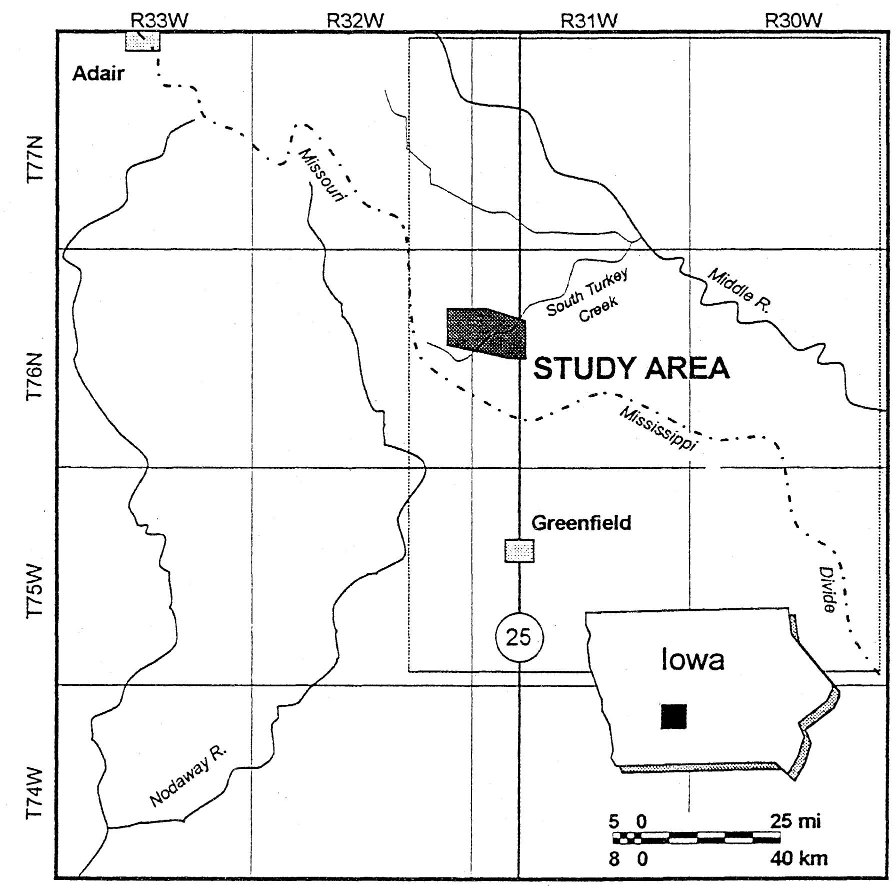
GREENFIELD QUADRANGLE - REVISITED

Geological Survey Bureau
Guidebook Series No. 21



Iowa Department of Natural Resources
Larry J. Wilson, Director
May 1996

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Prepared by

Thomas E. Fenton and Gerald A. Miller
Agronomy Department
Iowa State University
Ames, Iowa 50011

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NOTE

Geologic terminology used in this guidebook agrees with that of Dr. Robert Ruhe and associates as published in USDA Technical Bulletin 1349 (1967). Many of the figures and tables used in this guidebook are from this and contemporary references that utilize the same terminology. To avoid confusion, the authors carried this terminology throughout the guidebook. However, the classification of Iowa's Quaternary deposits and buried soils have undergone significant revision during the last few years, and the temporal, lithologic, and soil stratigraphic terminology used in this guidebook does not conform to that presently in use by the Iowa Department of Natural Resources, Geological Survey Bureau (GSB). The following tables provide comparisons of the stratigraphic terminology used in this guidebook with that presently used by the GSB.

TEMPORAL CLASSIFICATION

Guidebook	GSB
Recent	Holocene Stage
Wisconsin Tazewell Iowan Farmdalian	Wisconsinan Stage
Sangamon	Sangamonian Stage
Illinoian	Illinoian Stage
Yarmouth	Yarmouthan Stage
Kansan Aftonian Nebraskan	pre-Illinoian stages

LITHOSTRATIGRAPHY

Guidebook	GSB
Wisconsin loess	Peoria Formation
basal loess	Pisgah Formation
Loveland Loess	Loveland Formation
Kansan till or drift Nebraskan till or drift	A tills B tills C tills

SOIL STRATIGRAPHY

Guidebook	GSB
basal loess soil	Farmdale Geosol
Late Sangamon paleosol Sangamon paleosol Yarmouth-Sangamon paleosol	Sangamon Geosol
Yarmouth paleosol	Yarmouth Geosol
Aftonian paleosol	unnamed paleosols

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Thomas E. Fenton and Gerald A. Miller
Agronomy Department
Iowa State University
Ames, Iowa 50011

ABSTRACT

In the early 1950's, Dr. Robert Ruhe studied the Pleistocene deposits along the Chicago Rock Island & Pacific Railroad relocation in southwestern Iowa. This original study was extended to include a detailed research project of soil-landscape relationships in Adair County in the Greenfield Quadrangle. The results of all this research are published in USDA SCS Technical Bulletin 1349 entitled *Landscape Evolution and Soil Formation in Southwestern Iowa.* On this trip we will review the work of Dr. Ruhe and other studies that have evolved as a result of that original work. Properties of the Wisconsin loess and the underlying paleosols and deposits will be discussed at Stops 1 and 2. Stop 3 will be in the Greenfield Quadrangle. Soil-landscape relationships developed in that study will be demonstrated in a series of pits that show the relationships of soils and parent materials to the geomorphic history of the landscape.

ENROUTE TO ADAIR COUNTY

Our route to Adair and the Greenfield Quadrangle will be south of Ames on Interstate 35 and west on Interstate 80 to exit 76. After two stops near Adair we will go east on I-80 to exit 86 and then proceed 7.5 miles south on Highway 25. This takes us to the east edge of the South Turkey Creek area in Adair County. The route is highlighted in Figure 1. Enroute to Adair County, we will have the opportunity to observe the soils and landscape of the Clarion-Nicollet-Webster soil association. These soils developed from loam-textured glacial till or till-derived sediments. They comprise slightly over 20% of the land area in Iowa. The landform is the Des Moines Lobe and the drift is Cary (Late Wisconsin) deposited about 13,000 years before present (YBP). However, the major geomorphic surfaces on which the soils have developed are much younger, probably about 3,000 YBP. The Iowa State Capitol Building is located on the terminus of the Bemis Moraine. Wisconsin loess deposition in Iowa ended about 14,000 YBP and within the Clarion-Nicollet-Webster soil association the loess is buried by or incorporated in the Cary drift. West of the intersection of I-35 and I-80, I-80 roughly parallels the southern boundary of the Des Moines Lobe but it also crosses areas of loess-derived soils, bottom land and terraces. Just east of mile marker 110, (Highway 169) we are completely within the Sharpsburg soil association area and will remain in that area until we return to this point. Adair County and the Greenfield Quadrangle are within this soil association area. The soils and landscapes of this association will be discussed in detail at Stops 1, 2, and 3.

ADAIR COUNTY (CONDENSED FROM THE *SOIL SURVEY REPORT OF ADAIR COUNTY,* PUBLISHED JANUARY 1980)

Adair County is in the southwestern part of Iowa (Fig. 2). The total land area is 573 square miles, or 364,160 acres. Greenfield, the county seat, is about 50 miles southwest of Des Moines, the state capital, and about 75 miles east of Council Bluffs. Most of Adair County is farmland. The main crops are corn, soybeans, hay, oats, and pasture grasses. A large amount of the grain and forage crops is grown as feed for the swine, beef, and dairy cattle that are raised in the county. Most of the soils in Adair County formed under a native vegetation of prairie grasses and have a dark, fertile surface layer. The climate is subhumid and continental. Winters are cold, summers are warm, and the growing season is long enough for the crops commonly grown in the county to mature.

Climate

In winter, the average temperature is 24 degrees F, and the average daily minimum is 15° F. The lowest temperature on record, -28 degrees, was recorded at Greenfield on January 20, 1963. In summer, the average temperature is 73°, and the average daily maximum is 84°. The highest temperature, 106°, was recorded on July 21, 1974. Of the total annual precipitation, 24 inches (or 73%) usually falls between April and September, the period that includes the growing season for most crops. In 2 years out of 10, rainfall in the April to September period is less than 19 inches. The heaviest 1-day rainfall on record is 6 inches, recorded at Greenfield on September 11, 1972. There are about 50 thunderstorms each year, 25 of which occur in summer. The average seasonal snowfall is 27 inches. The deepest snow at any one time during the period of record was 60 inches. On the average, 17 days in the year have at least 1 inch of snow, but this number varies greatly from year to year.

Physiography, Relief, and Drainage

The highest elevation, 1,415 feet, is in the northwestern part of Adair County. The lowest elevation, 1,188 feet is in the southwestern part of the county. The topography ranges from nearly level to very steep. The upland divides are mainly gently sloping or moderately sloping. The side slopes along valleys typically are strongly sloping or moderately steep. Most valleys are nearly level or gently sloping. The foot slopes along the edge of valleys are mainly moderately sloping. The upland divide that separates the Missouri River Watershed from the Mississippi River Watershed is in Adair County. This divide is in the northwestern part of the county near Adair, Iowa. It extends southeasterly to near Greenfield and Orient, Iowa, and from there into Union County, Iowa. The northeastern part of Adair County is drained to the east by the Middle River. The southeastern part of the county is drained to the south by the Grand River. The western part is drained to the south by the Nodaway River. The extreme northwestern part of the county is drained to the west by Turkey Creek.

History

The area that is now Adair County was settled in 1849. The county was organized in 1851. It was named in honor of General John Adair, an officer in the War of 1812. The Mormon Trail, which passes through Adair County, was used by early settlers on their way west. In 1873, the Jesse James gang staged the first railroad stickup in the United States near Adair, Iowa. A monument is located at that site to recognize that historic event.

Water Resources

The supply of water for municipal, crop, and livestock use generally is adequate; however, at times it is inadequate in most areas of the county. On uplands, water moves downward through the loess mantle and is restricted by the underlying glacial till-derived paleosol, a buried soil. In wet periods, a perched water table develops in the loess above the paleosol and water seeps out on hillsides along the loess-till contact line. In spring, the supply of water from this perched water table commonly is good, but it generally is greatly reduced in summer. The average depth of farm wells is about 30 feet. Water for livestock is mainly supplied by small farm ponds and by creeks or rivers that are in pasture land. In 1975, there were about 1,365 farm ponds in Adair County. The average size of these ponds was 1 to 2 acres; however, the ponds range in size from 1/4 acre to 20 acres. Greenfield, Iowa, gets water from a well that is 3,850 feet deep. The well draws water from the Jordan Sandstone and makes use of a reverse osmosis system to remove excess salts from the water.

Farming

In 1967, 351,006 acres in Adair County was in farms. Of this total, 265,545 acres was used for crops, 63,692 acres was pasture land, 12,000 acres was woodland, 9,767 acres was farmsteads, and 876 acres was small areas of water. Corn is the main crop in Adair County. In 1975, 98,500 acres in corn was harvested for grain and yielded an average of 65.1 bushels per acre; 8,150 acres in corn was harvested for silage and yielded an average of 11.1 tons per acre. Soybeans is the second most important crop. In 1975, 55,500 acres in soybeans was harvested for grain and yielded an average of 27.7 bushels per acre. In 1975, 23,000 acres in oats yielded an average of 34.9 bushels per acre. In 1975, 44,500 acres was in hay. With the exception of some cash-grain farms, most of the farms in Adair County receive about half of their income from crops and about half from livestock. In 1975, 149,800 hogs, 37,800 beef cows, and 16,400 grain-fed cattle were marketed. There were 1,200 milk cows. In 1975, the average number of laying hens in Adair County was 37,000. Since the 1930s, the number of farms in Adair County has steadily decreased, and the average size of farms has increased.

PLEISTOCENE STUDIES IN SOUTHWESTERN IOWA

In the early 1950's, Dr. Ruhe studied a series of 50 cuts between Bentley and Atlantic, Iowa, and another series of cuts near Adair, Iowa (Fig. 3; Ruhe, 1954). The cuts were made for the relocation of the Chicago, Rock Island and Pacific Railroad. The relocation was necessary due to earth slides that had occurred along the original route. Note that at Adair, we are at the east end of that sequence of cuts. We are also located about 11 miles to the northwest of the Greenfield Quadrangle. The study of the railroad cuts and many other studies help to understand the distribution and properties of the Wisconsin loess and the underlying deposits in this part of the state.

Prediction equations for loess thickness and other related properties for Iowa conditions have been proposed by Hutton (1947), Ulrich (1950), Ulrich and Riecken (1950), Ruhe (1969), Worcester (1973), and Coleman and Fenton (1982). Location of the sites included in the latter study are shown in Figure 4. The upland divide of Stop 1 just to the south of the town of Adair is a part of the Missouri-Mississippi divide in Iowa. It is shown as site 5 in Figure 4. Worcester (1973) reported that on the divide, the total thickness of the Wisconsin loess is 500 cm (197 inches). Along the interfluve summits at approximate right angles to the divide, the loess thickness varies considerably from that of the divide. Figure 5 shows the relationship between loess thickness on stable summits and the natural log of distance from the source (Missouri River flood plain; Table 1). This relationship is based on sites selected to cross normal to previously mapped loess thickness contours. Earlier studies patterned after those of Smith in Illinois were linear rather than curvilinear traverses. Soil scientists have long been interested in loess distribution patterns because of the relationship to soil properties. For example, Figure 6 shows the relationship between the maximum clay content in the B horizon and the natural log of the loess thickness. Figure 7 shows the relationship between the maximum clay content in the B horizon and the distance from the loess source.

STOP 1 - ADAIR SUMMIT SITE

The description (Table 2) and data (Tables 3 and 4) for this site were modified after Worcester (site 6, 1973). The soil at this site is Sharpsburg silty clay loam with a maximum clay content of about 37%. At about 6 feet the texture of the loess is silt loam. Clay mineralogy of selected depths and clay fractions is shown in Figure 8. Grayish brown mottles are below about 32 inches and the matrix color is grayish brown (2.5Y 5/2) below 54 inches. No carbonates are present so this weathering zone is designated as deoxidized and leached. At 136 inches carbonates are present but the color is the same so the weathering zone designation is deoxidized and unleached. For this part of the state the grayish brown colors are considered to be relict and not indicative of the current moisture regime. This conclusion is supported by the hydrograph of Worcester (1973) and shown here as Figure 9. The water table during 1969 to 1971 was at a depth of 13 to 14 feet and had no relationship to the morphology in the upper part of the profile. Along the traverse between Bentley and Atlantic the general sequence of weathering zones in the loess was: OL, DU, OU, and DL (Ruhe, unpublished manuscript). From a few miles west of Atlantic and then eastward, the weathering zone sequence on landscape positions that are presently classified as well drained the sequence is : OL, DL, DU, and DL. The weathering zones were interpreted to be relict post-loess deposition features and not different loess deposits (Ruhe, Prill, and Riecken, 1955). Ruhe and Scholtes (1956) showed that the weathering zones were independent of faunal zones in the loess again supporting post-loess deposition changes rather than different loess deposits. Ruhe subsequently discussed the weathering zones in more detail (Ruhe, 1969). The terminology and definitions of the weathering zones as presently used in Iowa are given in the Appendix A (Hallberg et. al, 1978).

STOP 2 - JESSE JAMES MONUMENT SECTION

This stop is shown as Cut A in Figure 3 and 10. Note that we have dropped in elevation from over 1400 feet at Stop 1 to approximately 1360 feet at Stop 2. Stop 1 was underlain by a Yarmouth-Sangamon paleosol and Stop 2 is underlain by a Late Sangamon paleosol. Loess thickness has also decreased. On the primary divide of Stop 1 the Wisconsin loess was approximately 16 feet thick and at Stop 2 on a lowered interfluve the loess thickness is approximately 6 feet This area was visited by the 1965 INQUA Congress as a part of Field Conference C (INQUA, 1965). The section description of cut A, the Adair Hill section (Cut D) in the town park, and a description of Cut 33 from that field guide are given in Table 5. Also, the properties of the Yarmouth-Sangamon paleosol at Cut D (Adair Hill section) as compared to the Late Sangamon paleosol in Cut A are also given in Table 5 and will be discussed at this stop.

STOP 3. GREENFIELD QUADRANGLE

Introduction

In January of 1953, Dr. Robert Ruhe joined the Soil Survey to initiate research studies in soil geomorphology. Later that year, due to reorganization within the USDA, the soil geomorphology studies were placed with Soil Survey Investigations, Soil Conservation Service. During 1953, 1954, and early 1955, Dr. Ruhe studied the Quaternary stratigraphy, geomorphology, and pedologic relations in railroad cuts from Bentley, in Pottawattamie County, to east of Adair, Adair County, Iowa. The results of this work and the subsequent study of the Greenfield Quadrangle are published in Technical Bulletin 1349, *Landscape Evolution and Soil Formation in Southwestern Iowa* (Ruhe, 1967) as well as many other journal articles.

Study Area Within the Greenfield Quadrangle

Two areas were selected for detailed study, the South Turkey Creek area and the North Turkey Creek area. The former included parts of Sections 7, 17, and 18, T76N, R31W and parts of Sections 12 and 13, T76N, R32 (Fig. 11). The latter included parts of Sections 19, 20, 29, and 30, T77N, R31W and parts of Sections 24 and 25,T77N, R32W. The Missouri-Mississippi divide crosses Adair County southeasterly from the town of Adair to the north, northeast and east of the town of Greenfield. The study areas were east of the Missouri-Mississippi divide (Fig. 11).

Pleistocene Stratigraphy

The general Pleistocene stratigraphy recognized in southwestern Iowa in the 1950's is shown in Table 6 . It was composed mainly of two drifts overlain by two major loess deposits. From the top of the bedrock upward was Nebraskan drift, Kansan drift, Loveland loess, and Wisconsin loess with several substages recognized. Members of the sequence were separated by buried soils, weathered zones, erosion sediments, or interbedded sediments. Loveland loess generally was not recognized east of Atlantic, Iowa.

Areal studies were undertaken in this area to determine the geographical distribution of geomorphic surfaces identified in the traverse study from Bentley to Adair. Both the surfaces and the Pleistocene deposits were traced from Adair to the Greenfield Quadrangle. Another reason for selection of this area was the availability of a new topographic base map.

Wisconsin Loess

The Wisconsin loess from the railroad traverse was traced directly into the Greenfield Quadrangle. The basal increment of the Wisconsin loess was called Farmdale. It was distinguished from the overlying loess by the presence of a weakly developed buried A-C profile 9 to 12 inches thick. It occurred only on the upland divides and higher summits of interfluves. The bulk of the Wisconsin was considered to be post-Farmdale (Table 7). However, subsequent to this study, it was demonstrated that the dates obtained from the basal loess organic A horizon were not Farmdale in age but were, in many cases, younger than

Farmdale (Ruhe and Fenton, 1969). Radiocarbon dates from Adair County support the contention that the buried A horizon is time transgressive and cannot be called Farmdale based only on the presence of organic matter. A date of 18,700+700 (I 1411) was obtained from organic matter in the base of the Wisconsin loess near the west center of Section 17, T76N, R31W, within the Greenfield Quadrangle. A second date from Adair County (I 3702) was obtained from organic matter in the basal loess on the Missouri-Mississippi divide in the NE 1/4 of Section 11, T77N, R33W. That date was 21,150+450.

Equations have been developed to predict the age of the basal loess in Iowa. They are related to distance from the Missouri River, the assumed source area. Ruhe (1969) gives the following equation:

$$Y = 26500 - 55X$$

where Y is the radiocarbon date and X is distance in miles from the source. Worcester (1973) used the following equation for the same purpose:

$$Y = 23272 - 29.47X$$

The western edge of Adair County is at least 64 miles from the Missouri so both of the above equations predict the basal loess would not be Farmdale, which is considered to be in the range of 24,000 to 28,000 YBP.

Kansan Till

The upper till was identified as Kansan. A comparison of the textural and mineralogical composition of Nebraskan and Kansan till present in Cut 31 is given in Table 8. They do not differ greatly in properties. In many places, the Kansan till is mantled with Wisconsin loess. Weathering zones were identified in both the Nebraskan and Kansan tills. In the tills, the surficial soil grades downward into oxidized and leached till which in turn grades downward into oxidized and unleached till. This zone grades into unoxidized and unleached till. The surficial soil may be a paleosol of Yarmouth-Sangamon age, Late Sangamon age, or a surface soil of Wisconsin or recent age.

The terminology and literature references for the initial use of weathering zone terminology are given in Table 9. Terminology and definitions that are presently used to describe weathering zones in Iowa are given in Appendix A.

Nebraskan Till

The sequence of two tills identified in the railroad traverse, also were in the Greenfield Quadrangle. The lower most till was called Nebraskan. It is clay loam in texture and in many places is surmounted by a clayey-textured Aftonian paleosol. Its relationship to other deposits is given in Table 6.

Presently the tills discussed above are grouped together and called pre-Illinoian by geologists. Boellstrorff (1978) concluded that the currently used North American Pleistocene stage terms, except perhaps for Wisconsinan, are in need of redefinition or revision. This conclusion was based on deep borings and ash dates in some of the classical type locations in the Midwest, including Iowa. He described three compositional types of till and labeled them A, B, and C. There were at least two type C tills, at least one type B till, and at least four type A tills. Soil scientists in Iowa have continued to use the old nomenclature because of the significant weathering break marked by paleosols. In many sections in Iowa the upper till with a Yarmouth-Sangamon or Late Sangamon paleosol is separated from another till by a well developed paleosol that traditionally has been called Aftonian.

Landscapes and Soils

Landscape

The modern surface in this area does not slope continuously from the divide to the major drains. Slopes along the axes of the interfluves are broken at two or three places by distinct changes in gradient (Figs. 12, 13, and 14). Most interfluves have a sequence of stepped levels that rise from the valley shoulders to the upland divide. This sequence of levels is the result of multicyclic erosion of a glacial till landscape and is made more complicated by the mantle of Wisconsin loess. The high level, mantled by Wisconsin loess, is controlled by the Yarmouth-Sangamon surface (Fig. 15). This surface is on the divide area of the glacial till landscape and has been little modified by erosion. This surface is characterized by thick, intensively weathered paleosols (Fig. 16). Note that farther to the west in the Monona or Marshall soil association areas (Fig. 17) the Wisconsin loess on more stable landscapes is underlain by a Sangamon soil formed in Loveland loess. Thus, the Sangamon surface is separated from the Yarmouth surface and are distinct entities. The Late Sangamon surface was named for that erosion surface that truncated both the paleosol developed in Loveland loess and the underlying till and was overlain with Wisconsin loess. That erosion surface had to be younger than Sangamon but older than Wisconsin and thus the name Late Sangamon. In the Sharpsburg soil association area, Loveland loess is not present and the surface underlying the Wisconsin loess on more stable landscape positions was exposed to weathering processes and soil formation both in Yarmouth and Sangamon time and thus that geomorphic surface is named Yarmouth-Sangamon.

The intermediate levels in this area are, in most cases, also mantled with Wisconsin loess. These levels represent the Late Sangamon erosion surface that was cut into Kansan till below the level of the Yarmouth-Sangamon surface (Figs. 12, 13, and 14). The Late Sangamon surface rises gradually and then more abruptly up a concave backslope to the level of the Yarmouth-Sangamon surface. The younger erosion surface is characterized by a stone line on Kansan till which is overlain by finer textured transported sediment derived from the till (pedisediment). A paleosol is formed in the sediment, stone line, and uppermost part of the Kansan till. It is somewhat less developed than the Yarmouth-Sangamon paleosol.

The low level of the landscape is the Early Wisconsin (Iowan) erosion surface that is cut into Kansan till below the Late Sangamon surface (Figs. 12, 13, and 14). In places, the Early Wisconsin surface is mantled by Wisconsin loess but no paleosol separates the till from the loess.

The stable surfaces of the loess date from 14,000 YBP and are Tazewell in age. Late Wisconsin slopes have beveled the Tazewell loess. These slopes descend to alluvial fills lower on the landscape. Bases of the alluvial fills have been dated at 6,800 YBP. Thus, the majority of the slopes in the area are less than 6,800 years and are Recent in age. The same slopes bevel the weathering zones in the loess and place the formation of the zones sometime between 14,000 and 6,800 YBP. Figure 15 shows the distribution of deposits and erosion surfaces in the South Turkey Creek Area

Paleosols

Figure 18 shows the distribution of soils and exhumed paleosols in the South Turkey Creek area. Paleosols on the Yarmouth-Sangamon surface have a range in properties and morphology. Variations are related to the undulating swell and swale configuration of the surface. This surface was shown to have a local relief of 5 to 10 feet and that is characterized by distinctive, deep, intensively weathered paleosols. They are on the highest areas of the landscape, have gray colors, thick sola, clay or silty clay textured Bt horizons, strong subangular blocky structure in the B horizon, and lack weatherable minerals in the coarser size fractions. Clay contents and weathering ratios for several of these paleosols are shown in Figure 19 and Table 10. In areas where these Yarmouth-Sangamon paleosols are exhumed and become a part of the present land surface soil continuum and have a morphology related to the impact of prairie vegetation, they are members of the Clarinda series. In the same areas where the Yarmouth-Sangamon has been partially truncated and the clay-textured zone is less than two feet in thickness, the Lamoni series is mapped.

Paleosols on the Late Sangamon surface in the uplands are more uniform morphologically. They are not as intensely developed as the paleosols on the Yarmouth-Sangamon surface (Fig. 19 and Table 10). The pediment on which they occur was a surface of low relief with transverse level and slightly rounded interfluves that stood 5 to 10 feet above adjacent drainageways. On this surface there are positions of variable drainage ranging from well drained to poorly drained. The well drained soils in this area are similar to Typic Hapludalfs. However, all of the buried paleosols in this area have been enriched by material carried downward in solution from the overlying loess. The pH values are near neutral and the base saturation is about 90%. Clay contents and weathering ratios for several of these paleosols are shown in Figure 19. In areas where these paleosols are exhumed and become a part of the present land surface soil continuum and have a morphology related to the impact of prairie vegetation, they are members of the Adair series.

A comparison by horizon of the paleosols and soils on more recent surfaces is given in Table 10. Other paleosols developed in valley fill and other alluvial materials were mapped and described in the study area. They were concentrated in the North Turkey Creek area.

Soils

The soils we will examine and their relationship to landscape and parent materials are shown in Figure 20. A brief description of the Sharpsburg-Nira soil association is given in the following paragraphs. A detailed soil map of the area to be visited is shown in Figure 21. We will spend most of our time in the SW 1/4 of Section 12, T76N, R32W, which is a part of the the Greenfield Quadrangle covered in Dr. Ruhe's Technical Bulletin 1349 that is referred to as the South Turkey Creek area. The area where we have dug the soil pits is a few hundred feet west of the area that Dr. Ruhe mapped in detail. This area was selected because it is in pasture that allows us year around access but more importantly it also demonstrates the sequence of soils and parent material that are typical of this landscape. Series descriptions and data for the major soils in this area are given in Appendix B and brief descriptions of these soils are given following a description of the soil association area.

Sharpsburg-Nira Association. This association consists of soils on ridgetops and divides, on side slopes, or in drainageways. It makes up about 30% of the county. It is about 40% Sharpsburg soils, 20% Nira soils, and 40% minor soils (Fig. 20).

Sharpsburg soils are moderately well drained and are on upland divides and on the upper part of side slopes. The surface layer ranges in thickness from 10 to 20 inches and is black to dark grayish brown in color. When it is eroded it is very dark grayish brown and dark yellowish brown silty clay loam about 8 inches thick. The subsoil is silty clay loam about 29 inches thick. The upper part is brown, and the lower part is mottled brown, grayish brown, and yellowish brown. The substratum is light brownish gray silty clay loam that has strong brown mottles.

Nira soils are moderately well drained and are on short, convex side slopes on uplands and on slopes that border drainageways. The surface layer typically is very dark gray and very dark grayish brown silty clay loam about 10 inches thick. The subsoil is about 32 inches thick. The upper part is brown silty clay loam, the next part is multicolored silty clay loam, and the lower part is light gray silty clay loam that has many yellowish red mottles. The substratum is light gray silty clay loam that has strong brown mottles. It overlies a clayey, grayish-colored Yarmouth-Sangamon paleosol at a depth between 4 and 8 feet.

The minor soils in this unit include Adair, Clarinda, Lamoni, Shelby, Colo, Ely, and Zook soils. The somewhat poorly drained and moderately well drained Adair soils are on convex side slopes and ridges. The poorly drained Clarinda soils are at the head of drainageways and in narrow bands on side slopes. The somewhat poorly drained Lamoni soils are moderately sloping and strongly sloping and are on the upper part of side slopes and at the head of branching drainageways. The moderately well drained Shelby soils are on upland side slopes along the larger drainageways. The poorly drained Colo and Zook soils and the somewhat poorly drained Ely soils are in drainageways.

In many areas, runoff is rapid. Erosion generally is a moderate hazard, but in some areas it is a severe hazard. The contact zone between the loess and the glacial till is seasonally wet and seepy. Terraces can reduce erosion and thus improve crop production, and interceptor tile can be installed to reduce wetness. In most areas, the soils on ridgetops and on the less steep side slopes are used for row crops. The soils on the steepest side slopes generally are in meadow or permanent pasture.

Sharpsburg. Adair County is located in the Shelby-Sharpsburg-Macksburg soil association area (Fig. 22). The relationship of the clay content of the Sharpsburg to the other well drained to somewhat poorly drained loess-derived soils in Iowa is shown in Figure 23. The changes in clay content are systematic and are related to the distance from the loess source. Additional soil properties that vary with distance from the source are listed in Table 11. Sharpsburg soils are classified as fine, montmorillonitic, mesic Typic Argiudolls. They formed under prairie vegetation. In Adair County, the Sharpsburg soils occupy slightly more than 25% of the land area. Data for selected profiles of Sharpsburg soils sampled as a part of the Greenfield Quadrangle study are given in Appendix B. The type location for the Sharpsburg series is in Taylor County, two counties to the south. The series description is given in Appendix B together with particle size, pH, and organic matter data. Ruhe (1984) included three Sharpsburg sites from Page, Adair, and Madison Counties, Iowa (Sites 8, 9, and 10, Fig. 24) and one Sharpsburg site from Cass County, Nebraska (Site 7, Fig. 24) in a regional study designed to examine soil-climate systems across the prairies in the Midwest (data for Adair County site is in Appendix B). He concluded there was a major change in the soil-climate system between 96 to 97 degrees west longitude. Reasons for the change included differences in the age of the loess, different climate, and different vegetation. He found little evidence for mineral weathering and concluded that textural B horizons are anomalous in the system and may be the result of dust fall.

As the thickness of the surface soil of Sharpsburg is decreased due to accelerated erosion, the present system of Soil Taxonomy would require classification of soils with less than 10 inches of mollic colors to be classified as Mollic Hapludalfs. However, there are some important subsurface properties that also need to be considered in the classification. Tembhare (1973) showed significant differences in organic matter content and depth distribution and available phosphorus amount and distribution when moderately eroded Sharpsburg was compared to the intermediate member of the biosequence, Ladoga (Appendix B). Luce (1973) and Bicki et al. (1988) showed there were significant differences in percolation rates between the prairie, transition, and forested members of biosequences. The percolation rates and selected data for Sharpsburg and Ladoga soils are shown in Appendix B.

Nira. Nira soils are classified as fine-silty, mixed, mesic Typic Hapludolls. They formed under prairie vegetation. Their morphology in the B horizon is related to the deoxidized and leached weathering zone in the Wisconsin loess. They are mapped in two different major soil association areas and are associated with both the Sharpsburg and Otley soils. The type location is four counties to the east and is within the Otley association. The description and data from the site in the Greenfield Quadrangle were originally called Sharpsburg silty clay loam, gray subsoil variant (Appendix B).

Clarinda. Clarinda soils are classified as fine, montmorillonitic, mesic Vertic Argiaquolls. These soils formed in exhumed Yarmouth-Sangamon paleosols under prairie vegetation. The A horizon is generally formed in loess or silty sediments and ranges from 10 to 18 inches in thickness. The B horizon typically is about 5 feet thick but ranges from 3 to 10 feet or more in thickness. The Bt horizon is clay or silty clay and ranges from 45 to 60% clay. The B horizon has been little affected by recent soil forming processes. The lower solum increases in sand content and >2 mm material as it grades into less-altered Kansan till. These soils make up about 3% of the county. The series description and data from a site in Ringgold County are in Appendix B.

Clearfield. Clearfield soils are classified as fine, montmorillonitic, mesic Typic Haplaquolls. They formed in 3 to 5 feet of Wisconsin loess overlying a Yarmouth-Sangamon paleosol. Clearfield soils make up about 1% of Adair County. The series description and data are given in Appendix B.

Lamoni. The Lamoni soils are classified as fine, montmorillonitic, mesic Aquertic Argiudolls. They formed in partially truncated, exhumed Yarmouth-Sangamon paleosols under prairie vegetation. The part of the Bt horizon that is clay textured is 12 to 24 inches thick and contains between 40 and 50% clay. The series description and data are in Appendix B.

Adair. Adair soils are classified as fine, montmorillonitic, mesic Aquic Argiudolls. They formed in a thin mantle of loess or pedisediment and a Late Sangamon paleosol under prairie vegetation. Clay content typically ranges from 38 to 46% but may range up to 60%. There is generally a stone line at the top of the 2Bt horizon. Adair soils make up approximately 2% of the county area. The series description and data are in Appendix B.

Shelby. Shelby soils are classified as fine-loamy, mixed, mesic Typic Argiudolls. Shelby soils are on convex recent side slopes and typically have gradients of 9 to 18%. The extreme slope range is 1 to 40%. Average clay content of the Bt horizons is 32 to 35%, but thin layers up to 38% clay are within the range. Free carbonates are generally at depths of 40 to 50 inches, but the extreme range is 30 to 75 inches. They formed in Kansan or Nebraskan till. The series description and data are in Appendix B.

Mystic. Mystic soils are classified as fine, montmorillonitic, mesic Aquertic Hapludalfs. They formed in Late Sangamon paleosols derived from pre-Late Sangamon alluvium. They are on high structural benches that border valleys of major streams and their tributaries. They are higher than the modern floodplain but are at lower elevations than the recent upland slopes. The series description and data are in Appendix B.

Caleb. Caleb soils are classified as fine-loamy, mixed, mesic Mollic Hapludalfs. They are on convex ridgetops and side slopes of high benches. They formed in pre-Late Sangamon erosional sediments of variable texture on recent slopes below the Mystic soils. The series description and data are in Appendix B.

The concept of soils derived from exhumed paleosols was established prior to the Greenfield Quadrangle study. For example, the Clearfield series was established in 1948. However, our understanding of soil-landscape relationships and the predictability of the location of the soils on the landscape were greatly improved by the Adair County study. Table 12 lists the soil series that are derived from exhumed paleosols that are presently used in Iowa. Time limitations did not permit a visit to the North Turkey Creek area. It differs from the South Turkey Creek area in that the right valley walls of the major streams are more steep and more sheer than the left valley walls. During Recent dissection, the streams have impinged on their right walls and have steepened them. The left side of the valleys have the geomorphic record best preserved. The pediment, valley-slope fan, and floodplain with associated valley fill, which now occur as relict surfaces along the axes of the present interfluves, form conspicuous parts of the present landscape.

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FIGURES

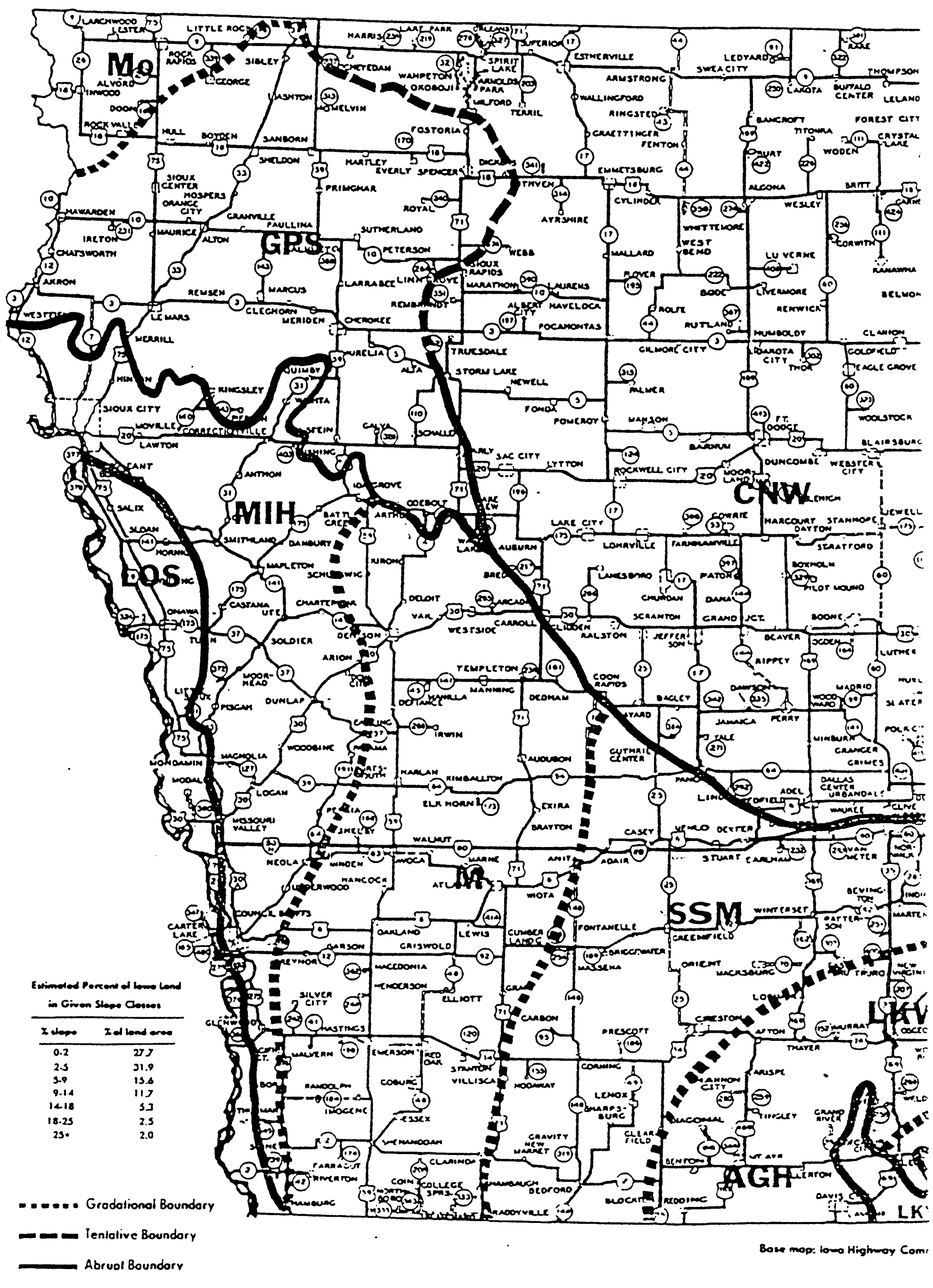
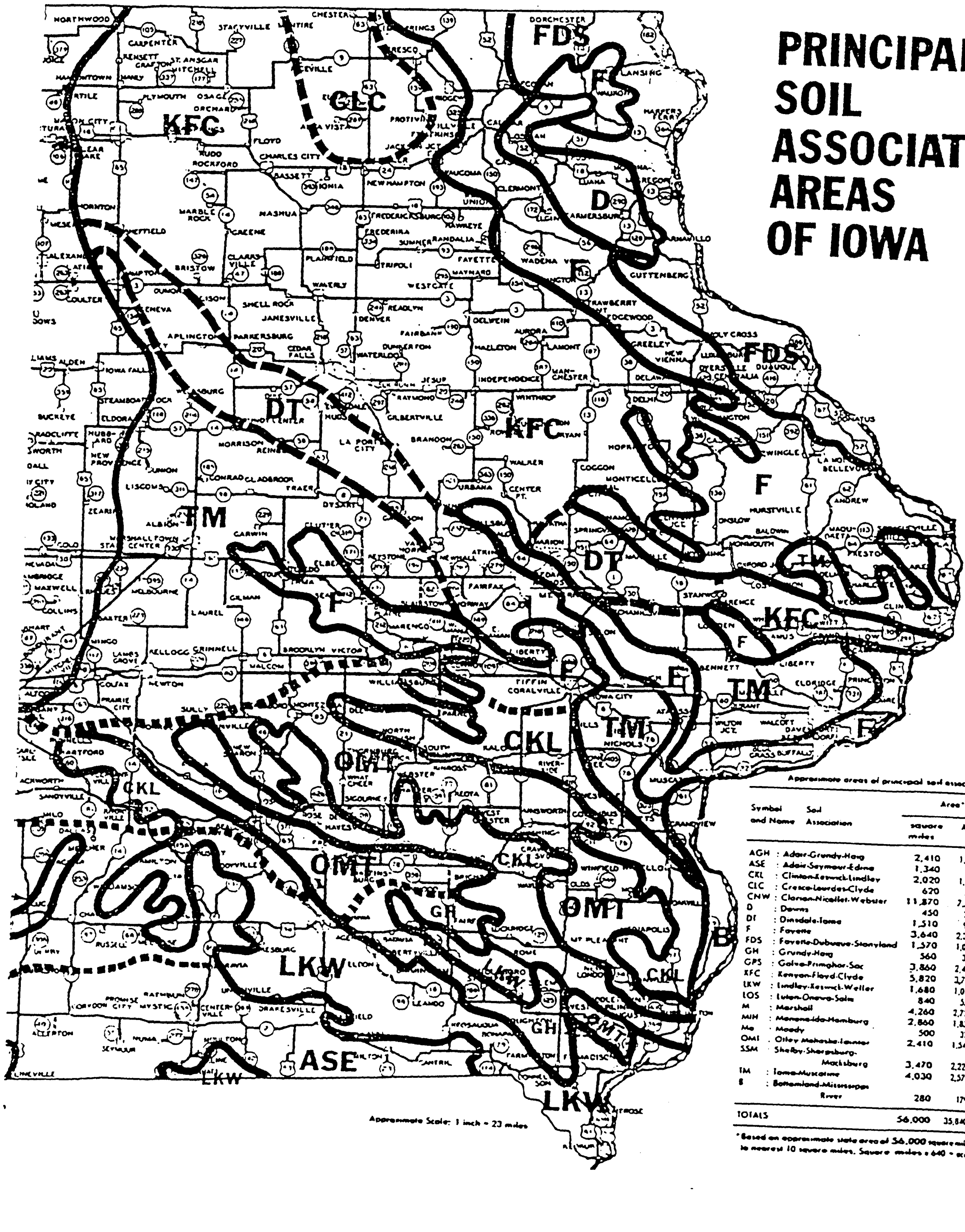


Figure 1. Soil association map on road base.

PRINCIPAL SOIL ASSOCIATION AREAS OF IOWA



Approximate areas of principal soil associations of Iowa.

Symbol and Name	Soil Association	Area* square miles	Area* Acres	Percent of state area
AGH	: Adair-Grundy-Haig	2,410	1,542,400	4 3
ASE	: Adair-Seymour-Edina	1,340	857,600	2 4
CKL	: Clinton-Keswick-Lindley	2,020	1,292,800	3 5
CLC	: Cresco-Lourdes-Clyde	670	396,800	1.1
CNW	: Clarion-Nicollet-Webster	11,870	7,596,800	21.2
D	: Downs	450	288,000	.8
DI	: Dinsdale-Tama	1,510	966,400	2.7
F	: Fayette	3,640	2,329,600	6 5
FDS	: Fayette-Dubuque-Stonyland	1,570	1,004,800	2 8
GH	: Grundy-Haig	560	358,400	1 0
GPS	: Galva-Primghar-Sac	3,860	2,470,400	6 9
KFC	: Kenyon-Floyd-Clyde	5,820	3,724,800	10 4
LKW	: Lindley-Keswick-Weller	1,680	1,075,200	3 0
LOS	: Luton-Onawa-Salix	840	537,600	1 5
M	: Marshall	4,260	2,726,400	7 6
MIH	: Monona-Ida-Hamburg	2,860	1,830,400	5 1
Mo	: Moody	500	320,000	.9
OMI	: Otley-Mahaska-Taintor	2,410	1,542,400	4 3
SSM	: Shelby-Sharpsburg-Macksburg	3,470	2,220,800	6 2
TM	: Tama-Muscatine	4,030	2,579,200	7 2
B	: Bottomland-Mississippi River	280	179,200	.5
TOTALS		56,000	35,840,000	100 0

* Based on approximate state area of 56,000 square miles, rounded to nearest 10 square miles. Square miles x 640 = acres.

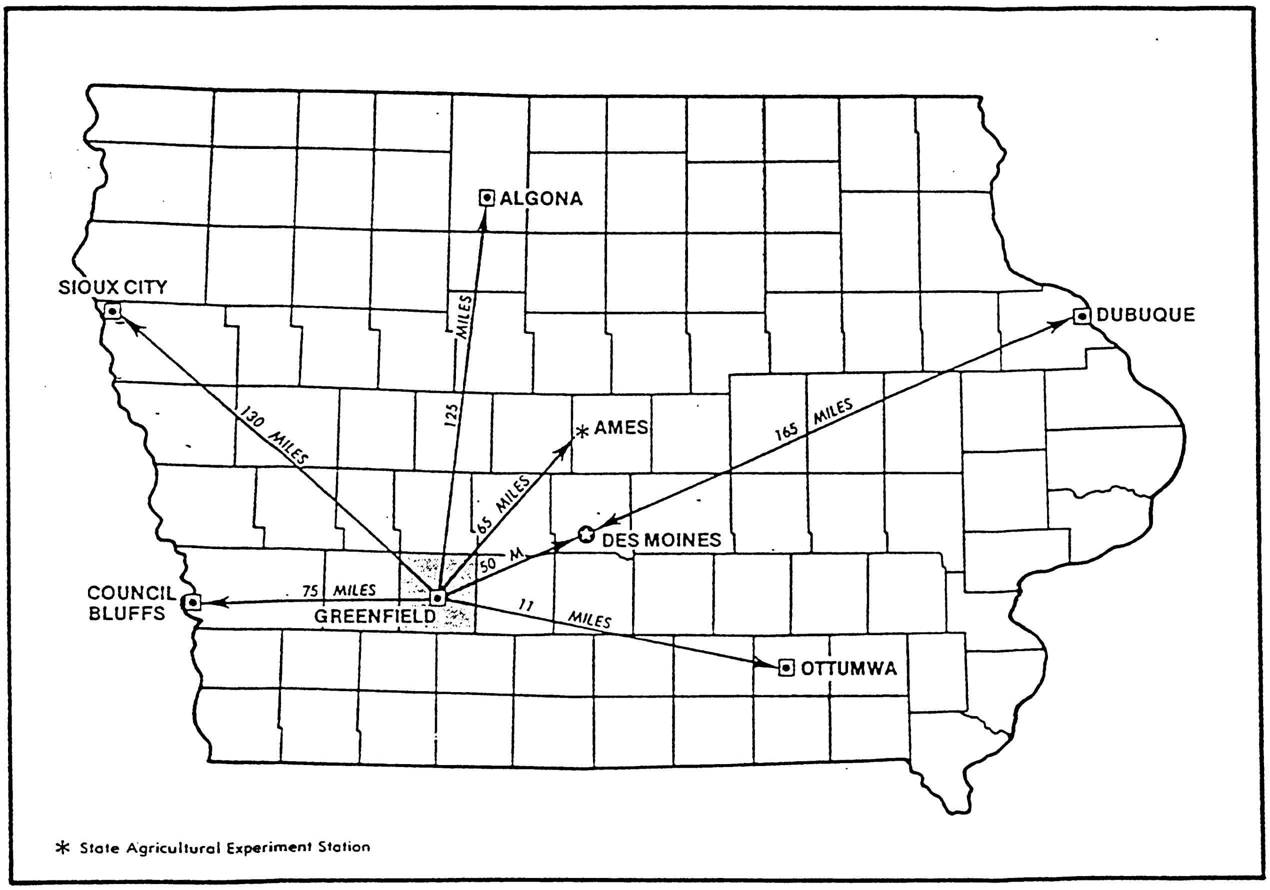


Figure 2. Location of Adair County in Iowa.

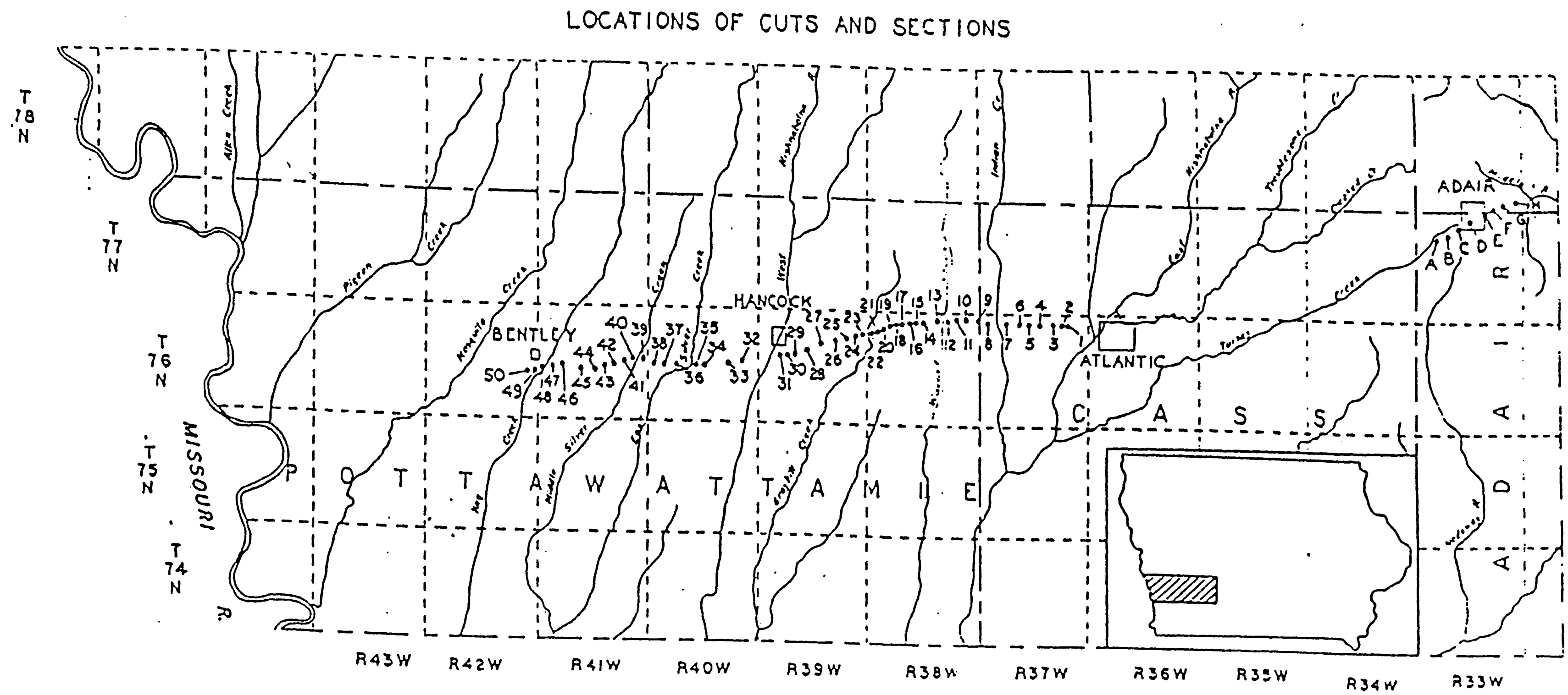


Figure 3. Location of cuts and sections along C.R.I. & P railroad relocations, southwestern Iowa. From R.V. Ruhe, 1953-54.

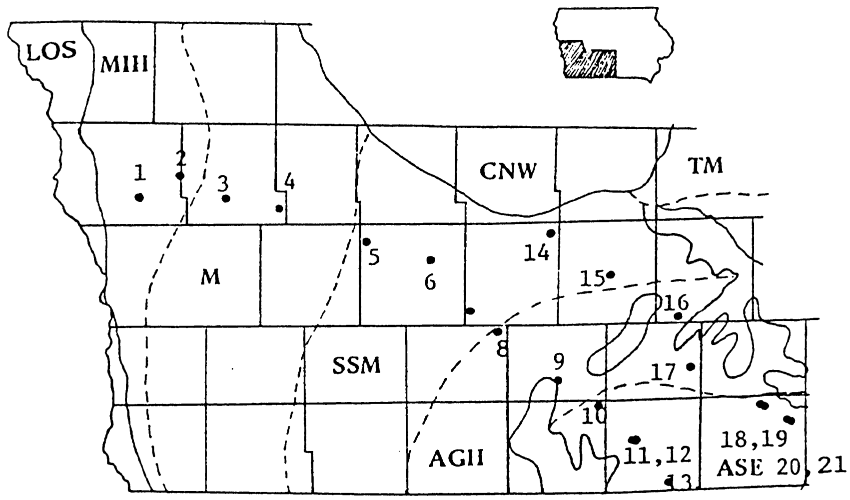


Figure 4. Loess traverse sampling sites and major soil association areas. Numbers indicate locations of sampling sites. From Coleman and Fenton (1982).

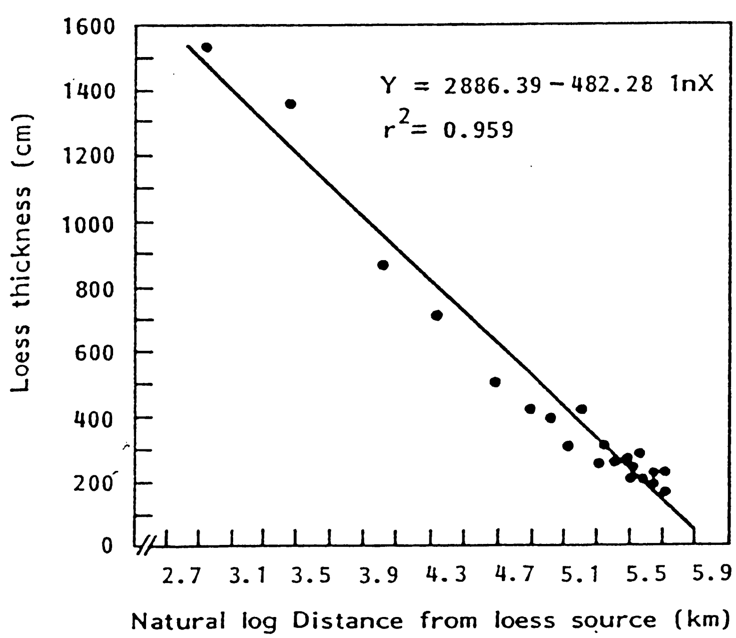


Figure 5. Relationship between loess thickness and the natural log of distance from loess source. From Coleman and Fenton (1982).

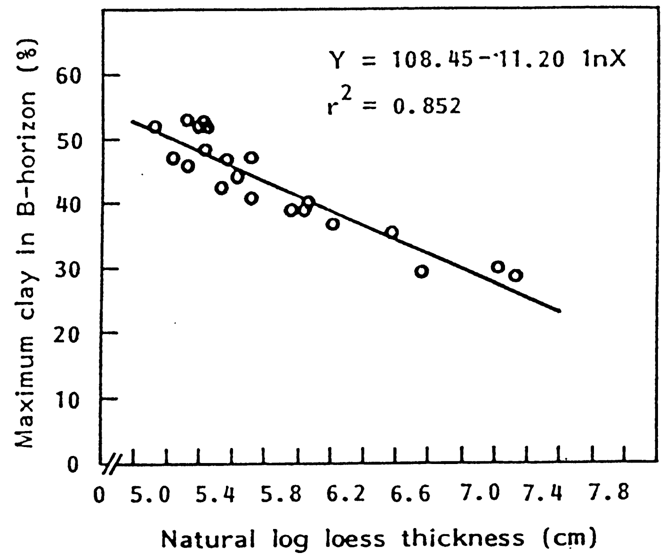


Figure 6. Relationship between maximum clay content of the B horizon and natural log of loess thickness. From Coleman and Fenton (1982).

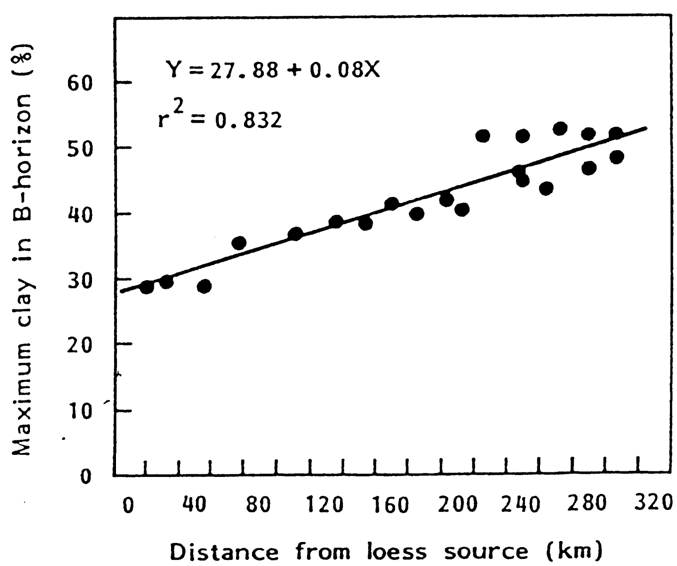


Figure 7. Relationship between maximum clay content of the B horizon and distance from the loess source. From Coleman and Fenton (1982).

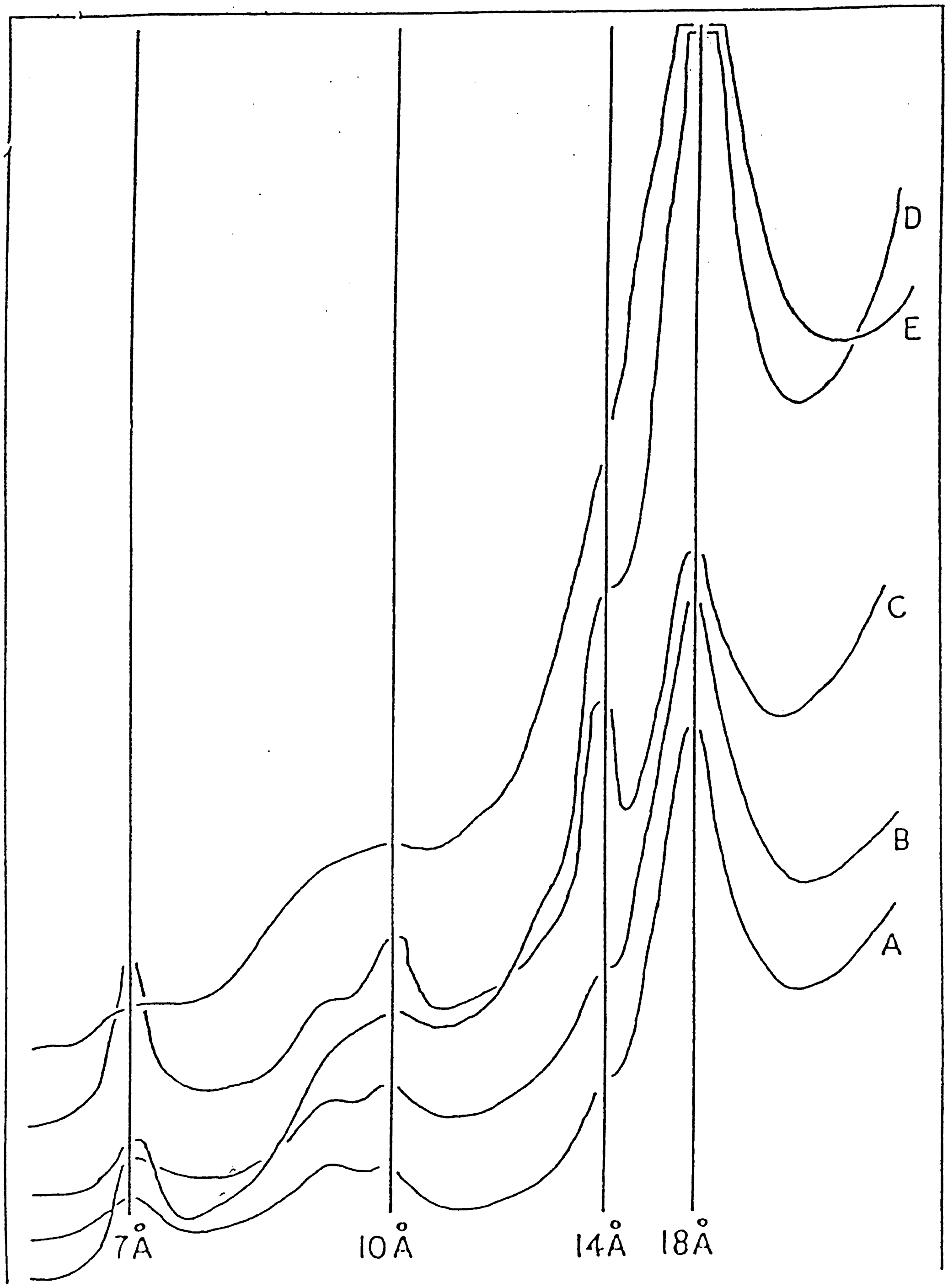


Figure 8. Smoothed X-ray diffractograms from Sharpsburg, Adair County. (Worcester, 1973). Curve A is <2 micron clay from calcarcous loess (136-140"), B is <2 micron clay from leached loess (84-89"), C is clay from clay maximum (19-24") and 1-2 micron diameter, D is from same depth but 0.5-1 micron diameter, E is from same depth and <0.5 micron diameter.

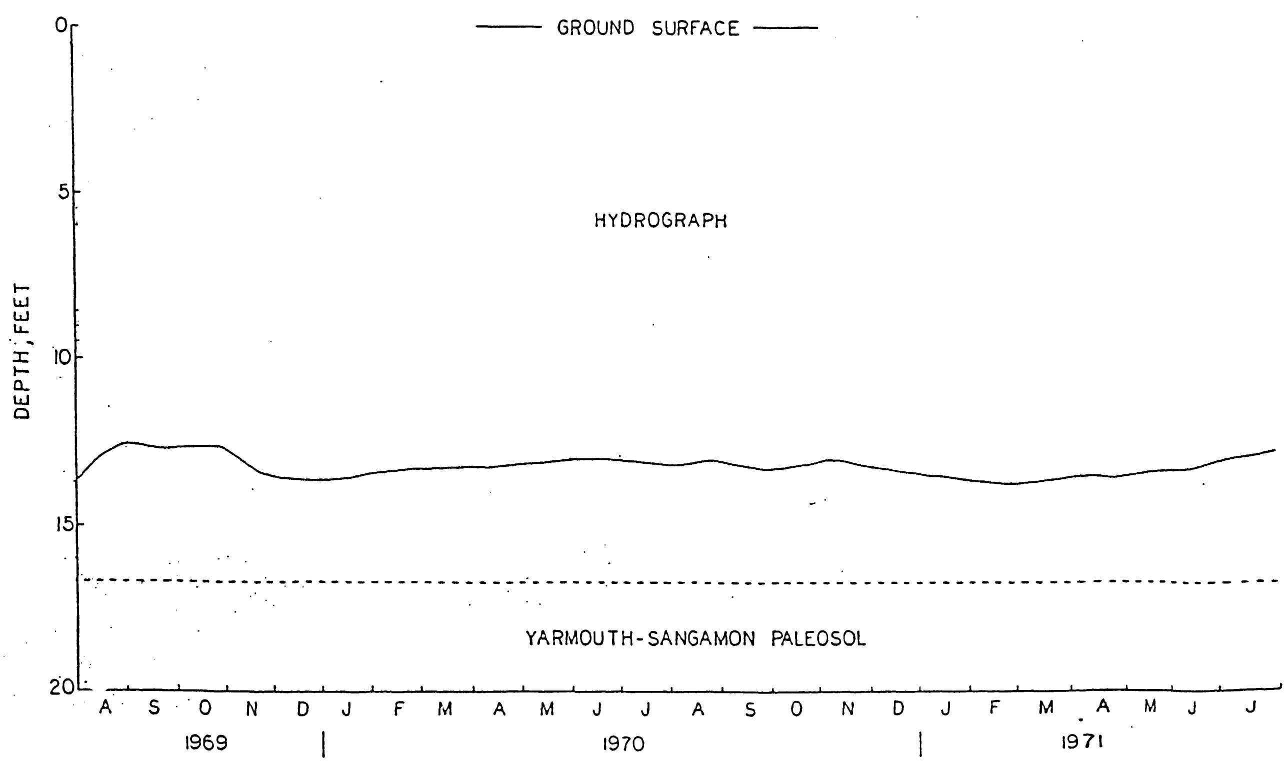


Figure 9. Hydrograph of Sharpsburg, Adair County (Worcester, 1973).

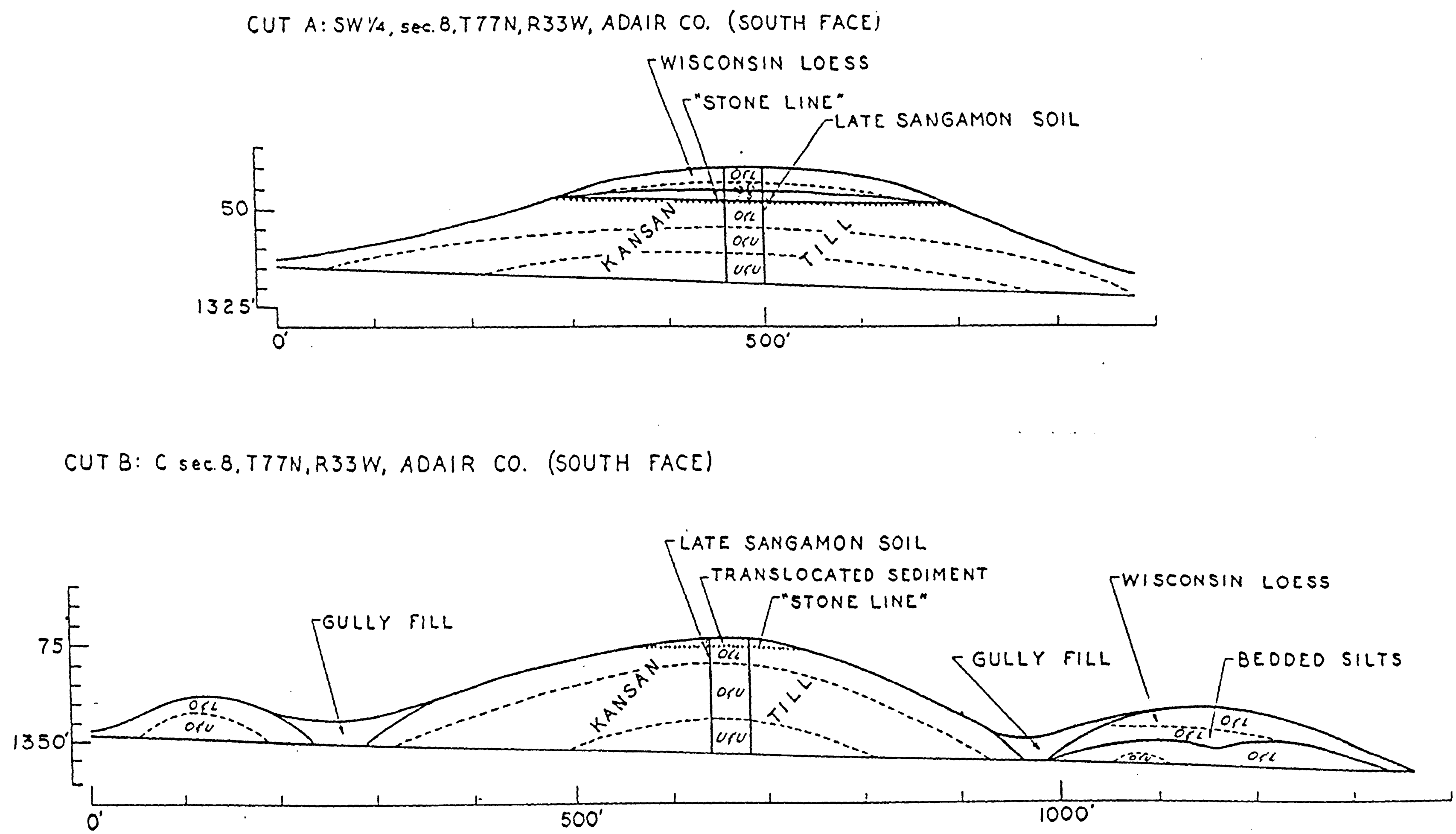


Figure 10. Cross sectional diagram of Cut A-Stop 2-Jesse James section and of Cut B (Ruhe, 1953-54).

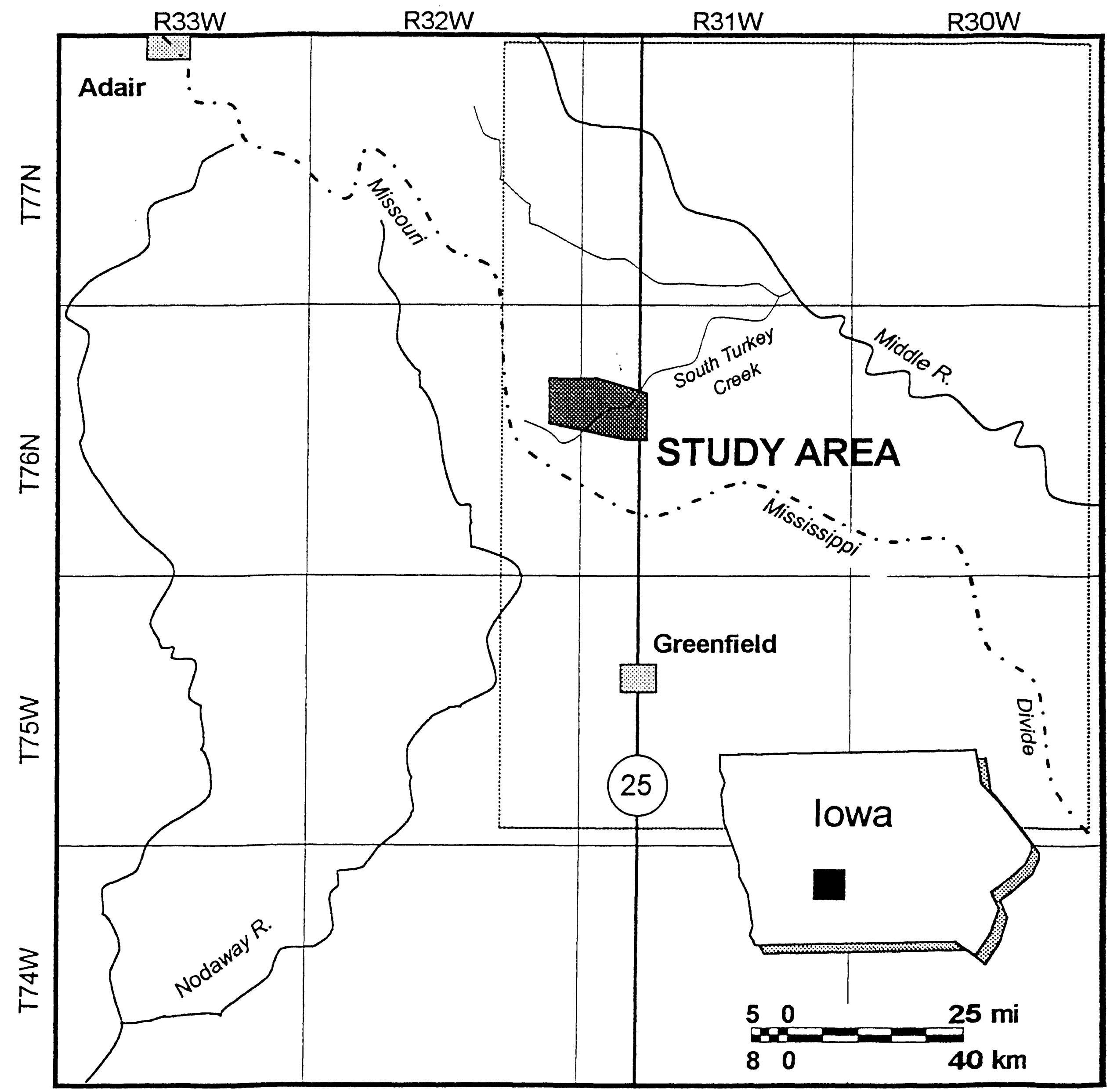


Figure 11. Location of South Turkey Creek Area, Greenfield Quadrangle, Adair County, Iowa (From Olson, 1996).

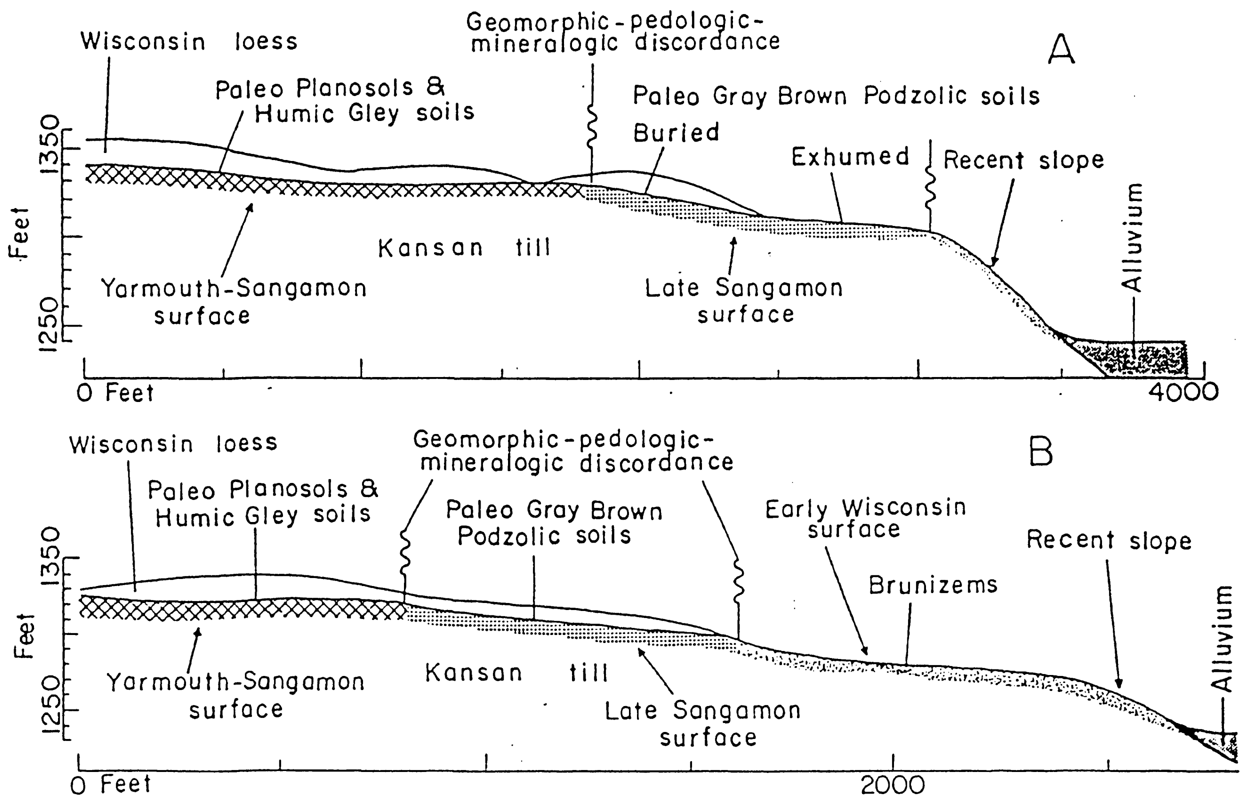


Figure 12. Cross section along interfluves A to P and A to F on Map of Figure 13 (From Ruhe, 1969).

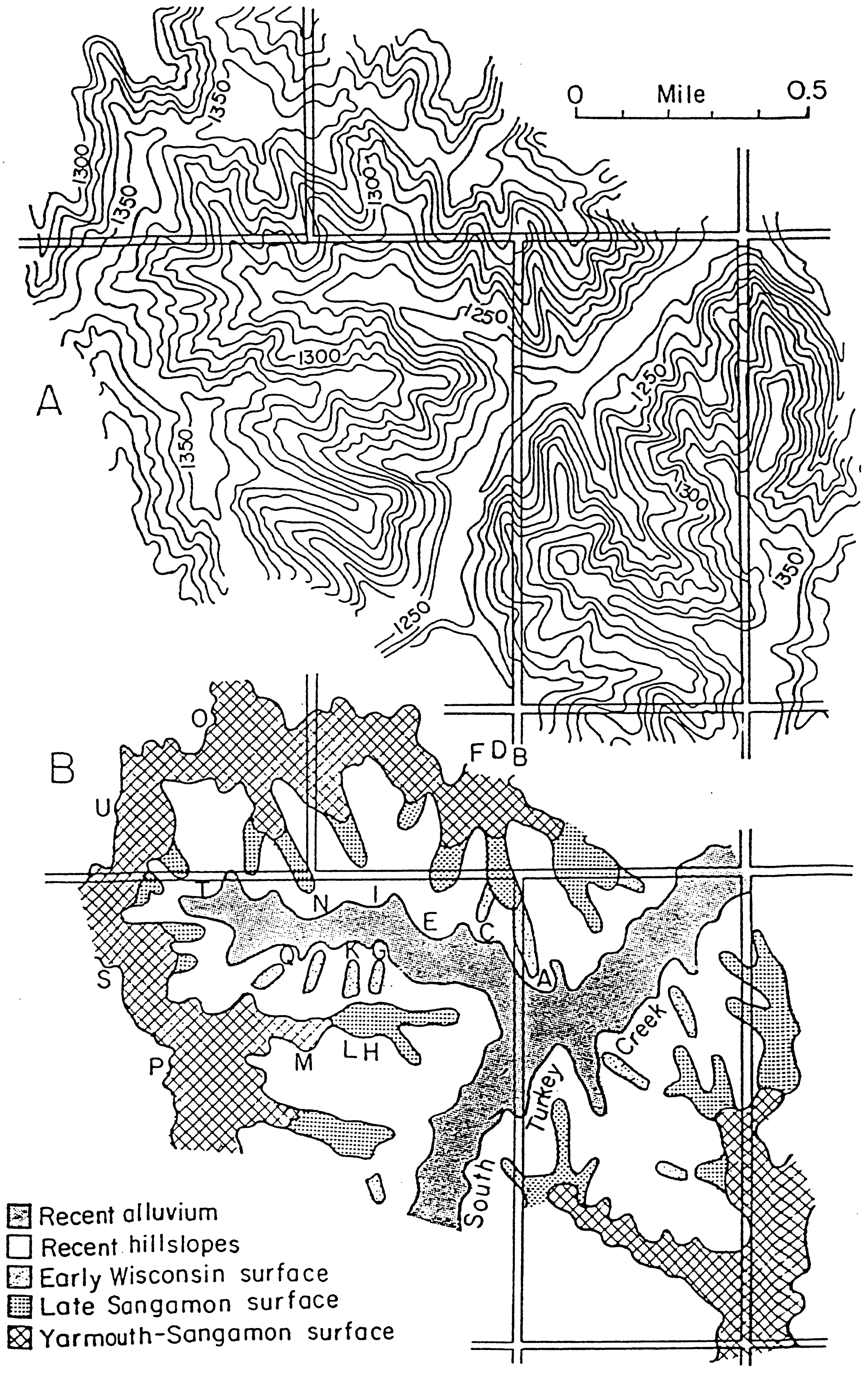


Figure 13. Topography and geomorphology of area along South Turkey Creek, Adair County Iowa (From Ruhe, 1969).

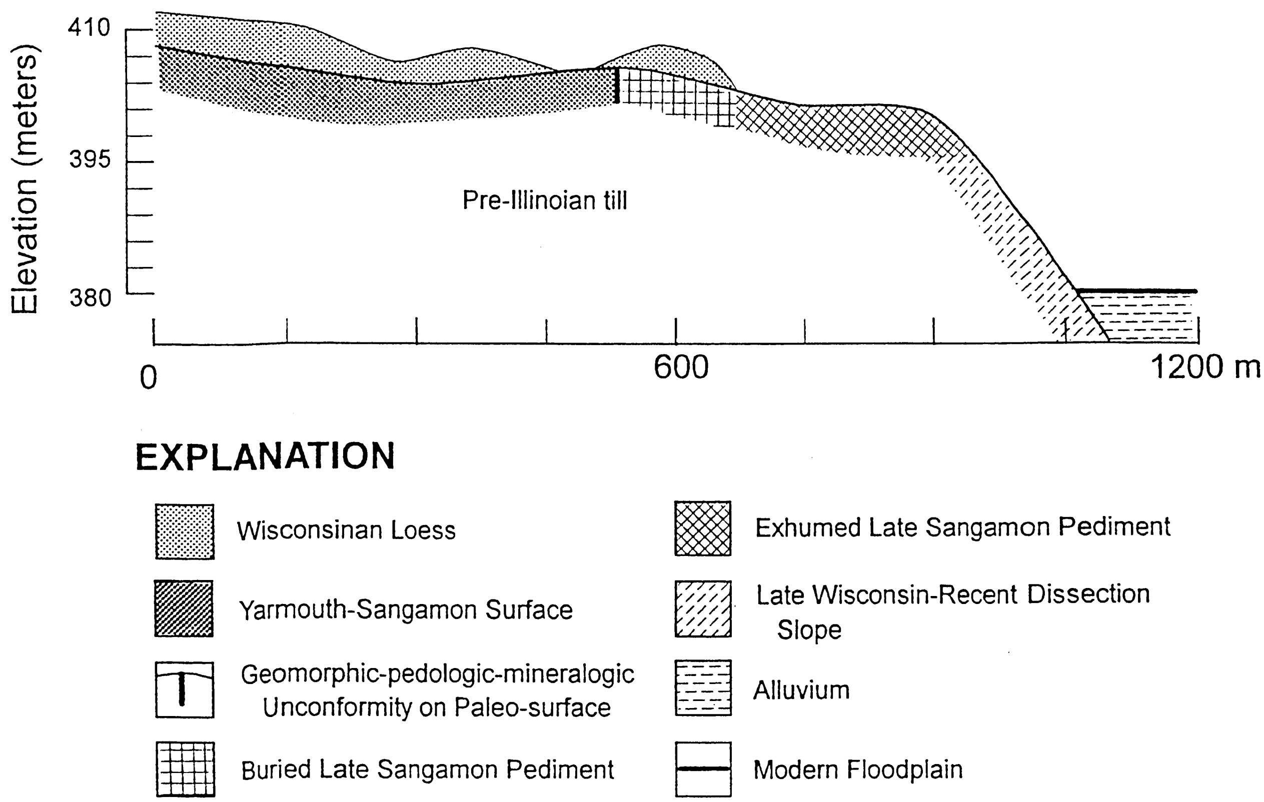


Figure 14. Relationship of deposits and geomorphic surfaces in South Turkey Creek (From Olson, 1996).

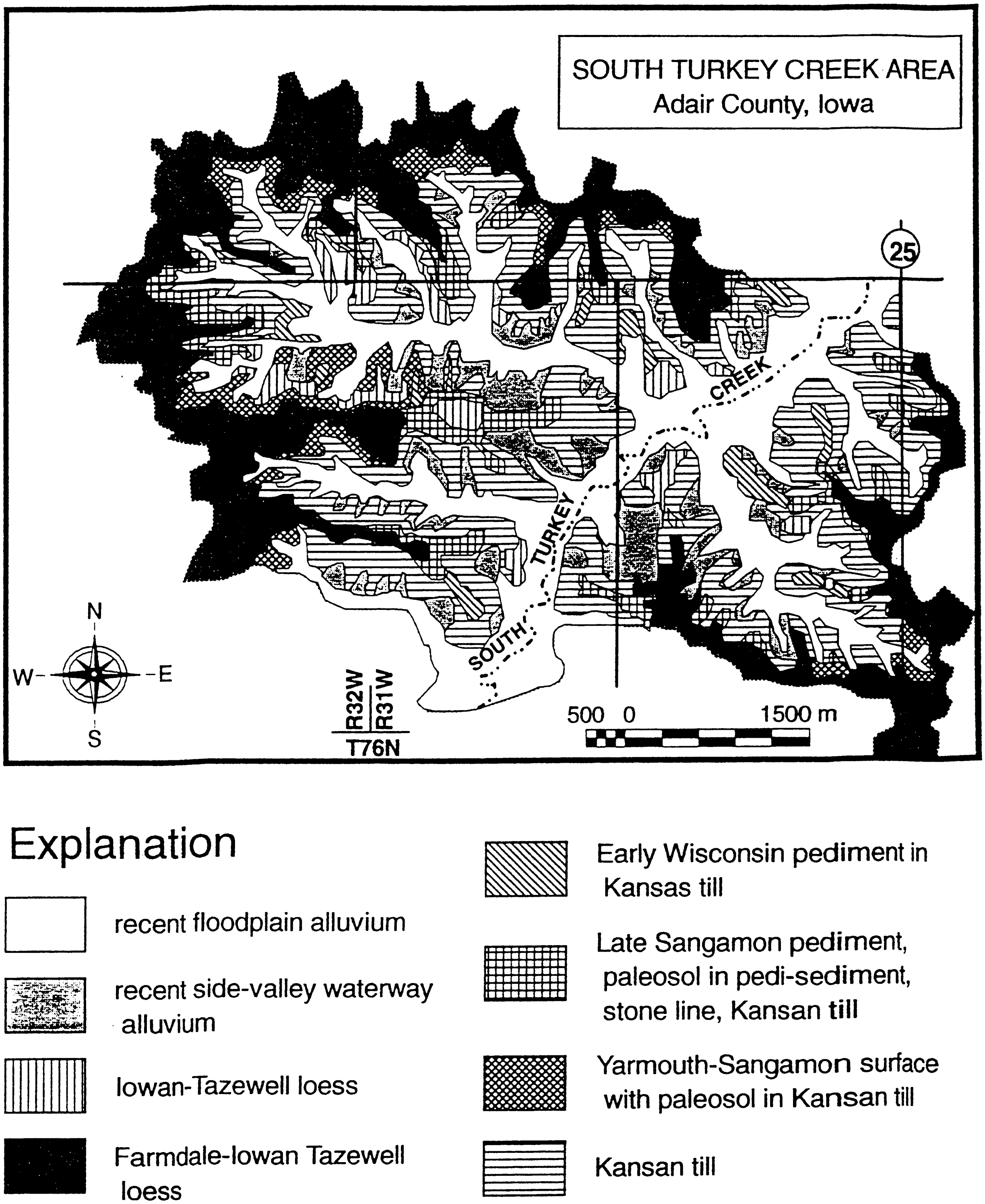


Figure 15. Distribution of deposits and erosions surfaces in South Turkey Creek (From Olson, 1996).

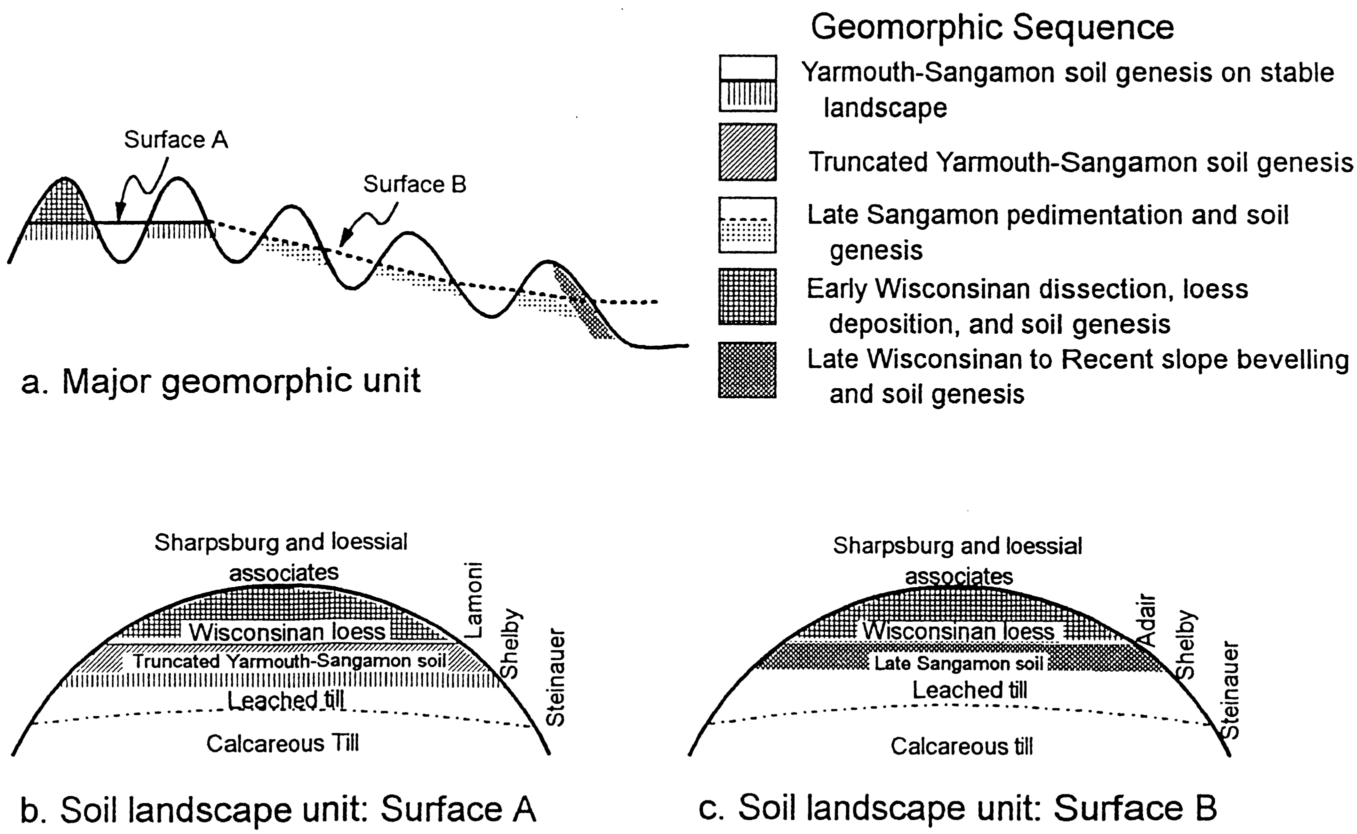


Figure 16. Geomorphic sequence in Sharpsburg soil association area (From Olson, 1996).

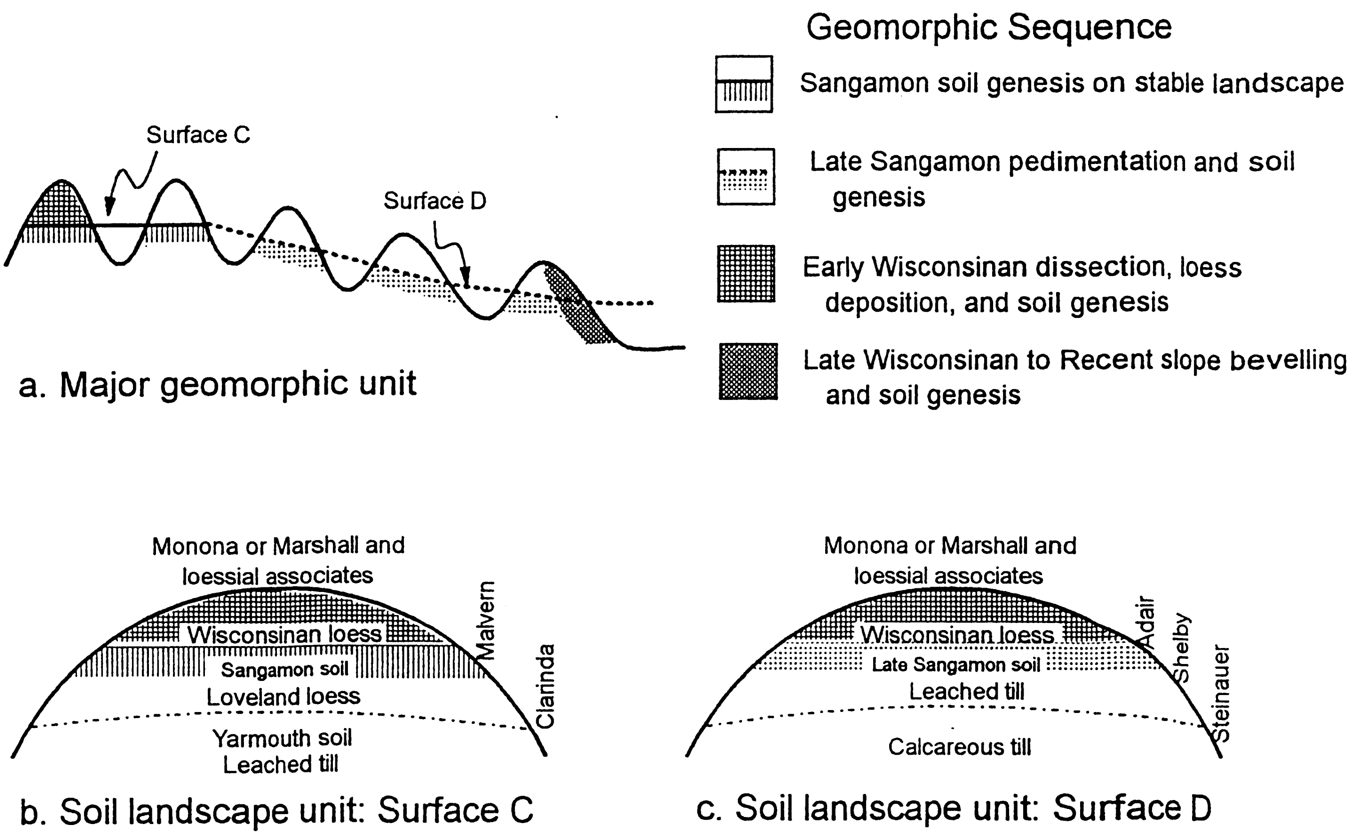
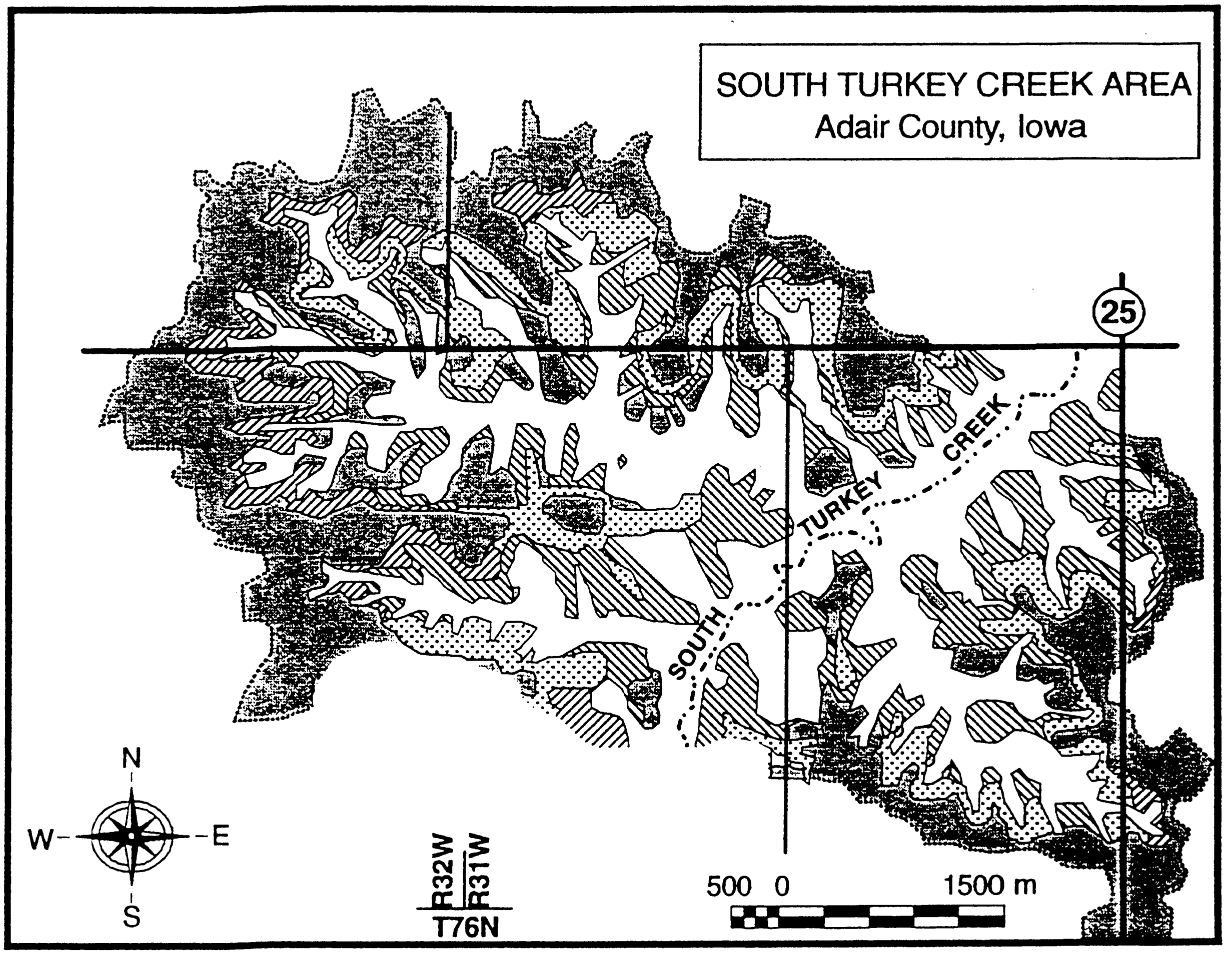


Figure 17. Geomorphic sequence in Monona and Marshall soil association areas (From Olson, 1996).



Explanation

- soils in Wisconsinan loess- *Sharpsburg*
- late Wisconsinan and Recent soils in pre-Illinoian till- *Shelby, Shelby-Steinauer Intergrades, Steinauer*
- Yarmouth-Sangamon paleosols in pre-Illinoian till- *Lamoni, Clarinda*
- Late Sangamon paleosols- *Adair, Adair-Clarinda Intergrades*
- soils in alluvium and waterway sediments

Figure 18. Distribution of soils and exhumed paleosols in South Turkey Creek (From Olson, 1996).

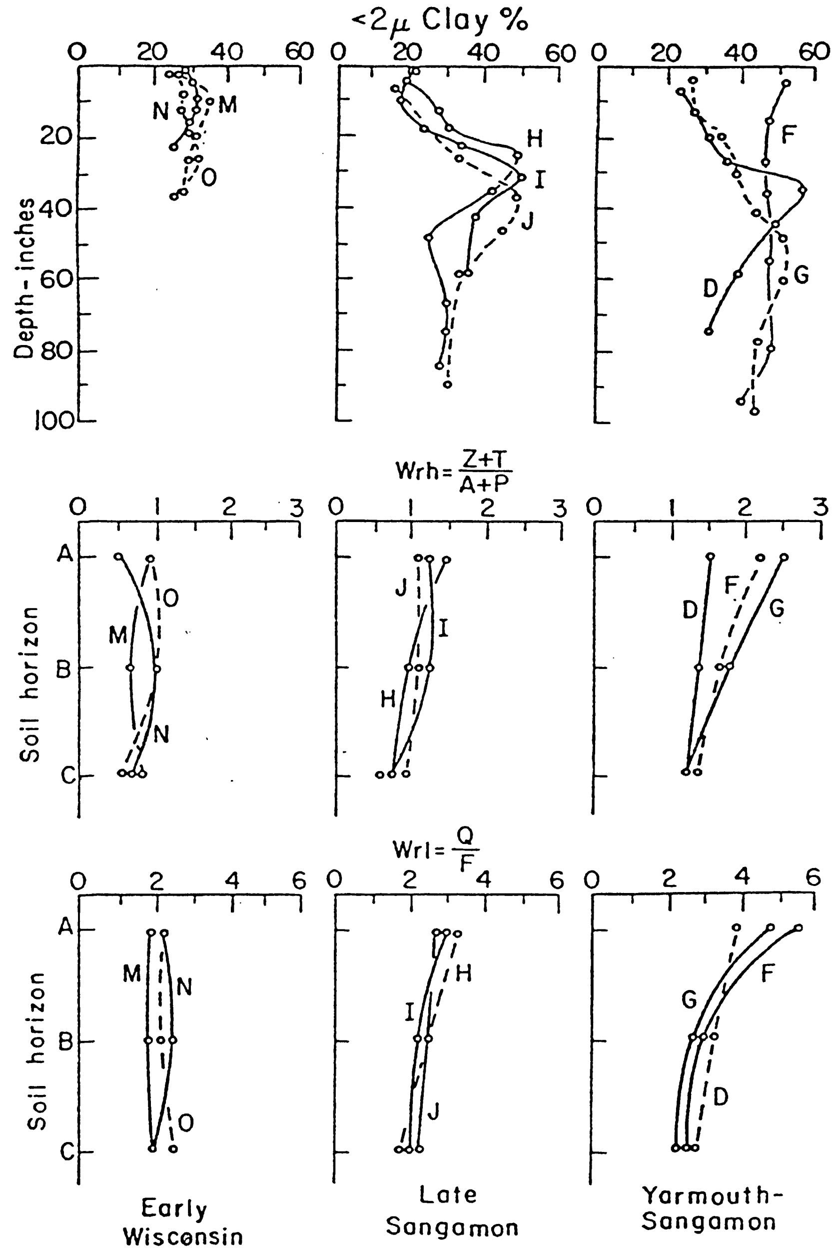


Figure 19. Clay distribution and mineral weathering ratios of Yarmouth Sangamon and Late Sangamon paleosols and soils on Wisconsin-age surface in Adair County, Iowa (From Ruhe, 1956).

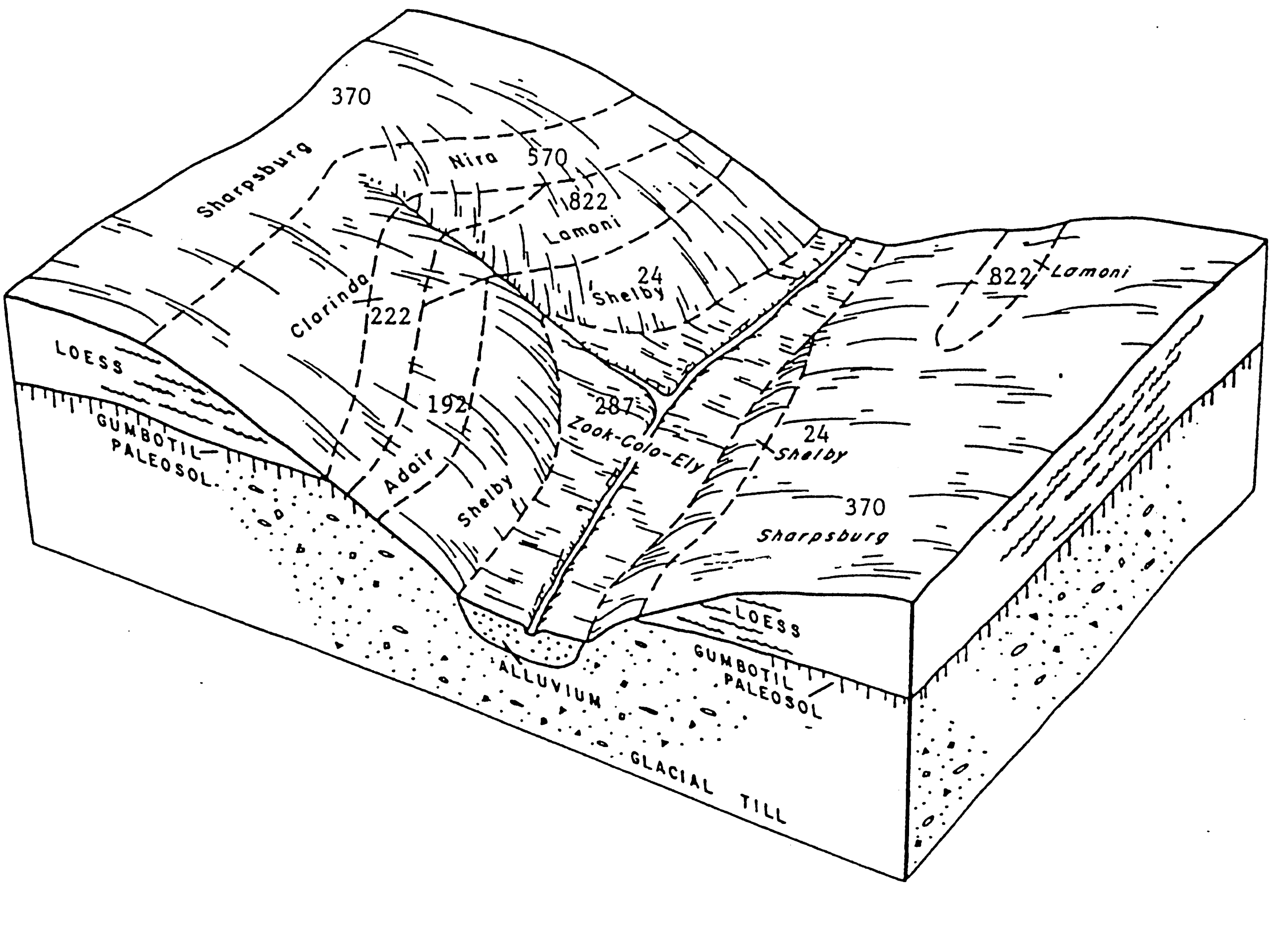


Figure 20. Relationship of landscape and parent material of soils in the Sharpsburg-Nira soil association.

ADAIR COUNTY, IOWA — SHEET NUMBER 25

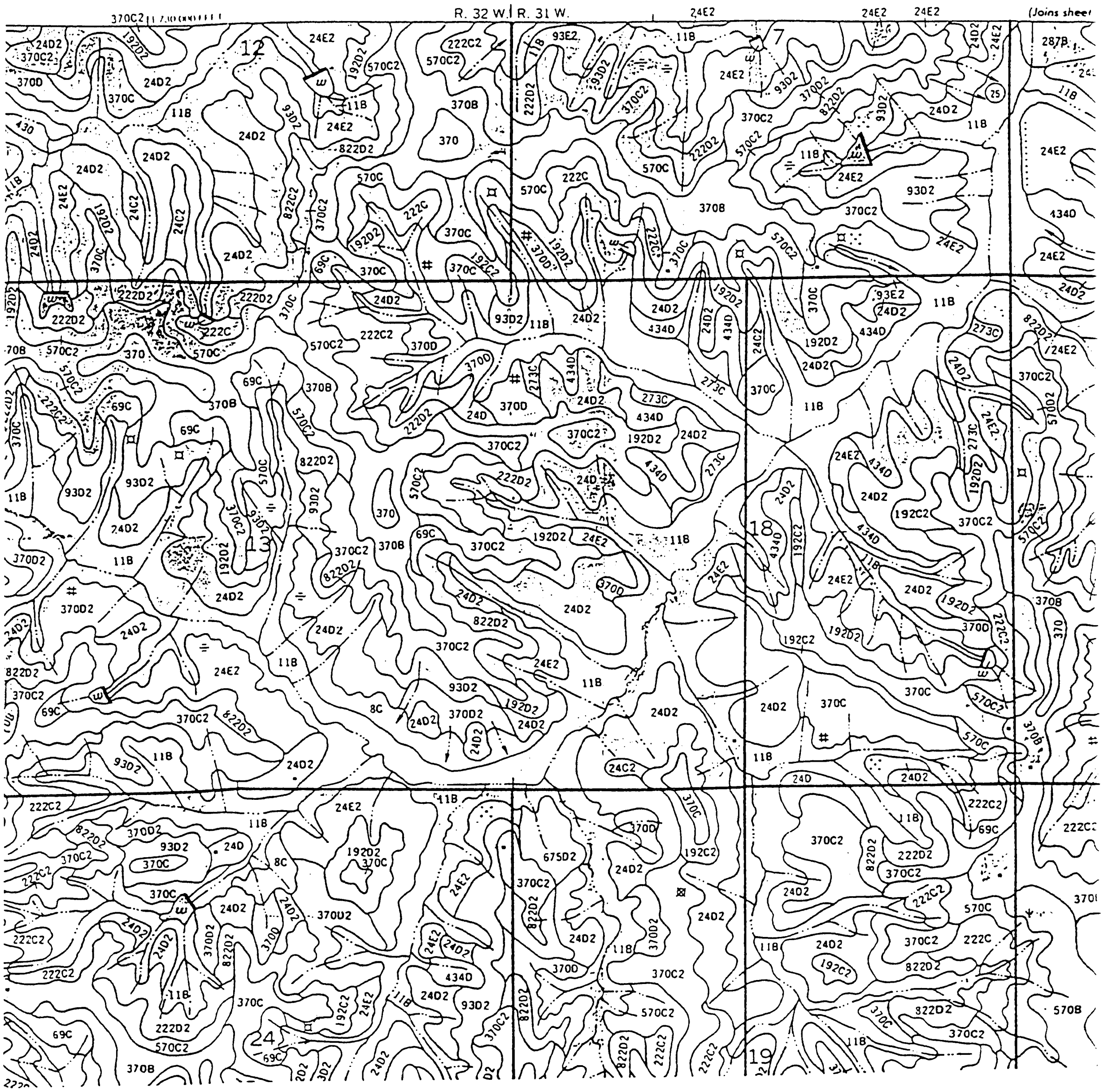
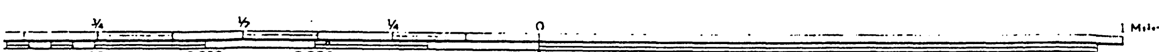


Figure 21. Soil map and legend, sheet 25, Adair County, Iowa.

SOIL LEGEND

Symbols consist of numbers or a combination of numbers and letters; for example 8B, 54, 175C2. The 1, 2, or 3 digit number designates the kind of soil or miscellaneous area. A capital letter B, C, D, E, F or G following a number indicates the class of slope. Most symbols without a slope letter are those for nearly level soils but some are for miscellaneous areas that have a considerable range of slope. A final number 2 or 3 following a letter indicates that the soil is moderately eroded or severely eroded respectively. A "+" used as a suffix to the soil symbol indicates an overwashed soil.

SYMBOL	NAME
8B	Judson silty clay loam, 2 to 5 percent slopes
8C	Judson silty clay loam, 5 to 9 percent slopes
11B	Colo–Ely silty clay loams, 2 to 5 percent slopes
13B	Vesser–Nodaway silt loams, 2 to 5 percent slopes
24C	Shelby clay loam, 5 to 9 percent slopes
24C2	Shelby clay loam, 5 to 9 percent slopes, moderately eroded
24D	Shelby clay loam, 9 to 14 percent slopes
24D2	Shelby clay loam, 9 to 14 percent slopes, moderately eroded
24E	Shelby clay loam, 14 to 18 percent slopes
24E2	Shelby clay loam, 14 to 18 percent slopes, moderately eroded
24F2	Shelby clay loam, 18 to 25 percent slopes, moderately eroded
51	Vesser silt loam, 0 to 2 percent slopes
54	Zook silty clay loam, 0 to 2 percent slopes
54+	Zook silt loam, overwash, 0 to 2 percent slopes
69C	Clearfield silty clay loam, 5 to 9 percent slopes
69C2	Clearfield silty clay loam, 5 to 9 percent slopes, moderately eroded
76B	Ladoga silt loam, 2 to 5 percent slopes
76C	Ladoga silt loam, 5 to 9 percent slopes
76C2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded
76D	Ladoga silt loam, 9 to 14 percent slopes
76D2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded
80C	Clinton silt loam, 5 to 9 percent slopes
80D2	Clinton silt loam, 9 to 14 percent slopes, moderately eroded
80E2	Clinton silt loam, 14 to 18 percent slopes, moderately eroded
93D2	Shelby–Adair clay loams, 9 to 14 percent slopes, moderately eroded
93E2	Shelby–Adair clay loams, 14 to 18 percent slopes, moderately eroded
133	Colo silty clay loam, 0 to 2 percent slopes
133+	Colo silt loam, overwash, 0 to 2 percent slopes
175C2	Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded
175D2	Dickinson fine sandy loam, 9 to 14 percent slopes, moderately eroded
179D	Gara loam, 9 to 14 percent slopes
179D2	Gara loam, 9 to 14 percent slopes, moderately eroded
179E2	Gara loam, 14 to 18 percent slopes, moderately eroded
179F2	Gara loam, 18 to 25 percent slopes, moderately eroded
192C2	Adair clay loam, 5 to 9 percent slopes, moderately eroded
192D2	Adair clay loam, 9 to 14 percent slopes, moderately eroded
212	Kennebec silt loam, 0 to 2 percent slopes
220	Nodaway silt loam, 0 to 2 percent slopes
222C	Clarinda silty clay loam, 5 to 9 percent slopes
222C2	Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded
222D2	Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded
269	Humeston silt loam, 0 to 2 percent slopes
273B	Olmitz loam, 2 to 5 percent slopes
273C	Olmitz loam, 5 to 9 percent slopes
287B	Zook–Colo–Ely silty clay loams, 2 to 5 percent slopes
315	Nodaway soils, frequently flooded, 0 to 2 percent slopes
368	Macksburg silty clay loam, 0 to 2 percent slopes
368B	Macksburg silty clay loam, 2 to 5 percent slopes
369	Winterset silty clay loam, 0 to 2 percent slopes
370	Sharpsburg silty clay loam, 0 to 2 percent slopes
370B	Sharpsburg silty clay loam, 2 to 5 percent slopes
370C	Sharpsburg silty clay loam, 5 to 9 percent slopes
370C2	Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately erodec
370D	Sharpsburg silty clay loam, 9 to 14 percent slopes
370D2	Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded
412G	Sogn soils, 25 to 40 percent slopes
428B	Ely silty clay loam, 2 to 5 percent slopes
430	Ackmore silty clay loam, 0 to 2 percent slopes
434D	Arbor loam, 9 to 14 percent slopes
451D2	Caleb loam, 9 to 14 percent slopes, moderately eroded
570B	Nira silty clay loam, 2 to 5 percent slopes
570C	Nira silty clay loam, 5 to 9 percent slopes
570C2	Nira silty clay loam, 5 to 9 percent slopes, moderately eroded
570D2	Nira silty clay loam, 9 to 14 percent slopes, moderately eroded
675C	Dickinson–Sharpsburg complex, 5 to 9 percent slopes
675D2	Dickinson–Sharpsburg complex, 9 to 14 percent slopes, moderately eroded
792D2	Armstrong loam, 9 to 14 percent slopes, moderately eroded
822C	Lamoni silty clay loam, 5 to 9 percent slopes
822C2	Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded
822D	Lamoni silty clay loam, 9 to 14 percent slopes
822D2	Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded
822D3	Lamoni clay, 9 to 14 percent slopes, severely eroded
870B	Sharpsburg silty clay loam, benches, 2 to 5 percent slopes
876B	Ladoga silt loam, benches, 2 to 5 percent slopes
876C	Ladoga silt loam, benches, 5 to 9 percent slopes
993D2	Gara–Armstrong loams, 9 to 14 percent slopes, moderately eroded
993E2	Gara–Armstrong loams, 14 to 18 percent slopes, moderately eroded
993F2	Gara–Armstrong loams, 18 to 25 percent slopes, moderately eroded
5030	Pits–Dumps complex



Scale 1:15 840

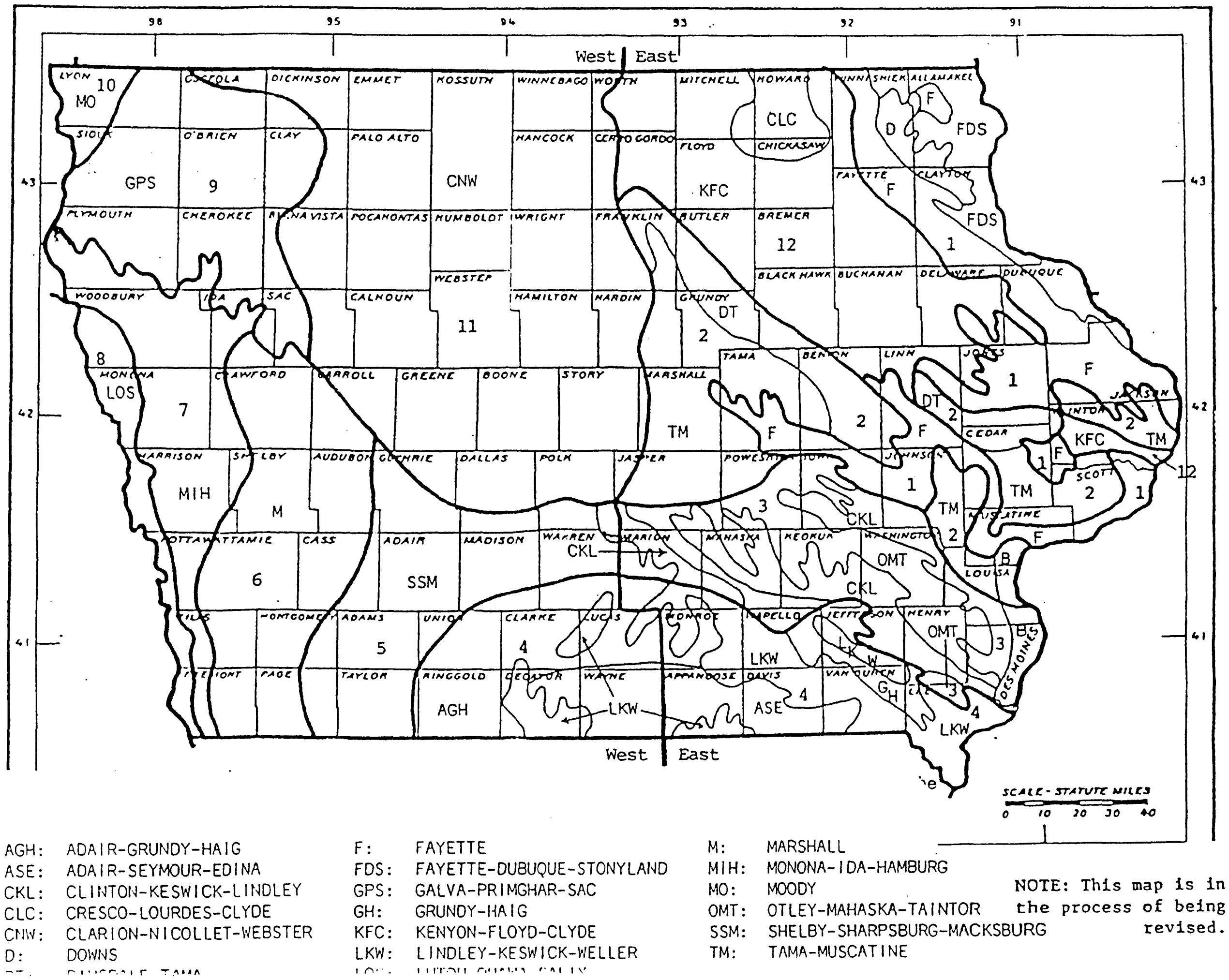


Figure 22. Map of Iowa delineating the 21 principal soil association areas (From Fenton et al., 1971).

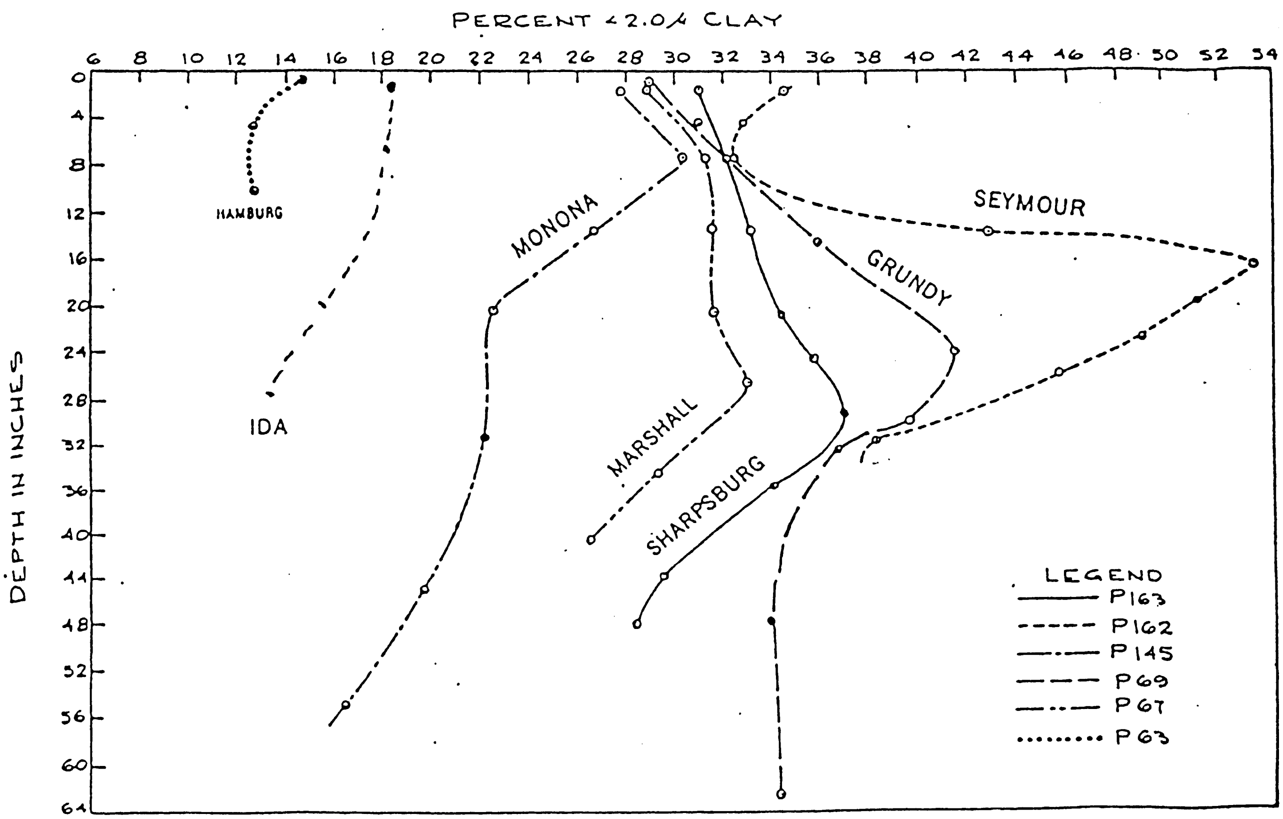


Figure 23. Less than 2 micron clay in soils along traverse no. 1 (From Hutton, 1947).

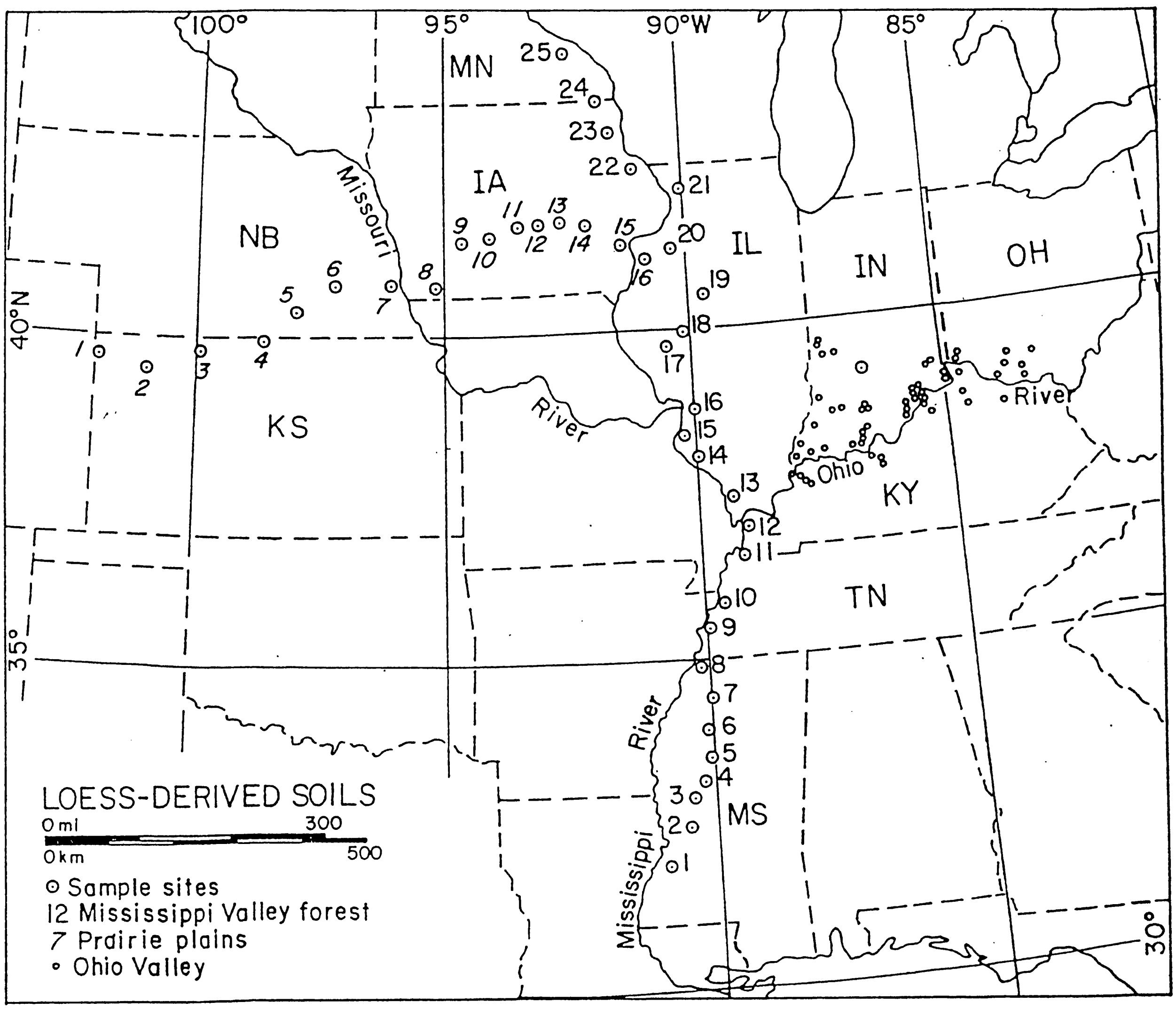


Figure 24. Location of loess-derived soils sampled by Ruhe (1984).

TABLES

Table 1. Correlation matrix of selected variables related to Missouri River loess source. From Coleman and Fenton (1982).

Variables[a]	LT-cm	Dist-km	Max-Clay	AVC-AP	B/A	DRA	DTDL-cm
LT-cm	1.000						
Dist-km	-0.870**	1.000					
Max-Clay	-0.841**	0.912**	1.000				
AVC-AP	0.181	-0.485*	-0.478*	1.000			
B/A	-0.635**	0.810**	0.850**	-0.787**	1.000		
DRA	-0.815**	0.865**	0.898**	0.372++	0.754**	1.000	
DTDL-cm	0.932**	-0.677**	-0.668**	0.029	-0.459**	-0.637**	1.000

[a]LT-cm = loess thickness in cm; Dist-km = distance from loess source in km; Max-Clay = maximum clay in the B horizon in percent; AVC-AP = average clay content of the plow layer; B/A = ratio between the maximum clay in B horizon versus the minimum clay content in the A horizon; DRA = drainage class; DTDL-cm = depth to deoxidized loess in cm.

**, *, and ++ denote significance at the 1, 5, and 10 percent levels, respectively.

Table 2. Profile description for Stop1-Sharpsburg, Adair County (After Worcester, 1973).

SOIL SERIES: Sharpsburg

LOCATION: NW1/4 NE1/4 sec. 10, T.77N., R.33W., Adair County, Iowa.

PARENT MATERIAL: 197 inches of Wisconsin loess over a Yarmouth-Sangamon paleosol.

HORIZON	DEPTH	DESCRIPTION	CLAY (%)
Ap	0-6"	Very dark brown (10YR 2/2) silt loam; moderate fine granular structure; friable; abrupt boundary.	32.8
A12	6-10"	Very dark grayish brown (10YR 3/2) silt loam; moderate fine subangular blocky structure; friable; clear boundary.	34.5
A3	10-14"	Dark brown (10YR 3/3) silt loam; weak medium subangular blocky structure; friable; clear boundary.	36.8
B1	14-24"	Dark grayish brown (10YR 4/2) silt loam; weak medium subangular blocky structure; friable; clear boundary.	35.9
B21	24-32"	Brown to dark brown (10YR 4/3) silty clay loam; moderate medium subangular blocky structure; friable; clear boundary.	32.1
B22	32-42"	Dark yellowish brown (10YR 4/4) silty clay loam; few fine distinct yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2) mottles; strong medium subangular blocky structure; friable; clear boundary.	27.5
B23	42-48"	Dark yellowish brown (10YR 4/4) silt loam; common fine distinct yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2) mottles; medium fine subangular blocky structure; friable; clear boundary.	27.3

Table 2. Continued.

				CLAY (%)
B3		48-54"	Light olive brown (2.5Y 5/4) silt loam; many medium prominent yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2) mottles; weak fine subangular blocky structure; friable; clear boundary.	27.2
C1		54-136"	Grayish brown (2.5Y 5/2) silt loam; many medium prominent yellowish brown (10YR 5/6) mottles; massive structure; friable; abrupt boundary.	26.9
	MDL			21.7
C2		136-160"	Grayish brown (2.5Y 5/2) silt loam; many medium prominent yellowish brown (10YR 5/6) mottles; massive structure; friable; abrupt boundary; calcareous.	22.2
	MDU			21.4
C3		160-192"	Grayish brown (2.5Y 5/2) silt loam; few fine prominent brown (7.5YR 5/4) mottles; massive structure; friable; abrupt boundary.	21.2
	DL			26.7
Ab		192-197"	Dark grayish brown (2.5Y 4/2) silt loam; massive structure; sticky; abrupt boundary; many organic carbon flecks indicate the basal soil of the Wisconsin loess.	29.8
IIB1		197-214"	Dark yellowish brown (10YR 4/4) silty clay loam; weak fine granular structure; firm; abrupt boundary; Yarmouth-Sangamon paleosol.	
IIB21		214-240"	Olive brown (2.5Y 4/4) clay loam; few fine distinct dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) mottles; strong medium subangular blocky structure; firm.	

Table 3. Particle size distribution for Stop 1-Sharpsburg, Adair County (Worcester, 1973).

DEPTH (IN.)	PARTICLE SIZE (MICRONS) > 62 %	31-62 %	16-31 %	8-16 %	4-8 %	2-4 %	1-2 %	0.5-1 %	< 0.5 %
0- 6	0.91	9.85	24.58	20.72	6.68	4.44	3.20	14.90	14.72
6- 10	0.83	14.85	23.98	14.36	6.98	4.48	3.90	12.20	18.42
10- 14	0.94	12.02	23.72	14.90	7.34	4.24	4.06	12.84	19.94
14- 19	1.10	12.32	22.54	15.58	8.14	4.76	3.86	15.86	15.84
19- 24	1.11	12.27	23.06	15.06	7.92	4.88	4.32	14.66	16.78
24- 28	1.02	13.78	24.66	15.14	7.42	5.00	4.44	14.72	13.82
28- 32	1.07	15.03	25.58	14.72	7.42	4.94	4.56	13.96	12.72
32- 37	1.11	15.21	27.46	16.08	7.14	5.06	4.42	13.48	10.04
37- 42	1.08	18.18	27.12	14.90	6.88	4.78	4.30	12.70	10.06
42- 48	0.95	16.03	26.98	16.84	7.86	4.30	4.16	11.98	10.90
48- 54	0.97	13.75	27.06	18.12	7.70	5.12	4.54	12.12	10.62
54- 59	0.74	13.82	26.52	18.18	8.60	5.28	4.64	12.00	10.22
59- 64	0.84	14.00	26.90	17.80	8.08	5.36	4.72	12.34	9.96
64- 69	0.94	15.14	27.34	17.40	8.24	5.34	4.46	12.20	8.94
69- 74	0.65	13.01	28.00	17.46	8.04	5.46	4.52	12.76	10.10
74- 79	0.77	14.23	27.38	17.72	8.36	5.46	4.54	12.38	9.16
79- 84	0.82	12.64	28.26	19.70	8.90	5.34	4.60	11.38	8.36
84- 89	1.10	14.70	28.68	18.50	8.14	5.38	4.62	11.00	7.80
89- 94	0.92	14.48	30.64	18.68	8.24	4.90	3.92	10.78	7.44
94- 99	0.70	0.0	29.34	0.0	0.0	4.64	6.12	9.34	9.62
99-104	0.80	13.26	31.84	18.80	8.62	5.64	5.00	10.54	5.50
104-109	1.00	16.27	32.57	17.86	7.36	5.00	4.78	9.66	5.50
109-114	0.85	14.77	31.02	19.02	7.72	5.24	5.04	10.30	6.04
114-119	0.64	14.00	29.72	18.74	8.64	5.64	5.44	8.90	8.28
119-124	0.96	11.50	30.74	19.76	7.68	4.92	4.80	10.04	9.60
124-129	1.22	13.94	31.88	19.14	8.28	5.04	4.74	10.24	5.52
129-136	0.85	17.27	31.26	17.22	7.18	4.54	4.30	10.42	6.96
136-140	0.98	14.47	33.37	17.88	6.48	4.58	4.24	11.00	7.00

Table 3. Continued.

DEPTH (IN.)	PARTICLE SIZE (MICRONS) > 62 %	31-62 %	16-31 %	8-16 %	4-8 %	2-4 %	1-2 %	0.5-1 %	< 0.5 %
140-145	0.87	15.62	33.55	15.86	6.68	4.88	4.46	11.28	6.80
145-150	0.62	16.26	31.54	17.20	6.88	4.56	4.52	11.38	7.04
150-155	1.05	15.82	32.81	17.34	6.88	4.52	4.30	10.58	6.70
155-160	0.96	17.85	32.39	16.56	6.80	4.08	4.16	11.14	6.06
160-165	0.79	16.92	33.03	17.26	6.66	4.12	4.42	10.60	6.20
165-170	0.47	16.04	32.79	17.44	6.70	4.64	4.56	9.30	8.06
170-175	0.43	14.44	33.27	18.22	7.34	4.66	5.14	10.36	6.14
175-180	0.44	13.92	32.57	17.62	7.42	4.80	4.38	11.33	7.52
180-185	0.39	10.95	29.26	19.68	8.26	4.62	4.36	11.66	10.82
185-192	1.11	11.51	25.80	19.42	7.94	4.86	3.68	11.30	11.68
192-195	1.15	10.37	23.94	19.10	9.88	5.78	3.90	10.40	15.48
195-197	2.69	12.91	23.64	17.10	8.70	5.18	4.04	10.72	15.02

Table 4. Selected chemical properties for Stop 1-Sharpsburg, Adair County (Worcester, 1973).

DEPTH (IN.)	DIST. (MI.)	CARB. %	ORG. C %	PH	FE %	MN %	PRIM. %	MICA %	CONC. %
0- 6	68.4	0.0	2.34	6.33	0.84	0.41	62.79	2.32	34.88
6- 10	68.4	0.0	1.37	6.11	0.83	0.40	48.33	2.58	49.07
10- 14	68.4	0.0	1.58	5.92	0.88	0.44	37.33	6.33	56.33
14- 19	68.4	0.0	0.62	5.90	0.91	0.44	37.81	3.98	58.20
19- 24	68.4	0.0	0.24	6.03	0.89	0.43	35.67	2.52	61.79
24- 28	68.4	0.0	0.18	5.90	0.86	0.42	36.06	7.37	56.55
28- 32	68.4	0.0	0.06	6.12	0.92	0.45	45.16	18.95	76.20
32- 37	68.4	0.0	0.0	6.25	0.91	0.50	28.47	25.24	46.27
37- 42	68.4	0.0	0.04	6.28	0.93	0.57	30.82	24.35	44.81
42- 48	68.4	0.0	0.02	6.21	0.97	0.53	24.67	21.59	53.72
48- 54	68.4	0.0	0.09	6.40	0.96	0.57	35.25	18.70	46.04
54- 59	68.4	0.0	0.08	6.36	0.98	0.45	24.09	16.32	59.58
59- 64	68.4	0.0	0.0	6.41	0.90	0.49	24.72	17.09	58.18
64- 69	68.4	0.0		6.58	0.91	0.49			
69- 74	68.4	0.0	0.0	6.54	0.94	0.36	20.19	17.90	61.91
74- 79	68.4	0.0		6.60	0.88	0.42			
79- 84	68.4	0.0	0.0	6.65	0.89	0.51	16.57	16.00	67.42
84- 89	68.4	0.0		6.82	0.90	0.71			
89- 94	68.4	0.0		6.86	0.99	0.58			
94- 99	68.4	0.0	0.0	6.80	0.97	0.46	17.01	16.67	66.32
99-104	68.4	0.45		7.21	0.88	0.40			
104-109	68.4	3.64		7.40	0.85	0.35			
109-114	68.4	2.73	0.39	7.57	0.87	0.34	19.23	12.30	68.47
114-119	68.4	3.18		7.31	0.85	0.24			
119-124	68.4	5.91		7.54	0.84	0.42			
124-129	68.4	4.55	0.0	7.59	0.89	0.61	20.78	9.33	69.87
129-136	68.4	4.09		7.58	0.74	0.45			
136-140	68.4	5.46		7.65	0.85	0.63			

Table 4. Continued.

DEPTH (IN.)	DIST. (MI.)	CARB. %	ORG. C %	PH	FE %	MN %	PRIM. %	MICA %	CONC. %
140-145	68.4	5.46	0.0	7.60	0.84	0.42	41.74	6.60	51.65
145-150	68.4	6.82		7.73	0.38	0.21			
150-155	68.4	5.91		7.70	0.53	0.43			
155-160	68.4	4.55	0.51	7.78	0.57	0.36	72.53	4.40	23.05
160-165	68.4	4.09		7.68	0.46	0.46			
165-170	68.4	0.91		7.61	0.42	0.19			
170-175	68.4	1.36	0.15	7.61	0.58	0.37	70.36	1.92	27.69
175-180	68.4	0.0		7.60	0.80	0.71			
180-185	68.4	0.0		7.45	0.84	0.39			
185-192	68.4	0.0	0.0	7.40	1.66	0.28	38.22	1.15	60.61
192-195	68.4	0.0	0.11	7.48	0.34	0.03	93.15	0.0	6.34
195-197	68.4	0.0	0.10	7.40	0.44	0.02	90.94	0.0	9.05

Table 5. Descriptions of Stop 2-Jesse James Section and of Adair Hill Section (INQUA, 1965).

Stop 14-3: Adair Hill section. Box lunch in town park at top of railroad cut.

The Kansan gumbotil in this section was reported previously by the originator of the term, George F. Kay (Kay and Apfel, 1929, p. 129). This section (cut D) will be compared with the next stop (cut A).

Wisconsin loess:

ft m

0-10.6 0-3.23 Yellowish-brown silt loam mottled gray, massive, friable, leached; oxidized and leached zone.

10.6-12.6 3.23-3.84 Light gray to grayish-brown silt loam, massive, friable, leached, with brownish-yellow to strong brown iron-oxide band at top, iron-oxide pipestems and nodules; deoxidized and leached zone.

12.6-13.2 3.84-4.02 Dark grayish-brown light silty clay loam, weak platy, friable, with hard yellowish-red and dark reddish-brown iron-oxide nodules, gritty, leached; Farmdale, A1b horizon.

Yarmouth-Sangamon paleosol:

13.2-14.7 4.02-4.48 Dark yellowish-brown silty clay loam mottled gray, fine granular, firm, with hard yellowish-red and dark reddish-brown iron-oxide nodules, leached; A3b horizon.

14.7-15.6 4.48-4.75 Grayish-brown silty clay loam, medium subangular blocky, firm, plastic, with iron-oxide nodules and with yellowish-red and dark reddish-brown coatings and clay skins on peds; leached; B1b horizon.

15.6-20.1 4.75-6.13 Gray silty clay, strong medium subangular blocky, firm, plastic, with iron-oxide nodules and coatings and clay skins; leached; B2b horizon.

20.1-22.6 6.13-6.89 Gray silty clay loam, moderate medium subangular blocky, firm, plastic, with iron-oxide nodules and coatings and clay skins, leached; B3b horizon.

22.6-25.4 6.89-7.74 Light gray silty clay loam, coarse angular blocky, firm, leached; C1b horizon; deoxidized zone.

25.4-26.9 7.74-8.20 Yellowish-brown loam, coarse angular blocky, friable, cobbly; C2b horizon; oxidized and leached Kansan till.

26.9-49.6+ 8.20-15.12+ Yellowish-brown loam, same but calcareous; oxidized and unleached Kansan till.

This paleosol is on the Mississippi-Missouri divide in Iowa and in the cut occupies a swale on the Kansan till surface. Sand content to the base of the C1b horizon is less than 10 percent, whereas the subjacent horizon has an abrupt increase in sand to 33 percent. Hence, the paleosol formed in sediment that filled a depression on the Kansan till plain. The paleosol is an analogue of a Humic Gley soil but much thicker and more weathered than any comparable soil on the land surface. Note that Loveland loess can not be identified between the Farmdale and the top of the paleosol. Hence, the paleosol must represent the interval from Kansan to Wisconsin or Yarmouth, Illinoian, and Sangamon. Thus the paleosol is designated Yarmouth-Sangamon.

En route Stop 14-3 to 14-4

Proceed 2 miles (3.2 km) southwest on State 90 to cut A.

Stop 14-4: Jesse James monument section.

In this railroad cut the Late Sangamon pediment and paleosol are exposed.

Wisconsin loess:

ft m

0-3.5 0-1.07 Dark yellowish-brown gritty silt loam, massive, friable, leached; oxidized and leached zone.

3.5-5.0 1.07-1.52 Gray gritty silt loam, massive, friable, leached, with iron-oxide nodules; deoxidized and leached zone.

5.5-6.3 1.52-1.92 Grayish-brown silt loam, weak platy and weak fine granular, yellowish-red and reddish-brown iron-oxide nodules and coatings, friable, leached; Farmdale, A1b horizon.

Late Sangamon paleosol:

6.3-6.8 1.92-2.07 Pale brown to brown gritty silt loam, weak medium granular, friable, with iron-oxide nodules, leached; A2b horizon in Late Sangamon pedi-sediment.

6.8-7.6 2.07-2.32 Brown to dark brown silty clay loam, fine subangular blocky, firm, with yellowish-red and reddish-brown iron-oxide nodules and coatings and clay skins, leached; B1b horizon in Late Sangamon pedi-sediment.

— — Stone line — —

7.6-8.9 2.32-2.71 Reddish-brown to brown gritty clay, strong medium subangular blocky, firm, plastic, with iron-oxide nodules and coatings and clay skins, leached; B2b horizon in Kansan till.

8.9-9.5 2.71-2.90 Brown to dark yellowish-brown clay loam, moderate medium subangular blocky, firm, with iron-oxide coatings and clay skins, leached; B3b horizon in Kansan till.

9.5-14.0 2.90-4.27 Yellowish-brown clay loam, coarse angular blocky, leached; C1b horizon in oxidized and leached Kansan till.

14.0-20.5 4.27-6.25 Same but calcareous with carbonate nodules; oxidized and unleached Kansan till.

20.5-28.2+ 6.25-8.60+ Dark gray clay loam and same as above; unoxidized and unleached Kansan till.

This paleosol occurs on an erosion surface (pediment) that is cut into and below the level of the gumbotil (Stop 14-3). See Ruhe (1956) for details. The pediment is marked by the stone line, and sediment above it is the pedi-sediment. Below the stone line is Kansan till. The paleosol is formed in three sediments (Ruhe, 1959). Age of the Late Sangamon surface will be demonstrated at the next stop. Properties of the paleosol on this younger Pleistocene surface differ markedly from properties of the paleosol on the Yarmouth-Sangamon surface (Table 14-1).

Proceed west on State 90, 17½ miles (28 km) to Atlantic, Iowa. At northwest corner of town square pick up county-road C and continue west 18 miles (29 km) to Hancock, Iowa. Wisconsin loess is thickening systematically westward and at next Stop in 2 miles (3.2 km) is 29 feet (8.8 m) thick. Loveland loess feathers out near Atlantic, Iowa, but this Illinoian loess also thickens westward and at the next stop is 18 feet (5.5 m) thick. Thicknesses of both loesses decrease systematically southeastward with distance from the source area in the Missouri River Valley (Wright and Ruhe, 1965).

Continue west 2 miles (3.2 km) from the intersection of U.S. 59 and county C in Hancock. Turn left (south) on ungraveled road: proceed 1 mile (1.6 km) and turn right (west). In a quarter mile (0.4 km) park on road and walk south to railroad and cut to west.

Stop 14-5: Cut 33 along Rock Island Railroad.

Loveland (Illinoian) loess, Sangamon paleosol, late Sangamon paleosol, Farmdale loess, and Wisconsin loess will be examined. In the east part of this cut that is 8/10 mile (1.3 km) long, the stone line surface bevels Kansan till and a paleosol is formed in pedi-sediment, stone line, and till as at Stop 14-4. Five hundred feet (150 m) to the west Loveland loess mantles Kansan till but the Sangamon paleosol, well displayed farther west, is missing;

Table 5. Continued.

hence the stone line surface cuts out Loveland and Sangamon and must be younger.

Farmdale loess mantles both Sangamon paleosol and the paleosol of the stoneline surface, so the surface is older than Farmdale and is post-Sangamon paleosol and pre-Farmdale, basal Wisconsin. Thus the surface and paleosol must be Late Sangamon. On the south side of the cut, Farmdale loess can be traced laterally to peat about 800 feet (245 m) west of the east end of the cut. The peat is radiocarbon dated at 24,500 ± 800 years (W-141), a good Farmdale date.

About 1,000 feet (300 m) westward, weathering zones in Wisconsin loess (Ruhe and Scholtes, 1956), Farmdale loess, and Sangamon paleosol in Loveland loess are exposed:

Wisconsin loess:

ft m
0-3.3 0-1.0 Present solum.
3.3-9.9 1.0-3.0 Yellowish-brown silt loam mottled gray, massive, friable, leached; oxidized and leached zone.
9.9-12.2 3.0-3.7 Same but calcareous; oxidized and unleached zone.
12.2-17.6 3.7-5.4 Gray silt loam, massive, friable, calcareous, iron-oxide band at top, iron-oxide pipestems and nodules within; upper deoxidized and unleached zone.
17.6-28.2 5.4-8.6 Yellowish-brown silt loam, massive, compact, calcareous, fossiliferous; oxidized and unleached zone.
28.2-29.0 8.6-8.8 Gray silt loam, massive, compact, leached; lower deoxidized and leached zone.
29.0-30.8 8.8-9.4 Dark grayish-brown silt loam, fine granular, friable, with charcoal fragments, leached; Farmdale Alb horizon; 75% silt, 24% clay.
30.8-33.3 9.4-10.1 Olive-gray silt loam, massive, friable, leached; Farmdale Cb horizon; 75% silt, 23% clay.

Sangamon paleosol:

33.3-34.0 10.1-10.4 Light brownish-gray light silty clay loam, fine granular, hard, with reddish-brown coatings on peds, leached; A2b horizon; 72% silt, 27% clay.
34.0-37.0 10.4-11.3 Brownish-gray silty clay, medium subangular blocky, firm, with reddish-brown coatings and clay skins on peds, leached; B1b horizon; 58% silt, 41% clay.
37.0-39.5 11.3-12.0 Same but heavier texture, stronger structure, more prominent coating and clay skins, leached; B2b horizon; 48% silt, 51% clay.
39.5-41.5 12.0-12.6 Same but lighter texture; weaker structure, less prominent coatings and clay skins, leached; B3b horizon; 58% silt, 40% clay.
41.5-50+ 12.6-15.2+ Olive-gray silty clay loam with brown mottles, massive, friable, leached; Cb horizon in Loveland loess; silt content downward 62, 58, 54%, clay content 37, 39, 39%.

Note the contrast between the surface soil and the Sangamon paleosol. See discussion of regional properties of these soils in Ruhe (1965). Note also that the reddish colors in the paleosol are the result of coatings of iron oxide on the surfaces of soil aggregates. Note further that Sangamon weathering extends deeply below the arbitrary base of the solum. See Ruhe and Scholtes (1956) for discussion of weathering zones in Wisconsin loess.

Proceed west 4½ miles (7.2 km). Turn left; cross railroad; immediately turn right and continue 1 mile (1.6 km). Cut 39 is on right. Organic matter from the base of a gully fill in Wisconsin loess in this cut is 6,800±300 years (W-235). This date equates with C14 dates of beginning of dominance of grass pollen in bogs on the Des Moines drift lobe. In this cut Wisconsin loess thickness has increased to 30 feet (9.1 m) and Loveland loess thickness to 20 feet (6.1 m).

Turn right and recross railroad. At half a mile (0.8 km) turn left and intersect blacktop at 1 mile (1.6 km). Continue ahead (west) on blacktop 5 miles (8 km) to Bentley and proceed westward. At 1 mile (1.6 km) west of Bentley, cut 50 along railroad is ¾ mile (1.2 km) to the south. In this cut Wisconsin loess thickness has increased to 38 feet (11.6 m) and Loveland loess thickness has increased to 26 feet (7.9 m).

Continue ahead on county road C 2½ miles (4 km) to Underwood. Turn left (south) on State 64 and proceed 12½ miles (20 km), to Council Bluffs and intersect State 192. Turn left (south) and follow 192 three miles (4.8 km) to U.S. 275. Turn right (west) on 275 and continue 4 miles (6.4 km) to Missouri River bridge. Proceed west to Omaha and Lincoln, Nebraska on U.S. Interstate 80.

Comparison of Properties of Yarmouth-Sangamon and Late Sangamon Paleosols.

Property	Yarmouth-Sangamon (Cut D)		Late Sangamon (Cut A)	
	(inches)	(cm)	(inches)	(cm)
Thickness of A+B horizons	113	287	36	91
Thickness of B2 horizon	53	135	15	38
Depth to weatherable minerals*	120	305	0	0
Depth to carbonate	147	373	90	229
	(percent)		(percent)	
Clay content B2 horizon	53		42	
	(ratio)		(ratio)	
Clay content B/C horizons	1.7/1.0		1.2/1.0	
	(percent)		(percent)	
Weatherable minerals*				
A horizon	0		18	
B1	0		10	
B2	0		12	
B3	0		—	
C1	4		8	
C2	13		—	
C3	22		16	

*Weatherable minerals are rock types in sand size and greater and include granite, basalt, gabbro, limestone, dolomite, and others.

Table 6. General Pleistocene section in southwestern Iowa.

Glacial stage		Interglacial stage	Evidence	Authority
Wisconsin	Mankato		Loess	Ruhe (1954)
	Cary			
	Tazewell-Cary.		Soil	
	Tazewell		Loess	
	Iowan			
	Farmdale-Iowan.		Soil	Mickelson (1950)
	Farmdale		Loess	
		Sangamon	Weathered zones, soils, peat, erosion.	Kay and Graham (1943) 15-55).
Illinoian			Loveland loess	Kay and Graham (1943 63-75). Mickelson ([illegible] Leighton and Willman (1950) 601-602).
		Yarmouth	Soils, erosion, sediments.	Kay and Apfel (1929) 257-281).
Kansan			Drift	Kay and Apfel (1929) 212-256).
		Aftonian	Soils, peat, weathered zones, erosion.	Kay and Apfel (1929) 183-199).
Nebraskan			Drift	Kay and Apfel (1929) 141-145).

Table 7. Loess thickness on interfluve summit south of West Branch.

Site	Location (Pl. III)	Elevation [1]	Farmdale	Post-Farmdale	Total
		Feet	*Inches*	*Inches*	*Inches*
Divide	C. 20, 4.50	1,340	9	172	181
Interfluve	C. 70, 3.85	1,333	6	150	156
Interfluve	D. 35, 3.95	1,330	12	114	126
Interfluve	E. 15, 3.85	1,326	6	122	128

[1] Elevation of basal surface on which loess was deposited.

Table 8. Textural and mineralogical comparison of Nebraskan and Kansan tills.

Texture and mineralogy	Nebraskan	Kansan
Texture: [1]	*Percent*	*Percent*
Sand and gravel (>62 μ)	27.1	29.4
Very coarse silt (62–31 μ)	11.8	13.9
Coarse silt (31–16 μ)	12.7	14.4
Medium silt (16–8 μ)	6.7	5.4
Fine silt (8–4 μ)	5.4	6.4
Very fine silt (4–2 μ)	6.3	4.1
Clay (<2 μ)	30.0	26.4
Mineralogy: [2]		
Quartz	80.0	80.0
Limestone-dolomite	8.2	6.0
Granite	5.1	6.0
Basalt	1.1	2.0
Quartzite	1.1	1.5
Chert	2.5	2.5
Sandstone	2.0	2.0

[1] Geologic data concerning particle-size distributions of sediments are reported in terms of a modified Wentworth size classification. Geologists generally consider the upper limit of clay size to be approximately 4 μ. To conform to the soil scientist's upper limit of clay at 2 μ, the size fraction 4–2 μ is classed very fine silt instead of clay as required by the Wentworth size classification. Geologists consider the upper limit of silt size to be 1/16 mm. (62 μ). The soil scientist's upper limit is 50 μ. To utilize particle-size distributions statistically, a scale of sizes that is based on strict geometric intervals is best. The modified Wentworth scale is so based. The soil scientist's scale is not. Data in this report are presented in both systems.

[2] Of sand and gravel fractions.

Table 9. Reference to initial use of weathering zone terms in Iowa.

O&L - oxidized and leached (Kay and Apfel, 1929, p. 109)

DO&U - oxidized and unleached (Kay and Apfel, 1929, p. 109)

DO&L - deoxidized and leached (Kay and Graham, 1943, p. 170; Ruhe, 1954)

DO&U - deoxidized and unleached (Ruhe, 1954)

U&U - unoxidized and unleached (Kay and Apfel, 1929, p. 109)

Table 10. Set of properties of the soil-landscape system on stepped erosion surfaces in Adair County, Iowa.

Soil	Thickness solum	Thickness B horizon	Clay content B horizon	Wrh	Wrl
	(in.)	*(in.)*	*(%)*		
Early Wisconsin surface					
M	29	22	34.6		
N	15	11	31.2		
O	32	23	32.2		
Averages	25	19	32.3		
A horizon				0.79	2.09
B horizon				0.92	2.12
C horizon				0.67	2.21
Late Sangamon surface					
H	39	29	49.5		
I	46	32	50.7		
J	70	56	49.1		
Averages	52	39	49.7		
A horizon				1.27	3.06
B horizon				1.04	2.49
C horizon				0.77	2.03
Yarmouth-Sangamon surface					
D	68	44	57.7		
F	85	62	50.7		
G	87	70	51.4		
Averages	80	59	53.2		
A horizon				2.05	4.64
B horizon				1.58	3.00
C horizon				1.21	2.48

Table 11. Changes in soil properties that occur as distance from loess source increases.

1. Thickness of loess decreases
2. Particle size of the loess decreases and clay content in the B horizon increases
3. Depth to paleosol decreases
4. Depth to deoxidized zone decreases
5. Ridges (summits) become wider
6. Steepness of side slopes decrease
7. Soils become less permeable and have poorer internal drainage
8. Depth to water table decreases
9. Depth to carbonates increases

Table 12. Soil series derived from exhumed paleosols used in southern Iowa and their extent (in acres).

Prairie	Transition	Forest
	Yarmouth-Sangamon	
Clarinda (296,335) Clearfield (41,439) Clearfield-Arispe (9,252)	Rinda (51,172)	Ashgrove (18,365)
	Truncated Yarmouth-Sangamon	
Lamoni (179,639) Shelby-Lamoni (21,833)	Bucknell (31,570)	
	Sangamon (Loess)	
Malvern (4,325)		
	Late Sangamon (Till)	
Adair (192,641) Adair-Shelby (188,884) Burchard-Adair (3,120) Lineville Var (2,295) Northboro (2,636)	Armstrong (162,969) Armstrong-Gara (108,000) Lineville (17,062)	Keswick (110,412) Lindley-Keswick (55,137)
	Late Sangamon (Alluvium)	
Mayberry (3,993)	Mystic (34,663) Mystic-Caleb (24,946) Mystic Var (670)	Galland (22,737) Galland-Douds (6,510)

APPENDICES

APPENDIX A. WEATHERING ZONE TERMINOLOGY

modified and adapted from:

Hallberg, G.R., T.E. Fenton, and G.A. Miller. 1978. Standard weathering zone terminology for the description of Quaternary sediments in Iowa. *In G.* R. Hallberg (ed.) Standard procedures for evaluation of Quaternary materials in Iowa. Tech. Info. Ser. 8:75-109. Iowa Geological Survey, Iowa City, Iowa.

In the past, the same terms have been applied to loess, till, and other sediments. The deoxidized criteria for loess are not wholly appropriate for till, and added descriptors are also necessary. Two sets of terminology will therefore be presented here. The numerical values for color refer to moist Munsell colors as determined on fresh samples. If samples are allowed to dry in the laboratory, they may change color irreversibly (Daniels et al., 1961).

As discussed, there are conceptual problems with the use of "oxidation" terms, inferred from sediment colors. Miller (1974) discussed the possible replacement of these terms with color-related connotative names: "brunambric" for oxidized; "pallic" for deoxidized; and "glaucic" for unoxidized. However, we have chosen to retain the use of the classical "oxidation" terms, in spite of their technical misconceptions, because of their long historical usage. When the conceptual problems and the nature and distribution of the iron compounds are understood, the color-related oxidation terms can be useful descriptive tools.

LOESS

Standard symbols, terms, and their defined use for loess are:

First Symbol - color reference.

- O - oxidized; 60% of matrix has hues of 2.5Y or redder, values of 3 or higher, and may have segregation of secondary iron compounds into mottled, tubules, or nodules.
- D - deoxidized; 60% of matrix has hues of 10YR, 2.5Y, and/or 5Y, values of 5 or 6 ; and chromas of 1 or 2 with segregation of iron (ferric oxides) into tubules (pipestems) or nodules.
- U - unoxidized; matrix has hues of 5Y, 5GY, 5GB, and 5G, values of 4, 5, or 6, and chromas of 1 or less (except 5Y 6/1 is deoxidized), with no segregation of iron into tubules or nodules. May include hues of N or values of 3 or less with the presence of zones with abundant organic matter; these are often described as organic bands.

Second Symbol - leached or unleached state.

- U - unleached; primary carbonates present.
- L - leached; no carbonates detectable.
- L2 - leached; primary carbonates absent, secondary carbonates present.

Modifier Symbols - when used precedes first symbol.

- M - mottled; refers to zones containing 20-50% contrasting mottles.

Examples:

- OL - oxidized, yellowish brown or strong brown matrix, and leached.

UU - unoxidized, dark greenish gray matrix and unleached.

MOL - mottled, oxidized - yellowish brown and strong brown matrix with gray mottles, leached.

MDU - mottled, deoxidized - grayish brown matrix with strong brown pipestems and strong brown mottles, unleached.

TILL

Standard symbols, terms, and their defined use for till are:

First Symbol - color reference.

O - oxidized; 60% matrix has hues redder than 2.5Y (ex. - 10YR, 7.5YR); hues of 2.5Y, with values of 5 or higher, but including 2.5Y 4/4; may have segregation of secondary compounds into mottles, tubules, or nodules, etc.

R - reduced; 60% matrix has hues of 2.5Y, with values of 3 or less, hues of 2.5Y, with value of 4, with chromas of 2 or less; hues of 5Y, N, 5GY, 5BG, and 5G, values of 4 or higher (usually values in this zone are 5 or higher). Colors in this zone are nearly always mixed as weak mottles, diffuse blends of color, or as discrete bands. Discrete vertical bands of reduced colors may occur for some distance adjacent to joints. These bands may eventually grade into uniform unoxidized material. In this zone there may be considerable segregation of secondary iron compounds (with oxidized colors) into mottles, nodules, or sheets along cleavage planes, or joints.

U - unoxidized; matrix uniform; has hues of 5Y and N, values of 5 or less, 5GY, 5BG, and 5G with values of 6 or less; with no segregation of iron compounds into mottles, nodules, etc.

Second Symbol - if used.

J - jointed, describes the presence of well-defined vertical joints in the till; joints often show oxidized and reduced colors, often have coatings or rinds of secondary iron-oxides; occasionally other secondary minerals such as calcite or gypsum.

Second or Third Symbol - leached or unleached state; same as for loess.

U - unleached.

L - leached.

L2 - leached of primary carbonates, but secondary carbonates present.

Modifier Symbols - when used precede first symbol, as with loess.

M - mottled; zones with 20-50% contrasting mottles; when used with the unoxidized zone designation it infers 20% or <u>less</u> mottles of reduced colors.

Examples:

JRU - jointed reduced unleached-mixed olive (5Y 4/4 and 5Y 4/3) and very dark grayish brown (2.5Y 3/2), with common gray (5Y 5/1) and light olive brown (2.5Y 5/4) mottles; prominent vertical joints, with 1 cm strong brown (7.5 Y 5/8) segregations along the joint; unleached.

JUU - jointed, unoxidized, unleached-uniform dark greenish gray (5GY 4/1) matrix, with few thin vertical joints, which have mottled light olive brown 92.5Y 5/6) and olive gray (5Y 5/2) faces, and a 3 cm rind of greenish gray (5GY 5/1); unleached.

MUL - mottled, unoxidized, leached - dark greenish gray (5GY 4/1) matrix with few, small gray (5Y 5/1) mottles; leached.

OTHER MATERIALS

Other materials, such as alluvium, lacustrine sediments, etc., can also be described by these terms. Dependent upon the texture and density of these materials, the terms for loess or till may be more appropriate.

DISCUSSION

As with any system of classification of natural entities, the boundaries between these "pigeonholes" are very transitional. The table below shows a vertical sequences of weathering zone abbreviations that might be encountered in a transitional but complete sequence in loess or till. The subdivision and color "quantification" of these zones have evolved from numerous descriptions of outcrops and core-samples from depths of 5 to 400 feet. As with any classification, judgements must be made on transitional samples.

Vertical sequence of weathering zones that might be encountered in a complete transitional sequence.

Loess	Till
OL	OJL
OL2	MOJL
MOU	MOJL2
MDU	MOJU
DU	MRJU
UU	RJU
	MUJU
	UJU
	UU

APPENDIX B

SOIL SERIES DESCRIPTIONS AND DATA

modified and adapted from
URL: http://www.statlab.iastate.edu/soils/osd/

LOCATION ADAIR IA+MO NE

Established Series
Rev. TEF-RJK-DBO
8/87

ADAIR SERIES

The Adair series consists of deep, moderately well drained and somewhat poorly drained, slowly permeable soils formed on uplands in a thin mantle of loess or loess and pedisediments and a paleosol formed in glacial till. Slope ranges from 2 to 30 percent. Mean annual temperature is about 50 degrees F, and mean annual precipitation is about 31 inches.

TAXONOMIC CLASS: Fine, montmorillonitic, mesic Aquic Argiudolls

TYPICAL PEDON: Adair clay loam with a slope of about 6 percent -cultivated. (Colors are for moist soil unless otherwise stated.)

Ap—0 to 6 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak fine granular structure; friable; few large root channels and wormholes; slightly acid; clear smooth boundary.

A1— 6 to 9 inches; very dark gray (10YR 3/1) clay loam, gray (10YR 5/1) dry; weak very fine granular structure; friable; few root channels and wormholes; sand grains more evident than in Ap horizon; slightly acid; gradual smooth boundary.

A2—9 to 17 inches; very dark gray (10YR 3/1) and dark brown (7.5YR 3/2) clay loam, gray (10YR 5/1) and brown (7.5YR 5/2) dry; amount of dark brown color increases as depth increases; weak very fine subangular blocky and fine granular structure; friable; few root channels and wormholes; few thin black (10YR 2/1) organic stains on vertical faces of peds; few pebbles and stones at base of horizon; medium acid; gradual smooth boundary. (Combined thickness of the A horizons is 10 to 20 inches.)

2Bt1—17 to 25 inches; mottled brown (7.5YR 4/4) and dark reddish brown (5YR 3/4) clay; moderate fine and medium subangular blocky structure; very firm; few very fine pores; many pores filled with clay; few distinct clay films on peds; few black (10YR 2/1) and few dark grayish brown (10YR 4/2) coatings on peds; common fine pebbles; medium acid; gradual smooth boundary. (8 to 12 inches thick)

2Bt2—25 to 34 inches; dark yellowish brown (10YR 4/4) clay loam; many fine distinct yellowish brown (10YR 5/6) and dark reddish brown (5YR 3/4) and few fine distinct brown (7.5YR 5/4) and grayish brown (2.5Y 5/2) mottles; moderate fine subangular blocky structure; very firm; few fine pores; few distinct clay films on some faces of peds; common fine pebbles; few fine concretions (iron and manganese oxides); medium acid; diffuse smooth boundary. (8 to 12 inches thick)

2Bt3—34 to 47 inches; dark yellowish brown (10YR 4/4) clay loam; many fine distinct yellowish brown (10YR 5/6) and many medium to large prominent olive gray (5Y 5/2) mottles; weak medium prismatic structure parting to weak and moderate medium subangular blocky; firm; few distinct clay films; common fine and medium pebbles; few fine concretions (iron and manganese oxides); slightly acid; clear smooth boundary. (8 to 14 inches thick)

2BC—47 to 60 inches; yellowish brown (10YR 5/6) clay loam; many large prominent olive gray (5Y 5/2) or grayish brown (2.5Y 5/2) mottles; mottles decrease in abundance as depth increases; some vertical cleavage parting to weak angular blocky structure; firm; few very fine pores; common fine and medium concretions (iron and manganese oxides); few soft accumulations of lime in lower part; neutral.

TYPE LOCATION: Adams County, Iowa; about 5 miles northeast of Corning; 54 feet west and 1,680 feet north of the southeast corner, sec. 12, T. 72 N., R. 34 W.

RANGE IN CHARACTERISTICS: Thickness of the solum ranges from 40 to 65 inches or more. The most acid part of the solum typically is medium acid, but the range includes strongly acid. Carbonates are leached to a depth of at least 48 inches and typically to about 60 inches or more.

The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 1 or 2. It typically is clay loam with about 27 to 35 percent clay, but loam, silty clay loam, and silt loam are in the range. A BA horizon up to about 5 inches thick is in some pedons.

The upper part of the 2Bt horizon dominantly has hue of 2.5YR to 10YR, value of 3 through 5, and chroma of 3 through 6 as matrix and mottle colors. Pedons that have a matrix of 10YR hue have many mottles of 5YR or redder hue. A few grayish mottles are in the upper part of the 2Bt horizon in some pedons. The upper part of the 2Bt horizon is clay loam, clay, or less commonly, silty clay. Content of clay typically is 38 to 46 percent, but ranges to 60 percent. A stone line is at the top of this horizon or at the base of the A or BA horizon, and some stones and pebbles are in the 2Bt horizon.

The lower part of the 2Bt horizon and the 2BC horizon have mottles ranging in hue from 5YR to 5Y. Grayish mottles are dominant in the lower part. These horizons are clay loam and content of clay ranges from 30 to 38 percent.

The 2C horizon has hue of 10YR, value of 4 or 5, and chroma of 2 through 6. Mottles are dominantly of low chroma and are common or many. This horizon is clay loam and content of clay ranges from 30 to 38 percent. This horizon contains pebbles and stones.

COMPETING SERIES: These are the Arispe, Chase, Flanagan, Greenton, Grundy, Herrick, Ipava, Lagonda, Lamoni, Macksburg, Mahaska, Malvern, Martin, Mayberry, Pawnee, Rutland, Seymour, Shorewood, and Wymore soils in the same family and the Armstrong, Lineville, Mystic, and Shelby series. Arispe, Flanagan, Greenton, Grundy, Herrick, Ipava, Macksburg, Mahaska, Martin, Rutland, Seymour, Shorewood, and Wymore soils have less sand and pebbles in the solum and lack 7.5YR or redder hue in the upper part of the B horizon. Chase and Martin soils have mollic epipedons greater than 24 inches thick. Lagonda soils have less sand and clay and have fewer reddish mottles in the upper part of the solum. Lamoni soils lack 7.5YR or redder hue in the matrix of the upper part of the Bt horizon, lack a stone line, and have 1 chroma mottles in the lower part of the B and the C horizon. Malvern soils have less sand in the upper part of the solum and lack a stone line. Mayberry soils have thicker Bt horizons and their lower B and C horizons did not form in glacial till. Pawnee soils lack hues of 7.5YR or redder in the upper part of the B horizon. Armstrong, Lineville, and Mystic soils lack mollic epipedons and have E horizons unless they have been removed by accelerated erosion. Shelby soils have Bt horizons that are lower in clay and the matrix has a hue of 10YR.

GEOGRAPHIC SETTING: Adair soils are on convex summits of narrow interfluves and on convex side slopes at slightly lower elevations than the gray, clayey Yarmouth-Sangamon paleosols. They are commonly in bands at the shoulders of side slopes where geologic erosion has exhumed the late Sangamon paleosols. Slope gradients commonly are 2 to 18 percent but range to 30 percent. These soils formed in late Sangamon paleosols formed in Kansan glacial till, except that the 10 to 20 inches above the pebble band is partly loess or loess and pedisediments. Mean annual temperature ranges from 49 to 54 degrees F, and mean annual precipitation ranges from 28 to 34 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Grundy, Seymour, and Shelby soils and the Clarinda, Marshall, Otley, Sharpsburg, and Tama soils. The Grundy, Marshall, Otley, Seymour, Sharpsburg, and Tama soils all formed in loess and are upslope from the Adair soils. Shelby soils formed in till and are downslope. Clarinda soils are at slightly higher elevations. They have grayer, more clayey Bt horizons. Marshall and Tama soils are higher in silt and lower in clay; and Marshall, Otley, and Sharpsburg soils have less red hue in the B horizons.

DRAINAGE AND PERMEABILITY: Moderately well drained or somewhat poorly drained. Surface runoff is medium or rapid, and permeability is slow. Where Adair soils are associated with Marshall, Otley, Sharpsburg, or Tama soils, seepy spots develop in wet seasons; but in years of average rainfall wetness is usually not a hazard.

USE AND VEGETATION: More than half of the soil is used for corn, oats, and meadow and the rest for pasture. Native vegetation was tall prairie grasses, but the underlying paleosol is believed to have formed under forest.

DISTRIBUTION AND EXTENT: Eastern, western, and southern Iowa, northern

Missouri, and southeastern Nebraska. The Adair series is extensive.

SERIES ESTABLISHED: Lucas County, Iowa, 1957.

REMARKS: The dark grayish brown coatings on peds in the 2Bt1 horizon are considered as evidence of wetness sufficient for a classification of Aquic.

Diagnostic horizons and features recognized in this pedon are: mollic epipedon - the zone from the surface to a depth of approximately 17 inches (Ap, A1, and A2 horizons); argillic horizon - the zone from approximately 17 inches to a depth of 47 inches (2Bt1, 2Bt2, and 2Bt3 horizons); udic moistures regime.

National Cooperative Soil Survey
U.S.A.

Adair Series, Adams County

Sample No.	Depth in.	Sand	Coarse Silt	Fine Silt	Clay	pH
9 - 151	0 - 6	28.3	24.4	17.2	30.0	5.1
9 - 152	6 - 9	27.3	20.1	19.7	32.9	5.0
9 - 153	9 - 17	26.6	18.9	16.8	37.7	5.0
9 - 154	17 - 25	29.1	11.6	12.9	46.4	5.4
9 - 155	25 - 34	30.4	11.2	14.9	43.5	6.2
9 - 156	34 - 47	32.8	12.2	16.2	38.9	6.7
9 - 157	47 - 54	37.0	12.9	17.1	33.0	7.4

LOCATION CALEB IA+MO

Established Series
Rev. JDH-RJD-JRW
6/79

CALEB SERIES

The Caleb series consists of deep, moderately well drained, moderately permeable soils formed in alluvial sediments derived from glaciers. They are on high structural benches. Slope ranges from 5 to 25 percent. Mean annual temperature is about 51 degrees F, and mean annual precipitation is about 33 inches.

TAXONOMIC CLASS: Fine-loamy, mixed, mesic Mollic Hapludalfs

TYPICAL PEDON: Caleb loam on a southeast-facing slope of 9 percent in a cultivated field. (Colors are for moist soil unless otherwise stated.)

Ap—0 to 6 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; weak fine granular structure; friable; medium acid; abrupt smooth boundary. (6 to 9 inches thick)

E—6 to 8 inches; brown (10YR 4/3) silt loam that contains about 25 percent sand; weak coarse platy structure parting to moderate fine subangular blocky; friable; discontinuous light gray (10YR 7/2) dry silt and fine sand coatings on faces of peds; very strongly acid; clear smooth boundary. (2 to 4 inches thick)

Bt1—8 to 12 inches; brown (10YR 4/3) clay loam; strong fine and medium subangular blocky structure; firm; nearly continuous light gray (10YR 7/2) dry silt and fine sand coatings and thin discontinuous very dark grayish brown (10YR 3/2) clay films on faces of peds; few fine dark reddish brown (5YR 2/2) bodies (oxides); strongly acid; clear smooth boundary.

Bt2—12 to 17 inches; brown (10YR 4/3) clay loam; few fine faint yellowish brown (10YR 5/6) mottles; dark yellowish brown kneaded (10YR 4/4); strong medium subangular blocky structure; friable; continuous light gray (10YR 7/2) dry silt and fine sand coatings and thin discontinuous dark brown (7.5YR 3/2) clay films on faces of peds; few fine dark reddish brown (5YR 2/2) bodies (oxides); very strongly acid; clear smooth boundary.

Bt3—17 to 24 inches; dark yellowish brown (10YR 4/4) clay loam, yellowish brown (10YR 5/6) kneaded; strong fine prismatic structure parting to strong fine angular blocky and subangular blocky; firm; thick discontinuous dark brown (7.5YR 3/2) clay films mainly on vertical faces; few fine dark reddish brown (5YR 2/2) bodies (oxides); roots confined mainly along faces of prism and exteriors of peds; medium acid; gradual smooth boundary.

Bt4—24 to 35 inches; mottled dark yellowish brown (10YR 4/4) and grayish brown (10YR 5/2) clay loam, yellowish brown (10YR 5/4) kneaded; strong medium prismatic structure parting to moderate medium subangular blocky; firm; thick patchy dark brown (7.5YR 3/2) clay films on faces of prisms and in old channels; few fine (5YR 2/2) concretions (oxides); medium acid; gradual smooth boundary.

Bt5—35 to 46 inches; dark yellowish brown (10YR 4/4) sandy clay loam, yellowish brown (10YR 5/4) kneaded; common fine faint grayish brown (10YR 5/2) and few fine faint strong brown (7.5YR 5/6) mottles; weak coarse prismatic structure; friable; few thin discontinuous dark brown (10YR 3/3) clay films on faces of prisms and in old channels; few fine dark reddish brown (5YR 2/2) concretions (oxides); slightly acid; gradual smooth boundary. (Combined thickness of the Bt horizons is 28 to 48 inches)

BC—46 to 60 inches; dark yellowish brown (10YR 4/4) to yellowish brown (10YR 5/4) sandy loam, yellowish brown (10YR 5/4) kneaded; few fine distinct yellowish red (5YR 4/6) and few fine faint strong brown (7.5YR 5/6) mottles; weak coarse prismatic structure; friable; few thin discontinuous dark brown (10YR 3/3) clay films on faces of prisms and in old channels; few discontinuous light gray (10YR 7/2) dry silt and fine sand coats on prism faces; slightly acid. (0 to 24 inches thick)

TYPE LOCATION: Wayne County, Iowa; about 4 miles west and 4 miles north of Corydon; 480 feet south and 2,415 feet east of the northwest corner of sec. 4, T. 69 N., R. 22 W.

RANGE IN CHARACTERISTICS: The solum typically is 5 or more feet thick, but it is as thin as 42 inches in some pedons. Carbonates are absent to below 5 feet. The solum ranges from medium acid to very strongly acid in the most acid part.

The A or Ap horizon typically is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) and typically is silt loam that contains a moderate amount of sand or is loam, but the range includes clay loam.

The E horizon typically is dark grayish brown (10YR 4/2) or brown (10YR 4/3) but the range includes grayish brown (10YR 5/2) and brown (10YR 5/3). It is silt loam or loam. In some pedons the E horizon is mixed in the Ap horizon and evident only as grainy coatings on surfaces of peds.

The Bt horizon typically has 10YR hue, value of 4 or 5 and chroma of 3 through 6. In some pedons mottles with chroma of 2 are below depths of 2 feet, but not within the upper 10 inches of the argillic horizon. Hue of 7.5YR or redder is restricted to mottles or special features such as oxides. When dry, light gray silt and fine sand coatings are evident throughout the solum.

The Bt horizon is quite variable in texture over short distances. It is clay loam, loam, or sandy clay loam and thin strata of sandy loam and loamy sand or coarser are below depths of 3 or 4 feet in some pedons. The finest part of the B horizon is typically clay loam with 32 to 35 percent clay. Strata of sandy loam or coarser texture are less than 6 inches thick where they are as shallow as 40 inches in depth.

COMPETING SERIES: These are the Argyle, Baltimore, Bassett, Blooming, Cadmus, Crocker, Dowagiac, Dunbridge, Gara, Koronis, Lester, Longlois, Lydick, Mohawk, Neda, Octagon, Oneco, Orwood, Racine, Razort, Renox, Waucoma, and Winneshiek soils of the same family and the Douds, Keswick, Lindley, and Mystic series. Argyle soils contain more silt in the upper part of the B horizon, and the lower part is formed in a reddish paleosol that formed in loam glacial drift in which illite is the dominant clay mineral. Baltimore soils have Bt horizons of 5YR or redder hue, which contain many mica flakes and pebbles, and 2C horizons of silt loam weathered from marble or dolomite. Bassett, Crocker, Gara, Lester, Mohawk, Racine, Keswick, and Lindley soils lack stratified, moderately coarse and coarse material in the lower part of the B horizon. Blooming soils have less sand in the lower part of the B horizons and in the C horizon, have less stratification in the lower part of the solum, and in addition,the upper part of the solum is formed in loess. Cadmus soils contain more gravel and sand in the Bt horizon and have a thinner solum. Dowagiac soils contain more sand in the lower part of the 10- to 40- inch control section and in the C horizon. Dunbridge and Winneshiek soils are underlain by limestone bedrock at depths of about 20 to 40 inches. Koronis soils have a thinner solum and are shallower to carbonates. Longlois soils have more gravel in the lower part of the solum and have C horizons of gravel and sand, and are on gentler slopes and are shallower to carbonates. Lydick soils have shale fragments in the solum, have more total acidity and have a C horizon that is dominantly sand and contains some shale fragments. Neda soils have a thinner solum and the Bt horizon is less acid and contains 5 to 20 percent shale fragments. Octagon soils have a thinner solum and have a 2C horizon of calcareous loam within a depth of about 3 feet. Oneco and Waucoma soils have more clay in the lower part of the B horizon and have limestone bedrock at depths of 40 to 60 inches. Orwood soils have more silt in the lower part of the B and C horizons. Razort soils tend to have a thinner solum and have less sand in the lower part of the B and C horizons, and are on gentler slopes. Renox soils have a thinner solum that contains more gravel throughout. Douds soils have an A horizon that is thinner or lighter colored or both. Mystic soils have a finer-textured Bt horizon of redder hue, and lower chroma and mottles are at shallower depths.

GEOGRAPHIC SETTING: Caleb soils are on convex ridgetops and side slopes of high benches. Their landscape configuration is partly related to valley fills, but the surfaces blend with the present erosional uplands. These areas are distinctly higher in elevation than the modern flood plains but are lower in elevation than the late Wisconsin dissection slopes on which the Gara, Shelby, and Lindley soils formed. Slope gradients range from 5 to 25 percent. Caleb soils formed in pre-Sangamon erosional sediments of variable texture and glacial origin. These materials appear to have been angularly truncated in many places, often resulting in an irregular mixture of material of contrasting textures. Mean annual temperature is about 49 to 53 degrees F, and mean annual precipitation is about 30 to 35 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: The competing Mystic soils are upslope on the more stable portion of the low-stepped interfluves. Pershing, Kniffin, and Ladoga soils which formed in loess are also upslope. Soils formed in recent flood plain sediments are downslope from the Caleb soils.

DRAINAGE AND PERMEABILITY: Moderately well drained. Runoff is medium on the low gradient slopes and rapid on the steeper slopes. Permeability is moderate. USE AND VEGETATION: Mainly used for growing hay and pasture. Some areas are occasionally cropped to corn and oats and some areas have widely spaced trees. Native vegetation was mixed prairie grasses and deciduous trees.

DISTRIBUTION AND EXTENT: Southern Iowa and possibly northern Missouri. These soils are of moderate extent along major streams and their tributaries.

SERIES ESTABLISHED: Appanoose County, Iowa, 1970.

National Cooperative Soil Survey
U.S.A.

Caleb Series, Wayne County

Depth in.	Sand	Coarse Silt	Fine Silt	Clay
0 - 6	22.99	45.01	8.28	23.72
6 - 8	24.71	41.05	7.48	26.76
8 - 12	23.90	34.46	10.20	31.44
12 - 17	25.69	25.27	15.52	33.52
17 - 24	25.77	18.07	21.20	34.96
24 - 35	41.57	13.07	14.88	30.48
35 - 46	65.62	6.22	7.28	20.88
46 - 66	62.80	8.52	11.04	17.64

LOCATION CLARINDA IA+MO

Established Series
Rev. RID-JDH-DBO
3/94

CLARINDA SERIES

The Clarinda series consists of deep, poorly drained, very slowly permeable soils formed mainly in a paleosol that developed in glacial till on uplands. Slopes range from 5 to 14 percent. Mean annual temperature is about 51 degrees F, and mean annual precipitation is about 33 inches.

TAXONOMIC CLASS: Fine, montmorillonitic, mesic Vertic Argiaquolls

TYPICAL PEDON: Clarinda silty clay loam on a south-facing convex slope of about 8 percent - pasture. (Colors are for moist soil unless otherwise stated.)

Ap—0 to 5 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; very fine granular and very fine subangular blocky structure; friable; medium acid; abrupt smooth boundary. (5 to 8 inches thick)

A—5 to 11 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; moderate fine subangular blocky structure; friable; many quartz grains; strongly acid; gradual smooth boundary. (5 to 8 inches thick)

2Bt—11 to 19 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; few fine distinct yellowish red (5YR 4/8) mottles; moderate fine subangular blocky structure; firm; common thick discontinuous dark gray (10YR 4/1) clay films on faces of peds; many fine white sand grains; strongly acid; gradual smooth boundary. (4 to 8 inches thick)

2Btg1—19 to 34 inches; gray (5Y 5/1) clay; common fine distinct yellowish brown (10YR 5/6 and 5/8) and few fine distinct yellowish red (5YR 5/8) mottles; weak medium subangular blocky structure; very firm; thick continuous gray (10YR 5/1) clay films on faces of peds; common fine white sand grains; strongly acid; gradual boundary. (12 to 24 inches thick)

2Btg2—34 to 47 inches; gray (5Y 5/1) clay; common coarse distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak medium prismatic structure parting to moderate medium to coarse subangular blocky; very firm; thick continuous gray (10YR 5/1) clay films; few fine white sand grains; slightly acid; gradual boundary. (12 to 24 inches thick)

2Btg3—47 to 67 inches; gray (5Y 5/1) clay; common coarse distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak medium prismatic structure parting to moderate medium subangular blocky; very firm; thick continuous gray (10YR 5/1) clay films; some very dark gray (10YR 3/1) organic clay films on peds and in channels and crevices; few fine and medium sand grains; neutral.

TYPE LOCATION: Wayne County, Iowa; about 1 mile west of Corydon; 1,940 feet east and 240 feet south of the northwest corner, sec. 24, T. 69 N., R. 22 W.

RANGE IN CHARACTERISTICS: The concept of the Clarinda series is centered on soils that formed in exhumed paleosols of Yarmouth-Sangamon age, but soils formed in paleosols of Aftonian age or "accretion-gley" are included if the color, clay content, and solum thickness are within the range given for the series. Solum thickness is commonly more than 5 feet.

The A horizon typically formed in loess or silty sediments. Total thickness ranges from 10 to 18 inches, except that some eroded areas have less than 10 inches of A horizon. The A horizon is black (10YR 2/1) or very dark gray (10YR 3/1). The A horizon typically is silty clay loam, but in some pedons it is silt loam. Some pedons have an AB horizon.

The 2B horizon has been little affected by recent soil-forming processes; the thickness and degree of expression is variable and in many places is related to geologic truncation of the original paleosol. The 2B horizon typically is about 5 feet thick, but it ranges from 3 to 10 feet or more in thickness. The 2Bt horizon, where present, is darker than the underlying 2Btg horizon; colors of 3 value or darker do not extend below a depth of 24 inches except as discontinuous coats. The 2Btg horizon has hues of 10YR, 2.5Y, or 5Y; value of 4 or 5; and chroma dominantly of 1. The 2Btg horizon contains varying amounts of yellowish brown and yellowish red mottles; mottles are few in the upper part. The 2B horizon is silty clay or clay and maximum clay content ranges between 45 and 60 percent. It contains some white fine sand. These sand particles increase in amount and size with increasing depth. In some pedons, small pebbles are in the 2B horizon at depths below 5 feet. The 2Btg1 and 2Btg2 horizons commonly are medium acid or strongly acid. In some pedons calcium has been replenished in the 2B horizon by seepage water from upslope or by leachate from the mantling material, so that reaction of the 2Bt horizon is quite variable. The 2Btg3 horizon grades into a 2C horizon of mottled gray and dark yellowish brown clay loam glacial till of Kansan age.

COMPETING SERIES: These are the Coatsburg and Sampsel series of the same family and the Adair, Ashgrove, Donnan, Lagonda, Lamoni, Lineville, and Seymour series. Coatsburg soils lack horizons with more than 45 percent clay and contain more sand and weatherable minerals. Sampsel soil, have higher chroma in argillic horizons that have less clay, have shale fragments in the lower part of the solum, and commonly are less acid. Adair soils have a redder B horizon, contain more sand, and commonly have a stone line in the upper part of the B horizon. Ashgrove soils lack a mollic epipedon. Donnan soils have less clay and more sand and are more friable in the upper part of the solum. Lagonda soils formed in part in loess and in part from a clayey paleosol; they have higher chroma colors and less clay in the upper part of the argillic horizon. Lamoni soils are not so fine textured and contain more sand. Lineville soils have an E horizon, have a B horizon with higher chroma, and have a higher sand content. Seymour soils formed in loess, have higher chroma in the upper part of the Bt horizon, and contain somewhat less sand.

GEOGRAPHIC SETTING: The Clarinda soils typically are on convex side slopes and coves at the head of drainageways. They are commonly on lower slopes that border the major drainage divides. Slope gradients range from about 5 to 14 percent. Clarinda soils formed in exhumed gray clayey paleosols which were formed in glacial till of Kansan age. Soils formed in loess are upslope and soils formed in till are downslope where slopes are long or steep. Mean annual temperature is 49 to 54 degrees F, and mean annual precipitation is 29 to 35 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Adair, Lamoni, and Seymour soils and the Clearfield, Grundy, Marshall, Sharpsburg, and Shelby series. Adair and Lamoni soils are on convex slopes below Clarinda soils. Seymour soils are on convex slopes above Clarinda soils. Clearfield, Grundy, Marshall, and Sharpsburg soils formed in loess on higher and generally less sloping positions in the landscape and are better drained than the Clarinda soils. Shelby soils formed in clay loam glacial till on slopes below the Clarinda soils and have a brownish colored B horizon.

DRAINAGE AND PERMEABILITY: Poorly drained. Runoff is medium or rapid. Permeability is very slow. These soils are seasonally wet and seepy.

USE AND VEGETATION: These soils are used for pasture and cultivated crops. Corn, soybeans, small grains, and hay are the principal crops. Native vegetation was prairie grasses.

DISTRIBUTION AND EXTENT: Southern Iowa and northern Missouri. They are of large extent.

SERIES ESTABLISHED: Taylor County, Iowa, 1954.

REMARKS: Classification only was updated 3/94 for final correlations in Iowa. Changes include proposals made in Amendment 17 of Soil Taxonomy. Competing series and other updates will be made later.

Diagnostic horizons and features recognized in this pedon are: mollic epipedon - the zone from the surface to a depth of 14 inches (Ap, A, and 2Bt horizons); argillic horizon - the zone from 11 inches to a depth of 67 inches (2Bt, 2Btg1, 2Btg2, and 2Btg3 horizons).

National Cooperative Soil Survey
U.S.A.

S871A-159-006

*** PRIMARY CHARACTERIZATION DATA ***

(RINGGOLD COUNTY, IOWA)

PRINT DATE 04/05/89

SAMPLED AS : CLARINDA ; FINE, MONTMORILLONITIC, MESIC SLOPING TYPIC ARGIAQUOLL
REVISED TO : ; FINE, MONTMORILLONITIC, MESIC TYPIC OCHRAQUALF

NSSL - PROJECT 88P 105, EROSION
- PEDON 88P 593, SAMPLE 88P3046-3057
- GENERAL METHODS 1B1A, 2A1, 2B

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

NATIONAL SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA 68508-3866

	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-7-	-18-	-19-	20-
				(- - - TOTAL - - -)			(- - CLAY - -)		(- - SILT - -)		(- - - - - - - - SAND - - - - - - - -)					(- COARSE FRACTIONS (MM) -) - - - - - - WEIGHT - - - - - -				(>2MM)
SAMPLE NO.	DEPTH (CM)	HORIZON		CLAY LT .002	SILT .002 -.05	SAND .05 -2	FINE LT .0002	CO3 LT .002	FINE .002 -.02	COARSE .02 -.05	VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	2 -5	5 -20	20 -75	.1- 75	WT PCT OF WHOLE SOIL
				<- - - - - - - - - - - - - - - - -					PCT OF <2MM (3A1)						- - - - - - - - ->	<------ PCT OF <75MM (3B1)			------>	
88P3046S	0- 8	AP		47.6	49.7	2.7			28.1	21.6	1.1	0.9	0.5	0.2	--	--	--	--	2	--
88P3047S	8- 18	2BT		48.3	48.6	3.1			27.2	21.4	1.3	1.1	0.6	0.1	--	--	--	--	2	--
88P3048S	18- 28	2BT		46.5	49.9	3.6			27.9	22.0	1.4	1.4	0.7	0.1	--	--	--	--	2	--
88P3049S	28- 43	2BTG1		45.8	49.7	4.5			28.8	20.9	1.8	1.5	0.8	0.2	0.2	--	--	--	3	--
88P3050S	43- 58	2BTG1		44.9	50.7	4.4			28.5	22.2	1.9	1.5	0.8	0.2	--	--	--	--	2	--
88P3051S	58- 69	2BTG2		43.2	52.1	4.7			27.9	24.2	1.8	1.8	0.9	0.2	--	--	--	--	3	--
88P3052S	69- 81	2BTG2		43.9	51.1	5.0			28.6	22.5	2.1	1.8	0.9	0.2	--	--	--	--	3	--
88P3053S	81- 97	2BTG3		46.1	49.4	4.5			27.0	22.4	1.8	1.8	0.7	0.2	--	--	--	--	3	--
88P3054S	97-112	2BTG3		46.3	48.7	5.0			26.4	22.3	1.9	1.8	1.1	0.2	--	--	--	--	3	--
88P3055S	112-130	2BTG3		49.0	46.3	4.7			25.7	20.6	1.8	1.8	0.9	0.2	--	--	--	--	3	--
88P3056S	130-140	BC		47.2	48.2	4.6			27.5	20.7	1.8	1.8	0.9	0.1	--	--	--	--	3	--
88P3057S	140-152	BC		50.9	44.5	4.6			26.0	18.5	1.8	1.8	0.8	0.2	--	--	--	--	3	--

	ORGN	TOTAL	EXT R	TOTAL	(- - DITH-CIT	- -)		(RATIO/CLAY)		(ATTERBERG)		(- BULK DENSITY	-)		COLE	(- - - WATER CONTENT			- - -)	WRD
	C	N	P	S	EXTRACTABLE				15			FIELD	1/3	OVEN	WHOLE	FIELD	1/10	1/3	15	WHOLE
DEPTH (CM)	6A1C PCT	6B3A <2MM	6S3 PPM	6R3A <- - - PERCENT OF	FE 6C2B	AL 6G7A <2MM	MN 6D2A - - - >	CEC 8D1	BAR 8D1	LL 4F1	PI 4F	MOIST 4A3A <- - -	BAR 4A1D G/CC	DRY 4A1H - - ->	SOIL 4D1 CH/CH	MOIST 4B4 <- - -	BAR 4B1C PCT OF <2MM	BAR 4B1C	BAR 4B2 - - ->	SOIL 4C1 CH/CH
0- 8	0.84							0.72	0.41										19.6	
8- 18	0.51							0.72	0.41										20.0	
18- 28	0.41							0.71	0.43										19.9	
28- 43	0.24							0.71	0.43										19.6	
43- 58	0.21							0.69	0.43										19.1	
58- 69	0.18							0.70	0.44										18.9	
69- 81	0.17							0.69	0.44										19.4	
81- 97	0.22							0.67	0.42										19.5	
97-112	0.16							0.67	0.44										20.3	
112-130	0.10							0.69	0.44										21.4	
130-140	0.11							0.72	0.46										21.7	
140-152	0.15							0.70	0.44										22.4	

AVERAGES, DEPTH 8-58: PCT CLAY 46 PCT .1-77MM 2

*** PRIMARY CHARACTERIZATION DATA ***
(RINGGOLD COUNTY, IOWA)

S871A-159-006

PRINT DATE 04/05/89

SAMPLED AS : CLARINDA ; FINE, MONTMORILLONITIC, MESIC SLOPING TYPIC ARGIAQUOLL
NATIONAL SOIL LABORATORY ; PEDON 88P 593, SAMPLE 88P3046-3057

	-1--	-2--	-3--	-4--	-5--	-6--	-7--	-8--	-9--	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	20-
	(- - - - NH4OAC EXTRACTABLE BASES - - -)					ACID-	EXTR	(- - - - - CEC - - - -)			AL	-BASE	SAT-	CO3 AS	RES.		COND.	(- - - - PH - - - -)		
DEPTH (CM)	CA 5B5A 6N2E	MG 5B5A 6O2D	NA 5B5A 6P2B	K 5B5A 6Q2B	SUM BASES	ITY 6H5A	AL 6G9A	SUM CATS 5A3A	NH4 OAC 5A8B	BASES + AL 5A3B	SAT 5C3	SUM 5C3	NH4 OAC 5C1	CACO3 <2MM 6E1G	OHMS /CH 8E1		MMHOS /CH 81		CACL2 .01M 8C1F 1:2	H2O 8C1F 1:1
	<- HEQ / 100 G --->																			
0- 8	28.5	8.7	0.3	0.6	38.1	5.7		43.8	34.2			87	100	TR					6.2	6.7
8- 18	21.3	10.3	0.5	0.5	32.6	6.3		38.9	34.8			84	94						5.8	6.5
18- 28	21.2	10.0	0.6	0.4	32.2	4.9		37.1	32.8			87	98						5.7	6.6
28- 43	19.0	9.9	0.8	0.4	30.1	4.6		34.7	32.3			87	93						5.8	6.6
43- 58	22.6	9.6	0.9	0.5	33.6	5.7		39.3	31.0			85	100	TR					5.9	6.8
58- 69	18.0	9.4	1.0	0.4	28.8	4.4		33.2	30.2			87	95						5.9	6.9
69- 81	18.9	9.4	1.1	0.4	29.8	4.7		34.5	30.4			86	98						5.8	6.7
81- 97	18.9	9.5	1.1	0.4	29.9	5.2		35.1	30.9			85	97						5.7	6.4
97-112	18.8	9.4	1.1	0.4	29.7	6.0		35.7	31.1			83	95						5.5	6.4
112-130	20.8	10.0	1.1	0.5	32.4	6.0		38.4	33.7			84	96						5.4	6.3
130-140	19.9	10.0	1.1	0.5	31.5	8.7		40.2	33.9			78	93						5.4	6.2
140-152	21.6	10.4	1.1	0.6	33.7	4.3		38.0	35.6			89	95						5.4	6.0

LOCATION CLEARFIELD IA

Established Series
Rev. FFR-DL-DBO
9/87

CLEARFIELD SERIES

The Clearfield series consists of deep, poorly drained, moderately slowly permeable soils formed in loess on uplands. They overlie a clayey, very slowly permeable paleosol, which is at a depth of 3 to 5 feet. Slope ranges from 5 to 14 percent. Mean annual temperature is about 50 degrees F, and mean annual precipitation is about 31 inches.

TAXONOMIC CLASS: Fine, montmorillonitic, mesic, sloping Typic Haplaquolls

TYPICAL PEDON: Clearfield silty clay loam with a slope of about 7 percent - cultivated. (Colors are for moist soil unless otherwise stated.)

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; cloddy parting to weak fine granular structure; friable; common roots; slightly acid; abrupt smooth boundary.

A1—7 to 13 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate fine and very fine subangular blocky structure; friable; medium acid; clear smooth boundary.

A2—13 to 17 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; few fine faint yellowish brown (10YR 5/4) mottles; moderate very fine subangular blocky structure; friable; medium acid; gradual smooth boundary. (Combined thickness of the A horizons is 10 to 18 inches.)

Btg1—17 to 25 inches; dark gray (10YR 4/1) silty clay loam; dark grayish brown (2.5Y 4/2) kneaded; many fine distinct reddish brown (2.5YR 4/4) mottles; weak medium subangular blocky structure parting to weak fine subangular blocky; firm; black (10YR 2/1) coatings in root channels and pores; thin discontinuous very dark gray (10YR 3/1) clay films; few dark concretions (manganese oxides); slightly acid; gradual smooth boundary.

Btg2—25 to 31 inches; olive gray (5Y 5/2) silty clay loam; common fine distinct dark gray (10YR 4/1) and few fine distinct brown (7.5YR 4/4) and yellowish brown (10YR 5/6 and 5/8) mottles; moderate medium subangular blocky structure; firm; thin discontinuous dark gray (5Y 4/1) clay films; few dark concretions (manganese oxides); medium acid; gradual smooth boundary.

Btg3—31 to 39 inches; gray (5Y 5/1) silty clay loam; many medium distinct strong brown (7.5YR 5/6 and 5/8) and few medium distinct gray (10YR 5/1) mottles; weak medium prismatic structure parting to moderate medium subangular blocky; friable; thin discontinuous dark gray (5Y 4/1) clay films on faces of prisms; slightly acid; clear smooth boundary. (Combined thickness of the Btg horizons is 13 to 25 inches.)

Bg1—39 to 48 inches; light gray (5Y 6/1) silty clay loam; many medium distinct yellowish brown (10YR 5/4) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; a concentrated area of dark concretions (manganese oxides) in the upper 4 inches of this horizon; slightly acid; abrupt smooth boundary.

Bg2—48 to 54 inches; dark gray (N 4/0) silty clay loam; many fine prominent brown (7.5YR 4/4) and yellowish red (5YR 4/8) mottles; weak medium subangular blocky structure; firm; few thin layers of light gray (10YR 6/1) silty clay loam with few fine prominent brownish yellow (10YR 6/6) mottles; medium acid; abrupt smooth boundary. (Combined thickness of the Bg horizons is 13 to 17 inches.)

2Abg—54 to 64 inches; black (10YR 2/1) silty clay loam; massive; firm; few vertical cleavage faces; slightly acid; gradual smooth boundary. (0 to 14 inches thick)

2Bbg—64 to 71 inches; dark gray (10YR 4/1) silty clay; few fine faint dark grayish brown (10YR 4/2) mottles; massive; firm; medium acid.

TYPE LOCATION: Union County, Iowa; about 3 miles east and 2 miles south of Creston; 1400 feet south and 1467 feet east of the northwest corner, sec. 21, T. 72 N., R. 30 W.

RANGE IN CHARACTERISTICS: Solum thickness above the paleosol typically is about 4 feet and ranges from 3 to 5 feet. The loess overlying a Yarmouth-Sangamon clayey paleosol is 3 to 5 feet thick. Carbonates are lacking throughout. The thickness of the A horizon, depth to the layer of maximum clay content, and depth to the silty clay paleosol decrease as slope gradient increases. The weighted clay average of the 10- to 40-inch-control section is near 35 percent, typically being 35 to 37 percent.

The A horizon has hue of 10YR or is neutral, value of 2 or 3, and chroma of 0 or 1. It contains between 32 and 38 percent clay, and the largest amount is in the lower part. The A horizon ranges from neutral to medium acid.

The Btg and Bg horizons have hue of 10YR, 2.5Y, or 5Y, value of 4 through 6, and chroma of 1 or 2. If value is 4 and chroma is 2 in the upper part, there are mottles of 1 chroma. Mottles of high chroma are throughout the B horizon. The Btg and Bg horizons are silty clay loam with 32 to 40 percent clay. Reaction is medium acid to neutral.

The Bg horizon of the modern soil is underlain by a paleosol which in the upper part ranges from black (10YR 2/1) to gray (10YR 5/1) and contains 40 to 50 percent clay. In some pedons a thin layer of sediment or sediment-loess mixture is just above the paleosol. It typically is silty clay loam and 5 to 10 inches thick. It ranges from very dark gray (N 3/0 or 10YR 3/1) to light gray (10YR 6/1).

COMPETING SERIES: There are no other series in this family. Other competing series are the Donnan and Nira series. Donnan soils lack a mollic epipedon, have more sand in the A and B horizons, and the underlying paleosol is at depths of 2 or 3 feet. Nira soils are dominantly brown in the upper part of the B horizon and are better drained.

GEOGRAPHIC SETTING: Clearfield soils are on nearly straight to slightly convex side slopes of uplands and head slopes of drainageways. Slope gradients range from 5 to 14 percent. The typical position is a head slope of 7 percent gradient. Clearfield soils formed in 3 to 5 feet of loess of Wisconsin Age underlain by a gleyed Yarmouth-Sangamon paleosol. The dominant clay-size mineral is montmorillonite. Mean annual temperature ranges from about 48 to 54 degrees F, and mean annual precipitation from about 28 to 34 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Nira soils and the Clarinda and Sharpsburg soils. The Nira and Sharpsburg soils are upslope and typically at a higher elevation. In places, Clearfield soils merge downslope into the Clarinda soils. Clarinda soils are formed mainly in an exhumed paleosol and lack the silty clay loam B horizon formed in loess. Sharpsburg soils are dominantly brown in the B horizon and lack the paleosol.

DRAINAGE AND PERMEABILITY: Typically poorly drained but range to somewhat poorly drained. Surface runoff is medium. Permeability is moderately slow in the modern soil and very slow in the underlying paleosol. These soils are distinctly seepy during parts of the year.

USE AND VEGETATION: When drained, they are commonly used for corn, soybeans, small grains, and hay. Native vegetation was tall prairie grasses.

DISTRIBUTION AND EXTENT: Central part of southwestern Iowa. They are moderately extensive.

SERIES ESTABLISHED: Taylor County, Iowa, 1948.

REMARKS: Formerly classified as Typic Argiaquolls (fine-silty, mixed, mesic). Available laboratory data indicate that most pedons do not have a clay increase within 12 inches that will qualify for an argillic horizon. The weighted clay average of the control section is marginal to the 35 percent clay limit between the fine and fine-silty families.

Diagnostic horizons and features recognized in this pedon are: mollic epipedon - the zone from the surface to a depth of 17 inches (Ap, A1, and A2 horizons); cambic horizon - the zone from 17 inches to a depth of 39 inches (Btg1, Btg2, and Btg3 horizons).

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Clearfield Series, Union County

Sample No.	Depth in.	Sand	Coarse Silt	Fine Silt	Clay	pH
5230	0 - 7	1.8	30.7	32.0	35.5	6.4
5231	7 - 13	1.6	26.5	31.3	40.3	5.9
5232	13 - 17	2.3	26.8	31.7	39.2	5.8
5233	17 - 25	2.0	25.5	36.0	36.5	6.1
5234	25 - 31	1.0	25.7	39.9	33.4	5.8
5235	31 - 39	3.7	27.1	37.9	31.3	6.1
5236	39 - 48	1.4	24.6	43.2	30.8	6.2
5237	48 - 54	1.8	24.6	38.5	35.1	5.9
5238	54 - 64	1.5	25.7	34.1	38.7	6.1
5239	64 - 71	1.8	21.7	27.9	48.8	5.9

LOCATION LAMONI IA+MO

Established Series
Rev. JDH-RID-DBO
6/94

LAMONI SERIES

The Lamoni series consists of deep, somewhat poorly drained, slowly or very slowly permeable soils formed in a paleosol that developed in glacial till on uplands. Slope ranges from 5 to 18 percent. Mean annual temperature is about 50 degrees F, and mean annual precipitation is about 33 inches.

TAXONOMIC CLASS: Fine, montmorillonitic, mesic Aquertic Argiudolls

TYPICAL PEDON: Lamoni silty clay loam with a west-facing convex slope of 9 percent - pasture. (Colors are for moist soil unless otherwise stated.)

A1—0 to 6 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate fine subangular blocky structure; friable; strongly acid; clear smooth boundary.

A2—6 to 11 inches; very dark grayish brown (10YR 3/2) clay loam, grayish brown (10YR 5/2) dry; faces of some peds very dark gray (10YR 3/1); moderate very fine subangular blocky and granular structure; friable; few black (10YR 2/1) worm casts; strongly acid; clear smooth boundary. (Combined thickness of the A horizons is 10 to 17 inches.)

2Bt1—11 to 14 inches; brown (10YR 4/3) clay; faces of peds dark grayish brown (10YR 4/2); few fine faint dark yellowish brown (10YR 4/4) mottles; moderate fine subangular blocky structure; firm; few very dark gray (10YR 3/1) worm casts; strongly acid; gradual smooth boundary.

2Bt2—14 to 19 inches; dark grayish brown (10YR 4/2) clay; many fine distinct yellowish brown (10YR 5/6) and few fine distinct strong brown (7.5YR 5/6) mottles; moderate fine subangular blocky structure; very firm; thin continuous clay films; some weatherable minerals; medium acid; gradual smooth boundary.

2Bt3—19 to 25 inches; grayish brown (2.5Y 5/2) clay; common fine distinct yellowish brown (10YR 5/6) and few fine prominent strong brown (7.5YR 5/6) mottles; moderate fine subangular blocky structure; very firm; thick continuous clay films; dark brown (7.5YR 3/2) concretions (oxides); few small pebbles; some weatherable minerals; medium acid; gradual smooth boundary.

2Bt4—25 to 33 inches; mottled light brownish gray (2.5Y 6/2), light gray (5Y 6/1), and yellowish brown (10YR 5/6) clay; moderate medium prismatic structure parting to weak medium subangular blocky; firm; thin discontinuous clay films on faces of prisms; common black (10YR 2/1) and dark brown (7.5YR 3/2) concretions (oxides); few small pebbles; medium acid; gradual smooth boundary. (Combined thickness of the 2Bt horizons is 16 to 30 inches.)

2BC—33 to 55 inches; yellowish brown (10YR 5/6) clay loam; common medium distinct light gray (5Y 6/1) and few medium faint strong brown (7.5YR 5/8) mottles; moderate medium prismatic structure parting to weak medium subangular blocky; firm; thin discontinuous clay films; some very dark gray (10YR 3/1) around root channels; many black (10YR 2/1) and dark brown (7.5YR 3/2) concretions (oxides); few small pebbles; slightly acid; gradual smooth boundary. (19 to 25 inches thick)

2C—55 to 80 inches; yellowish brown (10YR 5/6) clay loam; common medium distinct light gray (5Y 6/1) and a few medium faint strong brown (7.5YR 5/8) mottles; massive; firm; many black (10YR 2/1) and dark brown (7.5YR 3/2) concretions (oxides); few small pebbles; neutral.

TYPE LOCATION: Wayne County, Iowa; about 7 miles east of Humeston; 2,440 feet west and 30 feet south of the northeast corner of sec. 22, T. 70 N., R. 22 W.

RANGE IN CHARACTERISTICS: Solum thickness typically is 4 to 6 feet. The soil typically is medium acid to strongly acid in the most acid part, but the range includes slightly acid. Some pedons contain carbonates below a depth of 48 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It typically is silty clay loam, but the range includes loam, silt loam, clay loam, and clay.

The upper part of the 2Bt horizon typically has hue of 10YR or 2.5Y, value of 4, dominant chroma of 2, and mottles of higher chroma. The lower part has hue of 10YR through 5Y, value of 5 or 6, and chroma of 1 through 6. The amount of high chroma increases with depth. The color and texture of the 2Bt horizon are variable and related principally to the amount of truncated paleosol remaining. Hues redder than 10YR are restricted to mottles or oxides.

The part of the B horizons of clay texture typically is 12 to 24 inches thick, and the finest part contains between 40 and 50 percent clay. Depth to the finest part usually ranges from 10 to 18 inches but decreases as gradient increases on convex slopes. The amount of sand and small pebbles increase as depth increases. The upper part of the solum contains between 15 and 30 percent sand and the lower part and the C horizon between 30 and 45 percent.

COMPETING SERIES: These are the Adair, Arispe, Chase, Flanagan, Greenton, Grundy, Herrick, Ipava, Lagonda, Macksburg, Mahaska, Malvern, Martin, Mayberry, Pawnee, Rutland, Seymour, Shorewood, and Wymore series in the same family and the Clarinda, Clearfield, Coatsburg, Lineville, Sampsel, and Shelby soils. Adair soils lack mottles with chroma of 1 in the lower part of the B horizon and in the C horizon, have 7.5YR or redder hue in the matrix of the upper part of the Bt horizon, and typically have a pebble band in the upper part of the B horizon. Arispe, Flanagan, Greenton, Grundy, Herrick, Ipava, Macksburg, Mahaska, Rutland, Seymour, Wymore, and Clearfield soils have less sand and lack any pebbles in the upper 3 feet of the sola. Chase soils have a mollic epipedon more than 24 inches thick. Lagonda soils typically have less sand and lack pebbles in the upper part of the B horizon. Malvern and Mayberry soils have 7.5YR or redder hue in much of the B horizon. Martin soils formed in weathered shale. Pawnee soils typically have a thicker B horizon and a less acid solum. Shorewood soils have a thinner, less acid solum and contain free carbonates within a depth of 40 inches. Clarinda soils have clay or silty clay textures 3 feet or more thick. Coatsburg soils have grayer colors directly below the mollic epipedon and contain more illite in the lower part of the solum and C horizon. Lineville soils lack a mollic epipedon and are deeper to the horizon highest in clay. Sampsel soils have grayer colors directly below the mollic epipedon. Shelby soils have higher chroma in the upper part of the B horizon and are fine-loamy.

GEOGRAPHIC SETTING: The Lamoni soils typically are on moderately sloping convex side-valley slopes surrounding the nearly level, stable, upland divides. Slope gradients range from about 5 to 18 percent. Lamoni soils formed in partially truncated, exhumed, grayish brown, clayey paleosols which were formed in Yarmouth-Sangamon time in glacial till of Kansan age and were partially truncated prior to the recent cycle of soil development. The A horizon formed in loess or a mixture of loess and pedisediment. Mean annual temperature is about 49 to 53 degrees F, and mean annual precipitation is about 30 to 35 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Clarinda and Shelby soils. Clarinda soils commonly are upslope and the Shelby soils downslope. Generally the three soils cannot be mapped on the same slope; however, where the loess is thin, the Clarinda soils are on secondary interfluves or at the shoulder of side slopes in many places and the Lamoni soils are on side slopes. Where slopes are long, both Lamoni and Shelby soils are commonly on the same side slope. On steep slopes, Lamoni soils are usually on the interfluves or shoulders of slopes and the Shelby soils are on the entire side slope.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained. Lamoni soils are seasonally wet and seepy. Runoff is medium or rapid. Permeability is slow or very slow.

USE AND VEGETATION: Generally cultivated; main crops are corn, oats, hay, or pasture. Native vegetation was tall prairie grasses.

DISTRIBUTION AND EXTENT: Southern Iowa and northern Missouri. They are extensive.

SERIES ESTABLISHED: Scotland County, Missouri, 1969.

REMARKS: Classification only was updated 3/94 for final correlations in Iowa. Changes include proposals made in Amendment 17 of Soil Taxonomy. Competing series and other updates will be made later. Diagnotic horizons and features recognized in this pedon are: mollic epipedon - the zone from the surface to a depth of 11 inches (A1 and A2 horizons); argillic horizon - the zone from 11 to 33 inches (2Bt1, 2Bt2, 2Bt3, and 2Bt4 horizons); aquic moisture regime.

National Cooperative Soil Survey
U.S.A.

Lamoni Series, Wayne County

Depth in.	Sand	Coarse Silt	Fine Silt	Clay	pH
0 - 6	26.06	16.66	22.36	34.92	5.1
11 - 14	21.77	11.51	20.56	46.16	5.0
14 - 19	23.68	5.58	18.52	52.12	5.0
19 - 25	30.70	10.34	18.00	40.96	5.3
25 - 33	33.36	9.92	17.80	38.92	5.5

Established Series
Rev. LDL-RJK
6/94

MYSTIC SERIES

The Mystic series consists of deep, moderately well and somewhat poorly drained, slowly permeable soils formed primarily in loamy alluvium derived from glaciers on high structural benches. Slopes range from 5 to 18 percent. Mean annual temperature is about 51 degrees F, and mean annual precipitation is about 33 inches.

TAXONOMIC CLASS: Fine, montmorillonitic, mesic Aquertic Hapludalfs

TYPICAL PEDON: Mystic silt loam near the summit of a convex interfluve of 5 percent gradient cultivated. (Colors are for moist soil unless otherwise stated.)

Ap—0 to 6 inches; very dark grayish brown (10YR 3/2) silt loam (23 percent clay), grayish brown (10YR 5/2) dry; weak fine granular structure; friable; some mixing of brown (10YR 4/3) less than 5 percent; thin discontinuous light brownish gray (10YR 6/2) dry, silt and fine sand coatings on faces of some peds; medium acid; abrupt smooth boundary. (6 to 9 inches thick)

E—6 to 10 inches; brown (7.5YR 4/2) silt loam (27 percent clay); few fine faint reddish brown (5YR 4/4) mottles; weak coarse platy structure parting to moderate fine subangular blocky; friable; some mixing of very dark grayish brown (10YR 3/2) less than 5 percent; thin discontinuous light brownish gray (10YR 6/2) dry, silt and fine sand coatings on faces of peds; very strongly acid; clear smooth boundary. (0 to 6 inches thick)

BE—10 to 13 inches; brown (7.5YR 5/4) clay loam (30 percent clay); brown (7.5YR 4/2) coatings on faces of peds; few fine prominent red (2.5Y 4/6) mottles; moderate fine subangular blocky structure; friable; thin discontinuous light brownish gray (10YR 6/2) dry, silt and fine sand coatings on faces of peds; strongly acid; clear smooth boundary. (0 to 6 inches thick)

Bt1—13 to 17 inches; dark reddish brown (2.5YR 3/4) clay loam (36 percent clay); grayish brown (10YR 5/2) coatings on faces of peds; reddish brown (5YR 4/4) kneaded; strong fine subangular blocky structure; firm; continuous thick white (10YR 8/1) dry, silt and fine sand coatings on faces of peds; thin discontinuous clay films; few fine dark reddish brown (5YR 3/2) concretions (iron oxides); strongly acid; clear smooth boundary.

Bt2—17 to 23 inches; grayish brown (2.5Y 5/2) clay loam (38 percent clay); brown (7.5YR 4/4) kneaded; many fine prominent dark reddish brown (2.5YR 3/4) mottles;

moderate fine prismatic structure parting to moderate fine subangular blocky structure; firm; thin nearly continuous clay films; common fine dark reddish brown (5YR 3/2) concretions (iron oxides); strongly acid; gradual smooth boundary.

Bt3—23 to 32 inches; brown (10YR 5/3) clay loam (33 percent clay); grayish brown (10YR 5/2) coatings on faces of peds; few fine faint yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak medium and coarse subangular blocky; firm; thin discontinuous clay films on faces of prisms and root channels; many fine dark reddish brown (5YR 2/2) concretions (iron and manganese oxides); medium acid; gradual smooth boundary.

Bt4—32 to 43 inches; brown (10YR 5/3) clay loam (31 percent clay); few fine faint gray (10YR 5/1) and yellowish brown (10YR 5/6) mottles; weak medium prismatic structure; firm; few discontinuous clay films on faces of prisms and in root channels; fine dark reddish brown (5YR 2/2) concretions (iron and manganese oxides); slightly acid; gradual smooth boundary. (Combined thickness of the Bt horizons is 22 to 39 inches.)

BC—43 to 54 inches; pale brown (10YR 6/3) sandy clay loam (23 percent clay); common fine and medium faint light brownish gray (10YR 6/2) and few fine distinct yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure; friable; few discontinuous clay films on faces of prisms; few fine dark reddish brown (5YR 2/2) concretions (iron and manganese oxides); slightly acid; gradual smooth boundary. (0 to 12 inches thick)

C—54 to 64 inches; pale brown (10YR 6/3) sandy loam (17 percent clay); common fine and medium faint light gray (10YR 7/2) and few fine distinct yellowish brown (10YR 5/6) mottles; massive; friable; few fine dark reddish brown (5YR 2/2) concretions (iron oxides); slightly acid.

TYPE LOCATION: Wayne County, Iowa; about 4 miles west and 3 miles north of Corydon; 2,035 feet south and 575 feet east of the northwest corner of sec. 4, T. 69 N., R. 22 W.

RANGE IN CHARACTERISTICS: The solum ranges from 48 to 72 inches in thickness. There are no free carbonates in the solum. Coarser fragments do not occur in the upper 30 inches of the solum, but they are below this depth in some pedons as thin strata. The solum ranges from medium acid to very strongly acid in the most acid part.

The A or Ap horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). It typically is silt loam (with more than 15 percent sand) or loam but ranges to clay loam (with a clay content of 27 to 32 percent).

The E horizon has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 2 or 3. It is silt loam with more than 10 percent sand or loam. In some pedons the E horizon has been incorporated into the Ap horizon.

The BE horizon has hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 3 or 4. It is clay loam with a clay content of about 30 to 35 percent.

The Bt horizon is quite variable in texture over short distances, but it typically is clay loam, clay, or silty clay with a clay content ranging from about 35 to 48 percent. The Bt horizon has hue ranging from 2.5YR to 2.5Y, value of 3 through 5, and chroma of 2 through 4. In at least part of the Bt horizon, either hues of 7.5YR or redder are present as matrix colors or as many distinct or prominent mottles. Chroma of 1 with value of 4 or 5 are within the range when such horizons have many distinct reddish and yellowish brown mottles with hues of 7.5YR or redder.

The BC and C horizons have hue of 5YR, 7.5YR, or 10YR with value of 4 to 6 and chroma of 2 to 8. Moderately coarse to fine textured sediments high in quartz are common in the lower part of the **BC** horizon and in the C horizon. Strata of sandy loam are allowed but only if less than 6 inches thick when they are as shallow as 40 inches in depth.

COMPETING SERIES: These are the Armstrong, Hoyleton, and Sunbury series in the same family and the Adair, Caleb, Cantril, Galland, Gara, Keswick, Lineville, Lindley, and Shelby series. Armstrong, Adair, and Keswick soils contain a pebble band in the upper part of the solum, contain stones and pebbles throughout the major part of the B horizon, and do not have stratification in the lower part of the B and C horizons. Hoyleton and Sunbury soils contain less sand in the upper part of the solum and are less stratified in the C horizon. Caleb, Cantril, Gara, Lindley, and Shelby soils are fine-loamy. In addition, Caleb and Cantril soils are without 7.5YR or redder hues in the B horizon and Gara, Lindley, and Shelby soils do not have stratification in the lower part of the B and C horizons. Galland soils have a lighter colored A or Ap horizon. Lineville soils average less than 35 percent clay in the upper part of the argillic horizon, commonly are deeper to horizon of clay maximum, and are less stratified in the C horizons.

GEOGRAPHIC SETTING: Mystic soils are on convex ridges and sideslopes of high structural benches that border valleys of major streams and their tributaries. The areas are distinctly higher in elevation than the modern flood plains but are lower in elevation than the late Wisconsinan recent dissection slopes on which the Gara, Lindley, and Shelby soils formed. Slope gradients range from 5 to 18 percent. Mystic soils formed in late Sangamon paleosols which formed in alluvium. Mean annual temperature ranges from about 50 to 54 degrees F, and mean annual precipitation ranges from about 32 to 36 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Caleb, Gara, Lindley, and Shelby series. Caleb soils are downslope from the Mystic soils on that portion of the interfluve that has been truncated in recent (Wisconsinan) time. Gara, Lindley, or Shelby soils commonly are upslope on that portion of the glacial till slope dissected in late Wisconsinan time.

DRAINAGE AND PERMEABILITY: Moderately well drained and somewhat poorly drained. These soils are seasonally wet and seepy; surface runoff is medium to rapid. Permeability is slow.

USE AND VEGETATION: Many areas are used for hay and pasture but some areas are used for cultivated crops. Native vegetation was mixed prairie grasses and deciduous trees.

DISTRIBUTION AND EXTENT: Southern Iowa. They are of moderate extent.

SERIES ESTABLISHED: Appanoose County, Iowa, 1970.

REMARKS: Classification only was updated 3/94 for final correlations in Iowa. Changes include proposals made in Amendment 17 of Soil Taxonomy. Competing series and other updates will be made later.

National Cooperative Soil Survey
U.S.A.

Mystic Series, Wayne County

Depth in.	Sand	Coarse Silt	Fine Silt	Clay
0 - 6	24.13	23.67	29.28	22.92
6 - 10	20.32	25.04	27.72	26.92
10 - 13	22.50	19.58	27.48	30.44
13 - 17	18.59	21.99	23.40	36.12
17 - 23	22.03	28.17	21.88	37.92
23 - 32	23.12	22.48	21.24	33.16
32 - 43	26.72	19.92	22.00	31.36
43 - 54	56.78	7.58	12.36	23.28
54 - 64	67.33	7.31	8.32	17.04

LOCATION NIRA IA

Established Series
Rev. JDH-RID-FFR-JRW
10/82

NIRA SERIES

The Nira series consists of moderately well drained soils formed in loess on convex to straight side slopes of uplands. The grayish colors, mottling pattern, and iron segregations in the B and C horizons are related to a deoxidized and leached weathering zone in the loess. These soils are moderately permeable. Their slopes range from 2 to 14 percent. Mean annual precipitation is about 32 inches, and mean annual temperature is about 51 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, mesic Typic Hapludolls

TYPICAL PEDON: Nira silty clay loam - cultivated - on a convex southwest-facing slope of 3 percent. (Colors are for moist soil unless otherwise stated.)

Ap—0 to 7 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; weak medium subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A—7 to 10 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; weak fine subangular blocky structure; friable; few brown (10YR 4/3) peds; medium acid; clear smooth boundary. (Combined thickness of the A horizons is 10 to 15 inches.)

Bw1—10 to 17 inches; brown (10YR 4/3) silty clay loam; faces of peds are brown (10YR 4/3) and 20 percent very dark grayish brown (10YR 3/2); common medium distinct grayish brown (2.5Y 5/2) mottles; moderate fine subangular blocky structure; friable; few thin discontinuous clay films; few fine dark brown and black concretions (iron and manganese oxides); medium acid; gradual smooth boundary.

Bw2—17 to 22 inches; same colors as above but with many medium distinct grayish brown (2.5Y 5/2) mottles; silty clay loam; weak medium prismatic structure parting to moderate medium subangular blocky; friable; medium acid; clear smooth boundary.

Bw3—22 to 28 inches; gray (5Y 5/1) silty clay loam; faces of peds mottled yellowish brown (10YR 5/4) and grayish brown (2.5Y 5/2); common fine prominent strong brown (7.5YR 5/6) and very few fine prominent yellowish red (5YR 4/6) mottles or soft nodules; weak coarse prismatic structure parting to weak medium subangular blocky; friable; medium acid; gradual smooth boundary.

Bw4—28 to 34 inches; gray (5Y 5/1) silty clay loam; faces of peds are grayish brown (2.5Y 5/2) with 20 percent yellowish brown (10YR 5/4); common medium prominent strong brown (7.5YR 5/6) mottles; weak coarse prismatic structure parting to weak medium and coarse subangular blocky; friable; few fine yellowish red (5YR 4/6) soft accumulations (iron oxides); few clay coats in pores; medium acid; diffuse smooth boundary. (Combined thickness of Bw horizons is 18 to 20 inches.)

BC—34 to 42 inches; gray to olive gray (5Y 5/1) silty clay loam; many medium prominent yellowish brown (10YR 5/6) mottles; massive with some vertical cleavage; friable; common fine soft dark brown and black nodules (iron and manganese oxides); few clay coats in pores; medium acid; diffuse smooth boundary. (0 to 8 inches thick)

C—42 to 60 inches; gray (5Y 5/1) silty clay loam; many medium prominent yellowish brown (10YR 5/6) mottles; massive; friable; common fine soft dark brown and black accumulations (iron and manganese oxides); medium acid.

TYPE LOCATION: Keokuk County, Iowa; about 2 miles south of the Town of Kinross; 792 feet west and 1,888 feet north of the center of sec. 34, T. 77 N., R. 10 W.

RANGE IN CHARACTERISTICS: The solum typically is more than 40 inches thick but ranges from 30 to 50 inches. Free carbonates are absent in the solum and typically in all of the C horizon. Thickness of the A horizon, depth to clay maximum, maximum percent clay, thickness of the Bw horizon, and depth to relict gray colors decrease with increasing gradient on convex slopes. The gray colors and iron segregations or mottling pattern are relict features related to a deoxidized and leached weathering zone. Nira soils are medium or strongly acid in the most acid part of their sola.

The A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). It centers on silty clay loam with 30 to 34 percent clay and is 10 to 15 inches thick unless eroded.

In some pedons a thin AB or BA horizon of dark brown (10YR 3/3) is present.

Interiors and faces of peds in the upper 6 inches or more of the Bw horizon typically are brown (10YR 4/3) or dark yellowish brown (10YR 4/4), but interior colors or mottles of 1 or 2 chroma and 4 or 5 value are in the range. The colors of organic coatings on peds in this layer range to very dark grayish brown (10YR 3/2) and very dark brown (10YR 3/3). Within a depth of 30 inches the matrix color is 2.5Y or 5Y hue, has value of 5 or 6, and chroma is 1 or 2. In some pedons, above the layers with a gray matrix, are horizons that have a mottled matrix with about equal parts of grayish brown to light olive gray and brown (10YR 4/3) to yellowish brown (10YR 5/6). High chroma mottles and iron segregations are throughout the B horizon. The Bw horizons typically have a few discontinuous clay films in the upper part. The maximum amount of clay typically is 33 to 38 percent and is in the upper part of the Bw horizon or lower part of A horizon.

Color and texture of the C horizon are typical of a deoxidized and leached weathering zone and similar to those of the BC horizon.

COMPETING SERIES: These are the Exira, Galva, Keg, Marshall, Monona, Northboro, Ponca, Port Byron, Raddle, Sac, Salix, and Truman series of the same family. All of these soils lack grayish brown, gray, or olive gray matrix colors within depths of 30 inches. In addition, Keg and Salix soils are less acid in the most acid horizons and shallower to free carbonates.

GEOGRAPHIC SETTING: Nira soils are on somewhat short, convex to straight gently and moderately sloping side slopes surrounding the nearly level stable upland divides in the loess-covered pre-Wisconsin till plain. Slope gradients range from 2 to 14 percent. These soils formed in loess 4 to 8 feet thick, which is underlain by a gray clayey (Yarmouth-Sangamon) paleosol formed in glacial till. The soils formed partly in a deoxidized and leached weathering zone that overlies the glacial till. Mean annual temperature is approximately 49 to 52 degrees F; mean annual precipitation is approximately 30 to 34 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Clearfield, Mahaska, Macksburg, Otley, and Sharpsburg soils. Nira soils are downslope from the Mahaska and Macksburg soils and typically upslope from Clearfield, Otley, and Sharpsburg soils. They are most often present on convex side slopes or convex slopes that form the heads (coves) of drainageways rather than concave slopes at the heads (coves) as are Clearfield soils. Clearfield soils lack brown colors as coatings or matrix colors throughout the B horizon and are wet, Mahaska and Macksburg lack brown colors in the upper part of the B horizon, and Otley and Sharpsburg soils lack gray matrix colors within depths of 3 feet.

DRAINAGE AND PERMEABILITY: These soils are moderately well drained. The grayish colors are not considered to be indicative of present drainage conditions. Runoff is medium, and permeability is moderate.

USE AND VEGETATION: Mainly row crops of corn and soybeans with some oats and hay in a rotation. Native vegetation was tall prairie grasses.

DISTRIBUTION AND EXTENT: Southern and southeastern Iowa and possibly states adjoining these areas. The series is of moderate extent.

SERIES ESTABLISHED: Keokuk County, Iowa, 1971.

National Cooperative Soil Survey
U.S.A.

Nira Series, Keokuk County

Horizon	Depth in.	Sand	Coarse Silt	Fine Silt	Clay	pH
Ap	0 - 7	1.69	29.63	34.20	34.48	6.2
A3	7 - 10	1.36	26.98	32.80	34.84	5.6
B21	10 - 17	1.27	28.65	33.60	34.48	5.6
B22	17 - 22	1.15	27.53	36.12	35.20	5.5
B31	22 - 28	1.21	29.95	38.08	30.76	5.9
B32g'	28 - 34	1.32	33.60	36.12	29.56	5.7
B33g'	34 - 42	1.56	32.72	36.40	29.32	5.9

Soil type: Sharpsburg silty clay loam, gray subsoil variant
Soil No.: S55Iowa-1-6
Location: Greenfield Quadrangle; southwest quarter of northest quarter of Sec. 13, T76N, R32W, Adair County, Iowa
Slope: 6 percent straight, slightly convex at right angles
Collected by and date: R.B. Daniels and F.J. Carlisle, November 4, 1955

Horizon and Beltsville Lab. Number	Sample Depth	Description
A1p 56283	0-6	0 to 6 inches. Very dark brown (10YR 2/1.5) weak medium to fine blocky (fragmental), friable, silty clay loam; clear to A12.
A12 56284 56285	6-9 9-12	6 to 12 inches. Very dark brown (10YR 2/2), moderate fine subangular blocky and fine to very fin granular, friable, light to medium silty clay loam; gradual to A3B1.
A3B1 56286	12-15	12 to 15 inches. Mixed very dark brown and dark gray brown (10YR 2/2 and 10YR 4/2.5), moderate fine and very fine subangular blocky, friable, light to medium silty clay loam; gradual to B2.
B2 56287 56288	15-18 18-21	15 to 21 inches. Dark brown (10YR 3/3 to 10YR 35./3) with a few fine faint gray brown and dark yellowish brown (10YR 5/2 and 10YR 4/4) mottles, moderate to weak fine subangular blocky, friable, medium to light silty clay loam; thin discontinuous clay skins; gradual boundary to B3.
B3 56289 56290 56291 56292 56293	21-24 24-27 27-30 30-34 34-38	21 to 38 inches. Dark gray brown (10YR 4/2.5) with common fine and medium gray brown (2.5Y 5/2) and strong brown grading to yellowish red and dark reddish brown mottles, weak to moderate fine and medium blocky, friable, medium to light silty clay loam; thin discontinuous clay skins; diffuse to C1.
C1 56294 56295 56296 56297 56298 56299	38-43 43-48 48-54 54-60 60-66 66-72	38 to 72 inches. Gray brown (2.5Y 5/2) with common prominent strong brown to yellowish red and dark reddish brown mottles, coarse prismatic, moderately friable, light silty clay loam with thin continuous clay skins on vertical prism faces; vertical faces extend to 6 feet and at this depth are very coarse.

Notes: Colors of lower B2 and B3 horizons suggest profile may be less well-drained than S55Iowa-1-2, -4, and -5.

SOIL SURVEY LABORATORY Beltsville, Md

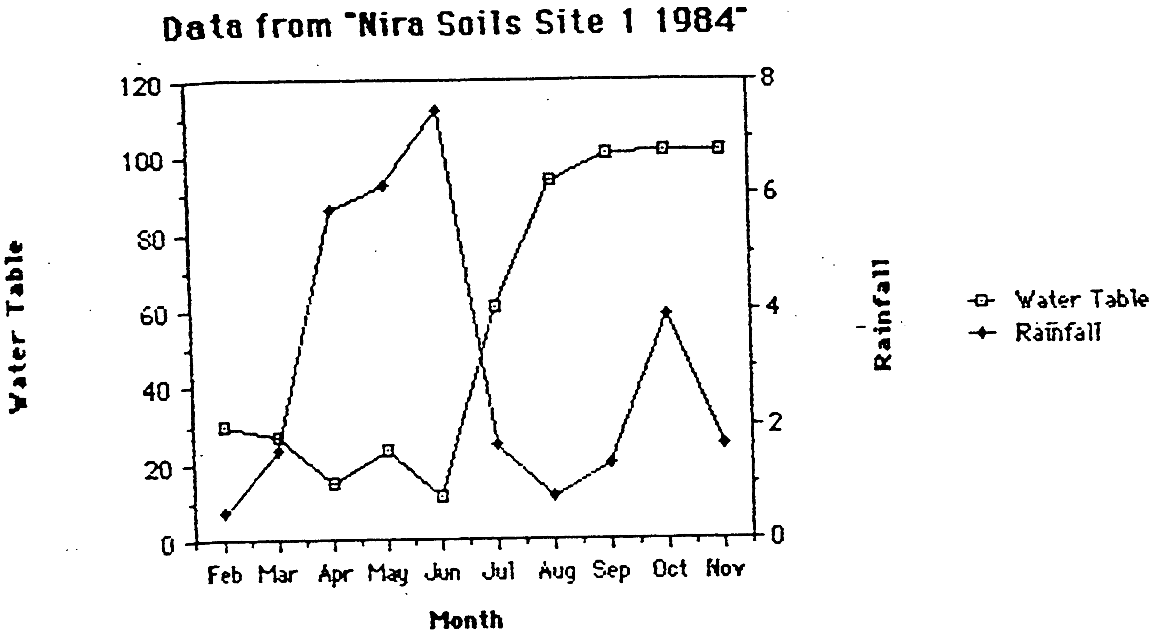
SOIL TYPE Sharpsburg silty clay loam, gray subsoil variant **LOCATION** Adair County, Iowa

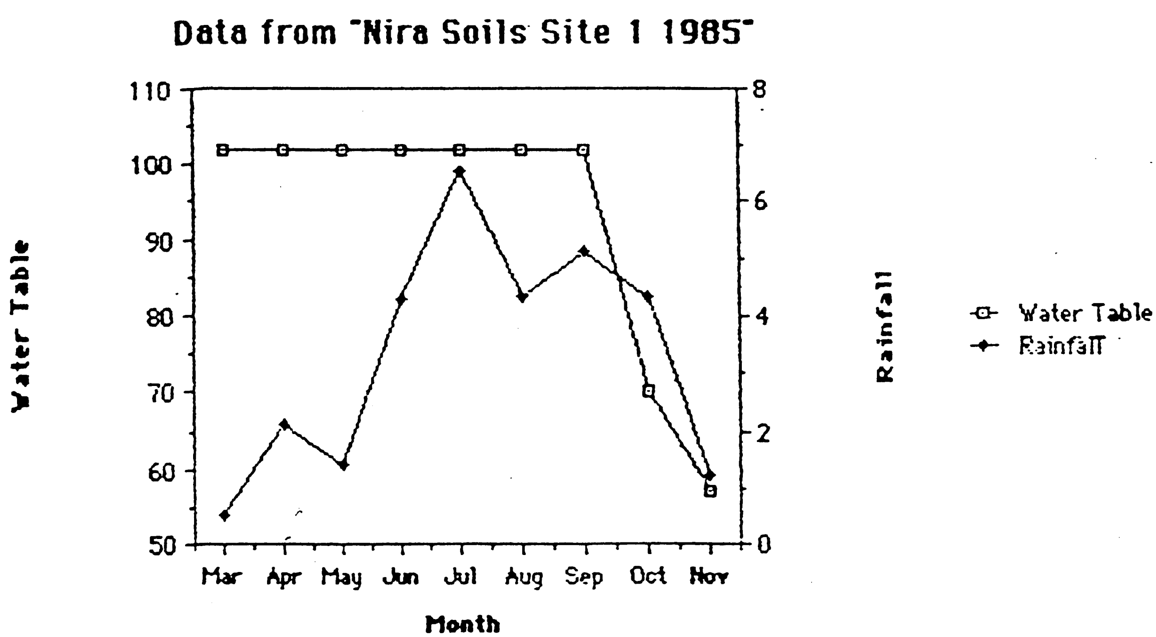
SOIL NOS. S55Iowa-1-6 **LAB. NOS.** 56283 - 56299

DEPTH INCHES	HORIZON	1B1a VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY < 0.002	0.2-0.02	0.02-0.002	> 2	TEXTURAL CLASS
		PARTICLE SIZE DISTRIBUTION 9in mm) (percent) 3A1										
0-6	A1p	0.1	0.2	0.1	0.3	1.8	60.7	36.8	33.8	28.9		
6-9	A12	-	0.1	0.1	0.2	1.0	59.8	38.8	31.3	29.6		
9-12	A12	-	0.1	0.1	0.2	1.1	60.1	38.4	31.6	29.7		
12-15	A3B1	-	0.1	0.1	0.2	1.1	60.7	37.8	31.6	30.3		
15-18	B2	-	0.1	0.1	0.2	1.1	62.4	36.1	31.9	31.6		
18-21	B2	-	0.2	0.1	0.2	1.1	63.4	35.0	32.1	32.5		
21-24	B3	-	0.4	0.2	0.2	1.1	64.5	33.6	31.8	33.9		
24-27	B3	-	0.4	0.4	0.5	1.1	65.6	32.0	32.6	34.4		
27-30	B3	-	0.3	0.2	0.3	1.2	67.3	30.7	33.5	35.2		
30-34	B3	-	0.1	0.1	0.2	1.0	68.8	29.8	35.9	34.0		
34-38	B3	-	0.1	0.1	0.2	1.0	67.7	30.9	34.7	34.1		
38-43	C1	-	0.2	0.2	0.3	1.3	67.9	30.1	35.2	34.2		
43-48	C1	-	0.2	0.1	0.3	1.1	68.8	29.5	35.5	34.6		
48-54	C1	-	0.2	0.2	0.4	1.1	70.8	27.3	36.7	35.4		
54-60	C1	-	0.2	0.2	0.5	1.3	70.8	27.0	39.4	33.0		
60-66	C1	-	0.3	0.3	0.8	1.9	69.3	27.4	38.4	33.3		
66-72	C1	-	0.1	0.2	0.5	1.2	69.8	28.2	17.6	33.7		

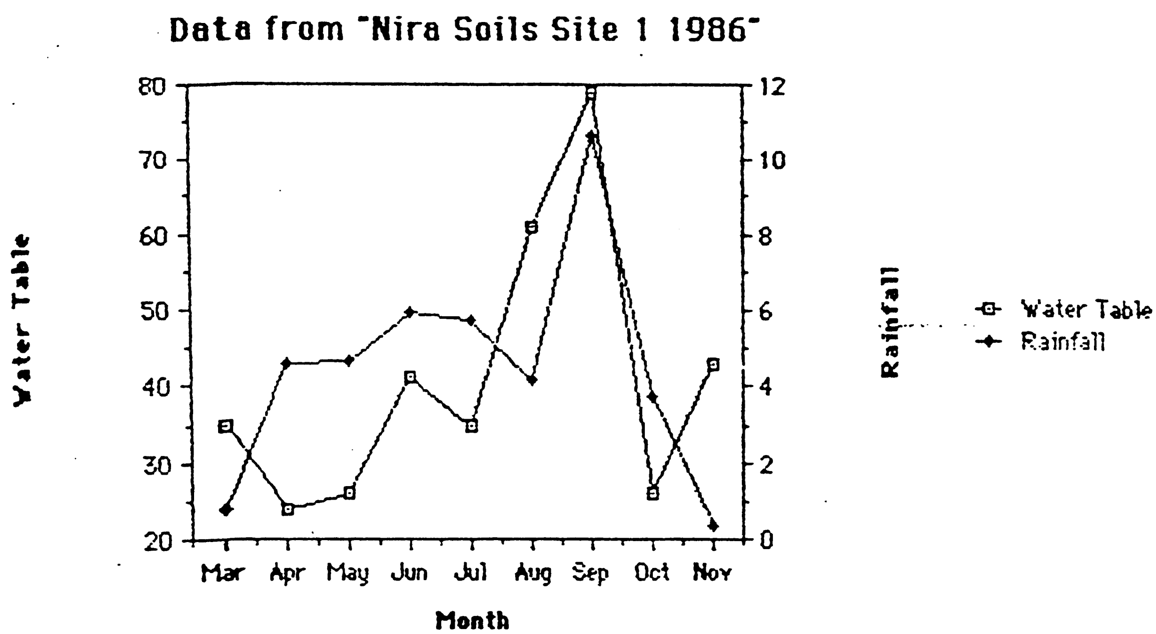
pH 8C1a 1:1	pH 1:5	pH 1:10	ORGANIC MATTER 6A1a ORGANIC CARBON %	6B1a NITROGEN %	C/N	EST% SALT (BUREAU CUP)	Electrical Conductivity EC - 10^3 millimhos per cm @25°C	$CaCO_3$ equivalent %	GYPSUM mg/100g SOIL	MOISTURE TENSIONS 1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %
5.7			2.15	.201	10.7							
5.6			1.80	.154	11.7							
5.7			1.48	.131	11.3							
5.8			1.16	.106	10.9							
5.8			0.74	.074	10.0							
6.0			0.59	.064	9.2							
6.2			0.47	.054	8.7							
6.2			0.38	.044	8.6							
6.5			0.31	.036	8.6							
6.6			0.23	.032								
6.6			0.20	.030								
6.7			0.19	.029								
6.9			0.16	.027								
7.0			0.14	.024								
7.0			0.12	.023								
7.1			0.12	.023								
6.9			0.12	.023								

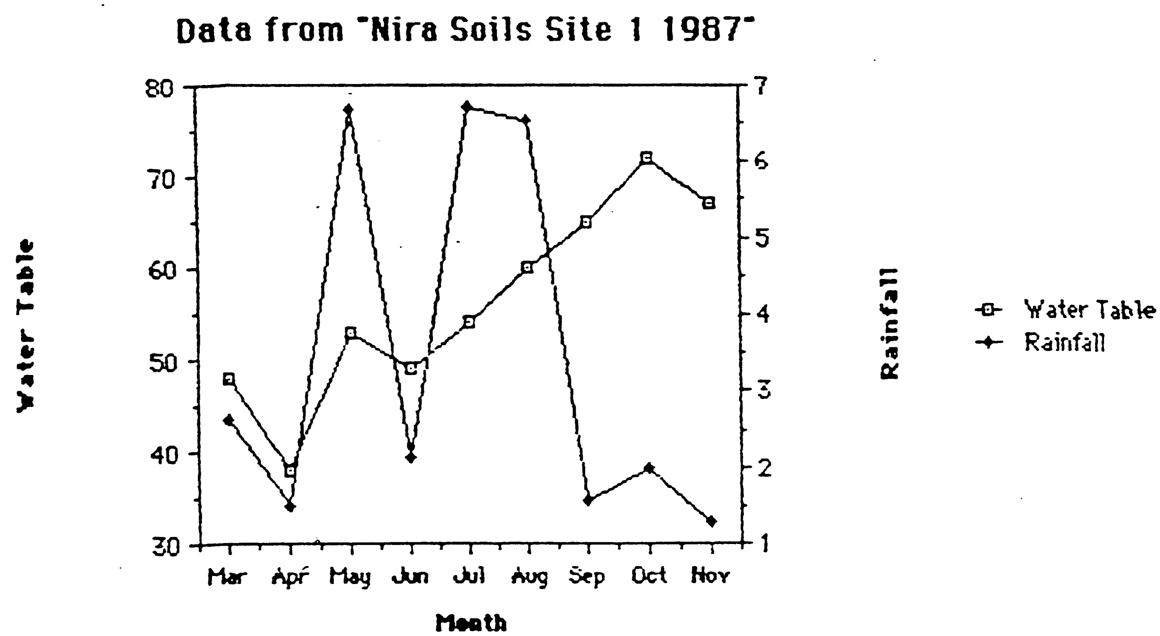
5A3a Cation Exchange Capacity Sum	EXTRACTABLE CATIONS 6N2b Ca	6O2b Mg	6H1a H	6P2a Na	5B1a 6Q2a K	5C3 Base Sat. % on Sum Cations	SATURATION EXTRACT SOLUBLE Na	K				MOISTURE AT SATURATION %
	← milliequivalents per 100g. soil →						← milliequivalents per liter →					
33.6	15.1	6.7	11.0	0.1	0.7	67						
33.5	14.6	7.5	10.5	0.3	0.7	68						
34.7	15.5	7.7	10.3	0.4	0.8	70						
32.4	15.1	7.9	8.7	0.3	0.4	73						
31.7	15.3	8.3	7.2	0.3	0.6	77						
32.0	15.5	8.7	6.9	0.3	0.6	78						
30.3	15.6	8.5	5.4	0.2	0.6	82						
31.0	15.8	8.7	5.6	0.3	0.6	82						
28.0	15.5	7.9	4.1	0.2	0.6	85						
26.9	15.1	7.9	3.1	0.2	0.6	88						
26.9	15.0	8.1	2.9	0.3	0.6	89						
26.0	15.5	8.1	2.8	0.3	0.6	90						
26.4	15.1	7.8	2.6	0.3	0.6	90						
26.1	15.0	7.7	2.5	0.3	0.6	90						
25.7	14.8	7.9	2.1	0.3	0.6	92						
26.2	14.4	7.7	2.3	0.2	0.6	91						
25.1	14.9	7.7	1.6	0.3	0.6	94						





Ringgold County water tables for Nira and Sharpsburg soils 1984-1987


Data from "Nira Soils Site 1 1986"
Water Table
Rainfall
Month
Mar Apr May Jun Jul Aug Sep Oct Nov
-□- Water Table
-♦- Rainfall


Data from "Nira Soils Site 1 1987"
Water Table
Rainfall
Month
Mar Apr May Jun Jul Aug Sep Oct Nov
-□- Water Table
-♦- Rainfall

LOCATION SHARPSBURG IA+KS MO NE

Established Series
Rev. FFR-RJK-DBO
10/89

SHARPSBURG SERIES

The Sharpsburg series consists of deep, moderately well drained soils formed in loess on uplands and high benches. Permeability is moderately slow in the upper part and moderate in the lower part. Slope ranges from 0 to 18 percent. Mean annual temperature is about 51 degrees F, and mean annual precipitation is about 32 inches.

TAXONOMIC CLASS: Fine, montmorillonitic, mesic Typic Argiudolls

TYPICAL PEDON: Sharpsburg silty clay loam with a convex slope of 8 percent - cultivated. (Colors are for moist soil unless otherwise stated.)

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; friable; few fine roots; slightly acid; abrupt smooth boundary.

A1—8 to 11 inches; very dark brown (10YR 2/2) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A2—11 to 17 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; some brown (10YR 4/3) peds; moderate very fine subangular blocky structure; friable; medium acid; gradual smooth boundary. (Combined thickness of the A horizons is 10 to 24 inches.)

Bt1—17 to 24 inches; brown (10YR 4/3) silty clay loam; very dark gray (10YR 3/1) coatings on faces of peds; moderate fine subangular blocky structure parting to weak fine subangular blocky; firm; common distinct very dark grayish brown (10YR 3/2) clay films; very few fine roots; medium acid; gradual smooth boundary.

Bt2—24 to 31 inches; brown (10YR 4/3) and yellowish brown (10YR 5/4) silty clay loam; few fine prominent light brownish gray (2.5Y 6/2 mottles; weak medium prismatic structure parting to moderate fine subangular blocky; firm; many distinct dark grayish brown (10YR 4/2) clay films; very few fine and medium roots; few fine dark concretions (iron and manganese oxides); medium acid; gradual smooth boundary.

Bt3—31 to 38 inches; brown (10YR 5/3) silty clay loam; common medium distinct light brownish gray (2.5Y 6/2) and strong brown (7.5YR 5/6) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; many prominent grayish brown (10YR 5/2) clay films; few fine dark concretions (iron and manganese oxides); medium acid; gradual smooth boundary. (Combined thickness of the Bt horizons is 21 to 38 inches.)

BC—38 to 46 inches; yellowish brown (10YR 5/4) silty clay loam; many fine and medium distinct grayish brown (2.5Y 5/2) and common medium prominent strong brown (7.5YR 5/8) mottles; weak medium prismatic structure; firm; common distinct grayish brown (10YR 5/2) clay films; few fine dark concretions (iron and manganese oxides); medium acid; gradual smooth boundary. (4 to 10 inches thick)

C—46 to 60 inches; mottled grayish brown (2.5Y 5/2), yellowish brown (10YR 5/4), strong brown (7.5YR 4/4) silty clay loam; massive; firm; very few fine roots; common fine dark concretions (iron and manganese oxides); slightly acid.

TYPE LOCATION: Taylor County, Iowa; about 8 miles north and 5 miles east of Bedford; 1870 feet east and 540 feet south of the Northwest corner, sec. 10, T. 69 N., R. 33 W.

RANGE IN CHARACTERISTICS: Solum thickness typically is 36 to 72 inches thick. Thickness of the A horizon, depth to clay maximum, maximum percent clay, thickness of the Bt horizon, depth to grayish mottles, and solum thickness decrease as gradient increases on convex slopes. The solum is medium acid or strongly acid in the most acid part.

The Ap horizon has value of 2 or 3 and value of 1 or 2. The A1 and A2 horizons have value and chroma of 2 or 3. The A horizon ranges from 25 to 34 percent clay.

The upper part of the Bt horizon has value of 4 or 5, and chroma of 3 or 4 and contains 36 to 42 percent clay. Pedons having colors in the matrix of 5 or 6 value and 2 chroma at depths of less than 32 inches are outside the range of the Sharpsburg series.

The lower part of the Bt horizon, the BC horizon, and the C horizon have hue of 7.5YR to 5Y, value of 4 through 6, and chroma of 2 through 6. The C horizon is silty clay loam or silt loam.

COMPETING SERIES: These are the Gymer, Oska, Otley, Polo, and Wenona series. Similar soils are the Grundy, Macksburg, and Wymore soils. Gymer and Oska soils have 7.5YR or 5YR hue in the Bt horizon. In addition, Oska soils have a lithic contact within depths of 40 inches. Otley soils have less organic carbon in the upper part of the B horizon, are typically not so deep to neutral reaction, and contain less total phosphorus and potassium. Polo soils have 7.5YR and 5YR hue in the lower part of the B horizon. Wenona soils have a higher content of sand in the lower part of the solum formed in glacial till. Grundy and Macksburg soils have lower chroma, mottles, or both in the upper part of the B horizon. Also, Grundy soils have 42 to 48 percent clay in the upper 20 inches of the argillic horizon. Wymore soils have 2.5Y or yellower hue, dominant chroma of 2 in the B horizon, and contain more clay.

GEOGRAPHIC SETTING: Sharpsburg soils are on convex ridgetops, upland divides, and convex side slopes and on high benches. Typically, they are on narrow ridgetops having slopes of 2 to 9 percent gradient. The full range of slope is from 0 to 18 percent. Sharpsburg soils formed in 6 to 14 feet of loess that contains less than 5 percent sand. Mean annual temperature ranges from about 47 to 58 degrees F, and mean annual precipitation ranges from about 28 to 32 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: The somewhat poorly drained Macksburg soils and the poorly drained Winterset soils form a drainage sequence with the Sharpsburg soils and commonly are on the more nearly level parts of the landscape. Adair, Clarinda, Lamoni, Pawnee, and Shelby soils are on adjoining lower parts of the landscape. They formed in till or in paleosols formed in till. Judson soils are on foot slopes downslope and formed in local colluvium. Clearfield and Nira soils are nearby at about the same elevations and have a grayish B horizon.

DRAINAGE AND PERMEABILITY: Moderately well drained. Surface runoff is medium to rapid. Permeability is moderately slow in the upper part of the subsoil and moderate in the lower part and in the substratum.

USE AND VEGETATION: Commonly used for growing cultivated crops. Corn, soybeans, small grains, and hay are grown. Native vegetation was tall prairie grasses.

DISTRIBUTION AND EXTENT: Southwestern Iowa, northwestern Missouri, northeastern Kansas, and southeastern Nebraska. They are extensive.

SERIES ESTABLISHED: Lancaster County, Nebraska, 1944.

REMARKS: Diagnostic horizons and features recognized in this pedon are: mollic epipedon - the zone from the surface to a depth of 17 inches (Ap, A1, and A2 horizons); argillic horizon - the zone from 17 inches to a depth of 38 inches (Bt1, Bt2, and Bt3 horizons); udic moisture regime.

National Cooperative Soil Survey
U.S.A.

Sharpsburg Series, Taylor County

Sample No.	Depth in.	Sand	Coarse Silt	Fine Silt	Clay	pH
46312	0 - 8	2.2	31.6	35.5	30.7	6.4
46313	8 - 13	1.9	28.6	34.0	35.5	6.4
46314	13 - 17	2.2	25.9	35.5	36.4	6.1
46315	17 - 24	2.3	25.1	36.1	36.5	5.8
46316	24 - 31	2.0	23.6	35.8	38.6	5.6
46317	31 - 38	1.7	24.1	36.0	38.2	5.7
46318	36 - 46	1.7	25.9	36.2	36.2	6.0
46319	46 - 60	1.8	22.9	39.4	35.9	5.9

Soil type: Sharpsburg silty clay loam
Soil No.: S55Iowa-1-5
Location: Greenfield Quadrangle; northeast corner of southeast quarter of northeast quarter of southeast quarter of Sec. 18, T76N, R31W, Adair County, Iowa
Slope: 2 percent straight, slightly convex at right angles to slope direction
Collected by and date: R.B. Daniels and F.J. Carlisle, November 5, 1955

Horizon and Beltsville Lab. Number	Sample Depth	Description
A1p 56266	0-6	0 to 6 inches. Very dark brown (10YR 2/1.5) cloddy, breaking to fine granular, friable, light silty clay loam; clear to A12.
A12 56267 56268	6-9 9-12	6 to 12 inches. Very dark gray to black (10YR 2.5/1) weak medium granular, friable, light to medium silty clay loam; gradual to A3B1.
A3B1 56269	12-15	12 to 15 inches. Very dark brown (10YR 2/2) with some mixing of dark brown (10YR 3.5/3), moderate fine subgranular blocky, friable, medium silty clay loam; gradual to B21.
B21 56270	15-19	15 to 19 inches. Dark brown (10YR 3/3) with about 25 percent very dark gray brown and very dark gray (10YR 3/2 and 10YR 3/1), moderate fine subangular blocky, moderately friable, silty clay loam; thin continuous clay skins; gradual boundary to B22.
B22 56271 56272 56273	19-22 22-26 26-30	19 to 30 inches. Dark brown (10YR 3/3) moderate fine subangular blocky, moderately firm, silty clay loam; thin continuous clay skins; few fine faint mottles in lower three inches; gradual boundary to B3.
B3 56274 56275 56276 56277	30-33 33-36 36-39 39-43	30 to 43 inches. Dark brown (10YR 3/3) grading with depth to dark brown (10YR 4/2) with common fine gray brown (2.5Y 5/2) and strong brown mottles, moderate to strong (dry), medium blocky, moderately firm, light to medium to silty clay loam; gradual diffuse to C1.
C1 56278 56279 56280 56281 56282	43-48 48-54 54-60 60-66 66-72	43 to 72 inches. Mottled yellowish brown and gray brown (10YR 5/4 and 2.5Y 5/2) with common very fine dark oxides, massive, friable, heavy silt loam to light silty clay loam; thin continuous clay skins on vertical cleavage faces to a depth of about 50 inches.

SOIL SURVEY LABORATORY Beltsville, Md

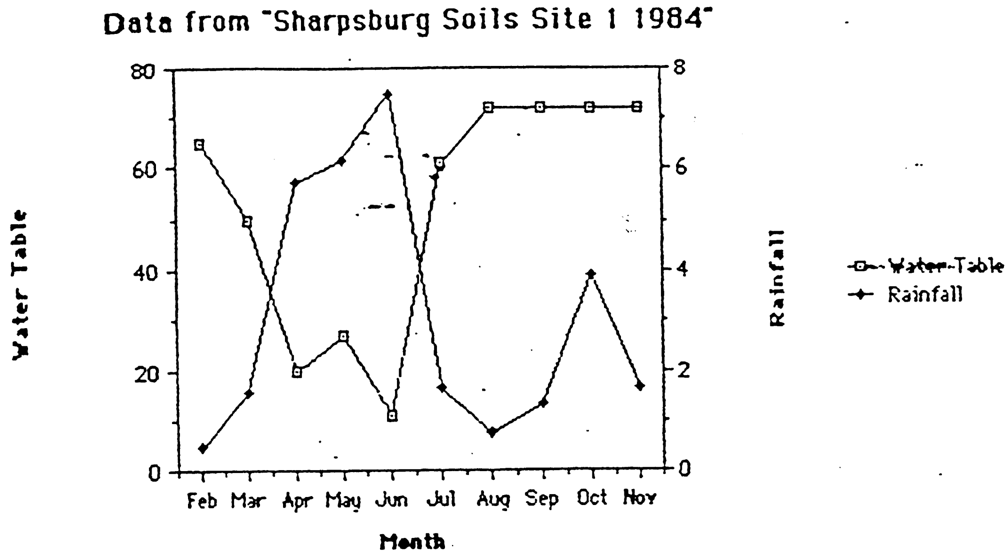
SOIL TYPE Sharpsburg silty clay loam **LOCATION** Adair County, Iowa

SOIL NOS. S55Iowa-1-5 **LAB. NOS.** 56266 - 56282

DEPTH INCHES	HORIZON	1B1a VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY < 0.002	0.2-0.02	0.02-0.002	> 2	TEXTURAL CLASS
		PARTICLE SIZE DISTRIBUTION 9in mm) (percent) 3A1										
0-6	Alp	0.1	0.3	0.3	0.5	1.2	64.5	33.1	35.9	30.1		
6-9	A12	-	0.2	0.2	0.4	1.1	62.3	35.8	33.1	30.5		
9-12	A12	-	0.2	0.2	0.5	1.1	61.2	36.8	31.4	31.2		
12-15	A3B1	0.1	0.3	0.2	0.4	1.2	59.8	38.0	29.8	31.4		
15-19	B21	-	0.2	0.2	0.4	0.9	59.7	38.6	30.7	30.1		
19-22	B22	-	0.2	0.2	0.4	0.9	59.5	38.8	29.1	31.5		
22-26	B22	-	0.1	0.2	0.3	1.1	60.3	38.0	29.7	31.9		
26-30	B22	-	0.1	0.1	0.3	1.3	61.1	37.1	31.4	31.2		
30-33	B3	-	0.1	0.1	0.2	1.3	63.6	34.7	33.1	31.9		
33-36	B3	-	0.2	0.2	0.4	1.4	64.2	33.6	34.8	31.0		
36-39	B3	-	0.1	0.1	0.3	1.3	64.0	34.2	32.2	33.3		
39-43	B3	-	0.1	0.2	0.4	1.4	65.0	32.9	34.9	31.7		
43-48	C1	-	0.1	0.2	0.4	1.4	64.7	33.2	34.0	32.3		
48-54	C1	-	0.1	0.1	0.3	1.2	66.0	32.3	33.9	33.5		
54-60	C1	-	0.2	0.2	0.5	1.3	67.3	30.5	31.5	37.4		
60-66	C1	-	0.1	0.2	0.5	1.5	68.6	29.1	35.9	34.5		
66-72	C1	-	0.1	0.2	0.6	1.1	69.7	28.3	34.5	36.7		

pH 8C1a 1:1	1:5	1:10	ORGANIC MATTER 6A1a ORGANIC CARBON %	6B1a NITROGEN %	C/N	EST% SALT (BUREAU CUP)	Electrical Conductivity EC - 10^3 millimhos per cm @25°C	$CaCO_3$ equivalent %	GYPSUM mg/100g SOIL	MOISTURE TENSIONS 1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %
6.4			2.16	.194	11.1							
5.2			1.99	.180	11.0							
5.3			1.75	.152	11.5							
5.4			1.44	.125	11.5							
5.6			1.08	.095	11.4							
5.8			0.80	.073	11.0							
5.8			0.61	.060	10.2							
5.8			0.44	.048	9.2							
5.7			0.37	.042	8.8							
5.7			0.31	.040	7.8							
5.9			0.27	.033	8.2							
5.9			0.23	.034								
5.8			0.21	.030								
6.2			0.16	.027								
6.0			0.15	.025								
6.3			0.14	.024								
6.2			0.16	.024								

5A3a Cation Exchange Capacity Sum	EXTRACTABLE CATIONS 6N2b Ca	6O2b Mg	6H1a H	6P2a Na	5B1a 6Q2a K	5C3 Base Sat. % on Sum Cations	SATURATION EXTRACT SOLUBLE Na	K				MOISTURE AT SATURATION %
	← milliequivalents per 100g. soil →						← milliequivalents per liter →					
30.1	16.7	4.7	7.9	-0.1	0.8	73						
29.5	12.2	5.1	11.6	-0.1	0.6	61						
29.4	12.2	5.8	10.8	-0.1	0.6	63						
30.0	12.9	6.6	9.8	0.1	0.6	67						
31.3	13.8	7.7	9.2	0.1	0.5	71						
32.0	14.8	8.6	7.7	0.3	0.6	76						
31.9	15.2	8.8	7.2	0.2	0.5	77						
31.6	15.5	9.1	6.2	0.2	0.6	80						
30.8	15.2	8.8	6.1	0.2	0.5	80						
30.1	14.9	8.6	5.9	0.2	0.5	80						
30.4	15.2	8.8	5.7	0.2	0.5	81						
31.0	15.9	8.8	5.4	0.3	0.6	82						
30.7	15.9	8.8	5.1	0.4	0.5	83						
30.2	15.9	8.8	4.3	0.6	0.6	86						
29.9	15.4	8.4	4.3	1.3	0.5	86						
28.4	15.0	8.4	3.9	0.6	0.5	86						
26.6	14.2	8.0	3.4	0.4	0.6	87						


Data from "Sharpsburg Soils Site 1 1984"
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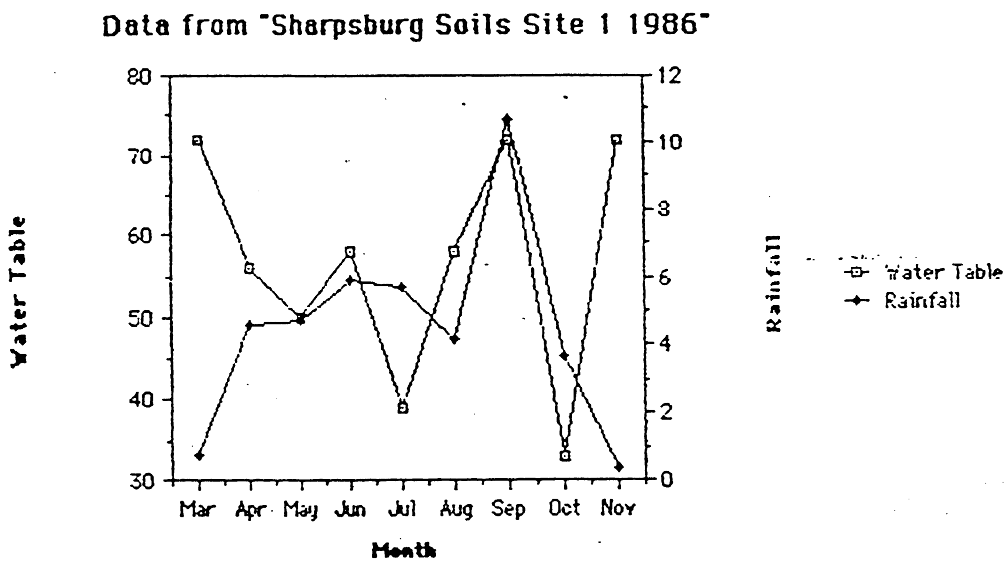
60
40
20
0
8
6
4
2
0
Water Table
Rainfall
Feb Mar Apr May Jun Jul Aug Sep Oct Nov
Month
Water Table
Rainfall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30
12
10
8
6
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Water Table
Rainfall
Mar Apr May Jun Jul Aug Sep Oct Nov
Month
Water Table
Rainfall

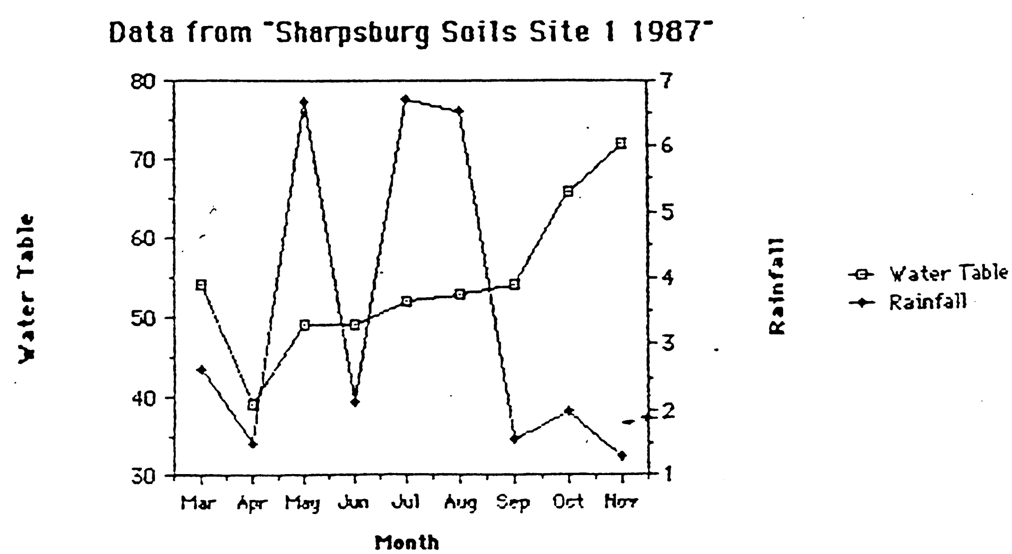

Data from "Sharpsburg Soils Site 1 1987"
80
70
60
50
40
30
7
6
5
4
3
2
1
Water Table
Rainfall
Mar Apr May Jun Jul Aug Sep Oct Nov
Month
Water Table
Rainfall

Table IA10: Sharpsburg silty clay loam, Adair County, Iowa (from Ruhe, 1984)

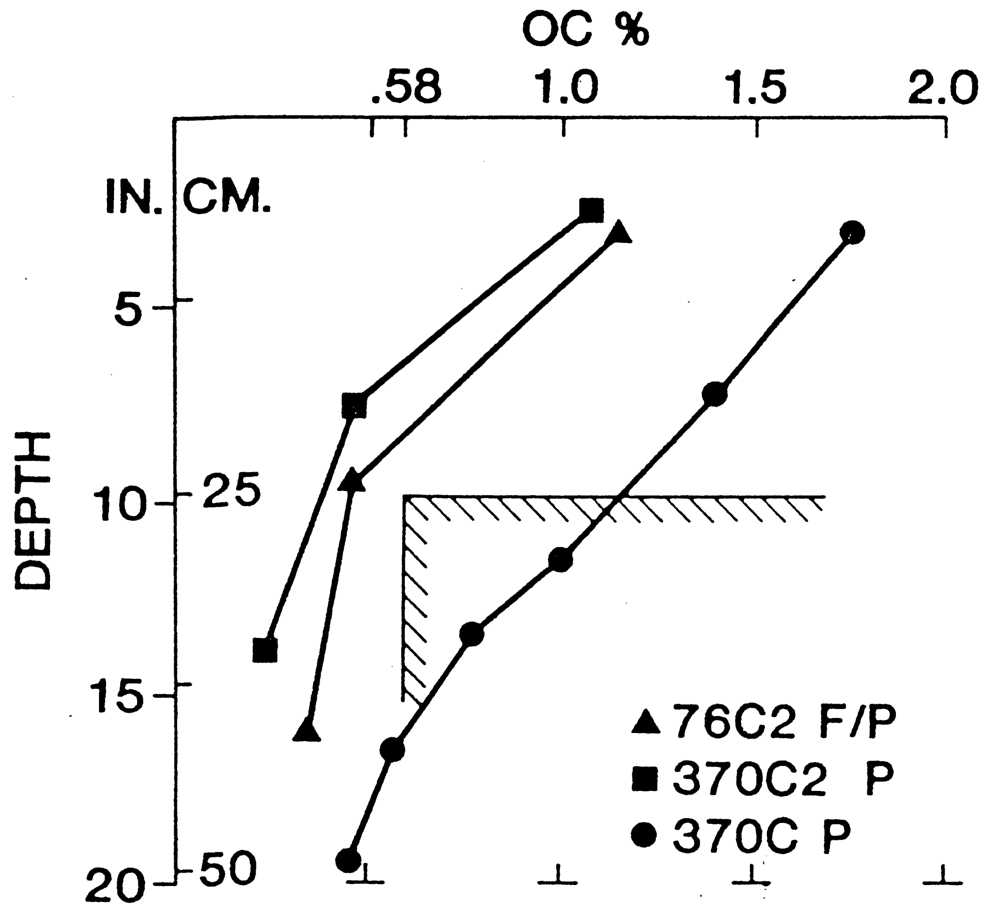
Sample	Depth (in)	Depth (cm)	Horizon	Description
IA10-1	0-9	0-23	A11	10YR 2/1 sicl, wfgr, fri, com roots
2	9-18	23-46	A12	10YR 2/2 sicl, wfgr, fri, com roots
3	18-27	46-69	AB	10YR 3/3 sicl, wfsab, sl fir, com roots
4	27-36	69-91	B21	10YR 4/3 sicl, mmsab, sl fir, com wcs, sp roots
5	36-45	91-114	B22	10YR 4/2 sicl, mmsab to mmpr, fir, com wcs on peds and pr, w/10YR 4/4 Fe stn
6	45-55	114-140	B3	10YR 6/2 sicl, wmpr, sl fir, w/sp wcs on pr, w/com 7.5YR 4/6 mots
7	55-66	140-168	C(OL)	2.5Y 5/2 sicl, mass, sl fir, w/com 10YR 4/6 mots
8	66-78	168-198		Same
9	78-90	198-229		Same
10	90-105	229-267		Same but finely laminated, bedded
11	105-120	267-305		2.5Y 5/2 and 10YR 4/4 sicl, wf lam, fri
12	120-135	305-343	(DL)	2.5Y 5/2 sil, mass, fri, w/hard 7.5YR 4/6 Fe pipestems
13	135-150	343-381		Same
14	150-165	381-419		Same
15	165-170	419-432	F	7.5YR 4/2 sicl, mass, dense, w/7.5YR 4/6 Fe stn and charcoal specks, Farmdale soil
16	170-182	432-462	YSB	7.5YR 3/2 sicl, smsab, fir, com scs, w/7.5YR 4/6 Fe stn, Yarmouth-Sangamon soil
17	182-186	462-472		Same but clay texture
18	186-196	472-500		Same

Table IA10 continued: Sharpsburg silty clay loam, Adair County, Iowa

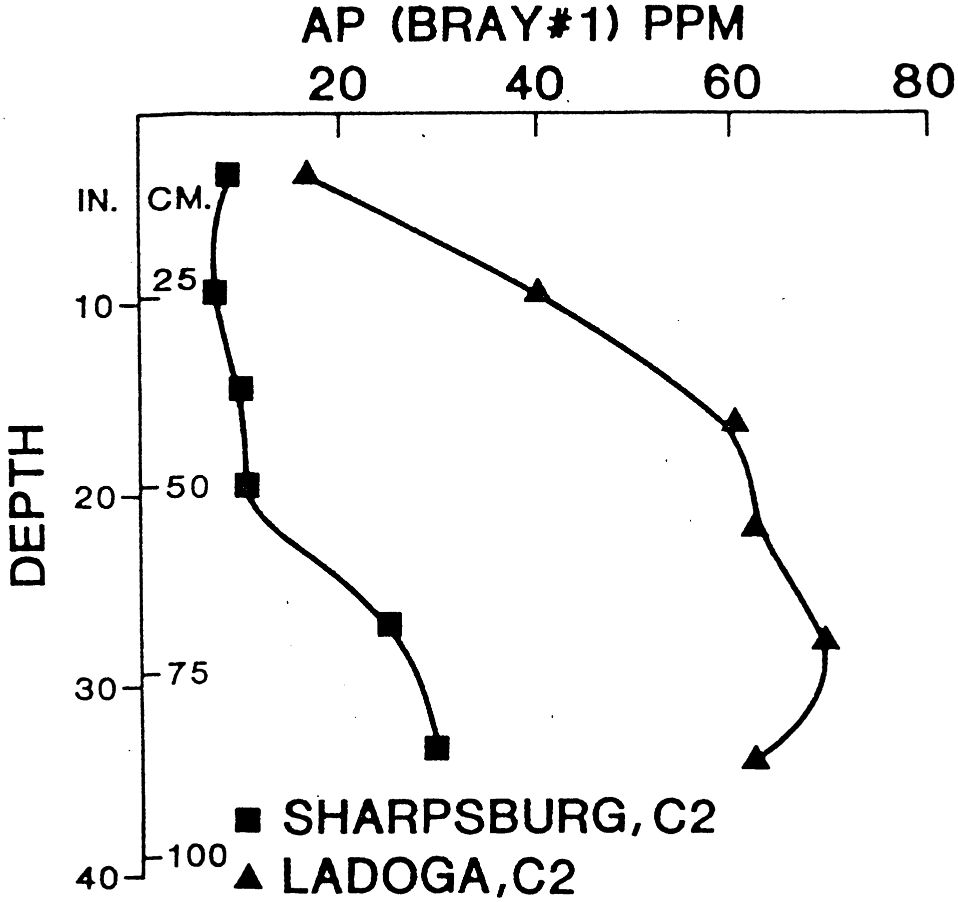
Horizon	Depth (in)	Depth (cm)	Particle-size <2μm (%)	2-16μm	16-62μm	>62μm	Clay Minerals K (%)	I	X	X_{14} (%X)	X_{17}
IA10-1	0-9	0-23	31.8	23.8	43.6	0.8	15	52	33	22	78
2	9-18	23-46	32.3	25.1	41.8	0.8	12	33	55	20	80
3	18-27	46-69	31.7	25.7	41.8	0.8	13	24	63	8	92
4	27-36	69-91	34.6	23.6	40.2	1.2	7	21	72	6	94
5	36-45	91-114	31.9	24.1	42.9	1.1	7	19	74	8	92
6	45-55	114-140	30.8	24.4	43.7	1.2	8	19	73	10	90
7	55-66	140-168	30.3	27.5	40.9	1.4	4	16	80	4	96
8	66-78	168-198	28.4	24.5	46.3	0.9	5	18	77	6	94
9	78-90	198-229	27.4	27.2	44.6	0.8	6	20	74	7	93
10	90-105	229-267	28.5	28.2	42.2	1.2	5	17	78	6	94
11	105-120	267-305	29.3	26.9	43.2	0.6	5	17	78	5	95
12	120-135	305-343	26.6	25.4	47.2	0.8	4	20	76	3	97
13	135-150	343-381	25.9	24.1	47.8	2.2	6	18	76	5	95
14	150-165	381-419	26.8	26.9	44.9	1.4	5	15	80	3	97
15	165-170	419-432	28.5	31.5	39.6	0.4	5	16	79	5	95
16	170-182	432-462	32.3	31.5	35.3	0.9	7	17	76	8	92
17	182-186	462-472	41.8	25.5	30.9	1.9	12	18	70	13	87
18	186-196	472-500	44.0	26.9	27.6	1.5	14	19	67	5	95

Table IA10 continued: Sharpsburg silty clay loam, Adair County, Iowa

Horizon	pH (1:1)	Extractable Bases Ca	Mg	Na	K	H	CEC	Base saturation NH_4O AC	Sum	Extract Fe	Organic C	$CaCO_3$
		(me/100g)								(%)		
IA10-1	5.9	12.56	4.40	.06	1.89	11.35	25.20	75	63	.73	2.95	
2	5.8	11.58	5.89	.08	0.89	10.26	25.33	73	64	.73	1.66	
3	5.6	12.63	7.71	.13	0.61	8.75	24.76	85	71	.72	.89	
4	5.7	14.83	9.30	.20	0.64	8.17	28.68	87	75	.85	.50	
5	5.8	14.93	9.13	.24	0.62	6.51	27.24	92	79	.75	.27	
6	5.8	14.91	8.93	.28	0.60	6.25	26.00	95	80	.71	.15	
7	5.9	14.80	9.14	.33	0.62	4.97	26.65	93	83	.61		
8	6.1	15.00	8.79	.33	0.63	4.58	26.60	93	84	.64		
9	6.3	14.65	8.56	.31	0.58	4.05	24.59	98	86	.57		
10	6.2	15.04	8.77	.31	0.62	4.05	25.37	98	86	.60		
11	6.1	14.82	8.70	.33	0.64	4.44	25.54	96	85	.63		
12	6.2	14.29	8.22	.31	0.64	4.15	24.65	95	85	.63		
13	6.1	13.62	7.83	.27	0.51	3.36	23.14	96	87	.59		
14	6.1	14.24	8.05	.29	0.56	3.14	23.91	97	88	.49		
15	6.2	15.37	8.49	.28	0.47	3.41	24.07	100+	88	.43		
16	6.3	15.94	8.34	.27	0.45	4.20	27.01	93	86	.32		
17	6.2	17.80	9.40	.26	0.49	5.07	29.67	94	85	.47		
18	6.1	18.90	8.54	.27	0.49	4.71	30.81	92	86	.32		



Depth distribution of organic carbon for units 370 Sharpsburg (prairie) and 76 Ladoga (transition) on 5 to 9% slopes, moderately eroded



Depth distribution of available phosphorus for units 370 Sharpsburg (prairie) and 76 Ladoga (transition) on 5 to 9% slopes, moderately eroded

Comparison of Percolation Test Results and Estimated Hydraulic Conductivities for Mollisols and Alfisols

THOMAS J. BICKI,* THOMAS E. FENTON, HARVEY D. LUCE, AND THOMAS A. DEWITT

ABSTRACT

Percolation tests were performed on an array of biosequences, topo-drainage sequences, and stage of profile development sequences of soils in Iowa and results were compared to estimated subsoil hydraulic conductivities from Soil Interpretation Records. Within a biosequence, Mollisols had higher percolation rates and lower coefficients of variation than Alfisols. The difference in permeability was attributed to higher subsoil clay content, higher subsoil bulk density, more continuous argillans, and stronger subsoil consistence in Alfisols. High coefficients of variation for percolation rates in Alfisols were attributed to large diameter root channels, lateral flow of water on sloping sites, and increased distinctness of subsoil horizon boundaries. Percolation rates of Mollisols commonly exceed Soil Interpretation Records' estimates of hydraulic conductivity by a factor of two or three while percolation rates of Alfisols approximate estimated subsoil hydraulic conductivity. In soils without argillic horizons, percolation test results of topo-drainage sequences are similar and reflect similar morphological characteristics. Soil Interpretation Records assign slower estimated hydraulic conductivity to some topo-drainage sequences as drainage becomes more restrictive. Percolation rates decreased in topo-drainage sequences of soils with argillic horizons as drainage became more restrictive, even though morphological characteristics were quite similar. Differences in percolation rates within topo-drainage sequences may reflect errors inherent in the procedure. Additional permeability data is needed to quantify and more accurately estimate subsoil hydraulic conductivity. Criteria used to establish estimated hydraulic conductivity in Soil Interpretation Records should be applied consistently among biosequences and topo-drainage sequences.

DESPITE ITS LIMITATIONS (Franzmeier et al., 1964; McGauhey and Krone, 1967; Bouma, 1971, 1973; Winneberger, 1972; Mellen, 1973; Healy and Laak, 1973) the percolation test remains the most widely used method of predicting site suitability and determining absorption field size for on-site sewage disposal systems (OSDS) (Winneberger, 1984). More precise and accurate methods are available to determine soil permeability but limitations of technical expertise, time, and expense often restrict their usage (Anderson and Bouma, 1977; Fritton et al., 1986).

T.J. Bicki, Dep. of Agronomy, Univ. of Illinois, Urbana-Champaign; T.E. Fenton, Dep. of Agronomy, Iowa State Univ., Ames; H.D. Luce, Plant Science Dep., Univ. of Connecticut, Storrs; and T.A. DeWitt, Soil Scientist, USDA-SCS, Springfield, MO. Contribution from the Iowa Agric. Exp. Stn. Received 13 July 1987. *Corresponding author.

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Numerous studies have indicated a relationship between percolation rates and soil characteristics (McGauhey and Krone, 1967; Derr et al. 1969; Persinger and Yahner, 1970; Healy and Laak, 1973; Lewis, 1975; Barbarick et al., 1976).

The percolation test has been described as a three-dimensional infiltration measurement, generally performed under unsaturated soil conditions with a variable hydraulic head (Chan, 1976; Hill, 1966). Bouma (1971) indicated that percolation rates varied considerably from saturated hydraulic conductivities because the percolation of water through the bottom and sidewalls of test holes is determined by flow patterns with undefined boundary conditions in a relatively large volume of soil with a hydraulic head greater than unity.

Percolation rates have been compared to hydraulic conductivity values determined by the double-tube method, (Bouma, 1971); core method, (Winneberger, 1974); and shallow well pump-in method (Fritton et al., 1986). Linear regression analysis of the resulting pairs of data have yielded prediction equations to estimate hydraulic conductivity from percolation rate. A site evaluation model developed by Fritton et al. (1982; 1986) utilizes percolation rates to calculate saturated hydraulic conductivity values.

Morris et al. (1962), Olson (1964), Huddleston and Olson (1967), and Bouma (1974) have suggested that soil survey information can be more accurate than percolation test results in assessing suitability of soils for OSDS. Permeability of the soil is a prerequisite for designing and sizing the absorption field after site suitability is established, however. Soil survey reports provide estimates of saturated hydraulic conductivity and assign permeability classes for selected horizons or depths for each soil series (Table 1). Saturated hydraulic conductivity is estimated on the basis of soil morphology and physical properties (Soil Conservation Service, 1978). Examination of estimated hydraulic conductivity values in soil survey reports in Iowa, leads one to conclude that the influence of native vegetation and natural soil drainage class on subsoil hydraulic conductivity, was either disregarded or not applied consistently. Percolation rates have been found to be correlated with native vegetation and natural soil drainage class in Iowa (Bicki, 1977; Luce, 1973).

The objectives of this study were to: (i) evaluate test holes. Test holes containing large-diameter root channels were found to transmit water at appreciably greater rates. Higher coefficients of variation in transition and forest end-members of biosequences located on sloping sites are related to lateral subsurface flow of water from upslope test holes to downslope test holes. The increased coefficients of variation in transition members and forest end-members of biosequences may also be related to the distinctness of subsoil horizon boundaries (Table 5). Alfisols were found to have more distinct horizon boundaries in the subsoil than Mollisols. Placement of the test zone in the same horizon becomes more critical as distinctness of boundaries increase because physical properties such as clay content, consistence, and bulk density change over a shorter vertical distance.

No significant differences were found in percolation rates among prairie (Mollisol) end-members and transition (Alfisol) members of the Taintor, Webster, and Kenyon biosequences. This suggests that B horizon morphology of transition members of these biosequences may be more similar to prairie end-members than forest end-members. Clay content, occurrence and thickness of argillans, and soil consistence are similar in the subsoil of prairie end-members and transition members of the Taintor, Webster, and Kenyon biosequences but additional sites should be examined to statistically evaluate morphological characteristics of these biosequences (Table 7). Coefficients of variation are lower in prairie end-members than transition members of the Taintor and Kenyon biosequences and are similar in the Webster biosequence, however.

The Grundy biosequence, a developmental stage IV

Table 4. Percolation test results and estimated hydraulic conductivity for selected biosequences and stage of profile development sequences.

Soil series†	Percolation test results				Estimated hydraulic conductivity‡
	n	Mean	Standard deviation	Coefficient of variation	
		m s^{-1} × 10^{-4}		%	m s^{-1} × 10^{-4}
Tama	2	31.10a*	4.72	15	4.23–14.10
Downs	2	9.17b	2.22	24	4.23–14.10
Fayette	3	9.17b	4.72	51	4.23–14.10
Otley	2	26.10a	9.44	36	4.23–14.10
Ladoga	3	13.30b	4.45	33	1.41– 4.23
Clinton	4	6.94b	4.45	64	1.41– 4.23
Grundy	2	1.11a	0.56	50	0.42– 1.41
Pershing	2	1.11a	0.56	50	0.42– 1.41
Weller	2	5.56a	2.50	45	0.42– 1.41
Mahaska var.§	2	31.10a	7.50	24	1.41– 4.23
Givin	2	5.00b	2.22	44	1.41– 4.23
Taintor	1	4.17a	0.83	20	1.41– 4.23
Rubio	1	2.78a	1.95	70	1.41– 4.23
Clarion	2	46.70a	13.60	29	4.23–14.10
Lester	2	16.90b	7.22	43	4.23–14.10
Hayden	3	15.60b	11.40	73	4.23–14.10
Nicollett	3	43.10a	19.20	45	4.23–14.10
LeSueur var.§	1	14.70b	6.95	47	4.23–14.10
Webster	2	21.10a	10.60	50	4.23–14.10
Cordova	1	25.30a	10.80	43	1.41– 4.23
Ames	2	5.00b	3.33	67	1.41– 4.23
Kenyon	3	30.30a	8.60	28	4.23–14.10
Bassett	1	21.90a	10.60	48	4.23–14.10

* Percolation rates within a biosequence followed by the same letter do not differ significantly at the 0.05 level as determined by an *F*-test (Snedecor and Cochran, 1967).
† Soil series are grouped by biosequence.
‡ Estimated hydraulic conductivity of 0.76- to 1-m depth from Soil Conservation Service SOI-5 Soil Interpretation Records.
§ Clay content in subsoil is slightly below the range established in the official series description.

Table 5. Morphological characteristics of soil biosequences.

Soil series	Clay content, %	Bulk density, Mg m^{-3}	Occurrence of argillans†	Structure‡	Moist consistence§	Horizon boundary¶
Tama	28.1a**	1.37a	1	1,m,pr/1,m,sbk	1	g
Downs	32.8ab	1.40b	1	2,m,sbk	1	c
Fayette	33.9b	1.43b	2	1,c,pr/1,m,abk	1	c
Otley	35.8a	1.32a	3	2,m,sbk	2	g
Ladoga	35.7a	1.40b	3	2,m,sbk	2	g
Clinton	37.2b	1.46b	3	2,m,pr/2,m,sbk	2	c
Grundy	36.3a	1.47a	4	2,m,pr/2,m,sbk	2	g
Pershing	36.1a	1.46a	2	2,m,sbk	2	g
Weller	38.4a	1.51a	3	1,m,sbk	3	g
Mahaska var.#	34.0a	1.43a	3	2,f+m,sbk	1	g
Givin	33.2a	1.47a	3	1,m,pr	2	g
Taintor	38.0–	1.46–	3	2,m,pr/2,f,sbk	2	g
Rubio	39.3–	1.45–	4	1,m,pr/2,m,sbk	2	g
Clarion	17.4a	1.55a	1	1,c+m,sbk	1	g
Lester	25.4b	1.44b	3	1,f+m,sbk	2	g
Hayden	31.5b	1.56a	4	1,f+m,sbk	2	c
Nicollet	20.5–	1.64–	1	1,f,sbk+m	1	g
LeSueur var.#	25.0–	1.61–	2	1,f,pr/1,m,sbk	2	g
Webster	30.2a	1.57a	1	1,m,sbk	1	g
Cordova	25.8–	1.61–	2	1,m,pr/1,sbk	1	g
Ames	29.4a	1.67b	4	1,m,pr/1,f,sbk	2	c
Kenyon	23.8–	1.76–	1	2,m,sbk	2	g
Bassett	26.8–	1.93–	2	1,f,pr/1,m,sbk	2	g

** Clay content and bulk density within a biosequence followed by the same letter do not differ significantly at the 0.10 level as determined by an *F*-test (Snedecor and Cochran, 1967).
† Occurrence of argillans: 1 = none; 2 = thin discontinuous; 3 = thin continuous; 4 = thick continuous.
‡ Soil structure described in the order: grade, size, and type. Soil structure grade: 1 = weak; 2 = moderate; 3 = strong. Soil structure size; f = fine; m = medium; c = coarse. Soil structure type: pr = prismatic; sbk = subangular blocky; abk = angular blocky; / = breaking to.
§ Moist consistence: 1 = friable; 2 = firm; 3 = very firm.
¶ Distinctness of horizon boundary: g = gradual; c = clear; d = diffuse.
# Clay content in subsoil is slightly below the range established in the official series description.

Table B-5. Sharpsburg

Depth Inches	Horizon	Sand 200-50μ %	Coarse Silt 50-20μ %	Fine Silt 20-2μ %	Clay <2μ %	Bulk Density g/cc	Gravi-metric Moisture	USDA Textural Classes
0-7	Ap	1.80	32.50	34.70	31.00			sicl
0-12	A1	2.10	29.40	32.60	35.40	1.25	28	sicl
12-16	A3	2.00	31.00	30.10	36.90			sicl
16-21	B1	2.30	27.40	31.20	39.10	1.26	27	sicl
21-24	B21	2.10	29.10	29.80	39.00			sicl
24-27	B21t	1.50	31.40	30.10	37.00			sicl
27-30	B22	1.70	29.20	32.80	36.30	1.32	27	sicl
30-33	B22							
33-36	B31	1.70	33.60	30.00	34.60			sicl
36-40	B31	1.80	32.60	29.30	36.30	1.40	25	sicl
40-44	B32	4.00	31.00	33.00	32.00			sicl
44-48	B32	2.80	35.30	30.20	31.70	1.45	26	sicl
48-53	B32	1.20	37.20	30.80	30.80			sicl
53-58	C1	1.00	35.40	31.40	31.70			sicl
58-63	C1							
63-68	C1	1.20	36.70	31.50	30.60			sicl
80-86	C2	2.10	40.30	30.80	26.80			sil
86-92	C2	2.30	35.80	35.60	23.60			sil
98-106	C2	1.80	37.00	37.00	22.80			sil

Percolation Test

Hole	Percolation Rate in./hr.
1	1.9
2	3.9
3	2.4
4	2.3

Mean Rate 2.6 in./hr.

Table B-9. Ladoga

Depth Inches	Horizon	Sand 200-50μ %	Coarse Silt 50-20μ %	Fine Silt 20-2μ %	Clay <2μ %	Bulk Density g/cc	Gravi-metric Moisture	USDA Textural Classes
0-8	Ap	1.90	40.60	35.70	21.80	1.37	23.1	sil
8-11	A3	1.50	35.10	36.00	27.40	1.36	23.4	sicl
11-15	B1	1.30	35.00	32.60	31.10			sicl
15-20	B21t	1.60	30.44	32.36	35.64	1.41	26.4	sicl
20-24	B21t	1.10	31.00	30.80	37.10	1.36	28.9	sicl
24-28	B22t	1.62	29.98	32.08	36.32			sicl
28-33	B22t	1.10	34.40	30.20	34.30	1.38	28.5	sicl
33-36	B23t	1.14	34.50	30.76	33.60	1.44	28.0	sicl
36-39	B23t	1.57	32.87	33.20	32.36			sicl
39-43	B23t	1.70	32.46	33.48	32.36	1.42	27.2	sicl
43-45	B31t							
45-49	B31t	1.70	31.66	33.76	32.88			sicl
49-56	B32t					1.38	31.1	
56-61	C							
61-66	C					1.44	30.4	
66-70	C	1.30	36.90	35.40	26.40			sil
70-76						1.46	30.1	
93-98		1.00	36.50	37.20	25.30			

Percolation Test

Hole	Percolation Rate in./hr.
1	0.8
2	1.0
3	1.9
4	1.8

Mean Rate 1.4 in./hr.

LOCATION SHELBY IA+KS MO NE

Established Series
Rev. FFR-RJK-DBO
5/88

SHELBY SERIES

The Shelby series consists of deep, moderately well drained or well drained soils formed in glacial till. They typically occupy convex side slopes of uplands but are also on narrow interfluves. They have moderately slow permeability. Slopes range from 1 to 40 percent. Mean annual precipitation is about 32 inches, and mean annual temperature is about 51 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, mesic Typic Argiudolls

TYPICAL PEDON: Shelby clay loam - on a convex slope of 13 percent - cultivated. (All colors are for moist conditions unless otherwise stated.)

Ap—0 to 7 inches; very dark brown (10YR 2/2) clay loam, black (10YR 2/1) to very dark brown (10YR 2/2) crushed, dark gray (10YR 4/1) dry; weak fine granular structure; friable; medium acid; clear smooth boundary. (6 to 10 inches thick)

AB—7 to 11 inches; very dark grayish brown (10YR 3/2) clay loam, mixed with very dark brown (10YR 2/2) and dark brown (10YR 3/3), very dark grayish brown (10YR 3/2) crushed, dark grayish brown (10YR 2/2) dry; moderate fine subangular blocky structure; friable; strongly acid; clear smooth boundary. (4 to 8 inches thick)

Bt1—11 to 17 inches; dark brown (10YR 3/3) clay loam; mixed with very dark brown (10YR 2/2) along channels; moderate fine and very fine subangular blocky structure; firm; thin continuous clay films; few stones and pebbles; strongly acid; clear smooth boundary.

Bt2—17 to 23 inches; dark yellowish brown (10YR 4/4) clay loam; somewhat mixed with very dark brown (10YR 2/2) along channels in the upper part; moderate fine subangular blocky structure; firm; medium continuous clay films; medium acid; clear smooth boundary.

Bt3—23 to 34 inches; brown (10YR 4/3) clay loam; few stones and pebbles; few fine faint grayish brown (2.5Y 5/2) and a few coarse distinct strong brown (7.5YR 5/6) and reddish yellow (7.5YR 6/8) mottles; weak fine and medium blocky structure; firm; medium continuous clay films; medium acid; gradual smooth boundary.

Bt4—34 to 48 inches; brown (10YR 4/3) clay loam; few stones and pebbles; common medium distinct grayish brown (2.5Y 5/2) and a few fine distinct strong brown (7.5YR 5/6) mottles; weak medium and coarse blocky structure; firm; medium discontinuous clay films on vertical faces; slightly acid; clear smooth boundary. (Combined thickness of the Bt horizons is 20 to 57 inches.)

C1—48 to 60 inches; mottled grayish brown (2.5Y 5/2) and dark yellowish brown (10YR 4/4) clay loam; few stones and pebbles; massive; firm; thin discontinuous clay films on vertical faces; common white soft to very hard carbonate nodules less than 1/4 inch in diameter; strongly effervescent; moderately alkaline; gradual smooth boundary. (8 to 16 inches thick)

C2—60 to 72 inches; mottled grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/6) clay loam; few stones and pebbles; massive; friable; strongly effervescent; moderately alkaline.

TYPE LOCATION: Adair County, Iowa; about 6 miles north of Greenfield; 1,617 feet east and 2,109 feet south of the northwest corner, sec. 18, T. 76 N., R. 31 W.

RANGE IN CHARACTERISTICS: Solum thickness typically is 40 to 50 inches with an extreme range of 30 to 75 inches. The depth to free carbonates commonly is 40 to 60 inches, but depths as shallow as 30 inches or deeper than 60 inches are in the range. The dominant clay mineral is montmorillonite, but the mineralogy class is mixed.

The Ap or A horizon typically has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. They typically are loam or clay loam, but some pedons are silt loam. The AB horizon typically has value and chroma of 2 or 3.

The Bt horizon typically is 12 to 36 inches thick. It has hue of 10YR with value and chroma of 3 or 4 in the upper part and 10YR hue, value of 4 or 5 and chroma of 3 to 6 in the lower part. Soils with strong brown mottles in the Bt horizon at depths as shallow as 20 inches and with few relict grayish brown mottles in the lower part of the Bt horizon are in the range. The average clay content of the Bt horizon typically is 32 to 35 percent; however, thin layers within the Bt horizon have up to 38 percent clay in some pedons. The A and B horizons range from strongly acid to neutral.

The C horizon is neutral to moderately alkaline.

COMPETING SERIES: These are the Atkinson, Barce, Burchard, Calmar, Corwin, Cresco, Durand, Foresman, Friesland, Griswold, Hitt, Hochheim, Jasper, Joslin, La Rose, Linkville, Markesan, Moingona, Mona, Morrill, Pana, Parr, Plattville, Prairieville, Ringwood, Rockton, Rotamer, Schoolcraft, Sibleyville, Symerton, Tippecanoe, Velma, Wea, and Winnebago series. Atkinson, Calmar, Plattville, and Rockton soils have sola terminated by limestone bedrock. Barce soils contain less clay. Burchard soils have free carbonates at shallower depths and typically have somewhat thicker sola. Corwin, Griswold, La Rose, Markesan, Pana, Parr, Symerton, and Velma soils typically have thinner sola, are less acid in the most acid part of the sola, and are shallower to carbonates. Cresco soils have very firm consistence and grayish colors on the faces of peds in the B horizon. Durand soils have less sand in the A horizon and have reddish hues in the 2B horizon. Foresman and Jasper soils have stratified alluvium within a depth of 40 inches. Friesland soils have a lower content of sand in the lower part of the sola. Hitt, Joslin, Morrill, and Winnebago soils have redder hues. Hochheim soils have thinner sola and formed in sandy loam and gravelly loam glacial till. Linkville soils have less clay in the lower part of their sola. Moingona soils formed in alluvium and colluvium. Mona soils have less sand and more clay in the BC and C horizons. Prairieville soils have 2B horizons. Ringwood and Rotamer soils have thinner sola. Schoolcraft soils have 2C horizons formed in sand or gravelly sand. Sibleyville soils have thinner sola and are underlain at 20 to 40 inches by sandstone or sandy and silty shales. Tippecanoe and Wea soils have less clay in the lower part of their sola and are stratified in the B and C horizons.

GEOGRAPHIC SETTING: Shelby soils typically occupy convex side slopes of 9 to 18 percent. The extreme slope range is from 1 to 40 percent. They formed in Kansan or Nebraskan glacial till. Mean annual temperature is approximately 51 degrees F, and mean annual precipitation is about 29 to 33 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: The Shelby series occurs in association with and topographically below the Marshall, Sharpsburg, Grundy, Seymour, Arispe, and Otley soils which formed in loess. They are also associated with the Adair, Burchard, Clarinda, Lamoni, Lineville, Pawnee, and Steinauer soils which formed in till and with Caleb soils which formed in side valley alluvium on high benches or dissected remnants of benches. Adair and Lineville soils have redder hues or reddish mottles in the upper part of the B horizon. Caleb soils have more stratification in their lower sola. Clarinda and Lamoni soils have a gray, finer textured B horizon. Pawnee soils have a finer textured B horizon. Steinauer soils are calcareous throughout. Shelby soils form a biosequence with the Gara (Mollic Hapludalfs) and Lindley (Typic Hapludalfs) soils.

DRAINAGE AND PERMEABILITY: Moderately well drained or well drained. Permeability is moderately slow. Runoff is medium to rapid.

USE AND VEGETATION: The strongly sloping to steep Shelby soils are used mainly for pasture. The less sloping areas are mostly cultivated. Corn, hay, and small grains are the principal crops. The native vegetation was prairie grasses.

DISTRIBUTION AND EXTENT: Southern Iowa, northeastern Kansas, northern Missouri, and eastern Nebraska. Shelby soils are of large extent.

SERIES ESTABLISHED: Shelby County, Missouri, 1903.

REMARKS: Diagnostic horizons and features recognized in this pedon are: mollic epipedon - zone from the surface to a depth of 17 inches (Ap, AB, and Bt1 horizons); argillic horizon - the zone from approximately 11 inches to 48 inches (Bt1, Bt2, Bt3, and Bt4 horizons); udic moisture regime.

National Cooperative Soil Survey
U.S.A.

SOIL SURVEY LABORATORY Beltsville, Md

SOIL TYPE Shelby clay loam, deep to carbonates **LOCATION** Adair County, Iowa

SOIL NOS. S56Iowa-1-6 **LAB. NOS.** 5748 - 5755

DEPTH INCHES	HORIZON	1B1a VERY COARSE SAND 2-1	COARSE SAND 1-0.5	MEDIUM SAND 0.5-0.25	FINE SAND 0.25-0.10	VERY FINE SAND 0.10-0.05	SILT 0.05-0.002	CLAY < 0.002	0.2-0.02	0.02-0.002	> 2 (<76mm)	TEXTURAL CLASS
		PARTICLE SIZE DISTRIBUTION 9in mm) (percent) 3A1										
0-7	A1D	1.2	4.0	6.6	15.0	10.0	34.8	28.4	36.0	17.3	4	cl
7-11	AB	1.4	3.9	6.0	13.7	9.7	32.6	32.7	33.4	16.6	1	cl
11-17	B21	1.5	4.6	6.0	12.0	8.0	32.7	35.2	30.1	17.4	1	cl
17-23	B22	1.7	3.9	5.1	10.9	8.7	33.7	36.0	29.4	19.3	2	cl
23-34	B31	1.2	4.2	5.7	11.9	9.2	33.9	33.9	31.0	18.9	2	cl
34-48	B32	2.0	4.3	5.6	11.3	8.3	36.4	32.1	31.0	20.0	1	cl
48-60	C21	2.2	4.3	5.6	13.0	11.0	36.5	27.4	34.6	20.8	2	cl/l
72-82	C23	1.8	4.4	5.4	10.9	9.1	38.2	30.2	31.2	22.5	3	cl

pH 8C1a 1:1 %	pH 1:5	pH 1:10	ORGANIC MATTER 6A1a ORGANIC CARBON %	6B1a NITROGEN %	C/N	EST% SALT (BUREAU CUP)	Electrical Conductivity EC - 10³ millimhos per cm @25°C	6E1e CaCO₃ equivalent %	GYPSUM mg/100g SOIL	MOISTURE TENSIONS 1/10 ATMOS. %	1/3 ATMOS. %	15 ATMOS. %
5.6			2.56	0.221	11.6							
5.5			1.65	0.155	10.6							
5.4			1.02	0.103	9.9							
5.7			0.49	0.056	8.8							
5.6			0.25	0.036	6.9							
6.4			0.16	0.030								
7.8			0.09					6				
7.7			0.08					9				

5A3a Cation Exchange Capacity Sum	EXTRACTABLE CATIONS 5B1a 6N2b Ca	6O2b Mg	6H1a H	6P2a Na	6Q2a K	5C3 Base Sat. % on Sum Cations	SATURATION EXTRACT SOLUBLE Na	K				MOISTURE AT SATURATION %
	← milliequivalents per 100g. soil →						← milliequivalents per liter →					
26.1	13.1	3.4	9.1	0.1	0.4	65						
26.0	13.6	4.0	8.0	0.1	0.3	69						
25.5	14.1	4.0	7.0	0.1	0.3	73						
29.4	14.4	4.1	10.4	0.1	0.4	65						
21.5	14.5	3.5	3.1	0.1	0.3	86						
26.3	16.0	2.6	7.3	0.1	0.3	72						
calcareous												
calcareous												

Iowa Department of Natural Resources
Energy and Geological Resources Division
Geological Survey Bureau
109 Trowbridge Hall
Iowa City, Iowa 52242-1319
(319) 335-1575