1963

Poinsett Silty Clay Loam: Its Genetic Factors

Norman Eugene Zischke

Recommended Citation

Zischke, Norman Eugene, "Poinsett Silty Clay Loam: Its Genetic Factors" (1963). *Electronic Theses and Dissertations*. 2940.
https://openprairie.sdstate.edu/etd/2940

3d

POINSETT SILTY CLAY LOAM
ITS GENETIC FACTORS

BY

NORMAN EUGENE ZISCHKE

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Department of
Agronomy, South Dakota State
College of Agriculture
and Mechanic Arts

August, 1963

POINSETT SILTY CLAY LOAM
ITS GENETIC FACTORS

This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

F. C. Westin
Thesis Adviser

L. O. Fine
Head of the Major Department

ACKNOWLEDGMENTS

The author wishes to express his gratitude to Dr. F. C. Westin, Professor of Agronomy, for stimulation and guidance throughout the course of the study and the preparation of this thesis.

Appreciation is expressed to Dr. George J. Buntley, Associate Professor of Agronomy for his help with profile descriptions and preparation of graphs, and to Dr. Everett M. White, Associate Professor of Agronomy, for his guidance in laboratory phases of the study.

Sincere appreciation is extended to my wife for her constant encouragement and interest.

NEZ

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Poinsett soils of eastern South Dakota present a problem in soil classification and mapping because of local profile textural variations. Although these soils have a silty matrix which in some profiles appears to be loess, profiles only a few feet away contain admixtures of gravel, cobble and stone. Moreover, their substrata are mottled and often stratified by color and texture. The silty materials from which the Poinsett soils are developed are more friable and appear to be more permeable than glacial till, but the admixtures of gravel, cobble, and stone make them less desirable than loess as a soil forming material.

The purpose of this study is to investigate the mode of origin of the parent materials of the Poinsett soils and to compare the Poinsett soils with the Moody soils which are developed from loess, and the Vienna soils which are developed from glacial till.

HISTORY OF THE POINSETT SERIES

Until the early 1940's the Barnes series, which is developed from glacial till of Wisconsin Age, was considered to be the major Chernozem soil in eastern South Dakota. Figure I shows the Barnes area in 1938.

With continued refinement of the series concept, the range of the Barnes series was considered to be too broad, and in 1945 the Vienna soils were separated from the Barnes series on the basis of having thicker sola and of having been developed from glacial drift of the Iowan and Tazewell substages of the Wisconsin glaciation (27). This was followed by separation of the Kranzburg series in 1951. The Kranzburg series is confined to soils having the A and B horizons developed in loess over a substratum of glacial till (14).

The soils now classified in the Poinsett series were considered to be in the Kranzburg series prior to the soil survey of Brookings County, South Dakota in 1956 (30). Detailed mapping in the Brookings County soil survey revealed that the soils now classified in the Poinsett series were not uniformly silty and had stratified substrata rather than glacial till substrata. The lack of uniformly silty textures, and the presence of stratification in the substrata resulted in the soils now classified as Poinsett being separated from the Kranzburg series. The Poinsett soils were considered to be developed in silty glacial drift of Cary Age and the Kranzburg series was confined to loess mantled Iowan and Tazewell glacial till.

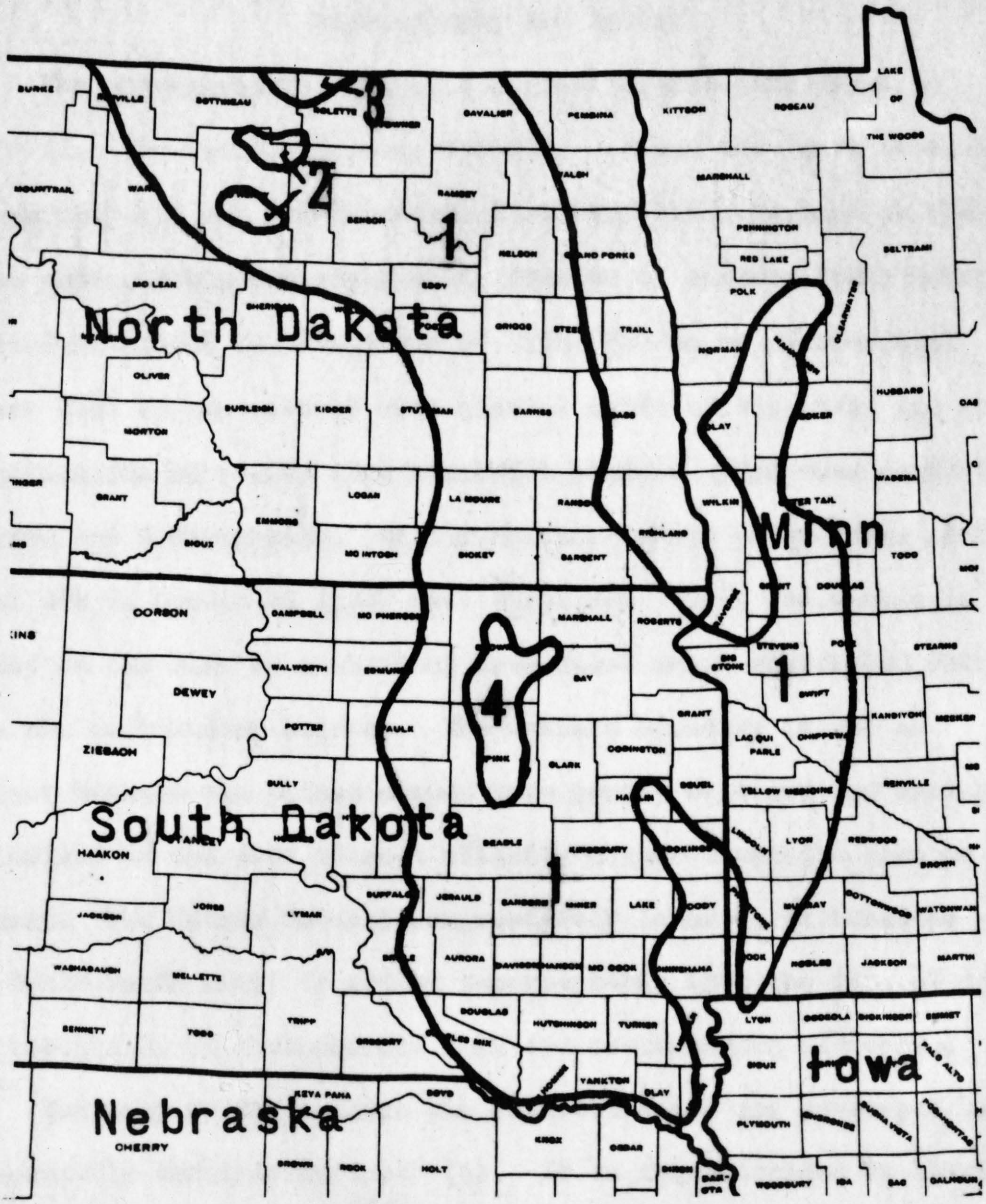

Figure I. The Barnes area in 1938

1- Barnes-Parnell
2- Valentine-Nuecess-Dune sand
3- Taylor-Nebish
4- Fargo-Bearden

Source: Yearbook of Agriculture, Soils and Men (23)

ENVIRONMENT OF THE POINSETT AREA

Physiography and Relief

The physiographic divisions of South Dakota are shown in Figure II. The Prairie Coteau, standing between the James River lowland on the west and the Minnesota River-Red River lowland on the east, is the most conspicuous topographic feature of eastern South Dakota (6). The Prairie Coteau is considered by Flint (6) to be an erosional remnant that is now covered with glacial drift of Wisconsin Age and is a continuation of a much more extensive plateau which runs north into Manitoba and Saskatchewan. At its northern range where parts of the Coteau are in excess of 2,000 feet above sea level, the Coteau is bounded on the east by a striking escarpment which stands 800 feet above the surrounding terrain. The western boundary is not as distinct because the Coteau slopes more gently westward and because the lowland on the west is at a slightly higher elevation than on the east. The Coteau becomes progressively lower as it broadens toward the south until it merges imperceptibly into the general upland topography of northwestern Iowa and southwestern Minnesota.

The Cary drift in which the Poinsett soils are developed has a "pronouncedly morainic surface" (6). It is characterized by short choppy slopes and a swell and swale type of topography with many undrained depressions.

Geology

In the pleistocene epoch Flint (6) recognizes four major glacial advances. From oldest to most recent they are: the

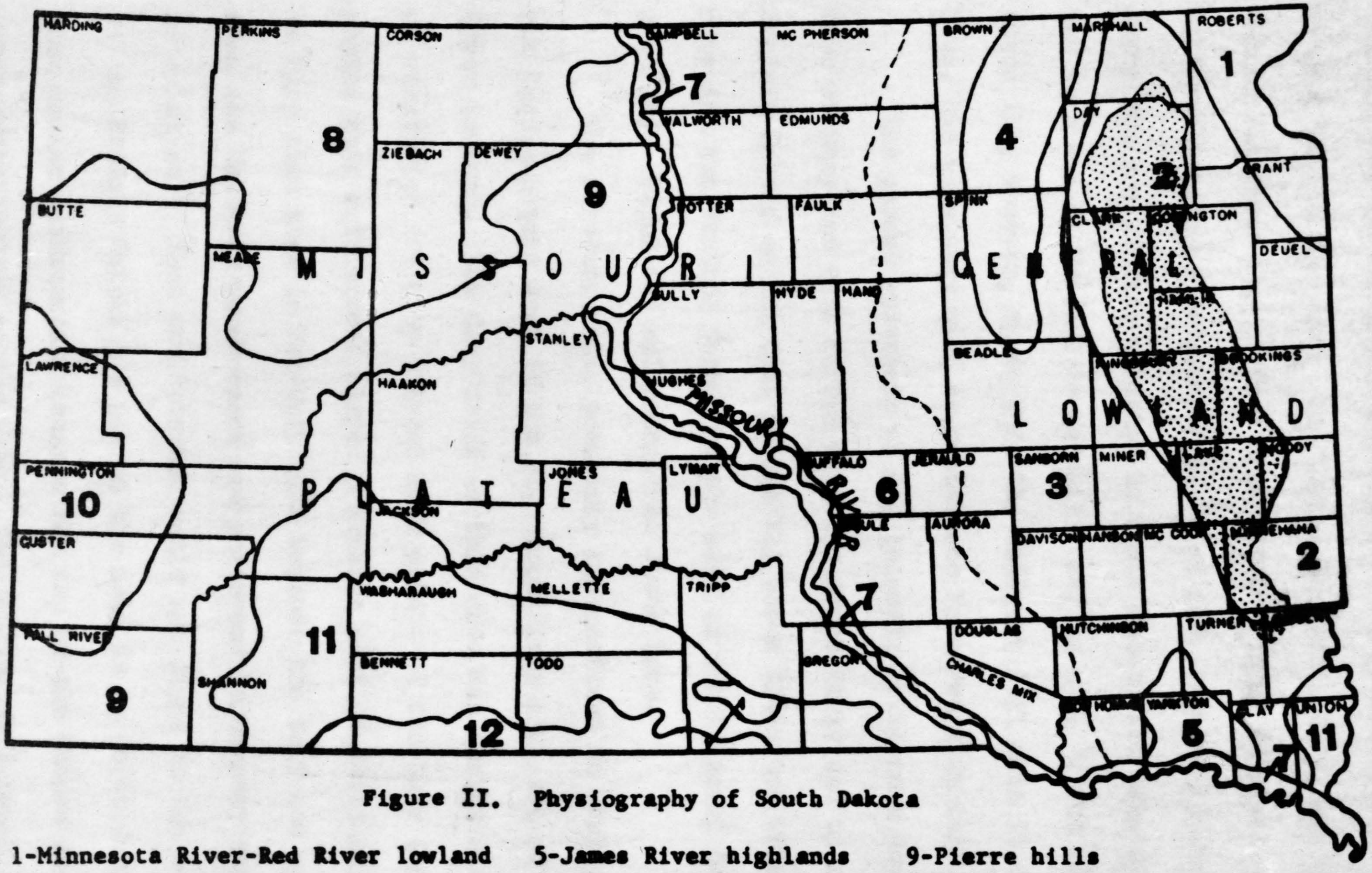

Figure II. Physiography of South Dakota

1-Minnesota River-Red River lowland
2-Prairie Coteau
3-James River lowland
4-Lake Dakota plain
5-James River highlands
6-Missouri Coteau
7-Missouri River trench
8-Northern plateaus
9-Pierre hills
10-Black Hills
11-Southern plateaus
12-Sand Hills

░ Poinsett Area

Source: Flint (6)

Nebraskan, Kansan, Illinoian, and Wisconsin. In South Dakota all four substages of the Wisconsin were correlated by Flint (6). From oldest to most recent they are: the Iowan, Tazewell, Cary, and Mankato (6). Figure III shows the surface areal distribution of glaciated areas in South Dakota as correlated by Flint (6). Agnew (1) does not correlate the Mankato substage in South Dakota but maintains that what has been called Mankato is actually Cary in age. Flint (6) and Agnew (1), however, agree that the Poinsett soil area is of Cary Age. Thus, the name Cary will be assumed to be correct in this study.

The parent materials of the Poinsett soils were deposited by a lobe of Cary ice that flowed down the James River and up onto the Prairie Coteau as far east as the Big Sioux River but which did not override the Prairie Coteau on the east or the Missouri Coteau on the west (6). Flint (6) calls this the James Lobe.

The Poinsett soils presently are confined to that portion of the Cary substage west of the Big Sioux River and east of the James River lowland. The Cary drift in this area was sorted and redeposited as stratified drift by glacial melt waters of the Cary ice. Flint (6) states that melt waters played a greater part in rearranging the drift in Cary time than in Pre-Cary time because the Cary ice was thinner than its Tazewell predecessor and possessed "a broader peripheral zone of ablation." That the Poinsett soils are found on the western side of the Prairie Coteau but not on the east is no doubt due, in part, to less relief differential between the top of the Coteau and the surrounding lowland on the west. The smaller difference in elevation

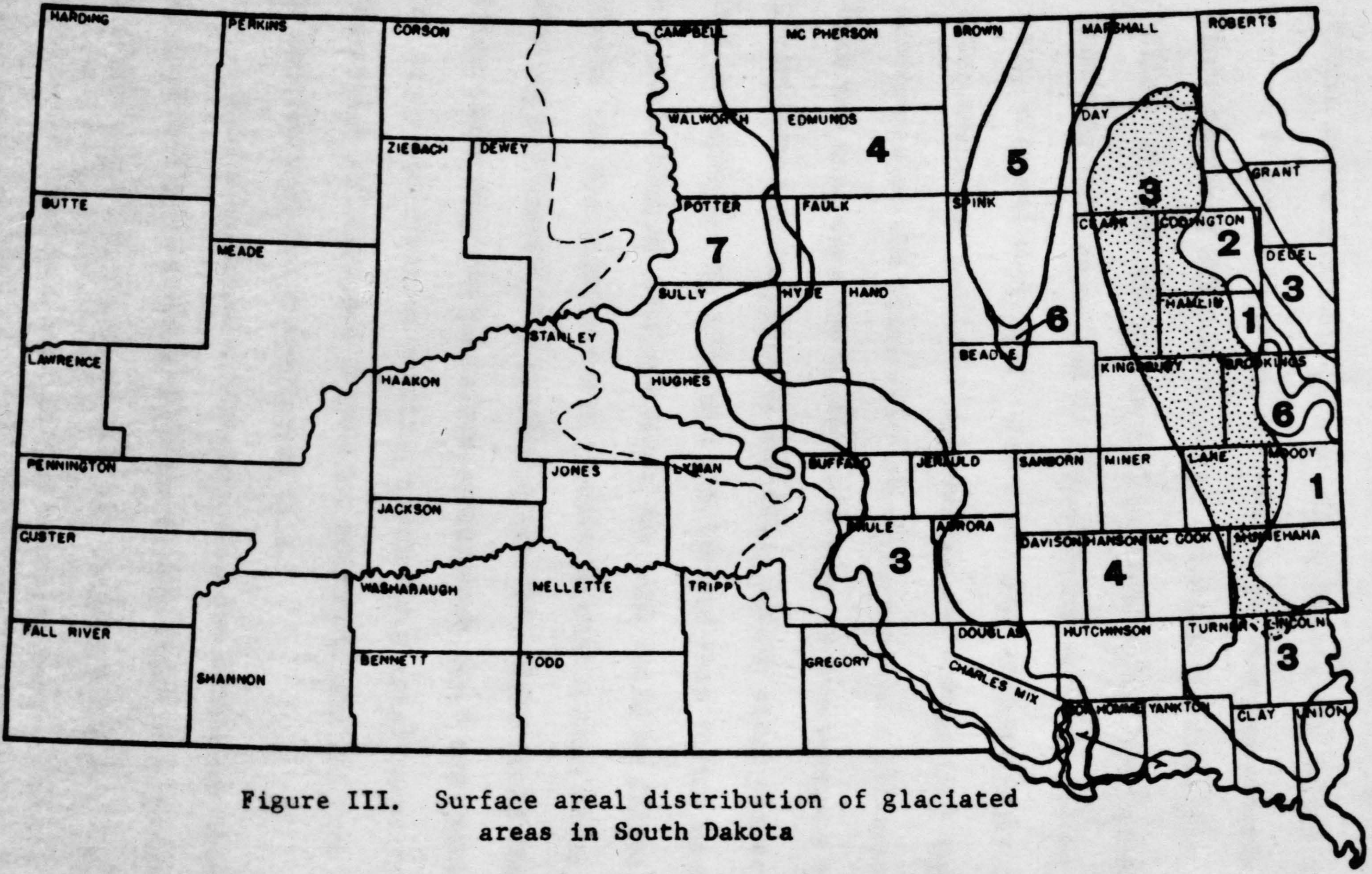

Figure III. Surface areal distribution of glaciated areas in South Dakota

1-Iowan
2-Tazewell
3-Cary
4-Mankato
5-Glacial Lake Sediments
6-Outwash and alluvium
7-Iowan-Tazewell Undifferentiated

⁙ Poinsett Area

Source: Flint (6)

between the Coteau and the lowland and the gentler side slope on the west of the Coteau would have allowed the ice to ride up higher on the Coteau and broaden the area where melting could take place.

In the study area, the Poinsett soils are associated with the finer textured Sinai soils which are found on mesa-like, flat-topped hills. Wilding and Westin (31) postulate that the "Sinai parent materials were deposited by slow-flowing water in and on the stagnated, thin, marginal Cary ice." Flint (6) says that the Cary ice overrode a loess-mantled landscape and Wilding and Westin (31) explain the occurrence of the Sinai soils on flat, mesa-like hilltops by stating that the thin Cary ice abraded the tops of loess-capped hills and incorporated loessial silts and clays within shear planes of the ice and as superglacial till upon the ice and that "after maximum extension and stagnation of this ice sheet the lows would be filled with ice blocks and the highs exposed or covered with a thin sheet of ice." Wilding and Westin (31) further state "the highs would then melt out first since they are positions of thinnest ice," and "after melting, the highs would become settling basins or glacial lakes for the deposition of laminated loess-like sediments derived from shear planes in the ice and from superglacial till."

Upon stagnation of the Cary ice, the landscape highs were, in all probability, surrounded by ice blocks which were pushed up against them and which stood higher than the landscape highs. The landscape highs would then have been natural settling basins for the loessial silts and clays which were carried in shear planes in the ice and as superglacial till upon the surrounding ice blocks when the ice melted. Schou (19) mentions sediments deposited in this way on "plateaux" or flat topped hills in Denmark, and Christiansen (3) discusses deposition of sediments on landscape highs that have been surrounded by "dead ice" in the Moose Mountain area of Saskatchewan. "Dead ice" as used by Christiansen (3) refers to ice that has become detached from the main glacier and has stagnated on the glacier margins. Deposition of stratified sediments in a similar manner is described by Flint (5) and Gravenor and Kupsch (7). The silty Poinsett parent materials probably were deposited by slow flowing waters while the finer-textured Sinai parent materials were deposited in relatively quiet pools in the ice blocked lakes.

Climate

The Poinsett area is classed by Visher (25) as dry subhumid microthermal. Thornthwaite (21) classifies the southern tip of the area as moist subhumid microthermal with the remainder classed as dry subhumid microthermal.

The entire area is characterized by dry, cold winters, and moist, warm summers with rapid and extreme fluctuations in daily and seasonal temperatures.

The average annual precipitation for the southern end of the area is 25 inches which diminishes more or less uniformly to 21 inches in the northern end (22). Average annual temperature is 46° F. in the southern part and 42° F. in the northern part of the area (22).

Vegetation

Native vegetation of the Poinsett area was a mixture of mid and tall grasses. Weaver (28) and Griffiths (8) list as mid grasses: little bluestem (_Andropogon scoparius_), grama (_Bouteloua sp._), needlegrass (_Stipa sp._), and Junegrass (_Koeleria cristata_) as dominants on the uplands. Dominant species on the lowland were big bluestem (_Andropogon furcatus_), sand dropseed (_Sporobolus cryptandrus_), and switchgrass (_Panicum virgatum_) (28, 29).

METHODS OF INVESTIGATION

Field Methods

The Poinsett sampling site was determined by running a transect on the Lake County ARS Farm. The site selected is located in an area which was felt to represent the central concept of the Poinsett soils.

The Moody soil was sampled at a site correlated as Moody in Minnehaha County, South Dakota and the Vienna at a site correlated as Vienna in the soil survey of Brookings County, South Dakota (30).

All of the profiles were sampled from pits six feet deep. The profiles were sampled from bottom to top to avoid any contamination of the pit face in sampling.

The horizon boundaries were marked on the pit face and then divided into subhorizons where stratification or any other visual change occurred. If there were no visual boundaries, the main horizons were arbitrarily divided into 3-inch subhorizons. Samples of the subhorizons were taken from an area one foot wide on the pit face and the bulk horizon samples were taken immediately adjacent to this area.

Depth to carbonates and primary structural units were determined in the field. Samples of the primary structural units then were taken inside where secondary structure, color, texture, clay skins, and all other observations were made under constant light and temperature on the three profiles simultaneously to diminish human errors in observation.

Clay skins were determined with a 14-power hand lens. A sand sizing glass with a scale graduated from 0.1 to 1.0 mm. was used to observe sand grains and pore spaces.

Laboratory Methods

Samples were air dried and crushed with a wooden rolling pin to pass a 2 mm. sieve. The material that passed a 2 mm. sieve was mixed thoroughly and quartered and all laboratory analyses were made on this material. The sample for determination of iron and manganese was taken from the portion finer than 2 mm. with a plastic scoop and handled with plastic or glass utensils throughout the analysis to avoid any metallic contamination.

The pipette method of Kilmer and Alexander (13) as outlined in Agricultural Handbook No. 60 (24) with several slight modifications was used for mechanical analysis. Modifications were: after destroying organic matter with H_2O_2 and weighing, the soils were centrifuged instead of filtered to remove dissolved mineral and organic matter. The soils were centrifuged once with water and twice with methanol at a speed of 3,000 rpm. Quart milk bottles graduated to 900 cc. were used in place of 1,000 cc. graduated cylinders as settling containers. An additional pipetting was made to determine .005-.002 mm. material. Settling times were taken from the nomograph in Jackson's text (11) for the 20, 5 and 2 micron fraction and the 50 micron fraction was determined by difference. All pipettings were taken at a 10 cm. depth at a temperature of 30° C.

Calcium carbonate equivalent was determined by using Jackson's method (10). The length of the glass discharge tube was shortened to avoid a siphoning effect after the reaction had ceased.

The procedure of Jeffries and Johnson (12) for determination of free iron oxides was used with the following modification: the standard curve was established by dissolving standard iron in aqua regia. The dissolved iron was then precipitated with NH_4OH, the precipitate centrifuged out and the supernatent discarded. The precipitate was washed twice with a 1% solution of NH_4NO_3 and the supernatent discarded each time. The precipitate then was taken up in the buffer solution. The iron content of this solution was determined by evaporating 50 ml. aliquots to dense fumes with sulfuric acid, and adding water to make an approximately 20% sulfuric acid solution. These solutions were passed through a Jones reductor and the reduced iron titrated with $KMnO_4$. Portions of the stock solution containing 0.5 to 20 mg. of iron were diluted to 50 ml. and their optical densities determined using a Bausch and Lomb Spectrophotometer at 410 mu light maximum.

Free manganese was determined by using Black's (2) procedure on 50 ml. aliquots of the same stock solutions used to determine iron.

FIELD RESULTS AND DISCUSSION

Profile Descriptions

Poinsett Soil Profile

Field Name: Poinsett silty clay loam
Field Classification: Chernozem
Location: 2144 feet south of the north fence and 1277 feet east of the west fence of that portion of the northwest 1/4 that lies east of the railroad track in section 35, T107N, R53W, Lake County, South Dakota
Climate: Average annual precipitation: 22-23"
Average annual temperature: 44-45° F.
Parent Material: Stratified silty Cary drift (Flint)
Physiography: On a rather low, broad, flat-topped undulation in an undulating Cary drift landscape.
Relief: Undulating countrywise, very gently sloping sitewise; local relief differential 10 to 20 feet.
Slope: 1-2%, very slightly convex
Aspect: South-facing

Alp	0-7"	Very dark brown to very dark grayish-brown (10YR 2.5/1.5 moist, 3.5/1.5 dry) crushing to black (10YR 2/1 moist, 3.5/1.5 dry) silty clay loam; puddled clods separating to weak, medium and coarse, subangular blocks; consistence if friable moist; hard dry; noncalcareous. This changes with a false plow depth boundary to,
B21	7-13"	Olive brown (2.5Y 4/4 moist, 5/3 dry) interior matrix color with very patchy, very dark gray, (2.5Y 3/1 moist, 4/2 dry) ped coatings and very few, medium very dark gray (2.5Y 3/1 moist, 4/2 dry) filled worm channels; silty clay loam; weak to moderate coarse prisms separating to weak, medium prisms, in turn separating to weak to moderate, medium and coarse subangular blocks; thin, very patchy and moderate, extremely patchy clay skins; consistence is friable moist, hard dry; noncalcareous. This grades with a smooth boundary into,
B22	13-21"	Olive brown (2.5Y 4/3 moist, 5/3 dry) interior matrix color with extremely patchy, very dark gray (2.5Y 3/1 moist, 4/2 dry) ped coatings and very few, medium very dark gray

		(2.5Y 3/1 moist, 4/2 dry) filled worm channels; silty clay loam; weak to moderate, coarse, prisms separating to weak, medium prisms, in turn separating to weak to moderate, medium and coarse subangular blocks, in turn separating to weak to moderate fine and very fine subangular blocks; very thin slightly patchy and moderate, very patchy clay skins; consistence is friable to firm moist, hard dry; noncalcareous. This changes abruptly and with a smooth boundary to,
B2ca	21-25 1/2"	Olive brown to light olive brown (2.5Y 4.5/3 moist, 6/2 dry) interior matrix color with nearly continuous, olive brown to light olive brown (2.5Y 4.5/3 moist, 6/2 dry) ped coatings; few, faint gray (2.5Y 5/1 moist, 7/1 dry) mottles; silt loam; weak to moderate coarse prisms separating to very weak, medium and coarse, subangular blocks; very thin, extremely patchy clay skins; consistence is firm moist, hard dry; strongly calcareous; common, fine, soft lime segregations. This grades with a clear smooth boundary into,
B31ca	25 1/2-32 1/2"	Olive brown to light olive brown (2.5Y 4/3 moist, 6/2 dry) interior matrix color with common, medium faint, gray (2.5Y 5/1 moist, 7/1 dry) mottles and few, fine prominent, yellowish brown (10YR 5/8 moist, 6/6 dry) iron stains and olive brown to light olive brown (2.5Y 4.5/3 moist, 6/2 dry) ped coatings; silt loam; weak to moderate, coarse, and very coarse, prisms, separating to the weak, coarse, angular blocks that are the inherent structure of the parent material; very thin, extremely patchy clay skins; consistence is firm moist, hard dry; strongly calcareous, with many, medium soft lime segregations. This grades with a clear smooth boundary into the B32ca.
(1)	25 1/2-28 1/2"	Same as bulk horizon except for: Olive brown to light olive brown (2.5Y 4.5/3 moist, 6/3 dry) matrix color.
(2)	28 1/2-32 1/2"	Same as bulk horizon except for: Light olive brown (2.5Y 5/3 moist, 6/2 dry) matrix color; few, fine and medium, soft lime segregations.

B32ca	32 1/2-39 1/2"	Olive brown (2.5Y 4/3.5 moist, 6/3 dry) interior matrix color with common, medium, faint, gray (2.5Y 5/1 moist, 7/1 dry) mottles and common, medium prominent, yellowish brown (10YR 5/8 moist, 6/6 dry) iron stains and a few, small, manganese stains in the interior of the peds and nearly continuous, olive brown (2.5Y 4/3.5 moist, 6/3 dry) ped coatings; weak to moderate, very coarse prisms separating to the weak to moderate coarse, angular blocks that are the inherent structure of the parent material; very thin extremely patchy clay skins; consistence is firm moist, hard dry; strongly calcareous, with common, medium and coarse soft lime segregations. This grades with a smooth boundary into the B33ca.
(1)	32 1/2-34"	Same as bulk horizon except for: Olive brown to light olive brown (2.5Y 4.5/3 moist, 6/2 dry) matrix color; consistence is friable to firm moist, hard dry; common, medium, soft lime segregations.
(2)	34-36 1/2"	Same as bulk horizon except for: Many, medium and coarse prominent, strong brown (7.5Y 3/8 moist, 5/8 dry) iron stains and a few, medium prominent, grayish brown (2.5Y 5/2 moist, 7/1 dry) mottles; few, medium soft lime segregations.
(3)	36 1/2-37 1/2"	Same as bulk horizon except for: Common medium prominent, dark yellowish brown (10YR 4/8 moist, 5/6 dry) iron stains and a few, fine, prominent, grayish brown (2.5Y 5/2 moist, 7/1 dry) mottles and many, small black (10YR 2/1 moist, 3/1 dry) manganese stains.
(4)	37 1/2-38 1/2"	Same as bulk horizon except for: Grayish brown (2.5Y 5/2 moist, 6/2 dry) matrix color with common, fine, faint, light olive brown (2.5Y 5/6 moist, 6/6 dry) iron stains, and many, small, black (10YR 2/1 moist, 3/1 dry) manganese stains; few, medium, soft lime segregations.
(5)	38 1/2-39 1/2"	Same as bulk horizon except for: Dark brown to brown (10YR-2.5Y 4/3 moist, 5.5/3 dry) matrix color with many medium and large, prominent, yellowish brown (10YR-2.5Y 5/8 moist, 10YR 6/6 dry) iron stains and a few, fine, prominent, gray (5Y 5.5/1 moist, 2.5Y

		7/1 dry) mottles and many, small, black (10YR 2/1 moist, 3/1 dry) manganese stains; consistence is friable to firm moist, hard dry; many, fine and medium soft lime segregations.
B33ca	39 1/2-47 1/2"	Light olive brown (2.5Y 5/6 moist, 10YR-2.5Y 6/6 dry) matrix color with a few, fine and medium, very prominent, gray (2.5Y 5/1 moist, N 7/0 dry) mottles and a few, small, manganese stains, moderately patchy olive brown to light olive brown (2.5Y 4.5/3.5 moist, 5.5/2 dry) ped coatings; weak to moderate very coarse prisms separating to weak to moderate coarse, angular blocks that are the inherent structure of the parent material; consistence is firm moist, hard dry; strongly calcareous with few, fine threads and seams of segregated lime. This grades with a smooth boundary into the C11ca.
(1)	39 1/2-40 1/2"	Same as bulk horizon except for: Olive brown (2.5Y 4/3 moist, 10YR-2.5Y 5.5/3 dry) matrix color; few, fine, faint, gray (2.5Y 5.5/1 moist, 7/1 dry) mottles, very few, medium, prominent yellowish brown (10YR 5/8 moist, 6/6 dry) iron stains and many small, black (10YR 2/1 moist, 3/1 dry) manganese stains.
(2)	40 1/2-41"	Same as bulk horizon except for: No matrix color, many medium and coarse, prominent, dark yellowish brown (10YR 4/8 moist, 7/6 dry) iron stains, many medium and coarse prominent gray to light gray (2.5Y 6/1 moist, 7/1 dry) mottles, and many, small, black (10YR 2/1 moist, 3/1 dry) manganese stains; consistence is friable to firm moist, hard dry.
(3)	41-41 1/2"	Same as bulk horizon except for: No matrix color; many, medium and coarse prominent, dark yellowish brown (10YR 4/8 moist, 7/6 dry) iron stains, many medium and coarse prominent gray to light gray (2.5Y 6/1 moist, 7/1 dry) mottles, and many, small, black (10YR 2/1 moist, 3/1 dry) manganese stains; consistence is friable moist, slightly hard dry.
(4)	41 1/2-42"	Same as bulk horizon except for: No matrix color; many, medium and coarse prominent, dark yellowish brown (10YR 4/8 moist, 7/6 dry) iron stains; many, medium and large, prominent gray

		to light gray (2.5Y 6/1 moist, 7/1 dry) mottles; few, fine and medium, soft lime segregations.
(5)	42-43 1/2"	Same as bulk horizon except for: Light olive brown (2.5Y 5/3.5 moist, 6/2 dry) matrix color with common, medium and coarse, prominent, yellowish brown (10YR 5/8 moist, 6/6 dry) iron stains; few medium, prominent, light brownish-gray (2.5Y 6/2 moist, 7/1 dry) mottles; consistence is friable moist, slightly hard dry; few to common, medium soft lime segregations.
(6)	43 1/2-46"	Same as bulk horizon except for: No matrix color; many, medium, and coarse prominent, yellowish brown (10YR 5/8 moist, 6/6 dry) iron stains; common, medium prominent, light brownish gray (2.5Y 6/2 moist, 7/1 dry) mottles; consistence is friable moist, slightly hard dry; very few, very fine threads and seams of segregated lime.
(7)	46-47 1/2"	Same as bulk horizon except for: Dark yellowish brown (10YR 4/8 moist, 10YR-2.5Y 6/6 dry) iron stained matrix color with common, medium, prominent, light brownish gray (2.5Y 6/2 moist, 7/1 dry) mottles; consistence is friable moist, hard dry; slightly to strongly calcareous with very few, very fine threads and seams of segregated lime.
C11ca	47 1/2-56"	Yellowish brown (10YR 5/6 moist, 6/6 dry) matrix color with common medium and coarse prominent, gray (2.5Y 5/1 moist, N 7/0 dry) mottles and a few, small, manganese stains; strongly calcareous with very few, very fine threads and seams of segregated lime. This grades with a smooth boundary into the C12ca.
(1)	47 1/2-52"	Same as bulk horizon except for: Light brownish gray (2.5Y 6/2 moist, 7/1 dry) matrix color with common, medium prominent, dark yellowish brown (10YR 4/8 moist, 5/8 dry) iron stains; consistence is friable moist, slightly hard dry.
(2)	52-56"	Same as bulk horizon except for: Yellowish brown (10YR 5/6 moist, 6/6 dry) iron stained matrix color with common, medium prominent, gray (2.5Y 5/1 moist, N 7/0 dry) mottles,

and many, small black (10YR 2/1 moist, 3/1 dry) manganese stains; consistence is friable moist, hard dry.

C12ca 56-60"+ Gray (2.5Y 5/1 moist, N 7/0 dry) matrix color with common, medium, prominent yellowish brown (10YR 5/6 moist, 6/6 dry) iron stains and a few, fine, manganese stains; silt loam; massive, strongly stratified parent material; consistence is firm moist hard dry; strongly calcareous with common, small and medium, soft lime segregations.

(1) 56-57" Same as bulk horizon except for: Grayish brown to light brownish gray (2.5Y 5.5/2 moist, 7/2 dry) matrix color with common, fine and medium prominent, yellowish brown (10YR 5/6 moist, 6/6 dry) iron stains; consistence is friable moist, soft to slightly hard dry.

(2) 57-59" Same as bulk horizon except for: Yellowish brown (10YR 5/6 moist, 6/6 dry) iron stained matrix color with common, medium, prominent grayish brown to light brownish gray (2.5Y 5.5/2 moist, 7/2 dry) mottles and many, small black (10YR 2/1 moist, 3/1 dry) manganese stains; consistence is friable to firm moist, soft to slightly hard dry; few, medium soft lime segregations; common iron-manganese pipestem concretions.

(3) 59-60" Same as bulk horizon except for: Grayish brown to light brownish gray (2.5Y 5.5/2 moist, 7/2 dry) matrix color, with common, medium prominent, yellowish brown (10YR 5/6 moist, 6/6 dry) iron stains, few, very small, soft lime segregations; common, iron-manganese pipestem concretions.

Note: Many, very fine and common, fine pores from 0-25 1/2 inches and few, fine and medium pores from 25 1/2 to 60 inches; common to many, angular transparent quartz grains throughout the profile; few, subangular translucent quartz grains from 0-25 1/2 inches and many, subangular, translucent quartz grains from 25 1/2 to 60 inches; few, subangular dark minerals from 21 to 25 1/2 inches, common, subangular dark minerals from 25 1/2 to 39 1/2 inches and many subangular dark minerals from 39 1/2 to 60 inches; few to common small iron-manganese concretions from 25 1/2 to 60 inches.

Moody Soil Profile

Field Name: Moody silty clay loam
Field Classification: Chernozem-Brunizem intergrade
Location: 400 feet north, 245 feet east of the southwest corner of section 5, T109N, R48W, Minnehaha County, South Dakota
Climate: Average annual precipitation: 25-26"
Average annual temperature: 49-50° F.
Parent Material: Calcareous, silt loam loess in the Iowan drift area (Flint), Illinoian drift area (Agnew)
Physiography: The nearly level crest of a smooth side-sloped, loess-subdued undulation
Relief: Strongly undulating countrywise, very gently sloping sitewise, local relief differential 30 to 40 feet.
Slope: 1-2%, convex
Aspect: Southeast-facing

ABp	0-7"	Very dark gray to very dark grayish brown (10YR 3/1.5 moist, 4/1.5 dry) with inclusions of B horizon that are dark yellowish brown (10YR-2.5Y 4/4 moist, 5/3 dry) light silty clay loam; puddled clods separating to weak, medium and fine subangular blocks; consistence is friable moist, hard dry; noncalcareous. This changes with a false plow depth boundary to,
B21	7-13"	Olive brown (2.5Y 4/4 moist, 10YR-2.5Y 5/3 dry) matrix color with few, medium, very dark gray (10YR 3/1 moist, 4/1 dry) worm casts and filled worm channels; light silty clay loam; weak coarse and medium prisms separating to weak, medium, fine and very fine, blocks; very thin, extremely patchy clay skins; consistence is friable moist, slightly hard dry; noncalcareous. This grades with a smooth boundary into,
B22	13-18"	Olive brown (2.5Y 4/4 moist, 10YR-2.5Y 5/3 dry) with very patchy, very dark grayish brown to dark grayish brown (2.5Y 3.5/2 moist, 5/2 dry) ped coatings; light silty clay loam; weak to moderate coarse and medium prisms separating to weak to moderate, medium, fine and very fine, subangular blocks; thin, very patchy clay skins; consistence is friable moist, hard dry; noncalcareous. This grades with a smooth boundary into,

B23ca	18-24"	Olive brown (2.5Y 4/4 moist, 10YR-2.5Y 5/3.5 dry) with very patchy, very dark grayish brown to dark grayish brown (2.5Y 3.5/2 moist, 5/2 dry) ped coatings; weak to moderate, coarse and medium prisms separating to weak, medium and fine subangular blocks; thin, very patchy clay skins; consistence is friable moist, hard dry; noncalcareous. This grades with a wavy boundary into,
B24	24-29"	Olive brown (2.5Y 4/4 moist, 10YR-2.5Y 5/3.5 dry) with very patchy, olive brown (2.5Y 4/3 moist, 5/3 dry) ped coatings; silt loam; weak to moderate, coarse prisms separating to weak, medium and coarse subangular blocks; thin, very patchy clay skins; consistence is friable moist, hard dry; noncalcareous. This grades with a wavy boundary into the B25.
(1)	24-26 1/2"	Same as bulk horizon.
(2)	26 1/2-29"	Same as bulk horizon.
B25	29-35"	Olive brown (2.5Y 4/4 moist, 10YR-2.5Y 5.5/3.5 dry) with extremely patchy, olive brown (2.5Y 4/3 moist, 5/3 dry) ped coatings; silt loam; weak to moderate coarse and very coarse prisms separating to weak, coarse, subangular blocks; very thin, very patchy clay skins; consistence is friable moist, slightly hard dry; noncalcareous. This changes abruptly and with a wavy boundary to the B31ca.
(1)	29-32"	Same as bulk horizon.
(2)	32-35"	Same as bulk horizon.
B31ca	35-42"	Olive brown (2.5Y 4/3 moist, 5.5/3 dry) interior matrix color with thin, nearly continuous, dark grayish brown to olive brown (2.5Y 4/2.5 moist, 5/2.5 dry) ped coatings; few, fine, distinct, gray to light gray (2.5Y 6/1 moist, 7/1 dry) mottles in the interior peds; silt loam; weak, very coarse prisms; very thin, extremely patchy clay skins; consistence is friable moist, slightly hard dry; strongly calcareous with common fine and medium, hard lime concretions. This grades with a smooth boundary into the B32ca.

(1)	35-38 1/2"	Same as bulk horizon.
(2)	38 1/2-42"	Same as bulk horizon.
B32ca	42-49"	Olive brown to light olive brown (2.5Y 4.5/3 moist, 6/3 dry) interior matrix color with nearly continuous dark grayish brown to olive brown (2.5Y 4/2.5 moist, 5/2.5 dry) ped coatings; few, fine, distinct, gray to light gray (2.5Y 6/1 moist, 7/1 dry) mottles, a few, very fine, oxidized iron stains and a few, very fine manganese stains; silt loam; weak, very coarse prisms; very thin, extremely patchy clay skins; consistence is friable moist, slightly hard dry; moderately calcareous with few fine hard lime concretions. This grades with a smooth boundary in the C11ca.
(1)	42-45 1/2"	Same as bulk horizon.
(2)	45 1/2-49"	Same as bulk horizon.
C11ca	49-61"	Dark grayish brown to olive brown (2.5Y 4.5/2.5 moist, 6/3 dry) matrix color; few, fine, distinct, gray to light gray (2.5Y 6/1 moist, 7/1 dry) mottles; few, medium distinct, dark yellowish brown (10YR 4/6 moist, 6/6 dry) iron stains, and a few, very fine, manganese stains; silt loam; weak very coarse, prismatic structure; very thin, extremely patchy clay skins; consistence is very friable moist, soft dry; strongly calcareous with few, fine hard lime concretions. This grades with a smooth boundary into the C12ca.
(1)	49-52"	Same as bulk horizon.
(2)	52-55"	Same as bulk horizon.
(3)	55-58"	Same as bulk horizon.
(4)	58-61"	Same as bulk horizon.
C12ca	61-69"+	Light olive brown (2.5Y 5/3 moist, 6.5/4 dry) matrix color with a few, fine, gray to light gray, (2.5Y 6/1 moist, 7/1 dry) mottles and a few, medium, distinct, dark yellowish brown (10YR 4/6 moist, 6/6 dry) iron stains and

common, very fine, manganese stains; silt loam; massive; consistence is very friable moist, soft dry; strongly calcareous with few fine threads and seams of segregated lime and very few, fine hard lime concretions.

(1) 61-64" Same as bulk horizon.

(2) 64-69" Same as bulk horizon.

Note: Common to many, very fine and fine pores throughout profile and few, medium and large pores from 24 to 69 inches; many lightly iron stained subangular translucent quartz grains throughout profile; few to common angular and subangular dark minerals from 29 to 42 inches and many angular and subangular dark minerals from 42 to 69 inches; few, fine iron-manganese concretions throughout the profile.

Vienna Soil Profile

Field Name: Vienna loam, Tazewell variant
Field Classification: Chernozem
Location: 1389 feet south and 159 feet west of the northeast corner of section 25, T112N, R49W, Brookings County, South Dakota
Climate: Average annual precipitation: 21-22"
Average annual temperature: 44-45° F.
Parent Material: Calcareous, firm clay loam glacial till of Tazewell Age (Flint)
Physiography: Broad interfluve ridge in a landscape with an integrated drainage pattern
Relief: Undulating countrywise, very gently sloping sitewise; local relief differential 25 to 35 feet.
Slope: 1-2%, slightly convex
Aspect: Southeast-facing

Alp 0-5" Black (10YR 2/1 moist, 3.5/1 dry) crushing to black (10YR 2/1 moist, 4/1.5 dry); loam; puddled clods separating to weak, coarse, angular blocks in turn separating to weak, medium and fine subangular blocks; consistence is friable moist, slightly hard dry; non-calcareous. This changes with a false plow depth boundary to,

B1 5-9" Dark brown (10YR-2.5Y 3/3 moist, 4/2.5 dry) with moderately patchy, black (10YR 2/1 moist, 3.5/1 dry) ped coatings; common, medium, black (10YR 2/1 moist, 3.5/1 dry) worm casts and filled worm channels; loam; weak, coarse and medium prisms separating to angular blocks; consistence is friable moist, slightly hard dry; noncalcareous. This changes clearly and with a smooth boundary to,

B21	9-14"	Dark brown (10YR-2.5Y 3/3 moist, 4/2.5 dry) with very patchy black to very dark gray (10YR 2/1 moist, 3.5/1 dry) worm casts and filled worm channels; loam; weak to moderate coarse and medium prisms separating to weak to moderate, medium and coarse subangular blocks; very thin, very patchy clay skins; consistence is friable to firm moist, hard dry; noncalcareous. This changes clearly and with a smooth boundary to,
B22	14-17"	Dark brown to brown (10YR-2.5Y 3.5/3 moist, 4.5/3 dry) with very patchy, very dark grayish brown (10YR-2.5Y 3/2 moist, 4.5/2 dry) ped coatings; few, medium, black (10YR 2/1 moist, 3.5/1 dry) worm casts and filled worm channels; loam; weak, very coarse, prisms separating to weak to moderate, coarse and medium prisms in turn separating to weak to moderate, fine and medium subangular blocks; thin, very patchy clay skins; consistence is friable to firm moist, hard dry; noncalcareous. This grades with a smooth boundary to,
B2ca	17-20"	Light olive brown (2.5Y 5/3 moist, 6/3 dry) with moderately patchy olive brown (2.5Y 4/4 moist, 10YR-2.5Y 5/3 dry) ped coatings; few, medium grayish brown (2.5Y 5/2 moist, 6/2 dry) worm casts and filled worm channels; loam; weak, very coarse prisms separating to weak, coarse and medium prisms in turn separating to weak to moderate, medium, fine and very fine, blocks; very thin extremely patchy clay skins; consistence is firm moist, hard dry; strongly calcareous with few to common, medium soft lime segregations. This changes clearly and with a smooth boundary to,
B31ca	20-27"	Light olive brown (2.5Y 5/4 moist, 6/3 dry) with moderately patchy, olive brown (2.5Y 4/4 moist, 5/3 dry) ped coatings; loam; weak, very coarse, prisms separating to weak coarse and medium prisms in turn separating to weak to moderate, medium, fine and very fine subangular blocks; very thin, extremely patchy

		clay skins; consistence is firm moist, hard dry; violently calcareous with few, medium soft lime segregations. This changes clearly and with a wavy boundary to the B32ca.
(1)	20-23"	Same as bulk horizon.
(2)	23-27"	Same as bulk horizon.
B32ca	27-33"	Light olive brown (2.5Y 5/4 moist, 6.5/3 dry) with moderately patchy, olive brown to light olive brown (2.5Y 4.5/3 moist, 5/2 dry) ped coatings; loam; weak very coarse, prisms separating to weak to moderate, medium fine and very fine, subangular blocks; very thin, extremely patchy clay skins; consistence is firm moist, hard dry; violently calcareous; with common, coarse soft lime segregations. This grades with a smooth boundary into the C11ca.
(1)	27-30"	Same as bulk horizon except for: Light olive brown (2.5Y 5/4 moist, 7/3 dry) interior matrix color.
(2)	30-33"	Same as bulk horizon except for: Few, medium, faint, clear boundary light brownish gray (2.5Y 6/2 moist, 7/2 dry) mottles.
C11ca	33-45"	Light olive brown (2.5Y 5/4 moist, 6.5/3 dry) matrix color with moderately patchy light olive brown (2.5Y 5/3 moist, 6.5/2 dry) ped coating; fine prominent yellowish brown (10YR 5/6 moist, 7/6 dry) iron stains and a very few, fine, prominent yellowish red (5Y 3/4 moist, 4/6 dry) iron stains; loam; very weak, very coarse prisms separating to very weak, coarse blocks, in turn separating to weak, medium, fine and very fine, subangular blocks that are the inherent structure of the parent material; very thin, extremely patchy clay skins; consistence is firm moist, very hard dry; strongly calcareous with many, coarse and medium, soft lime segregations. This grades with a wavy boundary into the C12ca.
(1)	33-36"	Same as bulk horizon.
(2)	36-39"	Same as bulk horizon.

(3)	39-42"	Same as bulk horizon except for: Light olive brown (2.5Y 5/4 moist, 7/3 dry) matrix color.
(4)	42-45"	Same as bulk horizon.
C12ca	45-53"	Light olive brown (2.5Y 5/4.5 moist, 7/3 dry) matrix color with many, medium and coarse, faint, yellowish brown (10YR 5/6 moist, 7/6 dry) iron stains and common, medium distinct, gray (2.5Y 5/1 moist, 7/1 dry) mottles; loam; very weak, fine and medium subangular blocks separating to medium, fine and very fine, subangular blocks that are the inherent structure of the parent material; consistence is firm moist, very hard dry; strongly calcareous with common, coarse and medium, soft lime segregations. This changes clearly and with a smooth boundary to the C13ca.
(1)	45-49"	Same as bulk horizon.
(2)	49-53"	Same as bulk horizon.
C13ca	53-60"+	Light olive brown (2.5Y 5/4.5 moist, 7/3 dry) matrix color with many, medium and large, faint, yellowish brown (10YR 5/6 moist, 7/6 dry) iron stains and common, medium distinct, gray (2.5Y 5/1 moist, 7/1 dry) mottles; loam; very weak, fine subangular blocks separating to weak, medium fine and very fine, subangular blocks that are the inherent structure of the parent material; consistence is firm moist, very hard dry; strongly calcareous with common, medium soft lime segregations.
(1)	53-56"	Same as bulk horizon.
(2)	56-60"+	Same as bulk horizon.

Note: Many very fine, and few, fine and medium pores from 0-14 inches common, very fine and fine, and few, medium pores from 14 to 23 inches, and few, very fine, fine and medium pores from 33 to 60 inches; few, angular transparent quartz grains from 0 to 17 inches and many, subangular, translucent quartz grains throughout the profile; few, subangular dark minerals from 5 to 17 inches, common subangular dark minerals from 17 to 27 inches, and many subangular dark minerals from 27 to 60 inches; few, fine iron-manganese concretions from 17 to 20 inches, many, fine iron-manganese concretions from 20 to 23 inches, few, fine iron-manganese concretions from 33 to 45 inches, and many fine iron-manganese concretions from 45 to 60 inches.

Discussion of the Colors of the Poinsett Soil

The Moody and Vienna profiles exhibited 10YR and 2.5Y hues which are assumed to be oxidized colors throughout. The Poinsett profile had 10YR and 2.5Y hues in the upper profile while light gray neutral hues which are assumed to be reduced colors are stratified with dull reds and browns in the substrata.

Variations in color between strata were not pronounced in the upper B3ca horizon of the Poinsett soils but increased with depth to extreme ranges of 1 unit in hue, 1 unit in value, and 5 units in chroma between stratifications in the lower parts of the Cca horizon. The greatest readable difference in the Vienna profile was 1/2 chip difference in value which occurred among some subhorizons of both the B3ca and Cca horizons. There were no color changes of readable difference in the subhorizons of either the B3ca or Cca horizons of the Moody profile.

The pronounced differences in color among strata of the Poinsett substrata are thought to be an inherent characteristic of the parent materials, since these differences occur in soil substrata throughout the Cary drift area. The dull reddish brown colors which are thought to represent iron in the oxidized state in some strata may have been deposited while in a reduced state and subsequently oxidized. However, this does not seem probable as the profile would exhibit more uniformly oxidized colors if this were the case. Another possible explanation is that the neutral gray strata were deposited slowly under reducing conditions and the reddish brown strata were deposited rapidly and covered before reduction could take place. However, the reddish brown strata do not necessarily exhibit coarser textures as would be expected if the materials were deposited at different rates. A more plausible explanation may be that temperature fluctuations reduced the quantity of melt water at various intervals and allowed the exposure and oxidation of materials during deposition.

Discussion of the Texture of the Poinsett Soil

The Poinsett soils are developed in silty materials. Frequently profiles are found which appear to be loess because there is no stratification or abrupt textural changes in the profile. However, one may find profiles with admixtures of gravel or stone, small bodies of till or stratified profiles within a few feet of the silty, loess-like profiles.

The characteristics of "extreme range and abrupt changes in grain size,""included bodies of till," and stratification are associated with ice contact stratified drift (5).

In contrast to the Poinsett soils the Moody soils do not exhibit any range or change in particle size, have no included bodies of till and are not stratified. Their profiles are uniformly silty throughout which is a characteristic associated with loess (20, 26).

Vienna soils have a heterogeneous particle size distribution characteristic of glacial till (16). There is no evidence of stratification in their profiles, indicating that they have not been subjected to sorting by melt waters during deglaciation.

Discussion of Soil Consistence of the Poinsett Soil

Soil consistence of the three profiles is friable to firm moist, and slightly hard to hard dry in the upper horizons. In the lower horizons the Moody profile was very friable moist, and soft to slightly hard dry. Consistence in the Vienna profile was firm moist, and hard to very hard dry; and the Poinsett profile was intermediate between the Moody and Vienna with firm moist, and hard dry consistence.

Soil consistence is thought to be a reflection of the permeability to water. If this assumption is correct the Moody soil would be the most permeable. The Poinsett soil would be less permeable than the Moody soil but more permeable than the Vienna soil, and the Vienna soil would be the least permeable of the three profiles.

LABORATORY RESULTS AND DISCUSSION

Free Iron

The data for free iron, reported as a percentage, in the three profiles, are shown in Figure IV and in Table 1 of the appendix.

All three profiles had relatively high contents of iron in the upper 24 inches when compared to the average for the rest of the profile. This may be due to the well drained environment in the A and B horizons since in this environment iron is in the ferric state and is immobile (33), while some iron has remained in the ferrous state in the lower horizons and has been removed by downward percolation of water. However, Ignatieff (9) mentions that the ferrous ions in the soil are fixed by the soil in the same manner as any basic ion and are not readily brought into solution by water. He goes on to state, "It would thus appear that in soil the downward movement of the divalent form would be very slow, and that large quantities of the soil iron would have to be reduced before any appreciable quantities of iron are moved in that state." Thus, it would seem that a more plausible explanation of the higher free iron content in the surface horizons is that more iron has been released by weathering and has been oxidized, in place, in the surface horizons and that the lower free iron content of the substrata is due to less severe weathering.

The difference in free iron content between subhorizons of the Poinsett substrata ranged from 0.1 to 0.5%. The differences in free iron percentage among subhorizons of the substrata in the Vienna profile were less frequent and of a smaller magnitude than in the

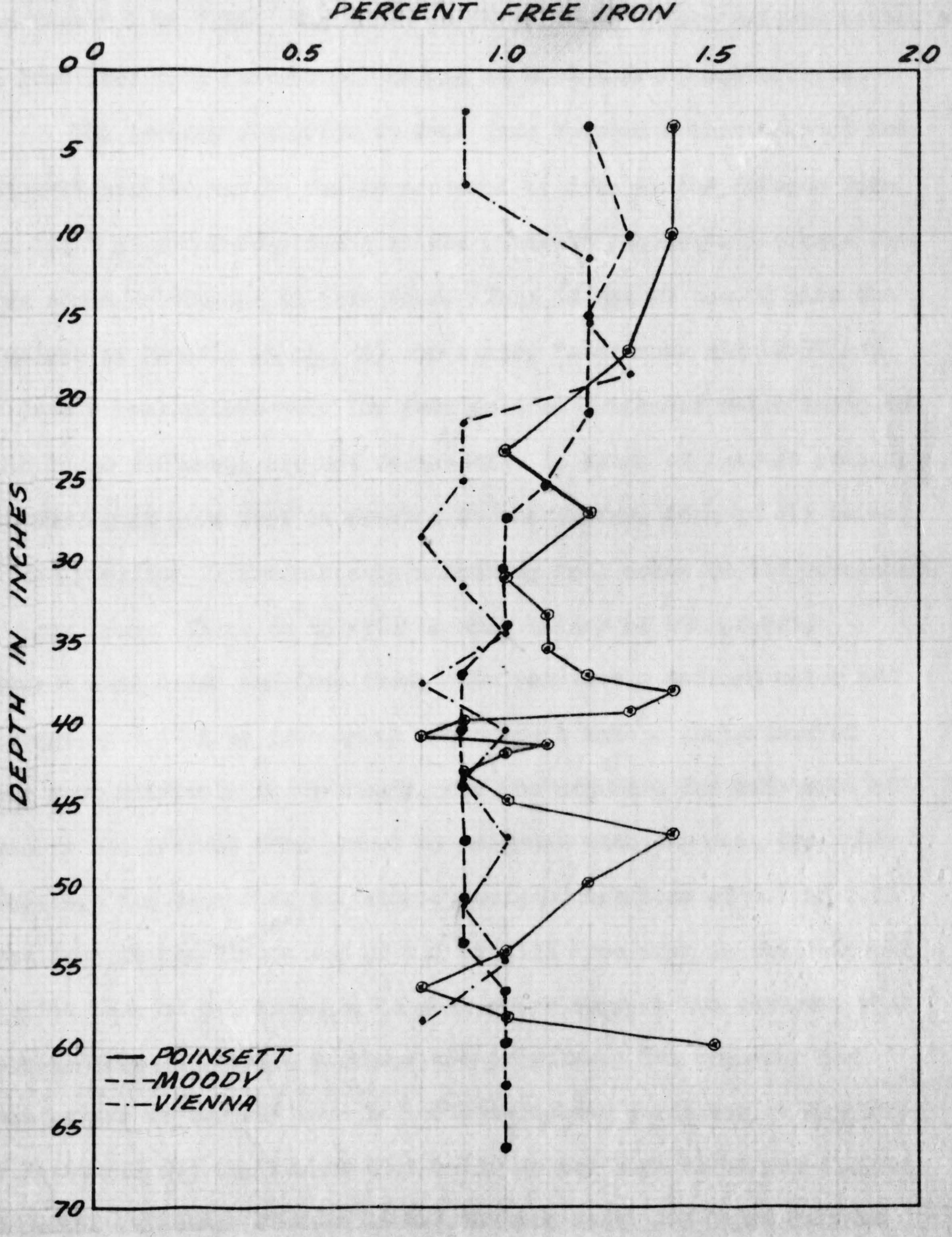

Figure IV. The percent free iron in the Moody, Vienna and Poinsett profiles

Poinsett profile. The range between subhorizons in the Vienna profile was from 0.1 to 0.2%. The Moody profile showed nearly uniform contents of free iron with infrequent changes of 0.1% between subhorizons.

The greater variation in free iron between subhorizons of the Poinsett profile may be due to movement of iron in the ferrous form. The light gray colors present in the Poinsett substrata indicate that iron could be present in this form. This is not in accord with the findings of Daniels _et al_. (4) who state, "sediments with 2.5Y and 5Y hues normally have very low ferrous iron contents; which indicates that these sediments are not necessarily in zones of intense reduction." However, that some iron is present in the ferrous form in all three of the profiles is indicated by comparing soil color to the percentage of free iron. There is no relationship in any of the profiles between soil color and free iron. The relatively uniform color and changes of 0.1% free iron among subhorizons make a comparison of this sort difficult in the Moody, and the argument for existence of iron in the ferrous form cannot be defended with the data from this profile. The fact that variations among subhorizons of 0.1 to 0.2% free iron in the Vienna and of 0.1 to 0.5% free iron in the Poinsett profile bear no relationship to soil color support the argument that ferrous iron is present in these two profiles. The argument that iron exists in ferrous form in soils in upland positions is supported by Ignatieff (9) who states that soils do not have to be waterlogged to permit existence of iron in the ferrous state but "that ferrous iron can persist in a stratum of soil of fairly low moisture content if the upper layers of soil are of such a nature that they prevent the free passage of air." The existence of such a barrier in the Moody profile would not seem probable from field observations and mechanical analysis, and, as has been stated previously, the presence of ferrous iron in appreciable amounts in this profile is doubtful. The Vienna profile which was developed in basal till appears to be much less permeable than the Moody, and it is probable that this extreme compactness would sufficiently hinder the movement of air to preserve iron in the ferrous state except where cracks were formed. In the Poinsett profile the stratified materials of different texture would lead to differential cracking, but it is doubtful that continuous cracks of any significant size would form. Hence the passage of air in the substrata would be considerably retarded, and it is probable that proportionately more iron is preserved in the ferrous state in the Poinsett soil than in the Vienna or Moody profiles.

The theory that more iron exists in the ferrous form in the Poinsett than in the Vienna and Moody profiles would be a possible explanation for the greater amount of iron staining and the greater number of concretions in the Poinsett than in the Vienna and Moody profiles. This is in accord with the conclusion of Winters (33) who states, "an hypothesis of surface diffusion of ferrous ions will account for the movement of iron to centers of concretion formation in soils containing excess $CaCO_3$." However, one cannot discount the possibility of certain strata being higher in free iron when they were deposited and the variation in free iron being an inherent characteristic of the parent material.

Free Manganese

Manganese, like iron, was more variable in the Poinsett substratum than in the substrata of the Vienna or Moody profiles. The data for free manganese are shown in Figure V and Table 2 of the appendix.

Although many manganese studies had been conducted on Podzolic soils (17, 32), there has been relatively little work done with Chernozem soils. Leeper (15) indicates in his study that pedocals should have steady values for manganese throughout the profile. He attributes the steady values in these soils to manganese being held on the exchange complex, and not soluble in water in neutral and alkaline soils, hence it would not be subject to leaching.

The Moody profile has nearly constant values for manganese throughout the profile. The Vienna profile, although showing some variation, had a maximum difference of only .025% among contiguous subhorizons and a range of .041% in the profile. The Poinsett profile shows much greater variation, and values for manganese range from .042 to .146% with a maximum difference of .057% among contiguous subhorizons.

The wide range in manganese values in the Poinsett profile may be due to the materials in some strata having higher manganese contents when the materials were deposited or to movement of manganese from some strata with subsequent concentration in others since deposition. Robinson (18) states that "manganese becomes very soluble in waterlogged conditions." Thus the theory of manganese movement is plausible since the gray colored strata in the Poinsett profile indicate that they have

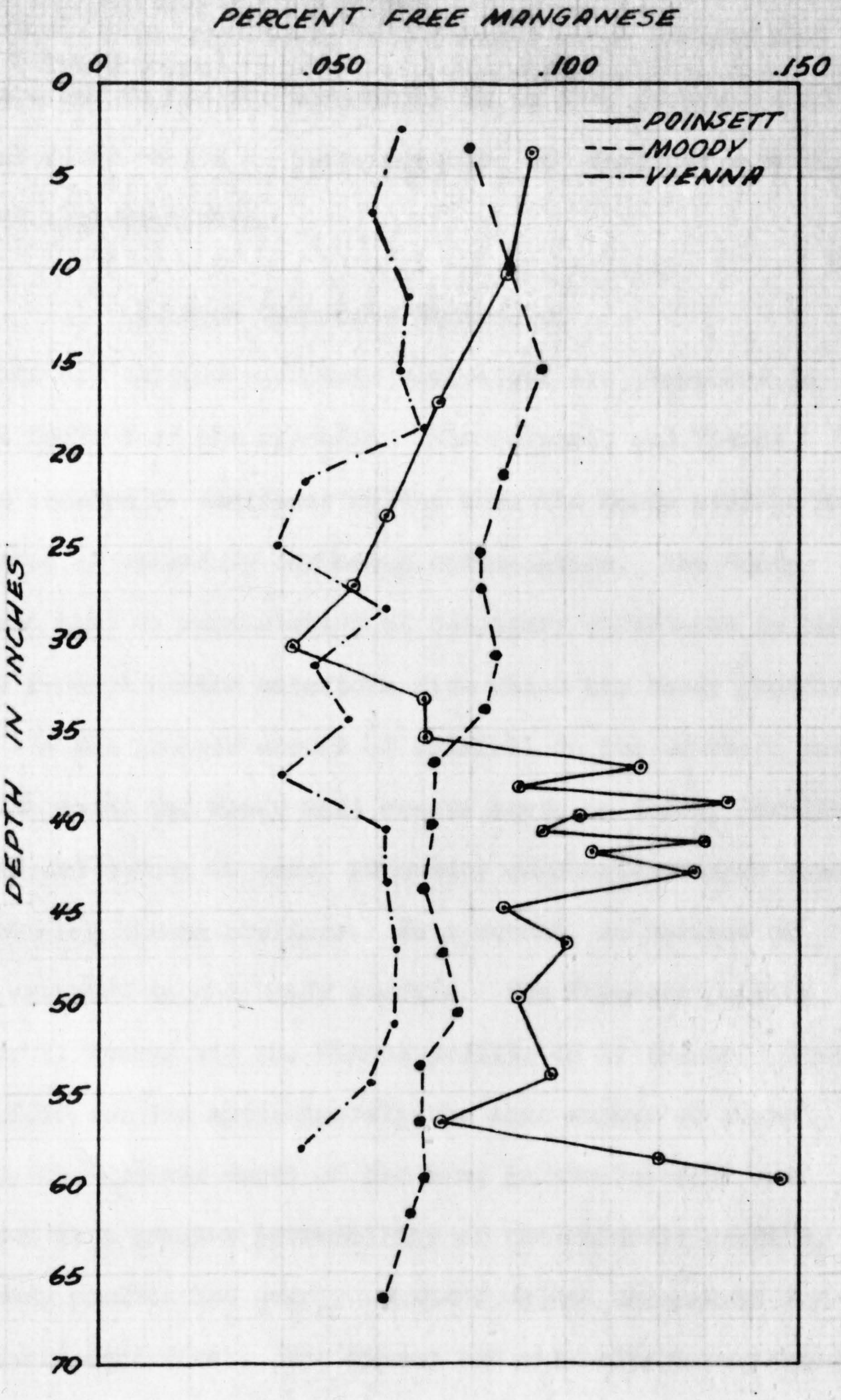

Figure V. The percent free manganese in the Moody, Vienna and Poinsett profiles at some time been subjected to rather severe reducing conditions. However, since there is no consistent relationship among reduced and oxidized strata and values for manganese, it is more probable that the parent materials varied in free manganese and that the variation is an inherent characteristic.

Calcium Carbonate Equivalent

The data for calcium carbonate equivalent are presented in Figure VI and Table 3 of the appendix. The Poinsett and Vienna profiles were leached to shallower depths than the Moody profile and also had an area of secondary carbonate accumulation. The Moody profile did not have an accumulation of secondary carbonates in the profile. The more permeable materials from which the Moody profile is developed and the greater amount of rainfall in the southern part of the state in which the Moody soil occurs have, no doubt, permitted percolating ground waters to carry secondary carbonates deeper than in the Poinsett and Vienna profiles. As a result, no horizon of accumulation occurred in the Moody profile. The Poinsett profile was leached to 21 inches and the Vienna profile to 17 inches. Since these two profile receive approximately the same amount of annual precipitation, the greater depth of leaching in the Poinsett soil probably is due to a greater permeability of the Poinsett profile.

The Moody profile had nearly constant values throughout for calcium carbonate equivalent. The Vienna had only slight variations below the horizon of secondary carbonate accumulation while the Poinsett exhibited definite and pronounced fluctuations in value

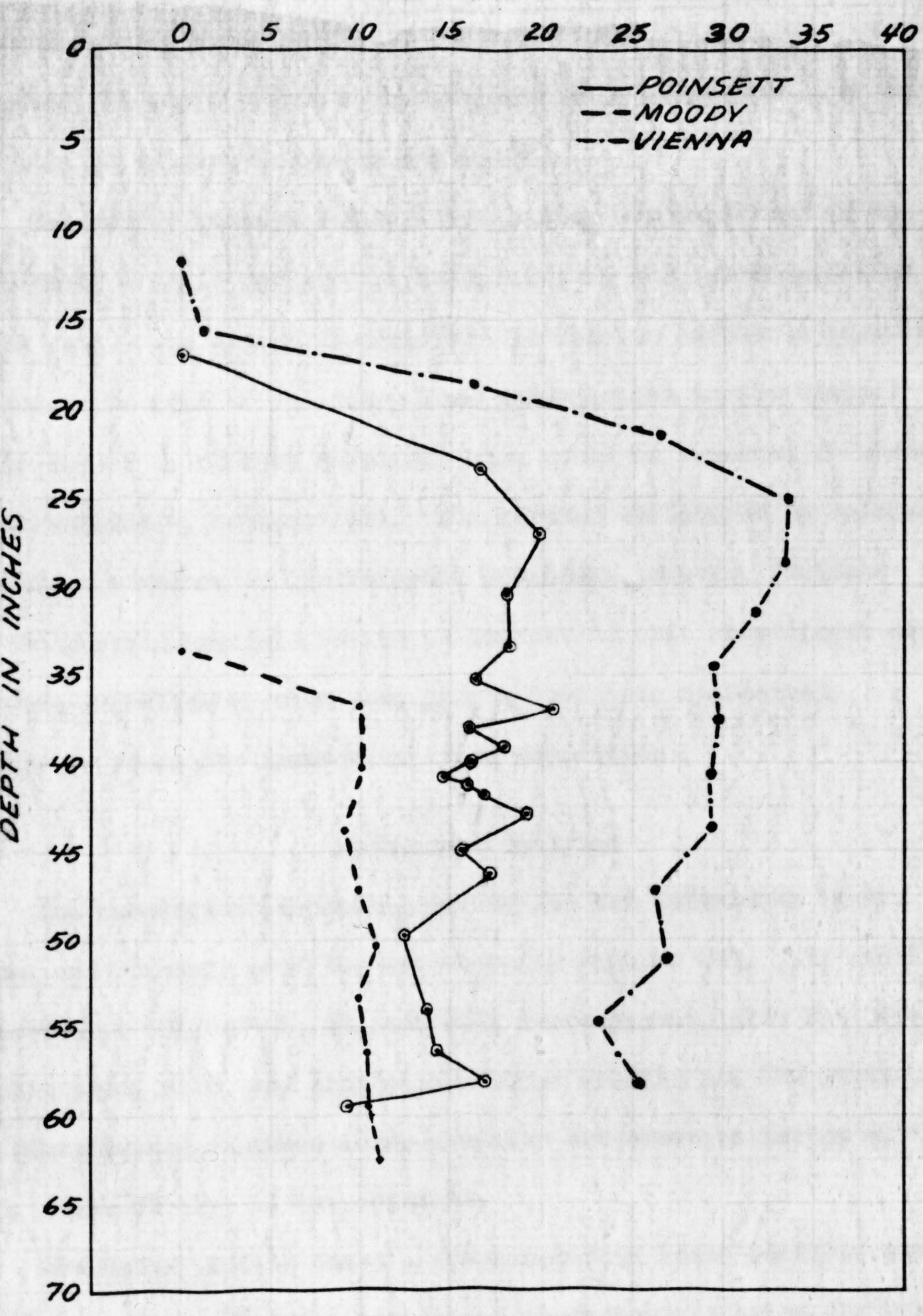

Figure VI. The percent calcium carbonate equivalent in the Moody, Vienna and Poinsett profiles between the lower subhorizons. There was some relationship between calcium carbonate equivalent and amount of segregated carbonates in the Vienna and Poinsett profiles, but since this relationship was not consistent, it seems probable that disseminated carbonates play the major role in calcium carbonate equivalent.

The nearly constant values for calcium carbonate equivalent in the Moody profile reflect the uniformity of the parent materials of this soil. The slight fluctuations in calcium carbonate equivalent below the area of secondary lime accumulation in the Vienna profile are of no greater magnitude than would be expected in heterogeneous materials, such as till. The greater variations in calcium carbonate equivalent in the Poinsett substrata,however, indicate that the parent materials varied in content of this constituent when they were deposited or that some strata have been selectively enriched by secondary carbonates since deposition.

Mechanical Analysis

The cumulative percentage curves for the individual Moody, Vienna, and Poinsett profiles are shown in Figures VII, VIII and IX, respectively. Figures X, XI, and XII, respectively, show the total per cent sand, silt, and clay of the three profile and the particle size distribution of these three profiles are shown in Tables 4, 5, and 6, respectively, of the appendix.

The Moody profile shows a characteristic loess particle size distribution with the major portion of the materials below the horizons of genetic development in the silt size fraction. The very small

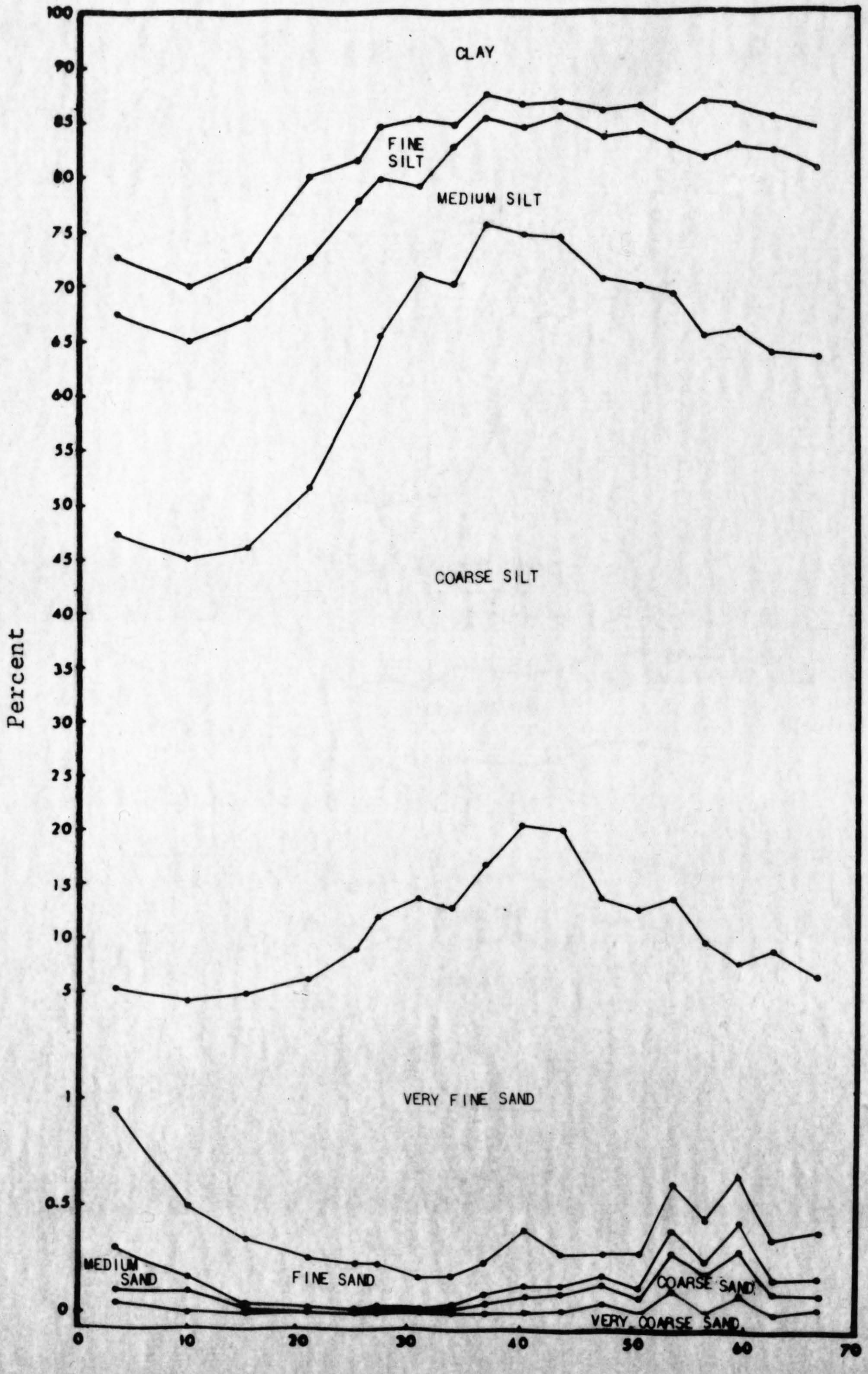

Figure VII. Cumulative percentage curves of particle sizes in the Moody Profile

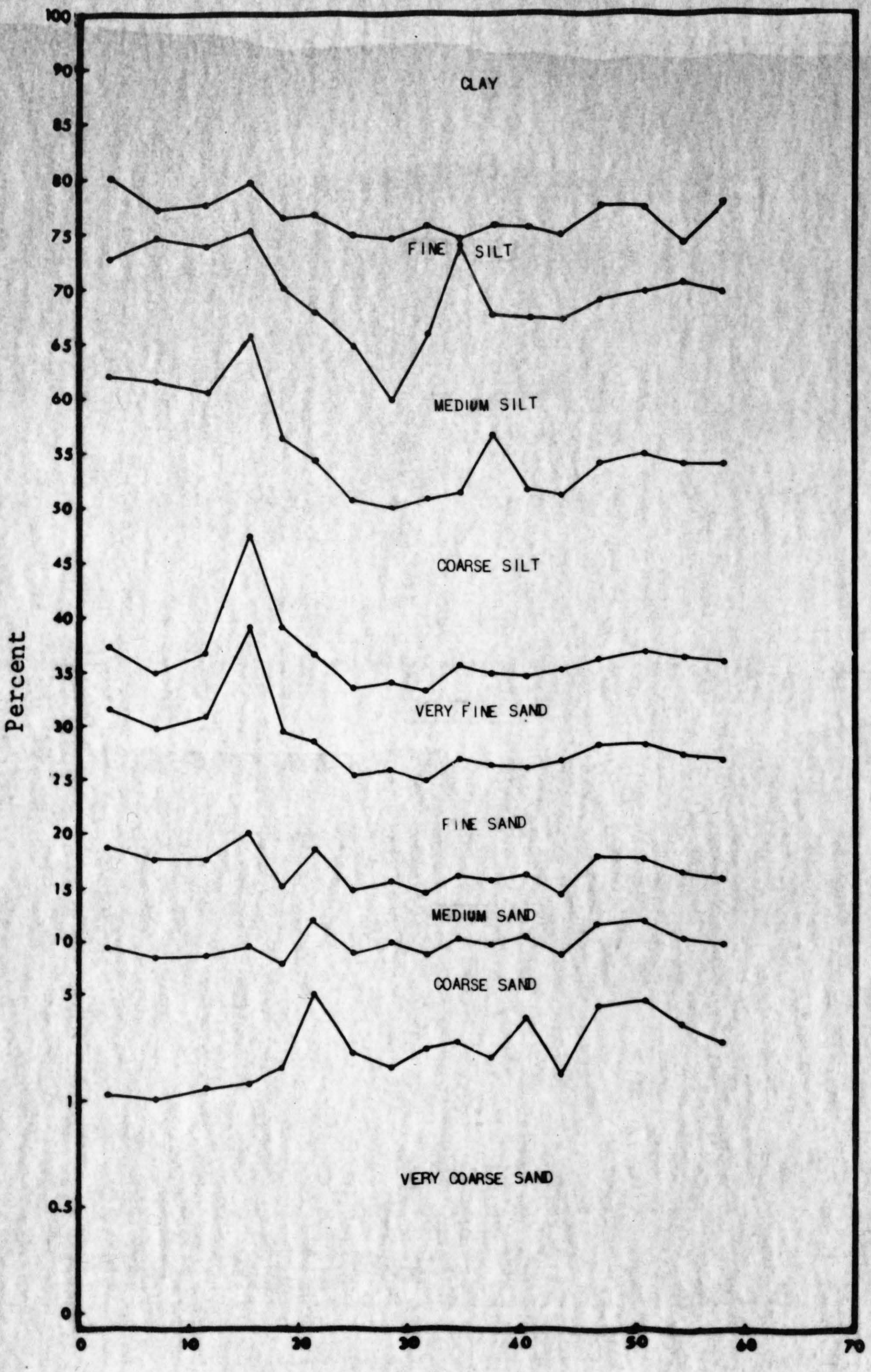

Figure VIII. Cumulative percentage curves of particle sizes in the Vienna profile

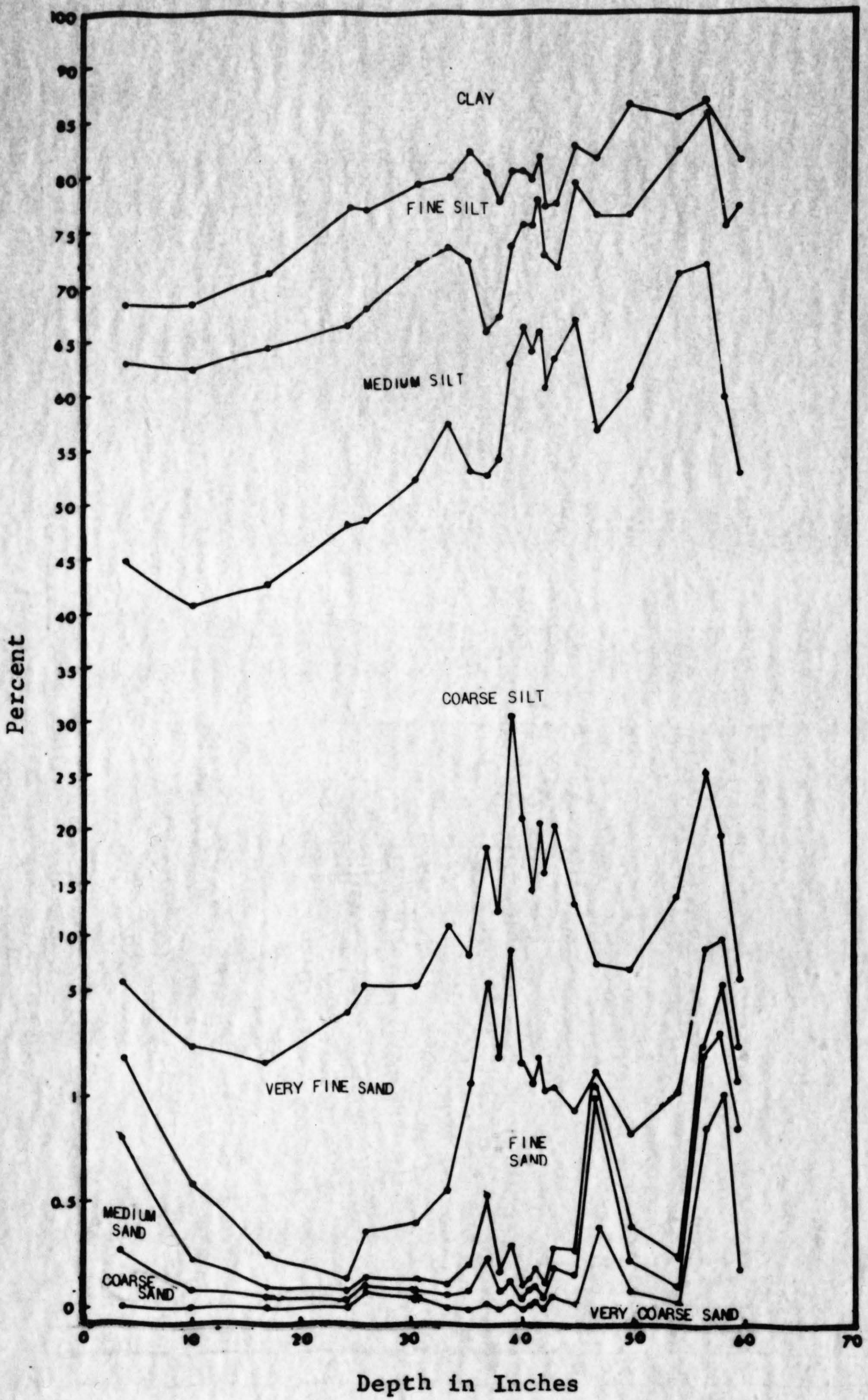

Figure IX. Cumulative percentage curves of particle sizes in the Poinsett profile

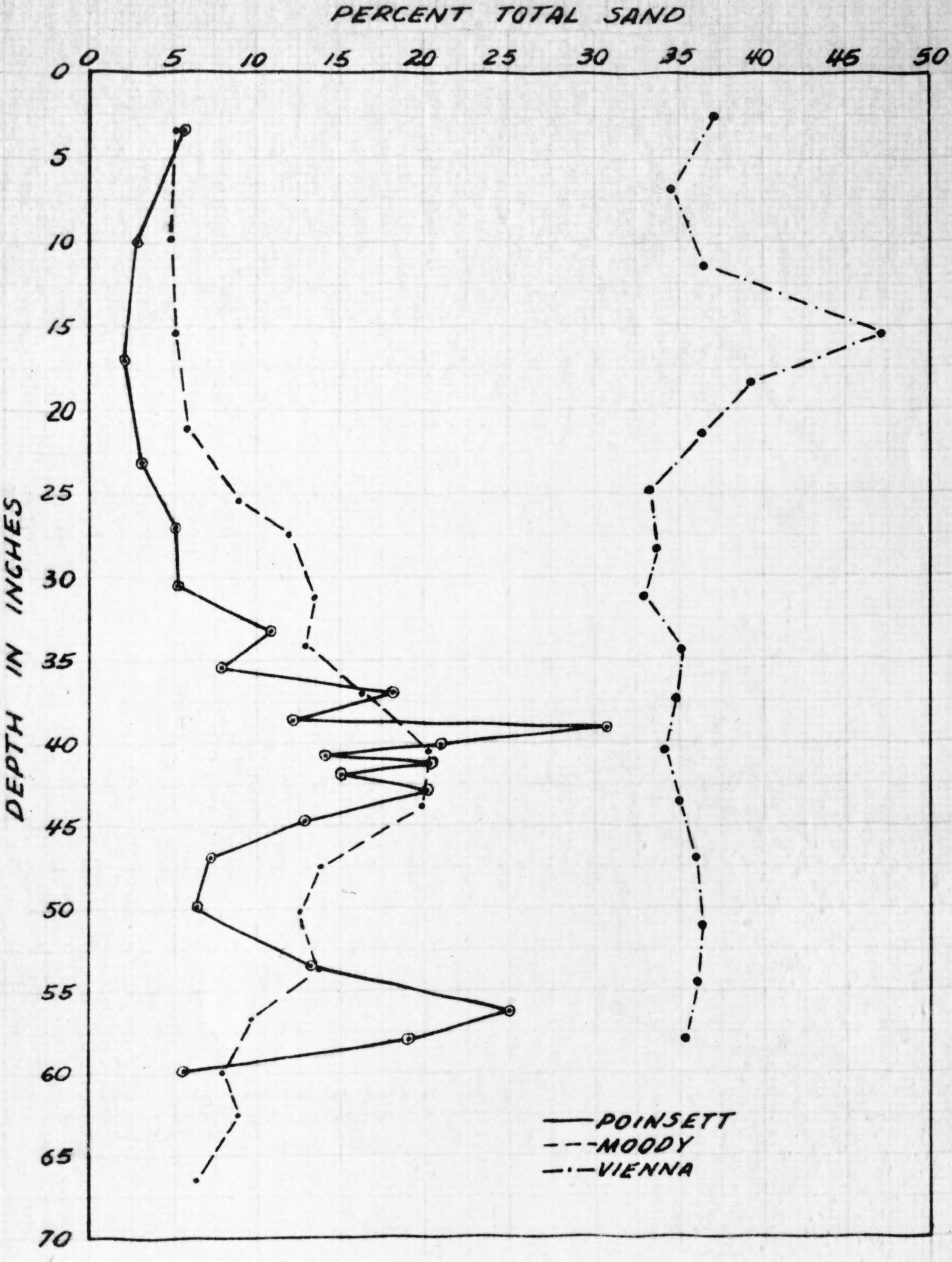

Figure X. The percent total sand in the Moody, Vienna and Poinsett profiles

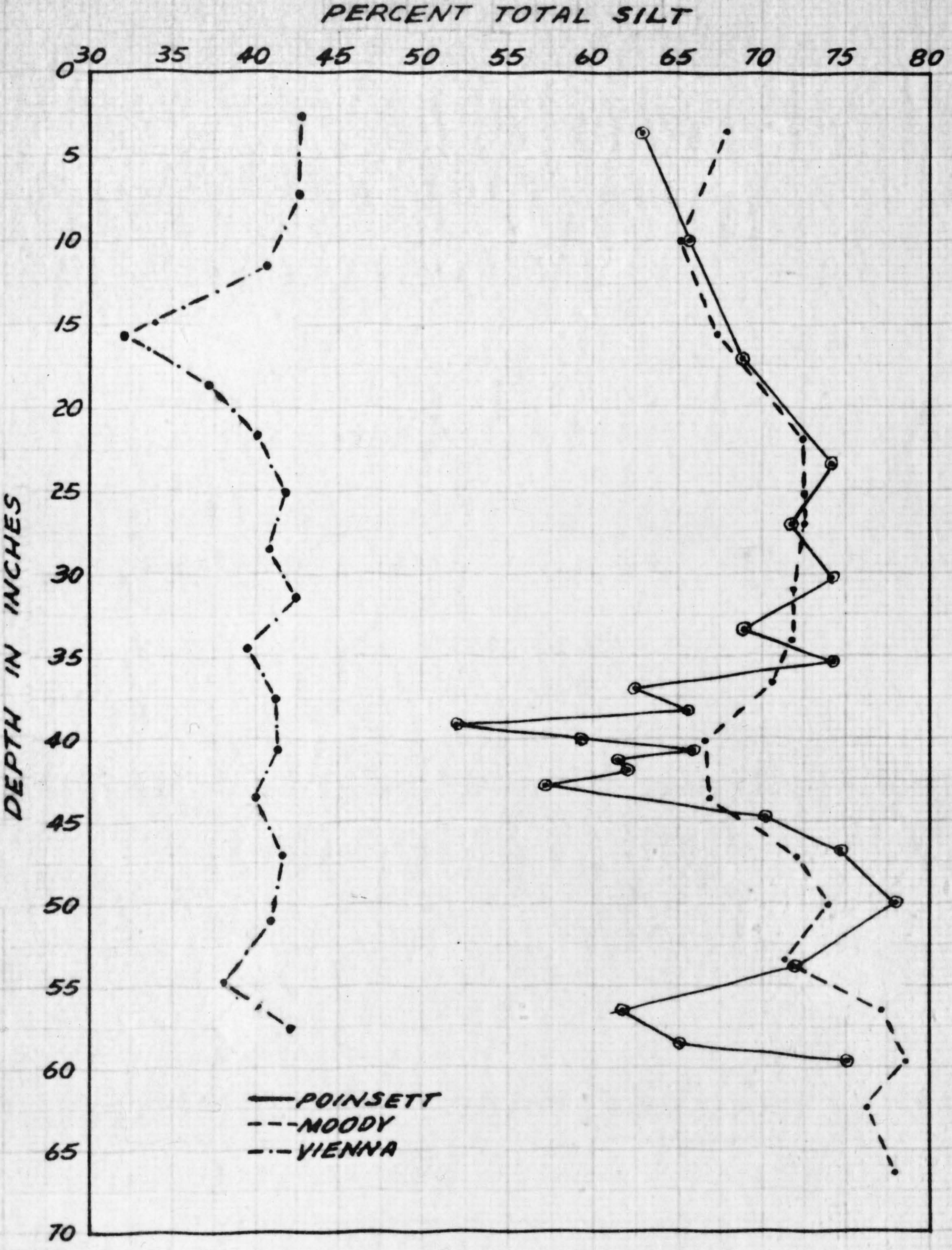

Figure XI. The percent total silt in the Moody, Vienna and Poinsett profiles

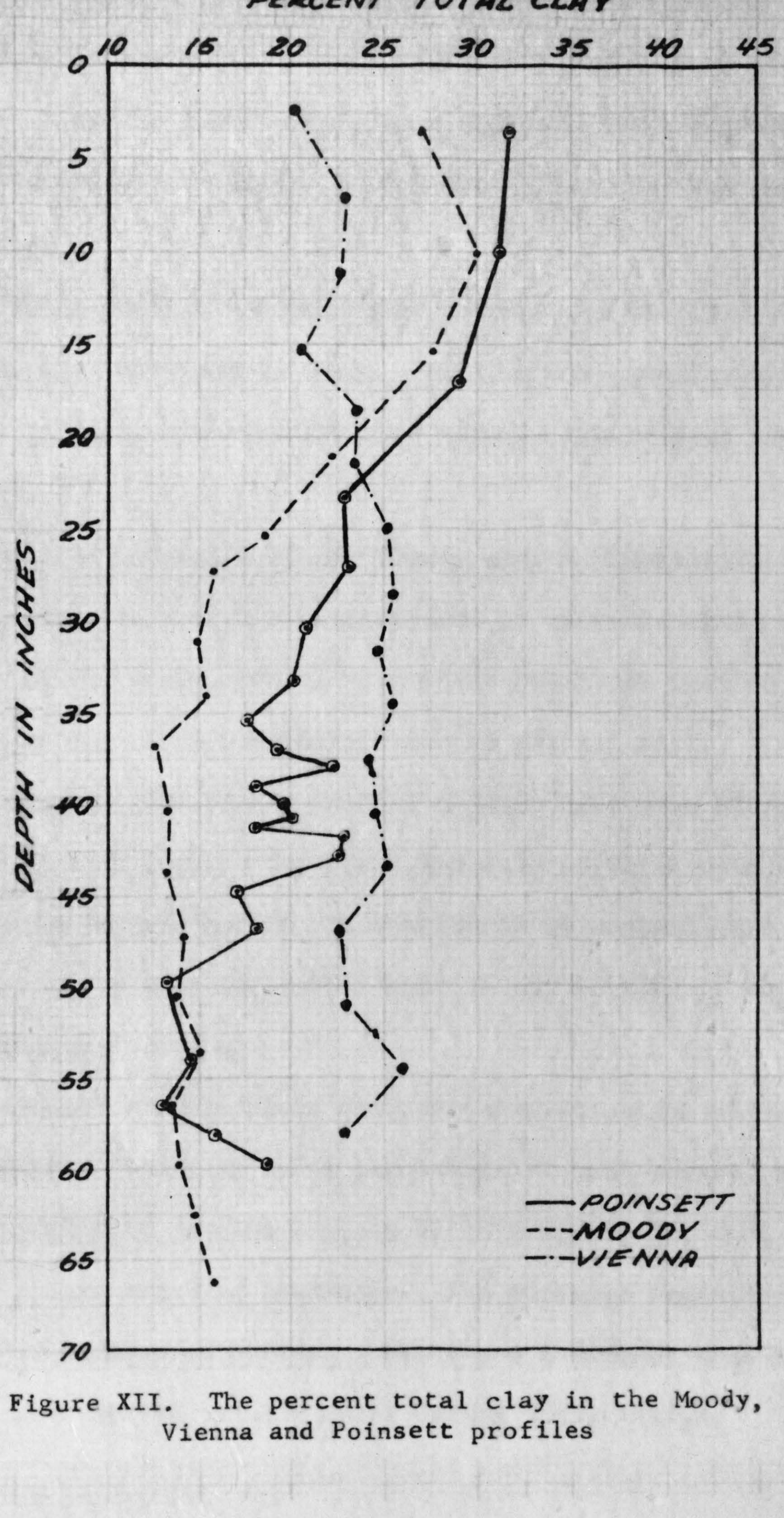

Figure XII. The percent total clay in the Moody, Vienna and Poinsett profiles percentage of materials coarser than 0.25 mm. appeared to be small carbonate concretions and it is doubtful that any sand grains coarser than 0.25 mm. were present. The minor fluctuations in very fine sand and medium silt in the lower subhorizons suggests that increments of loess have been added at different wind velocities when the materials were deposited.

The Vienna profile has much more material in the fraction coarser than 0.25 mm. than the Moody profile. It also has considerably more variation in particle size distribution between subhorizons than the Moody profile.

The coarser materials of the Vienna are representative of glacial till materials and the fluctuations in particle size, although greater than in the Moody, are of no greater magnitude than would be expected in heterogeneous materials, such as glacial till.

When sampling the Vienna profile a sandy krotovina was noted at the 14 to 17 inch depth. The sharp increase in total sand and decrease in silt in this horizon is attributed to contamination from this krotovina while sampling rather than to any sorting of the materials during deposition.

The Poinsett profile shows definite stratification in particle size distribution. The very small percentage of sand coarser than 0.25 mm. and high silt content support Flint's theory (6) that the Cary ice overrode a loess-mantled landscape. The definite variations in particle size distribution between subhorizons indicates that the material has been sorted by melt water during deglaciation.

SUMMARY AND CONCLUSIONS

A comparison of field observations and laboratory analyses of profiles of Moody, Vienna and Poinsett soils show that the parent materials of the Poinsett appear to be neither loess nor glacial till. The stratified substrata, admixture of gravel and stone, and included bodies of till indicate that the Poinsett parent materials were deposited primarily by melt waters of stagnated glacial ice. This is borne out by the abrupt textural changes in the Poinsett substrata which is characteristic of materials that have been sorted and deposited by water.

The greater variation in the percentages of iron, manganese, and calcium carbonate equivalent among subhorizons of the Poinsett profile than among subhorizons of the Moody and Vienna profiles may be due in part to movement and secondary enrichment by percolating ground waters, but a more plausible explanation is that the parent material varied in content of these constituents when it was deposited.

The Poinsett soils are leached to greater depth than the Vienna soils indicating that they are more permeable. They also appear to be more friable and easily tilled. The admixture of gravel and stone and the presence of stratification make them less desirable agriculturally than the Moody soils. These characteristics appear to set the Poinsett soil out as a unique and separate series.

LITERATURE CITED

1. Agnew, A. F. Geologic quadrangles of South Dakota, 1958-1961. South Dakota Geological Survey, Vermillion, South Dakota.

2. Black, C. A. Laboratory methods of soil investigation, soil fertility. Dept. of Agron., Iowa State College, Ames, Iowa. (no date)

3. Christianson, E. A. Glacial geology of the Moose Mountain Area, Saskatchewan: Saskatchewan Dept. Mineral Resources. Rept. 21, p. 35. 1956.

4. Daniels, R. B., Simonson, G. H., and Handy, R. L. Ferrous iron content and color of sediments. Soil Sci. 91:378-382. 1961.

5. Flint, R. F. Glacial and pleistocene geology. John Wiley and Sons, Inc., New York. pp. 146-159. 1957.

6. Flint, R. F. Pleistocene geology of eastern South Dakota. Geological Survey Professional Paper 262. Govt. Print. Off., Washington, D. C. 1955.

7. Gravenor, C. P. and Kupsch, W. O. Ice disintegration features in western Canada. J. Geol. 67:48-64. 1959.

8. Griffiths, D. A study of the forage plants of South Dakota with their fungus and insect enemies. M. S. Thesis, Agriculture College of South Dakota, Brookings, South Dakota. 1893.

9. Ignatieff, V. Determination and behavior of ferrous iron in soils. Soil Sci. 51:249-263. 1941.

10. Jackson, M. L. Soil chemical analysis. Par. 4-77, p. 79. Prentice Hall, Inc., Englewood Cliffs, New Jersey. 1958.

11. Jackson, M. L. Soil chemical analysis--Advanced course. p. 115. Pub. by the author, Dept. of Soils, Univ. of Wis., Madison 6, Wisconsin. 1956.

12. Jeffries, C. D., and Johnson, L. Determination of the easily reduced iron oxides in soils. Soil Sci. 92:402-403. 1961.

13. Kilmer, V. J., and Alexander, L. T. Methods of making mechanical analysis of soils. Soil Sci. 68:15-24. 1949.

14. Klingelhoets, A. J., Moxon, V. W., Lee, G. B. and Buntley, G. J. Soils of Jerauld County, South Dakota. Bul. 411, S. Dak. Agr. Exp. Sta. in cooperation with S.C.S. and B.P.I., Soils and Ag. Eng., USDA, Agr. Exp. Sta., Brookings, South Dakota. 1952.

15. Leeper, B. W. The forms and reactions of manganese in the soil. Soil Sci. 63:333-345. 1940.

16. Lyon, T. L., Buchman, H. O., and Brady, N. D. The nature and properties of soils. 5th ed. The Macmillan Co., New York. 1952.

17. Nikiforoff, C. C. Soils of the Phonero Podzolic group in western Oregon. Soil Sci. 44:447-465. 1937.

18. Robinson, W. O. Detection and significance of manganese dioxide in the soil. Soil Sci. 27:335-350. 1929.

19. Schou, Axel. Atlas of Denmark (Text and Photographs): Copenhagen, Hagerup. 1949.

20. Tamura, T., Ritchie, Jr., A., Swanson, C. L. W., and Hanna, R. M. Characteristics of eolian influenced soils in Connecticut: II. Soil Sci. Soc. Amer. Proc. 21:536-539. 1957.

21. Thornthwaite, C. W. An approach toward a rational classification of climate. Geog. Review. 38:44-94. 1948.

22. U.S.D.A., Yearbook of Agriculture (Climate and Man). Govt. Print. Off., Washington, D. C. 1941.

23. U.S.D.A., Yearbook of Agriculture (Soils and Men). Govt. Print. Off., Washington, D. C. 1938.

24. U.S.D.A., Agricultural Handbook No. 60 (Saline and Alkali Soils). Govt. Print. Off., Washington, D. C. 1954.

25. Visher, S. S. Climatic atlas of the United States. Harvard University Press, Cambridge. 1954.

26. Waggoner, P. E., and Bingham, C. Depth of loess and distance from source. Soil Sci. 92:396-401. 1961.

27. Watkins, W. I., Marco, M. B., Leighty, R. G., Arneman, H. F., Olson, O. C., Wold, R. L., Marsh, A. W., and Fieger, E. A. Soil survey of Rock County, Minnesota, Series 1938, No. 21. U.S.D.A. in cooperation with Univ. of Minn. Ag. Exp. Sta., Govt. Print. Off., Washington, D. C. 1949.

28. Weaver, J. F. North American prairie. Johnson Publishing Co., Lincoln. 1954.

29. Weaver, J. F., and Albertson, F. W. Grasslands of the Great Plains. Johnson Publishing Co., Lincoln. 1956.

30. Westin, F. C., Buntley, G. J., Shubeck, F. E., Puhr, L. F., and Bergstreser, N. E. Soil survey of Brookings County, South Dakota. U.S.D.A. in cooperation with S. Dak. Ag. Exp. Sta. Series 1955, No. 3, also issued as S. Dak. Exp. Sta. Bul. No. 468. 1958.

31. Wilding, L. P., and Westin, F. C. Characterization of the Sinai soils. Soil Sci. Soc. Am. Proc. 25:380-384. 1961.

32. Winters, E. Ferromanganiferous concretions from some Podzolic soils. Soil Sci. 46:33-40. 1938.

33. Winters, E. The migration of iron and manganese in colloidal systems. Bulletin 472, Univ. of Ill., Ag. Exp. Sta. 1940.

APPENDIX

Table 1. Free Iron of the Poinsett, Vienna, and Moody Profiles

Poinsett				Vienna				Moody			
Bulk horizons	Sub horizons	Depth inches	Free Fe %	Bulk horizons	Sub horizons	Depth inches	Free Fe %	Bulk horizons	Sub horizons	Depth inches	Free Fe %
A1p		0-7	1.4	A1p		0-5	0.9	ABp		0-7	1.2
B21		7-13	1.4	B1		5-9	0.9	B21		7-13	1.3
B22		13-21	1.3	B21		9-14	1.2	B22		13-18	1.2
B2ca		21-25½	1.0	B22		14-17	1.2	B23		18-24	1.2
B31ca		25½-32½	1.2	B2ca		17-20	1.3	B24		24-29	1.1
	(1)	25½-28½	1.2	B31ca		20-27	0.9		(1)	24-26½	1.1
	(2)	28½-32½	1.0		(1)	20-23	0.9		(2)	26½-29	1.0
B32ca		32½-39½	1.3		(2)	23-27	0.9	B25		29-35	1.0
	(1)	32½-34	1.1	B32ca		27-33	0.9		(1)	29-33	1.0
	(2)	34-36½	1.1		(1)	27-30	0.8		(2)	33-35	1.0
	(3)	36½-37½	1.2		(2)	30-33	0.9	B31ca		35-42	0.9
	(4)	37½-38½	1.4	C11ca		33-45	0.8		(1)	35-38½	0.9
	(5)	38½-39½	1.3		(1)	33-36	1.0		(2)	38½-42	0.9
B33ca		39½-47½	1.0		(2)	36-39	0.8	B32ca		42-49	0.9
	(1)	39½-40½	0.9		(3)	39-42	1.0		(1)	42-45½	0.9
	(2)	40½-41	0.8		(4)	42-45	0.9		(2)	45½-49	0.9
	(3)	41-41½	1.1	C12ca		45-53	0.9	C11ca		49-61	0.9
	(4)	41½-42	1.0		(1)	45-49	0.9		(1)	49-52	0.9
	(5)	42-43½	0.9		(2)	49-53	0.9		(2)	52-55	0.9
	(6)	43½-46	1.0	C13ca		53-60	1.0		(3)	55-58	1.0
	(7)	46-47½	1.4		(1)	53-60	1.0		(4)	58-61	1.0
C11ca		47½-56	1.3		(2)	56-60	0.8	C12ca		61-69	1.0
	(1)	47½-52	1.2						(1)	61-64	1.0
	(2)	52-56	1.0						(2)	64-69	1.0
C12ca		56-60	0.8								
	(1)	56-57	0.8								
	(2)	57-59	1.0								
	(3)	59-60	1.5								

Table 2. Free Manganese of the Poinsett, Vienna, and Moody Profiles

Poinsett				Vienna				Moody			
Bulk horizons	Sub horizons	Depth inches	Free Mn %	Bulk horizons	Sub horizons	Depth inches	Free Mn %	Bulk horizons	Sub horizons	Depth inches	Free Mn %
A1p		0-7	.093	A1p		0-5	.065	ABp		0-7	.079
B21		7-13	.088	B1		5-9	.059	B21		7-13	.088
B22		13-21	.073	B21		9-14	.067	B22		13-18	.095
B2ca		21-25½	.062	B22		14-17	.065	B23		18-24	.087
B31ca		25½-32½	.048	B2ca		17-20	.070	B24		24-29	.083
	(1)	25½-28½	.055	B31ca		20-27	.060		(1)	24-26½	.082
	(2)	28½-32½	.042		(1)	20-23	.045		(2)	26½-29	.082
B32ca		32½-39½	.093		(2)	23-27	.039	B25		29-35	.083
	(1)	32½-34	.070	B32ca		27-33	.045		(1)	29-33	.085
	(2)	34-36½	.070		(1)	27-30	.062		(2)	33-35	.083
	(3)	36½-37½	.116		(2)	30-33	.047	B31ca		35-42	.074
	(4)	37½-38½	.090	C11ca		33-45	.055		(1)	35-38½	.072
	(5)	38½-39½	.135		(1)	33-36	.054		(2)	38½-42	.072
B33ca		39½-47½	.108		(2)	36-39	.040	B32ca		42-49	.069
	(1)	39½-40½	.103		(3)	39-42	.062		(1)	42-45½	.070
	(2)	40½-41	.095		(4)	42-45	.062		(2)	45½-49	.074
	(3)	41-41½	.130	C12ca		45-53	.077	C11ca		49-61	.064
	(4)	41½-42	.106		(1)	45-49	.064		(1)	49-52	.077
	(5)	42-43½	.128		(2)	49-53	.064		(2)	52-55	.069
	(6)	43½-46	.087	C13ca		53-60	.045		(3)	55-58	.069
	(7)	46-47½	.100		(1)	53-56	.059		(4)	58-61	.070
C11ca		47½-56	.103		(2)	56-60	.044	C12ca		61-69	.067
	(1)	47½-52	.103						(1)	61-64	.067
	(2)	52-56	.097						(2)	64-69	.061
C12ca		56-60	.102								
	(1)	56-57	.073								
	(2)	57-59	.120								
	(3)	59-60	.146								

Table 3. Calcium Carbonate Equivalent of the Poinsett, Vienna, and Moody Profiles

Poinsett				Vienna				Moody			
Bulk horizons	Sub horizons	Depth inches	$CaCO_3$ Equiv. %	Bulk horizons	Sub horizons	Depth inches	$CaCO_3$ Equiv. %	Bulk horizons	Sub horizons	Depth inches	$CaCO_3$ Equiv. %
A1p		0-7	0.0	A1p		0-5	0.0	ABp		0-7	0.0
B21		7-13	0.0	B1		5-9	0.0	B21		7-13	0.0
B22		13-21	0.0	B21		9-14	0.0	B22		13-18	0.0
B2ca		21-25½	16.5	B22		14-17	1.0	B23		18-24	0.0
B31ca		25½-32½	17.3	B2ca		17-20	16.3	B24		24-29	0.0
	(1)	25½-28½	19.8	B31ca		20-27	31.1		(1)	24-26½	0.0
	(2)	28½-32½	18.0		(1)	20-23	26.4		(2)	26½-29	0.0
B32ca		32½-39½	18.6		(2)	23-27	33.6	B25		29-35	0.0
	(1)	32½-34	18.1	B32ca		27-33	33.4		(1)	29-33	0.0
	(2)	34-36½	16.4		(1)	27-30	33.4		(2)	33-35	0.0
	(3)	36½-37½	20.5		(2)	30-33	31.9	B31ca		35-42	9.0
	(4)	37½-38½	16.1	C11ca		33-45	29.5		(1)	35-38½	9.8
	(5)	38½-39½	17.8		(1)	33-36	29.4		(2)	38½-42	9.8
B33ca		39½-47½	16.6		(2)	36-39	29.7	B32ca		42-49	9.8
	(1)	39½-40½	16.1		(3)	39-42	29.3		(1)	42-45½	9.1
	(2)	40½-41	14.7		(4)	42-45	29.3		(2)	45½-49	9.8
	(3)	41-41½	15.8	C12ca		45-53	27.2	C11ca		49-61	10.4
	(4)	41½-42	16.6		(1)	45-49	26.1		(1)	49-52	10.7
	(5)	42-43½	19.0		(2)	49-53	26.9		(2)	52-55	9.8
	(6)	43½-46	15.6	C13ca		53-60	25.1		(3)	55-58	10.4
	(7)	46-47½	17.2		(1)	53-56	24.2		(4)	58-61	10.4
C11ca		47½-56	13.4		(2)	56-60	25.4	C12ca		61-69	10.3
	(1)	47½-52	12.5						(1)	61-64	11.0
	(2)	52-56	13.8						(2)	64-69	9.0
C12ca		56-60	14.7								
	(1)	56-57	14.3								
	(2)	57-59	15.8								
	(3)	59-60	9.3								

Table 4. Particle Size Distribution of the Moody Profile

Bulk horizons	Sub horizons	Depth in inches	Very Coarse Sand 2-1	Coarse Sand 1-0.5	Medium Sand 0.5-0.25	Fine Sand 0.25-0.10	Very Fine Sand 0.10-0.05	Coarse Silt .05-.02	Medium Silt .02-.005	Fine Silt .005-.002	Clay .002
			Particle Size Distribution (in mm.) (percent)								
ABp		0-7	0.04	0.07	0.20	0.64	4.22	42.23	20.34	5.22	27.04
B21		7-13	0.00	0.10	0.06	0.34	4.12	40.42	20.03	4.94	29.99
B22		13-18	0.00	0.02	0.02	0.31	4.54	41.33	21.03	5.19	27.56
B23		18-24	0.00	0.01	0.01	0.24	5.32	46.12	20.83	5.40	22.07
B24		24-29	0.00	0.02	0.02	0.21	7.78	50.01	19.22	3.03	19.71
	(1)	24-26½	0.00	0.00	0.02	0.22	8.53	51.37	17.56	3.66	18.64
	(2)	26½-29	0.00	0.01	0.02	0.20	11.52	53.52	14.45	4.54	15.74
B25		29-35	0.00	0.01	0.02	0.17	10.83	55.20	12.67	4.33	16.77
	(1)	29-33	0.00	0.01	0.01	0.14	13.26	57.56	8.11	6.01	14.90
	(2)	33-35	0.00	0.02	0.02	0.13	12.66	57.33	12.47	1.96	15.41
B31ca		35-42	0.00	0.18	0.00	0.21	13.39	56.76	12.77	2.15	14.54
	(1)	35-38½	0.00	0.05	0.04	0.14	16.36	58.66	9.89	2.12	12.74
	(2)	38½-42	0.00	0.08	0.05	0.25	19.82	54.50	9.75	2.13	13.42
B32ca		42-49	0.04	0.04	0.03	0.16	14.71	56.38	12.49	3.33	12.82
	(1)	42-45½	0.01	0.08	0.04	0.15	19.60	54.53	11.07	1.18	13.34
	(2)	45½-49	0.05	0.09	0.03	0.11	13.27	57.03	12.83	2.37	14.22
C11ca		49-61	0.11	0.04	0.04	0.17	10.54	57.14	15.24	2.35	14.37
	(1)	49-52	0.01	0.06	0.05	0.16	12.28	57.31	14.06	2.39	13.68
	(2)	52-55	0.11	0.18	0.10	0.23	13.08	55.51	13.34	2.40	15.05
	(3)	55-58	0.02	0.16	0.07	0.19	9.17	55.53	16.40	5.13	13.33
	(4)	58-61	0.09	0.21	0.13	0.22	7.07	58.22	16.91	3.34	13.81
C12ca		61-69	0.14	0.24	0.08	0.18	9.12	54.36	17.82	3.52	14.54
	(1)	61-64	0.01	0.09	0.06	0.10	8.55	54.75	18.57	2.69	14.81
	(2)	64-69	0.03	0.06	0.08	0.21	5.91	57.00	17.29	3.67	15.75

Table 5. Particle Size Distribution of the Vienna Profile

			Particle Size Distribution (in mm.) (percent)								
Bulk hori-zons	Sub hori-zons	Depth in inches	Very Coarse Sand 2-1	Coarse Sand 1-0.5	Medium Sand 0.5-0.25	Fine Sand 0.25-0.10	Very Fine Sand 0.10-0.05	Coarse Silt .05-.02	Medium Silt .02-.005	Fine Silt .005-.002	Clay .002
A1p		0-5	1.22	7.88	9.22	12.84	5.86	24.85	10.86	7.24	20.21
B1		5-9	1.04	7.35	8.90	12.23	5.09	26.82	13.21	2.57	22.79
B21		9-14	1.41	6.99	8.87	13.37	5.81	24.12	13.17	3.54	22.72
B22		14-17	1.46	7.75	10.56	19.01	8.44	18.13	9.60	4.43	20.62
B2ca		17-20	2.10	5.64	7.04	14.32	9.92	17.14	13.65	6.51	23.68
B31ca		20-27	2.19	6.18	5.85	10.34	8.02	18.90	13.05	11.96	23.51
	(1)	20-23	4.92	6.65	6.41	10.22	8.11	17.67	13.59	8.91	23.52
	(2)	23-27	2.67	5.90	5.69	10.85	8.00	17.36	14.22	10.23	25.08
B32ca		27-33	3.25	6.42	5.60	9.94	8.12	17.99	13.55	11.12	24.01
	(1)	27-30	3.30	6.40	5.53	10.37	8.14	16.08	9.75	15.03	25.40
	(2)	30-33	2.75	5.77	5.59	10.47	8.36	17.61	15.04	9.77	24.64
C11ca		33-45	4.62	6.32	5.80	10.49	7.87	17.70	14.86	9.02	23.32
	(1)	33-36	3.17	6.62	5.95	10.70	8.63	15.98	22.70	0.86	25.39
	(2)	36-39	2.60	6.98	5.78	10.70	8.52	21.19	11.19	8.14	24.18
	(3)	39-42	3.96	6.13	5.76	9.91	8.40	17.28	15.76	8.29	24.51
	(4)	42-45	2.07	6.43	6.42	11.39	8.59	16.09	10.01	7.90	25.10
C12ca		45-53	3.68	6.58	6.14	11.01	8.76	18.94	14.43	7.63	22.83
	(1)	45-49	4.58	7.10	5.95	10.35	7.91	18.07	14.92	8.66	22.46
	(2)	49-53	4.70	6.74	5.90	10.57	8.35	18.41	14.97	7.61	22.75
C13ca		53-60	4.06	6.16	6.08	10.87	8.56	17.44	15.59	8.63	22.61
	(1)	53-56	3.80	6.33	5.99	11.02	8.87	17.97	16.38	3.89	25.75
	(2)	56-60	3.20	6.44	5.94	10.97	8.74	18.51	15.69	7.93	22.58

Table 6. Particle Size Distribution of the Poinsett Profile

			Particle Size Distribution (in mm.) (percent)								
Bulk hori- zons	Bub hori- zons	Depth in inches	Very Coarse Sand 2-1	Coarse Sand 1-0.5	Medium Sand 0.5-0.25	Fine Sand 0.25-0.10	Very Fine Sand 0.10-0.05	Coarse Silt .05-.02	Medium Silt .02-.005	Fine Silt .005-.002	Clay .002
A1p		0-7	0.00	0.26	0.54	1.50	3.22	39.17	19.19	4.49	31.63
B21		7-13	0.00	0.08	0.15	0.35	2.32	37.94	21.55	6.15	31.46
B22		13-21	0.00	0.05	0.06	0.14	2.04	40.40	21.82	6.58	28.91
B2ca		21-25½	0.00	0.04	0.04	0.11	2.96	44.84	18.34	10.92	22.75
B31ca		25½-32½	0.00	0.02	0.06	0.20	4.79	45.90	18.69	8.58	21.76
	(1)	25½-28½	0.08	0.03	0.04	0.22	4.80	43.57	19.24	8.99	23.03
	(2)	28½-32½	0.05	0.02	0.07	0.26	4.81	46.88	19.86	7.38	20.67
B32ca		32½-39½	0.00	0.05	0.12	2.88	10.91	41.36	15.67	6.50	22.51
	(1)	32½-34	0.00	0.06	0.06	0.43	10.29	46.62	16.12	6.23	20.19
	(2)	34-36½	0.00	0.09	0.13	1.21	6.65	44.88	19.35	10.08	17.61
	(3)	36½-37½	0.03	0.22	0.28	4.99	12.65	34.62	13.26	14.61	19.34
	(4)	37½-38½	0.00	0.08	0.10	2.18	9.87	41.78	13.29	10.47	22.23
	(5)	38½-39½	0.04	0.10	0.17	8.19	22.23	32.15	10.69	9.13	17.30
B33ca		39½-47½	0.09	0.23	0.25	1.18	14.43	48.61	11.75	4.74	18.72
	(1)	39½-40½	0.00	0.05	0.07	2.07	18.84	45.26	9.50	4.59	19.62
	(2)	40½-41	0.02	0.07	0.06	1.23	12.72	49.67	12.06	4.03	20.14
	(3)	41-41½	0.03	0.08	0.09	2.18	18.06	45.36	12.05	3.98	18.17
	(4)	41½-42	0.00	0.05	0.07	0.97	14.20	45.43	11.84	4.68	22.76
	(5)	42-43½	0.06	0.14	0.09	1.02	18.84	42.96	8.47	5.78	22.64
	(6)	43½-46	0.03	0.14	0.11	0.65	11.87	53.96	12.65	3.47	17.12
	(7)	46-47½	0.38	0.62	0.32	0.64	5.30	49.75	19.59	5.31	18.09
C11ca		47½-56	0.04	0.16	0.15	0.68	10.42	48.01	18.00	6.19	16.35
	(1)	47½-52	0.09	0.14	0.16	0.43	5.78	53.75	16.37	9.84	13.44
	(2)	52-56	0.04	0.08	0.13	1.00	12.13	57.68	11.61	2.73	14.60
C12ca		56-60	0.69	1.47	1.08	1.86	5.84	44.84	17.94	6.46	19.82
	(1)	56-57	0.87	1.77	0.15	6.14	16.31	46.79	13.88	0.95	13.14
	(2)	57-59	1.06	2.30	2.10	4.27	9.33	40.79	15.89	8.52	15.74
	(3)	59-60	0.20	0.64	0.65	1.25	3.09	47.00	24.60	4.04	18.53