy suborders) with the aim of improving them?

It is clear however that at least the concept of taxonomic distance is essential for the improvement of all conventional national and international soil classification systems.

Key words: World Reference Base for Soil Resources (WRB), numerical taxonomy, Soil Taxonomy, pedometrics, numerical soil classification

## Visualizing Soil Landscapes

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Many of the concepts that soil science students must master are inherently spatial. Although we implicitly acknowledge the existence of spatial patterns in our courses, our ability to explicitly make these spatial patterns clear to our students has been limited. I will describe how we are teaching students complex soil geomorphological concepts in the field using geographic information system (GIS) software running on rugged tablet PCs equipped with GPS receivers. We use a high resolution, 5 meter Digital Elevation Model (DEM) as our base map, and then overlay various thematic maps derived from the detailed, second order soil survey data (SSURGO) that is available for all of Indiana. A dominant soil parent material map is one of our most useful layers, but soil drainage class, loess depth, fragipan distribution, and many other features can be displayed at any time for any part of the state at resolutions from 1:3,000,000 to 1:2,000. Although our focus is on teaching and learning, the approaches we have developed and the issues we have encountered as we have worked with these thematic maps have implications to soil classification and mapping as well.

Key words: soil geomorphology, spatial relationships, soil survey

## **The role of pedogenetic map units to predict landscape-level soil properties - is a paradigm changing?**

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Reconnaissance soil map data very often describe pedogenetically defined spatial entities while being based on various morphological and (increasingly also) analytical variables. Recently, GIS modelling has gained importance in soil mapping, data base development and soil quality evaluation. In many applications, digitized reconnaissance and auxiliary data of various resolutions are being processed simultaneously based on qualitative rules, static and sometimes even dynamic models. Digital soil mapping allows novel approaches to gap filling, spatial resolution, quality assurance, and uncertainty assessment. While land managers have a very specific need of soil data, modellers (e.g. climate change, land use effects) and policy makers and planners (e.g. risk assessment) often require spatially explicit information about soil properties, e.g. soil organic matter, degree of acidification, soil buffer capacity, etc. Such data can be derived from plot-level samples where these parameters were measured (or derived from measured parameters) and then upscaled, or where such data are available in map data bases (derived from estimated or measured “typical” soil profiles; one or several profiles representing the dominant soil in a given landscape). The question will be investigated, to which degree pedogenetically defined soil map units appear as predictors when soil properties are mapped using digital soil mapping. Soil organic carbon which is an important indicator for pedogenesis and soil condition will be analysed as an example.

Key words: soil classification, soil maps, digital soil mapping, soil organic carbon, upscaling, multiple regression analysis

## **Classification of European soils by their functional abilities**

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A new concept for soil quality (SQ) evaluation has been developed with the aim to support the Thematic Strategy for Soil Protection of the EU. In this concept SQ is defined as an account of the ability of soil to provide ecosystem and social services through its capacities to perform its functions and respond to external influences. The SQ description is based on the evaluation of functional abilities and reacting characteristics of soils, expressed by Partial Soil Quality Indices (PSQI).

A continental scale evaluation scheme of soil functional abilities has been elaborated. The variability in the soil's functional ability is also expressed and integrated to the PSQI, where found to be relevant. In the new scheme internal soil characteristics are taken into account in their spatial context to calculate PSSQ classes. PSSQ classes are formed on the basic principles of numerical classification. Results allow the classification of soil resources by individual soil functions, but also allow turning these multi-state characters of soil into a single coefficient of composite indicator of soil quality.

Seven PSQIs are calculated for the main soil functions defined in the Thematic Strategy, namely:

- 1, biomass production (Prod-PSQI)
- 2, storing, filtering and transforming nutrients, substances and water (Sft-PSQI)
- 3, hosting the biodiversity pool (Biod-PSQI)
- 4, acting as a platform for most human activities (Antr-PSQI)
- 5, providing raw materials (Raw-PSQI)
- 6, acting as a carbon pool (Soc-PSQI)
- 7, storing geological and archaeological heritage (Heri-PSQI)

First results from the application of the composite SQ indicator on a Pan-European dataset prove the great geographical variability of soil resources in the continent with regards to their functional abilities.

**Key words:** soil quality, soil resources evaluation, soil functions, functional classification

## **Globalsoilmap.net project and the North American node**

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The GlobalSoilMap.net project proposes to make a new digital soil map of the world using state - of - the - art and emerging technologies for soil mapping and predicting soil properties. About 80% of the global land surface will be mapped in 5 years. The map will consist of the primary functional soil properties at a grid resolution of 90 by 90 m. It will be freely available, web - accessible and widely distributed and used. The maps will be produced by a global consortium with center in each of the continents.

The National Soil Survey Center in Lincoln, Nebraska and the National Geospatial Research Development Center in Morgantown, West Virginia functions as the North American Node Leader and is a member of the Global Consortium and will work closely with the following international partners that will oversee and develop the information.

- Agriculture and Agri-Food Canada
- Instituto Nacional de Estadística y Geografía
- The Joint Research Centre (JRC)-European Union, ISPRA, Italy
- The Chinese Academy of Sciences-Beijing, China
- University of Sydney-Sydney Australia
- EMBRAPA Soils-Rio de Janeiro, Brasil
- Australian Commonwealth Scientific and Industrial Research Organization (CSIRO)-Canberra, Australia
- The World Agroforestry Centre (ICRAF)-Nairobi, Kenya

This new global soil map will be supplemented by interpretation and functionality options that aim to assist better decisions in a range of global issues such as food production and hunger eradication, climate change, and environmental degradation.

In November 2008, the Consortium obtained a grant from the Bill & Melinda Gates foundation to map most parts in Sub - Sahara Africa, and make all Sub - Saharan Africa data available.

From this grant there are also funds for coordinating global efforts and for the establishment of the global consortium. Proposals for additional funding streams to develop the data in other parts of the globe are currently underway.

**Key Words:** digital soil map, web accessible, Global Consortium,

## **Posters**

## **Deriving high precision soil texture data for a study area in Hungary**

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Detailed digital soil maps may explain large part of the within field yield variability thus they are essential components of the precision agriculture technology. There are four highly detailed soil data bases in Hungary which cover the whole agricultural area. 1.) The Kreybig-map (named after the leader of the mapping program, Lajos Kreybig) was compiled between 1932 and 1952 on 1:25,000 scale map sheets with Gauss-Krüger projection. 2.) The Géczy-map (named after the program leader, Gábor Géczy) was compiled between 1958 and 1961 on 1:25,000 scale map sheets of municipalities with Gauss-Krüger projection. 3.) The agrochemical soil data base was compiled from soil investigation data of the fields of the former large-scale farms in the 1980's. 4.) The land evaluation data base was compiled in the early 1980's for the reference sites of the land evaluation system.

A 266 sqkm study area at Lake Balaton, Hungary, one sheet of the Kreybig-map was selected to investigate soil texture data. Available information from the four data bases were used to derive a single digital soil texture map. Soil texture data (field assessment, liquid limit according to Arany, capillary rise) were interpolated by using Inverse Distance Weight (IDW) principle. Cross validation of measured and predicted data within the individual data sets was performed by sequentially omitting points and comparing them with the measured values. In the next step, texture data from different data sets were harmonized and the cross validation has been performed between different sources.

The results can be considered as first approach to delineate a fine-scale soil texture map.

By using ancillary variables (including digital elevation map and polygons of the soil maps), further improvement could be achieved.

This study has been supported by the OTKA 62436 grant.

Key words: digital soil mapping, soil texture data, detailed soil databases in Hungary

## **Elaboration of the OSIRIS framework for new, cost-effective soil survey and monitoring programs in Hungary**

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There is great diversity among countries in data availability. Hungary has long traditions in soil survey and mapping. Soil maps are available on different scales and a great portion of those are also digitized. Hungary has also one of the most detailed monitoring systems in Europe. The existing maps, data, and characterization systems served the society very well for many years. However the available data are no longer fully satisfactory for the current needs of policy making, the Agro-Environmental program, soil protection, soil management or modeling. In summary most of the maps are based on old information, often no longer valid, poor sampling strategies, and some laboratory methods that do not satisfy the current expectations for reliable quality data. The huge accumulation of monitoring data is poorly processed and interpreted, hence barely available for applications. It is very important that valuable historical data be evaluated and converted to relevant quality, and the new observations follow the international standards.

The objective of the OSIRIS project is to develop state of the art methodology for soil observation and information system for Hungary. The major elements of the objective are: the development of modernized data collection, data transformation, data interpretation and data delivery. The development of procedures and methods will follow international guidelines (WRB, ENVASSO, etc.) and the pilot products will be based on modern technologies of geo-statistics, GIS and digital soil mapping. The final product will be a framework for new, cost-effective soil survey and monitoring programs and methods to provide relevant information for local, regional and global purposes, such as policy making, soil protection, soil management, modeling etc. The work will be performed through close cooperation of universities and research institutes and will also include practical experts and stakeholders in the testing phase.

The soil information system to be developed will be capable to store and integrate qualified and converted archive soil data and data from new observations with modernized technology. The diagnostic unit and “qualifier” based database will allow easy interpretations and compilation of thematic maps (soil property maps, risk maps etc.) and targeted databases according to needs of the end users (from land owners to educators) or policy makers. The guidelines to be developed and part of the soil interpreted soil data are planned to be available online making access easy to the users.

Key words: soil information, soil databases, soil assessment, WRB

## **Classification of soils in Szeged and its vicinity into WRB (2006)**

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The classification system of WRB(2006) classifies the soils of urban and industrial areas as an individual soil group (under the term Technosols) for the first time. Our main aim was to classify soils in Szeged to according to the WRB(2006) nomenclature and to reveal the potential classifying failures and improve application of this system. After the evaluation and statistical analysis of diagnostic properties (humus, carbonate content, pH, heavy metals, artefacts etc.) three main soil types can be identified in Szeged with respect to the degree of human influence.

Profiles in the peripherals representing the original genetic soil type and profiles in orchards with some modifications were classified as soils slightly and moderately influenced by human activities. These profiles were classified into Phaeozem, Fluvisol, Gleyosol, Arenosol, Solonetz natural soil groups and received the suitable qualifiers. The “weakness” of WRB(2006) in terms of the suffix Toxic was proved through the example of the Fluvisol profile No. 23. This was the only profile where the topsoil concentration of four heavy metals exceeded the B threshold value. The topsoil of another Fluvisol profile (No. 19) also contained toxic metal concentration. However, there is not a Toxic suffix among the qualifiers of the Fluvisol soil group. Consequently, we suggest that the Toxic qualifier has to be involved the qualifiers of Fluvisol and all other soil groups since not only urban soils but natural soils in the peripherals can be contaminated by atmospheric deposition, surface runoff and agricultural activities.

Mixed profiles on outskirts fell into the category of strongly modified soils. After their classification into the WRB (2006) it can be established that the their names do also reflect their dual nature: The upper part of profiles was generally assigned into the Technosol soil group and was provided with the suitable qualifiers. The lower part composed of buried horizons was described with the Thapto- specifier and -ic added to the reference soil group name of the buried soil. The upper parts of these profiles are mostly characterized by suffixes Ekranic and Urbic and prefixes Toxic, Ruptic and Calcaric. Profiles completely altered by a very intensive human influence were placed into the group of Technosols due to the considerable transformation of their diagnostic properties (e.g. coverage by artificial objects, intensive compaction, horizontal and vertical variability, usually high amount of artefacts). Among the suffix qualifiers Calcaric, Ruptic, Densic and Arenic were used the most frequently. Furthermore, We found that three of the nine studied profiles were not situated in the city centre. Consequently, the location of these profiles in the city centre is not necessary since local influences can overwhelm the effect of artificial infill. Considering all the profiles, two of them in city centre can be consider to be the most anthropogenic: profile No. 11 with “technic hard rock” has the least chance to experience pedogenetic processes since the horizons are covered by thick, surface artificial object, and isolated from the outside world. However, in case of profile No. 22 with dense vegetation and without surface artificial object, the high amount of artefact inhibits pedogenesis.

Key words: Technosols, WRB, classification, human activities

## **The comparison of humic substances and its grouping in Hungary and in European countries**

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The quantity and quality of organic matters in difference soils are typical of the given soil. Organic matter playing significant role into fertility of every soil is different from viewpoint of qualitative and quantitative (STEFANOVITS, 1975).

The humification is the biological, microbiological and chemistry transformation of the organic residues into the soil humic substances (TATÉ 1987). The continental humic substances made of terrestrial, well-aired, loose plants are characterized with aerob decomposition.

The continental humic substances can be found under forests, lawns and other places where considerable repetitive disturbing was not realized during the humus formation (NÉMETH, 1996). Humus can form if the organic matter decomposition is not too fast and it can transform into bigger molecules influencing on soil nutrient service ability (ECKELMANN, 2005).

The grouping of the humic substances differs in each country because of the specific soil science and geographical position. WRB (World Reference Base for Soil Resources) handles the soil formation horizons uniformly. However, there are distinct national classification systems applied for some countries parallel to WRB. It is essential comparison of these systems over different soil denominations. The humus formation process can be divided into 3 parts in our countries in according to degree of plant decomposition.

The method characterizing processes is equal to main points in foreign literature but it is not detailed.

Our aim to present overlaps, parallels and differences between WRB denominations both in the European countries and the Hungary. Furthermore, we wish to reveal differentiations between some methods of humus determination and definitions (GRIFFITH, SCHNITZER 1975).

Key words: Humus forms, World Reference Base for Soil Resources (WRB), fertility

## **One hundred years of evolution of soil classification in Hungary**

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On the global level, the classification of soil resources became more and more a key field within the soil science discipline; and the classification of soils has changed over time more than any other classification systems. It was also the case in Hungary where, during the past century, several attempts were made to map and classify the country's most precious natural resource, soil.

In the present study we attempt to outline how soil classification systems changed following the developments in our understanding of the different influencing factors. We have selected the four main Hungarian systems presented in the last one hundred years, and also included the new national system that is currently being developed. The selected systems were the climazonal system by TREITZ, the general soil classification system of 'SIGMOND, the legend of the maps based on KREYBIG's method, the present Hungarian genetic soil classification system by STEFANOVITS and the new, diagnostic national system, the development of which is coordinated MICHÉLI ET AL.

We have compared the selected systems based on their original purpose, their main driving ideas, the number of taxonomic levels, the types of borders between classes, diagnostics, number of low-level classes, data requirements and their relationship to international trends.

To assess the evolution of our national systems, we have used the 2007 update of the World Reference Base for Soil Resources (WRB) as reference.

Using selected soil profiles we have also assessed how the application of these different classification systems would have resulted in different classification of the same soils, and how that might affect the use of legacy data based on these different systems.

**Key words:** soil classification, Hungary, soil data, World Reference Base for Soil Resources (WRB), legacy data

## Soil profile distance measures and classifications

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The quantitative grouping of sequences of soil layer descriptions into soil profile classes has not been developed much since the 1960's with the exception of the work of King and Girard (1988). Here we tackle the problem from pedological, utilitarian and joint points of view. A Web Based Application, OSACA, has been developed for this purpose. It calculates the taxonomic distances between observed profiles based on layer (horizon) characteristics. Characteristics can be either observed soil properties or layer class memberships.

The inter-profile distance is calculated in three ways: 1/ pedological distance, this focuses on the sequences of layers with scant regard to thickness, 2/ utilitarian distance, the metric is weighted by the layer thickness 3/ joint-distance, a combination of the pedological and utilitarian distances (the metric includes the relative layer thickness).

Given the inter-profile distance matrix, OSACA then proceeds to either allocate profiles to existing classes, or create a new classification of the profiles. The methods are described for a set of soil profiles for New South Wales Australia and applied for two different applications: soil taxonomy and prediction of soil water capacity.

The soil taxonomy outputs were compared to the Australian soil types using Rand Index. The pedology distance shows results more similar to the Australian soil types than the other two distances.

Soil water capacity was initially predicted by a set of neural network functions on soil texture, bulk density and soil depth. In our case, we used a simple linear model (multi-linear regression) on firstly the pedological distances, secondly the utilitarian distance and thirdly the joint distances. Distance performance was assessed by looking at the three adjusted coefficient of determinations. Utilitarian and joint distances have an adjusted coefficient of determination closer to 1, relatively to the pedological distances.

The pedological distance is more useful for creating classes for pedogenetic and geomorphic studies, whereas the utilitarian distance is more useful for environmental applications.

Keywords: numerical classification, soil taxonomy, pedological, utilitarian, joint distances.