A STUDY OF
PEDOLOGICAL PROCESSES IN CERTAIN
MANITOBA SOILS

A THESIS

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by

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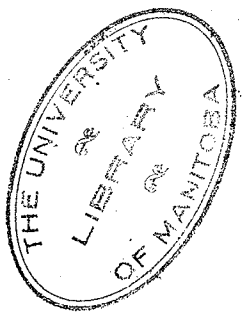

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A STUDY OF PEDOLOGICAL PROCESSES IN CERTAIN MANITOBA SOILS

1. STATEMENT OF PROBLEMS:

The blackearth soils cover a large portion of Southern Manitoba. These soils have been mapped by the Manitoba Soil Survey and classified on the basis of morphological characteristics. It was noted that the dark color of the surface horizons was common to all the soils. However, there was considerable variation in the color of the sub-surface horizons, in the structure, and in other morphological features.

An investigation was undertaken to ascertain if chemical and physical studies would provide criteria for differentiating the blackearth soils of Manitoba.

2. LITERATURE REVIEW:

The first investigation of chernozem soils, of which we have record, was carried out by Russian soil scientists. Glinka (19), in his publication, "The Great Soil Groups of the World and Their Development" showed the gradual change in the concept of chernozem development. Early scientists, such as Tomonosoff, Pallas, Murchison, Petzhold, believed that the chernozem originated as a marine deposit left behind when the Arctic Ocean receded. The high nitrogen content was explained as due to animal origin.

Rupprecht (19) was first to attack the problem from a botanical standpoint. He stated that the chernozem had developed from steppe grass vegetation and was a land plant soil wholly analogous for the grassy soils of northern Russia. Karpinski (19) held that the character of the parent rock had a

predominant influence.

In 1883, Dokutschajeff, in his publication "The Russian Tschernosem" maintained that the chernozem could not be developed under frost conditions, and that the influence of climate in the soil forming process was many sided. The climate influenced the type of vegetation, the annual increase in accumulated vegetable matter, the amount of decomposition of plant materials, and the character of the decomposition processes. He also realized that the humus content would be strongly influenced by the mechanical constitution of the parent rock, since it is the latter that determines the water and air permeability of the soil. This permeability would determine the rate of decomposition of the organic matter present in the profile.

Dokutschajeff recognized one of the characteristic features of all chernozems; the occurrence of passage ways of burrowing animals. These appeared in the soil profile as oval or irregular formed spots which could be seen in the humus horizon only when they were filled with the lighter colored parent rock, or in the latter only when they were filled with material from the humus horizon.

The Russians (19) divided their chernozem into three main zones:

1. Northern or leached chernozems.
2. Deep or thick chernozems.
3. Southern or ordinary chernozems.

These soil zones paralleled the climatic zones. In the center of the region the dark coloring of the soil was most striking, the amount of humus the greatest, and the humus layer the thickest.

Investigation was also carried on into the development of root systems in the different horizons of the chernozems. The largest number of roots was found in the A horizon, with the B_2 horizon having the least. In the thick chernozems an abundance of root systems penetrated to a great depth. Penetration depended on moisture, nutritive matter, temperature and condition of aeration.

Dokutschajeff (18), who was the founder of soil science in Russia, established many fundamental principles. Among his principles were:

1. Geographical distribution - dependence of the character of soil on its geographical position.

2. Topographical distribution - connection between the nature of soil and the relief.

Neustruev (37) dealt with the factors and processes responsible for the formation of a definite profile. The processes were manifested by a succession of horizons characterized by certain morphological properties such as color, texture, structure, chemical composition, constitution, consistency, etc. The factors of soil formation deal with climate, parent material and relief.

Tumin's classification (37) dealt with the following variations:

1. thickness of the humus horizons,
2. quantity of humus,
3. depth of effervescence level,
4. form in which carbonates were manifested,
5. structure of humus and humus-less horizons,
6. activity of burrowing animals,
7. parent rock.

Joffe (24) states that one of the fundamental laws of pedology is the law of the adaptability of soil types of the

globe to definite natural (primarily climatic) conditions.

One of the aims of pedology is to unravel the fundamental laws governing the processes of soil formation in relation to weathering, one of the primary physio-chemical forces of nature responsible for soil genesis. Each type of soil formation, with its inherent characteristics and properties, could be identified with a definite zone of homologous soil forming processes. Weathering processes include oxidation, hydration, carbonation, solution and deposition.

Zakharov (Joffe 24) investigated the relation of climate to the process of weathering. He noted that in arid and semi-arid temperature climates, leaching took place but not sufficiently for thorough percolation, and, as a result the carbonates were retained in the belt of weathering.

Dokutschajeff (Joffe 24) concluded that the now-prevailing climate is an all important factor in formation; therefore chernozem was a recent formation.

3. MORPHOLOGICAL DESCRIPTION OF THE SOIL TYPES STUDIED:

The blackearth soils studied by the author were obtained from selected sites typical of the morphological conditions under investigation. The blackearth soil profile (Darlingford) was obtained from the north-west corner of 5-3-6W. The brown-blackearth soil profile (Waskada) was obtained from the south-west of 10-3-20W. The northern blackearth soil profile (Newdale) was obtained from the eastern portion of 18-14-24W. These areas had already been covered by a reconnaissance soil survey. The morphological descriptions of these soils were obtained at the time of sampling.

These descriptions are given below:

Darlingford Phytomorphic Associate

Location - .21 miles S. N.W. 5-3-6W.

Horizon depth	Description
0 - 12"	Color:* Black to very dark grey. (10 Y R 2/1 to 10 Y R 3/1)**
	Texture: Heavy clay loam to clay loam.
	Structure: Granular; forming weak, irregular columns 2 - 3" in diameter.
	Consistence: Very friable.
	Intrusions and concretions: Tongued into the horizon below.
	Reaction: Slightly alkaline.
12"- 21"	Color: Black to very dark brown (10 Y R 2/1 to 10 Y R 2/2) gradually decreasing in intensity with increasing depth.
	Texture: Heavy clay loam.
	Structure: Coarsely granular to small nutty angular aggregates, tends to form irregular columnar clods.
	Consistence: Friable.
	Intrusions and concretions: Flecked with lime carbonate in lower portion.
	Reaction: Slightly alkaline.
21"- 33"	Horizon of lime carbonate accumulation.
	Concretions: Mottled with lime carbonate. Reaction: Alkaline.
33" +	Color: Light grey to very pale brown (10 Y R 7/2 to 10 Y R 7/3).
	Texture: Clay loam.
	Structure: Laminated in the lower portions.
	Concretions: Lime carbonate.
	Reaction: Alkaline.

Darlingford Phytomorphic Associate - (cont.)

Geological Parent Material: Calcareous boulder till (limestone and some shale).

Topography: Slightly undulating.

Stones: Few

Drainage: Well drained

Vegetation: Tall prairie grasses and associated herbs.

* color of soil in air dry condition.

** designation of color by Munsell Soil Color Chart.

Waskada Phytomorphic Associate

Location: .8 miles S.W. 10-3-20W.

Horizon depth	Description
0 - 5"	Color: Very dark grey brown (10 Y R 2/2). Texture: Silty clay loam to clay loam. Structure: Finely granular. Consistence: Very friable. Intrusions: Slightly tongued into horizon below. Reaction: Slightly acid.
5" - 14"	Color: Brown (10 Y R 4/3), color becoming lighter with increasing depth. Texture: Clay loam. Structure: Column-like, grading into prismatic; columns irregular and bluntly pointed; nutty aggregates. Consistence: Compact. Intrusions: Roots elongated. Reaction: Slightly acid.
14" - 28"	Horizon of lime carbonate accumulation. Texture: Clay loam. Concretions: Lime carbonate. Reaction: Alkaline.
28" +	Color: Very pale brown to pale brown (10 Y R 7/3 to 10 Y R 6/3). Structure: Laminated. Concretions: Lime, carbonate. Reaction: Alkaline.

Waskada Phytomorphic Associate - (cont.)

Geological Parent Material: Calcareous boulder till.

Topography: Undulating (gentle slopes 1½ - 3%).

Stones: Few

Drainage: Well drained

Vegetation: Mixed tall and short prairie grasses with associated herbs.

Newdale Phytomorphic Associate

Location: E½ 18-14-24W.

Horizon depth	Description
0 - 8"	Color: Very dark grey (10 Y R 3/1).
	Texture: Clay loam.
	Structure: Finely granular.
	Consistence: Very friable.
	Intrusions: Slight tonguing into horizon below.
	Reaction: Slightly acid.
8" - 18"	Color: Dark brown (25 Y R 3/2), color fading from upper to lower portion of this horizon (due to infiltration of dust particles from horizon above); surface of aggregates darker in color than interior.
	Texture: Heavy clay loam.
	Structure: Nutty aggregates, forming weak columns.
	Consistence: Compact.
	Concretions: Flecked with lime carbonate in lower portion.
	Reaction: Slightly alkaline.
18" - 32"	Horizon of lime carbonate accumulation.
	Texture: Clay loam.
	Concretions: Lime carbonate.
	Reaction: Alkaline.
32" +	Color: Light brownish grey to light grey (10 Y R 6/3 to 10 Y R 7/2).
	Texture: Clay loam.
	Concretions: Lime carbonate.
	Reaction: Alkaline.

Newdale Phytomorphic Associate - (cont.)

Geological Parent Material: Calcareous boulder till.

Topography: Undulating.

Stones: Few

Drainage: Well drained

Vegetation: Tall prairie grasses and associated herbs.

A study was also made, for comparison purposes, of a grey-wooded soil associate. The soil used was the Erickson Phytomorphic Associate. The soil samples were obtained during the soil survey of the Rossburn area in Manitoba. The description was obtained from the soil survey data (59).

Description of Soil Profile Showing "Grey-wooded" Soil Characteristics. Mapped as the Grey-wooded Phytomorphic Member of the Erickson Soil Association

Location: East Centre of N.E.¼ of 31-19-22

Collected and described by R. E. Wicklund, Oct. 9, 1940.

Depth	Description
0--1/2"	Leaf litter, undecomposed.
½--2"	Black fairly well decomposed organic matter, charred in appearance. Abrupt division between this and the lower horizon.
2--5½"	Brownish grey fine sandy clay loam, grey and ash-like when dry, platy macro structure, pulverulent micro structure. Crumbles readily. Acid reaction.
5½--11"	Light brown clay loam, fine nutty aggregates, firm and hard when dry. Acid reaction.
11--17"	Light brown clay loam, coarsely nutty aggregates with brown organic coating. Firm when dry, somewhat tacky when wet. Neutral to alkaline reaction.
17--24"	Grey brown, slightly altered glacial till, breaks into cubes or small aggregates. Alkaline in reaction. Effervesces. (Some shale mixed with limestone till).
24" +	Khaki glacial till with calcareous mottling.

Geology - Glacial till.

Association Member - Phytomorphic.

Stones - Few.

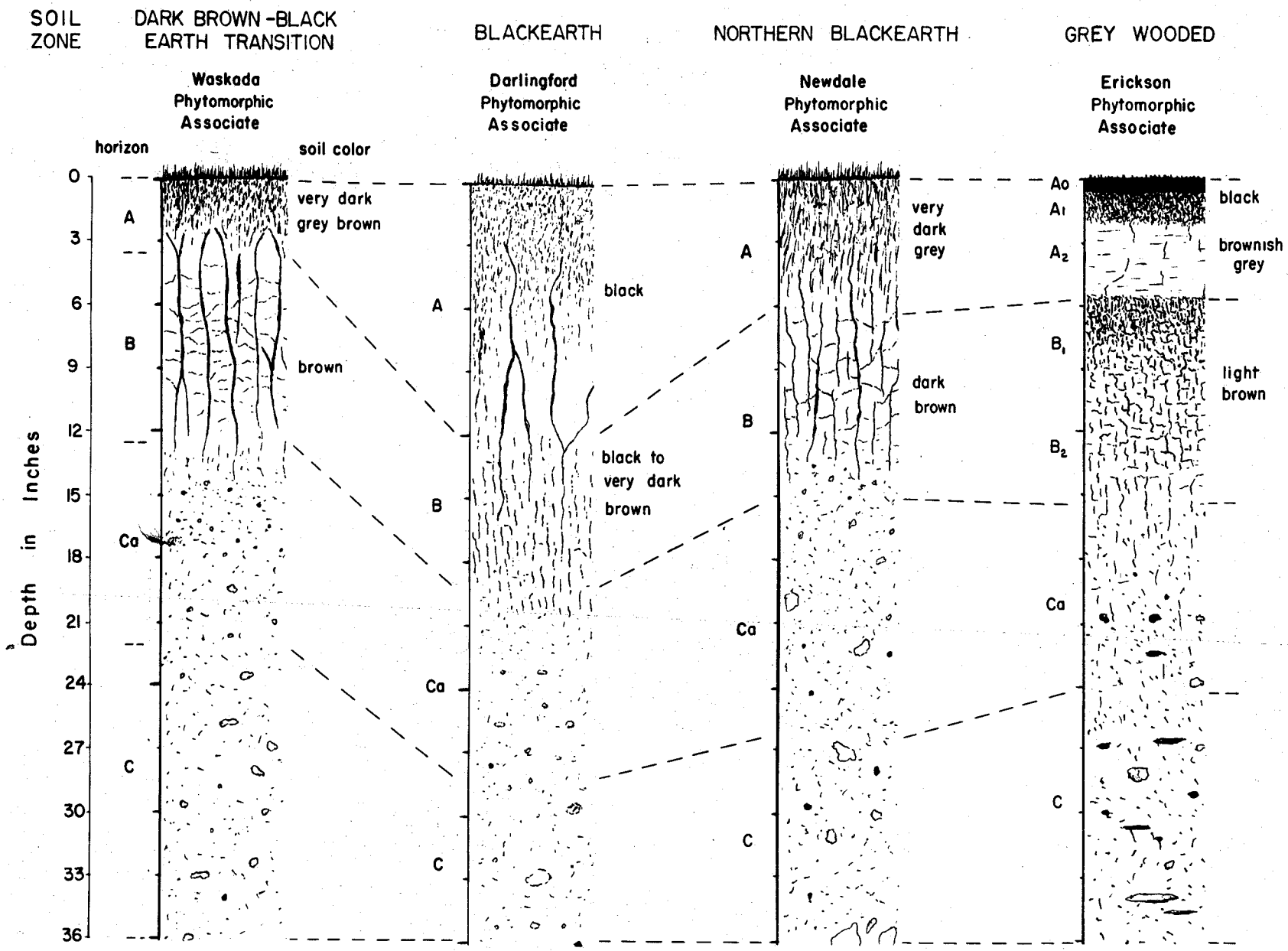
Vegetation - Aspen, willow, birch, cranberry, cherry, hazel.

4. GENERAL DESCRIPTION OF SOILS STUDIED:

Darlingford Phytomorphic Associates:

This soil profile was obtained from the Manitou-Clearwater Prairie area which lies between the 1400 and 1600 foot contours.

Chart No. 1 SKETCHES OF THE SOIL PROFILES STUDIED



The topography of the Darlingford soil is generally smoothly undulating and in some cases almost level. The soil is developed on light khaki boulder till under tall prairie grass vegetation, with islands of aspen poplar interspersed as groves in locally humid sites. This type of vegetation, in comparison with that on the Waskada soil, indicates a more favourable soil-moisture climate.

Observations of crops grown indicate that these soils may be used for any type of agriculture, and with good management they can be expected to produce satisfactory crops of wheat, coarse grains, corn, intertilled crops and fair crops of grasses and legumes. However droughts may occur occasionally and moisture conservation practices are required.

Waskada Phytomorphic Associate:

This soil profile was obtained from the Waskada Till Plain Area with an elevation of from 1550 to 1900 feet.

The topography of the Waskada soils varies from roughly to smoothly undulating, and as a result a variable complex of soils are found in association with the well drained associate. Consequently, there is a topographical sequence in which the drainage is variable. Drainage is excessive on the knolls and hillocks, and imperfect to poor in the depressions. Due to the variation in drainage and in the amount of water that enters the soil profile, the soil may vary considerably in different parts of the same field. The soils on the higher positions are shallow and subject to erosion. In the lower positions the soils are darker in color and are generally saline where drainage is impeded.

This soil was developed on light khaki glacial till under mixed tall and short prairie grasses, characteristic of mixed prairie and steppe vegetation, with associated herbs. This native vegetation indicates a transitional climate between that of the drier and semi-arid steppe to the west and that of the sub-humid prairie to the east. The combination of dry land and prairie types of vegetation indicates a fluctuation between dry and moist seasons and points to severe drought periods interspersed with relative moist seasons. Tree vegetation occurs only where the ravines are deep enough to give protection and to form effective snow traps. The open treeless aspect of this area is in marked contrast to the Darlingford area with its scattered aspen groves.

The Waskada soils are largely used for the production of wheat. In favorable years the yield of wheat, crested wheat and legumes is good while the yield of oats and barley is only fair to poor. Where irrigation is provided these soils produce excellent gardens.

Newdale Phytomorphic Associate:

This soil profile was obtained from the Newdale Till Area with an elevation of from 1550 to 1900 feet.

The topography is generally undulating with numerous ravines, depressions and knolls. Drainage varies from excessive on the knolls to poor and impeded in the depressions. In this area grassland and aspen grove vegetation predominates with the well drained soils developed under grassland conditions. In the southern portion of the belt, rings of aspen occur in the depressions.

The Newdale soils are suitable for general agriculture.

For a long time this soil type has been referred to as the "oat country" due to the excellent crops of oats with heavy weight per bushel. It has been suggested that this is due to the cooler conditions which prevailed, resulting in higher precipitation - effectivity, although the actual rainfall was similar to that in the southwestern portion of the province. This point will be dealt with in more detail in a later chapter.

Erickson Phytomorphic Associate:

This is a grey-wooded soil that was obtained from the Riding Mountain Area at an elevation slightly above 1900 feet.

The Erickson soils were formed at higher altitudes and under the influence of more moist conditions than the blackearth soils. The soil characteristics indicate that there was sufficient moisture to cause leaching of the upper part of the profile, but not enough to leach the lime out of the soil profile. It was also noted that there was not so marked a difference in the depth of the profile on the higher positions and the slopes as in the case of the grassland soils.

The original vegetation was spruce and allied deciduous boreal forest trees. Due to forest fires the vegetation at the present time is dominantly broad leafed trees, especially poplar, which have come in as second growth.

These soils are favorable for mixed farming, livestock production and forestry.

5. CLIMATIC DATA:

The climatic data was compiled by the Soils Department, University of Manitoba, from meterological records published by