A PETROGRAPHIC COMPARISON OF THE LOVELAND AND PEORIA LOESSES OF NORTHERN KANSAS

by

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TABLE OF CONTENTS

INTRODUCTION

Purpose of the Investigation

This investigation is concerned with two aspects of the Loveland and Peoria silt members of the Sanborn formation in north-central Kansas. The Sanborn formation consists of gravels, sands, and silts which extensively blanket the uplands of the Great Plains of Kansas.

The first purpose is a purely academic endeavor to determine the mineral composition of selected sand and silt size particles of the loess phase in each silt member. Any similarity or difference between the average composition of each loess will aid in distinguishing these members in the field and will give an insight as to their possible source. A need for distinguishing criteria is evident in field situations where as many as three loess phases and two intervening soil profiles are present. Positive identification of each member can be made by the use of the contained molluscan fauna (Frye and A. B. Leonard, 1952). However, in many situations the fauna is nearly absent; its absence being due to weathering or the virtual absence of molluscan shells at the time of deposition. Thus it becomes rather difficult to apply the included molluscan fauna to a local correlation of loesses. Results of this investigation show that light and heavy mineral studies can be used successfully for both local and regional correlation of loess deposits.

The second aspect of the investigation, largely dependent upon the results of the first, is the determination of the heavy and light minerals from which clay minerals were ultimately derived. The Kansas Highway Commission is interested in determining the nature of these clay minerals as they influence the engineering properties of loess when involved in highway construction.

In the initial study of clay minerals, some means of relating these clay minerals to the parent material is clearly needed. It is the intention of this investigation to provide the preliminary support for subsequent clay mineral studies. The impetus given to studies of clay minerals and their engineering characteristics in the area of investigation is the possible association between the location of certain highway failures and the location of stations where the buried Sangamon soil has been intersected or cut through during road building operations. Attention is specifically referred to Plate I and the geological report of the Kansas Highway Commission dealing with a part of U. S. Highway 36 in Norton County, Kansas. In this particular locality the highway failures are largely confined to stations where the Sangamon soil has been disturbed.

In the area under study it may be that the problems of highway construction are entirely hydrologic or possibly a combination of hydrologic and clay mineral problems. It has not been determined what each contributes to the whole problem. It is known that the less permeable Sangamon soil allows a zone of water to be perched above it. That this zone is present is

Explanation of Plate I

This generalized diagram shows areas of failure in relation to geology and movement of groundwater.

Terrace

Buried Soils

Silts and Clays

Sand

Mortar Bed

Clay

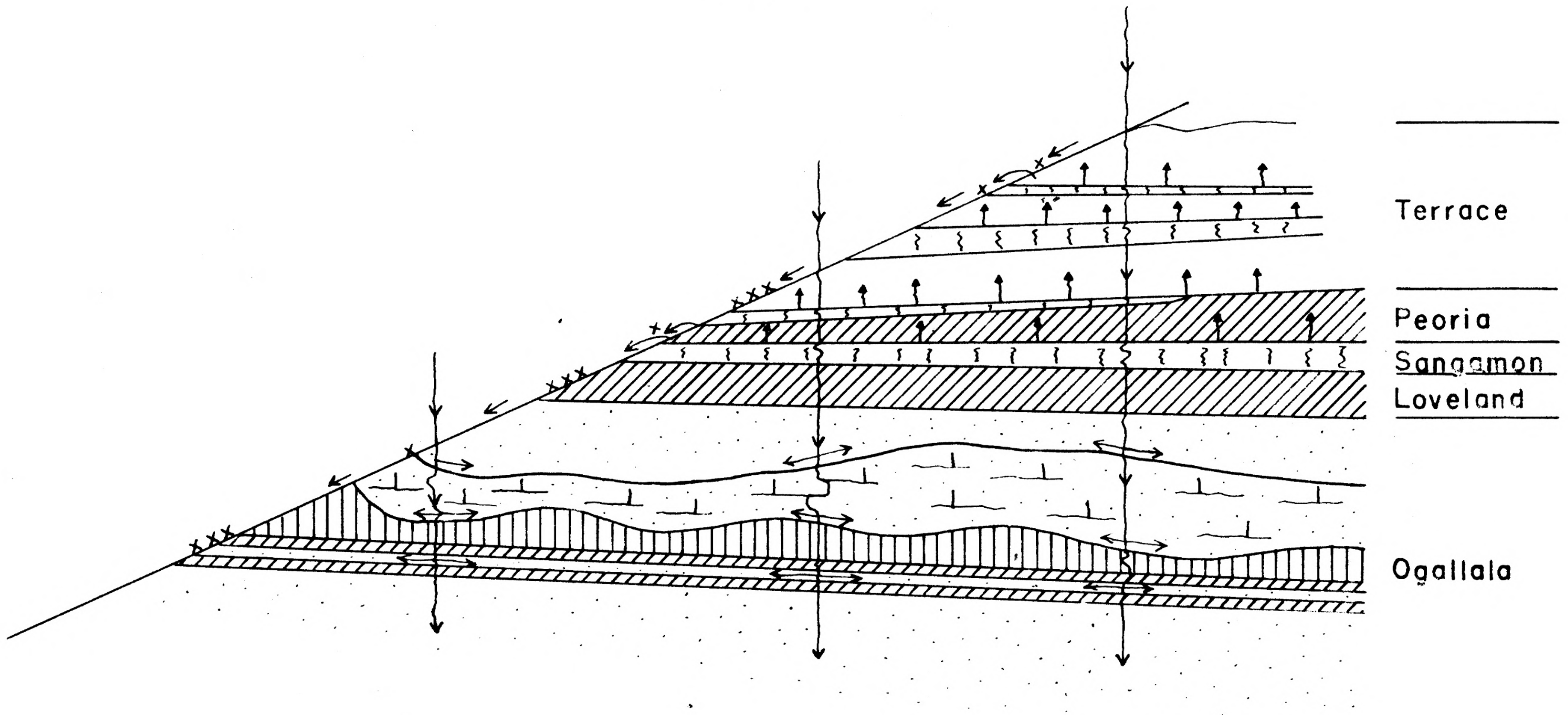
Direction of Water Movement

Capillary Water

Failures

Diagram courtesy of Kansas Highway Commission

Plate I



evidenced by the tendency of test holes to flow shut when the zone is penetrated (Plate I). In some locations appreciable weakening of the loess can be detected as much as eight to ten feet above this contact. If the water is to escape it must move laterally in all directions or upward by capillarity. As a result, there is an overall softening of the subgrade and subsequent failures can be expected. Whenever feasible from the engineering standpoint, the design of future road construction in the area suggests that the grade line be at least 10 feet above the Sangamon soil (Kansas Highway Commission Geological Report 36 79 F 92(4), Republic County, Kansas. Proposed future design does not improve the situations found along the present grade lines.

It is anticipated that the results of this investigation will have widespread application to those areas mantled by thick loessial deposits which include buried soils.

Area of Investigation

Generally, the study included the sampling of loess deposits along or adjacent to Highway U. S. 36 from Belleville in Republic County to Oberlin in Decatur County, Kansas. These locations were selected because of good exposures of the Sanborn formation in an east-west direction. A second reason for choosing this area was to observe highway failures associated with cutting through these loess deposits. The samples studied from the Iowa Point section in Doniphan County, Kansas and at the

Loveland type section in Iowa were for correlation and check purposes. They served no other purpose than this.

Specifically, the area included some of the northernmost counties lying in an east-west direction across the State of Kansas. The west county line of Decatur County (100 degrees, 45 minutes West) marks the western boundary. To the East of this boundary line are Decatur, Norton, Phillips, Smith, Jewell, Republic, and Doniphan Counties. The Missouri River represents the eastern boundary of the study. Washington, Marshall, Nemaha, and Brown Counties were omitted from the study principally because of limited exposures of the Sanborn formation. Attention is directed to Fig. 1; an index map of Kansas showing the area covered by the investigation. Table 1 lists the geographic locations of exposures which were sampled.

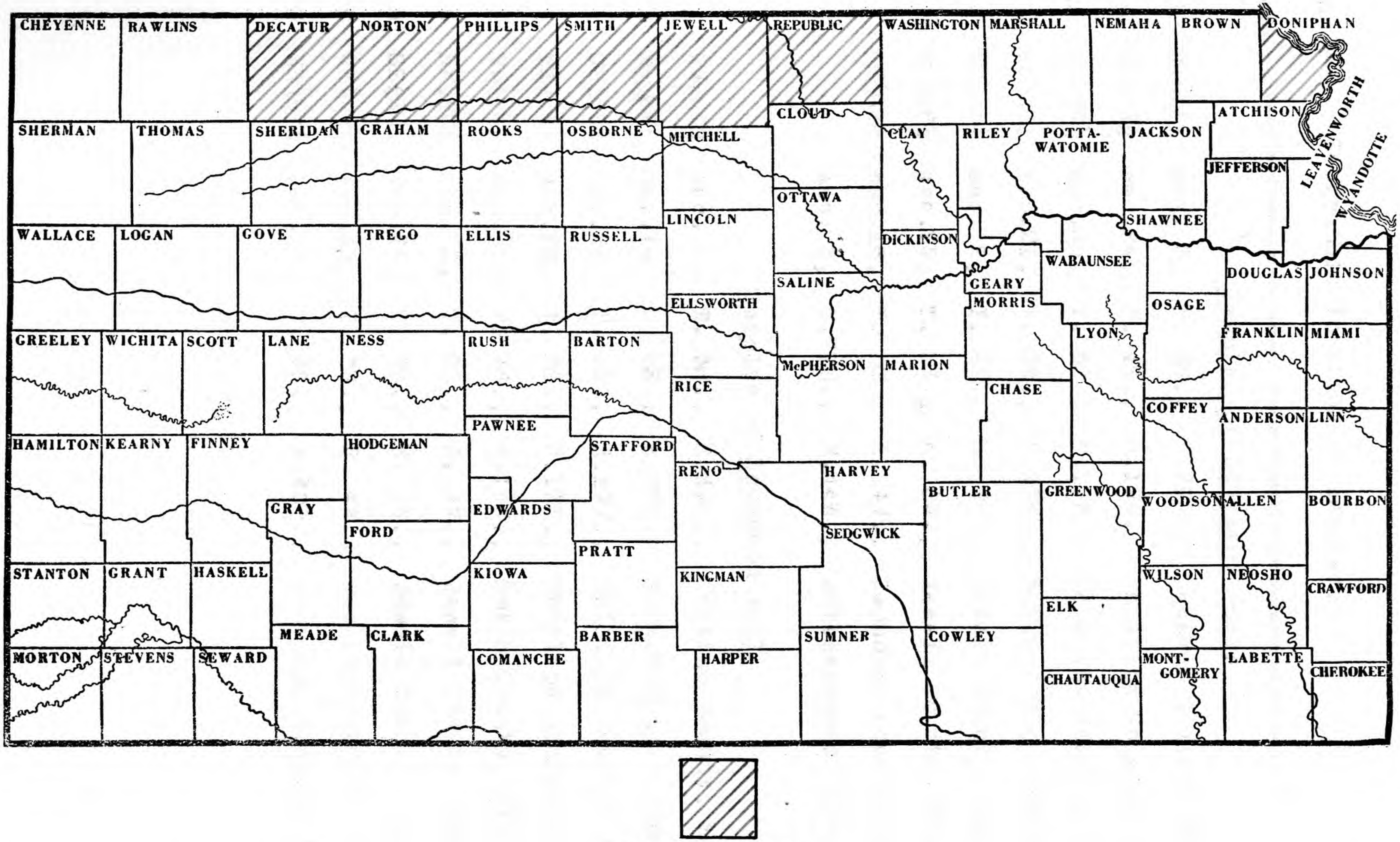


Fig. I. Index map of Kansas showing area of investigation excluding Loveland type section in Iowa.

Table 1. Geographic location of samples.

			Samples of Loveland loess		
1L	NW¼NE¼	sec. 2,	T. 3S.,	R.29W.,	Decatur County, Kansas
2L	SW¼SW¼	sec.24,	T. 4S.,	R.19W.,	Phillips County, Kansas
3L	NE¼NE¼	sec.35,	T. 3S.,	R.17W.,	Phillips County, Kansas
4L	NW¼NE¼	sec.21,	T. 3S.,	R.12W.,	Smith County, Kansas
5L	NW¼NW¼	sec. 2,	T. 2S.,	R. 9W.,	Jewell County, Kansas
6L	SE¼SE¼	sec.25,	T. 3S.,	R. 8W.,	Jewell County, Kansas
7L	NE¼NE¼	sec.16,	T. 3S.,	R. 4W.,	Republic County, Kansas
8L		sec. 3,	T.77N.,	R.44W.,	Pottawatomie County, Iowa
			Samples of Sangamon soil		
1S	NW¼NE¼	sec. 2,	T. 3S.,	R.29W.,	Decatur County, Kansas
2S	NW¼SW¼	sec.14,	T. 4S.,	R.23W.,	Norton County, Kansas
3S	SW¼SW¼	sec.24,	T. 4S.,	R.19W.,	Phillips County, Kansas
4S	NE¼NE¼	sec.35,	T. 3S.,	R.17W.,	Phillips County, Kansas
5S	NW¼NE¼	sec.21,	T. 3S.,	R.12W.,	Smith County, Kansas
6S	NW¼NW¼	sec. 2,	T. 2S.,	R. 9W.,	Jewell County, Kansas
7S	SE¼SE¼	sec.25,	T. 3S.,	R. 8W.,	Jewell County, Kansas
8S	NE¼NW¼	sec.16,	T. 3S.,	R. 4W.,	Republic County, Kansas
9S	NE¼SE¼	sec. 6,	T. 2S.,	R.20E.,	Doniphan County, Kansas

Table 1 (concl.).

			Samples of Peoria loess		
1P	NW¼NE¼	sec. 2,	T. 3S.,	R.29W.,	Decatur County, Kansas
2P	NW¼SW¼	sec.14,	T. 4S.,	R.23W.,	Norton County, Kansas
3P	SW¼SW¼	sec.24,	T. 4S.,	R.19W.,	Phillips County, Kansas
4P	NE¼NE¼	sec.35,	T. 3S.,	R.17W.,	Phillips County, Kansas
5P	NW¼NE¼	sec.21,	T. 3S.,	R.12W.,	Smith County, Kansas
6P	NW¼NW¼	sec. 2,	T. 2S.,	R. 9W.,	Jewell County, Kansas
7P	SE¼SE¼	sec.25,	T. 3S.,	R. 8W.,	Jewell County, Kansas
8P	NE¼NW¼	sec.16,	T. 3S.,	R. 4W.,	Republic County, Kansas
9P	NE¼SE¼	sec. 6,	T. 2S.,	R.20E.,	Doniphan County, Kansas
			Sample of Brady soil		
1B	SW¼SW¼	sec.24,	T. 2S.,	R.19W.,	Phillips County, Kansas
			Sample of Ogallala formation		
1O	SW¼SW¼	sec.13,	T. 5S.,	R.19W.,	Phillips County, Kansas
2O	SW¼SW¼	sec.13,	T. 5S.,	R.19W.,	Phillips County, Kansas
3O	SW¼SW¼	sec.13,	T. 5S.,	R.19W.,	Phillips County, Kansas
4O	SW¼SW¼	sec.13,	T. 5S.,	R.19W.,	Phillips County, Kansas

REVIEW OF LITERATURE

Origin of Loess

Theories on the origin of loess run the entire extent of geological possibilities. Druif (R. J. Russell, 1944) has tabulated over 20 theories offered for its origin. The controversy stems largely from attempting to apply the term loess in a genetic sense in some instances and in a lithologic sense in other cases. Often disputes are not referenced to a common usage and as a result, disagreement is to be expected. Early workers did not formulate a precise definition for loess; it has come from the synthesis of descriptions regarding loess as a homogeneous, nonstratified, porous, calcareous, and slightly indurated sedimentary rock. It was also characterized as yellow to buff in color, vertically jointed, and having the ability to stand in vertical sections.

Baron von Richtofen's (1882) classic work on the loess deposits of China clearly established him as the originator of the eolian hypothesis, even though it was suggested as early as 1848 by Ehrlich. Richtofen urged an eolian hypothesis supplemented by a fluvio-lacustrine hypothesis. He maintained that dust blown from the great arid plateaus of the interior of China was deposited on the fertile plains of North China. Seasonal torrential rains later caused much of these deposits to be redeposited along lower valleys and topographic depressions.

Russell's (1889) ideas on the formation of the adobe in the Great Basin paralleled those of Richtofen. He also contended that sediment in "playa" lakes, whose beds were dry throughout most of the year, were deposited in the same manner. McGee (1891) concluded that the loess of Iowa represented a silt deposit along the border of the former ice cap. Hume (1892) regarded Russian loess as being also a glacial silt distributed by winds and floods from a glacier. Davison (1894) offered a snowdrift theory for loess origin. Snowdrifts, built by the previous winter gales, released tremendous amounts of meltwater during the summer melting. The drifts formed chiefly in the valleys and each year a new layer was added to the previous one. Two strong supports of the theory were the imperceptible gradation of one loess layer into another and drifts being confined largely to valleys so as to give the valley phase of the loess the greatest thickness.

Chamberlin (1897) proposed a theory which shared honors between eolian and fluvial agencies. It is this combination theory that most American geologists are in agreement with at the present time. This theory visualized rivers transporting glacial debris beyond the ice cap to broad flood plains from whence winds picked up the debris and deposited it on adjacent bluffs.

In considering glacial versus desert origin for loess, Kirk (1945) stated that the source for loess was the outwash plains of glacial rivers made pulverent by frost action. He further suggested that the wind system necessary for depositing the loess was provided by anticyclonic winds generated from the center of the ice cap and the prevailing westerlies. The place of deposition in this case was the tundra forest border surrounding the ice sheet. He emphasized extensive frost action as being a factor in the removal of silt as fast as it was deposited.

Origin of Mississippi Valley Loess

Chamberlin's (1897) observations on the distribution of loess along the leading valleys of the Mississippi River and along the border of the former Iowan ice sheet led him to the strong conviction of a vital connection between the loess deposits and the great streams of the area. The idea presented by Chamberlin is a combination of eolian and aqueous theories. Because the distribution and constitution of loess in the Mississippi Valley is so intimately associated with the former stream valleys, he advocated a glacio-fluvial hypothesis and adopted it as the fundamental explanation for the loess. He postulated that periods of warm weather and warm rains released tremendous volumes of meltwater carrying a large silt and sand load. The silty waters extended themselves over wide flats; later to withdraw to their established channels. After each periodic retreat of the waters, the exposed silt-covered flats were swept by winds which carried off large volumes of dust. That a vegetative cover was developed on the bluff areas is attested to by the presence of terrestrial molluscan fauna found in association with the loess. The vegetative cover offered lodgment for the dust particles settling from the wind.

The early hypotheses offered for the origin of the loess were concerned with the outwash coming from a single ice sheet. McGee (1878) found the development of a "forest bed" over the true glacial drift. Overlying this layer of carbonaceous material was developed another sequence of glacial drift modified by the alluvial action of a retreating glacier. The "forest bed" was established to have been developed during an interglacial period, thus the countryside must have been overrun by at least two glacial advances.

Despite the difficulties in applying the aqueous hypothesis to the entire Mississippi Valley, most workers were in agreement with its contents. Keyes (1898), thinking that the eolian side of the question had received too little credence, especially in this country, published his observations made along the Missouri River at Jefferson City, Missouri. This location was particularly favorable for observation in that the Missouri River had passed through both drift and driftless regions before reaching this point. The vast bars of silt along the course, often a mile or more wide, are continuous on one side or the other from Dakota to its mouth. Strong winds catching the silt particles carry them into the open country. The amount of dust taken from the valley was noted and in the course of a year's time amounted to one-fourth inch. Keyes was content to think of the northern deposits as the result of glacial agencies but refused to accept it in explanation of the lower Mississippi Valley deposits.

After having given considerable attention to the development of soils during interglacial periods, workers began to speculate on the time of loess accumulation. Shimek (1909) pointed out that the presence of a gravel pavement at the base of the loess indicated a long interval of erosion before loess accumulation. This would place the time of accumulation as being throughout the entire interglacial period. To Penck (1913) the presence of mammalian fossils proved that the loess formed while boreal animals occupied the region. Interglacial beds not far away yielded remains of animals characteristic of milder climates. Because of the correlation of mammalian fauna in two adjacent regions, he considered the time of accumulation to be toward the end of the interglacial period. To Chamberlin (1897), the widespread distribution of loess along the major stream valleys was made possible only by overloaded streams coming from the ice cap. If this be the case, streams would have their greatest competency at the time of maximum glaciation; also the time of greatest loess accumulation. Each of the foregoing theories implied the time of origin by differences in climatic conditions. Believing that the three theories proffered thus far tended to tear each other down, Visher (1922) expressed the opinion that the retreat of the ice cap exposed a zone of drift to outblowing glacial winds and further stated that only at this time was there sufficient source material for loess accumulation. In reference to the pebbles which Shimek found at the base of the loess, he accounted for their possible presence due to the deflating action of the glacial winds and producing a type of "desert pavement".

Russell (1944) maintains that the field relationships of the Mississippi Valley loess does not permit it being eolian, lacustrine, fluvial, or of direct sedimentary origin. The loess grades upslope into its parent material; terrace deposits similar to backswamp clays of the Recent Mississippi River. These terrace deposits weather to a brown loam which later moves downslope and increases in thickness and mantles bluff areas. During the weathering process the material, whether it be a true loess or not, goes through the process of loessification. This process of loessification involves the accumulation of carbonates, the disintegration of coarse particles, incorporation of snails, and the appearance of characteristics typifying a loess deposit.

Doeglas (1949) pointed to a distinct heavy mineral suite in the terrace deposits, which Russell considered to be the colluvial source for the loess, different from that found in the loess deposits. The Tertiary deposits and the terrace sands disclose a staurolite-kyanite-zircon assemblage; the loess an epidote-garnet-hornblende assemblage. He also found that where there was an admixture of the two assemblages there was also evidence of creep. Because the one deposit could not have been derived from the other by colluvial means, he considered the loesses of the lower valley to be eolian.

The Loveland and Peorian Loesses of Nebraska

It was during the Sangamon interglacial stage (Illinoian-Wisconsin) that the gumbotil was developed on the Illinoian till of Nebraska. This was accompanied by the erosion and deposition of the alluvial, colluvial, and upland phases of the Loveland formation (Condra, et al., 1947). Both the Loveland and Peorian are given formational rank in Nebraska because there are certain phases of each which are not true loesses. It is the combination of the several phases which are given formational rank. The Loveland loess of Nebraska was traced eastward into the Sangamon type section of Illinois by Condra in 1932 and Kay in 1934. Kay and Graham (1944) reported that the Loveland loess of the Illinoian drift area in Iowa had been established by stratigraphic methods as being younger than the Illinoian glacial drift and older than the Iowan glacial drift, that is, it is late Sangamon in age. The soil developed on the Loveland loess is referred to as the Loveland soil in Nebraska. It is called the Sangamon soil in Kansas and Illinois (Frye and A. B. Leonard, 1951).

Condra, et al. (1947) consider the Loveland loess to have originated from the reworking of alluvial deposits, exposed older Pleistocene deposits, exposed silt and sand of the Ogallala and other High Plains formations.

Overlying the eroded Loveland loess is the uneven Todd Valley sand which represents the valley fill coming from the

Iowan ice sheet during early Wisconsinian time. This is directly overlain by the Citellus zone. This zone represents the remains of burrows made by ground squirrels in Loveland loess. This is not a true stratigraphic horizon but shows that the rodents burrowed in post-Loveland to pre-Peorian time.

Peoria loess was deposited on the eroded Loveland loess, Todd Valley sand, and Citellus zone during the withdrawal of the Iowan ice sheet during the time interval between the Iowan and Mankato substages in Iowa (Condra, et al., 1947). It is considered to have been deposited during the relatively dry cycle following the withdrawal of the ice sheet. Its source seems to have been the exposed silty alluvium along the large river valleys such as the Missouri and Platte and from other lesser sources. It has its thickest development along bluffs bordering the flood plains and gradually thins toward the eroded Loveland surfaces on the upland areas.

The Loveland and Peoria Members of Kansas

All loess deposits of Kansas are included in the Pleistocene Sanborn formation (Frye and Fent, 1947). These deposits are Illinoian and Wisconsinan in age. In the official classification of the Kansas Geological Survey, the Sanborn includes the following members: (Illinoian) (1) Crete sand and gravel member; (2) Loveland silt member with the Sangamon soil commonly developed within its top; (Wisconsinan) (3) unnamed early Wisconsin alluvial deposits; (4) Peoria silt member with the

Brady soil commonly developed at its top; (5) unnamed late Wisconsinan alluvial deposits; (6) Bignell silt member.

Frye and A. B. Leonard (1951) stated that the Loveland member in Kansas is applied to both the waterlaid silts in valley situations and to the loess of the uplands. The two facies of the silt unit have been determined to be stratigraphically continuous along some valley-side slopes, occupying the same stratigraphic position, are the same age, and can be mapped together conveniently. In many instances it is difficult to assign the silt as being either fluviatile or eolian in origin.

The Loveland loess has been recognized along the Missouri and Kansas River Valleys. It has been traced to the north-central, central, and southwestern parts of Kansas. In some of these regions the Loveland consists of water-laid silts. In the northwestern Kansas counties widespread deposits classed as Crete or Crete-Loveland are covered with a thin and irregular Loveland loess. The Loveland loess is not recognized as such east of the Flint Hills area even though a well-developed section of the Sangamon soil is present. The Smoky Hill region of western Kansas shows little development of the Loveland loess.

The Peoria silt member in Kansas includes loess and some alluvial silts which are stratigraphically continuous with each other. Stratigraphically and faunally it was found to be equivalent to the Peoria loess of western Iowa and to the Farmdale, Iowan, and Tazewell loesses of Illinois (A. B. Leonard, 1951). The Peoria silt member ranges from a coarse silt and very fine sand along the Republican River in northwestern and north-central areas of Kansas, to a medium silt and clay in northeastern Kansas. The thickness of the Peoria ranges from 90 feet at the Sanborn type section in Cheyenne County to over 100 feet in Doniphan County (Frye and Walters, 1950). The member is commonly a buff color with a reddish cast in the eastern part of the state but grades to a light tan to the west.

Because the loess becomes finer-textured and decreases in thickness away from the main stream valleys, and because of the upland occurrence, the molluscan fauna, degree of sorting and the presence of buried soils; it is considered to be eolian in origin (Swineford and Frye, 1951).

The Loveland and Peoria Loesses in the Area of Investigation

Loveland Member. Shimek (1909) was the first to use the name Loveland when he referred to a dense reddish or yellow silt and clay occurring above the Kansas till and below another buff loess. The name was applied to the present type section for the Loveland along the Missouri River Valley at the town of Loveland, Iowa.

In the area of investigation the Loveland was found to occupy three former physiographic situations. It was found to occur as an upland loess; a water-deposited clay and silt; and also as a colluvial deposit on the valley slopes. The light tan-gray to gray silt and fine sand averages about four feet in thickness in single exposures. Locally it is impregnated with caliche nodules in the basal part. In many areas there is a tendency for basal Loveland loess to merge imperceptibly with the coarse sands and gravels of the Crete sand and gravel member. The Loveland is bounded at the top by the buried Sangamon soil which developed during the Sangamonian interglacial stage.

This buried soil is a persistent marker bed in the area and has been successfully used as a stratigraphic datum. This soil is commonly two to three feet thick with a depth of leaching continuing into the underlying Loveland loess for another one foot. Below the zone of leaching is a zone of caliche accumulation of one to three feet thick. The color of the Sangamon soil ranges from a gray-black to a reddish-brown and sometimes to a dark buff.

Peoria Member. Alden and Leighton in 1917 showed that what had been called Iowan loess was in reality post-Iowan; from this time on usage changed the name of the loess from Iowan to Peoria. The term "Peorian" has been used in Iowa to refer to loess of post-Iowan to pre-Mankatoan age (Kay, 1931 and Kay and Graham, 1943) as well as to equivalent deposits in Nebraska (Lugn, 1935; Schultz and Stout, 1945; and Condra, *et al.*, 1947).

In the area of investigation the Peoria member refers to the continuous loess and water-laid silt deposits (Frye and Fent, 1947; Frye, *et al.*, 1948; and Frye and A. B. Leonard, 1951). Stratigraphically this unit has been shown to be the equivalent of the Peorian of Nebraska (Leonard, 1951; Condra, *et al.*, 1947) and Iowa (Kay and Graham, 1943). The Peoria loess is uniform in composition and general appearance from Jewell County westward to the Kansas-Colorado border. It is commonly 20 to 30 feet thick and is a highly fossiliferous, calcareous, and massive silt. The member is lighter in color than the overlying Loveland; being an overall light tan color. Commonly developed at the base of the Peoria loess is an "inverted" A zone soil horizon developed presumably at the beginning of Peorian time. It possibly represents slow accumulation of upland silt that was converted to soil before the main body of Peoria loess was deposited.

Measured Section

The following measured section of the Sanborn formation is considered representative for the area of investigation.

Highway cut in the $NW\frac{1}{4}$ sec. 11, T.3S., R.23W., Norton County, Kansas (Frye and A. B. Leonard, 1952).

	Thickness feet
Quarternary--Pleistocene	
Sanborn formation	
Peoria silt member (Wisconsinan Stage, Iowan-Tazewellian Substages)	
3. Silt, massivs, gray to yellowish-tan, mealy; contains snails	25.0
Crete-Loveland member (Illinoian Stage)	
2. Silt, sand, and some gravel. Sangamon soil in upper part, a well-drained profile with brown A horizon and reddish-brown B horizon containing vertebrate fossils. The soil thins toward the north and at the bluff of Prairie Dog Creek Valley only 1.5 feet (predominantly A horizon) overlies Ogallala formation. Maximum thickness at south part of exposure	7.9
Tertiary--Pliocene	
Ogallala formation--Ash Hollow member	
1. Sand, silt, and gravel, cemented loosely throughout with calcium carbonate	31.0
Total thickness measured	63.9

INVESTIGATION PROCEDURE

All samples for petrographic study were taken as spot samples from varying horizons within the loess phases of each of the silt members. By selecting samples throughout the entire vertical section of each exposed loess phase, it was thought that certain mineral suites might be collected which would be diagnostic only for that member. This procedure has the further advantage of making known any mineralogical differences due to weathering. Further, this practice makes it possible to evaluate each mineral species as a correlative index.

Samples were placed in cloth sample bags and appropriately marked as to county, member, quarter-quarter section, and to a metal reference rod placed near the collecting site.

Two hundred grams of air-dried sample were selected for petrographic study; the rest being set aside for future use in clay mineral studies.

A sodium silicate solution (1 gram of Na_2SiO_3 per 40 milliliters of deionized water) was chosen as a dispersing agent. Eighty milliliters of this solution was added to the 200-gram sample which was placed in a boston round bottle. The bottle was then filled to within one inch of the neck with deionized water. After the bottle was stoppered and labeled it was placed on a reciprocating shaker for eight hours.

On completion of dispersion, the samples were shaken for a very few minutes prior to the sieving operation. All future references to sieve sizes are those of the U. S. Standard Sieve Series. Number 120, 200, 230, and 270 sieves were placed in a nest and the sample was wet sieved. As this investigation does not deal directly with the clay mineralogy of the members and as the samples were acid treated in the procedure, all silt and clay particles passing through the No. 270 sieve were discarded. All sand fractions retained on the No. 120 sieve were likewise discarded.

The remaining sample retained on the No. 200, 230, and 270 sieves was mixed and placed in a 250-milliliter beaker. To this was added a 50 percent solution of concentrated hydrochloric acid and water. The sample was boiled in this solution for 30 minutes to remove iron oxide stains, clay coatings, and all carbonaceous material from the sample. The sample was then thoroughly washed and placed in an oven to dry. Considerable controversy has arisen over the preference of hydrochloric acid to a less active acid in the previously described acid treatment of the sample. The effectiveness of removing stains and calcareous material by using hydrochloric acid cannot be denied. However, there is some objection to the use of this acid in that its use results in the loss of certain minerals by solution. Whether these minerals, which might have proven to be a significant part of the total mineral assemblage of a member, have been destroyed by this procedure is questionable. However, regardless of the virtues of this treatment, if a mineral is to be a reliable index of the members concerned, it should possess stability in the laboratory as well as at the collecting site.

Number 200, 230, and 270 sieves were placed in a nest on a mechanical shaker and the oven-dried sample was sieved for five minutes. Only the fine sand fraction passing through the No. 200 sieve and retained on the No. 230 sieve was chosen for petrographic study. It was found that this size particle was the most desirable for making mounted detrital sections. The fraction passing through the No. 120 sieve and retained on the No. 200 sieve was placed in a vial and set aside for future reference. The fraction passing through the No. 230 sieve and retained on the No. 270 sieve was likewise placed in a vial and set aside for possible future reference.

A heavy and light mineral separation was then performed, using bromoform (specific gravity-2.89 at 20 degrees C.) as the separating medium. A two-inch length of one-fourth inch rubber tube was fitted to the stem of a two-inch funnel. Regulation of the flow of the bromoform was controlled by a tube clamp placed on the loose end of the tube. The funnel and attachments were placed on a stand and bromoform was poured in to a depth of one-half inch above the neck of the funnel. As bromoform has a high rate of evaporation, watch glasses were placed over the funnels. The watch glasses were removed only when the sample was added and for occasional stirring.

While the separatory apparatus was being set up, the sample was being heated to 200 degrees C. to remove any trace of dampness. Grains poured into bromoform have a tendency to adhere to each other, thus making a satisfactory separation improbable. Muscovite, for example, has a specific gravity slightly greater than that of bromoform. Muscovite as a detrital mineral occurs as rounded and platy grains; the form being controlled by pronounced cleavage in one direction. Often air is trapped along the cleavage so as to produce a buoyant effect on the grain. As a result, the muscovite grains float with the light weight minerals; i.e., quartz and feldspar, when on the basis of specific gravity it should sink with other heavy minerals. Heating the sample releases the trapped air within the muscovite grains and prevents them from adhering to each other or to light mineral grains. If the amount of muscovite in a sample is high, some contamination can be expected despite preheating the sample.

The sample was stirred while being placed in the bromoform and occasionally thereafter. The sample remained in the bromoform overnight. The minerals floating on the bromoform were designated as the light fraction; those descending in the bromoform were termed as heavy minerals. Fifteen minutes prior to releasing the heavy minerals from the bromoform, the light fraction was stirred very gently for the last time and allowed to stand.

A coarse filter paper was selected to collect the heavy and light fractions. A two-inch funnel, equipped with filter paper, was placed directly under the funnel containing the bromoform. The level of the bromoform was then drawn down to the neck of the funnel by releasing the tube clamp for short periods of time. Care was exercised in preventing the lights from mixing with the heavy minerals.

The filter paper and heavy mineral grains were then washed with ethyl alcohol to remove any remaining bromoform. This washing treatment was duplicated five or six times. Water was then used to wash all grains of excessive alcohol. The light fraction was recovered and washed in the same manner as the heavy minerals. All bromoform, alcohol, and water washings were saved with the intent of recovering the expensive bromoform at a later time.

The mineral grains were then oven dried; later to be mounted in Canadian balsam (refractive index-1.54) on glass slides. The completed slides were then appropriately labeled and filed for future use.

Two hundred mineral grains were chosen at random for the mineral identification of each slide. Index of refraction, color, position of extinction, optical sign, cleavage, twinning, pleochroism, crystal habit, inclusions, surface form, and grain outline were determined in making the identification.

The results of the mineral identification are given in Tables 2, 3, and 4. The average frequency of all minerals and their ranges are tabulated in Table 5.

Table 2. Mineral analysis of the heavy and light fractions of the Loveland loess. All figures are percentages excepting actual numbers given for opaques and iron oxide coated grains.

Minerals	Samples							
	1L	2L	3L	4L	5L	6L	7L	8L
				Light Fraction				
Quartz	28.5	46.0	51.0	46.5	51.0	51.0	45.0	61.0
Orthoclase	33.4	22.0	28.0	31.2	18.7	17.3	23.0	11.0
Microline	0.0	1.0	2.0	0.0	0.5	0.4	1.0	0.9
Plagioclase	34.8	27.4	16.0	19.7	25.4	30.8	29.0	25.0
Chalcedony	3.3	3.1	3.0	2.6	3.4	1.4	1.5	0.5
Volcanic ash	0.0	0.5	0.0	0.0	1.0	0.0	0.0	1.5
Coated grains and opaques	18.0	12.0	8.0	10.0	18.0	7.0	11.0	10.0
				Heavy Fraction				
Hornblende	60.0	68.0	73.0	63.5	44.0	49.0	49.0	46.0
Lamprobolite	3.4	3.2	4.5	4.3	1.4	4.5	6.1	0.5
Muscovite	1.9	4.1	2.0	2.4	17.0	4.5	7.5	7.5
Epidote	15.0	12.0	12.0	16.9	9.7	28.0	18.3	32.0
Zircon	7.2	5.0	3.5	5.3	8.3	6.0	8.0	8.0
Garnet	6.2	6.2	3.0	3.4	11.5	1.5	5.2	5.2
Tourmaline	0.5	0.0	0.5	1.4	3.2	2.0	1.4	1.0
Tremolite	5.8	1.6	1.5	1.4	2.3	3.5	3.3	2.0
Biotite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Enstatite	0.0	0.0	0.0	0.0	1.6	0.0	1.0	0.0
Sphene	0.0	0.0	0.0	0.4	1.0	1.0	0.5	0.0
Augite	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Coated grains and opaques	31.0	25.0	15.0	8.0	12.0	20.0	15.0	15.0

Table 3. Mineral analysis of the heavy and light fractions of the Sangamon soil. All figures are percentages excepting actual numbers given for opaques and iron oxide coated grains.

Minerals	Samples								
	1S	2S	3S	4S	5S	6S	7S	8S	9S
					Light Fraction				
Quartz	27.0	41.0	47.0	56.0	54.0	56.5	54.0	42.0	55.0
Orthoclase	44.0	29.0	26.0	36.0	32.5	21.8	13.0	23.1	29.0
Microcline	0.5	1.5	0.0	1.0	0.0	1.0	0.5	1.0	0.0
Sanadine	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Plagioclase	24.0	29.0	23.0	5.0	9.9	19.7	30.0	31.0	12.0
Volcanic ash	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
Chalcedony	4.0	0.0	2.5	2.0	3.5	1.6	2.0	2.0	4.0
Coated grains and opaques	9.0	10.0	8.0	5.0	10.0	13.0	8.0	14.0	13.0
					Heavy Fraction				
Hornblende	55.0	58.0	60.0	65.0	63.5	49.0	60.0	47.0	58.0
Lamprobolite	5.3	4.0	1.0	5.5	5.0	3.0	2.9	2.1	3.7
Muscovite	2.0	0.5	6.0	1.5	1.0	3.2	10.0	8.7	7.3
Epidote	11.0	18.0	15.0	11.0	14.0	17.2	17.3	17.2	18.0
Zircon	14.2	12.0	9.0	7.0	9.0	11.0	3.8	12.5	4.3
Garnet	5.0	1.5	5.0	4.5	3.5	8.2	2.0	9.4	9.0
Tourmaline	3.5	1.5	0.0	0.0	0.5	1.6	1.4	0.5	0.0
Tremolite	3.0	3.5	4.5	3.5	3.5	4.3	2.4	2.0	2.7
Biotite	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Enstatite	0.0	0.0	0.0	0.0	0.0	1.6	0.0	1.0	0.0
Sphene	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0
Brookite	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Coated grains and opaques	7.0	20.0	14.0	11.0	9.0	13.0	14.0	8.0	7.0

Table 4. Mineral analysis of the heavy and light fractions of the Peoria loess. All figures are percentages excepting actual numbers given for opaques and iron oxide coated grains.

Minerals	Samples								
	P1	P2	P3	P4	P5	P6	P7	P8	P9
					Light Fraction				
Quartz	30.0	19.6	31.0	48.0	31.0	38.0	42.0	50.0	54.0
Orthoclase	44.0	33.0	30.0	25.0	47.0	25.0	24.0	21.0	17.0
Microcline	1.6	0.0	0.5	0.5	0.5	0.0	0.0	0.5	2.0
Plagioclase	22.0	37.0	27.0	16.0	10.7	30.0	26.0	25.0	9.0
Volcanic ash	9.0	9.4	11.0	4.0	6.1	5.0	7.0	2.0	10.0
Chalcedony	3.7	1.0	1.0	7.0	4.7	2.0	1.0	2.0	8.0
Coated grains and opaques	13.0	11.0	14.0	8.0	10.0	13.0	10.0	11.0	17.0
					Heavy Fraction				
Hornblende	67.0	61.0	69.0	57.0	24.0	65.0	60.0	65.0	55.0
Lamprobolite	8.2	6.6	6.2	9.0	5.0	3.4	4.2	5.8	2.0
Muscovite	4.1	8.0	5.0	14.0	54.0	6.9	6.8	9.1	21.0
Epidote	10.7	13.2	9.6	12.0	10.0	16.0	19.0	18.3	17.0
Zircon	1.5	1.4	1.1	4.5	2.0	2.6	3.0	2.9	0.0
Garnet	0.0	2.4	1.7	0.5	1.5	3.4	4.0	5.8	1.0
Tourmaline	0.0	0.0	0.0	0.5	0.0	0.0	1.0	1.5	1.0
Tremolite	7.0	8.0	7.3	0.0	0.0	2.6	2.0	0.9	1.0
Augite	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.0	0.5
Riebeckite	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
Hypersthene	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zoisite	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5
Enstatite	1.0	0.0	0.0	2.0	0.0	0.0	0.0	1.5	1.0
Coated grains and opaques	11.0	12.0	20.0	15.0	8.0	11.0	13.0	9.0	18.0

Table 5. Average and range of the major mineral constituents of the Loveland loess, Sangamon soil, and Peoria loess. All figures are percentages.

Minerals	Loveland loess		Sangamon soil		Peoria loess	
	Average	Range	Average	Range	Average	Range
			Light Fraction			
Quartz	47.7	28.5-61.0	48.0	27.0-56.5	38.2	10.6-54.0
Orthoclase	23.1	11.0-33.4	28.3	13.0-44.0	30.0	17.0-47.0
Plagioclase	26.0	16.0-34.8	20.4	5.0-31.0	22.5	9.0-37.0
Chalcedony	2.4	0.5- 3.4	2.4	1.6- 4.0	3.4	1.0- 8.0
Volcanic ash		trace		trace	7.0	2.0-11.0
			Heavy Fraction			
Hornblende	56.6	44.0-73.0	57.3	47.0-63.5	57.0	24.0-69.0
Lamprobolite	3.5	0.5- 6.1	3.6	1.0- 5.5	5.6	2.0- 9.0
Muscovite	5.9	1.9-17.0	4.5	0.5-10.0	14.3	4.1-54.0
Epidote	18.0	9.7-32.0	15.4	11.0-18.0	14.0	9.6-19.0
Zircon	6.4	3.5- 8.3	9.2	3.8-14.2	2.1	0.0- 4.5
Garnet	5.3	1.5-11.5	5.3	1.5- 9.4	2.3	0.0- 5.8
Tourmaline	1.3	0.0- 3.2	1.0	0.0- 3.5	0.4	0.0- 1.5
Tremolite	2.7	1.4- 5.8	3.3	2.0- 4.5	3.2	0.0- 8.0

SUMMARY AND CONCLUSIONS

Relative Merit of Individual Minerals for Distinguishing Between Loesses

This petrographic study of heavy and light fractions of the fine sand in the Loveland and Peoria loesses has shown that they may be differentiated from each other with certainty in the area of investigation.

The most reliable single index for determining differences is the presence of a relatively high percentage of volcanic ash in the Peoria loess as compared to its virtual absence in the Loveland loess. A binocular examination of washed but untreated Peoria loess will reveal the presence of the ash.

The average percentages and ranges of quartz, orthoclase, and plagioclase in each of the members were not sufficiently different, singly or collectively, to be of value for recognition purposes. This also applied to chalcedony, but to a lesser degree. The low values of chalcedony certainly did not recommend its use.

Hornblende, lamprobolite, and epidote of the heavy fraction could not be used for this purpose. Their value lies in suggesting a possible source for the loess deposits. Of the heavy minerals, zircon and garnet offer the greatest use for recognition purposes. The percentage of each in the loess deposits was consistent even though both were minor in quantity. The constancy of minor amounts of zircon and garnet made them ideal as index minerals. In general, the total of each in the Loveland was double to that found in the Peoria loess.

Muscovite is peculiar among detrital minerals in that it is likely to occur in floods. This occurrence is in some respects the opposite of a placer (A. B. Sperry, personal communication). Its presence was erratic both horizontally and vertically within a single horizon. Evidence of this is shown in the table of mineral averages and ranges (4.1 to 54 percent). A small fluctuation in the transporting medium influenced its presence. This critical adjustment is related to the large surface area of the thin and platy grain as compared to its volume and specific gravity. Muscovite is not the only mineral found to occur in such sporadic concentrations. Tyler (1936) found a tendency for pyrite, as well as celestite and jarosite, to occur as floods in the St. Peter sandstone of Wisconsin.

Tremolite and tourmaline were absent from each of the loesses in some cases; when present, each of them accounted for a small percentage of the total of the heavy minerals. This range does not recommend their use for recognition purposes.

The minerals which were rare and occur only in one or a few samples were not of diagnostic significance because their discovery was a matter of chance.

Measured Section

The following measured section of the Ogallala formation was considered representative for the area of investigation.

Road cut of county road in SW$\frac{1}{4}$ sec. 13, T.5S., R.19W., Phillips County, Kansas (Frye, Swineford, and A. B. Leonard, 1946).

	Feet
Sanborn formation: Silt and sand, tan	8.0
Ogallala formation:	
Quartzite, fine-grained, dense, green	1.5
Sand, massive, green and red; contains fragmentary Mastodon tooth. (Sample 1, taken from upper 1 foot)	5.0
Quartzite, fine-grained, fairly well cemented, green	1.0
Sand and silt, massive, green; spotted and streaked with calcium carbonate. (Sample 2, taken from upper 1 foot)	3.0
Silt and sand, massive, partly silicified, hard, light gray	1.5
Sand, silty, massive, tightly cemented with calcium carbonate; weathers to a deeply etched surface of vertical columns and horizontal sheets	1.0
Sand, fine, and silt, green; speckled with calcium carbonate	2.5
Quartzite, fine-grained, lenticular, light green; lenses out along road ditch	1.5
Silt and fine sand, partly covered, light greenish-gray; weathers to ash gray; contains a few nodules of calcium carbonate. (Sample 3, taken from upper 1 foot)	2.5
Sand, fine, and silt, indistinct bedding; very light greenish-gray; weathers to platy and nodular surface; loosely cemented throughout with calcium carbonate; forms indistinct bench along nearby canyon side	4.5
Silt, sandy, calcareous; contains calcium carbonate in irregular nodules and stringers; upper part more clayey, dark gray, contains less carbonate. (Sample 4, taken from upper 1 foot)	6.0
Total Ogallala formation	30.0

Material Source for Loveland and Peoria Silt Members

The occurrence of Nebraskan and Kansan deposits in the area of investigation are imperfectly known and have a limited areal extent. The deposits of Nebraskan and Kansan age are the fragmentary terraces of the Meade formation found along the slopes of the major river valleys. The few terrace remnants represent former larger alluvial terraces which have been removed by erosion. These terraces are unusual in that they show a reversal in the normal stratigraphic sequence; the older terraces lie farther from the river channels than do younger terraces and they lie at a higher elevation (Frye and A. B. Leonard, 1952). The extent of Nebraskan and Kansan deposits in north-central Kansas is virtually unknown, however, it is unlikely that the deposits of outwash material from the glaciated region to the north could have provided a sufficient bulk of material to account for the vast accumulation of loess in the area.

The Crete sand and gravel member of the Sanborn formation is well developed in north-central Kansas. It occurs as valley fills and terraces along the major stream valleys of the area. Its lithology reflects a local source as pebbles of Cretaceous chalk and pebbles of Ogallala "mortar bed" are found commonly with the sands and gravels of the Crete member (Frye and A. B. Leonard, 1952). The imperceptible gradation of the Crete member into the valley phase of the Loveland member suggests that the loess is also of essentially local materials. It is easy to visualize a southwesterly wind (that direction is suspected during this time) deflating the existing river valleys of their fine sand and silt and depositing such on the adjacent uplands.

A review of Table 4, showing the average and range of mineral frequencies of each loess, displays such similarity of certain mineral frequencies, that it suggests a common source for loess phases of the Loveland and Peoria silt members. There is not sufficient difference in the amounts of quartz, orthoclase, and plagioclase to be valuable for recognition purposes, but the high percentage of feldspars in all samples implies a common source for all loesses concerned in this study.

Further evidence for a common source was the occurrence of a hornblende-epidote suite in almost identical proportions in each of the loesses. This consistent suite comprised nearly 75 percent of the heavy minerals of all samples studied. Other minor similarities may be noted in Table 4. In all cases a comparison of mineral angularity, index of refraction, mineral zonation, inclusions, mineral alteration, and color of individual mineral grains suggests the same source. The rare detrital minerals found in the Peoria loess, not present in the Loveland loess or the Sangamon soil, are probably present because of a lesser amount of weathering of the Peoria loess. That a larger amount of leaching has taken place in the lower member is evidenced by its large accumulation of caliche.

Too little detail is known of Pliocene and early Pleistocene drainage history in north-central Kansas, but on the basis of the investigations of the Kansas Geological Survey (Frye and

A. B. Leonard, 1952) it appears that the present system of drainage was initiated during late Kansan or early Illinoian time. The principal rivers developed in the area were the Republican River, the North and South Forks of the Solomon River, and Prairie Dog Creek. The enlargement of this system was accomplished in a westerly direction by headward erosion of the rivers. As the system became more integrated and enlarged, it is likely that the clastic material of the Ogallala formation became available to the tributaries of the major streams. Concerning the origin and distribution of the Ogallala formation, Frye (1948) stated the following:

> In the central and southern Great Plains region Tertiary deposits accumulated first in the area where Colorado, Wyoming, and Nebraska meet; during Pliocene time they spread southward over the region of western Nebraska, Kansas, Oklahoma, Texas, eastern Colorado, and New Mexico. These Pliocene strata represent stream deposits of coarse to fine material over most of the region and are largely classed as the Ogallala formation. The depositing streams of the Ogallala flowing east and southeast from the Rocky Mountain region spread a sheet of sediment over an erosional surface of low relief, filled the shallow pre-Pliocene valleys, and built the surface of the earlier interstream divides. By the end of Ogallala deposition, a graded alluvial plain extended in Kansas from near the Flint Hills westward to the Rocky Mountain region; and there merged with the erosional surface in the mountains. This surface may have remained in a state of equilibrium while the so-called Algal limestone was formed in consequent depressions and abandoned channel lakes. Later the streams started to erode and develop valleys below the upper surface of the Ogallala. The history of the Great Plains during subsequent time was characterized by alternate periods of erosion and of deposition, modified at times by widespread eolian activity, stream piracies, faults in a few areas, and the development of solution-subsidence basins. Sometime after the close of Ogallala deposition the geologic epoch called Pliocene ended, and that called the Pleistocene began.

Reference is made to the measured stratigraphic section of an average exposure of the Ogallala formation in Phillips County (page 34). A heavy and light mineral separation was performed on the coarse sand and silt horizons as shown on the measured section. All samples were taken far back into the road cut and directly under the quartzite ledges. Results of the study are as follows: All figures are percentages of the total minerals in each fraction.

<u>Sample 1</u>: Light fraction

Quartz	61.0
Orthoclase	18.0
Plagioclase	17.0
Microcline	2.0
Chalcedony	2.0
Volcanic ash	0.0

Heavy fraction

Hornblende	64.0
Lamprobolite	3.0
Epidote	14.0
Zircon	10.0
Garnet	3.0
Muscovite	4.0
Tremolite	2.0

<u>Sample 4</u>: Heavy fraction

Hornblende	17.0
Lamprobolite	1.0
Epidote	23.0
Zircon	45.0
Garnet	8.0
Muscovite	5.0
Tremolite	1.0

The light fraction of samples 2, 3, and 4 showed similar amounts of quartz, orthoclase, and plagioclase. As in sample 1, no volcanic ash was detected in samples 2, 3, and 4. The heavy mineral fraction of sample 1 was exceptionally large; it constituted 10 percent of the total heavy and light minerals. Contrasted to this was a very light recovery of heavy minerals from samples 2, 3, and 4. The amounts were hardly sufficient to make a single mounted specimen. The upper horizon revealed a large hornblende-epidote assemblage; the lower three horizons showed a small zircon-epidote assemblage. The absence of volcanic ash in the samples of the Ogallala formation is possibly due to weathering. However, exposures of the Ogallala formation to the west of Phillips County contain lenses of relatively pure volcanic ash. Extensive leaching of the Ogallala in the area sampled is supported by zones of caliche accumulation in the lower horizons of the section. The minor amounts of hornblende in the lower horizons, as compared to more stable minerals; i.e., zircon and garnet, is possibly due to differences in the rate of weathering of these minerals.

The individual mineral grains of the Ogallala formation are conspicuously angular; particularly the grains of hornblende. Most of the hornblende grains are prismatic needle-like terminations developed on the fine prismatic cleavage. With the exception of angularity, minerals of the Ogallala are quite like those found in the loess deposits.

On the basis of this observation, it appears that the Ogallala formation may have served as a chief source for the Loveland and Peoria loesses. Further studies on the Ogallala must be accomplished before this contention is beyond dispute.

This study has shown that the volcanic ash present in the

Sanborn formation was not derived from the Ogallala formation; that is, if the section studied is representative of the entire formation. Studies of the volcanic ash in the Peoria loess also show that it is unlike the Pearlette ash of the Meade formation. Swineford and Frye (1946) found a constant index of refraction for the Pearlette ash to be 1.499-1.502. The index of refraction for some of the ash shards in the Peoria loess is slightly above the upper limit for the Pearlette ash and the range of the indices is not nearly so constant as that of the Pearlette ash. The work of Swineford and Frye (1946) also revealed the presence of elongate bubble inclusions in the shards of the Pearlette ash. Their study further showed an abundance of fibrous ash shards. The ash shards of the Peoria loess contain nearly spherical bubble inclusions and fibrous shards are almost completely lacking.

The Ogallala formation and the Pearlette ash of the Meade formation represent the only known continental sedimentary sources for ash in the loess deposits. Because of the absence of ash in the Ogallala formation, at least in the sampled section, and the unlike character of Pearlette and Peoria ash shards; it is proposed that the ash fell from the atmosphere and was deposited contemporaneously with the silts and fine sands borne out of the river valleys and deposited on the uplands.

In an attempt to explain the absence of volcanic ash in the Loveland loess and the Sangamon soil, a sample of Brady soil was examined for the presence of ash shards. The Brady soil is developed at the top of the Peoria loess. The geographic location of this sample from Phillips County is given in Table 1. Any differences in the amounts of volcanic ash should be directly confined to differences in weathering. Results revealed no loss in the percentage of ash; establishing its stability in loess deposits of early Wisconsinan age. The extent of leaching and weathering during Sangamonian time is not certain but the well-developed soil indicates that the time was considerable. Exposures which were visited showed a much greater amount of weathering and leaching of the Loveland and Sangamon soil as compared to the Peoria loess. The absence of volcanic ash in the Loveland and its associated soil may possibly be due to a much longer period of weathering. Volcanic action over the world released ash throughout all of Tertiary times and extended this fall into the Quarternary. That the amount of ash being deposited was constantly fluctuating with time is shown by lenticular beds of ash in continental Pliocene and early Pleistocene deposits. It is likely that that lack of ash in certain loesses could be attributed to a slackening in the amount of ash being dropped on the earth's surface.

Results of X-Ray Clay Mineral Study

Samples of the Loveland loess, Sangamon soil, and Peoria loess from Phillips County were selected and prepared for X-ray diffraction study by the Geological Laboratory of the Kansas Highway Commission. Medium sized clay particles, 0.2 to 0.08 microns, revealed a predominance of montmorillonite and minor amounts of illite in all samples.

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A PETROGRAPHIC COMPARISON OF THE LOVELAND AND PEORIA LOESSES OF NORTHERN KANSAS

by

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This investigation endeavored to distinguish between the Loveland and Peoria silt members of the Sanborn formation in northern Kansas through the use of light and heavy mineral determinations. A secondary purpose was to provide the preliminary study needed for the future clay mineral investigations of the Kansas Highway Commission. It is possible that certain highway failures in the area are associated with troublesome clay minerals derived from weathered Loveland or Peoria loess.

The Loveland and Peoria loesses in the area can be distinguished from each other by the presence of volcanic ash in the Peoria loess (7 percent average) contrasted to a nearly complete absence of the ash in the Loveland loess and its associated Sangamon soil. Zircon and garnet are also useful index minerals; their frequency in the Loveland being double to their frequency in the Peoria.

The high percentage (75) of hornblende and epidote in both loesses indicates a probable common source for both. A study of the Ogallala formation revealed that certain horizons contain this same hornblende-epidote assemblage.

For these reasons, it is possible that the Ogallala formation served as one of the chief sources of sand and silt for the Loveland and Peoria loesses.