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Miscellaneous Series #51

SOIL MORPHOLOGY AND CLASSIFICATION

CLASSIFYING THE SOILS WITHIN A SOIL SURVEY AREA
IN THE HIGH PLAINS

SOILS OF EASTERN COLORADO

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I. References

1. Soils and Men
Yearbook of Agriculture, U.S.D.A. 1938, pp 863-1209.
2. Kellogg, Charles E., 1937 Soil Survey Manual, U. S. Dept. of Agri.
Misc. Pub. 274.
3. Kellogg, Charles E., 1936 Development and Significance of the Great
Soil Groups of the United States. U. S. Dept. of Agri. Misc. Pub. 229.

II. Definition of terms

A. Importance

1. In recognition of important soil characteristics.
2. In writing clearly understood reports.
Soils and Men
1938 Yearbook of Agriculture, Page 1162-1180.
A Glossary of Special Terms used in the Soils Yearbook.

III. Formation of soils

- (a) General statement - Soil profile characteristics are produced by climatic and biological forces acting on parent materials. The character of parent material, topography, and length of time these forces have acted modify the results of their influence.

As a formula: $S = M(C \text{ plus } B)T \text{ plus or minus } D$

(b) Effect of parent material

- (1) Parent materials tending to produce fine textured soils.
 - a. Primary minerals - Feldspars, Micas, Ferromagnesian.
 - b. Secondary minerals - Kaolin, Serpentine, Talc, Hematite, Zeolites.
 - c. Igneous rocks - Diabase, Peridotite, (dark colored rocks).
 - d. Sedimentary rocks - Shale, Limestone, Mudstone, Dolomite.
- (2) Parent materials tending to produce sandy soils.
 - a. Primary minerals - Quartz minerals.
 - b. Secondary minerals - Recrystallized quartz.
 - c. Igneous rocks - Granite.
 - d. Sedimentary rocks, - Sandstone, Conglomerate.

(c) Effect of topography

- (1) Steep slopes prevent deep surface soils from forming.
- (2) Depressions or basins encourage abnormal climatic forces.
- (3) Well drained, nearly level areas are considered normal.

(d) Effect of length of time forces have acted

- (1) Young soils resemble parent materials (bottom soils),
- (2) Old soils may give no hint of character of parent material.

(e) Effect of vegetation on soil characteristics.

(1) Trees

- a. Deciduous - shallow topsoil, medium in organic matter.
- b. Coniferous - shallow topsoil, low in organic matter.

(2) Grasses

- a. Tall grasses - thick black topsoils, big and little bluestem, needle grass.
- b. Short grasses - fairly thick dark brown topsoil. Chiefly Buffalo and Grama grass.

(3) Native vegetation is largely dependent on climate.

(f) Effect of climate

- (1) Profile characteristics of "mature" soils are dependent on the climate under which they are developed.
- (2) Rainfall - evaporation lines of similar ratio conform more nearly to soil group boundaries than any other climatic data.

IV. Soil classification and distribution in United States

A. Systems used in United States.

- 1. System dependent on parent materials - used for some purposes.
- 2. Soil province system - obsolete.
- 3. On basis of chemical and physical properties of "mature" soil profiles. (Genetic system)
 - (a) First used by Russian soil scientists.
 - (b) Introduced to United States by Dr. Marbut.

B. Genetic system of soil classification.

Soils and Men
1938 Yearbook of Agriculture, Page 993, Table 2.
Classification of Soils on the Basis of Their Characteristics.

V. The Processes of soil development

A. Calcification

- 1. Proceeds under
 - (a) Grass vegetation
 - (b) Little leaching
- 2. Mechanics
 - (a) Calcium absorbed by plant roots
 - (b) Stored in vegetative part of plant
 - (c) Plant dies and is decomposed by bacteria
 - (d) As bacteria die calcium tends to become soluble
 - (e) Ca combines with CO_2 and water to form $\text{Ca}(\text{HCO}_3)_2$
 - (f) Bicarbonate carried downward

- (1) Some Ca exchanged to keep colloid saturated
- (2) Remainder carried down till water is absorbed by roots
- (g) Ca deposited as CaCO_3 at average depth of water penetration
- 3. Results in
 - (a) Little downward movement of clay
 - (b) Ca saturated clay
 - (c) Bacteria and nutrient elements conserved in surface soil
 - (d) Tends to form a lime zone in subsoil
 - (e) Fertile soils for farm crops
- 4. Soil groups profoundly affected by process
 - (a) Prairie soils
 - (1) Keeps colloids immobile
 - (b) Chernosem soils and reddish chestnut soils
 - (1) Keeps colloids immobile
 - (2) Forms lime zone
 - (c) Soils of drier regions
 - (d) Rendzinas

B. Podzolization

- 1. Proceeds under
 - (a) Humid climate
 - (b) Forest vegetation
- 2. Mechanics
 - (a) Salts leached out of soil
 - (b) Little bases brought up to tree leaves so soils become acid
 - (c) Colloids become saturated with H
 - (d) Tannins and toxic substances allow fungi to develop
 - (e) Fungi decompose pine needles and leaves forming organic acid
 - (f) Iron and other inorganic materials become mobile due to
 - (1) Effect of soluble organic matter
 - (2) Hydrogen saturated colloids
 - (g) Iron moves downward
 - (h) Iron precipitated and oxidized in subsoil due to
 - (1) Remaining bases in subsoil flocculate
 - (2) Deposited by dry subsoil
 - (3) Coarser materials break soil capillaries
 - (4) Organic anions are oxidized and reducing influence lost
- 3. Results in
 - (a) Leaching out of soluble salts including Ca and Mg carbonates
 - (b) Colloids saturated or nearly saturated with H
 - (c) Fungi predominate in surface soils
 - (d) Accumulation of iron and colloids in subsoil at expense of surface soil
 - (e) Infertile soils for farm crops
- 4. Soil groups profoundly affected by process
 - (a) Podzol soils
 - (b) Gray-brown podzolic soils
 - (c) Brown podzolic soils
 - (d) Red podzolic soils
 - (e) Yellow podzolic soils
 - (f) Prairie soils

C. Laterization.-- May be more a geological than soil development process

- 1. Proceeds under
 - (a) Humid warm or hot climate
 - (b) Tropical vegetation

2. Mechanics
 - (a) Intense weathering processes
 - (b) Hydrolysis of minerals is rapid
 - (c) Bases released to solution around individual soil grains very rapidly
 - (d) Luxuriant vegetation grows and decomposes rapidly
 - (e) Bases brought to surface and released rapidly
 - (f) Resultant neutral or alkaline solution immediately around the soil grains favors solution of silica and aluminosilicates
 - (g) Silica leached out
 - (h) Quartz silica, iron oxides, alumina, manganese remain
 - (i) As hydrolysis nears completion, soil may become acid
3. Results in
 - (a) Soil high in iron and alumina
 - (b) Soil low in silica
 - (c) Colloid low in base exchange capacity
 - (d) Colloid swells little, non-sticky
4. Soil groups profoundly affected by process
 - (a) Laterites and lateritic soils
 - (b) Red and yellow forest soils

D. Salinization

1. Proceeds under
 - (a) Periodic excessive moistening and drying
 - (b) Source of excess salts
2. Mechanics
 - (a) Where sodium chloride or sulfate are present
 - (1) Part of colloid becomes sodium saturated
 - (2) Excess sodium salts prevent the usual reaction with water
 - a. Hydrolysis of exchangeable Na to form NaOH
 - b. Colloid kept flocculated by excess electrolytes
 - c. OH ion concentration not high unless flooded with sodium carbonate from higher solonetz soils
 - (b) Where either Na or Mg salts cause salinization
 - (1) Soils structureless
 - (2) Salts may deposit in layers at the surface or below
3. Results in
 - (a) Soils alkaline but not highly alkaline in reaction
 - (b) Structureless soils of flocculated colloids
 - (c) Salt streaks or layers in soil profile
 - (d) Colloids partially Na saturated
 - (e) No profound change in soil constitution
4. Soil groups profoundly affected by process
 - (a) Solonchak
 - (b) Sierozem
 - (c) Desert soils

E. Solonization (Desalinization and alkalization)

1. Proceeds under
 - (a) Periodic excessive moistening and drying
 - (b) Excess salts being lost by good underdrainage
2. Mechanics
 - (a) Assume a soil high in soluble salts and colloids partially saturated with sodium
 - (b) Excess salts are leached out
 - (c) Exchangeable Na is hydrolyzed forming NaOH
 - (d) Colloids become highly dispersed

- (e) Soil OH ion concentration becomes high
 - (f) Organic matter becomes highly dispersed
 - (g) Subsoil becomes prismatic dispersed clay
3. Results in
 - (a) Soil high in OH ion concentration
 - (b) Highly dispersed organic and inorganic colloids
 - (c) Impervious soil development
 4. Soils profoundly affected by process
 - (a) Solonetz
 - (b) Solonetzic brown soils
 - (c) Soloth
- F. Solodization
1. Proceeds under
 - (a) Alternate excessive moistening and drying
 - (b) Solonetz of adequate underdrainage
 2. Mechanics
 - (a) Colloids moved downward at expense of surface soils
 - (b) Leaching starts exchanging Na for H in colloid
 - (c) Soil becomes more acid
 - (d) Columns of subsoil become rounded on top and finally lose their dark color and compaction
 - (e) Gray surface soil deepens, may become 2 to 3 feet thick
 - (f) Vegetation begins to return
 3. Results in
 - (a) Soil colloid saturated with H
 - (b) Gray surface soil, dark brown subsoil
 - (c) Round topped columnar subsoils
 4. Soil groups profoundly affected
 - (a) Soloth
 - (b) Solonetz
 - (c) Solonetzic brown soils
- G. Gleization
1. Proceeds under
 - (a) Continuously saturated soils
 - (b) Low evaporation
 - (c) Supply of organic matter
 2. Mechanics
 - (a) Reduction of iron, organic matter, and silicate compounds
 - (b) Solubility or dispersion of colloids causing sticky layers
 - (c) Grayish or bluish color of reduced layers
 - (d) Source of soluble iron may seep away to be oxidized elsewhere
 3. Results in
 - (a) Layers of sticky bluish clay containing
 - (1) Dispersed, soluble, or reduced iron, silica, Ca, Mg, etc.
 - (b) Deposits of bog iron
 - (c) Coffee colored drainage waters
 - (d) Lateritic layers in some soils
 4. Soils profoundly affected by the process
 - (a) Bog
 - (b) Wiesenboden
 - (c) Lateritic
 - (d) Tundra

CLASSIFYING THE SOILS WITHIN A SOIL SURVEY AREA
IN THE HIGH PLAINS

6.

I. Great soil group

- A. Determine great soil group by consulting the 1938 Yearbook of Agriculture, map.
- B. Determine the transitory factors that may merit special attention
 1. If near a line separating great soil groups special effort to separate the soils in these two groups is warranted. Some of the transitory factors meriting attention are:
 - a. Presence or absence of a lime zone in subsoils when area is near the so-called "lime line"
 - b. Color of topsoil (nearly black, dark brown, brown, light brown) if near a line separating soil groups dependent on topsoil color for their identity

II. Allow only topsoil texture to vary within series

Baldwin quoting Marbut lists the features of a soil that are considered in soil mapping. These are listed and in general the latitude of each feature allowed within a series in the Pedocal zone is outlined.

- A. Number of horizons in the soil profile. This number must remain constant within a series
- B. Color of the various horizons
Not more than one of the following groups may be included in a single series
 1. Surface soil
 - a. Very dark grayish brown or almost black (Chernozem or Prairie)
 - b. Very dark reddish brown (Reddish Prairie soils)
 - c. Dark brown or dark grayish brown (Chestnut soils)
 - d. Dark reddish brown (Reddish Chestnut soils)
 - e. Brown or grayish brown (Brown soils)
 - f. Reddish brown (Reddish Brown soils)
 - g. Light brown, or light grayish brown (Sierozem or Desert)
 - h. Light reddish brown (Red Desert soils)
 2. Subsoil (generally considered as upper subsoil. The lower subsoil color in the Pedocal region generally differs little from the parent material)
 - a. Very dark grayish brown or almost black
 - b. Very dark reddish brown
 - c. Dark brown, dark grayish brown, brown, or grayish brown
 - d. Dark reddish brown or reddish brown
 - e. Light brown or light grayish brown
 - f. Light reddish brown

3. Color of lower horizons depends on parent material so enters into series differentiation indirectly

C. Texture of the horizons

1. Topsoil

The topsoil texture is unlimited within a series and is stated in the soil type name. If topsoil is significantly lighter or heavier than the subsoil and over 8 inches thick the average thickness within each delineated area should be shown as a subscript to the soil field number

2. Subsoil texture

This feature is underscored as it is the one most frequently allowed too much range within a series. Subsoil textures may be grouped as follows; and subsoil texture must remain within a single group to be considered within one series

- a. Clay, so-called "clay land"
- b. Loam to clay loams, so-called "hardlands"
- c. Sandy loams, and fine loamy sands, so-called "semi-hardlands"
- d. Sands and loamy sands, so-called "sandy lands"

3. Substrata textures vary with parent material so enter into series differentiation indirectly

D. Structure of the horizons

Structure changes often accompany texture changes. Series differences based on a structure change only are not common. Surface soil structure is usually not well developed. The upper subsoils often exhibit highly developed structure. However, within a single subsoil textural group it has not been necessary to recognize more than two series

1. The normal, friable subsoil (Colby)
2. The Planosol, semi-claypan, or solonetic subsoil (Weld)

E. Relative arrangement of the horizons

This relative arrangement must remain constant within a series

F. Chemical composition of the horizons

Within a series the chemical composition of the horizons must remain as constant as is discernable in the field. This, of course, will relate in a general way to the following:

1. Organic matter content as is reflected by soil color
2. Carbonate content as it is determined by effervescence with dilute hydrochloric acid.
3. Acidity (or alkalinity, pH) determined with indicators
4. Soluble salt content, determined by means of a salt bridge

G. Thickness of the horizons

The following table gives the thickness limitations of the surface and subsoil of representative Brown soils in eastern Colorado. Departure from these thicknesses necessitates classifying the soil as a different phase or new series

	Normal, friable subsoil, "hardland" Brown soil Colby Series	Planosol, semi-claypan, "solonetic" subsoil, "hardland" associated with Brown soils Weld Series	"Semi-hardland" Brown soil 1 Pinneo Series
Surface soil	2 to 10 inches	1 to 5 inches	6 to 18 inches
Upper subsoil	0 to 3 inches	3 to 16 inches total of upper 2 layers not over 18"	8 to 20 inches
Lower subsoil	Same appearance as parent material	Same appearance as parent material	Same appearance as parent material

¹Proposed but not correlated series name.

H. Geology of the soil material

Soils developed on parent materials of similar chemical and physical constituents and geologic age may be included in the same series if their other characteristics are sufficiently similar. The following is a partial list of soil parent materials that are encountered in eastern Colorado. They are listed beginning with the most recent:

1. Recent alluvium and colluvium
2. Loess
3. Tertiary age materials
 - a. Terrace gravels
 - b. Ash hollow sandstone (mortar beds)
 - c. Sydney gravel
 - d. Valentine sandstone
 - e. Arikaree sandstone
 - f. Brule clay
 - g. Chadron clay
4. Extrusive igneous rocks, basalt
Age of extrusive rocks varies considerably

5. Cretaceous age materials
 - a. Laramie
 - b. Fox Hills
 - c. Pierre
 - d. Niobrara
 - e. Benton
 - f. Dakota
 - g. Morrison

6. Jurassic, Triassic, Permian and Pennsylvanian age materials
 - a. Sundance
 - b. Jelm
 - c. Lykins
 - d. Lyons
 - e. Ingleside
 - f. Fountain

7. Pre-Cambrian age materials
 - a. Schists, gneiss, granite

SOILS OF EASTERN COLORADO

The following is a classification of the soil series recognized thus far in eastern Colorado. The classification table by Baldwin, page 993, 1938 Yearbook of Agriculture, was used as a guide. Parent material and subsoil textural group are in parenthesis following each series name.

I. Zonal soils - Pedocals

A. Light-colored soils of arid regions

1. Desert soils

2. Red Desert soils

3. Sierozem

- a. Billings (Alluvial terrace, clay land)
- b. Ordway (Cretaceous salty shale, clay land)
- c. Rocky Ford (Alluvial terrace, hardland)
- d. Prowers (Loess, hardland)
- e. Fort Lyons (Tertiary outwash, hardland)
- f. Minnequa (Outwash and Benton beds mixed, hardland)
- g. Penrose (Benton beds, hardland)
- h. Otero (Outwash and mixed materials, semi-hardland)

4. Brown soils

- a. Fort Collins (Alluvial terrace, hardland)
- b. Colby (Loess, hardland)
- c. Baca (Clayey loess, hardland)
- d. *Frick (Mixed loess and cretaceous beds, hardland)
- e. Capulin (Mixed loess and basalt, hardland)
- f. *Stonoham (Tertiary beds, hardland)
- g. *Keota (Colluvial on, and from Brule clay, hardland)
- h. *Fremont (Cretaceous sandstone and shale, hardland)
- i. Berthoud (Reworked outwash terrace, hardland)
- j. Greeley (Alluvial terrace, semi-hardland)
- k. *Bijou (Alluvial terrace, semi-hardland, non-calcareous)
- l. Gilcrest (Alluvial terrace, gravelly semi-hardland)
- m. *Pinneo (Wind-modified tertiary beds, semi-hardland)
- n. *Otis (Wind-modified non-calcareous tertiary or cretaceous, semi-hardland)
- o. Torry (Cretaceous sandstone, semi-hardland)
- p. Larimer (Tertiary gravel, gravelly semi-hardland)

5. Reddish Brown soils

- a. Springer (Wind-modified tertiary beds, semi-hardland)

B. Dark-colored soils of the semi-arid, subhumid and humid grasslands

1. Chestnut soils

- a. Orman (Alluvial terrace, clay land)
- b. Winnefred (Cretaceous shales, clay land)
- c. Tripp (Alluvial terrace, hardland)
- d. Keith (Loess, hardland)
- e. Rosebud (Tertiary beds and loess mixed, hardland)
- f. Goshen (Colluvial-alluvial slopes, hardland)
- g. Cheyenne (Alluvial terrace, semi-hardland)

- h. *Denova (Wind-modified tertiary beds, semi-hardland)
- i. *El Paso (Wind-modified, tertiary beds, semi-hardland, non-calcareous)

2. Reddish Chestnut soils

3. Chernozem soils

4. Prairie soils

- a. Falcon (Dawson arkose, semi-hardland, and sandy land)

5. Reddish Prairie soils

Zonal soils - Pedalfers

A. Soils of the forest-grassland transition

B. Light-colored podzolized soils of the timbered regions

1. Podzol soils

- a. Sylva (Dawson arkose, semi-hardland)

 Other pedalfer groups have no recognized series in eastern Colorado.

II. Intrazonal soils

A. Halomorphic (saline and alkali soils of imperfectly drained arid regions and littoral deposits)

1. Solonchak or saline soils

- a. *Deora (Alluvial, hardland, dark brown)
- b. Apishipa (Alluvial, hardland, light brown)

2. Solonetz soils

3. Soloth

- a. Butler (Upland depression, clayland, calcareous)
- b. Scott (Upland depression, clayland, non-calcareous)
- c. Randall (Upland depression, clayland)

B. Hydromorphic soils of marshes, swamps, seep areas, and flats

1. Wiesenboden (Meadow soils)

2. Alpine meadow soils

3. Bog soils

4. Half bog soils

5. Planosols

Planosols associated with Brown soils

- a. Nunn (Alluvial terrace, clayland)
- b. *Briggsdale (Dawson formation and cretaceous beds, clayland)
- c. Weld (Loess, hardland)
- d. *Platner (Tertiary beds and loess mixed, hardland)
- e. *Joos (Dawson formation and sandy cretaceous beds, hardland)

Planosols associated with Chestnut soils

- a. Yale (Alluvial terrace, hardland)
- b. Dawes (Tertiary and loess, hardland)
- c. Dunlap (Loess, thick solum, hardland)
- d. Richfield (Clayey loess and tertiary beds, hardland)

Planosols associated with Reddish Chestnut soils

- a. Pullman (Tertiary mountain outwash, hardland)

6. Ground water Podzol soils

7. Ground water Laterite soils

C. Calomorphie

- 1. Light brown or light grayish brown soils associated with Brown soils
 - a. Epping (Brule clay, hardland)
 - b. Orella (Chadron clay, hardland)

III. Azonal soils

1. Lithosols

- a. Canyon (Ogallala sandstone, hardland or mixed)
- b. Potter (Very limy tertiary beds and caliche, hardland)
- c. Pierre (Cretaceous shale, clayland)
- d. Sogn (Limestone, hardland, very dark brown surface)
- e. Laporte (Limestone, hardland, brown surface)
- f. *Carnero (Cretaceous sandstone, semi-hardland)
- g. Neville (Redbeds, hardland, colluvial slopes)
- h. Bridgeport (Colluvial, Brown soil zone, calcareous, hardland)
- i. Table Mountain (Mountain colluvial footslope, hardland, non-calcareous)
- j. *Carrizo (Colluvial slope, mixed cretaceous, loess and basalt, hardland)

2. Alluvial soils, developing on stream flood plains.

Topsoil color, presence or absence of lime and textural group are given after each series. (Due to the spotted occurrence of various textures in first bottom soils. These soils are divided only into three textural groups: Clayland, hardland, and sandy. The semi-hardland is generally included with the sandy group.)

- a. Wabash (Very dark brown, non-calcareous, hardland)
 - b. Lamoure (Very dark brown, calcareous, hardland)
 - c. Cass (Very dark brown, non-calcareous, sandy)
 - d. Harlem (Very dark brown, calcareous sandy)
 - e. Sarpy (Brown or light brown, non-calcareous, sandy)
 - f. Las Animas (Brown or light brown, calcareous, sandy)
 - g. Genesee (Brown or light brown, non-calcareous, hardland)
 - h. Laurel (Brown or light brown, calcareous, hardland)
3. Sands (dry) all from wind-modified sands of various origin.
Topsoil color and presence or absence of lime are given.
They are all incoherent sandy soils
- a. *Dailey (Thick, dark brown, non-calcareous)
 - b. Valentine (Brown or light brown, non-calcareous)
 - c. Dwyer (Brown or light brown, calcareous)
 - d. Enterprise (Brown to reddish-brown, occasionally calcareous)
 - e. Dunesand (Brown, non-calcareous on land with many high dunes)

* Suggested series names not correlated as yet by the U.S.D.A. Soil Correlation Committee.