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Characteristics and Genesis of the Parleys and Mendon Soils Series in Northern Utah

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CHARACTERISTICS AND GENESIS OF THE PARLEYS AND MENDON SOILS SERIES IN NORTHERN UTAH

by

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Soils Series in Northern Utah

by

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The study was designed to test the genetic theory of soil development of two soils derived from different geological material, but developed under conditions of similar climate, topography, biological activity, and age. An attempt was made to relate the soils characteristics to their present classification. Parleys and Mendon series which developed from Bonneville and Salt Lake Formation, respectively, were selected for that purpose. Along the east side of Cache valley, two pedons representing each of the studied series were selected to have similar soil formers except for their parent material.

Evidently, these studied soils have been developed from different heterogenous sediments. Mendon soils have been developed from Salt Lake Formation to at least 51 cm depth, whereas, the solum horizons are attributed to the Bonneville Formation. The Parleys soil seems to be mainly developed from Bonneville Formation. But the upper solum horizons are probably interlayered with fine deposits of Holocene age. Those soils which derived from different geological deposits show a high degree of similarity between them. Heterogeneity and the nature of the soil parent material, and similarity of their climatic and developmental conditions are believed to be the major causes to inhibit many genetic variables between them.

In northern Utah, the Mendon soils are classified as Calcic Pachic Argixerolls, at the subgroup level. This study has shown that most of the Mendon pedons do not have a Pachic epipedon. Therefore, these studied soils could be grouped together in one subgroup. The result is Calcic Argixerolls in fine-silty, mixed, mesic family. Re-examining Mendon series in Cache valley and reclassifying them on the basis of Pachic epipedon would be an interesting subject for further study.

(76 pages)

INTRODUCTION

The theory of soil development recognized in 1886 was that soil is a function of the combined activity of soil forming factors (Joffe, 1936). The forming factors are parent material, climate, biological activity, relief, and time. In general, the concept presumes that given a combination of these soil formers only one type of soil will exist. The requirement necessary for testing this theory can be rigidly fulfilled only under controlled experimental conditions; but in nature, testing of a single factor of this concept can be approximated in an area where the soils are characterized by a relative constancy of all soil forming factors except one. Under such conditions a continuous function between these soils is likely to be obtained.

In northern Utah, many developed soil properties are attributed to the influence of climatic conditions rather than their parent materials. Recent work (Southard and Miller, 1966) has shown that these relationships are not as clear cut as originally believed. The fact is, there has been limited work done and the exact relationships between soils and parent materials are not well established.

The study reported here is based upon two soils assumed to be derived from different parent materials and developed under similar climatic, topographic, and age conditions. The study sites were selected in such a way that the independent genetic variable in Jenny's formula would be parent material, while other soil formers have been considered approximately constant (Jenny, 1941).

Statement of the problem

The purpose of this study is to test the genetic theory of soil development and resolve the functional relationships between two soil series which appear to have about the same set of soil forming factors. An attempt was made to develop a basic set of criteria to interpret the different characteristics between these soils from the genetic view point.

Parleys and Mendon soils have been selected for this study of soil development because these soils have apparently developed under the same conditions except for parent material. The Parleys and Mendon soils occur near each other on the east side of Cache valley, on slopes of equal gradient and at the same elevation (4500 to 5100 feet) and exposure. Since they occur at the same elevation and similar topographic positions below the levels of ancient Lake Bonneville their relative and absolute age are presumed similar. These similarities afford a high degree of control for testing the soil genetic theory. Both of the series studied are quite productive and important to agriculture in the areas of their occurrence. The major differences between the two soils is presumably the nature of the material from which they have formed. Parent material for Parleys is reported to be Lake Bonneville sediments, whereas the Mendon soil is derived from the Salt Lake Formation, calcareous and tuffaceous Tertiary sandstone. If the soil forming factors are reasonably similar except for differences in the parent materials, then a basis for testing the soil genetic theory exists. The hypothesis is that these two soils have been derived from different parent materials and will have inherited or developed properties with measurable differences which can be traced to the parent materials and which serve as the criteria for separation of the two soils at the series level of classification.

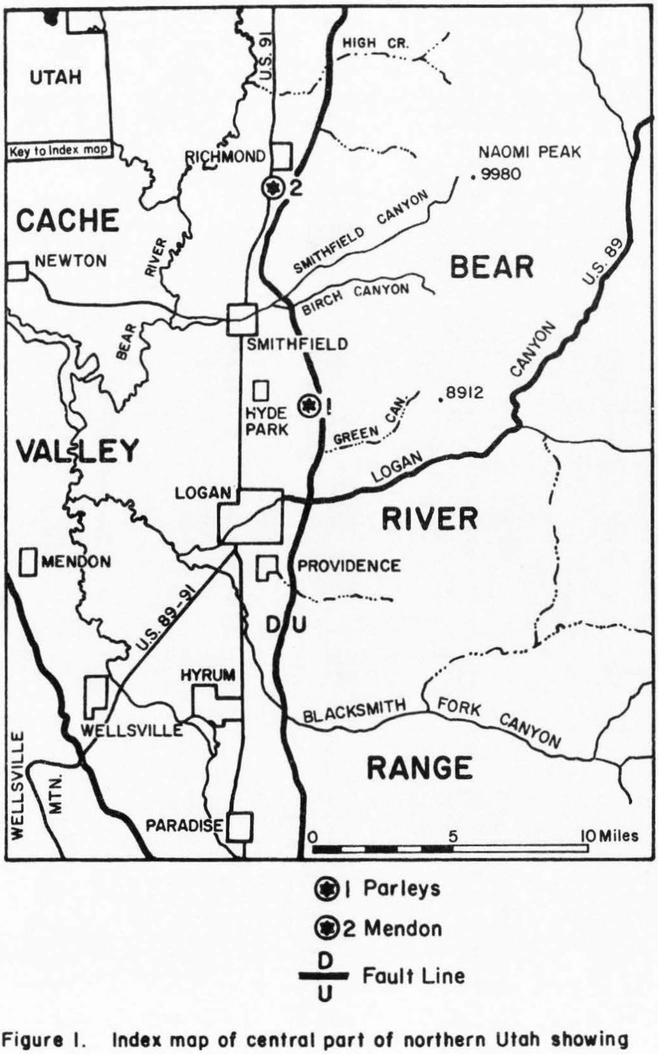

Figure I. Index map of central part of northern Utah showing site location of studied soils.

The study area is located in the eastern part of Cache valley (Figure 1); the location of Parleys and Mendon soils are about 1 mile southeast of Hyde Park and 0.5 miles southwest of Richmond, respectively.

REVIEW OF THE LITERATURE

In northern Utah, it has been hypothesized that many soils have their properties influenced largely by their parent material (Southard and Miller, 1966). However, only a few studies have been reported to support this hypothesis, and little is known about the genesis of the many soil series especially with respect to the different sediments in which they formed. Southard and Miller (1966) stated that the kind of clay in some northern Utah soils is reflected strongly by the influence of the parent material rather than other environmental factors. Al Taie (1958) in his work on some soils associated with different parent materials of Lake Bonneville, showed that the parent material has a large influence on the soil characteristics and that differences in the soil clay minerals is due to the heterogeneity of their parent materials.

Hale (1958) studied the relationships between two methods of sampling of Parleys and Mendon soils for chemical characterization. He compared increment versus horizon sampling. Hale gave no indication of any relationship existing between horizons and he did not give any comparison between these soil characteristics from the genetic viewpoint.

Mechanical analysis and calcium carbonate of Parleys and Mendon soils in Cache valley has been reported by Erickson and Mortensen (1972). A previous examination of these data shows several discontinuities in the particle size distribution which suggests changes in the depositional or developmental history of the two soils. A detailed minerological and chemical study, therefore, is necessary to provide an answer to the differences in the materials from which these soils are developed.

It was stated before, that these soils are developed under similar climatic conditions. The study area, east of Cache valley, is located within the North Central climatic region (Roylance, 1967). Table 1 shows the average of the temperature and precipitation for the period 1931 to 1960 within this region.

Table 1. Temperature and precipitation averages for the period 1931-1960, in North Central Climatic Region, Utah

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature (F)	27	32	39	49	58	66	75	73	64	52	38	31	50
Precipitation (Inches)	1.6	1.4	1.7	1.8	1.6	1.1	.6	.8	.7	1.4	1.4	1.5	15.7

In Cache valley, precipitation increases with elevation, and seasonal variations are significant. The average annual precipitation ranges from 15 to 20 inches. Rainfall is light in summer and is the heaviest in the spring. About half of the precipitation occurs as snow, most of which falls in the period from December through March. The average annual snowfall ranges from 60 to 80 inches. The mean annual air temperature is 50 degrees F, and the climate is characterized by cold winters.

Recorded temperatures of the valley show that the maximum temperature of 90 degrees F or higher occurs an average of less than 25 days a year. The frost-free season is 120 to 160 days and the growing season of the study area ranges from 114 to 150 days (Erickson and Mortensen, 1972). It is slightly longer along the higher lake terraces and mountain foot slopes.

A brief geological view of Cache valley and the parent material of related soils

"Cache valley is a narrow elongate Basin which lies in the northeast corner of the Great Basin Province" (Williams, 1958). The northern part of the valley is in Franklin, Idaho, and the southern part in Cache County, Utah, where the studied area is located (See Figure 1). The highest elevation is Naomi Peak in the Bear River Range (about 9980 feet), and the major part of the valley occurs at elevations between 4400 and 5200 feet (Williams, 1958).

The Bear River is the largest stream in the area; it crosses the valley from northeast to southwest and serves as a drainage for all other streams. The Logan River source is Franklin Basin, where the river enters the valley east of Logan City. The valley floor, where downtown Logan is situated, is a nearly level surface underlain by fine-grained sandy sediments deposited at the toe of the Lake delta. The interior of the valley is covered mainly by deposits of former Lake Bonneville, whereas, in the foothill areas around the valley, Tertiary rocks of the Salt Lake Formation are dominant (Williams, 1948).

The geological map of the study area shows that each of the Parleys and Mendon is located on alluvial Lake Bonneville sediments and Salt Lake Formation, respectively. The Bonneville Formation of Quaternary period forms most of the valley floor of the study area, whereas, the Tertiary Salt Lake Formation is well exposed along the east side of the valley (See Figure 2).

The Salt Lake Formation has been divided into three members from the oldest to youngest, which are: Collinstone Conglomerate Member, Cache Valley Member, and Mink Creek Member (Adamson et al., 1955). The conglomerate

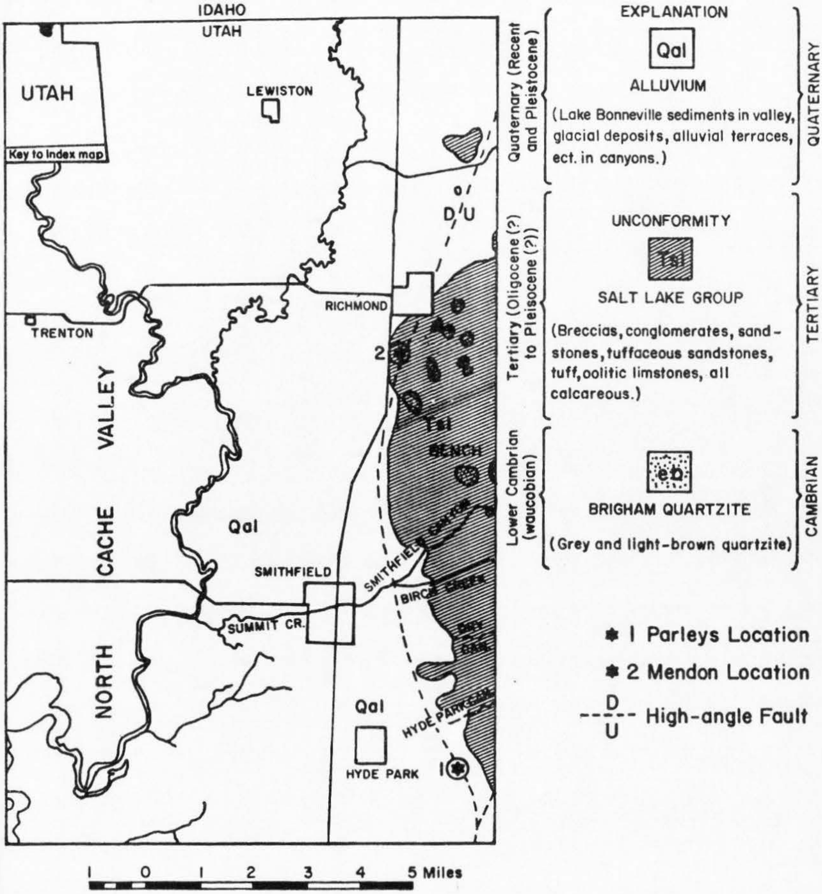

Figure 2. Geological map of the northern part of Cache Valley, Utah showing the site location of studied soils. (Adapted from J. Williams, 1948)

Members consist of rounded to subangular pebbles, cobbles, and some boulders of Paleozoic rock cemented by calcite. In the most southern and central part of the valley, the tuffaceous bed that crops out is designated as Cache Valley Member. It consists of tuff, tuffaceous sandstone, tuffaceous limestone, oolitic limestone and pebble conglomerate (Williams, 1952). Adamson et al. (1955) have reported that the Mink Creek Member contains generally light-colored tuffaceous conglomerate and overlies the Cache Valley Member along the northeastern side of the valley. However, within the study area and along the east side of Richmond City, only Cache Valley and Conglomerate Members are well exposed.

In Cache valley, it has been reported that most of the conglomerate material of Salt Lake Formation was deposited along the flanks of the mountains, whereas, the light-colored tuff, limestone, and sandstone were deposited farther away from the mountain masses (Adamson et al., 1955). Williams (1958) has explained the source of the fine material along the east side of Cache valley in this way: "Lake Bonneville transgressed the foothill slopes of soft weathered rock of the Salt Lake Formation, and waves stirred up much of the fine sand and silt, which was transported by the current onto the embankment."

The Bonneville Formation includes deposits which accumulated in the lake during its highest stage. Gilbert (1890) referred to this stage as the Bonneville stage. The Bonneville Formation consists of unconsolidated deposits ranging from boulder gravel to fine silt and clay (Williams, 1958). Near the Bonneville shore line, deposits are composed of coarse material and much of the gravel is well rounded, whereas, farther from shore the gravels are subangular (Maw, 1968). Pack (1939) suggested that the formation of the lake terraces is possible only at the time when the lake level is stationary. Williams (1962) recognized two units of the Lake Bonneville Group: 1) the older Alpine and Bonneville Formation and 2) the younger Provo Formation. In the southern part of the study area and where the Parleys soil is located, the Lake Bonneville sediments consist mostly of gravel, silt, sand, and clay.

Previous geomorphological study of the Smithfield Quadrangle indicated notable alluvial deposits along the Smithfield and Birch Canyons, Dry Canyon, Hyde Park Canyon, and Green Canyon in the southeast part of the study area. All of these alluvial deposits include fine-grained sediments along the streams and in alluvial fans. This fan upon which most of Smithfield is situated was built by the stream of Smithfield Canyon after the fall of Lake Bonneville below about 4450 feet; and possibly the fan forms a veneer on an older fan or even a delta built into Lake Bonneville. The alluvial fans are believed to be of Holocene age (Galloway, 1970).

Previous studies of soil genesis and evaluated soil-forming factors

The concept of soil-forming factors has been accorded a prominent position in the pedological literature. According to Simonson and Cline (1961) the processes of soil formation should be regarded as the results of a variety of chemical, physical, and biological reactions, all of which are potential contributors to the development of every soil (DeVilliers, 1964). Jenny (1941) developed the idea of soil formers into useful tools of research. In his interpretation, he stated that the common soil characteristics become variable and may be expressed as a function of soil-forming factors. Early studies in the United States evaluating the pedogenetic theory of soil development have been reported. All of them have regarded one or more of the soil formers as genetic variables, while others are assumed to be constant.

Jarvis et al. (1959) studied the role of the parent material and its influence on the physical and chemical characteristics of four soil series in southeastern Kansas. The studied series had developed mainly on residum and colluvium of sandstone, limestone, and shales. They point out that the soils which have developed from sandstone have high sand and low clay contents. The other soils which are derived from fine-textured parent materials have very little sand and varying amounts of clay. They reported that the dominant clay mineral in some of these soils is montmorillonite, whereas a mixture of illitic and montmorillontic clays are dominate in others. In their study, it was shown that a smaller amount of quartz, illite, kaolinite, and vermiculite are present in many of the clay fractions of those soils. It was concluded that in some soils of their study, clay minerals were inherited directly from their parent material; and the morphological differences among these series are attributed to the variations in their parent materials and other variable factors. Harradine and Jenny (1958) evaluated the dependence of soil texture and soil nitrogen on the climate and the parent material as variable factors. In their study, a number of interesting evidences were obtained. Soil derived from basic-igneous rocks have higher moisture equivalents and higher nitrogen content than those derived from acid-igneous rocks. Their conclusion was that there was a linear relation between soil nitrogen and moisture equivalents.

Yassaglon et al. (1969) showed significantly different properties among eight soils which were developed under similar climatic, topographic, and age conditions. They reported that among the soils studied, differences in their morphological, physical, and chemical properties were due to the variation in the parent material and in the vegetational cover. Also they observed that soils with cambic horizons have C horizons with lower base saturation than soils with argillic horiozn. They point out that the distribution of the extractable aluminum appears to be influenced by the vegetation cover and the kind of the parent material. "Spruce (Picea ex elsa L.) has affected soil properties more intensively than scotch pine (Pinus sylvestris L.) or grasses." They concluded that acid rocks tend to develop into soils with cambic horizons while marble forms argillic horizons regardless of the type of vegetation. Hutcheson and Haney (1963) studied the chemical and mineralogical relationships between three closely associated parent materials and their sola. The soils that were studied have developed under similar conditions of relief and climate with somewhat different sedimentary deposits of Ordovician age. In their study, petrographic examination showed weathering of glauconite in the sand and silt fraction as the solum surface was approached. They reported that glauconitic clay decreased in the more weathered upper solum horizon, whereas, kaolinite, vermiculite and other 2:1 expanding lattic minerals became more dominate. They stated that during the soil development, it appeared that the following sequence of weathering was occurring:

Illitic mineral (Glauconite) ⟶ Vermiculite ⟶ Montmorillonite & interstratified 2:1 layer silicates ⟶ Kaolinite

J. M. DeVilliers (1964) tested the correlation between the inherent soil characteristics and their parent material. His work indicates that the preweathering and soil creep with implied mixing of materials of different provenances can give rise to a high degree of non-genetic variability in the initial state of the pedogenic system.

James and Jenny (1966) correlated the variability of soil nitrogen with the parent material and mean annual precipitation. This study is based mainly upon the genetic theory of soil-forming factors (Joffe, 1936). In order to obtain such correlation, they studied the influence of mean annual precipitation and parent material on availability of soil nitrogen, using two soils derived from acid and basic igneous rocks. In both soils, they showed that soil nitrogen is significantly related to mean annual precipitation, but with increase in precipitation, soil derived from basic igneous parent material is richer in nitrogen than soil derived from acid igneous parent material. Because soil nitrogen increased with precipitation, and since availability of nitrogen is related to the total nitrogen; therefore, it was concluded that the availability of nitrogen is a function of mean annual precipitation, and soils from different parent materials have distinct available nitrogen-precipitation functions. Somasir and Huang (1973) studied the nature of K-feldspars of four soils developed from different parent materials. In their study, soils derived from lacustrine sediments had a higher orthoclase:microcline ratio than those derived from glacial till deposits. They reported that the variation of the proportion of orthoclase to microcline with particle size distribution is more likely to be an inherited property. It was concluded that the nature and amount of K-feldspar was dependent upon the initial source rocks from which those soils are derived unless the soils were highly weathered.

White (1973) evaluated the age of soil landscape derived from Pierre Shale. He reported that in the area of his study, soils with blowout basins were more weakly developed and appeared to be younger than soils in comparable areas without deflation basins. He stated that the geomorphological evidence did not hold precisely with the concept of soil-age development. His conclusion that the age of these soils was less than estimated from geomorphic relationships for Pleistocene terrace systems was that "Soils in one area with deflation basins have development comparable to soils derived from late-Wisconsin drift."

Throughout the history of the development of soil classification the significance of the quantitative and observable measurements is not questionable. The recent classification system relies more on both the quantitative measurement and qualitative characteristics (Soil Survey Staff, 1972). It is true that in any soil system, our understanding of the pedogenetic processes are derived mainly from observable and measurable properties of the soil body (Simonson, 1959). Change et al. (1973) pointed out that the different trends of bulk density and selected mobile and immobile constituents could serve as evidence for change in the soil system. Stahnke et al. (1969) reported that sand fractionation and study of heavy mineral suites in soil horizons could be used to indicate the homogeneity of the parent material.

In the above studies, a number of attempts have been made to evaluate the soil-forming factors; each of them has taken one or more of the soil-forming factors to be constant, while the others were assumed to be variable. This supposedly provides a means of estimating the influence of a specific soil property on soil formation. In the study reported here, all the soil-forming factors were considered constant except parent material which was chosen as the only genetic variable between two soil series. Hopefully, this variable soil-forming factor could serve as a criterion for testing the genetic theorem and illustrate the variability between the studied soils which have been separated at the subgroup level in northern Utah.

Classification of Parleys and Mendon soils

According to the Soil Survey Staff (1972), the Parleys soil series is classified as fine-silty, mixed, mesic, Calcic Argixerolls and the Mendon soil series as fine-silty, mixed, mesic, Calcic Pachic Argixerolls. Both of these soils are classified as Argixerolls at the great group levels, and they are a member of fine-silty, mixed, mesic family. At the subgroup level, Parleys is classified as a Calcic Argixerolls, whereas, Mendon soil is Calcic Pachic Argixerolls (Erickson and Mortensen, 1972). The differences between these subgroups is based upon the thickness of the mollic epipedon which is thicker (more than 50 cm) in the Pachic subgroup.

The analytical data of these series as reported by Erickson and Mortensen (1972) in the Cache area, show a similar distribution of the calcium carbonate within the Mendon and Parleys soils, although the amount of carbonate within the Mendon soil is much higher. Presumably, this similarity in carbonate distribution should reflect the nature of the pedogenetic processes of these soils associated with their differences in the parent material. The study will attempt to show how these differences relate to the differences of the soils studied and their classification.

METHODS AND PROCEDURES

The two soil series which were selected for this study were Parleys and Mendon, and each series was sampled at one location by its genetic horizons. Special care was taken in choosing sampling sites to obtain pedons which were as near to the model concept as possible. The pedogenetic factors encountered in the study area have been carefully evaluated; both of the selected pedons occur on the same slope (3 to 4 percent), at the same elevation (4500 to 5100 feet) and same west exposure on the east side of Cache valley in northern Utah.

Field procedure

At each site a pit 3 feet wide and 5 feet long was excavated. The pits were sampled by horizons, starting with the lowest horizon and working upward to avoid contamination. If the horizon was more than 30 cm thick, it was subdivided into 2 equally thick subhorizons for sampling. These samples were taken to the laboratory where they were air-dried and crushed to pass a 2mm sieve.

From the same side of the pit and prior to the bulk sampling, bulk density samples were taken by selecting clods which were representative of each horizon. Thin section samples were selected from the same clods.

Laboratory procedures

Calcium carbonate equivalent. Calcium carbonate equivalent was determined by the method proposed by the U. S. Salinity Laboratory Staff

(1954). The procedure involves treating a finely ground sample (less than 60 mesh) with an excess of a 0.5N HCl. After the carbonates were decomposed, the excess acid was titrated with 0.25N NaOH.

Soil reaction. Soil reaction was determined on a saturated paste with a Beckman Model H-2 glass electrode pH meter.

Organic matter. Organic matter was determined according to Peech et al. (1947). The method is based on the oxidation of organic carbon by potassium dichromate in sulfuric acid. The mixture was allowed to stand one hour and filtered. The color intensity was read at 610 mm (blue photube in Spectronic 20) using three organic mater standards (soils).

Bulk density. Bulk density was determined by the clod method (Black et al., 1965).

Total soluble salts. Total soluble salts were determined on a saturated extract with electrical resistance (Black et al., 1965). The method involves measuring the conductivity of the extract with a pipette conductivity cell using a Model RC-IR conductivity (Wheatstone) bridge.

Cation-exchange capacity. Cation-exchange capacity was determined by the modified procedure of Bower et al. (1952). Saturation with sodium acetate (NaOAc), centrifuge and washing with 99 percent isopropyl alcohol. The results are expressed in me per 100 g of oven dry soil.

Extractable cations. Atomic adsorption spectrophotometer, model Jarell Ash-800 was used for Ca, Mg, and K determination, after extracting with 1.0N ammonium acetate at pH 7.0.

Free iron oxide. Free iron oxide was determined by atomic adsorption spectrophotometer method; the procedure is a slight modification of the method given by Kilmer (1960). The extracting solvent used was sodium dithionite ($Na_2S_2O_4$). The mixture was adjusted to pH of 3.5-4.0 with 1.0N HCl.

Total aluminum and silica. Determination of alumina and silica were made, using the method modified by Katz (1968). The procedure involved wetting 0.5 gm soil with NaOH. Concentrated HCl was added to the mixture and the solution were made up to volume. For alumina determinations, 3 ml of 5 percent KCl were added in order to repress ionization effects. Standard calibration solution for both silica and alumina were prepared and the percent-absorption was recorded for all samples by atomic adsoprtion spectrophotometer (Model-Jarell Ash-800).

Extractable aluminum. Extractable aluminum was determined with the atomic adsorption spectrophotometer. The procedure is a slight modification of the method adapted by Lunin (1949). The extracting agent was ammonia acetate (NH_4OAc) at pH 4.8.

Water content. Water content at 1/3 atm. was determined by the method given by Richards (1955). This method used the pressure membrane apparatus. Pressure was applied until equilibrium (48 hours) was approached and percent moisture was then recorded.

Particle size distribution. The procedure used was that proposed by Jackson (1958). The soil was fractionated by treating with sodium acetate (pH5) to destroy the carbonates and the organic matter was removed by oxidation with H_2O_2. Dispersion of the soil was accomplished by washing and boiling in a 2 percent Na_2CO_3 solution. Particle size separation was performed by the centrifuge method using 250 ml bottles, and the centrifuge times were calculated from the equation by Jackson (1956).

Pretreatment of fine silt and clay-size material for x-ray. The 0.2μ and 0.2-2.0μ clays and the 2-5μ fine silt fraction of selected horizons were prepared for x-ray analysis. The method used is that given by Jackson (1958). Samples of each size fraction were saturated, one with potassium and the other with magnesium.

Thin section. Thin section samples of selected horizons were dried in an oven over night at 110 degrees C. They were placed in milk cartons and a resin was poured around it, enough to cover the sample completely. The resin consisted of one part Paraplex-444 with two parts Styrene. To this mixture 0.5 percent by volume of Lupersol was added. The samples were placed in a vacumn dessicator, and evacuated until the air bubbles escaped. The system was allowed to set for three minutes and then the vacumn was released slowly over a period of minutes. The procedure was repeated three times.

The samples were then removed and placed in a low temperature oven (40 to 50 degrees C) over night. This allowed the resin to harden slowly to avoid cracking. When the resin was hard enough, the samples were placed in the oven at 110 degrees C for more than 2 hours and in some cases over night to complete the hardening process.

The samples were cut and then cemented to glass slides, using epoxy resin to cover the section. The section was labeled and dried at room temperature over night and ground to a thickness of 0.03 mm using carborundum powder and water.

Petrographic study. Petrographic study of fine sand fraction was made on selected horizons. The slides were prepared by mixing a sample with epoxy resin. The samples were then ground to a thickness of 0.03 mm to identify the minerals with the petrographic microscope.

FIELD MORPHOLOGY OF SOILS SERIES

The morphology of two pedons, representing Parleys and Mendon series, were described in detail. Regardless of the presumption of their pedogenetic factors, the pedons used were very close to the model concept for the series which they represent.

Parleys series

Parleys series is medium to fine textured, well drained, deep and neutral to moderately alkaline. These soils were formed from material that was derived mainly from the Lake Bonneville Formation. They occur on lake terraces at elevations of 4500 to 5100 feet, usually on slopes of 0 to 20 percent. The total area of this series is about 17,176 acres, which represents 7 percent of the total soils in the Cache valley survey area.

The pedon was sampled in an alfalfa field, about 1300 feet west and 250 feet north of E 1/4 corner of Sec. 11, T12N, RIE, southeast of Hyde Park, Cache County, Utah. The exposure is toward the west, on a 3 percent slope (See Figures 3 and 4).

The profile description follows:

Horizon	Depth (cm)	
AP	0-25	Dark brown (10YR 4/3) silty clay loam; very dark grayish brown (10YR3/2) moist; moderate fine granular structure; hard, firm, sticky and plastic; many fine and many medium roots; many large pores; non-calcareous (pH 7.6 paste); clear smooth boundary.

Figure 3. Landscape of Parleys Soil.

Figure 4. Profile view of Parleys soil.

Horizon	Depth (cm)	
B1	25-43	Brown to dark brown (10YR 4/3) silty clay loam; dark grayish brown (10YR 4/2) moist; moderate medium subangular blocky structure; hard, sticky, and plastic; many medium and many fine roots; few fine and few medium pores; non-calcareous (pH 7.5 paste); clear wavy boundary.
B21t	43-61	Brown (10YR 5/3) silty clay loam; dark yellowish brown (10YR 4/3) moist; strong medium subangular blocky structure; very hard, firm, sticky and plastic; many fine roots; few pores; non-calcareous (pH 7.5 paste); clear smooth boundary.
B22t	61-74	Brown (10YR 5/3) silty clay loam; brown to dark brown (10YR 4/3) moist; strong medium subangular blocky structure, hard, friable, sticky and plastic; many fine roots; few medium and fine pores; calcareous; (pH 7.7 paste); clear smooth boundary.
B3ca	74-94	Brown to dark brown (7.5YR 4/4) silty clay loam; dark yellowish brown (10YR 4/4) moist; moderate medium subangular blocky structure, hard, friable, sticky and plastic; many fine roots; few medium and few fine pores; calcareous (pH 7.8 paste); clear, wavy boundary.
Clca	94-107	Brown (10YR 5/3) silty clay loam; brown to dark brown with dark brown (10YR 4/3 and 10 YR 3/3) moist; moderate medium subangular blocky structure, hard, friable, sticky and plastic; few fine roots; many fine and medium pores; numerous lime veins strongly calcareous (pH 7.8 paste); gradual smooth boundary.
C2ca	107-124	Brown (10YR 5/3) silt loam; brown to dark brown (10YR 4/3) moist; weak medium subangular blocky structure, hard, friable, sticky and plastic; few fine roots; many fine and many medium pores; numerous lime veins through strongly calcareous (pH 7.9 paste); diffuse smooth boundary.
C2ca	124-160	Brown (10YR 5/3) silt clay loam; brown to dark brown (10YR 4/3) moist; weak medium subangular blocky structure, hard, friable, sticky and plastic; few fine roots; many fine and many medium pores; numerous lime veins through strongly calcareous (pH 7.9 paste).

The Ap horizon is 25 cm thick and has a moderate fine granular structure. The horizon is dark and thick enough to qualify as a mollic epipedon. The separation of A and B horizons was based mainly on the structure differences, the B horizon has a moderate medium subangular blocky structure. The similiarity of their morphological characteristics, indicates that those horizons have been mixed by plowing.

In terms of field-observable morphology, both the B21t and B22t have some evidence that these horizons were formed through illuviation of clay, so both can be said to have an argillic horizon. The existence of this horizon will be discussed more later in terms of the mechanical and free-carbonate analyses.

The Calcic horizon was clearly distinguishable in the field but it lacks abrupt boundaries. Observable changes in the texture of the C horizon suggest that the parent material was stratified. The blocky structure extends from the B horizon through the C horizons and is probably pedogenetic in origin; but the calcareous nature of the pedon below 74 cm and brownish appearance through all horizons seems to be mostly inherited from the parent material.

Mendon series

This soil is well-drained, deep, and neutral to moderately alkaline. It was formed in alluvium and colluvium derived from light-colored tuff, tuffaceous sandstone, and limestone of the Salt Lake Formation. They are on lake terraces or rolling dissected foothills along the west side of Cache valley, and extend along the east side between the towns of Richmond and Smithfield. Their elevation ranges from 4500 to 5100 feet, and slopes vary from 0 to 20 percent. The total area of this series is about 12,362 acres, representing 3.4 percent of the total mapped area in Cache County, Utah.

The pedon was taken in an alfalfa field, about 577 feet west and 474 feet north of SE corner, Sec. 35, T14N, RIE, south of Richmond, Cache County, Utah. The exposure is toward the west on a 4 percent slope (See Figures 5 and 6).

The pedon description follows:

Horizon	Depth (cm)	
Ap	0-25	Very dark grayish brown (10YR 3/2) silty clay loam; very dark gray (10YR 3/1) moist; strong medium granular structure; hard, firm, sticky and plastic; many fine and many medium roots; slightly calcareous (pH 7.4 paste); clear smooth boundary.
B21t	25-41	Dark brown (10YR 3/3) silty clay loam; very dark grayish brown (10YR 3/2) moist; weak medium prismatic structure parting to moderate medium subangular blocky structure; hard, firm, sticky and plastic; slightly calcareous (pH 7.4 paste); abrupt smooth boundary.
B3ca	41-51	White (10YR 8/2) silty clay loam; light brownish gray (10YR 6/2) moist; strong medium subangular blocky structure; hard, very firm, sticky and plastic; very few fine and very few medium roots; few fine pores; strongly calcareous (pH 7.7 paste); clear wavy boundary.
C1ca	51-79	White (2.5Y 8/2) silty clay loam; gray brown (2.5Y 5/2) moist; moderate medium subangular blocky structure; hard, very firm, sticky and plastic; very few fine and very few medium roots; common large and common fine pores; few medium faint mottling; strongly calcareous (pH 7.8 paste); clear smooth boundary.
C2ca	79-104	Light gray (2.5Y 7.2) silt loam; gray brown (2.5Y 5/2) moist; massive structure; slightly hard, very firm, slightly sticky and slightly plastic; very fine and very medium roots; many fine and many large pores; strongly calcareous (pH 7.8 paste); clear smooth boundary.

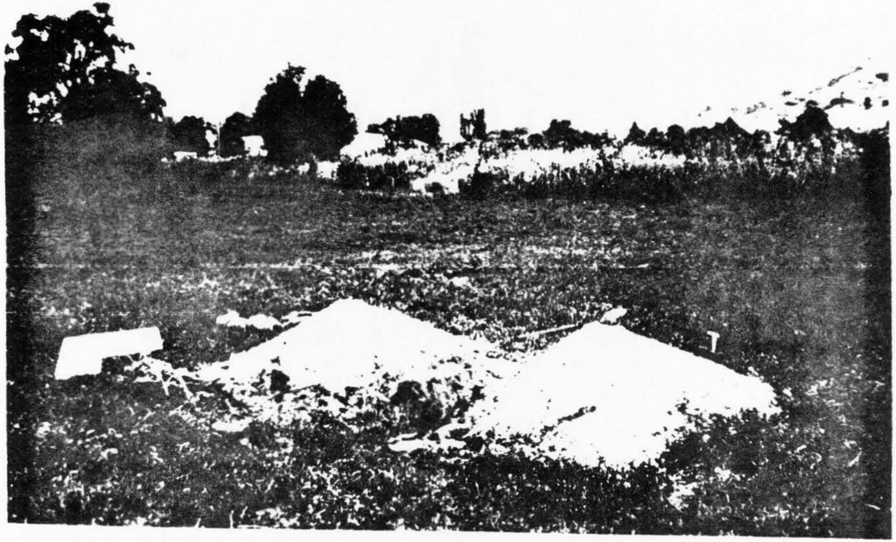

Figure 5. Landscape of Mendon Soil.

Figure 6. Profile view of Mendon soil

Horizon	Depth (cm)	
C2ca	104-135	Same as above, separated for the Laboratory analyses.
C3ca	135-152	Light gray (2.5Y 7.2) silt clay loam; gray brown (2.5Y 5/2) moist; massive structure, slightly hard, friable, slightly sticky and slightly plastic; common medium and common fine pores; strongly calcareous (pH 7.9 paste).

This epipedon is 25 cm thick, with well developed medium granular structure. Both the color and thickness of this horizon meets the requirement necessary for the mollic epipedon; but it does not qualify for Pachic (less than 50 cm depth). Further field investigation in three mapped areas of the Mendon series was done to verify the epipedon thickness. These areas included both the study site and the area in which the typifying pedon of Mendon is located. Thirty borings were taken for this purpose. Collectively, the results indicate that 48 percent of Mendon pedons have an epipedon too thin to qualify as Pachic.

It is believed that both the A and B horizons were mixed by cultivation. The B horizon has weakly developed, medium-sized prisms that part to moderate medium-sized blocks. Field observations revealed some evidence of clay eluviation from the A horizon, although it is not very distinct. However, with the appreciable clay accumulation in the B horizon, it is believed that the horizon should continue to be recognized as an argillic horizon.

An abrupt change in color at the B3ca horizon, extending through the C horizon, coupled with random changes in the texture of the underlying material at 79 cm and 135 cm is an indication that a discontinuity in deposition occurred. The light color (high value in munsell notation), massive structure, and high amounts of the observable calcareous deposits within the C horizon, appears to be geologic rather than pedogenetic. The Mendon soil is described as well drained, but mottling observed in the C horizon of some pedons indicates the presence of free water in some years.

RESULTS AND DISCUSSION

Physical, Chemical, and Mineralogical Properties of the Soil

Mechanical analysis

Mechanical analysis and carbonate-free clay distribution of both pedons are presented in Table 2. The data indicate a marked difference in the sand and silt content of these two soils. In both soils, however, the clay percent increased gradually within the B horizons and then decreases again in the C horizons. In both pedons, the increase in clay from the surface into the B horizon does not meet the criteria for an argillic horizon, although carbonate-free clay and the fine clay (less than 0.2μ) indicates a significant amount of illuvial clay accumulated in the B horizon (more than 23% of fine clay). On the basis of carbonate-free clay, the results show that the B horizon of Mendon does qualify as an argillic horizon (the ratio of the fine clay to total clay of the B21t to Ap horizon is greater than 1.5:1). In the Parleys B horizon, however, the diagnostic feature is marginal (the ratio of the fine clay is 1.2:1).

The definition of an argillic horizon given by the Soil Survey Staff (1973), allows the use of any overlying horizon (not necessarily an Ap) in establishing the diagnostic features of the argillic horizon, if there is evidence that the overlying zone is considerably eluviated. In all cases, the most important feature used to distinguish between the illuvial and the eluvial horizon is the ratio of the clay content of the eluvial horizon to that illuvial horizon (1:2.1) and the ratio of the fine clay to total clay,

Table 2. Mechanical analysis of Parleys and Mendon soils

Horizon	Depth cm	Total			0.05 - 0.25 mm	Carbonate-free clay		
		Sand %	Silt %	Clay %	Sand %	Coarse Clay 2.0 - 0.2μ %	Fine clay less than 0.2 μ %	Total clay %
					PARLEYS			
AP	0-25	9.1	63.5	27.4	6.2	10.3	12.8	23.1
B1	25-43	7.4	59.9	32.7	4.7	10.3	9.1	19.5
B21t	43-61	9.4	59.1	31.2	6.9	23.0	2.2	25.2
B22t	61-74	14.7	57.9	27.4	9.6	10.5	15.5	26.0
B3ca	74-94	16.7	57.2	26.1	10.8			18.9
C1ca	94-107	10.1	62.1	27.8	7.7			19.9
C2ca	107-124	10.8	64.3	24.9	9.1			19.4
C2ca	124-160	7.6	63.8	28.6	6.5			
					MENDON			
Ap	0-25	10.7	58.0	31.3	8.8	8.0	15.9	23.9
B21t	25-41	10.1	57.1	32.8	9.1	6.4	23.5	29.9
B3ca	41-51	11.9	51.6	36.5	10.9	10.8	11.2	21.9
C1ca	51-79	11.0	57.9	31.1	10.1			20.9
C2ca	79-104	21.2	56.5	22.3	20.9			13.7
C2ca	104-135	21.6	52.7	25.7	21.1			18.6
C3ca	135-152	34.6	54.0	20.5	34.2			

which is usually much higher in the illuvial horizon (Soil Survey Staff, 1973). The carbonate-free clay of the Parleys pedon shows that there was an increase of the fine clay in the B22t over the B21t horizon (increased by more than 6 percent) which indicates that a considerable amount of the fine clay has been translocated from the above eluviated horizon. If this is the case, it is possible to use the B1 horizon as a part of the eluviated zone, the B22t horizon of Parleys meets the diagnostic feature necessary for an argillic horizon (ratio of fine clay of the B22t to that of the B1 horizon is 1.7:1). The fine clay of Parley's horizons shows a somewhat erratic distribution, even though there is measurable clay movement in the argillic horizon. Such distribution probably reflects alternating direction of the movement of the fine clay as a result of the periodic drying under the present climatic regime at the study site. Another possibility is that some of the fine clay in the Parleys Ap horizon during the Holocene period could have been deposited by water (Galloway, 1970).

In terms of mechanical analysis the sand size is the most immobile fraction in the soil that could be related mainly to the parent material rather than pedogenetic factors (Chang and Arnold, 1973). Both fine sand and silt can be mobolized by either water or wind action. Data in Table 2 indicate that there is a marked difference in the distribution of the fine sand and silt fraction between Parleys and Mendon C horizons, and such differences reflect different origins of their parent material. According to Williams (1947, 1948), the present site location of the Parleys and Mendon series occurs on the Bonneville Formation (silt and fine sand deposits) and tuffaceous, sandstone deposits of the Salt Lake Formation, respectively. The uniform high silt percent of the C horizon underlying Parleys as indicated in Table 2 is one of the typical features of the delta deposits (Bonneville Formation) from which Parleys soil probably developed.

In contrast, the rapid increase in the fine sand and random decrease in silt size fraction of Mendon C horizons does not appear to be related to Bonneville Formation. It is more likely that the marked periodical increases in the fine sand content of Mendon C horizon (more than 34 percent) is related to the Tertiary deposits of the Salt Lake Formation. Thus, the important question may be the mode of the deposition of these materials. Resolution of this question is beyond the scope of this study. In this respect, no definite answer could be given but two possibilities seem to be acceptable.[1] First, the marked increases in sand in the Mendon C horizons is probably due to the wave action during the period of the Lake Bonneville that eroded much of the foothill slopes composed of soft, calcareous, tuffaceous, sandstone of the Salt Lake Formation. If so, such wave action should be during Provo time (the most recent recession) when the lake receded below about 4450 feet. Secondly, the sandy material of Mendon C horizons is possibly part of the original deposit of the Salt Lake Formation (middle Tertiary) which had been eroded, tilted and faulted (pedimentation interval) prior to the Lake Bonneville period along the east side of the Cache valley.

In Table 2, it is clear that the more sandy Mendon C horizon is quite different from the above overlying horizons. This may suggest a lack of lithological uniformity of the materials from which this pedon has developed. The morphological features, calcium carbonate, and free iron

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[1]R. Oaks. 1974. Personal Communication. USU Geology Department.

oxide data emphasize that the Mendon parent material has a marked discontinuity at the 79 cm and 135 cm depth, and certainly this soil has developed from more heterogeneous parent material in comparison with Parleys parent material deposits. It is believed that these fine deposits on which the Mendon soil has developed are probably related to the Bonneville Formation. However, if one accepts the possibility that the sandy deposits of Mendon C horizon are related to the Salt Lake Formation, then presumably these fine material which form the upper part of Mendon pedon have been deposited in the deeper depth of the lake during the Bonneville period. Subsequently, the Mendon solum horizons probably have developed from the Bonneville Formation. Another possibility is that the upper part of Mendon pedon probably was influenced by deposits of the post Lake Bonneville (Holocene) over the materials of Salt Lake Formation. However, such possibility is not likely to occur since there are no geomorphological features (alluvial deposits and alluvial fans) of Holocene age along the study site of Mendon pedon whereas, the Tertiary Salt Lake Formation is well exposed. In contrast, Galloway (1970) reported a notable fine grain alluvial deposit which is located along the Hyde Park Canyon and north east to the Parleys study site location. These depositional features of Holocene age indicate that there was an active water movement during that period (4500 to 8000 years B.P). Therefore, it is reasonable to assume that these deposits could be easily carried by running water (slopewash material) over the delta of Lake Bonneville from which Parleys soil is largely developed. If so, this heterogeneity appears in the upper part of Parleys solum horizons and this pedon has been developed from fairly uniform parent materials. As evidence of such heterogeneity, the higher percentage of silt associated with a marked amount of fine clay (more than 12 percent) of Parleys Ap horizon is probably due to slope-wash deposits of Holocene age which may have occurred after the fall of Lake Bonneville below about 4450 feet.

Both study sites suggest an equal possibility that these soils could have been exposed to the active wind action from the north and southwest during the Neothermal age (Recent Epoch). During that age, the main attention should be focused on its middle part (Altithermal), when the climate of northern Utah was hotter, dryer, and vegetation cover was less than at the present time (Williams, 1956). Such climatic conditions probably favored active wind erosion which may have taken place in the study area during soil development. In both pedons, data of Table 2 indicate that there was a large amount of silt, and most of the total sand is fine (0.05 - 0.025 mm). These fine-sized sediments could possibly have been in part deposited by wind, as it eroded the unvegetated area after the lake receded, and carried the sediments to the east side of the valley. However, the data in Table 2 do not show any pronounced discontinuities in the silt and fine sand fractions which are the particle sizes readily transported by wind. Therefore, there is no conclusive evidence that deposition by wind, since the lake receded, contributed to the parent material of either soil.

Bulk density

The bulk densities values and porosities percentage are reported in Table 3. The results indicate that in both pedons, the bulk density of the B horizons is relatively higher than the surface horizons, while the C horizon has the lowest density. The less dense surface horizon of these pedons could be attributed to the results of higher organic matter content,

Table 3. Some physical characteristics of Parleys and Mendon soils

Horizon	Depth cm	Moisture retention against 1/3 atm. %	Moisture retention against 15 atm. %	Available moisture calculated Inch	Available moisture calculated cm	Accumulative available moisture Inch	Accumulative available moisture cm	Bulk density	Porosity %
					Parleys				
Ap	0-25	32.7	13.8	2.71	6.89	2.71	6.89	1.46	43.8
B1	25-43	32.0	15.7	1.87	4.75	4.58	11.64	1.62	37.7
B21t	43-61	30.0	15.0	1.83	4.64	6.41	16.28	1.72	33.8
B22t	61-74	27.3	12.3	1.29	3.29	7.70	19.57	1.69	35.0
B3ca	74-94	27.3	11.5	1.96	4.99	9.66	24.56	1.58	39.2
C1ca	94-107	29.5	12.6	1.05	2.66	10.72	27.22	1.21	53.5
C2ca	107-124	29.4	11.8	1.39	3.53	12.11	30.75	1.18	54.6
C2ca	124-160	31.0	13.0	3.01	7.65	15.12	38.40	1.18	54.6
					Mendon				
Ap	0-25	35.0	16.6	2.66	6.76	2.66	6.76	1.47	34.5
B21t	25-41	34.0	17.0	1.72	4.38	4.38	11.14	1.61	38.1
B3ca	41-51	34.8	13.5	1.27	3.24	5.66	14.38	1.52	41.5
C1ca	51-79	32.2	11.9	3.09	7.84	8.75	22.22	1.38	46.9
C2ca	79-104	26.6	10.5	2.11	5.35	10.85	27.57	1.33	48.8
C2ca	104-135	29.5	11.4	3.05	7.74	13.90	35.31	1.38	46.9
C3ca	135-152	24.2	9.9	1.31	3.35	15.22	38.66	1.38	46.9

porous granular structure, and to the loss of such material as clay, lime, and salts by weathering and leaching processes. Leaching of these materials to greater depths would increase the density in the B horizons.

Field observation and calculated porosity percentage have shown that the underlying C horizons of these soils have a porosity greater than 46 percent which accounts for having the lowest bulk density (less than 1.3) in comparison with their overlying horizon.

As shown in Table 3, values of the bulk density of these pedons did not indicate any marked difference between them; however, in their C horizons, the value is slightly higher in Mendon than in Parleys. Thus, such variations may reflect the difference in the porosity percent between those pedons; Parley C horizon is apparently more porous than Mendon C horizon. Because the clay distribution of these horizons did not show marked differences, and since the sand normally has a higher weight per unit volume than the clay, the slightly lower bulk density of Parleys C horizon is also accounted for by the lower percentage of sand and the relative higher total amount of organic matter content when compared with Mendon C horizon.

Water content

The difference between the amount of moisture retained in soil at 1/3 atmosphere and 15 atmosphere is assumed to be the moisture that is available to plants. The actual amount available depends primarily on the textural and structural relationships and the organic matter content. Examination of the data in Table 3 indicates that the Mendon pedon has a slightly higher moisture retention than the Parleys pedon to at least the depth of 78 cm. Above that depth, the slight difference in the amount of clay between these soils (less than 9 percent) may reflect moisture variations; the higher the clay percent, generally the higher the moisture retention value if other factors are equal. In the parent material horizon of these pedons, Parleys appears to have higher moisture retention values at both 1/3 atmosphere and 15 atmosphere than the Mendon pedon. Since sand fractions normally have lower retention values, the lower moisture retention value shown for the Mendon C horizon may be accounted for by the higher and more rapid increase in the sand percent of this horizon when compared with the Parleys C horizon.

Converting the moisture retention values to centimeter depth of available water may give a more exact picture in terms of soil-plant relationships. The data in Table 3 and Figure 7 gives the centimeters of available moisture calculated on the basis of the bulk density and difference in the moisture retained between 1/3 and 15 atmosphere. The accumulative curve of available moisture in these pedons, as shown in Figure 7, does not indicate an important difference between them. However, at depths below 100 cm the accumulative curve of Mendon soil tends to decrease, and Parleys soil has more available moisture.

Since the amount of the available moisture is influenced mainly by texture, organic matter, bulk density, and structure under similar drainage conditions, the variation in the amount of available moisture between these pedons C horizon seems to be reflected mostly by the difference in the amount of sand and organic matter. On that basis, the explanation of such differences could be expressed the same as in the moisture retention data as mentioned before.

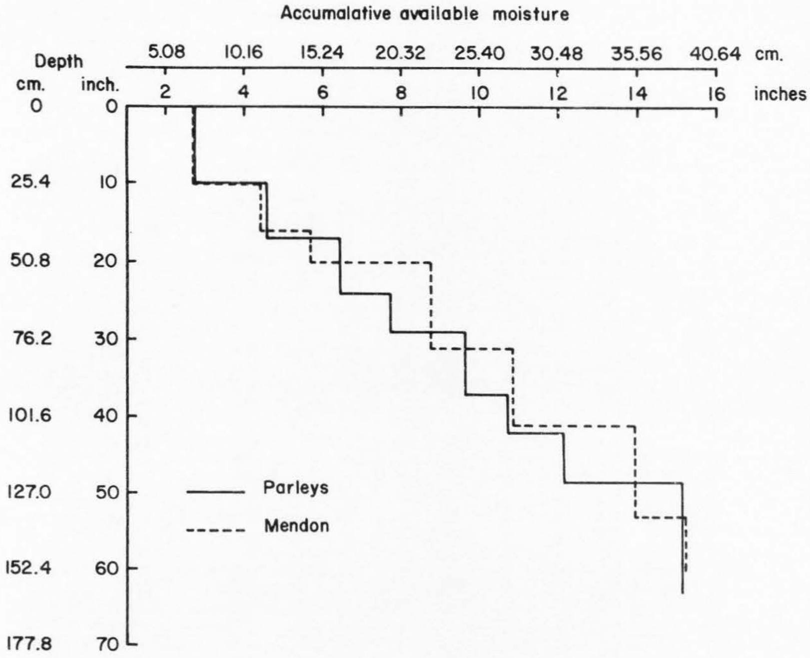

Figure 7. Accumalative available moisture with depth.

It is very obvious that the more sandy, massive, lower organic matter containing Mendon C horizon supplies lower amounts of available moisture when compared with the Parleys C horizon. This suggests that the Parleys pedon can maintain more available moisture to support plant root growth at a greater rooting depth than does the Mendon pedon. This view point is supported by field observation; root distribution in the Parleys C horizon extended deeper (more than 127 cm) in comparison with Mendon C horizon. Difference in the root depth between the two pedons is about 25 cm.

Free iron oxide content

Table 4 represents the data for free iron oxide in ppm. In both pedons, the results show slight variations below about 40 cm depth. Except for Parleys B horizon; the trend was a slight decrease in the amount of iron as the depth of soil increased. In both soils, the B horizon has lower amounts of iron compared with the surface horizon. With higher percent of fine clay in some subsurface horizons of these soils when compared with their epipedons, it is likely that the amount of free iron oxide is not related to the clay translocation. This suggests that the source of free iron oxide in the B horizon of these pedons is due mainly to the weathering in place of primary mineral rather than colloidal movement. This is to be expected as the environmental conditions under which those soils developed (high pH and low precipitation) were favorable to retention of iron in the oxidized-insoluble state in the respective horizons.

From data in Table 4, it has been shown that the free iron oxide in both soils studied did not exhibit any marked translocation during their

Table 4. Free iron oxide content (ppm elemental)

Horizon	Depth cm	Free iron oxide ppm Fe^{+++}
	PARLEYS	
Ap	0-25	5000
B1	25-43	5125
B12t	43-61	3500
B22t	61-74	4250
B3ca	74-94	4250
C1ca	94-107	3750
C2ca	107-124	3125
C2ca	124-160	3000
	MENDON	
Ap	0-25	1500
B21t	25-41	1250
B3ca	41-51	600
C1ca	51-79	700
C2ca	79-104	625
C2ca	104-135	525
C3ca	135-152	525

development. The trend of iron distribution tends to be similar in each pedon, even though there are important differences in the amount of iron between them. This similarity may be due to the fact that these pedons have been subject to somewhat limited weathering processes under their present climatic condition. In contrast to that, differences in the amount of iron seem to be more signficant between the two pedons rather than within each pedon horizon. Results show that the maximum difference in the free iron oxide between Parleys and Mendon C horizons is 3225 ppm. The Salt Lake Formation from which Mendon soil developed evidently had a lower amount of iron compared with Parleys parent material. It is believed that the relative high amount of free iron oxide in Parleys pedon (more than 5000 ppm) results from a higher amount of iron-bearing minerals. This premise is supported by certain evidence obtained from thin-section and petrography studies of these soils; Parleys horizons have higher amounts of hematite, limonite, and most of its carbonate and quartz grains have obviously been stained by iron oxide when compared with Mendon horizon.

It was mentioned in the morphological studies of these soils that the Parleys epipedon had a brownish appearance, whereas, in the Mendon, the color of this horizon tends to be less brown but more gray. It is possible that the brownish appearance of the Parleys epipedon is mainly due to a relative high amount of iron; while in the Mendon epipedon the organic matter is darkened more without the browning effect of iron compared with Parleys. If so, it is an indication that both organic matter and iron oxide act collectively to modify a specific color appearance in each pedon horizon which may be an inherited property.

Organic matter distribution

Examination of the data in Table 5 and Figure 8, shows that both of these pedons have moderately high amounts of organic matter in their surface horizons which decreases with increasing depth. Both surface horizons have enough organic matter (more than 1 percent) at sufficient depth to qualify as mollic. However, morphological data indicates that the Mendon epipedon appears to be darker (lower color value) in comparison with Parleys epipedon. The variation in the color between these epipedons

Table 5. Chemical characteristics of Parleys and Mendon soils

Horizon	Depth	pH paste	Organic matter %	Saturation extract conductivity ECe millimhos per cm	$CaCo_3$ equivalent %	CEC soil me/100g	Extractable cation Ca (me/100g)	Mg	Na	K	CEC me/100g clay estimated
				PARLEYS							
Ap	0-25	7.56	2.89	0.42	3.8	25.8	25.9	6.9	.11	1.54	73.06
B1	25-43	7.56	1.85	0.31	3.9	23.0	21.6	7.4	.17	.81	64.68
B21t	43-61	7.53	1.20	0.36	5.8	20.3	24.8	7.6	.14	.70	57.37
B22t	61-74	7.68	0.80	0.37	12.1	19.3	47.5	6.5	.23	.57	64.23
B3ca	74-94	7.79	0.75	0.30	33.6	17.4	46.1	6.3	.29	.57	60.92
C1ca	94-107	7.77	0.75	0.37	27.0	-	-	-	-	-	-
C2ca	107-124	7.86	0.70	0.35	22.4	-	-	-	-	-	-
C2ca	124-160	7.86	0.69	0.30	19.3	-	-	-	-	-	-
				MENDON							
Ap	0-25	7.38	3.10	0.35	4.4	27.0	43.4	5.2	.23	.68	66.45
B21t	25-41	7.44	1.30	0.25	5.8	25.0	50.9	6.0	.16	.65	68.90
B3ca	41-51	7.74	1.29	0.26	47.3	17.2	50.0	4.4	.12	.36	40.05
C1ca	51-79	7.79	0.48	0.31	36.1	-	-	-	-	-	-
C2ca	79-104	7.77	0.34	0.29	34.9	-	-	-	-	-	-
C2ca	104-135	7.80	0.34	0.26	33.4	-	-	-	-	-	-
C3ca	135-152	7.75	0.32	0.29	41.9	-	-	-	-	-	-

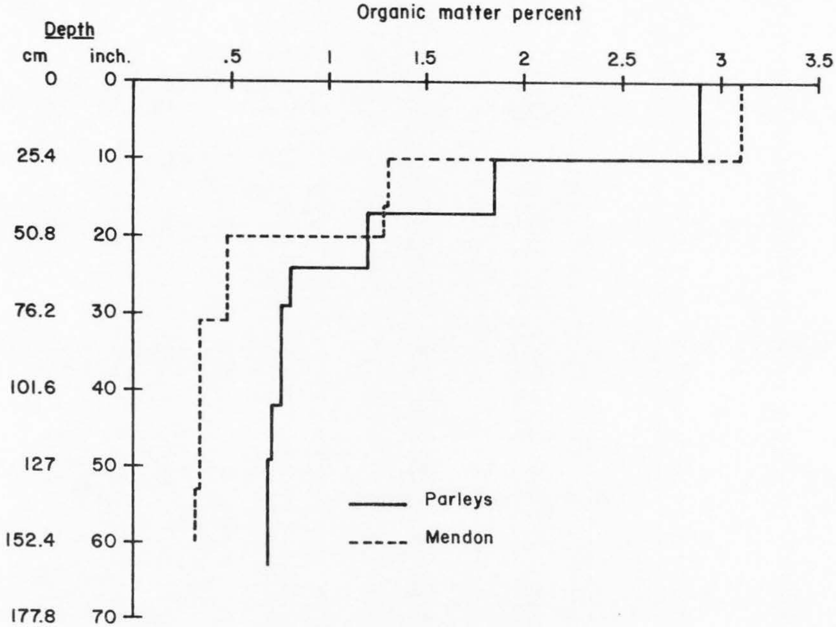

Figure 8. Organic matter percent with depth.

is due mainly to the differences in the amount of free iron oxide between them and the point has been discussed previously.

In both soils studied, the most marked difference in the amount of organic matter distribution appears in their parent material (See Figure 8). The Parleys C horizon has about twice the organic matter content as does the Mendon C horizon. Thus, the main variation between these two horizons could be described by noting one of the important features. Field description shows that the plant root distribution in Parleys soil extends to greater depths than in the Mendon pedon and it is possible that the strongly calcareous parent material or C horizon of Mendon soil may inhibit pronounced root growth.

Figure 8 shows another feature of the distribution of organic matter in these pedons. In the Mendon pedon, the amount of organic matter content changes rapidly between the solum and underlying C horizon, whereas in the Parleys soils the change is more gradual. This suggests that the accumulation of the organic matter in the Mendon solum has occurred during pedogenesis.

Strictly speaking, differences in the amount of the organic matter between the C horizons of these pedons is more significant than the difference between their sola. The variation is probably inherited from their parent material; Parleys appears to be developed from a parent material relatively high in organic matter compared to the Mendon parent material.

Calcium carbonate, pH, and soluble salts

The calcium carbonate equivalent of the soils is reported in Table 5. The data indicate that in both pedons, there is a small amount of carbonate in each surface horizon which increases gradually to the zone of the Calcic horizon. At the Calcic horizon, both Parleys and Mendon soils show abrupt changes in the amount of calcium carbonate in the B3ca horizon which increases to 21.5 percent and 41.5 percent, respectively. Although the carbonate is distributed throughout all of the horizons, there is evidence that both Parleys and Mendon have developed a Calcic horizon at 74 cm and 41 cm, respectively; but the evidence of this horizon is probably not as obvious in Mendon as in Parleys pedon. This may be due to the fact that Mendon has developed from more strongly calcareous deposits and its secondary carbonate enrichment is difficult to recognize compared with one in the Parleys. In the Mendon pedon, the depth of B3ca horizon did not qualify for Calcic (less than 15 cm), even though it has more than 5 percent lime carbonate compared with its underlying horizon. In such a case, "the horizon is considered a Calcic if the carbonate content of a 15 cm or more thick layer has at least 5 percent more of the lime compared with its next underlying layer" (Soil Survey Staff, 1973). On that basis, calculations based on the weighted 15 cm taken from C1ca to the B3ca horizon in Mendon, the depth of 41 cm to 56 cm shows that this layer contains 43.56 percent calcium carbonate within 15 cm depth, and apparently qualifies as a Calcic horizon.

In both soils, the nature of the lime distribution and the marked increase in calcium carbonate equivalent in their underlying C horizons indicates that these soils developed from calcareous parent material. Along the east side of Cache valley, both soils occur at elevations ranging from 4500 to 5100 feet. It is quite possible that their parent material deposits may have exhibited somewhat the same lime accumulation processes during the period since Lake Bonneville (about 11,000 years B.P.). In contrast, however, there is indication that the Mendon parent material was probably more calcareous than Parleys parent material. Evidence of a much higher layered calcareous underlying C horizon with less depth of leaching in the Mendon pedon emphasizes such a possibility. If this is the case, then it is an indication that those soils have developed from different parent material deposits and the most critical point is to explain the composition of these different materials and if possible differentiate the sources.

In Cache valley, Williams (1958) has reported that most of the strongly calcareous, soft, weathered rocks of Tertiary Salt Lake Formation have been eroded, transported by Lake water and redeposited again along the east side of the study area after the fall of Lake Bonneville below about 4450 feet (Bonneville-substage). The calcium carbonate distribution of these pedons suggest that Mendon soil probably has been largely developed and influenced by those calcareous deposits. If this is true, most of the natural distribution of the calcium carbonate in the Parleys pedon could be attributed to deposits laid down during the period of Lake Bonneville (Quartenary period) while as the more strongly calcareous nature of Mendon pedon could be explained mainly by deposits from the Salt Lake Formation (Tertiary period).

On that basis, it is possible to interpret the difference in the depth of leaching between these soils even though they developed under similar climatic conditions. In the study area, the 74 cm and 41 cm leaching depth of these pedons is to be expected from calcareous parent material-derived soil with about 16 to 20 inches precipitation. However, it is unrealistic to expect a similar depth of leaching of these studied pedons with such difference in the amount of calcium carbonate between their parent material; therefore, the depth of the leaching zone in Parleys pedon exceded the leaching zone in Mendon soil by more than 25 cm. Certainly, the less calcareous parent material-derived soil, the deeper the leaching, if one assumes that all other conditions are equal.

The results of the pH and ECe values of these pedons did not indicate any marked difference between them. However, the data in Table 5 indicate that the calcium carbonate percent and the extent of the leaching depth of these pedons correlated highly with their pH values. The results have shown that both of the studied soils are mildly alkaline in their surface horizon and both of them tend to become more alkaline with increasing depth. However, the increase in the pH value within each pedon horizon is less than expected from their calcareous substrata. These soils which derived from different calcareous deposits have shown somewhat similar distribution of the pH value between their C horizons. In this regard, no definite explanation could be given.

Results of electrical conductivity of the saturation extract of the soils are shown in Table 5. Both of them have relatively low amounts of ECe value within their horizons. Such low values are to be expected from the well-drained conditions under which those soils developed. The ECe value of these pedons indicate a similarity between them. This similarity probably reflect their similar drainage, climate, and developmental condition. However, in both soils, the salt concentration tends to be higher in the upper part of the profile. This could be explained as the normal function of evaporation from their surface.

Cation exchange capacity and extractable cations of some selected horizon

Cation exchange capacity and extractable Ca, Mg, and K are reported in Table 5. The data indicate that in both pedons the CEC decreased with depth. However, the calculated value of CEC (meq/100g clay) gives a quite different distribution than actual values and more realistic value can be expressed in terms of clay type and stage of weathering processes. The CEC per 100 g clay was estimated by assuming that each 1 percent organic matter is equivalent to 2 meq/100 g soil. The CEC value of the organic matter was subtracted from the total cation exchange capacity of the soil and on the basis of the clay percent the CEC/100 gm clay can be estimated. On the basis of 100 g of clay, except for Parleys surface horizon, there was a marked increase in CEC in the upper part of the B horizons. In both pedons, the increased values correlate fairly well with the increase in the fine clay (less than $0.2\underline{\mu}$). In Table 5 that calculated value of CEC of the Mendon upper B horizon appears to be slightly higher than in the corresponding part of the Parleys pedon (difference is more than 11 meq/100 g clay). X-ray data show that there are no important differences in the clay types between these pedons. However, the carbonate-free clay analysis has shown that Mendon upper B horizon has 8 percent more fine clay than does the Parleys and this difference should be considered to at least partially reflect such variation.

In both soils, the results of estimated CEC value is generally more than 64 meq/100 g (See Table 5). This value suggests that a mixture of illite and montmorillonite type of clay is present and the montmorillonite type probably is dominant. Grim (1968) reported that lacustrine parent materials would be expected to have soil containing illite and montmorillonite clay type. It is probable that both of the illite and montmorillonite type of clay was inherited from the parent material in both Mendon and Parleys.

One of the important differences between these pedons is the amount of the exchangeable basic cations in their solum horizons (Table 5). The Parleys soil has relatively higher amounts of exchangeable potassium, magnesium, and sodium while Mendon soil has a much higher amount of exchangeable calcium (more than 50 percent). Thus, the variation between these pedons could be attributed either to the difference in their parent materials or to the degree of weathering processes. The latter factor should be insignificant since there is adequate evidence that these soils reflect similar, limited weathering processes through their development. However, there is certain evidence that the variation in the amount of Mg, Na, and Ca appears to be inherited from their different parent materials. Petrography studies on some selected samples of those pedons indicate that Parleys has relatively higher amounts of plagioclase and chlorite minerals. These minerals are known to be sodium, calcium and magnesium bearing minerals, respectively. This could readily explain why the Parleys solum horizon has relatively higher amounts of sodium and magnesium when compared with the Mendon solum horizon. As mentioned before, the variation in the amount of calcium carbonate between these soils appears to be inherited from their different calcareous parent material; therefore, Mendon which has developed from more strongly calcareous parent material should have much higher amounts of calcium. It is very obvious from data in Table 5 that the calcium is the dominate exchange cation in both of these soils and certainly their epipedons meet the criteria of mollic in terms of base saturation percentage.

From data in Table 5, there is an indication that the Parleys pedon has considerably higher amounts of the potassium than the Mendon pedon. The amounts of potassium in both of these pedons tends to decrease with depth. There is a general lack of knowledge about the cultural practices imposed on these soils and minerological studies indicate no differences in amounts of potassium-bearing primary mineral. Therefore, the difference in potassium content is not explainable.

Thin section and petrography study

Thin-section and petrography analyses were done to detect the clay movement of the argillic horizon and the minerologic composition of the C and its overlying horizon. In both pedons, the argillic horizon shows traces of illuvial clay which has been moved along the vertical and horizontal ped faces of this horizon. As the stage is rotated, these few bodies of translocated clay appear to have undulating black band extinction with lack of any distinct birefringence. The lack of the distinct birefringence (lack of good orientation) is probably due to the carbonate influence. It is difficult to observe a distinct birefringence with fine-sized translocated clay. Examination of ped surfaces with a hand lens shows an absence of any detectable illuviation cutans (clay skins). Smooth ped faces as a result of the pressure orientation are well identified. It should be stressed that the clay skin feature is not one of the necessary requirements to be argillic if there is evidence of the pressure orientation and if there are other features of clay illuviation (Soil Survey Staff, 1973); but even then the lack of clay cutans in the B horizons are difficult to explain.

However, in both soils, it is believed that there are two important possibilities, in addition to the stress evidence, that may inhibit any distinct morphological feature of the illuviation processes such as clay skins. First, there is an appreciable amount of clay-size carbonate in all horizons which probably prevents clay dispersion and subsequently precludes clay skin development in argillic horizons. In both pedons there is less carbonate-free clay in comparison with total clay. Second, the climatic regime under which these soils have developed are typified by cool, wet winters, and dry summers. This climate provides wetting and drying cycles, that probably destroy illuviation cutans. Also, the biological mixing within each pedon upper horizons through soil development is probably important to the destruction of some of the clay cutan feature. Another possibility is that the mixing between A and B horizons by cultivation may also have influenced or eliminated some of the original features of illuviation. However, such possibility is not likely to occur, since the cultivation is usually not deeper than 25 cm in depth. Under such conditions, it is believed with the evidence obtained from free-carbonate analysis, that those pedons have an argillic horizon even though there is a lack of distinct illuviation cutans by thin section analysis.

Results of minerological analysis based on grain counts of the 0.05 to 0.25 mm sand fraction are given in Table 6. In both pedons, the results show that the minerological composition remains constant or changes slightly between the C and its overlying horizon. However, the data in Table 6 indicates an important difference between the parent material horizons of the two soils. Parleys appears to be developed from material which has higher amounts of calcite, hematite, limonite, chlorite, and plagioclase minerals than the Mendon. In the Mendon pedon, both the C and its overlying horizon has much higher amounts of quartz and carbonate with a considerable amount of biotite and volcanic glass when compared with the corresponding Parleys horizons.

in both pedons, quartz appears to be one of the major primary minerals in the horizons analyzed (at least 22 percent). It is possible that these soils have developed from materials which have marked amounts of quartz grains in their composition. The Salt Lake Formation has been reported to have appreciable amounts of sandstone (Williams, 1946). Sandstone is know to be one of the quartz-bearing rocks that is sometimes composed essentially of quartz grains. The large amounts of quartz minerals in the Mendon parent material (more than 35 percent) suggests that this soil developed from the tuffaceous, sandstone deposits of the Salt Lake Formation.

Another peculiar feature in these soil horizons is the shape of quartz grains. The shape of the primary minerals may be related largely to the source of the parent material. In the Parleys soil, rounding and cracking of the quartz grains is quite common. This may indicate that most of those grains have been largely transported by water during the period of Lake Bonneville. In the Mendon pedon, the quartz is more angular than that in the Parleys pedon. Such a difference in quartz grains may suggest that the angular quartz of the Mendon soil is inherited from the volcanic material of Tertiary origin. The small amount of glassy, elongated, silica minerals which have been observed in Mendon C horizon indicate such a possibility.

Table 6. Petrography study of the 0.25 to 0.05 mm sand fraction of Parleys and Mendon soils and the error of counting for each mineral

	Parleys			Mendon		
Horizon	B22t	Clca	C2ca	B21t	C2ca	C3ca
Depth cm	61-74	94-107	124-160	25-41	104-135	135-152
Quartz %	25.3	22.8	25.9	37.2	35.4	33.6
Range ±	2.7	4.9	2.7	1.0	1.1	4.1
*Calcite %	26.7	27.3	21.8	4.9	6.7	6.1
Range ±	3.6	3.3	3.4	0.9	1.4	1.9
Chlorite %	1.9	1.7	1.3	0.2	0.2	0
Range ±	1.5	0.6	1.4	0.1	0.2	0
**Carbonate grain %	34.0	45.0	49.1	40.1	54.5	51.9
Range ±	1.5	5.8	4.4	0.9	2.4	1.4
Hematite %	2.8	2.2	3.4	0.9	1.2	0.9
Range ±	0.5	0.3	2.4	0.3	0.4	0.3
Limonite %	2.5	2.3	1.4	0.1	0.4	0.3
Range ±	0.8	1.1	1.1	0.1	0.3	0.3
Plagioclase %	0	0	0.5	0	0	0.1
Range ±	0	0	0.1	0	0	0.1
Biotite %	0.5	0	0.3	0.2	1.5	2.3
Range ±	0.8	0	0.2	0.2	0.4	0.8
Glass %	0	0	0	0	0	1.2
Range ±	0	0	0	0	0	1.2

±Standard Deviation Value
*Calcite and (dolomite)?
**Aragonite?

The calcite minerals, with their extremely high birefringence, were easy to identify. These minerals are an important constituent of calcareous sandstone of the Salt Lake Formation. However, data in Table 6 show that Mendon horizons have less calcite when compared with Parleys horizons. Previous minerological study of the Bear Lake sediments in northern Utah has shown that calcite could be precipitated from the solution and distributed throughout the Lake water (Davidson, 1969). On that basis, it is possible that most of the relatively high amounts of calcite of Parleys parent material horizon (more than 27 percent) was formed directly by precipitation of the lime carbonates during the period of the Lake Bonneville. Petrographic study of these horizons (Table 6) indicate that the carbonates are the most prominent grains in the sand size fraction (more than 50 percent) although the percent is much higher in Mendon soil. In both the Parleys and Mendon these carbonate grains increase markedly by 11 percent and 14 percent, respectively, in the Calcic horizon. The carbonate grains appear not related to the calcite mineral since most of the grains are fine masses lacking birefringence.

Minerological analysis in Table 6 indicates that Parleys C horizon has relatively higher amounts of limonite and hematite mineral when compared with Mendon C horizon. These minerals are usually not too common occurring only in certain deposits such as in volcanic tuff deposits of the Salt Lake Formation. Hematites like limonites could result from weathering of iron-bearing minerals. The mineralogical data suggest that the Bonneville Formation, from which Parleys developed, has relatively higher amounts of iron-bearing minerals (hematite and limonite) than does the Mendon parent material.

Biotite was mainly distinguished from chlorite by more absorption features. Mineralogical analysis shows that Mendon C horizon has relatively high amounts of biotite (more than 2 percent) in comparison with Parleys C horizon. Albite twining (Plagioclase) was found as trace minerals in both soils although it is relatively higher in Parleys.

X-ray diffraction analysis of clay fraction

In Table 7, the results indicate the mineralogical composition of selected horizons of both Parleys and Mendon. The identifications were based mostly upon the peak heights as shown in the x-ray traces. For x-ray analysis the samples were saturated with Mg, and placed on fiber glass slides and dried at 95 degrees C for 2 hours, then saturated with ethylene glycol. The copper target x-ray tube was operated at 50 kilovolts and 25 milliamps.

As evidenced in Table 7, the results did not exhibit important differences in the mineral composition. In both pedons, the shift in the 14 A peak to 17 A upon glycerol solvation was considered as diagnostic for montmorillonite. There was no indication that the montmorillonite varied markedly between the B and C horizons. This mineral was obviously more concentrated in the fine clay than in the coarse clay fraction.

There was a distinct 10.1 A peak of illite and one for kaolinite with 7.3 A peak. The samples were not heated to destroy the kaolinite. Since the 14 A peak shifted by glycolation, it pointed to be a montmorillonite rather than chlorite. However, in all horizons, a distinct 5.0 A peak was quite common. The 5.0 peak could be either chlorite or muscovite. If the 5.0 A is said to be chlorite, then, the 14.0 A and probably low 7.0 A

Table 7. Estimated mineral abundance in clay fraction of Parleys and Mendon selected horizons. Clay minerals are identifed in decreasing order of abundance.

Horizon	Depth cm	0.2-2 µ clay	Less than 0.2 µ clay
		PARLEYS	
B1	25-43	Q, I, K, M, G	M, Q, I, K
B22t	61-74	Q, I, K, M, G	
C2ca	107-124	Q, K, I, M	
		MENDON	
B21t	25-41	Q, M, I, V	M, Q, I, K
C1ca	50-77	Q, M, K, I, V, Ca	
C2ca	102-168	Q, M, K, I, Ca	

Q = Quartz
I = Illite
K = Kaolinite
M = Montmorillonite
G = Gypsum
Ca = Calcite

and 3.5 A peaks must also be identified as chlorite. This is not likely to occur. The 14.0 and 7.0 A peaks were identified as montmorillonite and kaolinite, respectively. Second possibility is the 5.0 A peak is muscovite. If so, that would be somewhat surprising, because petrographic studies did not indicate the presence of muscovite. In this respect, no explanation could be given.

In both pedons, a distinct diffraction peak at 44 A is quite common in the coarse clay (0.2-2µ) fractions. The 44 A peak may indicate some mineral interestratification. The CEC value for the clay fraction (64 me/100 g) also suggests a mixture of illite and montmorillonite.

A considerable amount of illitic clay occurs in both the Parleys and Mendon pedons. In both pedons, kaolinite appears in very small amounts in the coarse clay and it is much less in the fine clay fraction. Hutcheson and Haney (1963) indicate that kaolinite represents an advancement in weathering over soils having illite, vermiculite, and montmorillonite clays. If, as was postulated before, these soils have been subject to limited weathering during their development, the small amount of kaolinite which appears in the Parleys and Mendon soils is probably inherited from their parent material. In this study area, the climatic regime under which those soils have developed does not favor kaolin formation. A previous study on some soils in Cache valley indicates that clays developed from the Wasatch Formation are usually high in kaolinite (Southard and Miller, 1966). There is the possibility that most of the kaolinite observed in Parleys and Mendon horizons was inherited from materials washing into the Lake from the Wasatch Formation in the mountains.

In Table 7, the most important differences between the soil pedons are the small quantities of vermiculite and the trace amount of gypsum which appear in the Mendon and Parleys horizon, respectively. The tracing of the 0.2-2μ fraction, show a distinct 14.9 A vermiculite peak in the B21t and C1ca Mendon horizons, whereas, 4.29 A peak corresponding to gypsum appears in the B1 and B22t of the Parleys horizon. The presence of the gypsum in Parleys horizon suggested by the x-ray traces is not in agreement with petrographic data given in Table 6. The 3.03 A peak probably corresponds to the calcite mineral. Calcite appears in very small amounts in the C1ca and C2ca of Mendon horizons. Perhaps, these calcite materials were not destroyed by the acid treatment during preparation for x-ray analysis as presumed. It is possible that each of gypsum and calcite may have originated as products and residuals from acid treatment samples, respectively. A very distinct and sharp 3.35 A peak of quartz has been found in all studied soil horizons (Table 7). Quartz appears to be predominate in both coarse and fine clay fractions. This mineral has been observed to be an important constituent of the soil parent materials, and its common occurrence in both of Parleys and Mendon horizons was to be expected.

SUMMARY AND CONCLUSIONS

Two soil series presumably derived from different parent materials and developed under similar climatic, topographic, biological and age conditions in northern Utah were studied. These were Parleys and Mendon series. They were reported to be derived from Bonneville and Salt Lake Formation, respectively. The locations were chosen to give similar environmental parameters except for their different parent material. Therefore, a detailed physical, chemical, and mineralogical analyses was made of the two pedons: (1) to test the genetic theorem of soil development, and learn more about their genesis and, (2) to relate these characteristics to the present classification of the studied soils along the east side of Cache valley.

The soil characteristics which were observed and analyzed can be differentiated into two distinct but not mutually exclusive kinds of properties. These are inherited and acquired (developed) properties. The measurable inherited properties of the soils are calcium carbonate, iron oxide, organic matter, and clay type. Most of these properties were shown to have a high degree of variability which supports the idea that their differences were attributable to their parent materials. The Parleys pedon developed from less calcareous sediments and was leached to a greater depth compared with the Mendon pedon. The conclusion is that the Salt Lake Formation, from which Mendon C horizons formed, were more calcareous deposits than were the Bonneville Formation. The Parleys soil derived from Bonneville Formation contains higher amounts of iron due to the presence of greater amounts of iron-bearing minerals than the Mendon soil developed from Salt Lake Formation. Therefore, differences in the amount of iron between these pedons is decidedly related to their different parent material. In both pedons, enough evidence was observed to conclude that most of the free iron has formed by weathering in place rather than collodial movement. These minimum figures of the amounts of iron oxide reflect the limited weathering under the conditions of low precipitation and relatively high pH. There was a marked difference in the amount of the organic matter between the soil C horizons. The parent material of the Parleys had more organic matter than the Mendon parent materials.

The important acquired properties of the studied soils are the color and thickness of their epipedons, and the illuvial clay of their argillic horizons. These series, which derived from different geological materials, show a similar degree of horizonation as well as similar acquired properties. This similarity could reinforce the presumption in the study that these soils developed under similar climatic conditions. The Parleys and Mendon epipedon is 25 cm and 41 cm in depth, respectively. In both soils the nature and magnitude of the organic matter of their epipedon is quite similar. Both organic matter and iron oxide combine collectively to develop a specific color property for each pedon. The darker color of Mendon epipedon is influenced by its organic matter with less amounts of iron oxide as compared with Parleys pedon. Because of the interrelationships between the amount of iron, organic matter and the color, differences in color between these soil epipedons is a pedogenetic (acquired) property. Genesis of the argillic horizon of the two soils show some unexplained discrepancies. This probably is due to the erratic distribution of the fine clay, especially in the Parleys. In this pedon, some of the fine clay may have been deposited by water in the upper part of solum during Holocene time. In both pedons, the nature of the distribution of the fine clay may also reflect the condition of the moisture fluctuation under the present climatic regime of Cache valley. Under this condition, the movement of fine clay could take place in any direction, even though there was illuviation of some fine clay. This process is associated with pressure evidence and high lime carbonate as well as periodic drying of the soils and may have physically retarded any pronounced feature of clay orientation. Thin sections from both pedons did not indicate a distinct evidence of the illuviation cutans (clay skins) in their argillic horizons. Alternatively, the increase in the fine clay (carbonate-free clay basis) was used as evidence to support the existence of the argillic horizons. On that basis, it was concluded that these pedons should continue to be recognized as having argillic horizons (fine clay ratio more than 1:1.2).

Evaluation of the parent material supports the idea of their different sources. In both of them, the texture pattern suggests heterogeneity of their parent material; but Mendon has developed from more heterogenous deposits than Parleys. The sand distribution of the Mendon pedon suggests depositional discontinuities between the solum and C horizons. The upper part of Mendon pedon (solum) may have developed from stratified deposits not related to the Salt Lake Formation. If so, these fine deposits have been attributed to Lake sediments during the Bonneville time. In contrast, the more sandy and calcareous deposits of the Salt Lake Formation in the

Mendon C horizons were contributors to the parent material to at least 51 cm depth. Along the east side of Cache valley, these calcareous, tuffaceous sediments of Salt Lake Formation possibly were deposited in Tertiary time by sedimentation processes or by wave action during the existence of Lake Bonneville. The Parleys soil appears to have developed from sediments of the Bonneville Formation even though there is some silt-sized material which is attributed to the alluvial deposits of Holocene Age. These deposits possibly were transported as slopewash material over the delta of Lake Bonneville and may be the major cause of the heterogeneity in the solum of the Parleys pedon. No certain evidence was obtained to conclude that these soil parent materials were exposed to active erosion during their development.

These soils show a remarkable similarity in most of the properties measured. The main differences were in the amount of calcium carbonate, extractable iron, and fine carbonate-free clay. These differences can probably be attributed to the difference in the parent material and, therefore, are inherited differences rather than developed due to pedogenetic processes.

In both studied soils, the color, depth, and organic matter percentage of each epipedon coincide with the concept of the Mollic; but neither of them qualifies for Pachic. Lack of an epipedon thick enough for Pachic excludes the Mendon from the Calcic Pachic Argixerolls at the subgroup level. If so, these two soils should be classified together at the subgroup level. The resulting classification of the two soils should be fine-silty, mixed, mesic family of Calcic Argixerolls which is a change from the current Calcic Pachic Argixerolls classification of the Mendon series.

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