CHAPTER 3

Soil Classification: Past and Present

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BACKGROUND AND HISTORY

Although not recognized as disciplines until the nineteenth century, pedology and soil science in general have their rudimentary beginnings in attempts to group or classify soils based on productivity. Early agrarian civilizations must have had some way to communicate differences and similarities among soils. The earliest documented attempt at a formal classification of soils seems to have occurred in China about 40 centuries ago (Lee, 1921). The Chinese system included nine classes based on productivity. The yellow, soft soils (soils derived from loess) were considered the best, followed by the rich, red soils. The evidence suggests that the Chinese soil classification system was used to levy taxes based on soil productivity (Simonson, 1962).

Cato (234–149 BC), a Roman scientist, contrived a classification of soils based on farming utility. His system employed 9 classes and 21 subclasses, and it guided decisions about use and care of the land for production of food and fiber (Stremski, 1975). The decline of the Roman Empire coincided with a general stagnation in the field of soil science, as noted by the low number of major contributions in the discipline until the nineteenth century.

The nineteenth century saw renewed interest in studying soil characteristics, in order to relate tax assessment to soil productivity. In Russia, this effort helped establish the discipline of pedology. The Russian government in 1882 hired V. V. Dokuchaiev to guide a program that would map and classify soils as a basis for tax assessment (Simonson, 1962).

Dokuchaiev and his students launched a new era in pedology that promoted the description and characterization of soils as natural bodies with a degree of natural organization, rather than viewing soils simply as mantles of weathered rock. This important notion fostered the concept of the pedon, from which data could be collected and compared. Even after the concept of the pedon took hold among pedologists to facilitate data collection, soil science still lacked standards to classify soils

Table 3.1 Families of Reddish Prairie Soils in the Southern Great Plains Correlation Area

Family	Stage	Texture Class	Drainage	Degree of Weathering	Size of Solum
Craig	Maximal	Medium	Good	Strong	Medium
Dennis	Medial	Medium to moderately fine	Good to moderately good	Strong	Medium
Hockley	Maximal	Moderately coarse	Good to moderately good	Strong	Medium
Kirkland	Medial	Moderately fine	Good to moderately good	Medium	Medium
La Bette	Medial	Loamy	Good	Medium	Medium
Pratt	Minimal	Coarse	Good	Weak	Medium
Teller	Minimal	Loamy	Good	Weak	Medium
Tishomingo	Medial	Moderately coarse	Good	Strong	Thin
Wilson	Maximal	Loamy	Moderately good	Strong	Medium

and describe the morphology and properties of soil profiles. This lack of standards hampered pedology and resulted in classification schemes shrouded with cloudy concepts that lacked operational definitions.

As an example, the U.S. 1938 classification system (USDA, 1938) followed the concepts of zonal and azonal soils, lacked operational definitions, and consequently failed to meet all the needs of the soil science community. In the 1938 system, one of the zonal soils, Reddish Prairie Soils, is described as dark-brown or reddish-brown soil grading through reddish-brown heavier subsoil, medium acid. This description is very vague, and without the knowledge that these soils occur in the southern Great Plains of the United States, the soil scientist might believe that these soils are in several parts of the world. Aside from the indistinct categories within the 1938 scheme, the system did not offer a means to differentiate soils both among taxa and within the same taxa. For example, Table 3.1 illustrates the families from a card dated November 26, 1951, used presumably by the correlators and field soil scientists to differentiate among the Reddish Prairie Soils. Obvious deficiencies include a lack of definitions for column headings such as stage, degree of weathering, and size of solum. Additionally, there are no operational definitions to differentiate any of the classes within the columns. This means that the differences among the differentiae, such as the degrees of weathering, are based on judgment and experience. The terms may have valid meaning to the local soil scientists. Soil scientists from different parts of the world, however, converging on the southern Great Plains, could engage in interesting discussions, but likely not reach agreement on whether a given soil exhibits medium or strong weathering. Furthermore, the differentiae are defined in neither the *Soil Survey Manual* (Soil Survey Staff, 1951) nor anywhere else.

The information in Table 3.1 is useful only to those who already have a familiarity with these soils. The differentiae provide little value in distinguishing these soils, even for the most experienced soil scientist.

Table 3.2 is also a card dated November 25, 1951, that attempts to provide facts about the Craig soils. Again, the information is scant and provides little value for a soil scientist unfamiliar with these soils or the area in general. Table 3.3 is a modern description of the same soil series.

MODERN SOIL CLASSIFICATION

After World War II, agriculture felt the effects of economic reconstruction and the expansion of global markets, and there was a renewed interest in soil conservation and alternative land uses, which helped invigorate soil survey activities. Soil scientists began identifying many new soils, and classification systems needed to track all the newly recognized soils. The United States Soil Conservation Service (now the Natural Resources Conservation Service), under the leadership of Guy Smith, accepted the challenge and made giant strides in improving soil classification. Work to develop a new U.S. soil classification system commenced in 1951.

Table 3.2 Description of Craig Soil (circa 1952)

Great Soil Group	Reddish Prairie (maximal)
Family	Craig
Series included	Craig
Drainage class	Good
Texture class	Loamy (medium)
Horizons	**Degree of Development**
A1	Strong
A3 & B1	Medium
B2	Strong
C	
Degree of weathering	Strong (moderately strong)
Size of profile	Medium
Kind of phases	Depth, slope, erosion
Parent material	Residuum from interbedded cherty limestone and shale
Climate	Moderately humid, temperate

Table 3.3 A Modern Description of the Craig Series

LOCATION CRAIG OK + MO

The Craig series is a member of the clayey-skeletal, mixed, thermic family of Mollic Paleudalfs. These soils have very dark brown and very dark grayish brown silt loam A horizons, dark grayish brown silt loam E horizons, brown silt loam BE horizons, dark yellowish brown and yellowish red very cherty clay loam Bt horizons, and BC horizons.

TAXONOMIC CLASS: Clayey-skeletal, mixed, thermic Mollic Paleudalfs

TYPICAL PEDON: Craig silt loam — rangeland.

(Colors are for moist soil unless otherwise stated.)

A1 — 0–7 in., very dark brown (10YR 2/2) silt loam, dark gray (10YR 4/1) dry; moderate medium and fine granular structure; hard, friable; many fine roots; common fine pores; medium acid; gradual smooth boundary (6 to 12 in. thick)

A2 — 7–12 in., very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; hard, friable; common fine roots and pores; few medium fragments of chert; strongly acid; gradual smooth boundary (0 to 10 in. thick)

E — 12–16 in., dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak medium granular structure; hard, friable; common fine roots and pores; few medium fragments of chert; strongly acid; gradual wavy boundary (3 to 5 in. thick)

BE — 16–21 in., brown (10YR 5/3) silt loam, pale brown (10YR 6/3) dry; weak medium subangular blocky structure; hard, friable; few fine roots and pores; 10% medium fragments of chert; common 2 to 8 mm dark concretions; strongly acid; gradual wavy boundary (3 to 12 in. thick)

Bt1 — 21–25 in., dark yellowish brown (10YR 4/4) very cherty clay loam; yellowish brown (10YR 5/4) dry; moderate very fine blocky structure; hard, friable; few fine roots and pores; 60 to 70% by volume of chert fragments from 2 mm to 100 mm in diameter; thin patchy clay films on faces of peds and chert fragments; common 2 to 5 mm dark concretions; strongly acid; gradual wavy boundary (4 to 16 in. thick)

Bt2 — 25–42 in., yellowish red (5YR 5/6) very cherty clay loam; common fine, medium, and coarse reddish and brownish mottles on the chert fragments; weak very fine blocky structure; hard, friable; few fine roots and pores; 75 to 85% by volume chert fragments from 2 to 100 mm; thin patchy clay films on faces of peds, on chert fragments, and in pores; strongly acid; gradual wavy boundary (10 to 30 in. thick)

BC — 42–60 in., yellowish red (5YR 5/6) very cherty clay loam; common reddish and brownish mottles; structure is obscured by the chert; hard, friable; fractured chert ranges from 2 to 100 mm in diameter and occupies about 85% of the volume; strongly acid

TYPE LOCATION: Craig County, Oklahoma; about 5 miles southeast of Vinita; about 3150 ft south and 50 ft east of the northwest corner of sec. I2, T. 24 N., R. 20 E.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 60 to more than 80 in. The depth to horizons containing more than 35% chert by volume ranges from 15 to 30 in. The soil ranges from medium acid through very strongly acidic throughout.

T**he A horizon** is black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3). It is loam, silt loam, cherty loam, or cherty silt loam. Coarse fragments more than 3 in. diameter range from 0 to 5% of the volume and coarse fragments less than 3 in. diameter range from 0 to 35% of the volume.

continued

Table 3.3 (continued) A Modern Description of the Craig Series

LOCATION CRAIG OK + MO
The E horizon is dark gray (10YR 4/1), dark grayish brown (10YR 4/2), brown (10YR 4/3, 5/3), gray (10YR 5/1), or grayish brown (10YR 5/2). Texture and coarse fragments are similar to those in the A horizon.
The BE horizon is very dark grayish brown (10YR 3/2), dark brown (10YR 3/3; 7.5YR 3/2), dark yellowish brown (10YR 3/4, 4/4), dark grayish brown (10YR 4/2), brown (10YR 4/3, 5/3; 7.5YR 4/2, 4/4, 5/2, 5/4), grayish brown (10YR 5/2), or yellowish brown (10YR 5/4). It is loam, silt loam, clay loam, silty clay loam, cherty loam, cherty silt loam, cherty clay loam, or cherty silty clay loam. Coarse fragments more than 3 in. in diameter range from 0 to 5% of the volume and coarse fragments less than 3 in. diameter make up 1 to 50% of the volume.
The Bt horizon is brown (10YR 4/3, 5/3; 7.5YR 4/4, 5/4), dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/4, 5/6), strong brown (7.5YR 5/6), reddish brown (5YR 4/3, 4/4, 5/3, 5/4), or yellowish red (5YR 4/6, 5/6). The lower Bt horizon also includes yellowish brown (10YR 5/8), pale brown (10YR 6/3); light yellowish brown (10YR 6/4), brownish yellow (10YR 6/6, 6/8), strong brown (7.5YR 5/8), light brown (7.5YR 6/4), reddish yellow (7.5YR 6/6, 6/8), or yellowish red (5YR 4/8, 5/8). The Bt horizon is cherty silty clay loam, cherty clay, cherty silty clay, very cherty silty clay loam, very cherty clay loam, very cherty clay, or very cherty silty clay. The upper 20 in. clay percentage ranges from 35 to 45. Coarse fragments more than 3 in. in diameter range from 5 to 10% of the volume and coarse fragments less than 3 in. in diameter range from 35 to 90% of the volume.
The BC horizon is strong brown (7.5YR 5/6, 5/8), reddish yellow (7.5YR 6/6, 6/8; 5YR 6/6, 6/8), yellowish red (5YR 4/6, 4/8, 5/6, 5/8), red (2.5YR 4/6, 4/8, 5/6, 5/8), or light red (2.5YR 6/6, 6/8). It is very cherty clay loam or very cherty clay. Coarse fragments more than 3 in. diameter range from 5 to 10% of the volume and coarse fragments less than 3 in. diameter range from 65 to 90% of the volume.
An R layer of cherty limestone occurs at depths ranging from 5 ft to 30 ft below the surface.
COMPETING SERIES: These are the Boxville, Braxton, Eldon, Eldorado, and Riverton series. Boxville and Braxton soils have clayey control sections. Eldon soils have mesic temperatures. Eldorado and Riverton soils have loamy-skeletal control sections.
GEOGRAPHIC SETTING: The Craig soils are on uplands. Slope gradients range from 0 to 5%, mainly less than 3%. The Craig soils are formed in residuum weathered from cherty limestones. The average annual precipitation ranges from about 37 to 47 in., the annual Thornthwaite P-E indices from 64 to about 80, and the average annual air temperature ranges from 57° to about 62° F.
GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Eldorado series, and the Bates, Dennis, and Parsons series. Bates, Dennis, and Parsons soils contain little or no chert.
DRAINAGE AND PERMEABILITY: Well drained; medium runoff; moderately slow permeability.
USE AND VEGETATION: Some areas cultivated to small grains and sorghums. Some areas are in native range of tall prairie grasses or in improved pasture. The native vegetation is tall grass prairie.
DISTRIBUTION AND EXTENT: Northeastern Oklahoma and possibly in southwestern Missouri, northwestern Arkansas, and southeastern Kansas. The series is minor in extent.
MLRA OFFICE RESPONSIBLE: Salina, Kansas.
SERIES ESTABLISHED: Craig County, Oklahoma; 1931.

During the same period, there were intensive activities under way in Europe to develop national systems. A most notable contribution was that of the French pedologists who had begun to develop their system in the early fifties, and published it in 1967 (CPCS, 1967). The U.S. System saw its debut in 1960 as the 7th Approximation, which was the first operational version of Soil Taxonomy. In the meantime, there were other groups developing concepts and terminology for specific uses. Two outstanding contributions include the Soil Map of the World Project, for which a legend was developed by the Food and Agricultural Organization of the United Nations (FAO, 1971–1981). Another group published the Soil Map of Africa (D'hoore, 1964). Later, the first effort toward a Soil Map of Europe was initiated (Dudal et al., 1970). Although legends were developed for these small-scale maps, the process also helped to develop units at the higher levels of classification. The maps then became a technique for validating the higher levels.

Similar discussions occurred in Europe. FAO organized several working meetings to develop the legend for the world map. Field trips during such meetings were critical in testing concepts and developing criteria. Commission V of the International Society of Soil Science (ISSS) also played an important role in this process through conferences and symposia. Each national, regional, or international group had an opportunity to report on its progress and obtain critical evaluation of its efforts. The universities and research communities developed methods for soil characterization and testing of the theoretical concepts. Thus the sixties and seventies were a period of intense activity in the development of soil classification systems; the activities were spurred both by national needs and a soft competition.

Perhaps the greatest modern breakthrough in soil classification is the recognition that the soil-forming processes frequently leave markers in the forms of diagnostic horizons and features. In turn, diagnostic horizons and features can be defined in terms of observable and measurable properties. One of the most difficult considerations in establishing concise definitions is that soils are not discontinuous natural units. Gradual transitions of soil properties and soil bodies occur on any landscape. The choice for the differentiating criteria becomes of paramount importance in applying the definitions of the diagnostic horizons or features in the field.

When the definitions are written using well-defined differentiating criteria and are applied consistently, soil scientists with different backgrounds and experiences should arrive at the same conclusions, regardless of any differing views on the genetic aspects of the soil. The genesis of the soil is important to the classification because it permits us to place similar soils in the same or similar taxa. Additionally, the genesis plays a major role in mapping soils because it helps us develop our predictive model of soil-landscape segments that can be delineated into usable soil maps with viable interpretations.

In summary, the diagnostic horizons represent the genetic aspects of soils, but genesis does not appear in the definitions. Well-defined diagnostic horizons and features allow soil scientists with different views and experiences to describe the same horizons and features, even though all the genetic processes that produced the horizons and features are not known or fully understood.

The diagnostic horizons and features form the building blocks of the various taxa of a soil classification system, and provide a powerful tool for communicating information about the soil and for differentiating among soils. According to Soil Taxonomy (Soil Survey Staff, 1999), the Craig series from Table 3.1 is in the family of clayey-skeletal, mixed, active, thermic Mollic Paleudalfs. Soil scientists, who are familiar with Soil Taxonomy, will know that the Craig soil has a thick argillic horizon with at least 35% clay and 35% rock fragments, and adequate bases. The Craig soil occurs in a warm, humid, or semihumid climate on stable landscapes. The surface layer is dark, likely from the accumulation of organic matter. The classification of the soil provides significant information about the properties of the soil.

The classification also provides a way to compare the soils quantitatively. The Dennis series from Table 3.1 is a fine, mixed, active, thermic Aquic Argiudolls (Soil Survey Staff, 1999). This series has more bases and fewer rock fragments than does the Craig series. The Craig series is also better drained than the Dennis series. The differences between the two series can be quantified: The Dennis series has a mollic epipedon that is 25 cm or more thick and less than 35% rock fragments. The Craig series has an umbric epipedon and more than 35% rock fragments in the upper 50 cm of the argillic horizon.

Soil classification systems have come a long way from their humble beginnings as a means of levying taxes based on production, and have progressed through various stages, including the descriptive stage illustrated above to rather sophisticated, quantitative systems. Most modern soil classification systems are developed to complement and support soil survey activities. Many countries have curtailed soil survey activities, thus the long-term value to pedologists is as a means of communicating important properties about the soil, and helping to differentiate among soils in a consistent manner.

Cline (1949) indicated that classifications are not truths that are discovered, but contrivances made by humans to suit their purposes. It is quite apparent from this book that many countries have developed sophisticated soil classification systems that fit their needs. Although Soil Taxonomy and the World Resource Base have been adopted by several nations, one of the lingering criticisms is that there is no universal soil taxonomic system, as there is for plants and animals. The Australian (Isbell, 1996), New Zealand (Hewitt, 1998), and Canadian (Agriculture Canada Expert Committee on Soil Survey, 1987) soil classification systems, to name a few, are directed toward a national effort. Although many countries have developed national soil classification systems, there are common features among them. Most national soil classification systems have shifted toward more quantitative definitions and criteria for diagnostic horizons and features, permitting the formation of mutually exclusive taxa. Concepts and models of soil genesis have guided the selection of diagnostic horizons and features, and it is no surprise that many national soil classification systems share common or roughly equivalent diagnostic horizons and features that provide a means of communication among soil scientists from various countries.

IMPROVEMENTS NEEDED

The diagnostic horizons and features represent a major innovation in soil classification that has been embraced by most pedologists, but there remain issues that have not been resolved to everyone's satisfaction. Soils, unlike discrete plants or animals, form a continuum over the earth's surface. Soil delineations are represented by one or more soils as a map unit; in reality, however, the map units contain many soils, not just the few designated in the map unit name. The confusion lies in classifying the pedon and its dimensions, and using the classification to represent the map unit. The concept of the pedon has been scrutinized (Holmgren, 1988), but not resolved. The map unit and pedon appear simple and straightforward at first, but continue to be sources of confusion or discomfort for many pedologists.

Anthropogenic soils pose another challenge to the soil science community. Humans have influenced and drastically changed the soil for centuries. At what point does the human influence change the classification of a soil? We have altered the surface by plowing and adding fertilizers, but when is the soil significantly changed to warrant different taxa from the native soil? Are there markers in the soil that capture the impact of humans on the soil resource? Or must we rely on sources outside the soil, such as the history of the area?

The World Resource Base (WRB, 1998) and other classification systems have made bold attempts to capture the human influences. The Anthrosol order in WRB tries to group together all the agricultural soils that are significantly impacted by humans. The Anthrosol order is required to have diagnostic horizons that are human-influenced. For example, the terric horizon is one of the diagnostic horizons used to key to the Anthrosol order. According to WRB (1998), "The terric horizon develops through additions of earthy manure, compost or mud over a long period of time. It has a non-uniform textural differentiation with depth. Its color is related to the source material or the underlying substrate. Base saturation is more than 50%." The requirement of base saturation is quantitative. The criterion of nonuniform textures requires some judgment on the part of the pedologist and may not be applied uniformly by all. "Additions of earthy manure, compost or mud" refers to the mode of deposition, and may be difficult to differentiate from nonhuman eolian and alluvial deposition. Does the mode of deposition affect use or management of the soil? Should soils like this have separate taxa because of the anthropogenic influences? These questions will be debated, and the answers depend largely on the purposes of the classification system. The soil science community is discussing the issues raised above, but will not likely reach agreement.

SUMMARY

Soil classification systems have evolved into sophisticated communication tools. Probably the greatest contribution in the last 50 years is the development of diagnostic horizons and features with associated quantitative definitions, which allow pedologists with different experiences to classify soils the same way.

Many countries have developed their own classification systems, whose features depend on the needs and soils of the country. Although there is no one-soil classification system that is used by all countries, most pedologists are familiar with diagnostic horizons and features, and have used them as an international means of communication.

Even with all the advances in soil classification, there are still classification difficulties between the soils that we classify and the soils that we map. Soils influenced and forever modified by humans present one of the greatest classification challenges. Although some classification systems have developed taxa for these soils, there are still questions as to their utility.

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