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The Classification, Morphology, and Genesis of Sinai Soils

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THE CLASSIFICATION, MORPHOLOGY AND GENESIS OF SINAI SOILS

BY

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This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and 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.

Thesis Adviser

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INTRODUCTION

Until 1945 the Barnes series and its catenal associates were the dominant glacial soils mapped in eastern North Dakota, South Dakota and western Minnesota. Soil characteristics of this inclusive series varied considerably. With the increased knowledge of these soils and subsequent refinement of the concept of soil series, the Sinai series in addition to numerous other series have been separated from the Barnes.

The Sinai series comprises well-drained Chernozem soils developed in calcareous, laminated, finely stratified, glacio-lacustrine material having composite silty clay loam and silty clay textures. These soils have developed under tall and mid-grass associations in the cool temperate, subhumid Northern Great Plains. Their present geographic distribution is in northeastern and east central South Dakota on the Cary substage (10) of the Wisconsin drift sheet; west of the Big Sioux River.

This series was established in Day County, South Dakota in 1952. It was named after a small town in the southwestern corner of Brookings County, South Dakota. Sinai soils occupy the nearly level to gently sloping tops of mesa-like hills surrounded and interlaced with a more or less continuous moat-like pattern of colluvial-alluvial drains and swales. They also occur on the gently sloping crests and part way down the sides of undulations in an undulating to strongly undulating landscape.

This series has been mapped in South Dakota on the Cary drift sheet in Brookings (52), Day (17), and Minnehaha Counties. Climatic factors of eastern South Dakota vary somewhat in traversing from north to south along the north-south axis of the Prairie Coteau. Average annual precipitation and temperature are lower in the northern section of the Coteau than in the southern area. The mean monthly precipitation and temperature follow this same general trend. Moreover there is a marked difference between these two areas in the number of weeks per year when the average weekly air temperature is above 32° F. This provides a longer frost free period in the southern portion of this area than in the northern section.

As a consequence of these climatic differences, one would expect the occurrence of parallel differences in the type of native vegetation along this transect. It is extremely difficult to compare native vegetation of the Sinai soils, since few areas of these productive soils are in a virgin condition. In fact, it is nearly impossible to find suitable sample sites which are not currently under cultivation. Important sources of information regarding native grassland communities of this area are accounts of early writers, such as bio-geographers and plant ecologists.

The question may be raised as to whether differences in soil environment along this transect are of sufficient magnitude to reflect differences in the Sinai profiles. It is the purpose of this study to compare the morphologic, chemical, and physical properties of five Sinai profiles--two from Day County and one from each of the following counties: Brookings, Kingsbury, and Minnehaha; to compare climatic conditions of these areas; to compare Sinai soil associates of these areas; and to make a recommendation as to the classification of these soils.

REVIEW OF LITERATURE

The Sinai series was proposed during the detailed soil survey of Brookings County, South Dakota (52) when the need arose for a name of a soil series derived from calcareous, laminated, glacio-lacustrine materials on the portion of the Cary drift sheet coincident with the Prairie Coteau. It was established in 1952 by the final correlation of the Day County soil survey (17). This soil series was originally included in the Barnes series, hence its evolution will be traced from this early, inclusive series.

The series concept was first used in 1903 (32) to cover geographically related soil types. The principal criteria for series separations was kind of parent material; color, number and thickness of horizons; and composite texture of the profile. In the early 1920's, Marbut (18) (19) proposed to change the emphasis from geographical relations to features within the soil profile. In 1927 (20) he stated that soil type should be determined by the following eight soil characteristics: the texture, structure, color, thickness, number, arrangement, and chemical composition of horizons; and the parent material.

The Barnes series (1) was established in Lamoure County, North Dakota in 1914 with the type location set in Grant County, South Dakota. As mapped in early surveys this series was a very general and inclusive unit, consequently it was mapped over a much broader area than it now covers. The original concept of this series included most zonal, azonal, and intrazonal soils developed in calcareous glacial drift and outwash sediments. Many of the currently recognized soil series in eastern

South Dakota, North Dakota, and western Minnesota were separated from the Barnes series. The map shown in Figure 1 illustrates the extent of the Barnes soils in 1938 in the United States.

The Barnes silt loam profile in the 1922 soil survey of Grant County, South Dakota (49), was described as having a very dark grayish-brown to black, fine granular, silt loam surface horizon 5 to 10 inches thick immediately overlying 20 to 25 inches of brown, granular, heavy silt loam or silty clay loam subsoil material. This was underlain by yellow or grayish-yellow, friable, silty clay loam material that contained a high per cent of lime carbonate in disseminated and concretionary forms. Parent material of this soil was friable yellowish-gray glacial drift. In this survey the characteristics of the Barnes series ranged widely. Textures varied from clays to very fine sandy loams. These soils occurred on topography that ranged from nearly level to steeply rolling positions. In some areas the profile of this soil was essentially stone-free while in others numerous boulders and stones occurred throughout the profile.

With such a wide range in characteristics, edaphologic use in either experimental or extension areas of this soil series was extremely limited. Predictions such as the adaptability to various crops, grasses, and trees; behavior and productivity under different management systems; and yields of adapted crops under definite sets of management practices were precluded until it was more sharply defined.

The profile characteristics defined by the Vienna series (27), established in Rock County, Minnesota, in 1945, caused the Barnes series to be restricted to the Cary and Mankato drift sheets. The Vienna series

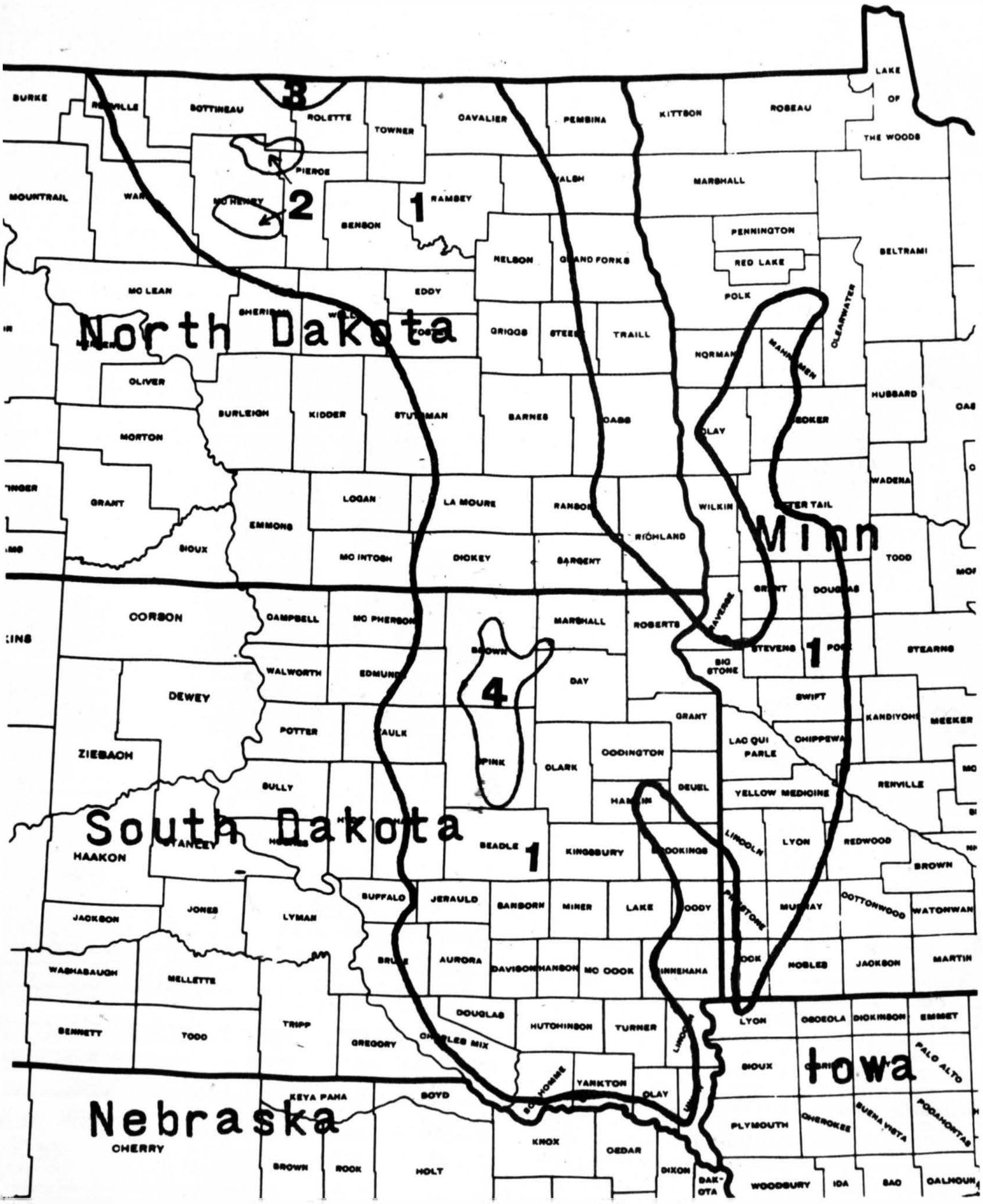


Figure 1. The Barnes Area in 1938

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

Source: Yearbook of Agriculture, Soils and Men (39) differed from the Barnes in having a finer-textured, thicker solum and little or no salt in the profile.

The Sinai soils were originally included within the Barnes, Corson, and Kranzburg series on the Cary drift sheet. Many areas that were mapped Barnes silt loam in the 1924 McCook County, South Dakota soil survey (47) and also in the 1926 Moody County, South Dakota soil survey (48) would now be included in the Sinai or Poinsett series. The Corson series (36) was tentatively established in 1942 for the Minnehaha County Soil Conservation District. It comprised Chernozem soils derived from clayey, alluvial or loess-like materials. They occupied intermediate slopes between loess derived soils on high ridges and till derived soils of lower slopes. Areas formerly mapped Corson on the Cary drift sheet in Minnehaha County have since been remapped and called Sinai silty clay loam (53). The Corson series differs from the Sinai series in being developed in finer-textured parent materials and in having a master B horizon developed through 60 inches. The Corson series is currently restricted to early substages of the Wisconsin age (6).

The Kranzburg series (37) was established in 1946 in order to limit the depth of loess capping the till in the Barnes series to 20 inches. Soils with 20 to 40 inches of loess overlying till were mapped Kranzburg. Both of these series have since been revised so that the current concept of the Barnes and Kranzburg series are soils with loess capping till to a maximum depth of 12 and 36 inches respectively. The Kranzburg series included many areas previously mapped Barnes silt loam as well as many areas which now would be classified Sinai silty clay loam or Poinsett silt loam.

The Sinai series (22) was tentatively established in 1949, for the detailed soil survey of Brookings County, South Dakota. The type location was set in the southwestern corner of this same county. As described by Mogen (22), this series is comprised of well-drained, zonal soils of the Chernozem region developed in weathered loess overlying laminated silts. They occupied, high somewhat dissected, lake plains in the region of the Cary drift sheet. The Sinai soils were then described as having dark gray to dark grayish-brown, soft, granular, silty clay loam A horizons underlain by dark grayish-brown to dark brown, fine-textured, prismatic B horizons. A moderately developed horizon of lime accumulation occurred in the upper part of the light yellowish brown, silty clay loam to silty clay parent material. Laminations of the silty substratum varied from weak to strongly developed and occasionally the substratum was slightly stratified with thin lenses of very fine sand. A few glacial gravel and stones occurred on the surface in some areas. The soil profile was said to resemble the Kranzburg and Moody series but to differ chiefly in the character of underlying strata. This series differed from the younger Bearden series in occupying higher topographic positions and in having more strongly developed, brighter colored, prismatic B horizons. The geographical location of the Sinai series was considered to be in eastern South Dakota within the region of the Cary drift sheet.

The Sinai series (23) was revised and established in 1952 by the final correlation of the soil survey of Day County, South Dakota (17). This revision dealt with the parent material, areal extent, and soil associates. The profile was described as being developed in laminated silts and varved silty clays rather than loess over laminated silts and silty clays. Its geographic distribution was extended to the lake plains of the Cary drift sheet in southwestern Minnesota. Additional soil associates included the Nutley, Beotia, and Great Bend series developed in lake-laid materials and the Barnes catena developed in till. The Nutley soils were Humic Gleys developed from varved silty clays. The Sinai soils were said to differ from those of Beotia and Great Bend series in having developed a textural profile.

Since the original concept of the Sinai series included soils developed in weathered loess over laminated silts and silty clays, many areas formerly mapped Sinai silt loam in the soil survey of Day County, South Dakota (17) would now be included in the Poinsett series. The Poinsett series (24) established in Brookings County, South Dakota in 1956, is comprised of well-drained Chernozem soils developed from silty, stratified Cary glacial drift in eastern South Dakota. They occupy topography ranging from nearly level ground moraine to steeply rolling terminal moraine. Poinsett associates include the Sinai, Barnes, and Ahnberg series. They differ from the Barnes and Ahnberg series, derived from clay loam till, by being developed in silty glacial drift, and from the Sinai series by being developed in coarser-textured materials and in lacking a textural profile. The central concept of the Sinai series is represented by Sinai silty clay or silty clay loam in contrast to Poinsett silt loam.

GEOGRAPHICAL SETTING

Geographical Location

The area under study is located in the eastern one third of South Dakota on the Prairie Coteau; east of 98^{o} longitude and between 43.5 and 45.7^{o} latitude. Figure 2 shows the geographical extent of the area studied in relationship to the Prairie Coteau.

Physiography

Physical divisions in South Dakota as they are now understood are shown in Figure 2. The Prairie Coteau, a highland plateau standing between the James River lowland and the Minnesota River-Red River lowland is the most conspicuous single topographic feature of eastern South Dakota according to Flint (10). It is bounded on the eastern slope by a striking escarpment which is 800 feet high in the northern part. The western margin is generally 100 to 200 feet lower than the eastern. This lofty, nearly flat-topped, iron-shaped plateau, which points north with its long axis trending a little east of south, slopes westward and becomes progressively lower and less distinct as it broadens toward the south. In elevation, the summits over large areas of this Coteau reach approximately 2000 feet northward of Lake County. Farther south the elevations decrease gradually to 1500 feet in southern Minnehaha County. Its southern boundary merges imperceptibly into the general upland surface of the region. This erosion remnant is part of a more extensive plateau that extends northward through North Dakota and into Manitoba and Saskatchewan (10). It is irregularly covered with glacial drift of Wisconsin age.

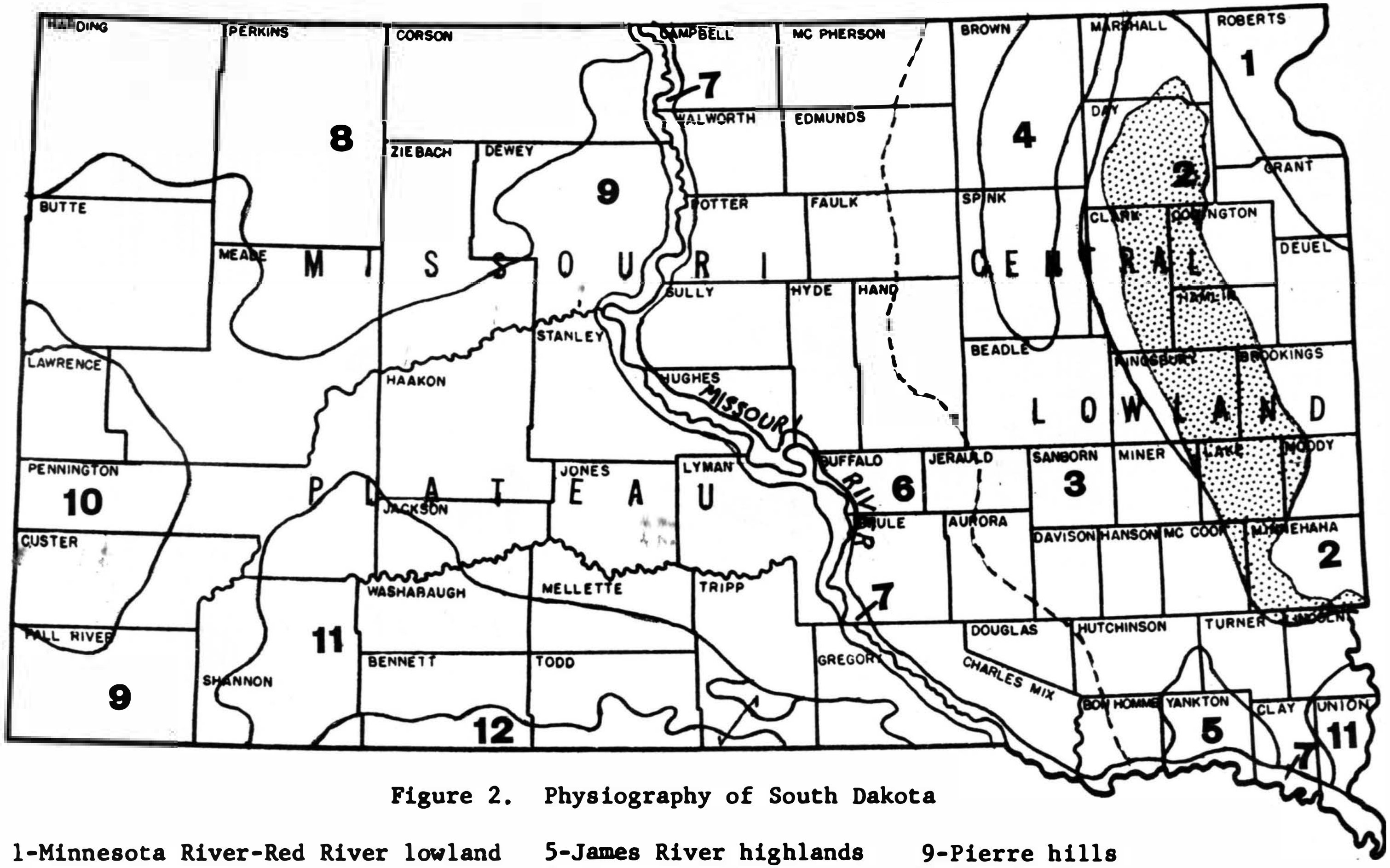


Figure 2. Physiography of South Dakota

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

Area of Study

Source: Flint (10)

Thickness of the drift varies from bedrock at the surface to drift several hundred feet thick. Fenneman (8) shows a hairpin-shaped boundary traversing the Prairie Coteau and separating the western lake section, a young glaciated plain, from the dissected till plains. Flint (10) says that in South Dakota these two sections correspond essentially to the areas in which Cary and Mankato drifts and Iowan and Tazewell drifts, respectively, are at the surface.

THE SOIL FORMING FACTORS

Climate

South Dakota, because of its inland position, has a continental climate with extremes of summer heat, winter cold, and rapid fluctuations of temperature. The fall, winter, and spring moisture falls principally as frontal precipitation and is the result of relatively cool, dry polar air masses converging with warm, moisture-laden air masses from the Gulf of Mexico.

Most of the summer precipitation comes as short, hard, sporadic showers of the convectional thunderstorm type. Spring is moist, cool, and windy; summer is sunny and hot; autumn is dry, cool, and sunny; and winter is cold and relatively long. Because of the latitude (43 and 46°) the days are long during the growing season.

The mean annual hours of sunshine for the eastern one-third of South Dakota approximates 2700 hours. The average percentage of clear days per year is 40, of partly cloudy days 30, and of cloudy days 30. The average annual snowfall for this area is about 30 inches, but variations from year to year and place to place are very great. In the northern portion of this state, average frost depth penetration is 40 to 50 inches while in the southern section it is only 30 to 40 inches (46).

According to Thornthwaite's 1948 (34) classification of climate, the eastern one-third of South Dakota is divided into two climatic types. A moisture index obtained by comparing water need with moisture surplus and deficit is an essential part of this classification. South of the Minnehaha-Moody County border and east of a line coincident with the western boundaries of Minnehaha and Clay Counties is an area classified as moist subhumid and designated C2. It has a moisture deficiency-surplus index from 0 to 20. The surrounding area is called dry subhumid, C1, and has an index of 0 to -20.

In order to characterize the climate of this region more explicity, it was necessary to group data collected from class A and B United States Weather Bureau stations into three subgroups representing the northern, central, and southern sections of the Prairie Coteau. Stations with relatively short-term records which lack either precipitation or temperature data are usually classed as B stations. Due to the paucity of reporting points in this area, data from both classes of stations were used in this study.

Class A stations are Roslyn, Wentworth, Brookings, Sioux Falls, and Centerville. Webster, Arlington, Flandreau, and Canton are classed as B stations. Roslyn and Webster were grouped to represent the climate of northern section while Wentworth, Arlington, Flandreau, and Brookings depict the climate of the central area. Sioux Falls, Centerville, and Canton represent the southern section. Monthly mean precipitation and temperature data reported for each section were obtained by calculating the arithmetic mean of data compiled from stations making up the specified section.

Climate within the soil is unlike that above it; however, climatic data are usually obtained from recording instruments placed on the earth's surface or at some distance above it. Differences in geographic position, that is, upland versus bottomland, tend to further complicate the correlation of surface climate with soil climate. The ideal soil genesis study would use data from the actual soil climate, since official weather records deal in macroclimate rather than microclimate. In order to minimize the above correlation difficulties, weather stations of approximately equal altitude and latitude have been grouped wherever possible.

The average annual precipitation for the northern, central, and southern sections of the Prairie Coteau is 21.07, 22.78, and 25.26 inches (42) (43). Average annual temperature for these sections is 41.6, 44.3, and 46.6^{o} F.

From Figure 3 it may be seen that the monthly march of precipitation for specified sections of the Coteau is assymetrical with respect to the June maximmm, however all three areas exhibit the same general warm season trend. The central section deviates from the pattern of the other two sections by having a more abrupt decrease in July precipitation. Rainfall of the southern section is generally higher throughout the frost free period with substantially greater precipitation received during the hot summer months.

Over 80 per cent of the precipitation of this region is received during the frost free period. Only a small portion of this precipitation percolates through the soil, and the rest is lost through surface runoff, direct evaporation, and transpiration by vegetation. Loss of water from the earth to the atmosphere constitutes an important water balance problem. Direct means of measuring these losses have proved extremely difficult and this inherent difficulty has led to the development of a number of formulas designed to estimate water loss directly by use of meterological

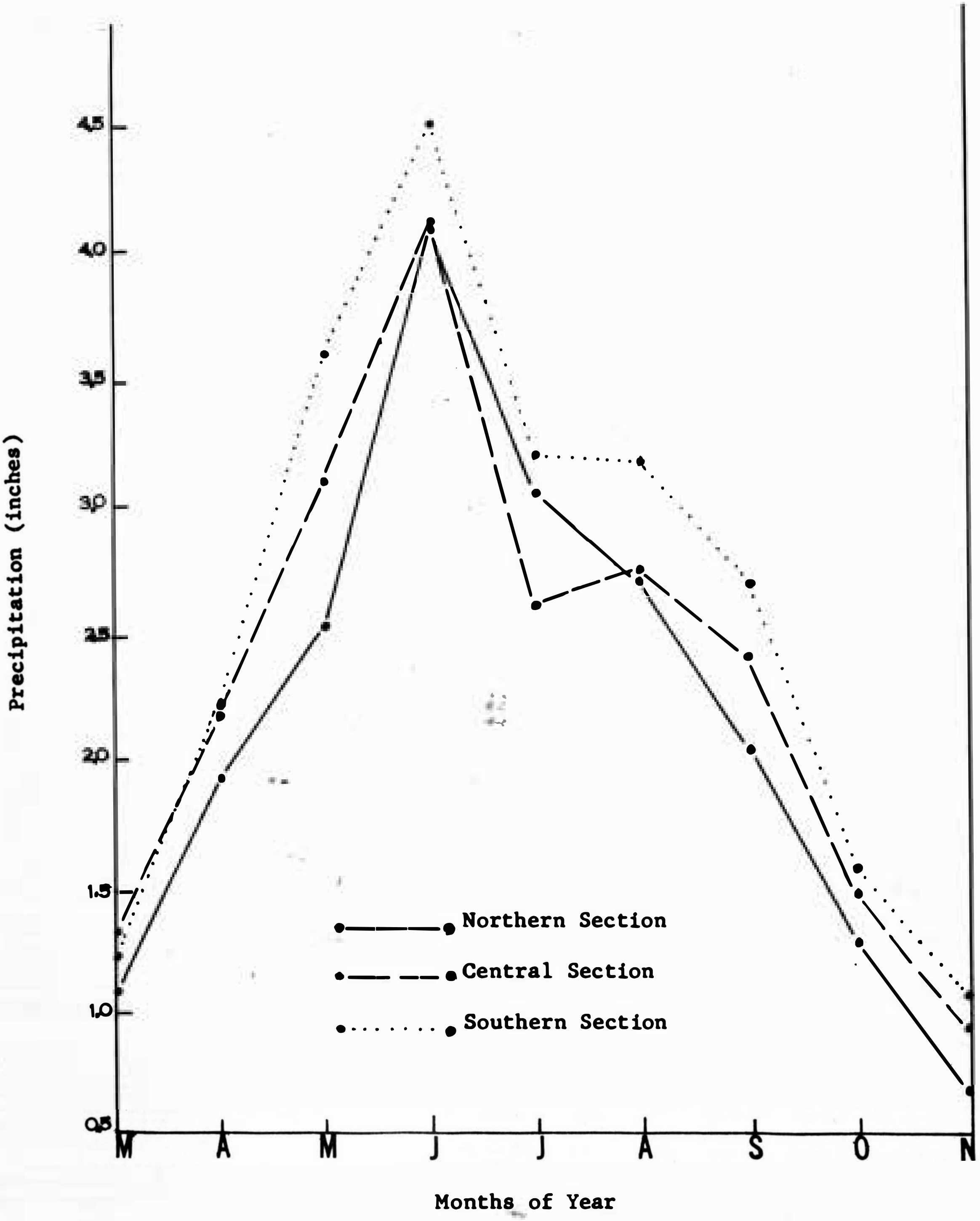


Figure 3. Average Monthly Precipitation for the Northern, Central, and Southern Sections of the Prairie Coteau

Source: U. S. Weather Bureau Data (42) (43) data. The approaches to this problem according to Palmer and Havens (25) fall into three groups; those using the flux of water vapor theory; those utilizing heat balance of the evaporating or transpiring surface; and those which are emperically determined, involving a relationship between evapotranspiration and one or more meterological factors. Van Wijk, et al. (44) and Penman (29) have attempted to estimate potential evapotranspiration by using the flux of water vapor and heat balance methods. Lang's rain factor, Meyer's N-S quotient, Martonnes' "index of aridity", and Thornthwaite's "precipitation effectiveness index" are some of the early empirical formulas used in estimating effective precipitation. Thornthwaite's (35) "potential evapotranspiration" belongs to the last category of Palmer and Havens groupings. It is generally accepted that the problem of developing a formula for potential evapotranspiration remains unsolved since none is free from assumptions, arbitrary constants, or technical difficulties of observation and measurement.

Thornthwaite's method (35) is basically an empirical relationship between potential evapotranspiration and mean air temperature. It is not considered to be the most accurate method nor is it based on the soundest theoretical principles but it does surprisingly well in spite of its simplicity and limitations (25). Widespread use of Thornthwaite's formula may be accredited to the fact that it can be applied at any location which records daily maximum and minimum temperatures. Although ease of application is not a suitable criterion of adequacy, it is of prime importance when meterological data required for vapor flux and heat balance methods are either not observed or observed only at a few widespread points.

Using the graphic technique developed by Palmer and Havens (25) to calculate potential evapotranspiration (PE) for the north, central and southern sections of the Prairie Coteau, it was found that the average PE's for the period from March 1, through October 31, are 26.33, 24.94, and 23.00 inches respectively. The results for the same period are plotted in Figure 4. The average monthly mean air temperature of each section was used for these calculations.

Charts showing the average daily soil moisture and average daily minimum temperature at various locations in South Dakota have been developed by Pengra (28). These charts for Sioux Falls, Brookings, and Watertown are shown in Figure 5. They indicate that, on the average, Sioux Falls has the shortest annual period of drought and Brookings the longest. A drought is defined as existing whenever the soil moisture is less than 50 per cent of soil moisture capacity or two inches of water in the rooting zone. Average minimum air temperature is highest at Sioux Falls and lowest at Watertown.

Just as precipitation between different sections of the Coteau varies, so also does temperature. In Figure 6 the average monthly mean temperature for each section is plotted for the period from March 1 through October 31. It may be noted that these sectional temperatures closely parallel each other and are nearly symmetrical with respect to the July maximum. Comparing temperatures of the northern section with those of the southern, there is a 5 to 10° temperature differential during the frost free period. Temperatures of the central section are intermediate between the cooler northern region and the warmer southern section.

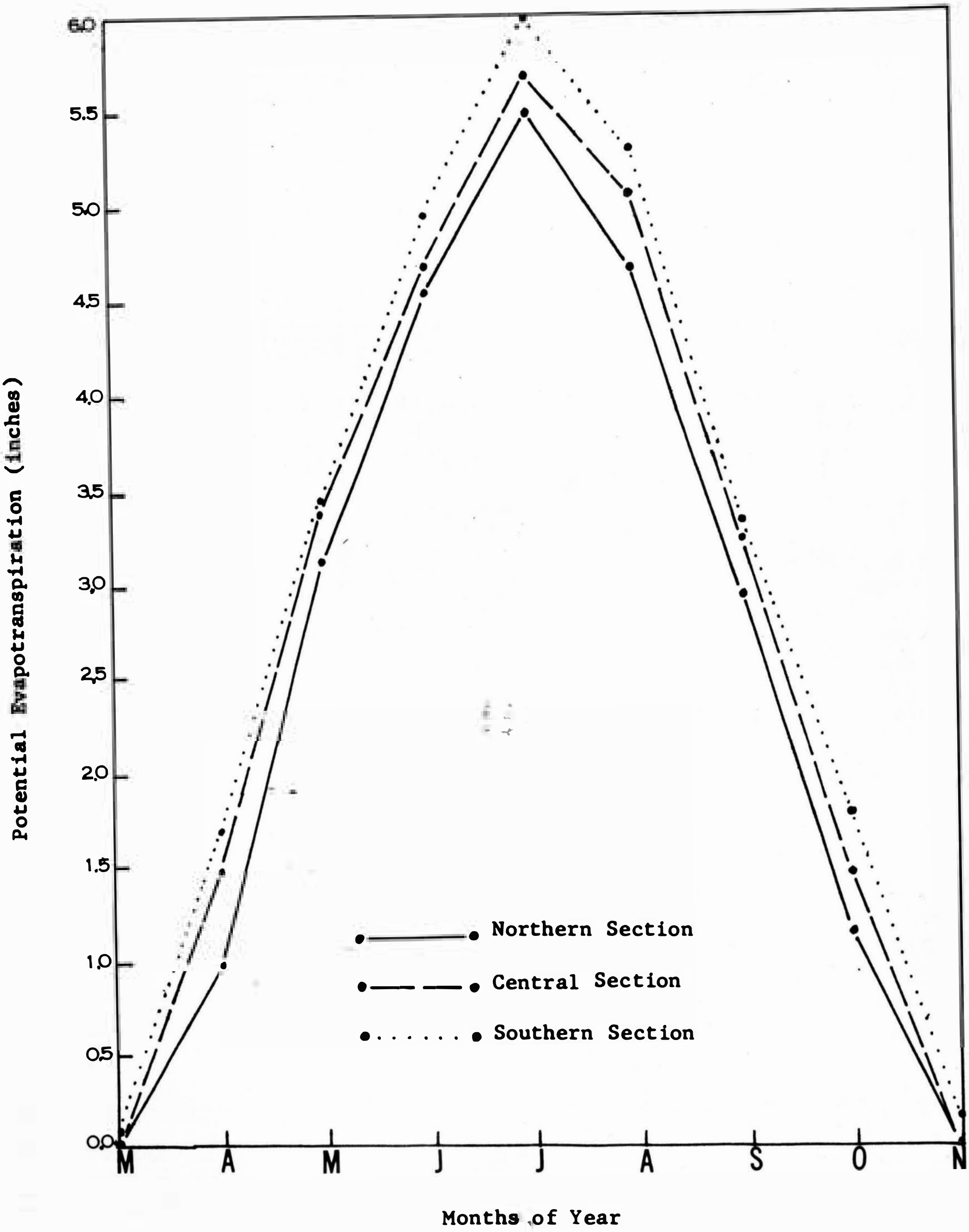
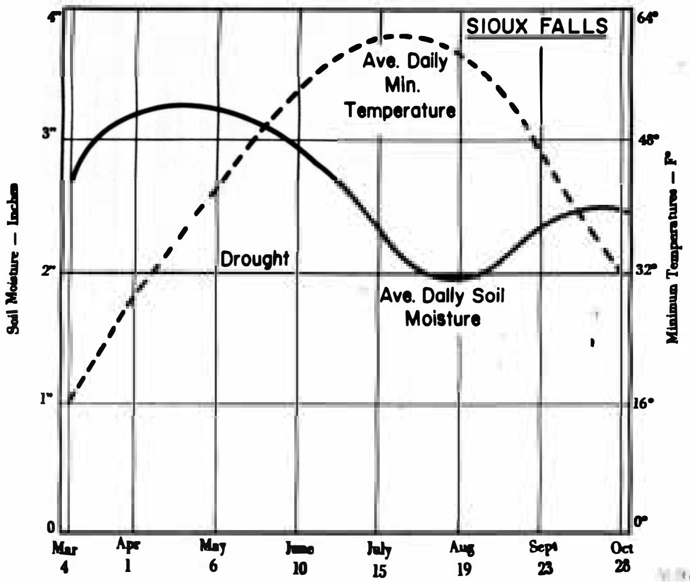
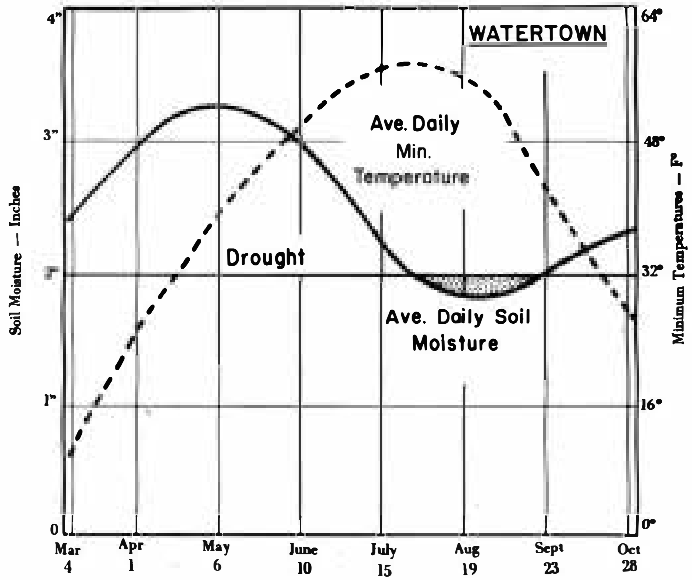


Figure 4. Potential Evapotranspiration of the Northern, Central, and Southern Sections of the Prairie Coteau

Source: Calculated using the Palmer and Havens (25) technique with U. S. Weather Bureau Data (42) (43)





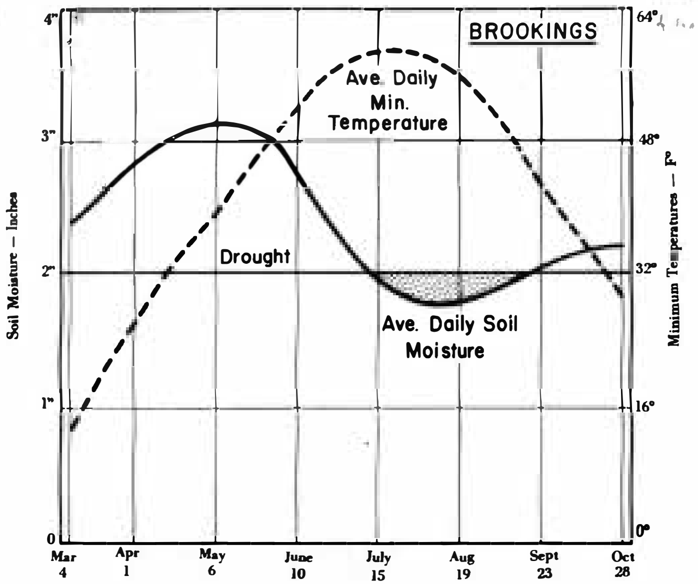


Figure 5. The Average Daily Soil Moisture and the Average Daily Minimum Temperature for Sioux Falls, Watertown, Brookings, South Dakota

Average Annual Period of Drought

Source: Pengra (28)

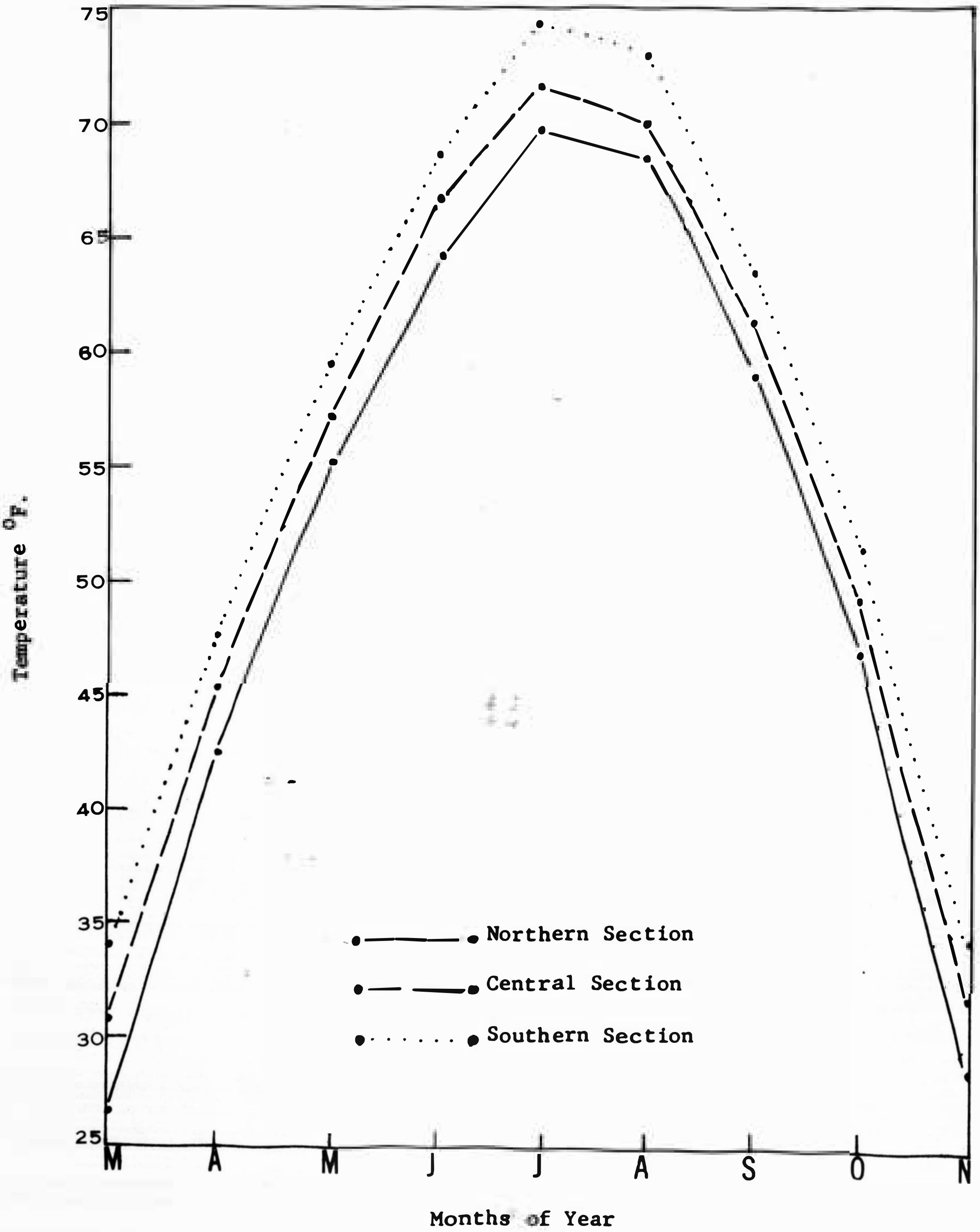


Figure 6. Average Monthly Temperature of the Northern, Central, and Southern Sections of the Prairie Coteau

Source: U. S. Weather Bureau Data (42) (43)

Figure 7 and 8 show the distribution of average annual precipitation zones and temperature isotherms in South Dakota.

The number of weeks in which the weekly mean air temperature is above 32° F. is 33, 34, and 36 in the north, central, and southern sections. This means that the southern soils are annually subjected to above freezing weathering conditions for a supplementary three week period. Assuming for a moment that present climatic conditions express those of the past, except for a regional cooling during the Mankato ice sheet, then this additional weathering over a period of 12,000 to 13,500 years (30) would give the southern soils of this drift sheet approximately 800 years of additional soil development age.

Vegetation

All five Sinai profiles were sampled at sites which have been under cultivation for an indefinite period of time. A large number of homesteaders made rapid settlement in this area about 1880, hence Sinai soils have not been intensively cropped for more than 80 years. It is almost impossible to find areas of these highly productive soils which are still in virgin condition, consequently cultivated sites were selected for sampling.

Griffiths (12), who made a study in 1893 of certain native grassland species in South Dakota, noted that tall grasses such as the following are found almost exclusively on low, moist, depressional or river-bottom positions: big bluestem (*Andropogon furcatus*), blue joint grass (*Calamagrostis canadensis*), slough grass (*Spartina pectinata*), and Indian reed (*Cinna Arundinacea*). He observed such grasses as little bluestem

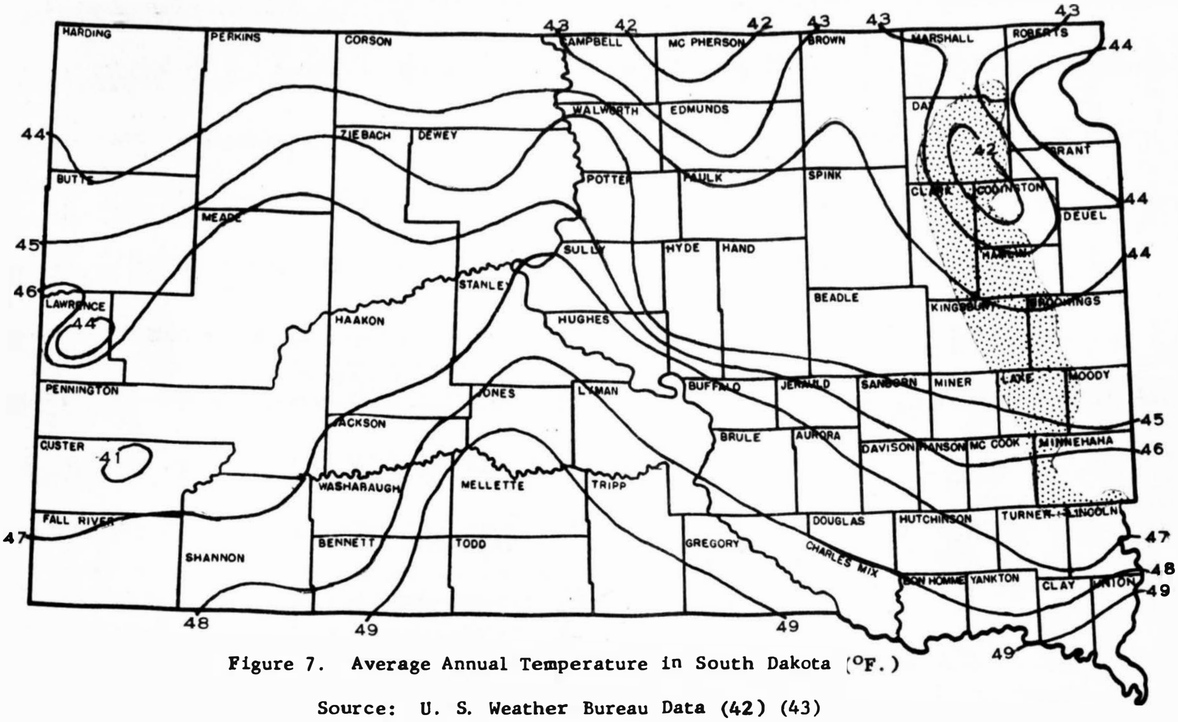


Figure 7. Average Annual Temperature in South Dakota (°F.)

Source: U. S. Weather Bureau Data (42) (43)

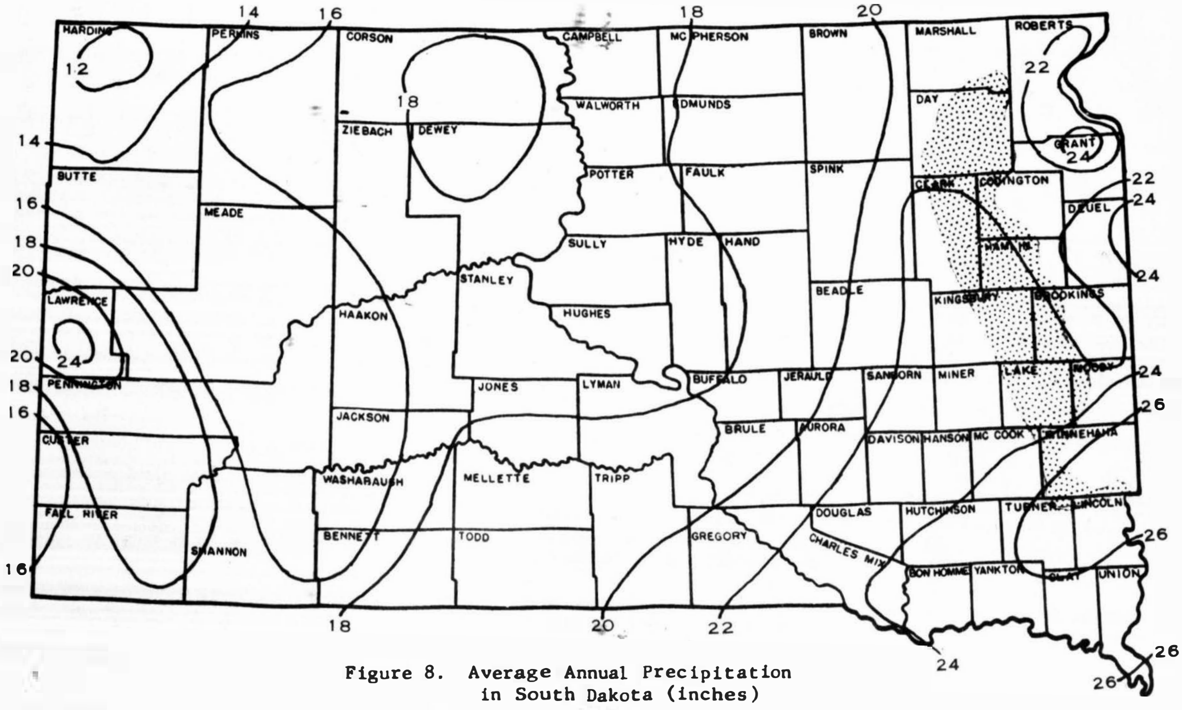


Figure 8. Average Annual Precipitation in South Dakota (inches)

Area of Study

Source: Yearbook of Agriculture, Climate and Man (40)

(Andropogon scoparius), porcupine grass (Stipa spartea), grama (Bouteloua sp.), and junegrass (Koeleria cristata) most commonly associated with the dry-soil, upland, prairie region of eastern South Dakota.

Harvey (13) indicates that the prairie grass formation of southeastern South Dakota represents a transition between more mesophytic eastern areas of Iowa and those dominantly xerophytic to the west. According to him, the present day prairie is preglacial in origin and has descended from the climatic prairie of Tertiary times. He adds,

> The formation is strictly of the prairie-grass type, its facies being determined mainly by six species: Bouteloua Oligostachya, B. curtipendula, B. hirsuta, Koeleria cristata, Andropogon furcatus, and A. scoparius, to which must be added Poa pratensis in valleys and on lower slopes. The Andropogons are the main sodformers of the crests and ridges, while the Boutelouas characterize the higher slopes, working up to crests and ridges. Koeleria seems to be more closely associated with Boutelouas, occurring on middle slopes mainly.

He points out that the open-mat association prevails over ridges and crests and extends down somewhat on slopes, passing through transitional conditions into the closed-mat associations of valleys, depressions, and bases of slopes.

Visher (45) relates that the dominant native plants of any region have not been selected by the climate of a brief period but by many centuries. He divided the prairie in South Dakota into two phases, low prairie and high prairie. The low prairie, which receives in addition to normal rainfall the run-off from the high prairies, is more mesic and has taller, more luxuriant, denser stands of vegetation than on well-drained uplands. Dominant grass species of the high prairie were junegrass, dropseed grasses, switchgrass, and bluestems. These grasses are mostly turf formers and generally have an average height at maturity of one foot or more. The chief herbs were the prairie clovers, golden rods, vervains, asters, blazing-stars and Indian turnips.

In Weaver's (50) discussion of the upland prairie, he notes that the dominant grasses of the area are nearly all of the mid-grass type. Dense shade produced by tall grasses restricts the growth of mid-grasses in lowlands but in uplands the soils are usually not sufficiently moist to promote dense stands of tall grasses.

He indicates that five species, distributed in three plant communities comprise the major upland prairie association. These species are little bluestem, side-oats grama, needlegrass, prairie dropseed, and junegrass. They form the most important dominants in the little bluestem, needlegrass, and prairie dropseed communities. Little bluestem is the most important dominant in its own most extensive upland type. In the western prairie area it alone composes an average of 55 per cent of the vegetation and it may furnish up to 90 per cent. From a total of 180 quadrats throughout the little bluestem type, the average percentage composition of the most abundant grasses was little bluestem 55, big bluestem 24.8, bluegrass 4.7, needlegrass 2.5, and prairie dropseed 2.7 (50). The large amount of big bluestem is its abundance on lower mid-slopes and more mesic, less rolling uplands. Weaver says that little bluestem easily exceeds in importance all other upland grasses combined.

Needlegrass is a chief dominant in a very much smaller grassland type, the needlegrass community. In Dakota, north of the area he studied, Weaver says that this type becomes progressively more important and needlegrass is the chief dominant over vast areas. Chief associates of it are the bluestems, junegrass, and side-oats grama (50).

The least extensive upland type is dominated by bunches of prairie dropseed. Minor areas over which it dominates are much less extensive than those of the needlegrass type. Prairie dropseed more often occurs as scattered bunches in the little bluestem or needlegrass communities than as a dominant within its own type, Weaver says. Where formed, it is composed of about the same species as the needlegrass type.

From the preceding, one may postulate that the Sinai soils, which occupy nearly level uplands, have developed primarily under the influence of mid-grass associations. It is quite probable that the percentage of tall grasses intermingled with mid-grasses was greater in the more mesophytic southern section of the Prairie Coteau than in the cooler, drier, northern portion. The northern area is believed to have had a greater percentage of short grasses intermixed with the predominant mid-grasses. If the Sinai soils developed under a grassland association similar to that of the little bluestem community, then the following grass species comprised the majority of native vegetation: little bluestem, big bluestem, needlegrass, prairie dropseed, junegrass, and side-oats grama.

Weaver (50) lists 35 forb species that were most abundant and important on uplands. Lead plant (Amorpha canescens), Psoralea sp., prairie clovers (Petalostemum sp.), asters (Aster sp.), goldenrods (Solidago sp.), daisy fleabane (Erigeron strigosus), prairie cat's-foot (Antennaria neglecta), and stiff sunflower (Helianthus laetiflorus) are the species which he ranked most abundant.

Parent Material and Time

The parent material of the Sinai soils is calcareous, finely stratified, glacio-lacustrine sediments. The Pleistocene or glacial period was characterized by four major glaciations. From oldest to most recent they are the Nebraskan, Kansan, Illinoian, and Wisconsin. In South Dakota the Wisconsin drift sheet was subdivided into four substages which are, from oldest to youngest, the Iowan, Tazewell, Cary, and Mankato (10). Their surface areal distribution is shown in Figure 9. Wright and Rubin (56) indicate that there may be some conflict as to the age of these areas. Radiocarbon dating seems to indicate that the Mankato type location is of Cary age. If these radiocarbon dates are correct then it is possible that the area in South Dakota called Cary by Flint is actually pre-Cary in age. Therefore, the name Cary will be used provisionally in this study. The Cary drift sheet in the western Great Lakes region is 10,370 to 12,795 years old according to Wright (55). Ruhe and Scholtes (30) state that this drift sheet is 12,000 to 13,500 years old.

On the Prairie Coteau of eastern South Dakota, mesa-like knolls in the Cary drift area are capped with finely stratified glacio-lacustrine sediments. These deposits provide the parent material of the soils studied. Nearly level summits of these knolls are usually flanked with moderately steep, abrupt slopes composed of silty glacial drift or loam-clay loam till.

On convex slopes and gentle crests of upland undulations the parent materials of the Sinai series and the associated Poinsett series

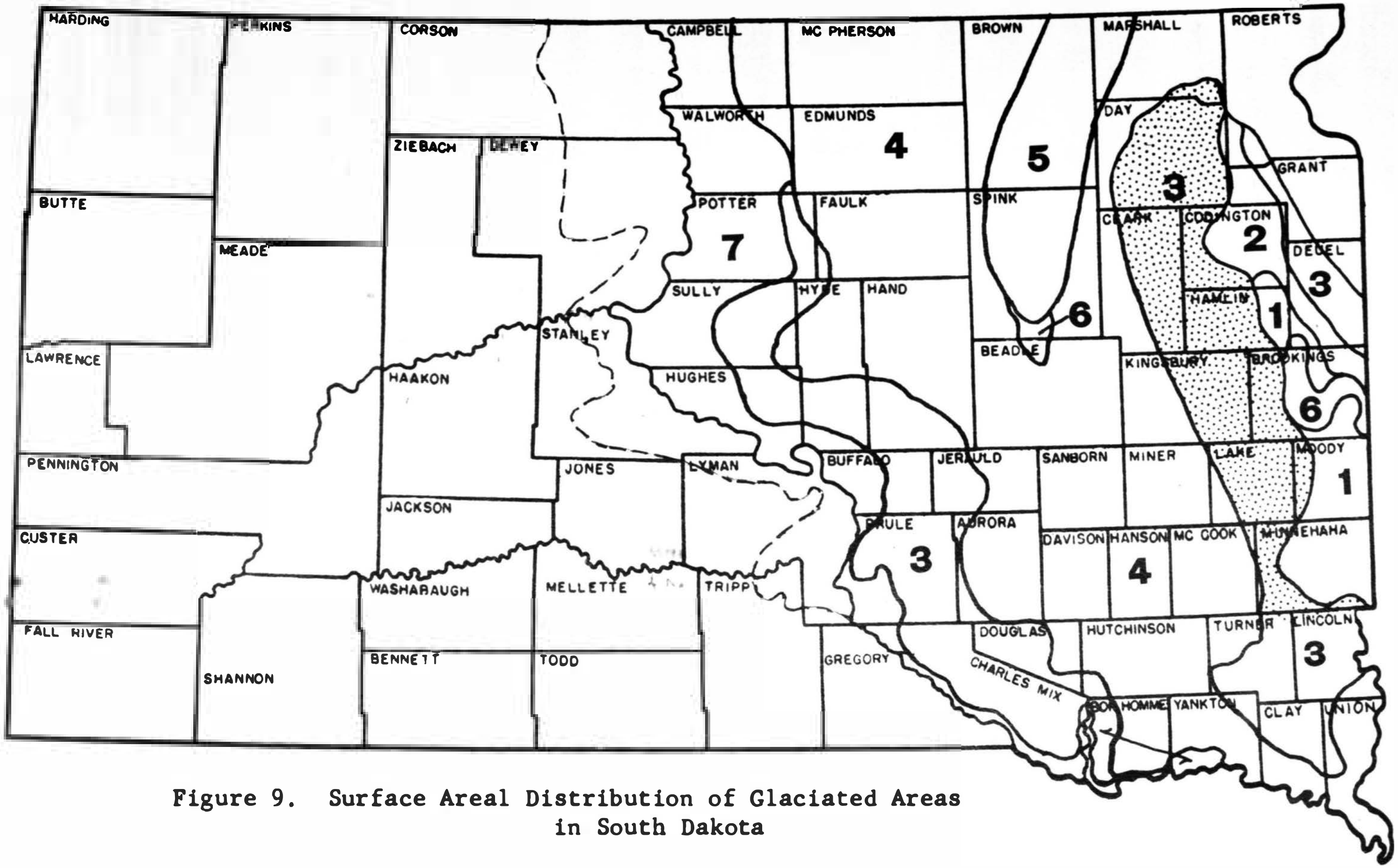


Figure 9. Surface Areal Distribution of Glaciated Areas in South Dakota

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

Area of Study

Source: Flint (10)

appear to be similar in origin but to differ primarily in the texture of the glacial sediments. The Sinai soils have developed in finer-textured parent materials than the associated Poinsett soils.

Flint (9) has discussed similar topographic features and sediments in his description of "Collapsed masses". In this discussion he noted that blankets of stratified sediment, coarse or fine, are deposited on thin ice and let down upon the ground as the ice melts. In Day County, many areas of collapsed topography showing Cary and post-Cary loess to be immediately underlain by parallel bedded silts, presumably of lacustrine origin, are described by him. He believes these relationships imply that during the retreat of the Cary glacial margin temporary lakes developed in part over buried Cary ice.

During the course of making detailed soil maps in Sinai areas, the writer noted several cuts and many five feet borings showing stone-free pockets of laminated silts interspersed between predominant, more stony, silty glacial drift. In some places the sediments appeared to be ice-contact stratified drift.

If the Cary drift sheet deposited ground and terminal moraines in the manner proposed by Goldthwaite (11), then these laminated deposits could have originated from streams washing fine sediments into pools contained within troughs of ice cored moraines. However, the sequences and principles of moraine formation suggested by him, may apply only to an "active" ice edge. There is some evidence to suggest that the relatively thin Cary glacier became stagnated in at least the terminal zone of the glacier.

By oral communication with Buntley (6) and Westin (51), the following hypothesis regarding the origin of Sinai parent materials was suggested. If the relief of the pre-Cary surface were loess mantled, as indicated by Flint (10), then the thin, advancing Cary ice sheet would have sheared off the tops of loess capped hills and incorporated loessial silts and clays within the ice as well as superglacial till on the surface of the ice. After maximum extension of this ice sheet, it stagnated, exposing high planed off, till-cored hills and filled the lows with ice blocks. These highs became settling basins or glacial lakes for the deposition of loess-like sediments into varves or laminae. The coarser-textured sediments, sands and gravels, settled out first because of more rapid flowing meltwaters during the youthful stages of ablation. The finer-textured sediments were deposited into relatively quiet pools by slow flowing meltwaters in later stages of ice block wastage. This hypothesis is substantiated by transects on abrupt, steep slopes which flank mesa-like Sinai positions. Transects on such slopes show textural stratification that becomes progressively coarser-textured with decrease in altitude to the point of till contact.

It is postulated by the writer that Sinai glacio-lacustrine parent material was deposited in temporary lakes by slow flowing water in and on the stagnated, thin marginal ice of the Cary glacier. In the more strongly pronounced, flat-topped, mesa-like positions, the origin of these sediments is believed to have resulted from fine-textured sedimentation in high, ice-blocked lakes similar to those proposed by Buntley and Westin. In the gently undulating and undulating morainic landscapes, sediments apparently have originated from "collapsed drift" or from small lakes within troughs of ice-cored moraines. The methods of deposition discussed here are undoubtedly interrelated and were active to some degree in all areas at the time these parent materials were laid down.

For purposes of this study the parent material of the Sinai soils is assumed to be of similar mineralogic composition. It is well known that differences in texture and thickness of strata occur in these laminated deposits, however the sola of all profiles studied appear to have been derived from similar parent material.

The chronologic age of these soils is also assumed to be constant. The soil development age is theorized to be greater in the southern portion of the Cary drift sheet than in the northern section because of differences in climate between these two areas.

Relief

The Cary drift sheet has a pronounced morainic surface (10). The Cary ground moraine, with an average relief of no more than 10 feet is characterized by little or no surface drainage, many depressions, and short, choppy slopes. The Cary drift sheet has a poorly integrated surface drainage pattern. There are no major drainage channels dissecting this drift plain consequently most upland drainageways lead to depressions.

The Sinai soils generally occupy the nearly level tops of mesa-like hills and the high saddles with sloping tops in a moderate to strongly undulating landscape. These hills are interlaced with a more or less continuous moat-like pattern of colluvial-alluvial drains and swales. The most pronounced, high, flat-topped positions occur in the central portion of the Cary drift sheet. The southern area of this drift sheet is almost void of such positions and in the northern section high, mesa-like hills usually have convex tops.

The altitude of the northern Sinai sample sites ranges from 1890 feet at one site to 1950 feet at the other and the surrounding areas have a local relief differential ranging from 60 to 75 feet. In the central area the altitude of the sample sites is 1800 feet at one site and 1850 feet at the other, and the surrounding area has a local relief differential from 35 to 40 feet. The southern Sinai sample site has an altitude of 1750 feet and the surrounding area has a local relief differential ranging from 25 to 35 feet. In general, the decrease in altitude from north to south is accompanied by a decrease in local relief differential.

All sample sites were located on east-southeasterly facing, 1 to 2 per cent, slightly convex slopes, hence the exposure of these soils to the forces of weathering and erosion are approximately equivalent. The soil forming factor of relief as regards to these samples is considered to be the same.

METHODS OF INVESTIGATION

Field Methods

The location of the Sinai region was taken from the map titled, "Major Soils of the North Central Region, U.S.A." (41). Additional information concerning the geographical extent of these soils was obtained through personal consultation with Westin (51). Figure 10 shows the present areal extent of the Poinsett-Sinai Association.

In the northern half of this area four Sinai profiles were selected for description and sampling. Two Sinai profiles, for which descriptions and laboratory data were available, were originally designated to represent these soils in their southern extent. Upon detailed field studies, it was decided that only one of these supposedly paired samples actually represented the well-drained Sinai soils of this area.

Profiles of these soils were sampled in Day, Brookings, and Kingsbury Counties, South Dakota. Two paired samples were selected in the Day County and the other two paired samples were collected from Brookings and Kingsbury Counties. The previously sampled southern Sinai profile is located in the west-central portion of Minnehaha County, South Dakota. The location of sample sites is shown in Figure 10. The general area of Sinai soils in Brookings and Day Counties was determined from county soil maps. It was necessary to field examine many prospective areas mapped as Sinai silty clay loam in order to find the most representative sample sites. All sample sites were located on similar topographical positions. Slightly convex, 1 to 2 per cent, east-southeasterly facing slopes which form the summits of high, upland undulations, are the positions which are

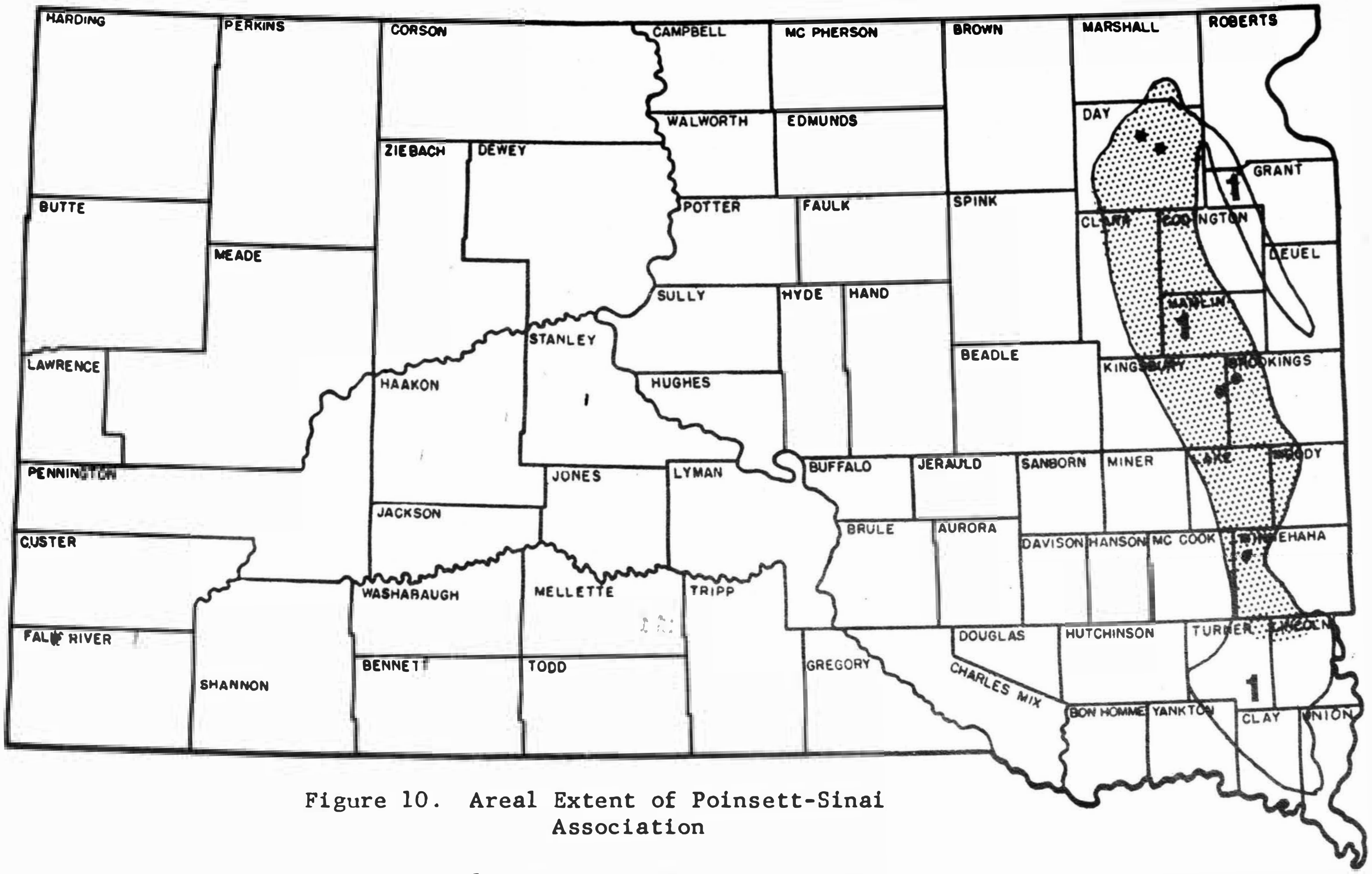


Figure 10. Areal Extent of Poinsett-Sinai Association

1. Poinsett-Sinai Association

Area of Study

● Sample Sites

considered to express well-drained zonality of these soils most characteristically.

After one of the paired samples was selected, a profile slice of it was placed on a tin trough and used for reference until the second sample of the paired set was located. By use of the reference profile it was possible to obtain paired samples that differed little in observable physical characteristics. Paired sites were from one to seven miles apart.

Profiles of the five soils used in this investigation were sampled from pits dug in cultivated fields. All pits reached to a depth of five feet. Prior to taking the samples the profile was divided into horizons and subhorizons and fully described. The horizon designations used in these descriptions are consistent with those used in the USDA Handbook No. 18 (33) except for the use of ABp, BAp, DB3ca, and B2ca-B3ca symbolism. An ABp horizon, as used here, refers to a horizon, where B material is incorporated into the plow layer and is still recognizable as such. The BAp symbol is used for a horizon which has characteristics more like B than A but has some A material incorporated. The use of DB3ca is a symbol used to show B3ca development extending into D materials. The B2ca-B3ca designation is used for a horizon that is intermediate in development between B2ca and B3ca horizons.

The horizon temperatures were determined with a Weston soil thermometer and these data are reported in the profile descriptions. Clay films, quartz grains, and pinholes were viewed through a 14 power hand lens to determine their quantity and characteristics. Pinholes as noted in the descriptions refer to the longitudinal, circular pores which perforate the fabric of the soil.

Bulk samples were taken from each horizon, the entire horizon being included. Sampling proceeded from the lowest horizon in the pit to the surface horizon in order to avoid contaminating the face of the horizons during the sampling operation. Separate color subsamples were taken at the time of macro-sampling so that all colors could be read under similar conditions, however abundance and size of mottles were noted in the field.

The southern Sinai sample site was reopened about two feet behind the face of the old pit. Samples of horizons as described by Buntley (5) were collected for partial laboratory analysis.

After each of the northern and central profiles were sampled, the surface horizon of the pit face was shaved back about two feet and three soil cores were taken from each of the underlying horizons to determine their bulk density. These data are not available for the previously sampled southern profile.

A detailed soil map of one square mile in extent was made surrounding each sampling site. Mapping was done on an aerial photograph with a scale of eight inches to the mile. Arbitrary numbers were used to designate the mapping units and these are shown in the delineations on the field sheets. Different sets of arbitrary numbers were used in the northern, central, and southern areas. A brief descriptive legend of these mapping units was drafted in the field as mapping of the respective areas progressed.

Laboratory Methods

All samples were air dried in the laboratory. After drying, those samples which contained gravel or rock were sieved to remove all individual particles or rock greater than 3/4 inch in diameter and discarded. The samples were prepared by rolling or crushing the soil lumps and sieving to remove gravel or rocks larger than 2 mm. in diameter. The material larger than 2 mm. but less than 3/4 inch is reported as per cent greater than 2 mm. and the percentage is based on total weight of sample less than 3/4 inch. The material less than 2 mm. was thoroughly mixed and quartered to about 1000 grams. For total carbon and inorganic carbon determinations a portion of this 1000 gram sample was ground to pass an 80 mesh sieve. All other laboratory analyses were made on the material passing a 2 mm. sieve. Data are reported on the oven dry basis and are the average of duplicate analyses with the exception of bulk densities which are the average of triplicate analyses.

The following laboratory methods were used for the four profiles collected in Day, Brookings, and Kingsbury Counties. The pipette method of mechanical analysis, as described by Kilmer and Alexander (16), slightly modified, was used. One variation of this method was the omission of the leaching operation after the sample was pretreated with 15 per cent hydrogen peroxide. Comparing the sand and clay percentages of samples which were leached after the hydrogen peroxide pretreatment, with those that were not leached, it was found that the error incured by omitting the leaching operation was less than one per cent. Quart milk bottles were graduated to 900 cc. and employed as settling containers instead of 1000 cc. graduated cylinders. The dispersing agent used in this procedure was sodium hexametaphosphate-sodium carbonate as described by Tyner (38).

The hydrogen ion concentration, expressed as pH, was measured with a Beckman glass electrode. This measurement was performed on the saturated soil paste.

The dry combustion method for total carbon as described by Winters and Smith (54) was employed. Inorganic carbon was determined by gravimetric determination of evolved CO_2 upon treatment of the soil with a 0.5 N solution of HCL. This reaction was brought to completion by gently boiling the mixture for three minutes (31). Organic carbon may be obtained by difference between the total carbon and the inorganic carbon. The analysis of inorganic carbon was run on all samples described as being calcareous as well as the first sample described as being noncalcareous immediately overlying calcareous horizons.

Calcium carbonate equivalent was calculated from the inorganic carbon analysis by using the gravimetric factor 2.2742 to convert CO_2 to $CaCO_3$. The assumption was made that $CaCO_3$ was the only source of the evolved CO_2. This may be somewhat erroneous since other carbonates are undoubtedly present but in lesser quantities.

Bulk densities were calculated by dividing the weight of the oven dry soil within a brass core by the volume of the core. Data for bulk densities are reported as grams per cubic centimeter. The per cent moisture at sampling time is also reported.

Determinations of the cation-exchange capacity were made by using normal sodium acetate solution of pH 8.2 as outlined by Bower et al. (4). In determining the extractable calcium, magnesium, sodium, and potassium, the soil was leached with normal ammonium acetate solution of pH 7, as described by Bower et al. (4). Extractable calcium and magnesium were determined from this soil extract by the Versonate titration procedure as outlined by Cheng and Bray (7). Extractable sodium and potassium were determined on the above extract with a Perkin-Elmer Model 146 flame photometer as described by Jackson (14). The internal standard procedure was used for this determination.

Extractable hydrogen was determined by the change in pH of normal ammonium acetate solution of pH 8.1 as described by Parker (26) and as modified by Mehlich (21).

The Kjeldahl method was used for the total nitrogen determination with a modification proposed by Bal (3). This involves wetting of the soil with water prior to digestion with concentrated H_2SO_4.

Electrical conductivity in millimhos per centimeter was measured on the soil saturation extract with a conductance bridge. Soluble sodium and potassium were determined on the saturation extracts of the soil paste with the Perkin-Elmer Model 146 flame photometer. The internal standard procedure was used for this analysis.

The color of the soil was determined in the office under constant fluorescent lighting conditions by matching the soil samples with color chips described in USDA Handbook No. 18 (33). All colors were read to the closest one-half color chip.

The profile samples collected from the re-opened Sinai pit in Minnehaha County were analyzed for total carbon, inorganic carbon, and cation-exchange capacity using the above procedures. A more complete laboratory analysis of this profile was made by the United States

Department of Agriculture, Soil Conservation Service, Soil Survey Laboratory at Lincoln, Nebraska. The laboratory methods used for this sample were comparable to those employed for the other four Sinai samples.

FIELD RESULTS AND DISCUSSION

Profile Descriptions

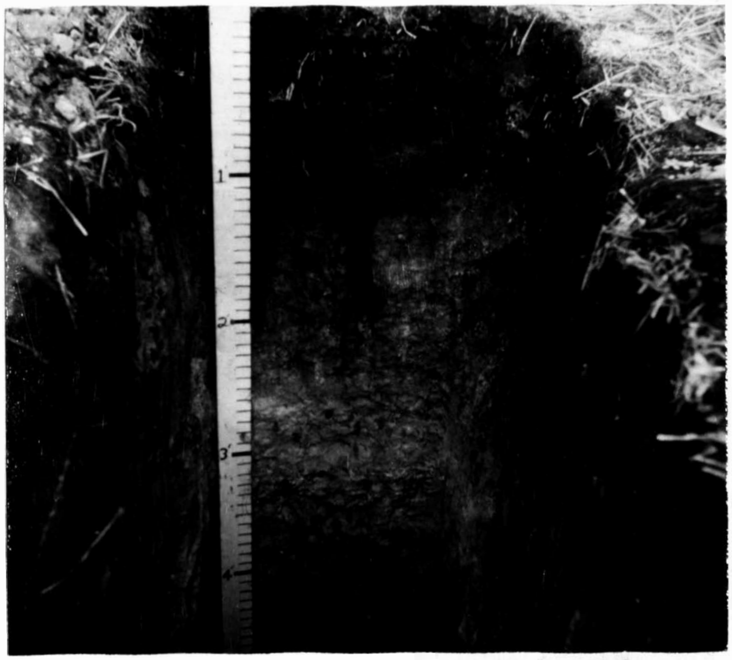


Figure 11. Pit View of Sinai Profile T-3

Figure 12. Laminated Glacio-Lacustrine Parent Material of Sinai Soils

Soil Profile Description - Brookings County T-1

Date: May 9, 1958
Field Name: Sinai silty clay loam
Field Classification: Chernozem
Location: 0.15 mile north and 0.2 mile west of east 1/4 corner of section 31, T112N, R52W, Brookings County, South Dakota
Vegetation: Cropped
Parent Material: Laminated, lacustrine silts and silty clays
Physiography: On crest of nearly level, smooth topped undulation sloping to a closed depression on north and south
Relief: Undulating to strongly undulating countrywise, nearly level sitewise
Slope: Slightly convex, east, 1-2%
Drainage: Well-drained
Profile Moisture: Moist through 60"
Permeability: Moderate to slow
Root Distribution: Concentrated between 0-37", a few scattered to 60"
Stoniness: Surface free, coarse quartz grain in profile from 0-17"
Erosion: Slight

Sinai Silty Clay Loam

Ap	0-6"	Black (10YR 2/1), (10YR 3/1.5 dry); silty clay loam; clods breaking into weak very fine and fine granular structure; soft to slightly hard dry, friable moist; many roots; finely divided, unstained, quartz grains predominate with a few coarse stained grains; noncalcareous; slightly acid; temperature 70° F.; false plow boundary.
B_{21}	6-10"	Very dark grayish brown (1Y 3/2.5), (1Y 5/2 dry); silty clay; the few, thick (1/8"), primary ped color coats are very dark brown (10YR 2.5/1.5), (10YR 3.5/1.5 dry); secondary ped color coats are very dark grayish-brown (1Y 3/2), (1Y 4/2 dry); weak coarse prismatic structure breaking to moderate fine and medium angular and subangular blocky structure; hard dry, friable moist; many roots; many pinholes; finely divided, unstained, quartz grains predominate with a few, coarse, stained grains; many dark colored vertical tongues; thin, continuous and moderate, very patchy clay films on vertical and horizontal faces of primary and secondary peds; noncalcareous; slightly acid; temperature 64° F.; clear smooth boundary.
B_{22}	10-17"	Olive brown (2.5Y 3.5/4), (2.5Y 5.5/3 dry); silty clay, a few, thick (1/8"), primary ped color coats

are very dark brown (10YR 2.5/1.5), (10YR 3/1.5 dry); secondary ped color coats are very dark grayish-brown (2.5Y 3.5/2), (2.5Y 5/2 dry); weak coarse prismatic structure breaking to moderate medium and fine subangular and angular blocky structure; hard to very hard dry, friable moist; common roots; many pinholes; finely divided, unstained quartz grains predominate with a few, coarse, stained grains; many dark colored vertical tongues; thin, continuous and moderate, patchy clay films on vertical and horizontal faces of primary and secondary peds; noncalcareous; neutral; temperature 64° F.; clear wavy boundary.

B2ca	17-26"	Mottled olive brown (2.5Y 4.5/3), (2.5Y 6/2 dry); silty clay loam; common, fine, distinct, dark brown iron stains (7.5YR 4/5), (10YR 5/6 dry); common, medium, faint, gray mottles (5Y 5/1), (5Y 6.5/1 dry); color coats of primary and secondary peds are olive brown (2.5Y 4/4), (2.5Y 6/3 dry); hard to very hard dry, friable moist; common roots; many pinholes; finely divided, unstained, quartz grains; a few dark colored vertical tongues; thin, continuous and moderate, very patchy clay films on vertical and horizontal faces of primary and secondary peds; strongly calcareous with common to many, medium, soft lime segregations; mildly alkaline; temperature 63° F.; clear irregular boundary.
B3ca1	26-30"	Mottled light olive brown (2.5Y 5/4) (2.5Y 6/4 dry); silty clay loam; common, fine, distinct, dark brown iron stains (7.5YR 4/5), (10Y 5/6 dry); a few, fine, distinct, black manganese mottles (10YR 2/1), (10YR 3/1 dry); common, fine, distinct, gray mottles (5Y 5.5/1), (5Y 6.5/1 dry); color coats of primary peds are olive brown (2.5Y 3.5/4), (2.5Y 5.5/2 dry) very weak coarse prismatic structure breaking to weak very coarse laminae which breaks in turn to weak medium horizontal blocky structure; hard to very hard dry, friable moist; common roots; many pinholes; finely divided, unstained, quartz grains; a few, fine, distinct, strong brown iron-manganese pipestem concretions; thin, very patchy clay films on vertical faces of primary peds; moderate to strongly calcareous with common, medium, soft lime segregations; mildly alkaline; temperature 62° F.; clear wavy boundary.
B3ca2	30-37"	No matrix color; silty clay loam; many, medium, distinct, dark yellowish-brown iron stains (10YR 4.5/5), (10YR 5/4 dry); many, medium, distinct, grayish-brown mottles (2.5Y 5/2), (2.5Y 6/1.5 dry); few, fine

distinct, black manganese mottles (10YR 2/1), (10YR 3/1); primary ped color coats are olive brown (2.5Y 4/6), (2.5Y 5.5/3 dry); very weak coarse prismatic structure breaking to weak very coarse laminae which breaks in turn to weak to moderate horizontal blocky structure; hard to very hard dry, friable moist; common roots; common pinholes; finely divided, unstained, quartz grains; many, fine, distinct, strong brown iron-manganese pipestem concretions filling old root channels; moderate to strongly calcareous with common, medium, soft lime segregations; moderately alkaline; temperature 62° F.; gradual wavy boundary.

C_{ca1}	37-46"	Mottled gray (2.5Y 5/1), (2.5Y 6/1 dry); silt loam; common, fine, distinct, dark yellowish-brown iron stains (10YR 4.5/5), (10YR 5/4 dry); a few, fine, distinct, black manganese mottles (10YR 2/1), (10YR 3/1 dry); weak to moderate very coarse laminae breaking to moderate to strong horizontal blocky structure; very hard dry, friable moist; few roots; few pinholes; finely divided, unstained, quartz grains; many, medium, distinct, strong brown iron-manganese pipestem concretions filling old root channels; moderately calcareous with a few, small to medium, soft lime segregations; moderately alkaline; temperature 62° F.; clear smooth boundary.
C_{ca2}	44-60"	Mottled dark grayish brown (2.5Y 4.5/2), (2.5Y 6/1 dry); silty clay loam; a few, fine, distinct, brown iron stains (7.5YR 4/5), (10YR 5/6 dry); a few, fine, distinct, black manganese mottles between laminae faces and in fine bands (10YR 2/1), (10YR 3/1 dry); moderate coarse laminae breaking to moderate to strong coarse horizontal blocky structure; very hard dry, friable moist; few roots; few pinholes; finely divided, unstained, quartz grains; common, medium and coarse, distinct, strong brown iron-manganese pipestem concretions filling old root channels; weak to moderately calcareous with a very few small, soft, lime segregations; moderately alkaline; temperature 62° F.

Remarks: Horizon temperatures taken at 2:00 p.m. at an air temperature of 78° F. Reaction is pH of soil paste using pH limits as defined in soil survey manual. Horizontal blocky structure is a term used for geologic material where prismatic structure dissects laminae.

Soil Profile Description - Kingsbury County T-2

Date: May 5, 1957
Field Name: Sinai silty clay loam
Field Classification: Chernozem
Location: 55 feet north and 0.8 mile west of the southeast corner of section 13, R53W, T111N, Kingsbury County, South Dakota
Vegetation: Cropped
Parent Material: Laminated lacustrine silts and clays
Physiography: On the crest of a nearly level, flat topped undulation
Relief: Undulating countrywise, nearly level sitewise
Slope: Slightly convex, in all directions, 1-2%
Drainage: Well drained
Profile Moisture: Moist thru 60 inches
Permeability: Moderate to slow
Root Distribution: Concentrated between 0-32" with a few to 60"
Stoniness: A few small stones (3-4" in diameter) on the surface, a few pebbles (1/4" in diameter) as well as coarse quartz grains in profile
Erosion: Slight

Sinai Silty Clay Loam

AB_p	0-6"	Black (10YR 2/1), (10YR 3.5/1.5 dry); silty clay loam; a few olive brown particles of B materials mixed throughout this horizon (2.5Y 4.5/4), (2.5Y 5.5/4 dry); clods breaking into very weak and weak fine granular structure; slight hard to hard dry, very friable moist; many roots; finely divided, unstained quartz grains predominate with a few stained grains; noncalcareous; medium acid; temperature 63° F.; false plow boundary.
BA_p	6-9"	Black (1Y 2.5/1), (1Y 3/1 dry); silty clay loam; thick (1/8") primary ped coat colors are black (10YR 3/1 dry), a few olive brown particles of B_2 material in this horizon (2.5Y 3/4) and light olive brown (2.5Y 4.5/4 dry); very weak medium prismatic structure breaking to weak medium and coarse subangular blocky structure, and weak fine granular structure; slightly hard to hard dry, friable moist; many roots; few pinholes; finely divided, unstained quartz grains predominate with a few coarse stained grains; many dark colored, vertical tongues; thin, very patchy clay films on primary structural peds; noncalcareous, medium acid, temperature 59° F., false relict plow boundary.
B_{21}	9-13"	Olive brown (2.5Y 3/4), (2.5Y 5/4 dry); silty clay loam; thick, (1/8"), primary ped color coats are

black (10YR 2.5/1) and very dark gray (1Y 3.5/1 dry); secondary ped color coats are olive brown (2.5Y 4/4) and light olive brown (2.5Y 5/3 dry); weak medium prismatic structure breaking to weak to moderate medium coarse angular blocky structure breaking in turn to moderate fine angular and subangular blocky structure; hard dry, friable moist; many roots, many pinholes; finely divided, unstained quartz grains predominate with a few coarse stained grains; many dark colored vertical tongues; thin, patchy with moderate, very patchy clay films on vertical and horizontal faces of primary and secondary peds; noncalcareous; neutral; temperature 56° F.; gradual wavy boundary.

B_{22} 13-18 1/2" Olive brown (2.5Y 3.5/4), (2.5Y 5/3 dry); silty clay loam; primary ped color coats are very dark gray (10YR 3/1.5), (1Y 3/1.5 dry); secondary ped color coats are olive brown (2.5Y 3.5/3), (2.5Y 5/2 dry); very weak medium prismatic structure breaking to moderate medium subangular blocky structure which breaks in turn to moderate to strong fine angular and subangular blocky structure; very hard dry, friable moist; many roots; many pinholes; finely divided, unstained quartz grains predominate with a very few coarse stained grains; many dark colored vertical tongues; thin, continuous with moderate, patchy clay films on the vertical and horizontal faces of primary and secondary peds; noncalcareous; neutral; temperature 54° F., clear wavy boundary.

B_{2ca} 18 1/2-24" Olive brown (2.5Y 4/4) (2.5Y 6/3 dry); silty clay loam; color coats of primary and secondary peds are olive brown (2.5Y 4/3), brown (2.5Y 5/3 dry); weak to moderate medium prismatic structure breaks to moderate medium and coarse subangular blocky structure which breaks in turn to moderate fine subangular and angular blocky structure; very hard dry, friable moist; common roots; many pinholes; finely divided, unstained quartz grains; many, medium, distinct, strong brown iron-manganese pipestem concretions and a few, fine, distinct, black manganese gunshot concretions; a very few dark colored vertical tongues; thin, patchy with moderate, very patchy clay films on vertical and horizontal faces of primary and secondary peds; moderate to strongly calcareous with a few, medium, soft lime segregations; mildly alkaline; temperature 52° F.; clear wavy boundary.

B_{3ca1} 24-32" Mottled olive brown (2.5Y 4.5/4), (2.5Y 6/3 dry); silty clay loam; common, fine, faint, gray mottles (5Y 5/1), (5Y 6/1 dry); and common, medium, fine, yellowish-brown iron stains (10YR 5/7), (10YR 5/8 dry); and a few, fine, distinct, black manganese mottles on the faces of the horizontal faces of peds (10YR 2/1), (10YR 3/1 dry); no readable color coats; moderate medium short vertical axis prismatic structure breaking to moderate coarse angular blocky structure which breaks in turn to moderate fine and medium subangular blocky structure; very hard dry, friable moist; common roots; many pinholes; finely divided, unstained quartz grains; a few, fine, distinct, iron-manganese pipestem concretions; thin, patchy clay films on vertical and horizontal faces of primary and secondary peds; strongly calcareous with common to many, medium, soft lime segregations; moderately alkaline; temperature 49° F.; clear wavy boundary.

B_{3ca2} 32-36" Mottled olive (5Y 5/3), (5Y 6.5/3 dry); silty clay loam; common, medium, faint, gray mottles (5Y 6/1), (5Y 7/1 dry); and common, medium, distinct, yellow brown iron stains (10YR 5/8), (10YR 6.5/7 dry); and few, fine, distinct, black manganese mottles on the horizontal faces of primary and secondary peds; (10YR 2/1), (10YR 3/1 dry); primary ped color coats are olive (5Y 5/3), (5Y 7/3 dry); weak coarse to very coarse short vertical axis prismatic structure breaking to moderate coarse horizontal blocky structure which breaks in turn to moderate to strong medium horizontal blocky structure; very hard dry, friable to firm moist; few roots; many pinholes; finely divided, unstained quartz grains; a few, fine, distinct iron-manganese pipestem concretions; thin, very patchy clay films on vertical faces of primary peds; moderate to strongly calcareous with few to common, small and medium, soft lime segregations and a few, (1/8-1/4"), bands of soft segregated lime above and adjacent to iron stained bands; moderately alkaline; temperature 48° F.; clear wavy boundary.

C_{ca1} 36-42" No matrix color; silty clay loam; common, medium, distinct, olive gray mottles (5Y 5/2), (5Y 7/1 dry); common, medium, distinct, olive mottles (5Y 5/3), (5Y 6.5/3 dry); few, fine, distinct, black manganese mottles between laminae faces (10YR 2/1), (10YR 3/1 dry); weak very coarse laminae breaking to moderate to strong coarse horizontal blocky structure; very hard dry, friable moist; few roots; many pores; finely divided unstained quartz grains; a few, fine, yellowish-brown iron-manganese pipestem concretions following old root channels; weak to moderately calcareous with a few, small, soft lime segregations; moderately alkaline; temperature 46° F.; clear smooth boundary.

C_{ca2} 42-54" Mottled olive gray (5Y 5/2), (5Y 7/1 dry); silty clay loam; common, fine, distinct, black manganese mottles between laminae faces (10YR 2/1), (10YR 3/1 dry); and diffuse yellowish-brown iron stained bands (10YR 5/6), (10YR 7/6 dry); weak very coarse laminae breaking to moderate very coarse horizontal blocky structure breaking in turn to moderate to strong medium and coarse horizontal blocky structure; hard dry, friable to firm moist; few roots; many pinholes; finely divided, unstained quartz grains; a few, fine, iron-manganese pipestem concretions; weak to moderately calcareous with very few, small, soft lime segregations and common to many, (1/8-1/4") bands of soft segregated lime above and adjacent to iron stained bands; moderately alkaline; temperature 42° F.; clear smooth boundary.

C_{ca3} 54-58" Mottled yellowish-brown (10YR 5/6), (2.5Y 7/6 dry); silty clay loam; common, fine, faint, olive gray bands (5Y 6/1), (5Y 7/1 dry); common, fine, distinct, black manganese mottles between laminae faces (10YR 2/1), (10YR 3/1 dry); weak very coarse laminae breaking to weak to moderate very coarse horizontal blocky structure which breaks in turn to moderate medium horizontal blocky structure; hard dry, friable to firm moist; few roots; many pinholes; finely divided, unstained quartz grains; a few, fine iron-manganese pipestem concretions; moderate to strongly calcareous with a very few, fine bands of soft segregated lime and many, medium bands of segregated lime; moderately alkaline; temperature 42° F.; clear smooth boundary.

C_{ca4} 58-60" Mottled light olive gray (5Y 6/2), (5Y 7/2 dry); silty clay loam; common, fine, distinct, black manganese mottles between laminae faces (10YR 2/1), (10YR 3/1 dry); common, fine, faint, light olive brown stained bands (2.5Y 5.5/6), (2.5Y 7/5 dry); weak very coarse laminae breaking to moderate coarse horizontal blocky structure which breaks in turn to moderate medium horizontal blocky structure; hard dry, friable to firm moist; few roots; many pinholes; a few, fine iron-manganese pipestem concretions; weak to moderately calcareous; moderately alkaline; temperature 40° F.

Remarks: Horizon temperatures taken at 2:45 p.m. at an air temperature of 80° F. Reaction is pH of soil paste using pH limits as defined in the soil survey manual.

Soil Profile Description - Day County T-3

Date: April 26, 1958
Field Name: Sinai silty clay loam
Field Classification: Chernozem
Location: 0.35 mile north and 0.15 mile west of section 6, T122N, R55W, Day County, South Dakota
Vegetation: Cropped
Parent Material: Laminated lacustrine silts and clays
Physiography: On crest of a nearly-level topped mesa-like undulation
Relief: Strongly undulating to rolling countrywise, nearly level sitewise
Slope: Very slightly convex, east-southeast, 1-2%
Drainage: Well drained
Profile Moisture: Moist to 32", slightly moist to 56", moist to 60"
Permeability: Moderate to slow
Root Distribution: Many to 32", a few to 60"
Stoniness: Surface free, profile free
Erosion: Slight

Sinai Silty Clay

A_{1p}	0-8"	Black (10YR 2/0.5), (10YR 2/1 dry); silty clay, coat colors are black (10YR 2/1), (10YR 3/1 dry); clods break into very weak fine granular structure; slightly hard dry, friable moist; many roots; many, small and medium, unstained, quartz grains and a few, coarse, stained ones; noncalcareous; slightly acid; horizon temperature 37° F.; false plow boundary.
B_{21}	8-12"	Dark grayish-brown (2.5Y 4/2), (2.5Y 5/2 dry); silty clay, thick (1/8"), primary ped color coats are black (10YR 2/1), (10YR 2.5/1 dry); secondary ped color coats are very dark grayish brown (1Y 2.5/2), (1Y 4/2 dry); very weak coarse prismatic structure breaking into moderate very fine and fine angular and subangular blocky structure; hard dry, friable moist; many roots, a few pinholes; many, finely divided, unstained, quartz grains and a few, coarse, stained grains; many dark colored vertical tongues; moderate, continuous clay films on vertical and horizontal faces of primary and secondary peds; noncalcareous; neutral; temperature 36° F.; clear gradual boundary.

B_{22} 12-15" Olive brown (2.5Y 3.5/4), (2.5Y 5/3 dry); silty clay; thick (1/8"), primary ped color coats are black (10YR 2/1), (10YR 2.5/1 dry); secondary ped color coats are dark gray (2.5Y 4/1), (2.5Y 5/2 dry); very weak coarse prismatic structure breaking into moderate fine and very fine angular and subangular blocky structure; hard dry, friable moist; many roots; a few pinholes; a few, finely divided, quartz grains and a few, medium, stained grains; many dark colored vertical tongues; moderate, continuous and thick, patchy clay films on vertical and horizontal faces of primary and secondary peds; noncalcareous; mildly alkaline; temperature 36° F.; abrupt wavy boundary.

B_{2ca1} 15-21" Olive brown (2.5Y 4/3), (5Y 6/2 dry); silty clay, primary ped coat colors are black (10YR 2/1), (10YR 3/1 dry); secondary ped coat colors are dark gray (2.5Y 4/1), (2.5Y 5/2 dry); weak coarse prismatic structure breaking into weak very coarse blocky structure which breaks in turn to weak to moderate fine and very fine angular and subangular blocky structure; hard dry, friable moist; many roots; few to common number of pinholes; a few, finely divided, unstained, quartz grains and many, coarse, stained grains; many dark colored vertical tongues; diffuse, yellowish-brown iron staining adjacent to old root channels; moderate, continuous and thick, very patchy-clay films on vertical and horizontal faces of primary and secondary peds; weak to moderately calcareous; mildly alkaline; temperature 36° F.; clear smooth boundary.

B_{2ca2} 21-26" Mottled olive (5Y 4.5/3), (5Y 6/2.5 dry); silty clay; common, medium, distinct, dark yellowish-brown iron stains adjacent to old root channels (10YR 4/6), (10YR 5/6 dry); coat colors are dark grayish-brown (2.5Y 4/2), (2.5Y 5.5/2 dry); very weak coarse prismatic structure breaking to weak very coarse blocky structure which breaks in turn to weak fine and very fine angular and subangular blocky structure; hard dry, friable to firm moist; many roots; common number of pinholes; few, finely divided, unstained, quartz grains and a few, medium, stained grains; a few dark colored vertical tongues; thin, continuous and moderate, patchy clay films on vertical and horizontal faces of primary and secondary peds; moderately calcareous with a very few, medium, diffuse, lime segregations and a few bands of lime between horizontal faces of peds; moderately alkaline; temperature

37° F.; clear smooth boundary.

$B_{2ca}3$ 26-32" Mottled pale olive (5Y 6/3), (5Y 7/2.5 dry); silty clay; common, medium, distinct, yellowish-brown iron stains (10YR 5/8), (10YR 5/6 dry); and common, fine, faint, grayish-brown mottles (2.5Y 5.5/1), (2.5Y 7/1 dry); coat colors are grayish-brown (2.5Y 5/2), (2.5Y 7/3); very weak coarse prismatic structure breaking to very weak coarse blocky structure breaking in turn to weak medium and fine angular and subangular blocky structure; hard dry, friable to firm moist; many roots; common to many pinholes; many, finely divided, unstained, quartz grains and a few, small, stained grains; a few, fine, distinct, yellowish-brown vertical iron-manganese pipestem concretions; a few dark colored vertical tongues; thin, continuous with moderate, patchy clay films on vertical faces and moderate, patchy clay films on horizontal faces of primary and secondary peds; moderate to strongly calcareous with a few, medium, diffuse, lime segregations and a few bands of lime between horizontal faces of peds; mildly alkaline; temperature 36° F.; clear smooth boundary.

$B_{3ca}1$ 32-40" Mottled light olive brown (2.5Y 5/5), pale yellow (2.5Y 7/4 dry); silt loam; mottling in form of a few, fine, distinct, gray bands (5Y 6/1), light gray (5Y 7/1 dry); coat colors are light olive brown (2.5Y 5/5), light-yellowish-brown (2.5Y 6.5/4 dry); very weak very coarse prismatic structure breaking to weak to moderate very coarse laminae; slightly hard to hard dry, very friable moist; a few roots; common to many pinholes; finely divided, unstained, quartz grains; a few, fine, distinct, strong brown vertical iron-manganese pipestem concretions; moderate, very patchy clay films on horizontal and vertical faces of primary and secondary peds; strongly calcareous; moderately alkaline; temperature 36° F.; clear smooth boundary.

$B_{3ca}2$ 40-43" Mottled light olive brown (2.5Y 5/4), (5Y 6/3 dry); silty clay; a few, fine, distinct, black manganese stains on laminae faces (10YR 2/1), (10YR 3/1 dry); a few, fine, faint, gray mottles (N 5/0), (N 7/0 dry); and a few, medium, distinct, brownish-yellow iron stains between laminae faces (10YR 6/8), (10YR 5/8 dry); very weak coarse prismatic structure breaking to moderate medium and fine laminae which break in turn to moderate to strong very fine horizontal blocky structure; slightly hard dry; friable moist;

a few roots; many, finely divided, unstained, quartz grains; a few, fine, distinct, strong brown vertical iron-manganese pipestem concretions; thin, very patchy clay films on vertical faces of primary peds; strongly calcareous with diffuse, soft lime segregations banded between laminae; moderately alkaline; temperature 36° F.; clear smooth boundary.

C_{ca1}	43-56"	Mottled light olive brown (2.5Y 5/4), (2.5Y 7/1 dry); silty clay; a few, fine, distinct, black manganese stains on laminae faces (10YR 2/1), (10YR 3/1 dry); and common, medium, distinct, gray mottles (5Y 6/1), (5Y 7/1 dry); very weak very coarse laminae breaking to weak medium and coarse laminae which break in turn into weak fine laminae; slightly hard dry, very friable moist; few roots; finely divided unstained quartz grains; common, medium, distinct, strong brown vertical iron-manganese pipestem concretions; moderately calcareous; moderately alkaline; temperature 37° F.; abrupt smooth boundary.
C_{ca2}	56-60"	No matrix color; silty clay; common, medium, faint, olive gray mottles (5Y 5/2), (5Y 7/2 dry); a few, fine, distinct, black manganese stains (10Y 2/1), (10YR 3/1 dry); and common, medium, faint, olive mottles (5Y 5/3), (5Y 7/3 dry); weak to moderate coarse laminae breaking to moderate to strong fine and medium fragmentary laminae; very hard dry very firm moist; a few roots; a very few, finely divided, unstained, quartz grains; a few fine, distinct, iron-manganese pipestem concretions; weak to moderately calcareous, moderately alkaline, temperature 38° F.

Remarks: Horizon temperatures taken at 8:45 p.m. at an air temperature of 41° F. Reaction is pH of soil paste using pH limits as defined in soil survey manual. An olive gray, clay horizon 47-48" was not sampled. Also at 38 1/4-39" a horizon of bedded lime mixed with silts was not sampled.

Soil Profile Description - Day County T-4

Date: May 9, 1958
Field Name: Sinai silty clay loam
Field Classification: Chernozem
Location: 145 feet east and 0.2 mile south of center of section 36, T124N, R57W, Day County, South Dakota
Vegetation: Cropped

Parent Material: Stratified silts, silty clays, loams and loamy sands
Physiography: On crest of a nearly level topped mesa-like undulation
Relief: Strongly undulating to rolling countrywise, nearly level sitewise
Slope: Slightly convex, east, 1-2%
Drainage: Well drained
Profile Moisture: Moist to 56", dry to 60"
Permeability: Moderate to slow 0-45", moderate 45-56", 56-60" moderately rapid
Root Distribution: Many to 38", a few to 60"
Stoniness: A few small pebbles on the surface, an occasional pebble (1/2-1") in profile, common pebbles (1/8-1/4") in sandy lenses
Erosion: Slight

Sinai Silty Clay Loam

A_{1p}	0-6"	Black (10YR 2/0.5), (10YR 2/1 dry); silty clay loam; clods break to weak fine and medium granular structure; slightly hard dry, friable moist; many roots; many, small, unstained, quartz grains and a few, medium, coarse grains; noncalcareous, medium acid; temperature 58° F.; false plow boundary.
B_{21}	6-10"	Dark grayish-brown (2.5Y 4/2), (1Y 4.5/2 dry); silty clay; thick (1/8"), primary ped color coats are black (10YR 2/0.5), (10YR 2/1 dry); secondary ped color coats are very dark grayish-brown (1Y 3/2), (1Y 4/2 dry); moderate medium and coarse prismatic structure breaking to weak to moderate fine and medium subangular blocky structure; hard dry, friable moist; many roots; a few pinholes; many, small unstained, quartz grains and a few, medium, stained grains; many dark colored vertical tongues; thin, continuous and moderate, patchy clay films on vertical and horizontal faces of primary and secondary peds; noncalcareous; neutral; temperature 58° F.; clear smooth boundary.
B_{22}	10-14"	Dark grayish-brown (2.5Y 4/2) (2.5Y 5/3 dry); silty clays; thick (1/8"), primary ped color coats are black (10YR 2/0.5), (10YR 2/1 dry); secondary ped color coats are very dark grayish-brown (2.5Y 2.5/2), (2.5Y 4.5/2 dry); weak to moderate medium and coarse prismatic structure breaking to weak coarse and medium subangular blocky which breaks in turn to moderate medium angular and subangular blocky structure; hard dry, friable moist; many roots, a few pinholes; a few, small, unstained, quartz grains and a few, medium, stained grains; many dark colored vertical

tongues; moderate, continuous with thick very patchy clay films on vertical and horizontal faces of primary and secondary peds; noncalcareous, neutral; temperature 54° F.; abrupt wavy boundary.

B_{2ca1} 14-18" Olive brown (2.5Y 4.5/3), (5Y 6/2.5 dry); silty clay; thick (1/8"), primary ped color coats are black (10YR 2/1), (10YR 3/1 dry); secondary ped color coats are dark grayish-brown (2.5Y 4.5/2), (2.5Y 5.5/3 dry); weak medium prismatic structure breaks to weak to moderate medium subangular blocky structure which breaks in turn to weak to moderate fine and medium angular and subangular blocky structure; hard dry, friable moist; many roots; common number of pinholes; common, small, unstained, quartz grains and a few, medium, stained grains; many dark colored vertical tongues; moderate, continuous clay films on vertical and horizontal faces with thick, very patchy clay films on vertical faces of primary and secondary peds; weak to moderately calcareous; mildly alkaline; temperature 56° F.; clear smooth boundary.

B_{2ca2} 18-22" Light olive brown (2.5Y 5/4), (5Y 6.5/3 dry); silty clay; coat colors are olive (5Y 5/3), (5Y 6/2.5 dry); weak to moderate coarse prismatic structure breaking to weak to moderate coarse angular blocky structure which breaks in turn to weak to moderate fine and medium angular and subangular blocky structure; hard dry, friable moist; many roots; common pinholes; many, finely divided, unstained, quartz grains and a very, few, medium, stained grains; diffuse, common, medium, distinct, yellowish-brown iron stains adjacent to old root channels; many dark colored vertical tongues; thin, continuous and moderate, patchy clay films on vertical and horizontal ped faces of primary and secondary peds; moderately calcareous with a very few, small, diffuse, soft lime segregations, and diffuse banding of lime between horizontal faces of peds; moderately alkaline; temperature 50° F.; clear smooth boundary.

B_{2ca3} 22-29" Mottled olive (5Y 4.5/4), (5Y 6.5/3 dry); silty clay loam; common, medium, distinct, strong brown iron stains adjacent to old root channels (7.5YR 5/8), (10YR 5/8 dry); coat colors are olive brown (2.5Y 4/4), (5Y 5.5/2.5 dry); weak to moderate coarse prismatic structure breaking into weak to moderate coarse angular blocky structure which breaks in turn to weak very coarse and coarse horizontal blocky structure; hard dry, friable moist; many roots; many pinholes; many, small unstained, quartz grains and a few, coarse, stained grains; common, medium, distinct, black manganese-pipestem concretions; many dark colored vertical tongues; thin, continuous clay films on vertical and horizontal faces and moderate, patchy clay films on vertical faces of primary and secondary peds; moderate to strongly calcareous with a very few, small, diffuse, lime segregations, and diffuse banding of lime between horizontal faces of peds; moderately alkaline; temperature 52° F.; clear smooth boundary.

B_{3ca1} 29-32" Mottled olive brown (2.5Y 4.5/4), (5Y 6/3 dry); clay loam; many, medium, distinct, strong brown iron stains adjacent to old root channels (7.5YR 5/6), (10YR 6/8 dry); and few, fine, distinct, gray mottles (5Y 5/1), (5Y 7/1 dry); coat colors are olive (5Y 4/4), (5Y 5.5/2.5 dry); weak coarse prismatic structure breaks to moderate very coarse laminae which breaks in turn to moderate medium and coarse horizontal blocky structure; hard to slightly hard dry, friable moist; many roots; many pinholes; many, small, unstained, quartz grains and a few, small, stained grains; common, medium, distinct, black manganese pipestem concretions; very thin lenses of very fine sands occur between horizontal faces of peds; a few dark colored vertical tongues; thin, continuous clay films on vertical faces and thin, very patchy clay films on horizontal faces of primary and secondary peds; moderate to strongly calcareous with a very few, small, diffuse, soft lime segregations and diffuse banded lime between horizontal faces of peds; moderately alkaline; temperature 48° F.; clear smooth boundary.

B_{3ca2} 32-38" Mottled light olive brown (2.5Y 5/4), (5Y 6/3 dry); clay loam; a few, fine, distinct, black manganese mottles on horizontal faces of peds (10YR 2/1), (10YR 3/1 dry); common, fine, distinct, dark yellowish-brown iron stains on horizontal faces of structural units (10YR 4/6), (10YR 5/8 dry); and common, medium, faint, gray mottles (5Y 5/1), (5Y 6/1 dry); coat colors are olive gray (5Y 5/2.5), (5Y 6/2.5 dry); very weak coarse prismatic structure breaking to moderate very coarse laminae which breaks into weak to moderate medium horizontal blocky structure; hard dry, friable moist; a few roots; many pinholes; many, small, unstained quartz grains and a very few, small, stained grains; a common number of iron-manganese pipestem concretions, some of which are black and others strong brown; very thin lenses of fine sands between horizontal faces of peds; thin, continuous clay films on vertical faces of primary peds; moderate to strongly calcareous with a very few, small, diffuse, soft lime segregations and diffuse banded lime between horizontal faces of peds; moderately alkaline; temperature 48° F.; clear smooth boundary.

B_{3ca3} 38-45" Mottled light olive gray (5Y 6/2.5), (5Y 7/2.5 dry); clay loam; a few, fine, distinct, black manganese mottles on horizontal faces of peds (10YR 2/1), (10Y 3/1 dry); and common, medium, distinct, yellowish-brown iron stains (10YR 5/6), (10YR 6/8 dry); very weak coarse prismatic structure breaking to moderate to strong very coarse laminae which breaks to moderate medium of fine horizontal blocky structure; hard dry, friable moist; a few roots, many pinholes; many, small, unstained, quartz grains and a common number of small stained grains; many (1/4-3/4" in diameter), vertical, strong brown iron-manganese pipestem concretions, a few, thin (1/8-1/4") lenses of fine sand interspersed between silty clay loam laminae; thin, patchy clay films on vertical faces of primary peds; strongly calcareous with common, small, soft lime segregations, and many seams and bands of lime 1/8" thick; moderately alkaline; temperature 48° F.; clear smooth boundary.

DB_{3ca} 45-56" Mottled olive (5Y 5/3), (5Y 6/3 dry); loam; many, medium, distinct, black manganese stains between faces of laminae (10YR 2/1), (10YR 3/1 dry); and many, medium, faint, olive gray mottles (5Y 5/2), (5Y 6.5/2 dry); very weak coarse prismatic structure breaking to weak to moderate very coarse laminae which breaks into weak medium and coarse horizontal blocky structure; hard dry, friable to firm moist; a few roots; many pinholes; many, small, unstained, quartz grains and many, small, stained grains; many strong brown, vertical iron-manganese concretions, iron-stained lenses of fine sands (1/2-1" thick) interspersed between loam laminae every 3-4 inches; thin, very patchy clay films on vertical faces of primary peds; strongly calcareous with common, small, soft lime segregations and many seams and bands of lime 1/8" thick; moderately alkaline; temperature 48° F.; clear smooth boundary.

D_{ca} 56-60" Multicolored, olive brown (2.5Y 4/4), (1Y 6/4 dry); loamy sand; very weak coarse and medium horizontal blocky structure breaking to single grain structure; soft dry, loose moist; a few roots; many, medium, unstained, quartz grains and many, small, stained grains; iron-manganese staining in thin bands; weak to moderately calcareous; moderately alkaline; temperature 46° F.

Remarks: Horizon temperatures taken at 5:45 p.m. at an air temperature of 76° F. Reaction is pH of soil paste using pH limits as defined in the soil survey manual. In sampling from 32-56" the sand lenses were avoided where possible; however very thin lenses of very fine sands coating laminae faces are probably the reason for clay loam and loam textures in these horizons. Pinholes increase in number and decrease in size with depth.

Soil Profile Description - Minnehaha County T-5

Date: August 15, 1956
Correlation Sample: S-56-SD-50-4-(1-7)
Field Name: Sinai silty clay loam
Field Classification: Chernozem
Location: 175 feet south and 370 feet west of the northeast corner of section 19, T104N, R52W, Minnehaha County, South Dakota
Vegetation: Cropped; 24-30" growth of pigeon grass in oat stubble
Parent Material: Glacio-lacustrine deposits - materials appear to be two storied
Physiography: Nearly level top of a mesa-like undulation; not as pronounced as Sinai positions in Brookings County
Relief: Undulating countrywise, nearly level sitewise
Slope: Convex, east, 1-2%
Drainage: Well drained (manual class)
Profile Moisture: Moist 0-19", dry 19-60"
Permeability: 0-36" moderate, 36" moderately slow
Root Distribution: Primary zone 0-19", secondary zone 19-44", few scattered below 44"
Stoniness: Surface free; some small quartz grains in the profile from 0-28" but free below 28"
Erosion: Slight

Sinai Silty Clay Loam

(4568) A_{1p} 0-8" Dark gray to dark grayish-brown (10YR 4/1.5 dry) with very dark gray ped coatings (10YR 3/1 dry); and very dark gray to very dark grayish-brown (10YR 3/1 moist) with black ped coatings (10YR 2/1 moist); slightly hard dry, friable moist; noncalcareous silty clay of cloddy to weakly developed fine granular and crumb structure. Thin, very patchy clay skins on a few of the secondary structural units. Quartz grains predominantly finely divided and bleached with some bleached quartz grains and some stained quartz grains also observed. Horizon temperature *70° F. This changes with a false plow depth boundary but with dark colored tongues extending into

(4569) B_2 8-19" Grayish-brown to light brownish-gray (2.5Y 5.5/2 dry) with dark gray to dark grayish-brown ped coatings (10YR 4/1.5 dry); and olive brown (2.5Y 4/3 moist) with very dark gray to very dark grayish-brown ped coatings (10YR 3/1.5 moist); hard dry, firm moist; noncalcareous silty clay of weakly to moderately developed medium prismatic breaking to moderate to strongly developed fine and very fine subangular blocky structure. Moderate, continuous and thick, patchy clay skins on both the vertical and horizontal faces of the primary structural peds and around the secondary structural units. Quartz grains predominantly bleached and finely divided with some coated, bleached quartz grains and some coated, stained quartz grains also observed. A few pinholes scattered throughout the horizon. Horizon temperature *74° F. This changes clearly but with a wavy boundary and with dark colored tongues extending into

(4570) B_{2cal} 19-28" Light olive brown (2.5Y 5/3 dry) with a few, medium, distinct, light brownish-gray mottles (2.5Y 5/2 dry) and a few, fine, distinct, strong brown iron stains (7.5YR 5/6 dry) and with light grayish-brown ped coatings (2.5Y 5/2 dry); and olive brown (2.5Y 4/3 moist) with a few, medium, distinct, grayish-brown mottles (2.5Y 5/2 moist) and a few, fine, distinct, dark brown to brown iron stains (7.5YR 4/4 moist) and with very dark grayish-brown ped coatings (2.5Y 4/2 moist); hard dry, firm moist; moderately calcareous silty clay loam with common to many, medium and large, soft, lime segregations, a very few of which have small, hard, lime concretions as cores. Weakly developed medium coarse prismatic breaking to moderately developed medium, fine, and very fine subangular blocky structure. Moderate, continuous and thick, very patchy clay skins on both the vertical and horizontal faces of the primary structural peds and around the secondary structural units. Quartz grains predominantly finely divided and bleached with some coated, bleached quartz grains also observed. Pinholes common throughout the horizon. Horizon temperature *71° F. This grades with a wavy boundary into

(4571) B_{2ca2} 28-36" No matrix color with many, medium, distinct, light olive brown and light gray mottles (2.5Y 5/3 and 7/1 dry) and a few, fine, prominent yellowish-brown iron stains (10YR 5/8 dry) and with grayish-brown ped coatings (2.5Y 5/2 dry); and no matrix color with olive brown and gray mottles (2.5Y 4/3 and 5/1 moist) and dark yellowish-brown iron stains (10YR 4/4 moist) and with dark grayish-brown ped coatings (2.5Y 4/2 moist); moderately to strongly calcareous silty clay loam with common to many, medium and large, soft, lime segregations oriented along the horizontal planes of the blocky structure as short, thin bands a very few of which have small, hard, lime concretion cores. Weakly developed, medium and coarse prismatic breaking to moderately developed medium, fine, and very fine subangular/angular blocky structure. Thin continuous, and moderate patchy and thick very patchy clay skins on both the vertical and horizontal faces of the primary structural peds and around the secondary structural units. Only finely divided, bleached quartz grains observed. Iron replacements in root channels starting in this horizon. Pinholes common throughout the horizon. Horizon temperature *71° F. This grades with a wavy boundary into

(4572) B_{2ca}- B_{3ca} 36-44" Light brownish-gray to light gray (2.5Y 6.5/2 dry) with yellowish-brown iron stained root channels (10 YR 5/6 dry); and gray (2.5Y 5/1 moist) with dark brown iron stained root channels (7.5YR 3/4 moist); very hard dry, very firm moist; weakly to moderately calcareous silty clay loam with a few to common, medium, soft, lime segregations. Very weakly developed coarse and medium prismatic breaking to moderately to strongly developed medium and fine angular/horizontal blocky structure. Thin continuous, and moderate patchy, and thick very patchy clay skins on both the vertical and horizontal faces of the primary structural peds and around the secondary structural units. Only finely divided, bleached quartz grains observed. A few pinholes scattered throughout the horizon. Iron replacements in old root channels continuing in this horizon. Horizon temperature *70° F. This grades with a wavy boundary into

(4573) B_{3ca1} 44-50" Light brownish-gray to light gray (2.5Y 6.5/2 dry) with common, large, distinct light yellowish-brown mottles (2.5Y 6/3 dry) and with brownish-yellow iron stained root channels (10YR 6/6 dry); and dark grayish-brown to grayish-brown (2.5Y 4.5/2 moist) with dark grayish-brown to dark brown mottles (10YR 4/2.5 moist) and dark brown iron stained root channels (7.5YR 3/4 moist); very hard dry, very firm moist; weakly to moderately calcareous silty clay loam with a few, small, soft, lime segregations. Very weakly developed coarse and medium prismatic breaking to moderately to strongly developed medium and fine angular/horizontal blocky structure. Thin continuous, moderate patchy, and thick very patchy clay skins on the vertical faces of the primary structural peds and around the secondary structural units. A few pinholes scattered throughout the horizon. Iron replacements in old root channels continuing but gradually becoming larger in this horizon. Quartz grains predominantly finely divided and bleached. Horizon temperature *66° F. This grades with a wavy boundary into

(4574) B_{3ca2} 50-60" Light gray (2.5Y 7/1 dry) with a few, medium, distinct, pale olive mottles and yellowish-brown iron stained root channels (10YR 5/4 dry); and gray (2.5Y 5/1 moist) with dark grayish-brown to dark brown mottles (10YR 4/2.5 moist) and dark yellowish-brown iron stained root channels (10YR 4/4 moist); very hard dry, very firm moist; weakly calcareous silty clay loam of moderately to strongly developed medium angular/horizontal blocky structure. Thin, patchy clay skins on the vertical faces of the primary structural peds. Quartz grains finely divided and bleached. A few pinholes scattered throughout the horizon. Iron replacements in root channels are larger and more pipestem-like in this horizon and tend to run horizontally. Horizon temperature *64°F.

Not Sampled 60-70" About the same in all respects as the 50-60" horizon.

Not Sampled 70-100" Stratified: strongly iron stained sand lenses alternating with moderately fine textured, comparatively quartz free sediments high in accumulated lime. Pebble lag at contact with underlying material.

Not Sampled 100" Clay loam glacial till

Remarks: *Profile temperatures taken at 10:30 a.m. at an air temperature of 85° F.

G. J. B. / 3-1-57 (5)

TABLE I. THICKNESS OF HORIZONS OF FIVE SINAI PROFILES

Horizon	Sinai Profiles				
	Northern		Central		Southern
	Day T-3	Day T-4	Brookings T-1	Kingsbury T-2	Minnehaha T-5
Alp, Ap	0-8	0-6	0-6		0-8
ABp				0-6	
BAp				6-9	
B2	8-15	6-14	6-17	9-18	8-19
B2ca	18-32	14-29	17-26	18 -24	19-36
B2ca-B3ca					36-44
B3ca	32-43	29-45	26-37	24-36	44-60
Cca	43-60		37-60	36-60	
DB3ca			45-56		
Dca			56-60		

TABLE II. AVERAGE MOIST COLOR OF HORIZONS OF THE NORTHERN, CENTRAL, AND SOUTHERN SINAI PROFILES

Horizon	Sinai Profiles		
	Northern	Central	Southern
Alp, Ap	(10YR 2/0.5)* black	(10YR 2/1) black	(10YR 3/1) very dark grayish-brown
ABp		(10YR 2/1) black	
BAp		(1Y 2.5/1) black	
B2	(2.5Y 4/2) dark grayish-brown	(2.5Y 3.5/4) olive brown	(2.5Y 4/3) olive brown
B2ca	(5Y 4.5/3) light olive gray	(2.5 4.5/4) olive brown	(2.5Y 4/3) olive brown
B2ca-B3ca			(2.5Y 5/1) gray
B3ca			(2.5Y 5/1) gray
Cca	(2.5Y 5/4) light olive brown	(5Y 5/2) olive gray	
DB3ca	(5Y 5/3) olive		
Dca	(2.5Y 4/4) olive brown		

* Munsell color notations are for the moist, broken face or crushed ped colors. (Crushed colors were read on the Alp and Ap horizons whereas broken face colors were read on all other horizons).

Discussion of Descriptions

Soil Development

From Table I it may be noted that the southern Sinai profile, T-5, is developed to a greater depth than either the northern or central Sinai profiles. The greater depth of development in this profile may be related to the greater quantity of precipitation that is received during the frost-free period in this region. It may also be due in part to the establishment of vegetation with deeper, denser, root systems during the genesis of this soil. The degree of profile development taking place within a given time on a given parent material and under the same type of vegetation seems to depend largely on the amount of water passing through the soil. It appears that the northern Sinai profiles, T-3 and T-4, are developed to a greater depth than the central profiles, T-1 and T-2. This is difficult to explain since a greater amount of warm season precipitation is received in the central area than in the northern. In Figure 4 the charts showing annual length of drought season indicate that the soil moisture is less limiting in the northern area during July and August than in the central section and least limiting in the southern area during these months.

The profile descriptions of these soils indicate that profile T-5 is slightly more strongly developed to a greater depth than the other Sinai profiles. Generally the strongest developed B2 horizon of the northern profiles occurs immediately below the A horizon. This is in contrast to southern profiles which express the strongest development in the lower part of the B2 horizon.

Soil Color

The color of a soil throughout the profile has an important bearing on many characteristics that influence the genesis of a soil. It is usually a reliable indicator of organic matter and internal drainage, but in the Sinai soils the color of only the upper portion of the profile is apparently related to soil genesis. Mottled colors relatively close to the surface in these soils are attributed to relict gleying conditions present during the origin of the parent glacio-lacustrine sediments and are considered to be lithochromic colors. Subsequently, well-drained conditions have resulted in a profile which has color characteristics of a well-drained soil in the upper portion of the solum and mottling of an imperfectly drained soil in the lower solum and substratum.

From Table II it may be seen that the average moist, broken face or crushed ped colors vary somewhat among these five Sinai samples. The northern and central profiles have surface horizons which are 0.5 - 1 unit lower in chroma and one unit lower in value, than the southern profile, T-5. The northern samples, T-3 and T-4, have B2 horizons 1 - 2 units lower in chroma than the central and southern profiles. Profiles T-3 and T-4 have yellower colored B2ca horizons than the central or southern profiles. The northern samples have 5Y hue B2ca horizons whereas the central and southern profiles have 2.5Y hue B2ca horizons. In comparing moist colors of the secondary ped color coats, the southern profile has 10YR hue color coats in contrast to more yellow 1Y and 2.5Y hue color coats of the central and northern profiles.

Greater value and chroma in the A and B2 horizons of the southern Sinai profile may be attributed to three factors: (a) in the southern area there are higher temperatures and greater precipitation during the growing season, hence more rapid oxidation of organic matter; (b) formation of greater quantities of unhydrated iron oxides in the B2 horizon of these soils; and (c) greater removal of organic matter by water erosion and leaching in this area.

Soil Consistence

Soil consistence is the term applied to the attributes of soil material that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation and rupture. Comparing moist consistence of these five Sinai profiles it may be noted that the southern profile, T-5, has firm and very firm B2 and B2ca horizons in contrast to friable consistence for these same horizons in the northern and central profiles. The B3ca horizons in profile T-5 are very firm while in northern and central profiles the B3ca horizons are friable or friable to firm. Dry consistence of various horizons varies little between these five profiles.

Tonguing

Vertical tongues of dark colored surface material extend to depths ranging from 30 to 40 inches in these soils. These tongues are believed to result from sloughing of A material into large cracks which are formed by shrinkage of these fine-textured materials during periods of low soil moisture. Extensive tonguing in the Sinai soils is a characteristic common to young Grumusols.

Detailed Field Sheets

The following field sheets were made using aerial photographs

(8" = 1 mile) as a base map. They have been reduced to a scale of six inches to the mile for thesis publication. The conventional signs and special symbols used on these field sheets are consistent with those listed in the USDA Handbook No. 18 (33). The only exception to this is the use of a different symbol to represent a wet spot or depressional area. On these field sheets depressional areas are enclosed within a boundary that has a solid line joining two opposite sides approximately in the middle of the area. All field examinations were accomplished using a 5 foot soil auger and an 18" tile spade.

Discussion of Detailed Field Sheets

It has often been said that a soil is known by its soil associates. Figures 13 through 18 are color coded detailed field sheets which show the areal relationships between the Sinai soils and their more important soil associates. Figure 18 is a soil map which surrounds a previously described and sampled Minnehaha County, South Dakota Sinai sampling site. The profile description and laboratory data for this soil are not reported in this study because it was felt that this sample did not represent the well-drained Sinai soils of this region.

In coloring the field sheets, all soils derived from glacial drift parent materials are coded according to the key shown below each figure. Generalized soil areas shown on these maps include mapping units which vary in drainage and slope characteristics. Except for the Poinsett and Sinai delineations, all soil areas which include a complex of two soil mapping units are colored according to the dominant unit of the complex. The Sinai and Poinsett soils are colored so that they include only members of their own catenas. The Sinai-Poinsett complex and the Poinsett-Sinai complex are grouped into one soil area. Complexes of either the Sinai or Poinsett soils with other soil mapping units are also shown as separate soil areas. In order to determine the approximate acreages of each generalized soil area the field sheets were gridded and the percentage of each generalized soil area is shown below the figure.

The Sinai soils aggregate approximately 10 to 20 per cent of the landscape in the areas mapped for this study. They appear to be distributed in more discrete mapping units of smaller size in the central and southern soil maps than in the two northern soil maps. These soils are closely associated with the Poinsett soils derived from silty glacial drift. The soil maps shown in Figures 17 and 18 indicate that in the southern area of this study the Sinai soils are closely associated with soils derived from loam glacial drift in addition to the Poinsett associates. Together these two soil associates occupy approximately 25 per cent of the area. Figures 13 and 14 indicate that in the central area the Sinai soils are closely associated with Poinsett soils which make up 20 to 40 per cent of the landscape. The soil maps shown in figures 15 and 16 indicate that in the northern area the Poinsett-Barnes complex and the Poinsett soils comprise from 20 to 30 per cent of the landscape.

Sinai soils not infrequently have the following soil associates on relatively steep slopes which flank nearly level summits. On 3 to 6 per cent fringe slopes surrounding summits, Sinai or Poinsett soils usually occur. Adjacent 7 to 15 per cent slopes are frequently occupied by Poinsett soils, soils derived from loam glacial drift, or till derived soils. In general the soils become coarser textured and more stony with descent from the summits to the depressions.

In an undulating landscape expressing a weakly developed integrated surface drainage system, the predominant Sinai soil associates are the Poinsett soils and soils derived from loam glacial drift. In this landscape, islands of soils derived from loam-clay loam till and loam glacial drift are interspersed without a detectable pattern between the predominant Poinsett and Sinai soils.

The soil map in Figure 15 shows a sizeable area of soils derived from gravelly alluvial sediments or ice-contact stratified drift. Apparently there is considerable variation in the distribution of these soils in Day County since another soil map in this same general area shows no delineations of this mapping unit.

The Ahnberg-like soils of the northern area frequently occupy the nearly level crests of upland undulations. This is in contrast to their southern equivalents which occur most frequently on relatively steep abrupt slopes adjacent to upland drainageways.

During the course of making these detailed soil maps it was noted that considerable variation in depth of leaching occurs in the Sinai soils within any one area. There is a general tendency, however, for these soils to be leached to slightly greater depths in the southern area than in the northern and central areas.

The percentage areal distribution of intrazonal, zonal-intrazonal intergrade, and zonal-azonal intergrade orders of soils was obtained by gridding the field sheets. In the northern, central, and southern areas, the average percentage of intrazonal soils is 12, 1, and 5 per cent respectively. Zonal-intrazonal intergrades in these same areas occupy

2, 8, and 6 per cent of the landscape. The percentage of zonal-azonal intergrade soils vary considerably and range from 1 to 15 per cent within any one area.

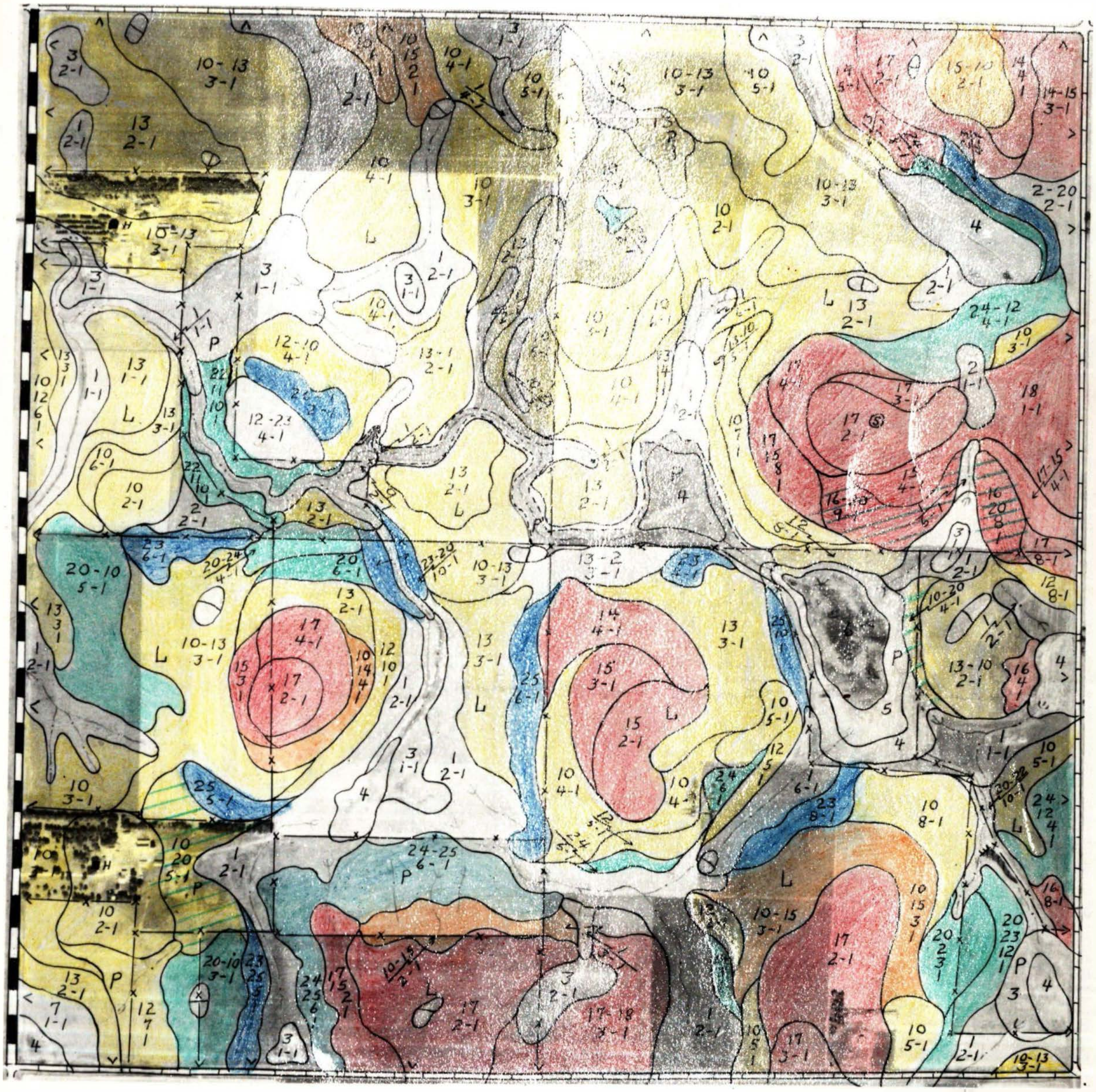


Figure 13. The Distribution of Glacial Drift Soils in Area T-1

Location: Sec. 31, T112N, R52N, Brookings County, South Dakota

	Areal Extent (%)
Sinai silty clay loam and silty clay, undifferentiated	11
Poinsett silt loams, undifferentiated	21
Poinsett-Sinai complex and Sinai-Poinsett complex	3
Ahnberg clay loams, undifferentiated	2
Soils derived from loam glacial drift, undifferentiated	6
Poinsett-undifferentiated loam glacial drift derived soils, complex	1
Sinai-undifferentiated loam glacial drift derived soils, complex	1

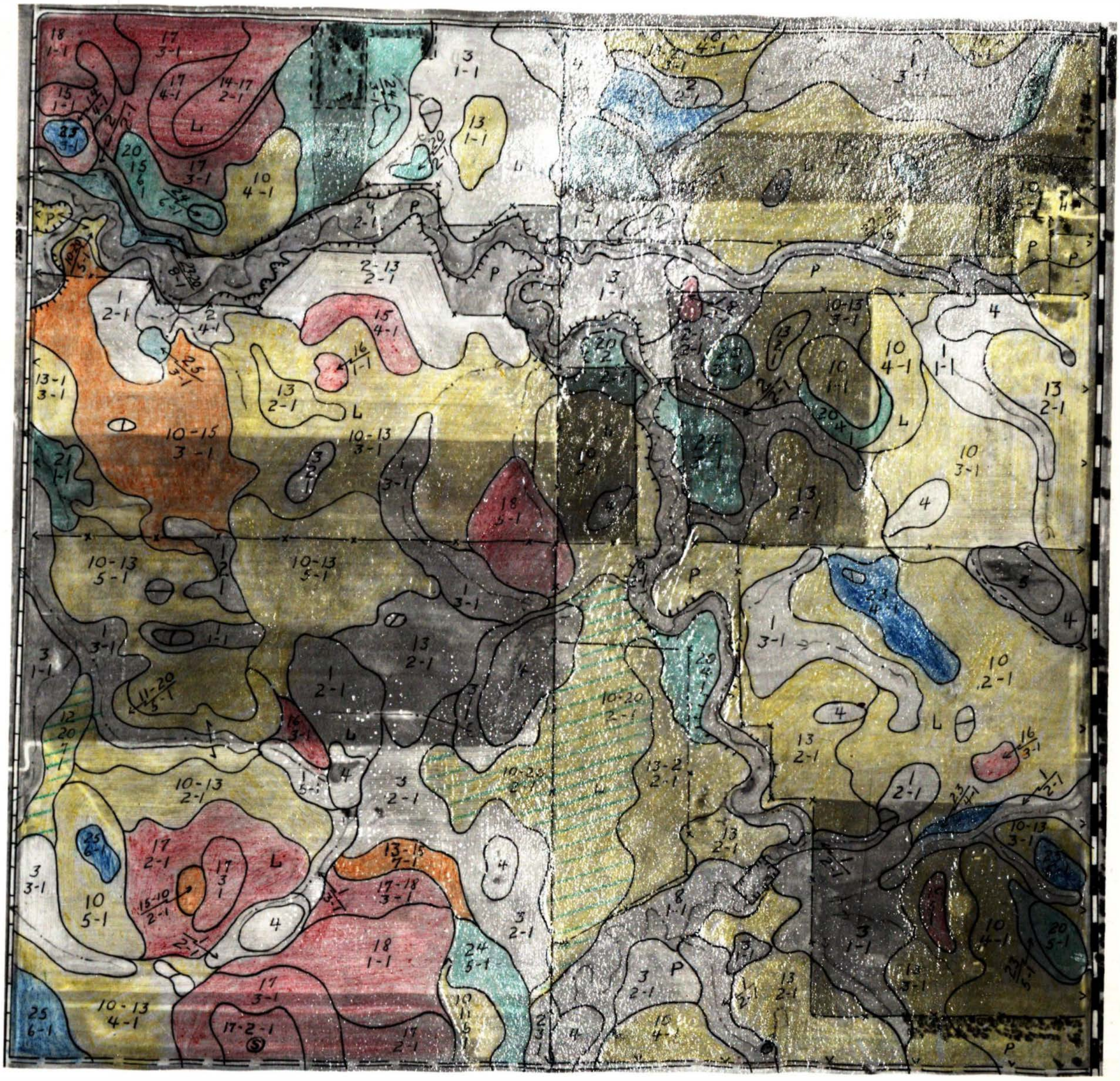


Figure 14. The Distribution of Glacial Drift Soils in Area T-2

Location: Sec. 13, R53W, T111N, Kingsbury County, South Dakota

	Areal Extent (%)
Sinai silty clay loam and silty clay, undifferentiated	15
Poinsett silt loams, undifferentiated	39
Poinsett-Sinai complex and Sinai-Poinsett complex	1
Ahnberg clay loams, undifferentiated	1
Soils derived from loam glacial drift, undifferentiated	10
Poinsett-undifferentiated loam glacial drift derived soils, complex	3

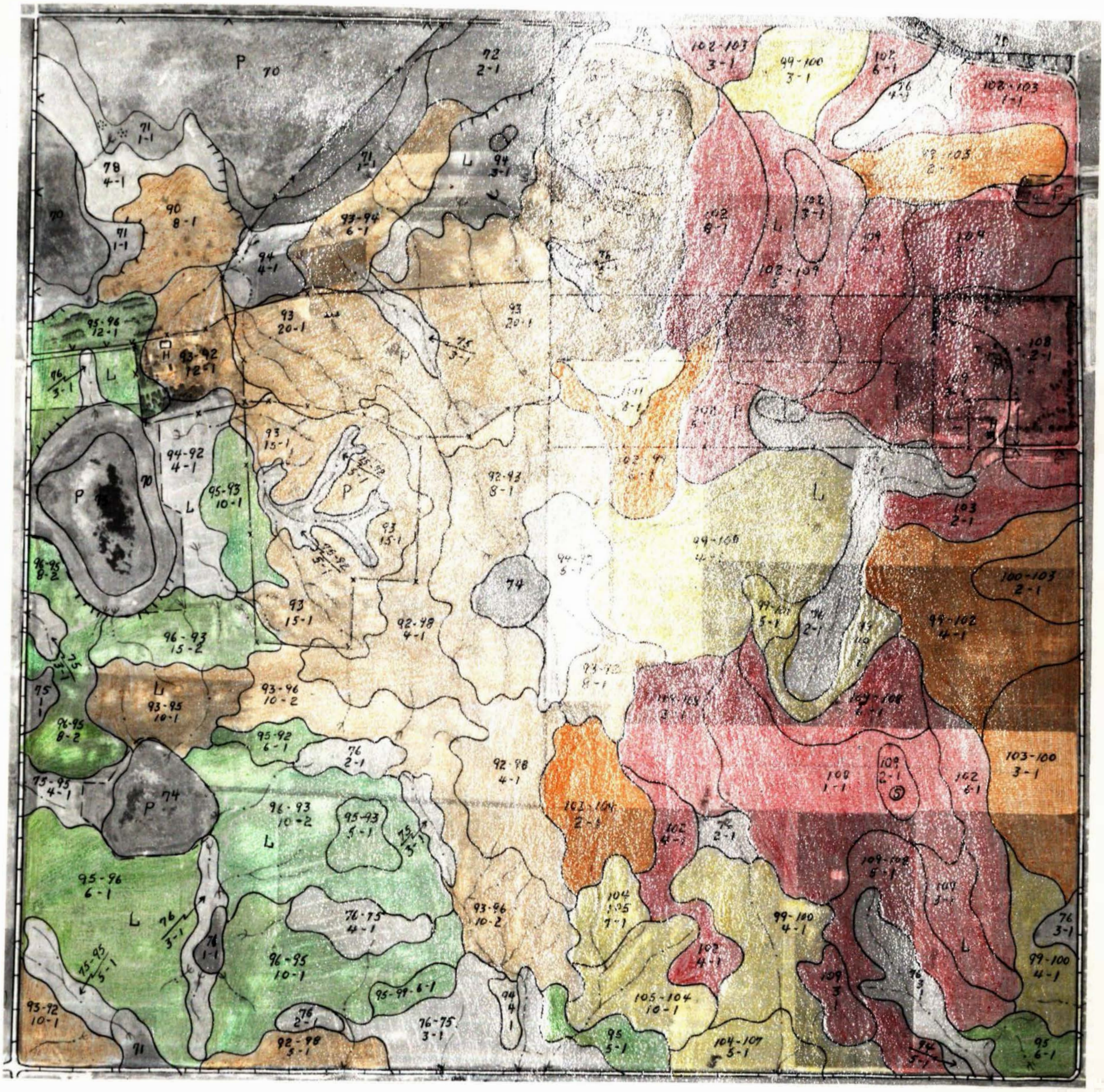


Figure 15. The Distribution of Glacial Drift Soils in Area T-3

Location: Sec. 6, T122N, R55W, Day County, South Dakota

	Areal Extent (%)
Sinai silty clay loam and silty clays, undifferentiated	18
Poinsett silt loams, undifferentiated	9
Gravelly loams, undifferentiated	23
Poinsett-Barnes complex	12
Poinsett-Sinai complex and Sinai-Poinsett complex	9

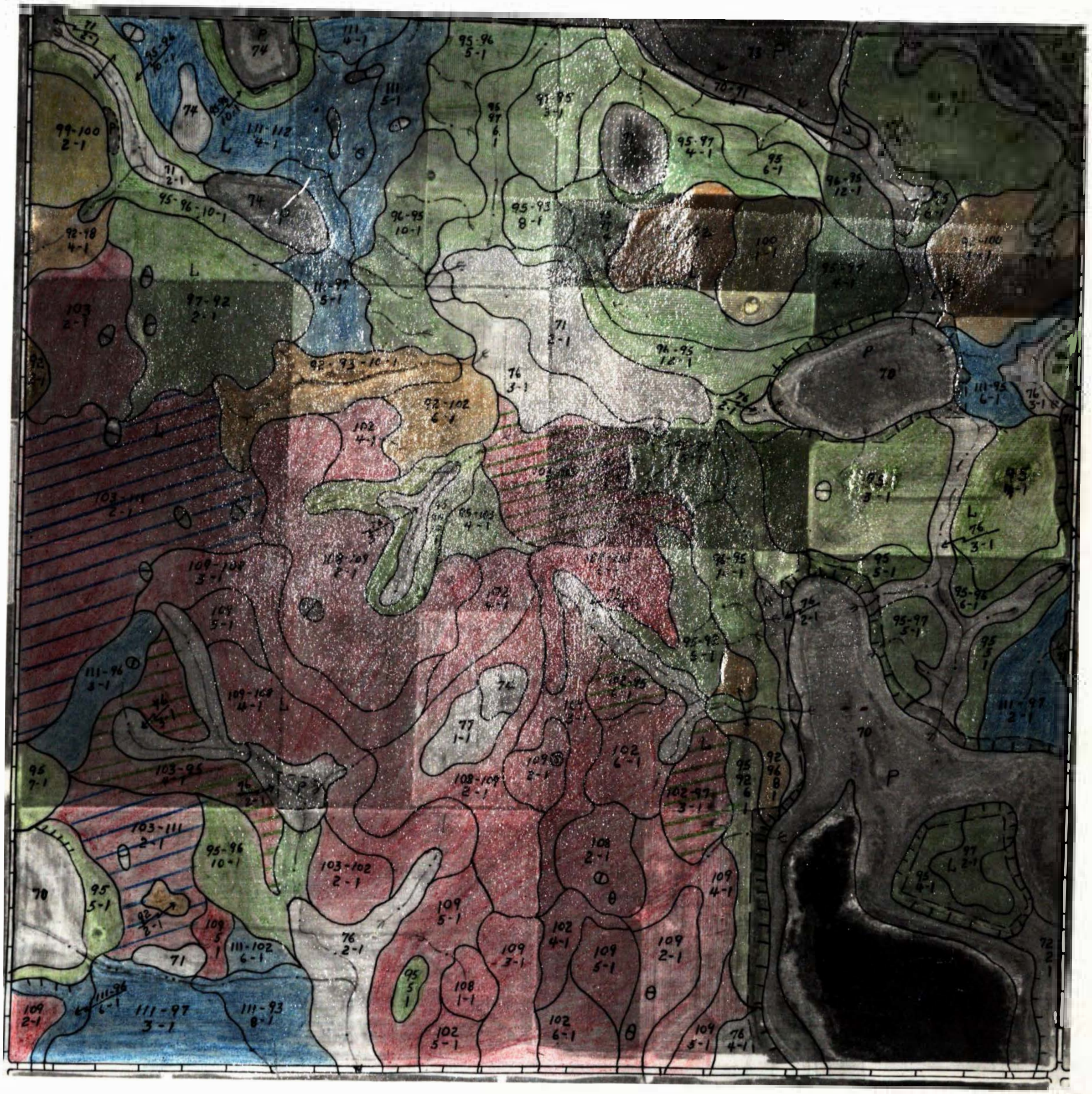


Figure 16. The Distribution of Glacial Drift Soils in Area T-4

Location: Sec. 36, T124N, R57W, Day County, South Dakota

	Areal Extent (%)
Sinai silty clay loam and Sinai silty clay, undifferentiated	23
Poinsett silt loams, undifferentiated	4
Poinsett-Sinai complex and Sinai-Poinsett complex	3
Gravelly loams, undifferentiated	4
Poinsett-Barnes complex	28
Ahnberg loam-clay loam	9
Sinai-Ahnberg complex	8
Sinai-undifferentiated loam glacial drift derived soils, complex	3

Figure 17. The Distribution of Glacial Drift Soils in Area T-5

Location: Sec. 19, T104N, R52W, Minnehaha County, South Dakota

	Areal Extent (%)
Sinai silty clay loam and silty clay, undifferentiated	10
Poinsett silt loams, undifferentiated	11
Poinsett-Sinai complex and Sinai-Poinsett complex	2
Gravelly loams, undifferentiated	1
Ahnberg clay loam	3
Soils derived from loam-clay loam till, undifferentiated	10
Soils derived from loam glacial drift, undiffeŕentiated	14
Poinsett-undifferentiated loam-clay loam till derived soils, complex	4

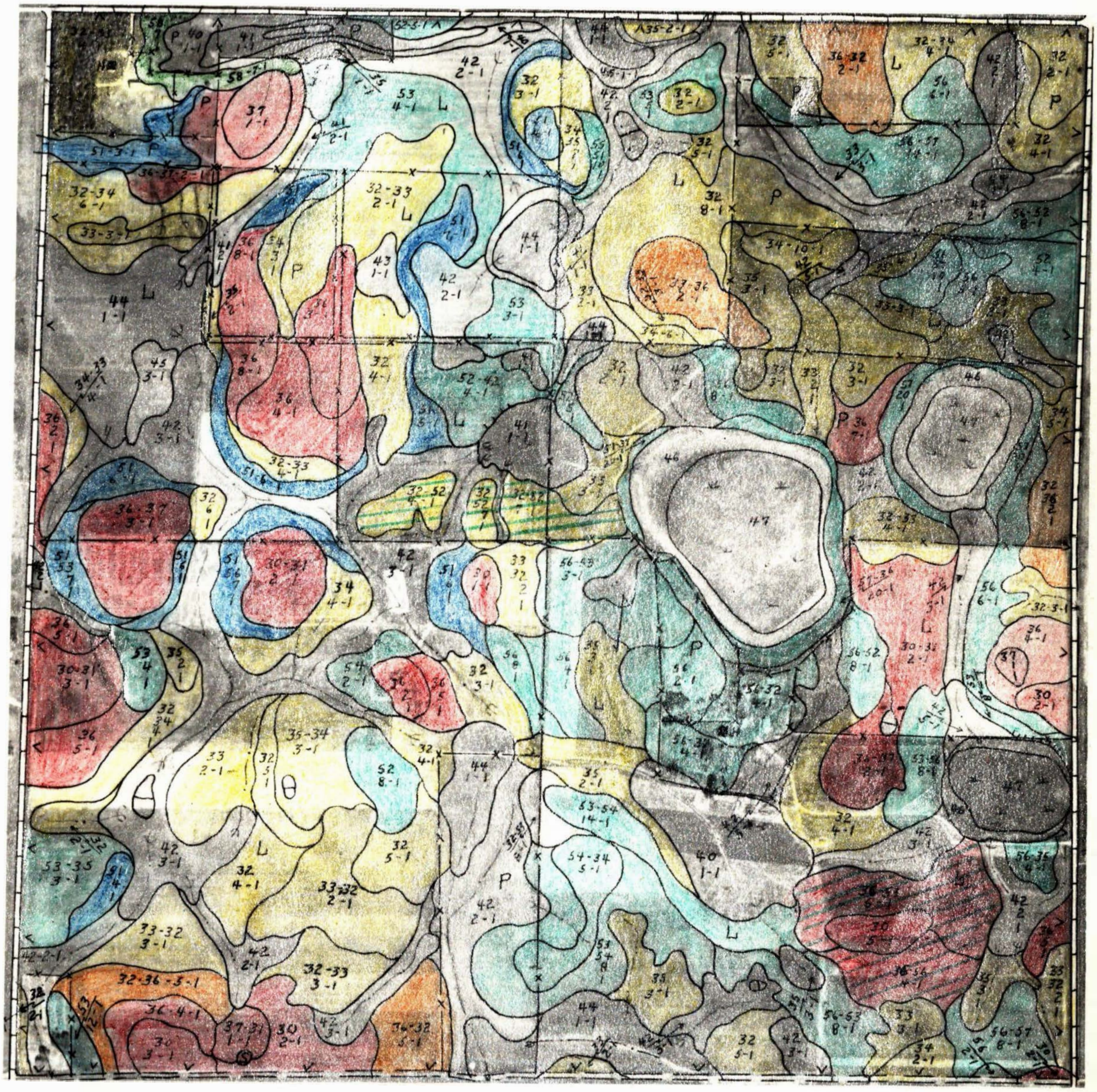


Figure 18. The Distribution of Glacial Drift Soils in Area T-6

Location: Sec. 18, T103N, R52W, Minnehaha County, South Dakota

	Areal Extent (%)
Sinai silty clay loam and silty clay, undifferentiated	12
Poinsett silt loam, undifferentiated	17
Poinsett-Sinai complex and Sinai-Poinsett complex	3
Ahnberg clay loam	4
Poinsett-undifferentiated loam glacial drift derived soils, complex	1
Sinai-undifferentiated loam glacial drift derived soils, complex	1
Soils derived from loam glacial drift, undifferentiated	20

Soil Legend for Detailed Field Sheets

The following legend gives a brief description of all soil mapping units which appear on field mapping sheets. Complexes that occur on these photos are composed of approximately 70 per cent of the first mapping unit and 30 per cent of the second mapping unit. In other words a complex of 93-92 would include about 70 per cent of unit 93 and 30 per cent of unit 92.

A. Mapping Legend for Brookings and Kingsbury Counties

Local alluvial and depressional soils

1. Waubay silty clay loam, drainageways -
   This soil differs from its northern equivalent, soil mapping unit 76, in having a lighter colored A horizon.

2. Local alluvial silt loams and loams, drainageways -
   This is a moderately well-drained, weakly developed, Chernozem soil derived from loam and silt loam local alluvial sediments. This soil occurs in upland drainageways. It differs from soil mapping unit one, chiefly in texture of the profile.

3. Oldham variant -
   This is moderately well to somewhat poorly drained, weakly developed, Chernozem soil intergrading to a Humic Gley soil derived from silty clay loam local alluvial sediments. This unit occupies slight upland swales, slightly concave depressions, and rims around small depressions. Seams of salt and mottling occur in this at a depth of 30 inches. It is leached to variable depths and occasionally is calcareous at the surface.

4. Oldham silty clay loam -
   This soil differs little from soil mapping units 71 and 45.

5. Parnell, poorly drained -
   This soil differs little from its northern equivalent, mapping unit 70 in Day County.

6. Marsh -
   This area includes soils in the very poorly drained range of the Parnell series. These soils consist of moderately fine and fine textured local alluvium washed into depressions of various sizes. The depressions are ponded with water 1 to 3 feet deep and have dense growths of marsh vegetation.

7. Tetonka silt loam -
This is an imperfectly drained, soloth soil derived from silt loam and silty clay loam, local alluvial sediments. This soil occupies the rim of small depressions. It is mottled and leached to five feet. It resembles mapping unit 74 in Day County.

8. Soil of intermittent stream bottom -
This is a moderately well to somewhat poorly drained, minimal zonal soil derived from intermittent stream bottom, silty and/or loamy alluvial sediments. This unit occurs on the flood plain of a small, drainage channel. This soil is generally leached 6 to 8 inches but occasionally it is calcareous at the surface.

9. Alluvial stream bottom soil -
This is a somewhat poorly drained, azonal soil derived from stream channel alluvial sediments. This unit occurs on a narrow flow plain adjacent to a small, intermittent stream. It lacks soil development and is calcareous at the surface.

Upland till and drift soils

10. Poinsett silt loam, stone free -
This soil differs from its northern equivalent, chiefly in having a lighter colored A horizon and in being leached to a slightly greater depth. This unit is leached to a depth ranging from 18 to 22 inches. In other respects it resembles unit 99 in Day County.

11. Poinsett silt loam, stone free, thin solum -
This soil has a lighter colored A horizon than its northern equivalent, but otherwise it resembles soil mapping unit 101 in Day County.

12. Poinsett silt loam -
This soil differs from its northern equivalent chiefly in having a lighter colored A1 horizon and in being leached to a slightly greater depth. It is leached to a depth ranging from 18 to 22 inches. In other respects it resembles soil mapping unit 102 in Day County.

13. Poinsett silt loam, stone free, moderately well-drained -
This soil differs from its northern equivalent in having a thinner, lighter colored A horizon and in being leached to greater depths. Lime is encountered in this soil at depths varying from 20 to 28 inches. In other respects this soil resembles soil mapping unit 100 in Day County.

14. Sinai silt loam -
This soil differs from its northern equivalent in having a lighter colored A1 horizon and in being leached to a slightly

greater depth. Lime is encountered at a depth ranging from 18 to 24 inches. In other respects this soil resembles soil mapping unit 102 in Day County.

15. Sinai silt loam, moderately well drained -
This soil differs from its northern equivalent in having a thinner, lighter colored A horizon. In other respects it resembles soil mapping unit 103 in Day County.

16. Sinai silt loam variant -
This soil is similar to mapping unit 14 except for a greater concentration of small stones, pebbles, and coarse quartz grains in the solum.

17. Sinai silty clay loam and silty clay -
This is a well-drained moderate to strongly developed Chernozem soil derived from glacio-lacustrine sediments. An individual of this unit was sampled to help characterize the well-drained Sinai soils of the central area.

18. Sinai silty clay loam and silty clay, moderately well-drained -
This soil differs from its northern equivalent in having a lighter colored A1 horizon and in being leached to a greater depth. It is leached to depths varying from 20 to 30 inches. In other respects this soil resembles soil mapping unit 109 in Day County.

20. Loam glacial drift soil -
This is a well-drained, weak to moderately well developed Chernozem soil derived from loam and clay loam glacial drift. This soil occurs on the crests and slopes of upland undulations. The profile of this soil has a loam or silt loam A horizon overlying a heavy loam or clay loam prismatic B horizon. Small stones and pebbles are common throughout the profile. This soil is leached from 15 to 18 inches in depth.

21. Loam glacial drift soil, moderately well-drained -
This is a moderately well-drained, weak to moderately well developed, Chernozem soil derived from parent materials of mapping unit 20. It occupies the nearly level crests and gentle slopes of upland undulations. The profile of this soil has a dark colored, thick A horizon overlying a prismatic B horizon which is underlain by a Cca horizon. This soil is leached to a depth ranging from 24 to 30 inches.

22. Loam glacial drift soil, thin solum -
This is an excessively drained, very weakly developed, Regosol intergrading to a minimal Chernozem soil derived from parent materials of mapping unit 20. This soil occurs on steep, short, choppy slopes adjacent to well developed drainageways. The

profile of this soil has a thin, calcareous A horizon overlying a very weakly developed prismatic B horizon, which is underlain by a Cca or Dca horizon.

23. Ahnberg-like, glacial drift -
This is a well-drained, moderate to strongly developed, Chernozem soil derived from firm clay loam, heavy silty clay loam, or silty clay glacial drift. This soil occurs on the sloping crests and side slopes of upland undulations. The profile of this soil has a loam or clay loam A horizon overlying a firm clay loam or silty clay, bright B horizon which is underlain by Cca or Dca horizons. This soil is calcareous with segregations of white-eyed lime occurring at a depth ranging from 8 to 14 inches.

24. Soil derived from loam glacial drift overlying stratified sands -
This is a well-drained, moderately well developed, Chernozem soil derived from loam or clay loam glacial drift overlying coarse stratified sands. This soil generally occurs on slopes adjacent to well developed drainageways. The solum of this soil is similar to mapping unit 20 but overlies stratified sands at a depth of 25 to 30 inches. This soil is calcareous at a depth ranging from 18 to 24 inches.

25. Ahnberg loam -
This is a well-drained, moderate to strongly developed, Chernozem soil derived from firm clay loam glacial till. This soil generally occurs on slopes adjacent to well developed drainageways. The profile of this soil has a loam A horizon overlying a firm clay loam, very bright, prismatic B2 horizon which is underlain by firm clay loam Cca horizons. Many segregations of white-eyed lime occur at depths from 16 to 18 inches.

26. Ahnberg-like, glacial drift, moderately well-drained -
This is a moderately well-drained, moderate to strongly developed, zonal soil derived from parent materials of mapping unit 23. This soil occurs on the nearly level crests and gentle slopes of upland undulations. The profile of this soil has a darker colored, thicker A1 horizon and a duller colored B2 horizon than mapping unit 23.

B. Mapping Legend for Minnehaha County

<u>Upland till and drift soils</u>

30. Southern variant of Sinai silty clay loam and silty clay -
This soil will not be discussed here because it has been described in detail previously.

30R. Southern variant of Sinai, thin solum -
This is an excessively drained Regosol intergrading to a zonal

soil derived from parent materials of mapping unit 30. This unit occupies short, steep, abrupt slopes flanking high, upland undulations. It has a thin, calcareous A horizon overlying a weak, prismatic B horizon which is underlain by a Cca horizon.

31. Southern variant of Sinai silty clay loam and silty clay, moderately well drained -
This soil differs from its northern equivalents, soil mapping units 18 and 108, in having a thicker, brighter colored solum, and in having numerous hard lime segregations in the horizon of lime accumulation. This soil is calcareous at a depth varying from 18 to 22 inches. In other respects it resembles soil mapping units 18 and 108.

32. Southern variant of Poinsett silt loam, stone free -
This soil differs from its northern equivalents, soil mapping units 10 and 99, in having a thicker, brighter colored solum; a thicker, stronger B2 horizon; and in having numerous hard lime segregations in the horizon of lime accumulation. This unit is leached to a depth varying from 24 to 26 inches. In other respects it resembles soil mapping units 10 and 99.

33. Southern variant of Poinsett, silt loam stone-free, moderately well-drained -
This soil differs from its northern equivalents, soil mapping units 13 and 100, in having a thicker, brighter colored, slightly finer-textured solum, and in having numerous hard lime segregations in the horizon of lime accumulation. This unit is leached to a depth varying from 16 to 24 inches. In other respects it resembles soil mapping units 13 and 100.

34. Southern variant, Poinsett silt loam -
This soil differs from its northern equivalents, soil mapping units 12 and 104, in having a thicker, brighter colored, slightly finer-textured solum, and in having numerous hard lime segregations in the horizon of lime accumulation. This unit is leached to a depth varying from 16 to 24 inches. In other respects this unit resembles soil mapping units 12 and 104.

35. Southern variant of Poinsett silt loam, moderately well-drained -
This soil differs from its northern equivalent, soil mapping unit 107, in having a thicker, brighter colored solum and in having numerous hard lime segregations in the horizon of lime accumulation. In other respects it resembles unit 107.

36. Southern variant of Sinai silt loam -
This soil varies from its northern equivalents, soil mapping units 18 and 102, in having a thicker, much brighter colored, slightly finer-textured solum, and in having numerous hard lime

segregations in the horizon of lime accumulation. Some areas of this unit appear to have a thin mantle of loess (1 to 3 feet thick) which caps silty glacial drift. This unit is leached to a depth ranging from 18 to 24 inches. In other respects this soil resembles units 18 and 102.

37. Southern variant of Sinai silt loam, moderately well-drained - This soil differs from its northern equivalents, soil mapping units 15 and 103, in having a much brighter colored, slightly finer-textured, thicker B horizon, and in having numerous hard lime segregations in the horizon of lime accumulation. This soil is leached to a depth varying from 18 to 30 inches. In other respects it resembles units 15 and 103.

39. Southern variant of Poinsett silt loam, stone-free, thin solum - This soil differs from its northern equivalents, soil mapping units 11 and 101, chiefly in having a brighter colored solum. In other respects it resembles units 11 and 101.

<u>Alluvial and depressional soils</u>

40. Oldham, noncalcareous variant -
This is a somewhat poorly drained, strongly developed, Humic Gley soil intergrading to a zonal soil derived from fine-textured local alluvial sediments overlying stratified glacial drift. This unit occurs on broad rims of moderately large depressions. The soil profile has a silty clay, black A horizon overlying clayey, angular blocky B horizons which are underlain by Cgca or Dgca horizons. Salts occur at 10 inches and gleyed horizons at 30 inches in this soil. This soil is noncalcareous throughout five feet.

41. Soloth, somewhat poorly drained -
This is an imperfectly drained, strongly developed, Soloth soil derived from the parent materials of mapping unit 40. It occupies flat-bottomed depressions. The soil profile has a gray, platy silty clay, A2 horizon, 18 to 22 inches thick, overlying an angular blocky, silty clay B2 horizon which is underlain by Cgca or Dgca horizons. This soil is noncalcareous throughout five feet.

42. Local alluvium silt loams, drainageways -
This is a moderately well-drained, weak to moderately-well developed, zonal soil derived from silt loam and silty clay loam local alluvial sediments. This soil occurs in upland drainageways and concave slopes of gentle upland undulations. It is calcareous at a depth ranging from 30 to 36 inches.

43. Soloth soil, uplands -
This is an imperfectly drained, Soloth soil derived from

laminated glacio-lacustrine and silty local alluvial sediments. It occupies small upland swales. The profile of this soil has a gray, weakly developed platy A2 horizon, 24 to 36 inches thick, overlying a moderately well developed, subangular blocky B2 horizon extending to five feet. This soil is noncalcareous throughout five feet.

44. Humic Gley, somewhat poorly drained -
This is a somewhat poorly drained, Humic Gley soil intergrading to a zonal soil derived from silt loam and silty clay loam local alluvial sediments. This soil occurs in slightly concave depressions. No salts were observed in the profile and lime occurred at a depth of 24 to 30 inches in depth. The surface of this soil is very gray.

45. Oldham silt loam -
This soil differs little from mapping units 4 and 71, Oldham soils of the northern region. Oldham silt loam is strongly gleyed starting at a depth of 6 to 10 inches in depth and extending through five feet.

46. Parnell, poorly drained -
This soil is equivalent to mapping units 5 and 70, Parnell poorly drained soils of the northern region,

47. Marsh -
This area is equivalent to mapping unit 6 of Brookings and Kingsbury Counties.

48. Alluvial loams, fans -
This is an azonal soil derived from loam alluvial fan deposits. This soil occurs adjacent to and below soil complex 59-58. The soil profile lacks development and is calcareous at the surface.

49. Somewhat poorly drained, sandy loams, beaches -
This is a somewhat poorly drained, azonal soil derived from water washed, sandy and gravelly loam, beach sediments. This soil occurs on low, narrow, beach-like positions adjacent to large depressions. The sandy loam or gravelly loam profile is calcareous at or within two inches of the surface.

49W. Well drained, sandy loams, beaches -
This is a well-drained, weakly developed, azonal soil intergrading to a zonal soil derived from parent materials of unit 49. This soil occurs on high rims of beach-like positions. The profile of this soil has a sandy loam or loam A horizon, overlying a very weakly developed, prismatic B horizon which is underlain by Cca or Dca horizons. This soil is noncalcareous in the solum.

51. Southern variant of Ahnberg loam -
This is a well-drained, moderate to strongly developed, zonal soil derived from firm clay loam glacial till. This unit generally occurs on moderately steep slopes adjacent to upland drainageways but it occasionally occupies crests of upland undulations. It differs from its northern equivalents, soil mapping unit 25 and 111, in having a brighter colored B2 horizon, in being leached to a greater depth, and in having hard lime segregations in the horizon of lime accumulation. This unit is leached to a depth ranging from 22 to 24 inches.

52. Glacial drift loams, weak to moderately well developed -
This is well-drained, weak to moderately well developed, zonal soil derived from silty clay loam and clay loam stratified glacial drift. This unit occurs on crests and slopes of upland undulations. It has a loam A horizon overlying a silty clay loam or silty clay B2 horizon which is underlain by Cca or Dca horizons. This soil is leached to depths varying from 14 to 16 inches and has numerous hard lime segregations in the lower portion of the horizon of lime accumulation. Small stones and pebbles are common in the profile.

53. Glacial drift loams, deep phase of unit 52 -
This soil differs from soil mapping unit 52 in having a slightly finer-textured solum, a brighter colored, thicker B horizon, and in being leached to a depth varying from 22 to 24 inches.

54. Glacial drift loams, moderately well-drained associate of unit 53 -
This is a moderately well-drained, weak to moderately well developed soil derived from parent materials of unit 52. This soil occurs on the nearly level crests and gentle slopes of upland undulations. The profile of this soil has a darker colored, less bright solum than soil mapping unit 53, and is leached to a depth varying from 24 to 30 inches.

55. Glacial drift loams, thin solum of unit 53 -
This is an excessively drained, very weakly developed regosolic soil intergrading to a minimal zonal soil derived from parent materials of soil mapping unit 53. This soil occurs on steep, abrupt slopes of upland undulations. The profile of this soil has a thin calcareous, loam A horizon overlying a loam, very weakly developed prismatic B horizon which is underlain by Cca or Dca horizons.

56. Glacial drift loams, weakly developed -
This is a well-drained, weakly developed, zonal soil derived from loam and silt loam glacial drift. This soil generally occurs on the side slopes of upland undulations. The profile of this soil has a loam A horizon overlying a very bright

colored, loam B horizon which is underlain by Cca and Dca horizons. This soil is leached to a depth ranging from 17 to 24 inches.

57. Glacial drift loams, thin solum of unit 56 -
This is an excessively drained, very weakly developed, Regosol intergrading to a zonal soil derived from parent materials of unit 56. It occurs on steep, abrupt slopes of upland undulations. The profile of this soil has a thin, calcareous loam A horizon overlying a very weakly developed prismatic B horizon which is in turn underlain by Cca and Dca horizons.

58. Till derived loam soil -
This is a well-drained, moderately well developed, zonal soil derived from loam-clay loam glacial till. This soil occurs on the crests and slopes of upland undulations. It is similar to soil mapping unit 51 but is less well developed and has a duller colored solum. This soil is leached to a depth varying from 15 to 24 inches.

59. Till derived loam soil, thin solum -
This is an excessively drained, very weakly developed, Regosolic soil intergrading to a zonal soil derived from parent materials of mapping unit 58. This soil occurs on abrupt, steep slopes of upland undulations. The profile of this soil has a thin, calcareous, loam A horizon overlying a very weakly developed, prismatic B horizon which is underlain by Cca and Dca horizons.

60. Southern variant of Pierce loam -
This is a somewhat excessively drained, weakly developed, minimal zonal soil derived from loamy sand, loam and sandy loam ice contact stratified drift. It occurs on steep, abrupt morainic slopes adjacent to large depressions. The profile of this soil has a loam A horizon, 2 to 4 inches thick, overlying a weakly developed, prismatic, loam B horizon which in turn is underlain by Cca and Dca horizons. This soil is leached to a depth varying from 18 to 20 inches.

C. Mapping Legend for Day County

Local alluvium and depressional soils

70. Parnell-poorly drained -
This is a poorly drained, Humic Gley soil derived from silty clay loam and silty clay local alluvial sediments. It occurs in large, flat-bottomed depressions. This unit is usually calcareous at the surface and mottling occurs throughout the profile. It has a thin AoA1 horizon overlying A1, B2, Cca horizons.

71. Oldham, local alluvium -
This is a somewhat poorly drained, Humic Gley soil derived from local alluvial sediments of loam, silt loam, and silty clay loam texture. This unit occurs on the rims of large depressions, in concave depressions and small upland swales. It is usually calcareous at surface but may be leached a few inches. Mottling occurs throughout the profile but to a lesser degree than mapping in unit 70.

72. Waubay, calcareous variant -
This is a somewhat poorly drained, intrazonal soil intergrading to a minimal zonal soil derived from 12-18 inches of sandy loam local alluvial sediments underlain by silt loam glacial drift. This soil occupies intrazonal positions on broad rims of large flat-bottomed depressions. The profile consists of a calcareous, loam, A horizon, overlying a loam prismatic B horizon which is underlain by a Dca horizon.

73. Parnell, very poorly drained -
This is a very poorly drained, Humic Gley soil derived from silty loam and silty clay loam local alluvial sediments. It occupies the same position as soil mapping unit 70. This soil differs from that unit in having a thicker, more peaty Ao horizon and in being more strongly gleyed throughout the profile. It is usually calcareous at the surface.

74. Tetonka silt loam -
This is an imperfectly drained Soloth soil derived from silt loam local alluvial sediments. It occupies small upland swales. The profile consists of a relatively thick (18-30 inches), weakly developed, platy A2 horizon overlying a moderate to strong subangular blocky B2 horizon. It is leached to variable depths but is usually calcareous in the lower part of the B2 horizon.

75. Local alluvial loams, drainageways -
This is a moderately well-drained, weakly developed, Chernozem soil derived from loam local alluvial sediments. This soil occurs in upland drainageways. The profile consists of a thick, black, loam A horizon overlying a prismatic, black, loam B2 horizon which is underlain by a Cca horizon. It is usually leached to a depth of 30 inches.

76. Waubay silt loam and silty clay loam, drainageways -
This is a moderately well-drained, weakly developed, Chernozem soil derived from silt loam and silty clay loam local alluvial sediments. It occupies upland drainageways. This soil differs from unit 75 only in texture of sediments.

77. Solodized solonetz -
This is an imperfectly drained solodized Solonetz soil derived

from laminated glacio-lacustrine sediments. It occurs in small upland swales. The profile consists of a light gray, weak, platy A2 horizon overlying a degraded, angular blocky B2 horizon. This soil is calcareous at 20 to 24 inches.

78. Foxhome, stony phase
This is an imperfectly drained, intrazonal soil derived from water worked glacial till. This unit occurs on nearly level to gently sloping undulations which separate large depressions. Strata of sands, gravels, and silts make up the parent material for this soil. Glacial rocks and boulders are common on the surface. This soil is calcareous within two inches of the surface and mottles throughout profile.

94. Waubay calcareous variant, fans -
This is an azonal soil intergrading to a minimal zonal soil derived from loam, sand loam, or loamy sand alluvial fan sediments. This soil occurs adjacent to and below soil unit 93. The profile consists of a calcareous, dark colored, loam A horizon, overlying a very weakly developed prismatic Bca horizon, which in turn overlies a Cca or Dca horizon.

Upland till and drift soils

90. Pierce, stony phase -
This is an excessively drained, Regosol derived from morainic outwash or mixed sandy, silty, and gravelly ice-contact stratified drift. This soil occurs on steep, broken slopes adjacent to large depressions. Numerous stones and boulders are present on the surface. The profile consists of a calcareous A horizon overlying a Cca or Dca horizon.

92. Gravelly loam soil -
This is a well-drained, weakly developed, Chernozem soil derived from moderately deep glacial alluvial sediments which overlies stratified mixed sand and gravels or gravelly outwash. This unit occurs on a high, outwash plain. The profile consists of a loam A horizon overlying a weak to moderately well developed prismatic B2 horizon which is underlain by Cca and Dca horizons. This soil is leached to depths from 16-20 inches.

93. Pierce, deep phase, thin solum -
This is an excessively drained Regosol intergrading to a Chernozem derived from morainic outwash or mixed sandy, silty, and gravelly ice-contact stratified drift. It occupies steep, abrupt morainic landscapes adjacent to large depressions. The profile consists of a calcareous, loam A horizon (2-4 inches thick) overlying a very weakly B horizon which is underlain by Cca or Dca horizon.

95. Poinsett-Barnes complex -
This complex is composed of well-drained, weak to moderately well developed Chernozem soils derived from silty glacial drift and/or loam till. Islands of till derived soils are surrounded by soils derived from silty glacial drift. This complex occurs on the crests and part way down the slopes of upland undulations. Profile formula for these soils is Alp, B2, B2ca, and Cca. This complex is composed of about 70 per cent Poinsett and 30 per cent Barnes.

96. Poinsett-Barnes complex, thin solum -
This complex is composed of excessively drained, very weakly developed, Regosols intergrading to minimal Chernozem soils derived from silty glacial drift and/or loam till. It is associated with unit 95 on steep, abrupt slopes of upland undulations. Profile formula for these soils is Alp, Blca, Cca, or Dca. These soils are usually calcareous at the surface. This complex is composed of about 70 per cent Poinsett thin solum and 30 per cent Barnes thin solum.

97. Waubay-Aastad complex -
This complex is composed of moderately well-drained, weakly developed, Chernozem soils derived from silty glacial drift and/or loam till. This complex occurs on the nearly level crests and on the slightly concave slopes of gentle upland undulations. Profile formula for these soils is Alp, B2, Cca, or Dca. This complex is composed of about 70 per cent Waubay and 30 per cent Aastad.

98. Deering loam -
This is a moderately well-drained, weakly developed, Chernozem soil derived from parent materials of unit number 92. It occupies the nearly level crests and the slightly concave slopes of gentle upland undulations. This soil is usually leached to a depth of 24 inches.

99. Poinsett silt loam, stone-free -
This is a well-drained, weakly developed, Chernozem soil derived from laminated silty glacio-lacustrine sediments. This soil occurs on the crests and gentle slopes of upland undulations. This unit has a nearly stone-free silt loam or light silty clay loam solum. It is leached to a depth of 12 to 16 inches. The profile consists of a silt loam A horizon overlying a silt loam or light silty clay loam B2 horizon which is underlain by Cca or Dca horizons.

100. Poinsett silt loam, stone-free, moderately well drained -
This is a moderately well-drained, weakly developed, Chernozem soil derived from parent materials of mapping unit 99. This soil occupies nearly level crests and gentle slopes of upland

undulations. The profile of this soil has a darker colored, thicker A horizon and is leached to a slightly greater depth than unit 99.

101. Poinsett silt loam, stone-free, thin solum -
This is an excessively drained, very weakly developed, Regosol intergrading to a minimal Chernozem soil derived from parent materials similar to mapping unit 99. It occurs on short, steep, choppy slopes of undulations. The profile consists of a thin, calcareous, silt loam A horizon overlying a very weakly developed prismatic B horizon which grades into Cca or Dca horizons.

102. Sinai silt loam -
This is a well-drained, moderately well developed, Chernozem soil derived from laminated, finely stratified glacio-lacustrine sediments. This soil occurs on the nearly level crests and adjacent flanking slopes of high upland undulations. The profile consists of a silt loam A horizon overlying a compound prismatic-subangular blocky B2 horizon which is underlain by laminated Cca or Dca horizons. The solum of this soil is leached to a depth of 14 to 16 inches. Stones are rarely found in the profile. This unit appears to be an intergrade between the Poinsett silt loam and the Sinai silty clay or silty clay loam.

103. Sinai silt loam, moderately well-drained -
This is a moderately well-drained, moderately well developed, zonal associate of mapping unit 102. It occupies the nearly level crests and gentle slopes of upland undulations. It differs from mapping unit 102 in having a darker colored, thicker A horizon and a duller colored B horizon.

104. Poinsett silt loam -
This is a well-drained, weakly developed, Chernozem soil derived from stratified, silty glacial drift. This soil occurs on the sloping crests and moderately steep slopes of upland undulations. The profile of this soil consists of a silt loam A horizon overlying a light silty clay loam prismatic B2 horizon which in turn overlies stratified Cca or Dca horizons. Small stones and coarse quartz grains are present throughout the profile. This soil is leached to depths ranging from 12 to 16 inches.

105. Poinsett silt loam, thin solum -
This is an excessively drained, very weakly developed, Regosol intergrading to a minimal Chernozem soil derived from parent materials similar to mapping unit 104. This unit occurs on steep, short, choppy slopes of upland undulations. The profile of this soil consists of a thin, calcareous A horizon overlying a very weakly developed, prismatic B horizon which in turn overlies Cca or Dca horizons.

107. Poinsett silt loam, moderately well-drained -
This is a moderately well-drained, weakly developed, Chernozem soil derived from parent materials similar to mapping unit 104. This soil occurs on the nearly level crests and gentle slopes of upland undulations. It differs from unit 104 in having a thicker, darker colored A horizon; a duller colored B horizon; and in being leached to a slightly greater depth.

108. Sinai silty clay loam and silty clay -
This soil is a well-drained, moderate to strongly developed, Chernozem soil derived from finely stratified glacio-lacustrine sediments. An individual of this unit was described and sampled to help characterize the well-drained Sinai soils.

109. Sinai silty clay loam and silty clay, moderately well-drained -
This is a moderately well-drained, moderate to strongly developed, Chernozem soil associated with mapping unit 109. It occupies the nearly level, flat-topped, high mesa-like hills surrounded by moat-like colluvial-alluvial drains and swales. This soil differs from unit 109 in having a thicker, darker colored A horizon, and a duller colored B horizon.

111. Ahnberg-like loam -
This is a well-drained, moderate to strongly developed, Chernozam soil derived from firm, heavy loam or clay loam glacial till. This unit occurs on gentle slopes of upland undulations. This soil resembles the Ahnberg soil of Brookings County but has a slightly less bright B2 horizon. The profile consists of a loam A horizon overlying a firm clay loam B2 horizon which overlies a Cca horizon. This unit is leached to a depth ranging from 12-17 inches.

112. Ahnberg-like loam, moderately well-drained -
This is a moderately well-drained, moderate to strongly developed, Chernozem soil derived from similar parent materials as unit 111. It occurs on the nearly level crests and gentle slopes of upland undulations.

LABORATORY RESULTS AND DISCUSSION

Laboratory Results

The results of the various laboratory analyses are given in Tables III through VII. The horizon and depth designations given are the same as those used in the profile descriptions. In these tables if the column is blank, it signifies that the determination was not made. If the column is marked with dash (-), it signifies that the determination was made but that the amount determined was below the limits of accuracy.

Discussion of Laboratory Results

Particle Size Distribution

A mechanical analysis of soils shows the distribution of the various sized particles comprising the soil mass. A mechanical analysis gives useful information in the study of the genesis, morphology, and classification of soils. It determines whether some material has moved from the A to the B horizon by mechanical or by other means in the process of soil development. The results of the mechanical analysis of five Sinai soils are shown in Table III.

The northern and central profiles, T-1, T-3, and T-4, indicate an accumulation of less than two micron clay in the B2 and B2ca horizons. In these profiles there is 4 to 6 per cent more clay in the B2 and B2ca horizons than in the A horizon, and in profiles T-1 and T-4, 8 to 12 per cent more clay in these horizons than in the underlying B3ca horizons. Profile T-2 showed no indication of clay accumulation in the B horizon.

This may be explained by the fact that it has an ABp surface horizon which has incorporated in it a portion of the underlying BAp horizon. Indication of clay accumulation in the B horizon is assumed to be genetically related to the profile and not an inherited property. It is possible, however, that this additional clay is the result of finer-textured parent laminae. Genetical accumulation of clays in these soils may be the result of translocation of clays out of the A horizon and subsequent deposition in the B horizon, or of the synthesis of clay in situ.

In the southern profile, T-5, the total less than two micron clay does not indicate a clay accumulation in the B horizon; however, the A and B2 horizons have from 7 to 8 per cent more clay than underlying horizons. This difference in clay content may be inherited from parent laminae or genetically related to the profile. In the southern soils there may be a greater proportion of the clay synthesized in situ than in the northern soils. This may be true since they are weathered under slightly more acid conditions than the northern profiles.

Organic Carbon

The distribution and amount of organic carbon are shown in Table VI for five Sinai profiles. The average organic carbon content of the northern and central paired profiles is compared separately with the southern profile and shown graphically in Figure 19. Data used in plotting the average organic carbon content of these profiles are those reported by the author. It may be noted that the organic carbon content is highest in the A horizon and gradually decreases with depth to the B3ca, Cca, or Dca horizons where it is practically nil. The northern profiles have the highest organic carbon content in the surface layers, followed next by the central, and lastly the southern profiles. From Figure 19 it might appear that there is little difference in content of organic carbon of surface horizons between the central and southern profiles, however it is believed that the average organic carbon content of the central profiles was lowered considerably by the relatively low organic carbon content of the ABp and BAp horizons of profile T-2. Profile T-1, which has an Ap horizon, has an organic carbon content of 3.46 per cent which is intermediate between the southern profile and northern profiles. It appears that the southern profile has a greater content of organic carbon below a depth of 10 inches than the central profiles but that the northern profiles have a greater content of organic carbon to a depth of about 30 inches than either the central or southern profiles.

Based on the assumption that a six inch slice of soil weighs 1000 tons, there is approximately 25 per cent more organic carbon to a depth of 20 inches in the northern Sinai profiles than in the southern profile, T-5.

It is likely that prior to the cultivation of these soils, greater contents of organic carbon were present in the southern Sinai soils than in either the central or northern Sinai soils. This would be a result of the fact that greater precipitation in the southern area during a longer frost free period was conducive to denser, more luxuriant native vegetation. Also, it is believed that a greater percentage of tall grasses were intermixed with mid-grasses in this region. According to Van't Hoff's law, the rate of a chemical reaction increases by a factor

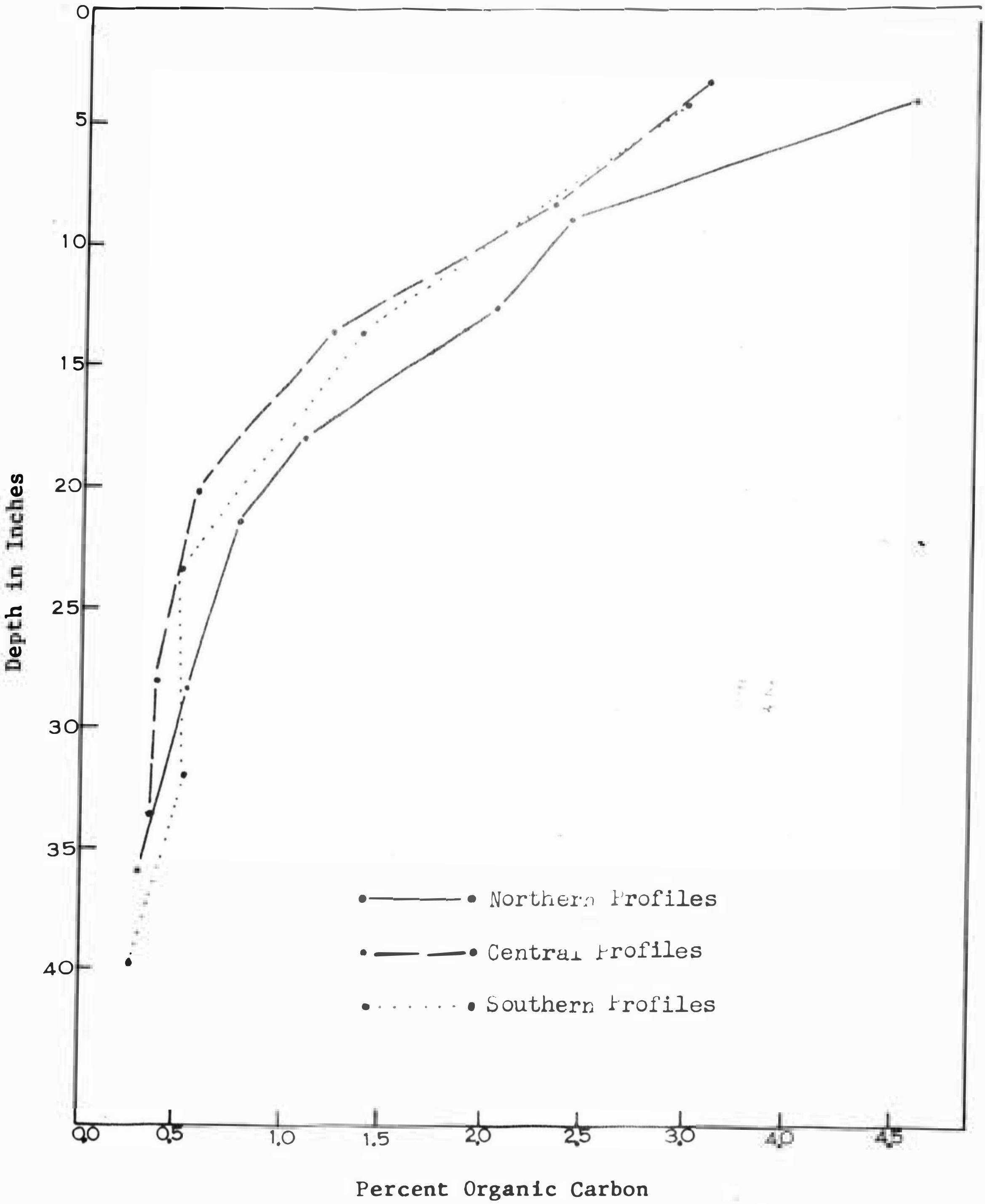


Figure 19. The Average Organic Carbon Content of the Northern, Central and Southern Sinai Profiles.

of two to three for every 10^{o} C. rise in temperature. This rule holds for numerous biological processes as well as chemical reactions. Higher temperatures of the southern area would tend to promote more rapid oxidation of organic matter but it is assumed that the accumulation of organic matter proceeded at a greater rate than oxidation. In the less mesophytic northern and central sections the climatic conditions were such that more sparce, less luxuriant vegetation was established; hence smaller quantities of organic matter were accumulated.

The current organic carbon status of these cultivated soils may be attributed to two factors: (a) under higher temperaturas and greater precipitation there is more rapid oxidation of the organic matter accumulated during undisturbed time, and (b) the removal of organic matter by water erosion is more effective in the southern area.

Total Nitrogen

The total nitrogen content of the five profiles is shown in Table VI. The average total carbon content of northern and central profiles is compared separately with the southern profile and shown graphically in Figure 20. It may be noted from this figure that the total nitrogen content is highest in the surface horizons and drops off rapidly with depth in all soils. The northern profiles have the highest total nitrogen content followed by the central profiles and then the southern profile. Jenny (15) states that a pronounced negative correlation exists between the percent nitrogen in the surface layer of cultivated soils and the annual temperature in degrees Fahrenheit. It is probable that higher temperatures and greater precipitation in the southern region are

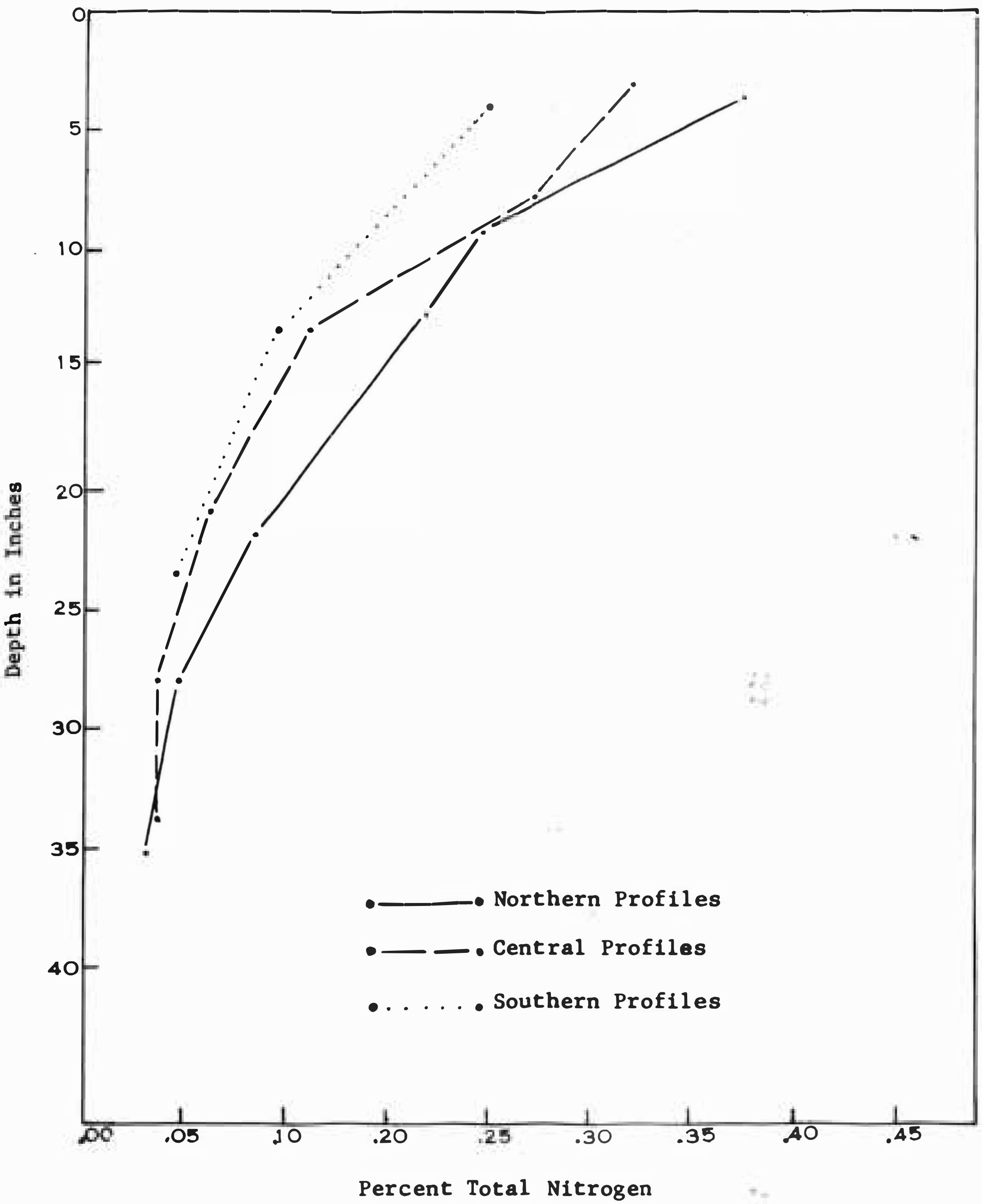


Figure 20. The Average Total Nitrogen Content of the Northern, Central, and Southern Sinai Profiles.

responsible for the lower total nitrogen content of the southern profile. Based on the assumption that a six inch slice of soil weighs 1000 tons, there is approximately 35 per cent more total nitrogen to a depth of 20 inches in the northern Sinai profiles than the southern profile, T-5.

Extractable Hydrogen and Per Cent Base Saturation

Extractable hydrogen and total per cent base saturation are good indicators of the extent of leaching in a soil. Tables IV and V show the data on these parameters for these five profiles. Here it is seen that hydrogen decreases with depth in all profiles. The southern profile has the most, and there appears to be little difference in the amount of extractable hydrogen between the northern and central profiles. The base saturation percentage of the A horizon, calculated on the basis of the summation of cations, is about 4 to 8 per cent higher for the northern and central profiles than for the southern profile. Base saturation for the A horizon in the northern profiles varies from 84 to 88 per cent. It is 80 per cent in the southern profile. The B2 horizons of these five profiles range between 91 and 96 per cent in base saturation. These data might indicate slightly more intense leaching in the A horizon of southern Sinai soils.

pH

The pH values of all five profiles are shown in Table VI. From these data it may be seen that the surface horizon of all five profiles are slightly acid and the B2 horizon is neutral. Horizons which contain segregated and disseminated lime are mildly alkaline. The pH of the A horizon in the northern Sinai profiles may be more closely related to content of organic matter than to the intensity of leaching.

Extractable Calcium

Data for the extractable calcium in these five profiles is shown in Table IV. These values indicate that there is somewhat greater leaching in the A and B2 horizons in the southern profile than in the central or northern profiles. This is substantiated by the lower per cent calcium saturation and the lower calcium to magnesium ratio in the southern profile than in either central or northern profiles. These data are consistent with the results of extractable hydrogen and per cent base saturation which indicate a trend for more intense leaching in the A and B2 horizons of profile T-5.

Cation Exchange Capacity

The exchange capacity of the soil is closely related to the amount of colloidal material present. It may be of either organic or inorganic nature. Arneman et al. (2) found that there is a high correlation between the organic matter content of the A horizons and the total cation exchange capacity. Although not as closely correlated, he found that there is also a highly significant correlation between the clay content and the total exchange capacity. The correlation coefficients are 0.734 and 0.646 respectively. The results for these five profiles are shown in Table IV. Total base exchange capacities of these soils appear to be closely related to the organic carbon content and to the content of clay.

Extractable Sodium and Potassium

Extractable sodium in these five profiles is shown in Table IV.

There is a gradual increase in sodium with depth in all profiles. The content of extractable potassium is highest in the surface horizon and decreases with depth in all profiles.

Per Cent Calcium Carbonate Equivalent

The per cent calcium carbonate equivalent in each of these five profiles is listed in Table V. These results might indicate that the southern Sinai profile is leached to a greater depth than northern profiles. This trend is also apparent in the field, however the variation in the depth of leaching of the Sinai soils is often of greater magnitude within an area than between areas. The calcium carbonate equivalent in horizons of genetic lime accumulation appears to be higher in the northern profiles than in the southern profile. Laminated segregations of lime in the lower portion of the solum and in the substratum are assumed to be an inherited property of the parent material.

TABLE III. MECHANICAL ANALYSIS OF FIVE SINAI PROFILES

Soil No.	Horizon	Depth inches	Particle Size Distribution (in mm.) (per cent) 2	Sand 2-.05	Silt .05-.002	Clay .002	Textural class
T-1	Ap	0-6	-	7.8	55.0	37.2	sicl
	B21	6-10	-	4.7	52.9	42.2	sic
	B22	10-17	-	6.1	52.9	41.3	sic
	B23ca	17-26	-	10.3	56.7	33.0	sicl
	B3ca1	26-30	-	8.0	58.7	33.3	sicl
	B3ca2	30-37	-	9.8	53.6	36.6	sicl
	Cca1	37-46	-	12.2	63.8	24.0	sil
	Cca2	46-60	-	13.7	58.5	27.8	sicl
T-2	ABp	0-6	-	7.3	53.1	39.6	sicl
	BAp	6-9	-	7.2	53.9	38.9	sicl
	B21	9-13	-	5.4	55.0	39.6	sicl
	B22	13-18½	-	6.5	56.5	37.0	sicl
	B2ca	18½-24	-	5.0	64.6	30.4	sicl
	B3ca1	24-32	-	5.7	63.6	30.7	sicl
	B3ca2	32-36	-	5.7	64.3	30.0	sicl
	Cca1	36-42	-	6.5	63.4	30.1	sicl
	Cca2	42-54	-	4.9	63.7	31.4	sicl
	Cca3	54-58	-	5.6	63.1	31.3	sicl
	Cca4	58-60	-	5.9	61.1	33.0	sicl
T-3	A1p	0-8	-	11.1	47.7	41.2	sic
	B21	8-12	-	6.1	48.4	45.5	sic
	B22	12-15	-	5.7	48.4	45.9	sic
	B2ca1	15-21	-	6.4	49.6	44.0	sic
	B2ca2	21-26	-	8.7	47.2	44.1	sic
T-3	B2ca3	26-32	-	9.0	48.2	42.8	sic
	B3ca1	32-40	-	6.7	71.7	21.6	sil
	B3ca2	40-43	-	1.7	52.9	45.4	sic
	Cca1	43-56	-	1.8	54.0	44.2	sic
	Cca2	56-60	-	2.7	41.6	55.7	sic
T-4	A1p	0-6	-	13.8	48.9	37.3	sicl
	B21	6-10	-	7.9	50.7	41.4	sic
	B22	10-14	-	8.7	48.1	43.2	sic
	B2ca1	14-18	-	4.5	49.3	46.2	sic
	B2ca2	18-22	-	6.2	50.0	43.8	sic
	B2ca3	22-29	-	15.5	50.2	34.3	sicl
	B3ca1	29-32	-	27.2	42.4	30.6	cl
	B3ca2	32-38	-	21.6	48.7	29.7	cl
	B3ca3	38-45	-	27.9	34.4	37.7	cl
	DB3ca	45-56	-	34.7	36.8	28.8	l
	Dca	56-60	1	82.6	9.8	7.6	ls
T-5*	A1p	0-8	-	2.7	51.3	46.0	sic
	B2	8-19	-	1.6	54.0	44.4	sic
	B2ca1	19-28	-	2.8	59.8	37.4	sicl
	B2ca2	28-36	-	4.2	60.3	35.5	sicl
	B2ca-B3ca	36-44	-	3.4	59.5	37.1	sicl
	B3ca1	44-50	-	3.5	61.1	35.4	sicl
	B3ca2	50-60	-	5.0	60.4	34.6	sicl

* Analysis by Soil Survey Lab., Lincoln, Nebraska.

TABLE IV. EXTRACTABLE CATIONS AND CATION EXCHANGE CAPACITY OF FIVE SINAI PROFILES

Soil No.	Hori-zon	Depth inches	Cation Exch. Cap. me./100gm.	Extractable Cations me./100gm. Ca	Mg	H	Na	K
T-1	Ap	0-6	37.7	21.9	7.3	5.1	0.2	1.7
	B21	6-10	37.6	23.8	8.0	3.5	0.2	1.4
	B22	10-17	34.9	29.7	7.9	0.8	0.3	1.1
	B23ca	17-26	23.7				0.3	0.7
	B3ca1	26-30	23.4				0.4	0.6
	B3ca2	30-37	23.8				0.5	0.6
	Cca1	37-46	19.2				0.9	0.7
	Cca2	46-60	20.4				0.6	0.6
T-2	ABp	0-6	37.1	21.2	8.4	6.0	0.2	1.2
	BAp	6-9	36.2	21.1	8.7	5.2	0.2	1.2
	B21	9-13	35.6	24.5	9.3	2.6	0.2	0.8
	B22	13-18½	33.4	25.5	8.2	0.8	0.2	0.7
	B2ca	18½-24	25.4				0.3	0.6
	B3ca1	24-32	23.0				0.4	0.6
	B3ca2	32-36	22.2				0.5	0.5
	Cca1	36-42	22.8				0.5	0.5
	Cca2	42-54	23.1				0.6	0.6
	Cca3	54-58	24.0				0.7	0.6
	Cca4	58-60	20.6				0.7	0.7
T-3	A1p	0-8	40.1	24.9	8.7	5.5	0.1	1.3
	B21	8-12	36.4	23.8	9.6	2.6	0.2	0.8
	B22	12-15	35.9	33.5	8.2	1.0	0.2	0.7
	B2ca1	15-21	26.2				0.2	0.5
	B2ca2	21-26	25.2				0.2	0.4
T-3	B2ca3	26-32	23.3				0.2	0.3
	B3ca1	32-40	12.7				0.3	0.2
	B3ca2	40-43	22.9				0.4	0.3
	Cca1	43-56	18.0				0.5	0.3
	Cca2	56-60	31.9				1.2	0.5
T-4	A1p	0-6	40.0	24.6	8.7	6.6	0.1	1.2
	B21	6-10	35.5	22.8	8.3	3.4	0.1	1.1
	B22	10-14	34.2	22.5	8.7	2.3	0.1	0.9
	B2ca1	14-18	29.9				0.2	0.7
	B2ca2	18-22	25.4				0.2	0.6
	B2ca3	22-29	19.9				0.3	0.4
	B3ca1	29-32	21.5				0.4	0.4
	B3ca2	32-38	19.9				0.5	0.3
	B3ca3	38-45	23.1				0.7	0.4
	DB3ca	45-56	24.1				0.6	0.3
	Dca	56-60	6.0				0.3	0.2
T-5**	A1p	0-8	31.8 38.4*	20.3	9.1	7.8	0.1	0.8
	B2	8-19	30.2 33.0*	22.2	10.6	3.9	0.1	0.5
	B2ca1	19-28	21.4 23.2*				0.1	0.4
	B2ca2	28-36	20.4 21.0*				0.2	0.4
	B2ca-B3ca	36-44	21.2 20.0*				0.2	0.3
	B3ca1	44-50	20.7 17.7*				0.3	0.4
	B3ca2	50-60	20.3 15.2*				0.3	0.4

* Analysis by author

** Profile analyzed by Soil Survey Lab., Lincoln, Nebraska.

TABLE V. BASE SATURATION, CALCIUM SATURATION, CALCIUM : MAGNESIUM RATIO, CALCIUM CARBONATE EQUIVALENT, AND ELECTRICAL CONDUCTIVITY OF FIVE SINAI PROFILES

Soil No.	Horizon	Depth inches	Base Sat. %	Ca:Mg ratio	Ca Sat. %	$CaCO_3$ equiv. %	Elect. cond. $Ec.x10^3$
T-1	Ap	0-6	86	3.0	60		0.4
	B21	6-10	91	3.0	64		0.5
	B22	10-17				1.6	0.5
	B23ca	17-26				22.3	0.7
	B3ca1	26-30				21.0	0.6
	B3ca2	30-37				21.8	0.7
	Cca1	37-46				16.8	0.8
	Cca2	46-60				17.8	0.7
T-2	ABp	0-6	84	2.5	57		0.6
	BAp	6-9	86	2.4	58		0.6
	B21	9-13	93	2.6	65		0.5
	B22	13-18½	98	3.1	72	1.5	0.6
	B2ca	18½-24				17.9	0.6
	B3ca1	24-32				20.4	0.6
	B3ca2	32-36				20.3	0.6
	Cca1	36-42				19.0	0.6
	Cca2	42-54				18.7	0.5
	Cca3	54-58				22.0	0.6
	Cca4	58-60				18.9	0.6
T-3	Alp	0-8	88	2.9	61		1.4
	B21	8-12	94	2.5	64		0.5
	B22	12-15				1.5	1.0
	B2ca1	15-21				24.6	0.4
	B2ca2	21-26				24.1	0.4
T-3	B2ca3	26-32				28.0	0.3
	B3ca1	32-40				28.0	0.5
	B3ca2	40-43				34.5	0.4
	Cca1	43-56				24.6	0.4
	Cca2	56-60				22.7	0.4
T-4	Alp	0-6	84	2.8	60		1.5
	B21	6-10	93	2.7	64		0.4
	B22	10-14	96	2.6	65		0.4
	B2ca1	14-18				15.2	0.4
	B2ca2	18-22				24.5	0.4
	B2ca3	22-29				24.2	0.4
	B3ca1	29-32				20.7	0.6
	B3ca2	32-38				22.9	0.9
	B3ca3	38-45				22.2	1.0
	DB3ca	45-56				20.9	0.7
	Dca	56-60				12.9	
T-5	Alp	0-8	80*	2.2*	53*		
	B2	8-19	90*	2.1*	60*	1*	
	B2ca1	19-28				19*	20.5
	B2ca2	28-36				18*	20.4
	B2ca-B3ca	36-44				17*	19.7
	B3ca1	44-50				16*	19.6
	B3ca2	50-60				16*	19.8

* Analysis by Soil Survey Lab., Lincoln, Nebraska.

TABLE VI. pH, ORGANIC CARBON, TOTAL NITROGEN, AND C:N RATIO OF FIVE SINAI PROFILES

Soil No.	Horizon	Depth inches	pH Sat. paste	pH 1:1	Organic carbon %	Total nitrogen %	C:N ratio
T-1	Ap	0-6	6.2		3.46	.300	11.5
	B21	6-10	6.3		1.94	.170	11.3
	B22	10-17	7.0		1.26	.126	10.0
	B23ca	17-26	7.6		0.51	.062	8.2
	B3ca1	26-30	7.8		0.37	.033	11.2
	B3ca2	30-37	7.9		0.33	.039	8.5
	Cca1	37-46	8.2		0.29	.029	10.0
	Cca2	46-60	8.0		0.33	.030	11.0
T-2	ABp	0-6	6.0		2.65	.253	10.5
	BAp	6-9	6.0		2.74	.260	10.5
	B21	9-13	6.6		1.40	.120	11.7
	B22	13-18½	7.2		0.96	.103	9.3
	B2ca	18½-24	7.6		0.63	.068	9.3
	B3ca1	24-32	7.9		0.46	.043	10.7
	B3ca2	32-36	7.9		0.38	.036	10.6
	Cca1	36-42	8.0		0.30	.032	9.4
	Cca2	42-54	8.0		0.23	.029	7.9
	Cca3	54-58	8.1		0.24	.029	8.3
	Cca4	58-60	8.1		0.26	.029	9.0
T-3	A1p	0-8	6.2		4.00	.290	13.8
	B21	8-12	6.8		1.94	.161	12.0
	B22	12-15	7.4		1.87	.164	11.4
	B2ca1	15-21	7.8		0.87	.085	10.2
	B2ca2	21-26	7.9		0.94	.090	10.5
T-3	B2ca3	26-32	7.8		0.52	.048	10.8
	B3ca1	32-40	8.0		0.30	.027	11.1
	B3ca2	40-43	8.1		0.42	.038	11.0
	Cca1	43-56	8.2		0.27	.026	10.4
	Cca2	56-60	8.1		0.33	.032	10.3
T-4	A1p	0-6	6.0		4.23	.364	11.6
	B21	6-10	6.8		2.66	.229	11.6
	B22	10-14	7.0		2.19	.180	12.2
	B2ca1	14-18	7.8		1.28	.125	10.2
	B2ca2	18-22	8.0		0.84	.084	10.0
	B2ca3	22-29	8.0		0.61	.057	10.7
	B3ca1	29-32	8.1		0.47	.040	11.7
	B3ca2	32-38	8.3		0.30	.037	8.1
	B3ca3	38-45	8.3		0.42	.030	9.0
	DB3ca	45-56	8.3		0.27	.025	9.6
	Dca	56-60	8.3		0.33	.013	8.5
T-5	A1p	0-8		6.1	2.26* 2.95	.201*	11.2*
	B2	8-19		7.2	1.04* 1.38	.096*	10.8*
	B2ca1	19-28		8.2	0.46* 0.48	.047*	9.8*
	B2ca2	28-36		8.2	0.32* 0.51		
	B2ca-B3ca	36-44		8.1	0.25* 0.25		
	B3ca1	44-50		8.2	0.24* 0.25		
	B3ca2	50-60		8.3	0.22* 0.26		

* Analysis by Soil Survey Lab., Lincoln, Nebraska.

TABLE VII. SATURATION EXTRACT SOLUBLE SODIUM AND POTASSIUM, SATURATION PERCENTAGE, AND BULK DENSITY OF FOUR SINAI PROFILES

Soil No.	Horizon	Depth inches	Sat. Ext. Sol. me./l. Na	Sat. Ext. Sol. me./l. K	Sat. %	Bulk Density (gm./cc.)	% H_2O*
T-1	Ap	0-6	0.1	0.5	62.2		
	B21	6-10	0.3	0.4	58.8	1.24	18.5
	B22	10-17	0.5	0.3	55.2	1.33	17.2
	B23ca	17-26	0.5	0.2	50.3	1.39	15.4
	B3ca1	26-30	0.6	0.1	53.8	1.39	15.1
	B3ca2	30-27	1.2	0.1	55.6	1.42	15.4
	Cca1	37-46	2.8	0.3	52.4	1.51	17.1
	Cca2	46-60	1.9	0.1	50.7	1.41	16.1
T-2	ABp	0-6	0.2	0.3	58.5		
	BAp	6-9	0.3	0.3	59.5	1.13	29.8
	B21	9-13	0.2	0.1	57.0	1.11	26.4
	B22	13-18½	0.2	-	57.0	1.38	23.7
	B2ca	18½-24	0.2	-	52.0	1.39	21.1
	B3ca1	24-32	0.4	-	52.5	1.43	19.2
	B3ca2	32-36	0.7	-	53.3	1.47	18.9
	Cca1	36-42	1.0	0.1	54.4	1.48	18.4
	Cca2	42-54	1.4	0.1	57.1	1.50	20.4
	Cca3	54-58	1.8	0.1	59.1	1.43	22.2
	Cca4	58-60	1.8	0.1	62.2	1.49	21.5
T-3	A1p	0-8	0.2	0.6	65.9		
	B21	8-12	0.2	0.2	58.4	1.14	28.3
	B22	12-15	0.3	0.2	61.4	1.33	28.7
	B2ca1	15-21	0.3	0.1	52.4	1.42	21.9
	B2ca2	21-26	0.4	0.1	54.5	1.54	20.5
	B2ca3	26-32	0.5	0.1	53.3	1.33	17.7
	B3ca1	32-40	1.0	0.1	47.0	1.34	12.9
	B3ca2	40-43	1.0	0.1	64.8	1.35	19.6
	Cca1	43-56	1.5	0.1	55.3	1.52	12.5
	Cca2	56-60	1.6	0.1	82.4		21.9
T-4	A1p	0-6	0.3	0.6	64.5		
	B21	6-10	0.1	0.3	60.2	1.17	29.2
	B22	10-14	0.1	0.3	59.7	1.27	26.3
	B2ca1	14-18	0.2	0.2	55.9	1.45	21.4
	B2ca2	18-22	0.3	0.2	52.5	1.47	21.7
	B2ca3	22-29	0.7	0.2	48.2	1.49	20.0
	B3ca1	29-32	1.2	0.2	49.8	1.44	19.7
	B3ca2	32-38	1.8	0.2	50.0	1.49	19.7
	B3ca3	38-45	2.8	0.2	55.3	1.40	21.7
	DB3ca	45-56	2.8	0.2	50.3	1.46	17.5
	Dca	56-60	3.2	0.3	28.3	1.62	6.8

* Per cent moisture at sampling.

SUMMARY AND CONCLUSIONS

Five Sinai soil profiles, collected from cultivated sites in the northern, central, and southern areas of their present geographical extent, were compared as to their physical and chemical properties and factors of soil formation. Detailed field maps were made to determine the predominant associated soils in each area.

If these results are typical of the areas they represent, they show that the southern profiles could be distinguished in the field from the central and northern profiles by the following characteristics: surface horizons 1 unit higher in value and 0.5 - 1 unit higher in chroma; B2 horizons 1 unit higher in value and 0.5 - 1 redder in hue; and more strongly developed subangular blocky B2 and B2ca horizons. The southern Sinai soils are developed and leached to greater depths than their northern analogues. Based on the results of the detailed soil maps, the predominant Sinai soil associates in the central and southern sections are the Poinsett soils and soils derived from loam glacial drift. This is in contrast to the northern area where the Poinsett-Barnes complex is the major Sinai associate.

The chemical analyses of these soils indicate that there is a trend towards more intensive leaching of extractable bases from the Ap and B2 horizons of the southern profile than there is in the central and northern profiles. The southern soil contains approximately 25 per cent less organic carbon and 35 per cent less total nitrogen in the first 20 inches of the solum than do the extreme northern soils.

An examination of the soil forming factors shows that climate is the only factor which varies measurably between the different areas studied.

It is quite probable that a corresponding variation in native vegetation existed before these areas were cultivated.

A cooler, drier climate of the northern portion of the Prairie Coteau favors slower oxidation of organic matter, slower formation of unhydrated iron oxides, and less intensive soil weathering.

These results indicate that the northern Sinai soils are clearly different from their southern analogues. In the central portion of the Coteau these soils are intergrades between the soils of the northern and southern areas but appear to have more characteristics in common with the northern soils. The author proposes that the name Sinai be retained for the soils in the northern and central areas of their present geographical extent; however, the series type location should be moved from Brookings County to Day County, South Dakota. Further study is necessary to determine the location of the boundary delineating Sinai soils, as defined by this study, from their southern analogues. On the basis of the pronounced climatic changes shown, it is believed that this boundary is nearly coincident with the Moody-Minnehaha County line.

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