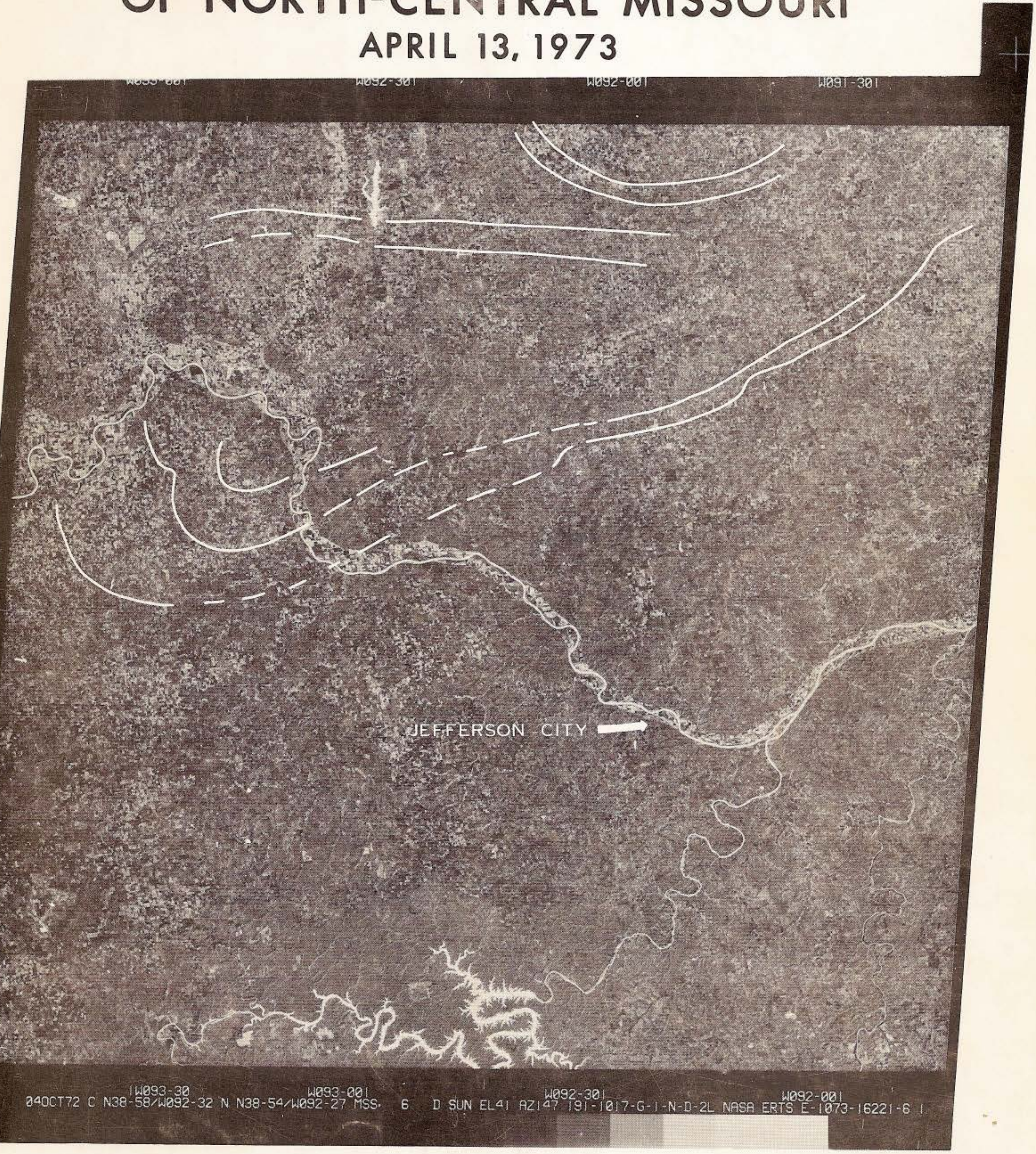
GUIDEBOOK

NORTH-CENTRAL GSA
FIELD TRIP NO. 2

PLEISTOCENE AND ENGINEERING GEOLOGY OF NORTH-CENTRAL MISSOURI

APRIL 13, 1973



PREPARED FOR THE ANNUAL MEETING OF THE NORTH-CENTRAL SECTION GEOLOGICAL SOCIETY OF AMERICA. SPONSORED BY THE UNIVERSITY OF MISSOURI – COLUMBIA – DEPT. OF GEOLOGY AND THE MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES, ROLLA, MISSOURI.

PLEISTOCENE AND ENGINEERING GEOLOGY

OF NORTH-CENTRAL MISSOURI

Prepared cooperatively by

Department of Geology, University of Missouri – Columbia

and

Missouri Geological Survey and Water Resources

Field Trip Leaders

M. J. Guccione and S. N. Davis – University of Missouri

W. H. Allen, Jr. and J. H. Williams – Missouri Geological Survey

Miscellaneous Publication No. 26

MISSOURI GEOLOGICAL SURVEY & WATER RESOURCES

WALLACE B. HOWE, STATE GEOLOGIST AND DIRECTOR

P. O. BOX 250

ROLLA, MO. 65401

CONTENTS

PLEISTOCENE AND ENGINEERING GEOLOGY OF NORTH-CENTRAL MISSOURI

INTRODUCTION by W. H. Allen, Jr.

This guidebook has been prepared for the North-Central GSA sectional meeting. It is designed to illustrate the complexities of the till in a near terminal location. The southern boundary as previously mapped (Geologic Map of Missouri, 1961, McCracken) lies just south of the Missouri River, a straight line projected distance of 25 miles from the area discussed on the field trip. To the southwest Todd (1896, plate XII) mapped the drift boundary only fifteen miles from the general area discussed in this field guide. The information provided in this guidebook must only be considered as tentative. Consequently very few conclusions are offered regarding placement of units within a recognized or classical stratigraphic framework. Instead emphasis is placed on the local correlation along the 10 mile east-west traverse covered on the field trip.

The regional picture is suggested on the frontal cover by the ERTS-1 frame 16221-6. The southern till boundary is very indistinct on the imagery; therefore it has not been drawn in on the photo. Two roughly parallel lines that are south of the Missouri River in Saline County may be traced across the state to the northeast where they merge with the Kansan till boundary in Illinois as illustrated by Willman and Frye (plate 2, 1970). Two pronounced deviations from a relatively straight line are noted on the southern most linear. These deviations occur on the axis of two minor anticlines: the Brown Station Anticline to the west and the Mexico Anticline to the east. The former is more completely discussed under the heading of Bedrock Geology later in this text. The positive nature of these two structural elements, early in Pleistocene time, seems to have affected the distribution of the till in their immediate vicinity. Verification of this influence must be made.

Further north two subparallel lines are faintly visible. They appear to terminate at Swan Lake, a point that is tentatively suggested as the southern boundary of the Nebraskan till by Heim and Howe (1962). Their data was based on over 1200 exploratory water wells drilled in the Northwestern part of the state.

The crescent shaped lines that are indicated in the northeastern part of the image parallel the present course of the Salt Fork River. They suggest either a terminal (Nebraskan ?) or recessional moraine however there is no data available to substantiate either interpretation.

No explanation can be offered for the fact that two or more lines seem to parallel each other throughout most of their recognizable length. For the most part these lines are approximately 4 to 10 miles apart. Work plans are presently being formulated to investigate the significance of all the lines indicated on the imagery. To date the most intensive study (drilling, probing and field investigations in the strip mines) has been carried out north of Columbia in the general area covered by this field trip.

The ERTS-1 images have provided a new and economical approach to mapping of Pleistocene deposits. However, they only serve as a means to an end; specifically (1) they indicate areas where intensive field investigations must be carried out, and (2) they provide a regional picture for investigations which are problem and site oriented.

References

Heim, G.E. and Howe, W.B., 1962, Pleistocene drainage and Depositional history in northwestern Missouri, Kansas Acad. Sci., Vol. 66, No. 3, pp. 378-392.

McCracken, M.H., et. al., 1961, Geologic Map of Missouri, Missouri Geological Survey.

Todd, J.E., 1896, Formation of the Quaternary Deposits, in Surface Features of Missouri, edited by Charles R. Keyes, Missouri Geological Survey, Vol. X, pp. 114-217.

Willman, H.B. and Frye, J.C., 1970, Pleistocene Stratigraphy of Illinois, Illinois Geological Survey, Bull. 94.

Acknowledgments

Appreciation is expressed to G.J. Kukla, G.R. Hallberg, R.F. Burmester, W.R. Wood, and J.C. Baker for their helpful discussions in the field regarding correlation and stratigraphic problems. Students from UMC (Dept. of Geology and Dept. of Anthropology) and UMR (Dept. of Geology) have assisted in preparing the cuts for the trip. Their contribution has been quite helpful.

Special thanks are expressed to those individuals who prepared papers for the guidebook. Peabody Coal Company, represented by R. Scott Brundage, has made the access roads and strip mines available for study and open to the field trip as has the City of Columbia for the landfill operation. Their cooperation is appreciated.

PLEISTOCENE STUDIES IN NORTH-CENTRAL MISSOURI

by S. N. Davis
University of Missouri - Columbia

Some of the earliest detailed observations of Pleistocene deposits in the central part of the United States were made by G. C. Swallow in Missouri prior to the Civil War. Despite this early start, later studies in Missouri have lagged behind most of the adjacent states. In the vicinity of Columbia work has been completed primarily by graduate students from the University of Missouri-Columbia and most of these studies have been master's theses with specialized objectives. Few regional investigations have been attempted. The present field trip will afford an opportunity to view exposures which are being studied as part of a new regional project. Conclusions from this study are tentative, so we hope that participants in the field trip will enjoy a lively discussion.

The bedrock topography of the glaciated region in northern Missouri is important in the interpretation of Pleistocene history. Because of the considerable information available through water well and test drilling work, it has been possible to delineate the principal preglacial drainageways in Northwestern Missouri. Most of the buried valley systems were inherited from topography that presumably developed during the late Tertiary. Nevertheless, deposits which might be classified as Tertiary are rare. Chert gravel and residual clays on top of bedrock have been observed in only a few places. Some of these gravels and clays may be Tertiary.

Missouri River marks the approximate southern boundary of glacial deposits in the state. The bulk of these deposits have been classified as Kansan and Nebraskan, although correlations have been generally based only on the fact the tills overlie bedrock and locally underlie Wisconsinan and probable Illinoian loess. In the few places in northern Missouri where zones of deep weathering or "gumbotil" separate an upper from a lower till, the lower till has been called Nebraskan and the upper till has been called Kansan. The apparent complexities of the Nebraskan, Kansan, and Illinoian sequences in adjacent states, however, suggest that considerable caution should be exercised with existing correlations in Missouri.

Till, fluvio-glacial sands and gravels, and lacustrine silts and clays of early to middle Pleistocene age are overlain by a blanket of middle to late Pleistocene loess in northcentral Missouri. The loess ranges in thickness from more than 100 feet in the northwestern corner of Missouri to only two or three feet on flat uplands of northcentral Missouri. South of the Missouri River, the loess ranges in thickness from about a maximum of 70 feet near the river to only a few feet in the upland areas of southcentral Missouri.

The present drainage system in northcentral Missouri is a composite of exhumed ancient valleys and superposed valleys associated with streams that developed upon Pleistocene till plains. Floors of the lower reaches of the principal buried valleys lie as much as 100 feet below the beds of present-day streams. Away from the buried valleys, however, the major present-day streams are cut into Paleozoic bedrock. Well developed terraces, ranging in age from late Illinoian to Recent, flank most modern streams.

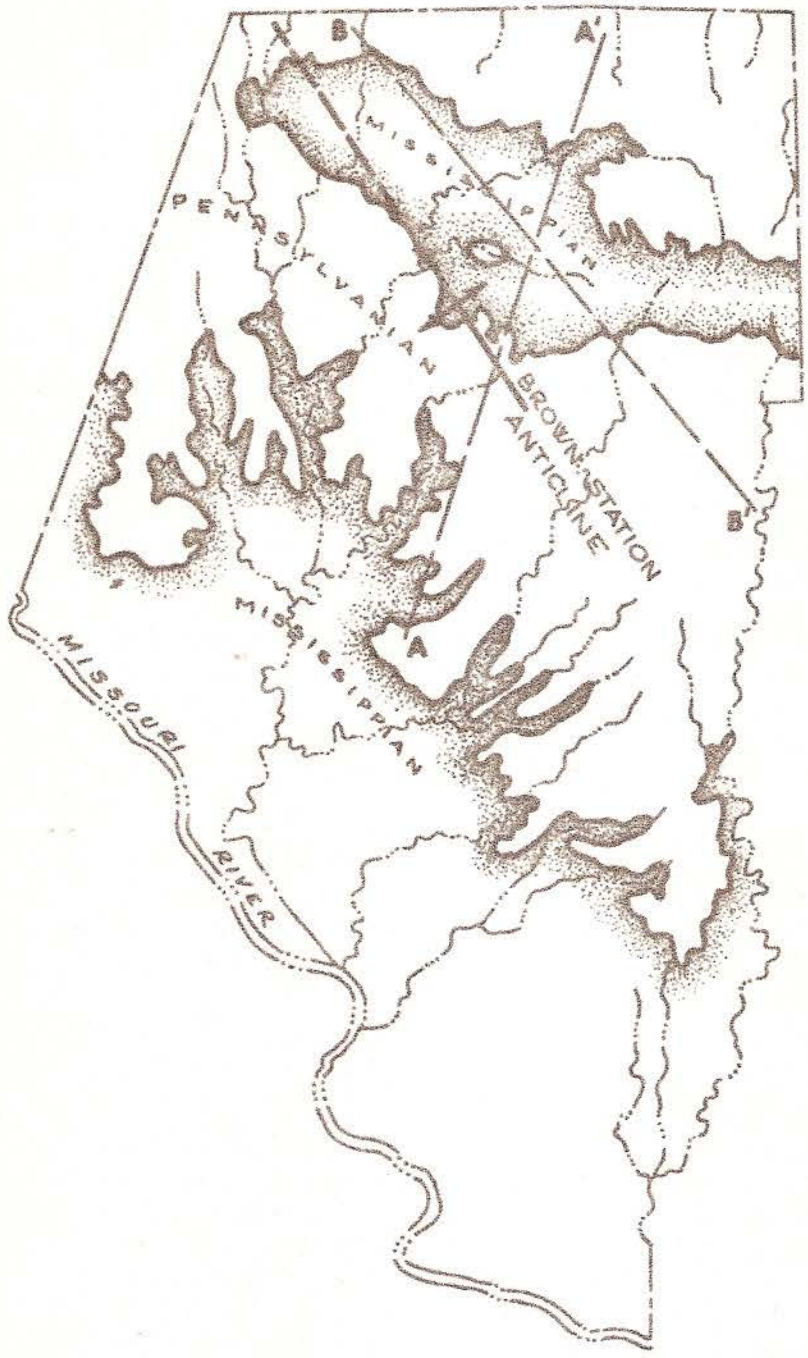
BEDROCK GEOLOGY

by M. J. Guccione

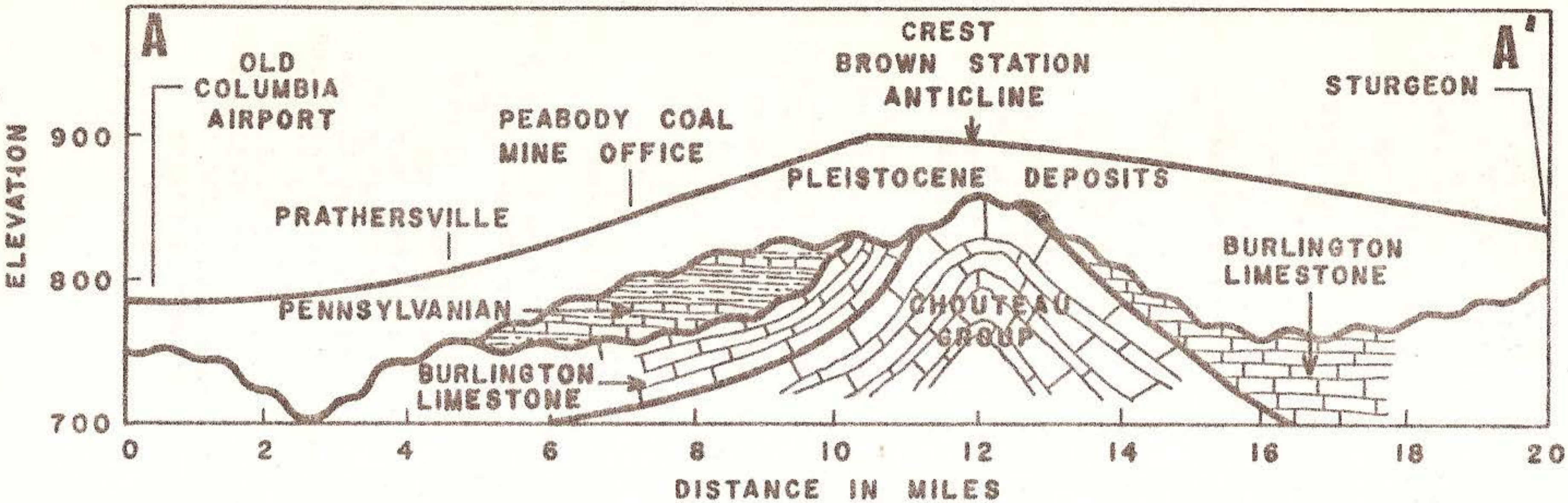
Bedrock in Columbia is part of the Lower Middle Mississippian, the Osagean Series, Burlington Limestone. The Burlington is a biosparite with abundant crinoid stems and white chert nodules. North of Columbia it is almost exclusively calcareous but south of town it becomes dolomitic. The regional dip in central Missouri is 1° north, therefore the area of the field trip is upsection and is underlain by the Cherokee and Marmaton Groups of the Desmoinesian Series (Lower Middle Pennsylvanian). These cyclothem deposits consist of relatively thin bedded limestones, shales, siltstones, clays and coals.

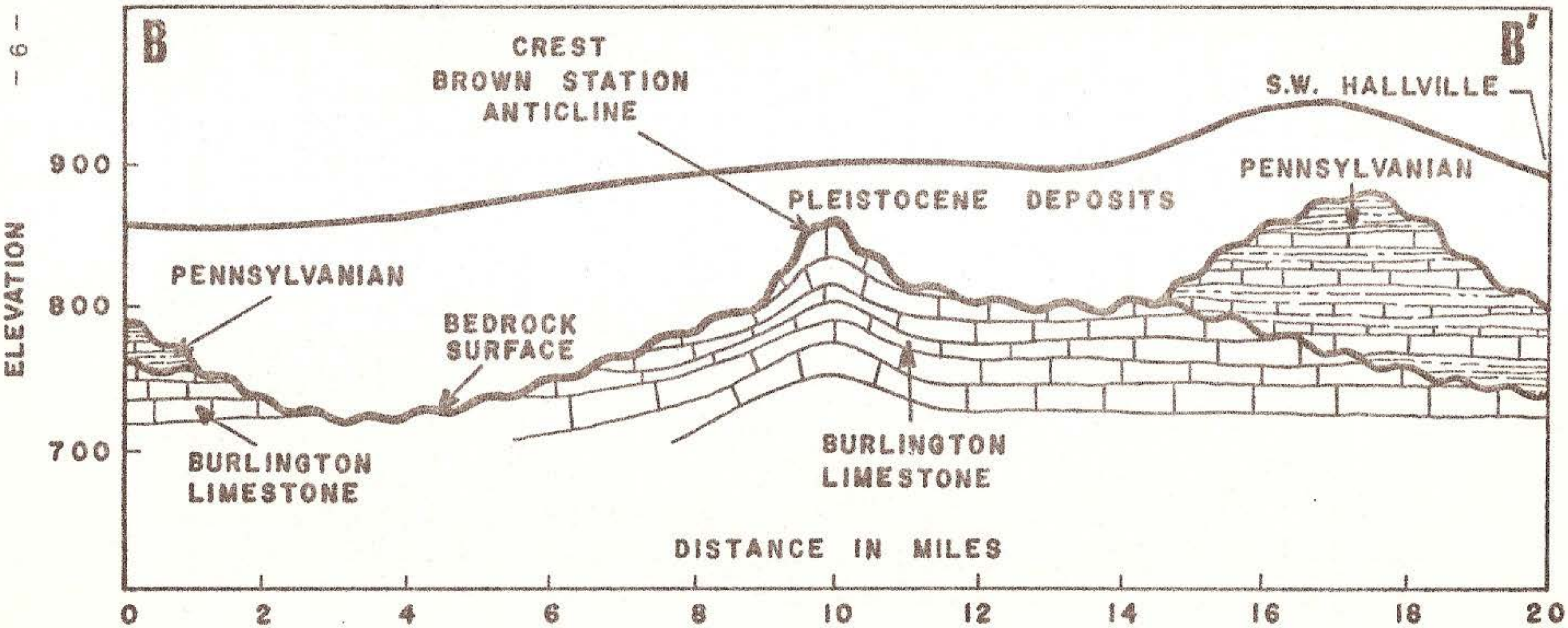
Coal was the most important mineral resource in the county, the largest mining operation being the Mark Twain Mine operated by Peabody Coal Company. The Bevier Coal of the Cherokee Group, averaging 3 feet in thickness, was the unit most extensively mined. Most of the strip mines, including the ones visited on the field trip, are concentrated around the northwest and south flanks of the Brown Station Anticline where the coal is exposed in valley walls and the Pleistocene cover is thinner. Peabody Coal ceased mining operations in the fall of 1972 because the low quality of Pennsylvanian coal in Missouri did not meet new environmental standards. At the present time land reclamation work is in the process.

The most significant structure in the area is the Brown Station Anticline which trends N 15° W. There is evidence to suggest that the structure may actually be a monocline rather than an anticline. The southwest flank of the structure is well exposed in streams and dips as much as 30° to the southwest. The northwest flank is largely covered by Pleistocene sediments but dips are inferred to be only 1/2°. The anticline plunges to the southeast and is not well exposed. To the northwest the beds flatten however the Mississippian Limestone is still at the surface. At the crest of the anticline the older Chouteau Limestone crops out surrounded by younger Burlington Limestone and the latter is in turn surrounded by the younger Pennsylvanian strata.



Boone County, showing lines of cross sections
(Taken from Geologic Map of Missouri, compiled by Mary H. McCracken, 1961)


A
A'
OLD COLUMBIA AIRPORT
CREST BROWN STATION ANTICLINE
STURGEON
PEABODY COAL MINE OFFICE
PLEISTOCENE DEPOSITS
PRATHERSVILLE
BURLINGTON LIMESTONE
PENNSYLVANIAN
CHOUTEAU GROUP
BURLINGTON LIMESTONE
ELEVATION
900
800
700
0
2
4
6
8
10
12
14
16
18
20
DISTANCE IN MILES

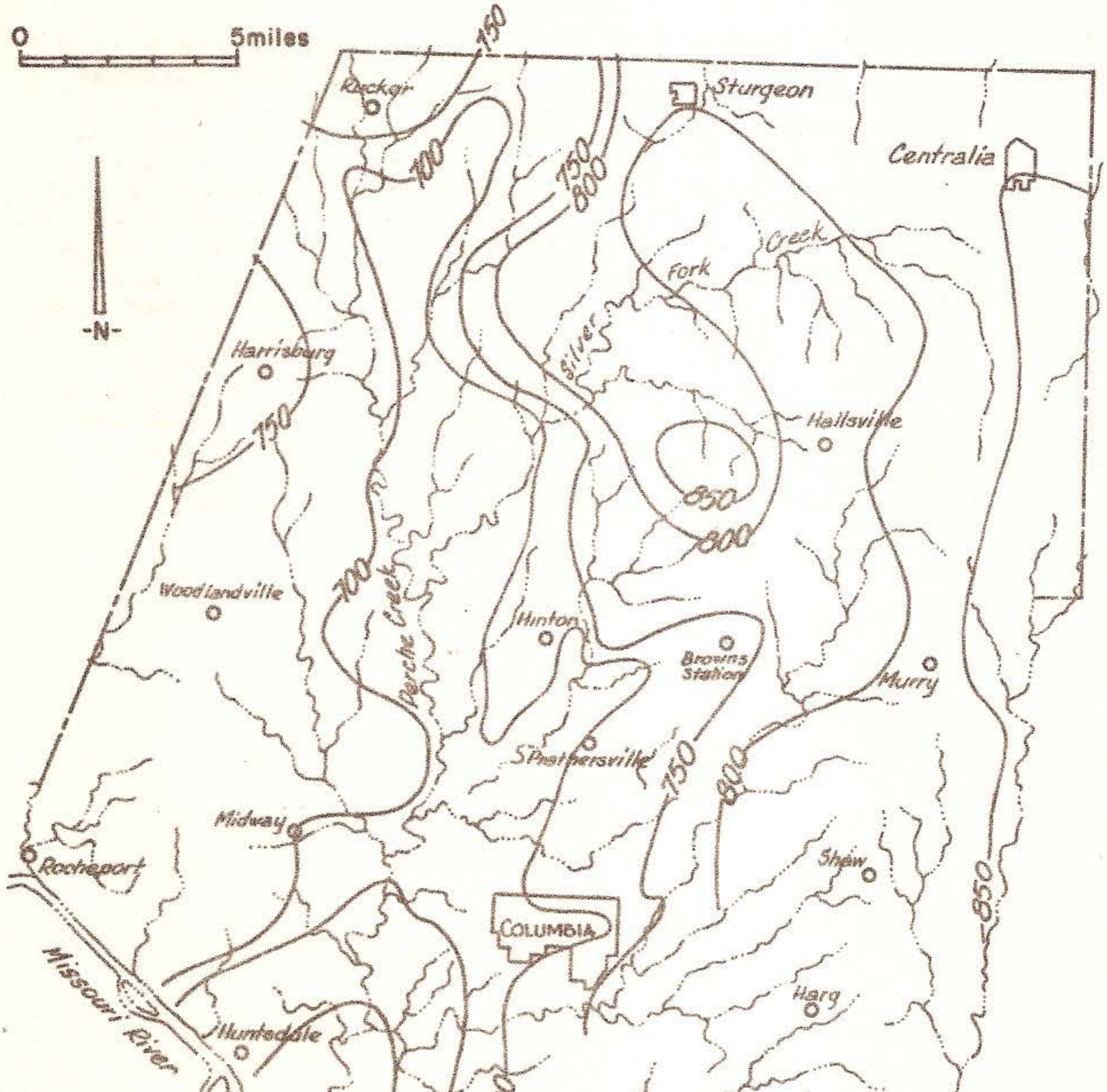

B
B'
CREST BROWN STATION ANTICLINE
S.W. HALLVILLE
PENNSYLVANIAN
PLEISTOCENE DEPOSITS
PENNSYLVANIAN
BEDROCK SURFACE
BURLINGTON LIMESTONE
BURLINGTON LIMESTONE
ELEVATION
900
800
700
DISTANCE IN MILES
0
2
4
6
8
10
12
14
16
18
20

Geomorphology

The unusual drainage patterns in the area seem to be determined by the preglacial bedrock topography which is partly affected by the structure and/or the more resistent limestone exposed by folding. A local divide follows the trend of the anticlinal crest in the southern part of the Brown Station Anticline where the bedrock elevations are higher and the beds are steeply dipping to the southwest. This crest seems to be separated from a higher portion of the bedrock divide to the east by a small swale. Silver Fork Creek surrounds it on three sides and Rocky Fork Creek and Hinkson Creek drain the south edge. On the northern part of the anticline where nearly horizontal limestone beds are exposed at lower elevations, Perche Creek and Lick Fork Creek cross the structure with no indication that folding has altered the southerly flow of the streams. However the presence of the Burlington at the surface drastically increases the sinuosity of Lick Fork Creek and all other streams where they flow over the limestone. Topographic high coincides with the bedrock highs and is the Mississippi-Missouri River divide in the area to the east except where breached by Cedar Creek. Both Pennsylvanian strata and the more resistant Burlington make up this bedrock divide but only the less resistant Pennsylvanian has been dissected and exposed by Cedar Creek.

Deposition of Pleistocene sediments was draped over the bedrock uplands and gently slopes away in all directions. Subsequent development of drainage systems has encountered four situations. Some of the ancient valleys were completely filled with sediment and have not been reexcavated by modern streams. A second situation that occurred was a modern stream following an old bedrock valley where infilling of the valley was incomplete or subsequent compaction has resulted in a topographic swale. Thirdly bedrock and associated topographic highs have diverted modern streams and in the last case bedrock highs have been breached.

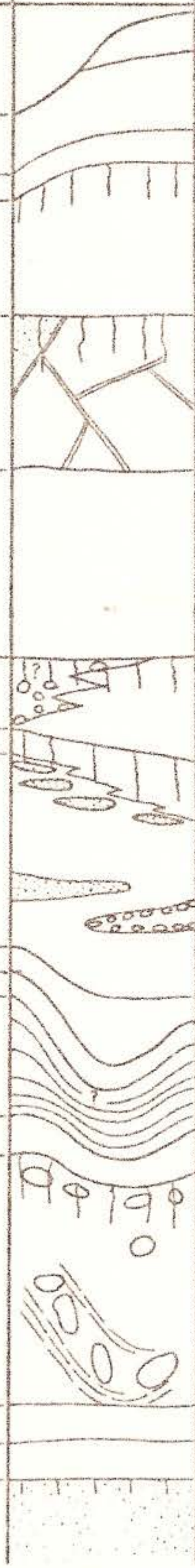
Perche Creek and one of its tributaries, Silver Fork Creek are excellent examples of a combination of all four situations. Perche Creek is a superimposed stream developed on a much larger buried valley. This valley was quite wide where it emptied into the old Missouri River, wider than the present Perche Creek. Upstream it narrowed rapidly as it flowed over limestone and widened abruptly as the bedrock changed to the softer Pennsylvanian beds. In its upper reaches the stream could not cut through the Burlington limestone exposed along the Brown Station Anticline and was diverted northwest for a very short distance. It finally crossed the structure where the beds were nearly horizontal but did not cross the bedrock divide. Perche Creek closely followed the ancestoral Perche Creek's valley and Silver Creek, one of its tributaries, also developed on a buried tributary valley.



BEDROCK CONTOUR AND PRESENT DRAINAGE SYSTEM - BOONE CO.

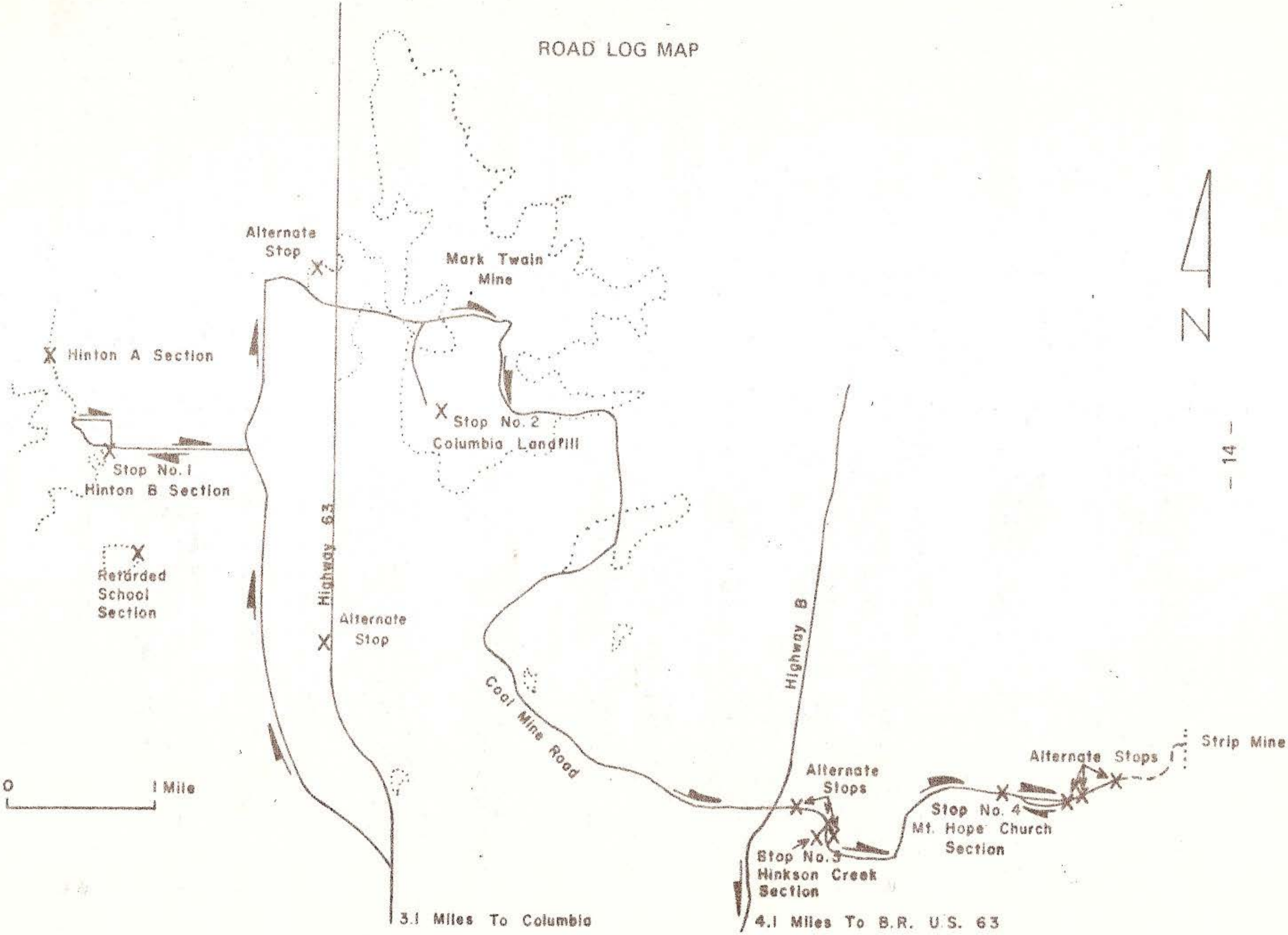
However as it eroded headward or downward it breached the buried bedrock divide at the edge of the steeply dipping Brown Station Anticline. Once "over the hump" Silver Fork was trapped in a swale of another bedrock valley. It eroded eastward, upstream: therefore the downstream portion of the buried valley has not been dissected and is filled with 150 feet of Pleistocene deposits Additional evidence that Silver Fork Creek was entrapped in an east-west depression is the elevation of ajacent uplands. To the south the undissected upland is 900-915 feet in elevation and to the north elevations are 870-880 feet, indicating the normal flow should be northerly. The upper reaches of the Silver Fork does just that. Headward erosion has butted the stream against a north-south bedrock divide. It has not been able to breach this high and has eroded southward. Hence the Silver Fork Creek has an unusual U shaped drainage pattern. Other streams in the county also have complex drainage patterns but Silver Fork is the most unusual and the best example of this complexity.

Tentative Stratigraphic Column for Columbia Strip Mine Area



Sections where units are exposed	Stratigraphy	Lithology
Trailer, Mt. Hope Church & Church East, Hinton B, Hinton A, Rt. B, Rt. 63 & Hinkson		Loess
		Clay, sandy with some pebbles, mottled gray and yellowish brown
Curve, Hinkson Cr. Rd? Mt. Hope Church & Church East		Clay, good paleosol
Rt. 63, Powerline N & S		
Rt. B, Powerline N & S Curve?		Clay, silty, with a little sand and few pebbles, gray, leached, plastic
Powerline N, S, SW, NW, Mt. Hope Ch. East, Mt. Hope Ch., Trailer, Retarded School, Hinton B, Hinkson Cr.? Hinkson Cr. Rd., Hinton A, Rt. B? Rt. 63		Till, silty, sandy, pebbles sparse, may be sandy upper part and highly oxidized, often deoxidized below with deep oxidized vertical joints and $CaCO_3$ nodules
Rt. B, Powerline N, S, NW & SW Curve?		Clay, silty, with some sand and a few pebbles, gray leached, plastic, difficult to distinguish from upper silty clay except by stratigraphic position
Hinton B, Retarded School, Mt. Hope Church?		Sand, silty, maroon, paleosol developed, laterally may change to gravel, paleosol developed
Hinton		Clay, silty, compact yellowish red and gray mottled, paleosol developed
Hinkson Cr., Retarded School, Hinton core, Rt. 63, Mt. Hope Ch., Hinton A		Till, quite sandy, gravel and sand lenses common especially in upper part, compact, often yellow brown with gray along joints, unoxidized, unleached at base at some localities
Hinton A, Mt. Hope Ch?		Silt, dark gray, not compact
Mt. Hope Ch.		Silt, clayey, gray, noncalcareous, contorted
Mt. Hope Ch.		Silt, excellent bedding with some clay and fine sand laminations, paleomagnetically negative, contorted.
Mt. Hope Ch., Hinkson Cr., Rt. 63		Silt, light brownish gray, few pebbles, compact contorted
Hinkson Cr., Hinkson Cr. Rd., Mt. Hope Ch., Powerline S & SW.		Till, clayey, little sand, cobbles abundant, mostly rounded chert, few erratics, compact, highly contorted, paleosol developed
Hinkson Cr.		Clay
Hinkson Cr.		Clay, silty, gray
Hinkson Cr., Mt. Hope Ch., Rt. 63		Bedrock, Pennsylvanian sandstones or limestones, or Mississippian limestones, may have paleosol developed

ROAD LOG MAP


Alternate Stop
Mark Twain Mine
Hinton A Section
Stop No. 2
Columbia Landfill
Stop No. 1
Hinton B Section
Retarded School Section
Highway 63
Alternate Stop
Coal Mine Road
Highway B
Strip Mine
Alternate Stops
Alternate Stops
Stop No. 4
Mt. Hope Church Section
Stop No. 3
Hinkson Creek Section
0
1 Mile
3.1 Miles To Columbia
4.1 Miles To B.R. U.S. 63
N

ROAD LOG & DETAILED SECTION DESCRIPTIONS

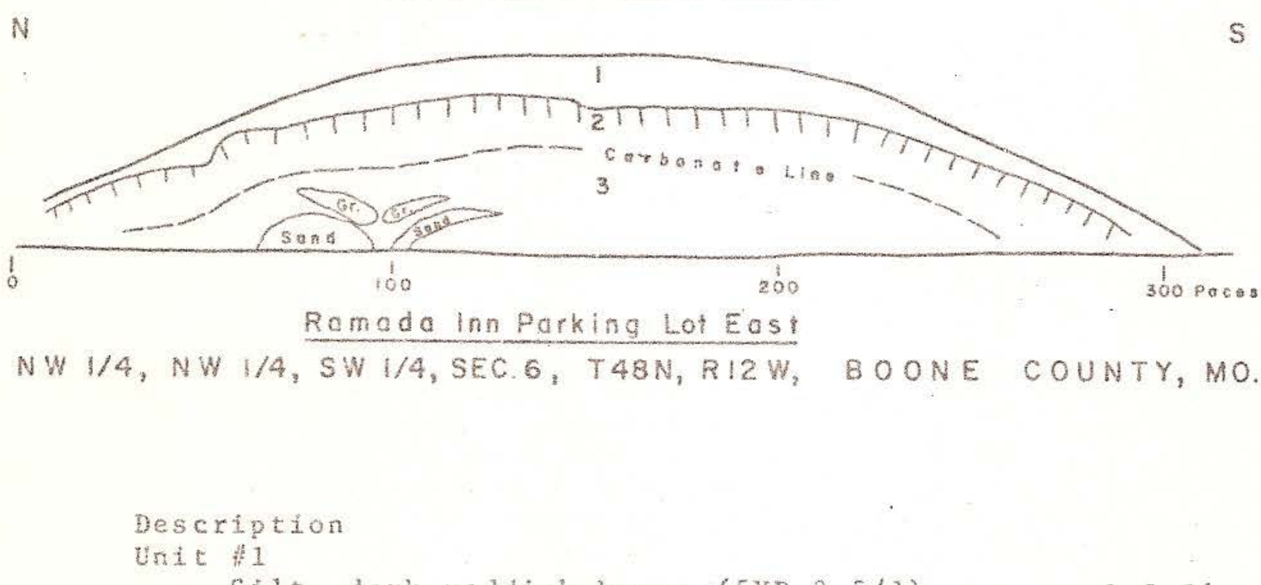
Milage — Friday, April 13, 1973

0.0 Cars will leave from the rear (east parking lot of the Ramada Inn as soon as participants have picked up box lunches and drinks. Departure will be no later than 12:30 pm.

Note: Ramada Inn Section described below by M.J. Guccione may be inspected on one's own time. It is not considered an official field trip stop, but it does merit attention because of the large proportion of locally derived chert which constitutes the coarse fraction in the till.

Location: NW1/4, NW1/4, SW1/4, Sec.6, T.48N, R.12W, Boone Co., Mo.
Behind Ramada Inn, just north of I-70 & east of Rt. 63. Cut stretches from Vandiver Drive to I-70.

Diagramatic Cross Section



Ramada Inn Parking Lot East

NW 1/4, NW 1/4, SW 1/4, SEC.6, T48N, R12W, BOONE COUNTY, MO.

Description
Unit #1

Silt, dark reddish brown (5YR 2.5/1) grading down to dark brown (7.5YR 3/2) in 6". Abrupt increase in clay content and color change to yellowish red (5YR 4/8), brown	1.5-5'

(10YR 4/3) and very dark gray (7.5YR 3/0) mottled. Clay skins & peds. B Horizon grades down 2' to gray (10YR 5/1) deoxidized clay skins, reddish yellow (7.5YR 6/8) and red (2.5YR 4/6) mottled. Mottles coarser than above-up to one in. in diameter Manganese pellets throughout B zone in basal 2-4 in. (pebble content increases toward base).

Unit #2

Stone Line-concentration of cobble gravel & coarse sand, mostly chert, also erratics, of granite, quartzite graywacke, gabbro. Follows contour of present slope generally but 2 gulleys are present. 0.7'

Unit #3

Till, Paleosol developed, B Horizon top yellowish red (5YR 4/8) mottled with red (2.5YR 4/8). Clay skins and peds present to depth of 5'. Mn along joints becomes common 2.5' below stone line. Deoxidation (olive 5Y 5/2) at 2' becomes greater, up to several in. in diameter, to a depth of 4'. Leached to a depth of 4 1/2'-6 1/2' though secondary calcite may be present up to 1/2' above that. $CaCO_3$ found as concentrations and disseminated along joints. Clay content drops at change from mottled light olive gray (5Y 6/2) and yellowish brown (10YR 5/8) to an oxidized light olive brown (2.5Y 5/4), Mn staining & $CaCO_3$ along joints. Joints several to 4 in. apart. Locally more oxidized surrounding sand lenses. Abundant red shale pebbles completely disintegrated to clay. Till fabric random. 2 large lenses of sand & 2 of gravel. In one sand lense it coarsens to small gravel at base with one large rotten greenstone boulder (0.8' diameter). In the sand lense one large limestone boulder (1.4' diameter). 12.5'

0.2 Right (north) at Route 63 intersection

0.5 Mississippian contact on right; Pennsylvanian shales behind Hudson Gas Station on left.

3.5 Turn left (northwest) on Route VV.

4.0 Pennsylvanian shale and limestone on left (west).

4.5 Cross Rocky Fork bridge (Burlington Limestone in valley wall to left).

5.2 Pennsylvanian Limestone and shales in fields to left.

6.4 City limit - Hinton

7.2 Left (west) on gravel road; lake behind house on left.

7.8 Cross bridge (Slacks Branch).

8.2 Stop #1 - Hinton B Section.

Hinton B Section

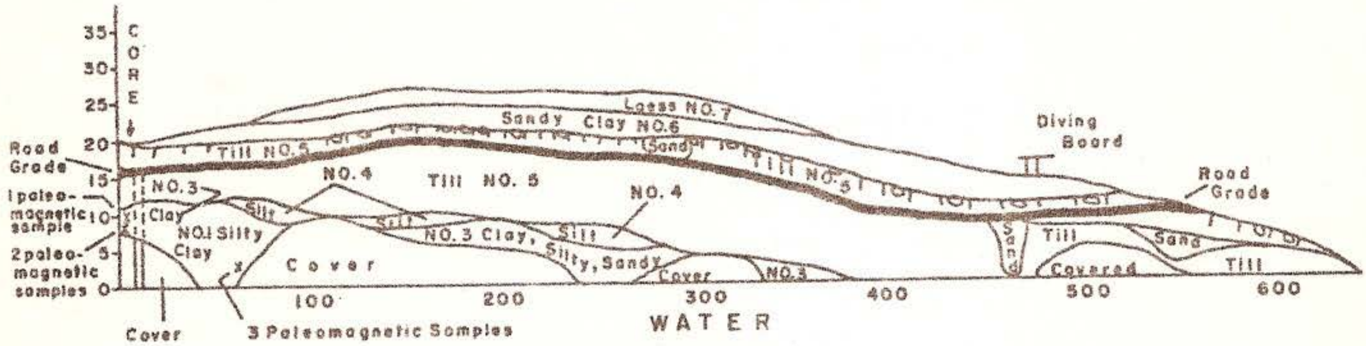
Section measured and described 1973 by James C. Baker, S.N. Davis, M.J. Guccione, and W.H. Allen.

Location: NE1/4, NW1/4, SE1/4, Sec.3, T.49N., R.13W., Boone Co., Mo.
Strip mine along tributary to Slacks Branch.

Discussion

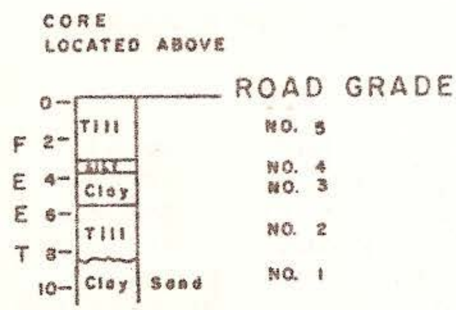
With the exception of the upper most loess and colluvial slope wash deposits the units described below are considered to be early Pleistocene in age. Included are two tills and an intervening silt. The lower till is poorly exposed at this site, however it is readily apparent 0.7 mile to the south in the Retarded School section and in a core extracted from the northern end of the Hinton B cut. A paleosol occurs at the top of this compact sandy till which is normally calcareous. Leaching has occurred to a depth in excess of 4 1/2 feet. An abundance of locally derived coarse materials, including shale, coal, and some chert, is present. The above paleosol is overlain by a silt of varying thickness which also has paleosolic development in the upper part at both locations. In the Retarded School Section, the silt is interbedded with sand and gravel lenses and the thickness is greater than 10 feet. The overlying till is not compact. Its texture is more silty than the lower compact sandy till, and northern erratics are common. Frequently the two tills are in juncture position and the field criteria which has proven most useful in differention is the contrast in compaction and texture. The upper till appears to be discontinuous as determined by exploratory drill holes located on the crest of surrouding hills.

Overlying the upper till, which has a minimal soil profile development in the upper portion, is a thin colluvial slope wash unit. This in turn is overlain by Wisconsian loess which is generally less than two feet thick.



Hinton B Section

NE 1/4, NW 1/4, SE 1/4, SEC. 3, T49N, R13W, BOONE COUNTY, MO.



ELEVATION ~740+

Unit	Description	Thickness (feet)
7	Loess, mottled gray (5Y 6/1) with strong brown (7.5YR 5/6) grading down to brown (10YR 4/3) modern soil developed	0-2'
6	Clay, sandy, yellowish brown (10YR 5/4) with grayish brown (10YR 5/2) mottles.	
5	Till, paleosol developed and partially exhumed: 0-0.7' A dark grayish brown (10YR 4/2), silt loam	

2' B_2 matrix yellow brown (10YR 4/2) with few yellowish red (5YR 4/6) mottles, clay, fine angular blocky, gray (5Y 6/1) mottling at base, leached 2.5', yellow

3-10' C brown (10YR 5/6) sandy silt. mottled with gray (5Y 6/1), deoxidation becomes more predominent with depth, oxidation restricted to deep, well developed, vertical joints along with $CaCO_3$ nodules, coarse angular blocky structure, sandy silt. 3-10'

4 Silt, strong brown (7.5YR 5/6) mottled with brown (5YR 5/2), massive, well sorted, leached

3 Clay, silty, paleosol developed:

2' B_2 matrix brown (7.5YR 5/4) with dark brown (7.5YR 4/4) coatings, strong medium angular blocky to prismatic in lower portion.

C gray (10YR 6/1) with some yellow brown (5YR 5/6), leached but $CaCO_3$ nodule along joint.

Laterally this unit thickens and becomes more sandy.

2 Described below from core.

1 Clay, silty, suggested truncated paleosol:

2.5' yellowish red (5YR 5/6) with light gray (5YR 7/1) along joints, some sand, medium coarse angular blocky, leached 2.5' from upper contact and 6.5' to upper contact of unit 4.

Core taken from north end of section verifies suggested paleosol in unit 1. Till, unit 2, is found in core but not exposed in outcrop. It is described below.

2 Till with well developed paleosol and sharp contact with unit 3

0.5' B_2 dark yellow brown (10YR 4/4) with gray (10YR 6/1) diffuse mottles, sandy clay, manganese stained along joints, strong angular blocky.

1.0'	B_2	yellow brown (10YR 5/6), gray (10YR 5/1) inclusions and diffuse strong brown (7.5YR 5/8) mottles, manganese stains, massive to weak subangular blocky.
1.5'	C	yellow brown (10YR 5/6) with gray (10YR 6/1) mottles, manganese stains massive to prismatic.
0.5'		Gradational contact with unit 2 below, brownish yellow (10YR 6/8) with light brownish gray (10YR 6/2) mottles and some strong brown (7.5YR 5/8) mottles, leached.

8.2 Continue ahead

8.3 Right (north) on Coal Mine Road.

8.5 Right (east) into farm lane road.

8.8 Right (south) back to main gravel road.

8.9 Left (east) on gravel road.

9.2 Recross Slacks Branch.

10.0 Left (north) on Route VV.

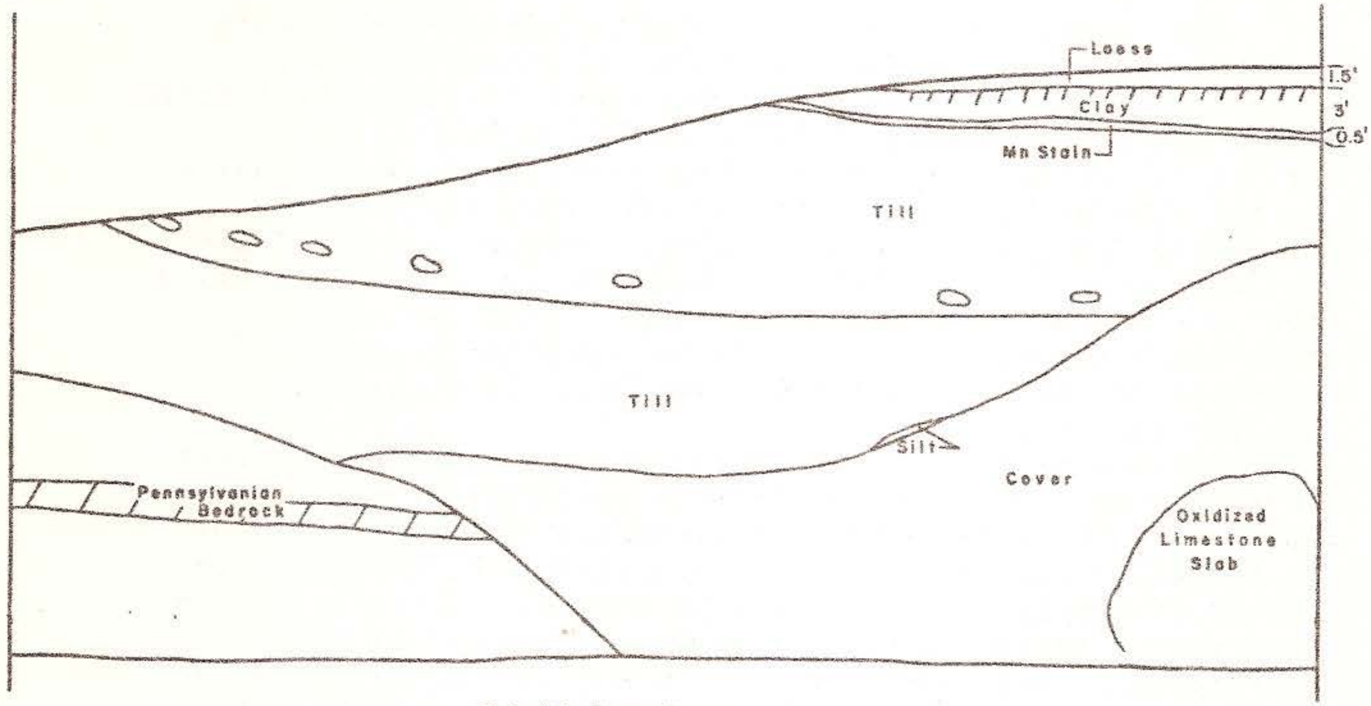
11.3 Right (east) on Coal Mine Road.

11.6 Alternate Stop (strip mine north of road - 2 tills - diagramatic section on next page)

11.9 Route 63 under pass - west of 63, Pennsylvanian limestone (Fort Scott) on left (north).

12.7 Turn right (south) into Columbia's Sanitary Landfill Area.

13.6 <u>Stop #2</u> - Columbia Sanitary Landfill Area



Rt. 63 Section

NW 1/4, SE 1/4, NW 1/4, SEC. 36, T50N, R13W, BOONE COUNTY, MO.

ELEVATION ~780

Columbia Sanitary Landfill

Section measured and described 1973 by James H. Williams, Donald L. Williams, and Ralph Fredrickson.

Location: NW1/4, Sec. 6, T. 49 N., R. 12 W., Boone County, Missouri, Peabody Coal Strip Mine.

Discussion

The landfill is a joint City of Columbia-Boone County venture with city officials immediately responsible for operational procedures. These procedures, however, must follow rules and regulations that are established by the Division of Health, State of Missouri. This present site was donated to the city and county by Peabody Coal upon concession of stripping operations by the company. From an engineering geologic aspect, a strip mine represents an excellent setting for consideration in landfill siting. Locations such as this usually receive a favorable recommendation in reports prepared by the Missouri Geological Survey for Division of Health officials.

Exposed bedrock at the landfill represents the thickest limestone sequence of Pennsylvanian sediments in central Missouri. The interbedded limestone and shale cropping out in the walls are mapped as portions of the Cherokee-Marmaton Groups (Pennsylvanian, Des Moinian series). These sediments represent a typical open massive Pennsylvanian fauna of brachipods, fusulinids, corals, and pylloid algae. Fossils are sparse in the shales. The limestone, particularly the Higginsville, is noted for a large number of Chaetetes.

The city previously operated a landfill east of Columbia on Cedar Creek. However, the present site is preferred as it is more centrally located for city and county operation. This site has obvious advantages, especially sequential utilization of land poorly suited for many other uses and a location where groundwater pollution hazards are essentially absent. However, some problems have existed at this site which are unusual to many of the strip mine localities in Missouri. Seepage of pollutants through solution enlarged openings in the limestone and permeable fissile shale together with moving large limestone boulders left as an aftermath of the strip mining have hindered landfill operations.

The landfill operation began in the lower portion of a partially water filled deep excavation. Consequently, the lower part of the landfill has been poorly compacted and was placed in a water saturated environment. The present status of landfill operations has improved although compaction and cover are less than adequate, in part caused by excessive wetness of the only cover material available. Strip mine landfill operations elsewhere in the state have had fewer mud and water problems by operating on better drained and consolidated older spoil banks.

A major side effect of the landfill operation has been the appearance and continuation of several leachate seeps off the northern end of the trench currently being filled. A leachate is the resulting solution produced from the interaction between water and landfill refuse. The leachate being produced at this landfill probably formed from a combination of water percolating through the refuse from rainfall and water already present in the trench when landfilling was begun. As leachate production in a landfill does not normally occur until saturation of the refuse is achieved, leachate production is normally a later event in landfills. However, due to the water already present in the trench, saturation was achieved quite early with subsequent leachate production.

The trench currently being filled is only one of several trenches in the area. The north-south landfill trench intersects a second trench at the north end of the landfill operation. This second trench extends towards the east before bending back to the south, and is water filled. Leachate produced in the landfill is unable to migrate downward due to the relatively impermeable shale and underclays, therefore it migrates horizontally until it reaches the second trench at a slightly lower elevation than the landfill. The high organic carbon and oxygen demand of the leachate completely depleted the dissolved oxygen content of the water in the second trench, causing anaerobic conditions to develop. The leachate seeps have since been sealed off from the rest of the lake by a dam, thus creating a leachate pond. The lake has since recovered and is no longer black.

The leachate emerging from the landfill has been analyzed on two occasions by the author (Don Williams) with the date listed in Table 1. Also listed is analysis of the leachate pond, and analysis of two leachates from Rolla and Jefferson City landfills for comparison.

Sample CLFS would probably be considered a typical sample for this landfill while CLFS-2 appears to be diluted by an influx of fresh water, and was collected within 24 hours of a large rain.

All figures in mg/l.

	CLFS-1	CLFS-2	Pond CLFL-2	JCLF-1	RLF-2
Date	10-26-72	3-23-73	10-26-72	2-15-73	2-28-73
Temp.	16°	13.8°	--	11.9	12.9
Color	black	black	black	gray	gray
pH	5.88	6.47	6.40	5.56	5.45
emf	-205	-320	-80	-120	+76
filt. size	.45	.45	.45	1.2	1.2
Total Alk	3538	2986	3302	3460	4218
"other buffer"	2972	186	2802	3818	3911
HCO_3	566	2800	500	--	307
Total $S=(H_2S)$	1.5	90	.12	.02	.02
Ca	795	486.	700.	728.5	770
Mg	325	292	325	208.8	165
Na	280	157	240	430	743
K	126	76.2	106	137.5	313
Cl	315	--	300.	700	600
SO_4	403	--	389	100	--
NO_3-N	.2	.1	.2	.62	.93
NO_2-N	.02	.02	.02	.02	.02
NH_4-N	50	6.9	34	122.	260
TOC	1700	--	1575	--	--
FE total	74.	5.4	57.	305.	328.
Mn	9.8	3.8	8.6	73.3	25.6
Pb	.31	.1	.22	.25	.33
Zn	.87	.54	.1	7.5	31.
Cu	.03	.05	.02	.05	.05

Compaction could be improved with machinery designed specifically for use in landfill operation such as motorized compactors. However, the City of Columbia must weigh economic advantages as gained by improved compaction and more efficient land utilization against the fact that there is more than adequate land suitable for landfill expansion available within the strip mine area. They are presentl minimizing the cost to the customer partly in an effort to reduce permiscuous dumping of garbage on town and country roads. The cost of pickup is $2.25 a month. All items are picked up including large items on a special request basis by the customer. The city provides bags for pickup and this reduces problems of blowing litter at the site. The city is presently using two bulldozers on the site with two scrapers available. When consides that each bulldozer alone has initial costs ranging from $35,000 upwards to $55,000, it is apparent that a several hundred thousand dollar investment is required even in the initial stages of landfill operation.

13.6 Turn around, proceed north.

14.4 Right (east) on Coal Mine Road.

14.8 Main Pit area (Mark Twain Mine) - recreation lake on left (north), settling pond and processing plant on right (south).

15.2 Peabody Coal Company - Mark Twain Mine Office on right, maintenance shed on left. Stay on road between office and shed. Proceed southeast.

16.6 Cross abandoned railroad tracks.

16.7 Power station on left.

17.8 Cross county road - gravel.

18.5 Cross county road - gravel.

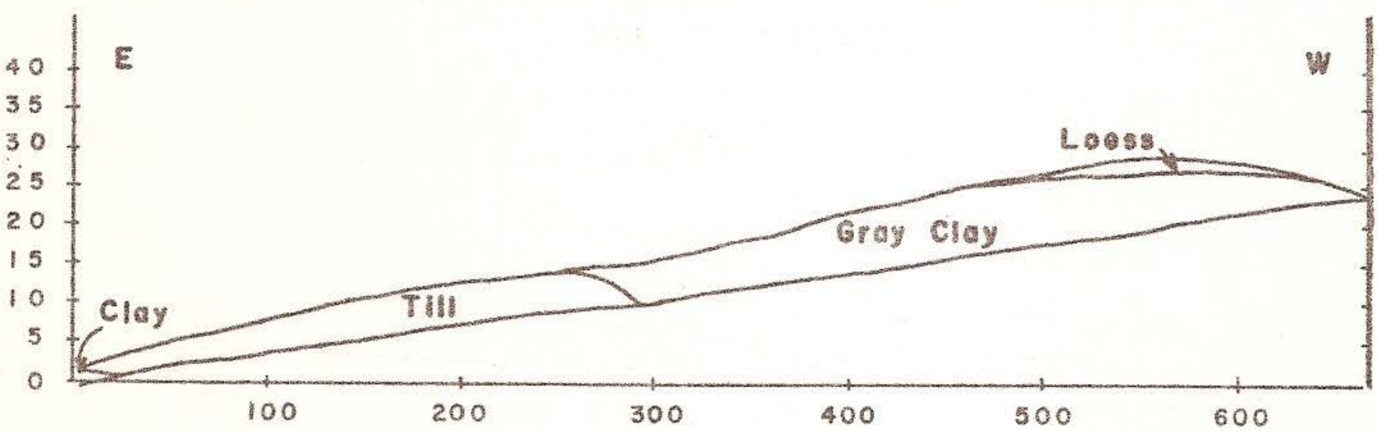
18.7 Cross county road - gravel.

21.5 Cross County road - gravel.

21.8 Stop, then cross county road.

23.5 Stop, then cross Route B and railroad tracks.

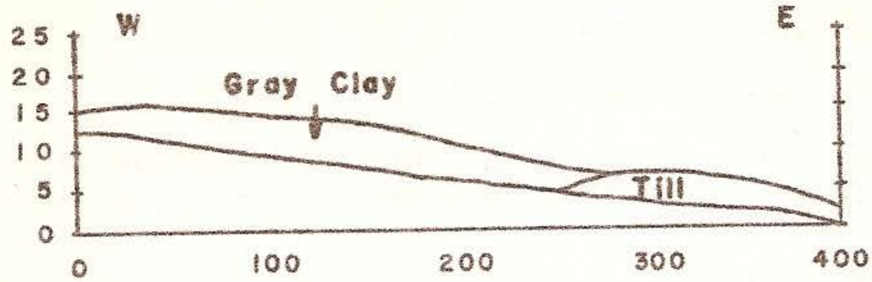
23.6 Alternate stop - Four sections described below from west to east along road and into curve



Route B Section — South Side

NW 1/4, NE 1/4, NE 1/4, SEC. 21, T49N, R12W, BOONE COUNTY,

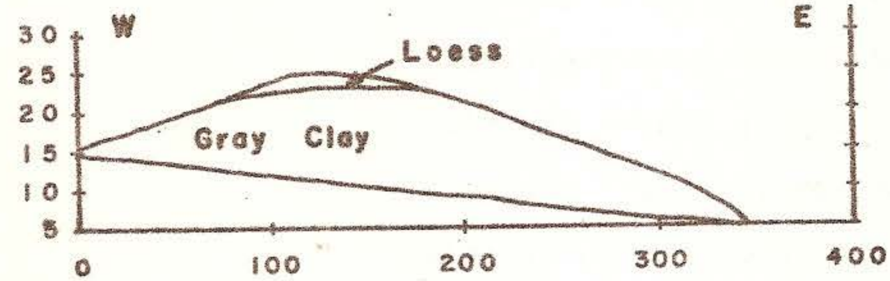
ELEVATION ~ 860



Route B Section — North Side

NW 1/4, NE 1/4, NE 1/4, SEC. 21, T49N, R12W, BOONE COUNTY, M

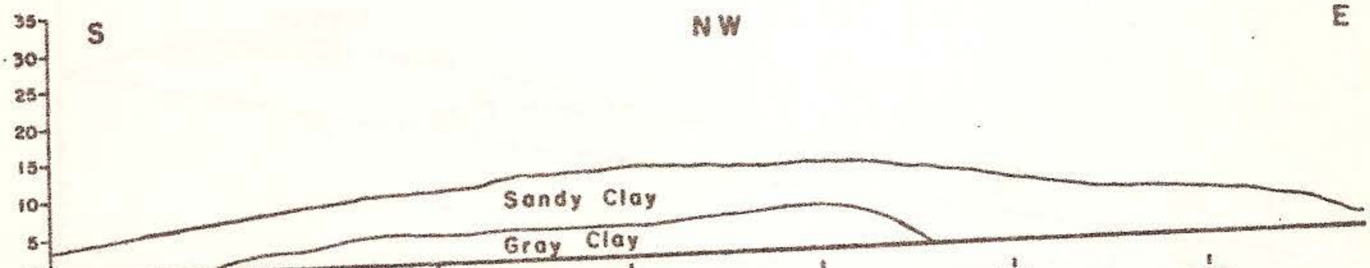
ELEVATION ~ 855



Route B Section North Side Road

NE 1/4, NE 1/4, NE 1/4, SEC. 21, T49N, R12W, BOONE COUNTY MO.

ELEVATION ~ 845

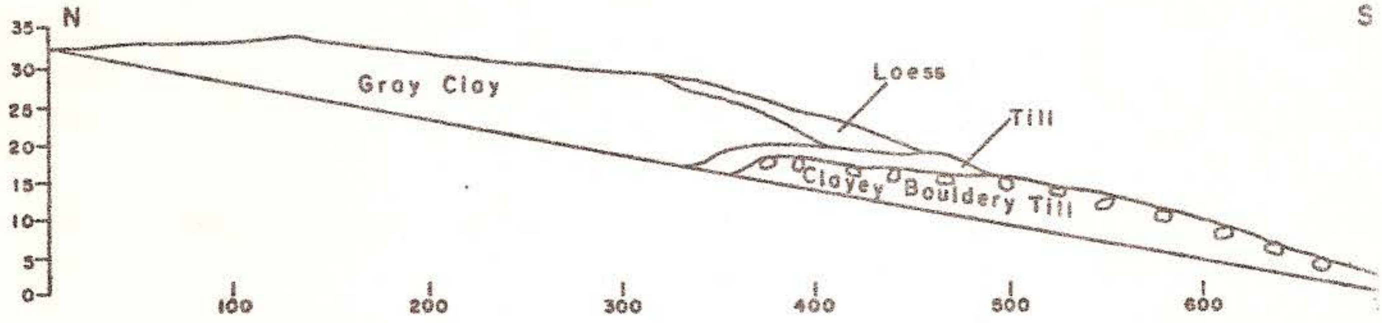


<u>Road cut on curve - South side</u>

NW 1/4, NW 1/4, NW 1/4, SEC. 22, T49N, R12W, BOONE COUNTY, MO.

ELEVATION ~ 845

24.2 Alternate stop - Hinkson Creek Road Section



Hinkson Creek Road Section

NW 1/4, SW 1/4, NW 1/4, SEC. 22, T49N, R12W, BOONE COUNTY, MO.

ELEVATION ~ 830

24.3 Stop #3 - Hinkson Creek Strip Mine Section

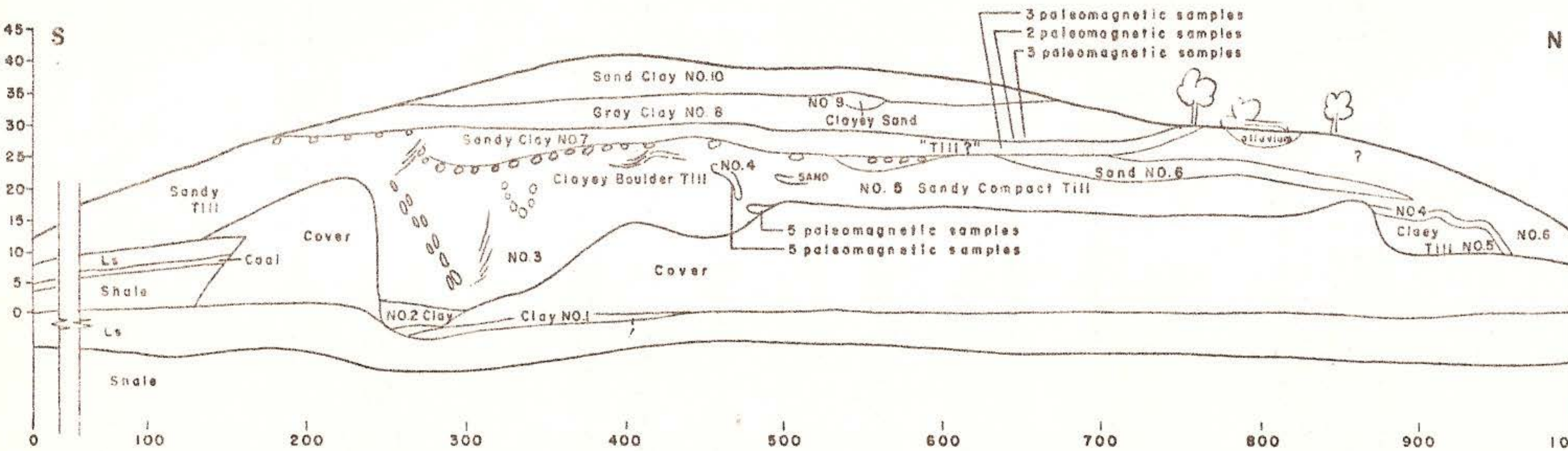
Hinkson Creek Section

Section measured and described 1973 by W.H. Allen and M.J. Guccione

Location: The Hinkson Creek exposure is a strip mine along west side of Hinkson Creek at the north corporate boundary of Columbia 1/2 mile east of Route B on west line of section 22, T.49N., R.12W.

Discussion

This exposure demonstrates a complex stratigraphy and the extremely contorted nature of the older deposits. Two gray clays have been preserved in a small protective swale of the Pennsylvanian bedrock and are uncontorted. This is the only exposure where these two units are preserved. Overlying them is the oldest



Hinkson Creek Section

CENTER WEST LINE, SEC. 22, T49N, R12W, BOONE COUNTY, MO.

ELEVATION ~830

till exposed in the area. It is distinctive because of compactness, high clay content, deformation, scarcity of erratics, and abundance of rounded chert cobbles in the upper portion. Some of the chert is pink and is associated with the Mississippian Warsaw Limestone. The closest logical source for this chert is in NE Missouri, approximately 75 miles distant. A paleosol has been developed on the top of the till. Leaching has occurred to a depth of 1 1/2 feet and clay illuveation has produced clay skin rinds around the cobbles. Toward the base of the unit the percentage of clay decreases. This unit is also exposed in the Hinkson Creek Road Section where a well developed boulder pavement occurs at road level.

Separating the lower clayey till from the compact sandy till above it, is a compact silt often contorted and sometimes surrounded by blocks of the lower till. The compact sandy, highly calcareous till is probably responsible for the deformation of the lower units. Sand and gravel lenses are extremely common, particularly at the upper and lower contacts. This unit has been tentatively correlated with the compact sandy lower till at the Hinton B section though there is no paleosol developed at this location. A gradational till-like material separates the sandy compact till from the Ferrelview-like silty clays above. Two similar clays crop out in this area separated by a till. If this till is missing from the section then either or both of the clays may be exposed at this section. The lower contact of the clay is at a uniform elevation over 900 feet along the face of the cut and is only truncated at the north edge. This geometry indicates the unit is a discrete deposit rather than slope wash. Locally clayey sands are incised into the clay. Overlying the Ferrelview-like units is a more oxidized sandy clay.

Unit	Description	Thickness (feet)
10	Clay, sandy, gray (10YR 6/1) with yellowish red (5YR 4/8) mottles, soil profile developed, leached.	0.6'
9	Sand, clayey, gray (5Y 6/1) with strong brown (7.5YR 5/6) mottles, lower contact sharp, slightly calcareous, unit local.	0-2.8'
8	Clay, silty, gray (5Y 6/1) with some yellow brown (10YR 5/6) mottles, blocky, few feldspar fragments, pebbles scarce with some chert fragments, sand content increases toward base, lower contact gradational, no evidence of paleosol at top.	0-6'
7	Clay, sandy, till?, gray (5Y 6/1) with strong brown (10YR 6/6) mottles but the latter more abundant than in above unit, erratics present,	

		commonly a heavy manganese concentration in the middle, leached	0-7'
6	Sands	and gravels, coated with manganese stains laterally grades from well sorted sands to gravels, may have some till (unit 5) inclusions, weakly to strongly calcareous.	0-3'
5	Till,	oxidized yellow brown (10YR 5/6) predominently, deoxidized gray (10YR 6/1) in thin zones along joints, sandy, compact, sand lenses and semicemented gravels common, stone line in many places, highly calcareous throughout	0-10'
4	Silt,	gray to light brownish gray (10YR 6/1-2) compact, coarse and some found swirled within lower till (unit 3)	0-2'
3	Till,	yellow brown (10YR 5/6) with gray (5Y 6/1) commonly concentrated as clay skins around pebbles, silty clay, rounded cobbles and boulders of chert common, decreasing in abundance in lower portion coarse angular blocky,structure slickensided, becomes a little more sandy toward base where clay skins disappear, compact, leached 1.5', highly contorted in places.	0-20'
2	Clay,	silty, no sand, solid gray (5Y 6/1), fine blocky, clay skins, not compact, contact with above unit sharp, noncalcareous.	0-3'
1	Clay	(2.5Y 5/0) gray, contact with bedrock clear.	0-1.5'
	Pennsylvanian bedrock with no paleosol developed.		

24.3 Proceed downhill to southeast.

24.6 Cross Hinkson Creek bridge.

24.7 High terrace on left (north).

25.6 Cross County road.

26.0 Dissected high terrace on right (south).

26.4 Stop #4 - Mt. Hope Church Section

Mt. Hope Church Section

Section measured and described by W.H. Allen and M.J. Guccione

Location: SW1/4, SW1/4, SE1/4, Sec.14, T.49N., R.12W., Boone Co., Mo.
Road cut at east valley wall of Hinkson Creek along Peabody Coal access road.

Discussion

This section is distinctive in that the tills exposed are extremely thin and have been protected from complete erosion by Pennsylvanian sandstone which occurs on the western end of the cut as a bedrock high. Prior to glaciation, a paleosol appears to have been developed in the Pennsylvanian material.

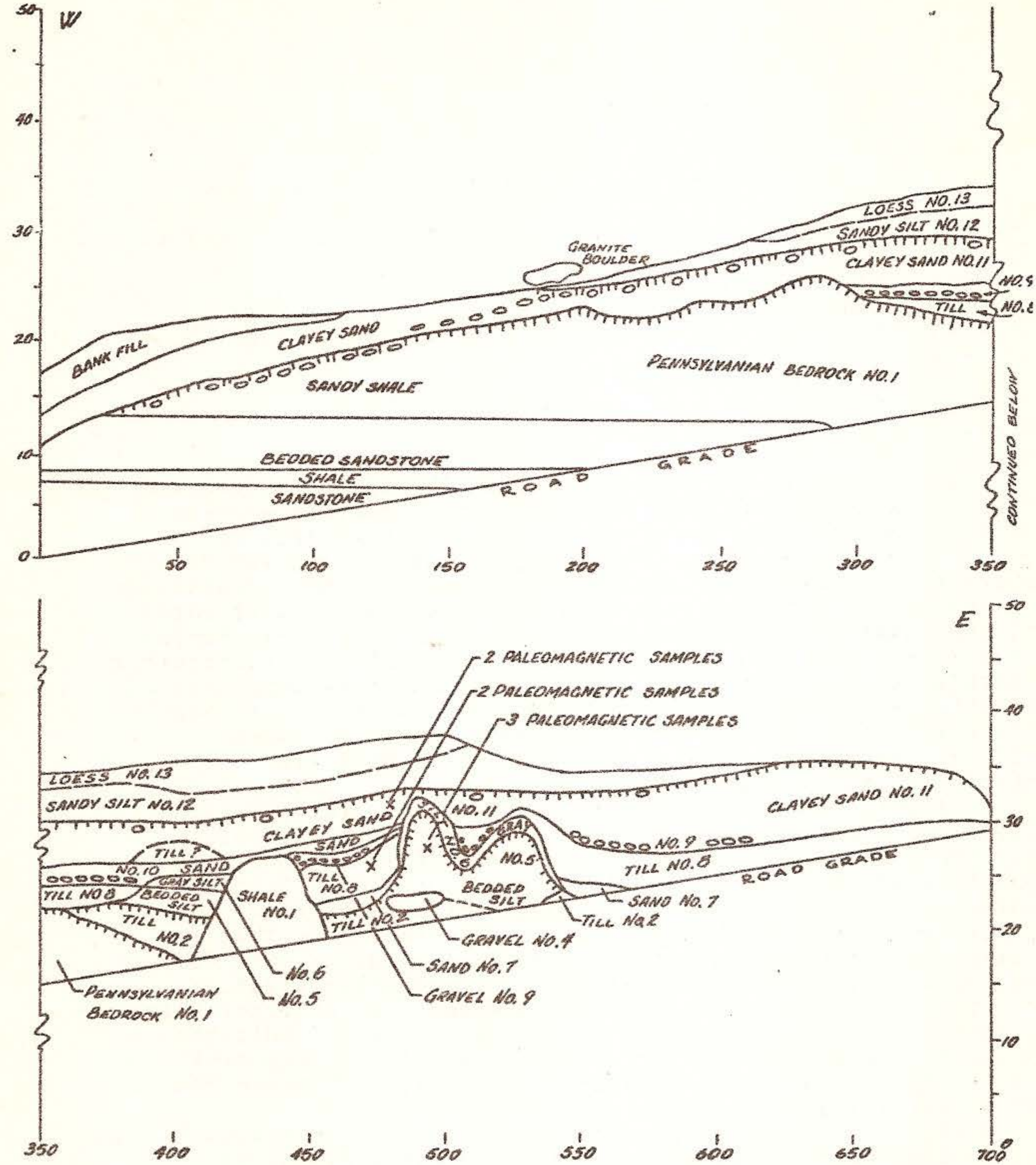
The clayey till, exposed in the road ditch, is correlated with the basal till (bouldery) which is more completely represented in the Hinkson Creek Strip Mine section. It is contorted in both locations. It is overlain by bedded silts which have a negative paleomagnetic declination. The suggestion is herein offered that the lowermost till is early Kansan or older (personal communication, G.J. Kukla, 1973). Overlying the contorted silts is a thin gray clay.

A slightly compact sandy till (unit 8), correlated with unit no. 5 in the Hinkson Creek S. M. Section, is discontinuously present along the face of the cut. It is not quite as compact or as thick as it is at the previous stop. At this location there are no carbonates remaining in the till.

Overlying the till is a gravel and boulder zone that is relatively continuous across the face of the cut. It is dominately composed of weathered granite however other erratics are noted also. The upper part of this unit has a higher clay content. In places clay skins are observed, which indicates some pedogenic development prior to emplacement of the overlying sands. No distinct boundary can be traced between the sands (unit 10) and the gravels (unit 9).

Unit 11 has a facies change along the cut. In places it has the distinct appearance of a till; in other places it appears to be a coarse fluvial material. It may be correlated with the upper till at the Hinton B cut however it is too thin and weathered to tell on the basis of field criteria.

The paleosol developed in the upper part of unit 11 (seen as a redish line across the face of the cut) has a well developed profile. About 200 feet from the western end, the redish



Mt. Hope Church Section

SW 1/4, SW 1/4, SE 1/4, SEC. 14, T49N, R12W, BOONE COUNTY MO.

ELEVATION ~ 839

color is lost in a small depression where the material takes on a grayish cast. To the west of this point there is a truncated profile and a marked increase in stones at the top. This stone line continues downslope where it cuts across the surface of the paleosol developed in Pennsylvanian materials.

A thin colluvial sandy silt overlies the redish paleosol. It appears to be the same unit that was seen at the top of the section in the Hinkson Creek S. M. stop.

The uppermost unit is a loess with a modern day soil profile developed in it.

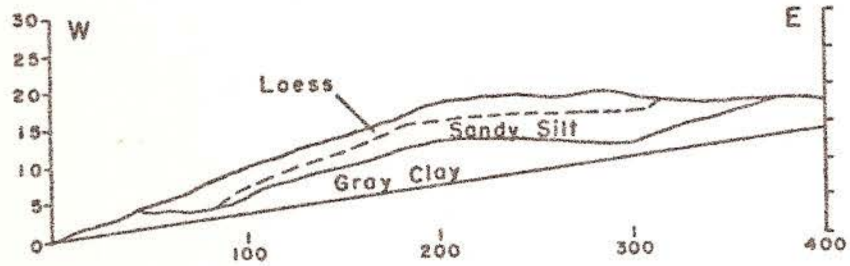
Unit	Description	Thickness (feet)
13	Loess, modern profile well developed	2'
12	Silt, sandy, yellowish brown (10YR 5/4) with grayish brown (10YR 5/2) mottles, Manganese stained.	4.5'
11	Sand, Clayey grades to till? in places, scattered stones at top, contact with above distinct, paleosol developed:	
	0-0.3' A3 B1 silt, clayey, sandy, strong brown (7.5YR 5/6) with red (2.5YR 5/6) mottles, some manganese stains, medium angular blocky, few rounded pebbles.	
	0.3-1.3' B2 clay, sandy, red (10R 4/8) interior, ped coatings strong brown (7.5YR 5/6) with light brownish gray (10YR 6/2) mottles, red mottles strong at top.	
	1.3-3.5' C clay, sandy, yellow brown (10YR 5/8) interior of peds, some clay skins, gray (10YR 5/1), leached, some concentration of stones at base, in places looks like till.	0-3.5'
10	Sand, strong brown (7.5YR 5/8), medium grained, leached, mostly massive though some bedding evident in depressions.	
9	Gravel, rubbed color yellowish red (5YR 5/8) with gray (10YR 6/1) mottles and manganese stains, rotten granite,	

	gabbros and greenstone boulders, some chert, in places gravel has clay skins indicating possible weathering and profile development	0-1'
8	Till, brownish yellow (10YR 6/6-5/6), deoxidized light gray (10YR 7/2) and manganese stains along joints, sandy silt, platy to coarse angular blocky, leached, upper and lower boundaries distinct	0-2.5
7	Sand, yellow brown (10YR 5/8), medium grained, well rounded, noncalcareous.	
6	Silt, clayey, gray (10YR 6/1) with few dark gray (10YR 6/8) mottles, sand and silt content increases laterally, platy, leached.	0-2'
5	Silts, bedded, brownish yellow (10YR 6/5), deoxidized in mottles and along joints gray (10YR 6/1), very thin laminae of clay and fine sands interbedded, manganese stained and platy at top, leached throughout, highly contorted in places. Paleomagnetic Reversal.	
4	Gravel, sandy, yellow brown (10YR 5/6) with brownish yellow (10YR 6/8) mottles, pebbles angular to subrounded, some boulders, limestone and chert predominent, northern erratics scarce to absent.	0-3'
3	Silt, clayey, pale brown (10YR 6/3) with few yellow brown (10YR 5/4-5/8) mottles, angular blocky, compact, leached.	0-1'
2	Till, brownish yellow (10YR 6/6) with light brownsih gray (2.5Y 6/2) clay skins, manganese coatings, platy to fine weak angular blocky, sandy clay, chert pebbles common, weakly calcareous, highly contorted.	0-3'+
1	Pennsylvanian sandstone with paleosol developed on it 0-1.5' Sandy clay, brownish yellow (10YR 6/8) with gray (10YR 6/1) mottles, moderate medium blocky. 1.5-2.5' Clay, yellowish brown (10YR 5/6) with light brownish gray (10YR 6/2)	

	and yellowish red mottles (5YR 4/8), some manganese stains, strong coarse, angular blocky.	
2.5-3.5'	Clay, sandy, red (2.5YR 4/6), with light gray (10YR 7/2) mottles, some manganese stains, strong angular blocky.	
3.5-4.0'	Sand, yellow brown (10YR 5/8), fine well sorted, disintegrated sandstone. Red clay seam, same as unit from 2.5-3.5'. Sand, same as unit 3.5'-4.0'. Sands become more lithified with depth.	0-4.1+

26.4 Continue east on Coal Mine Road.

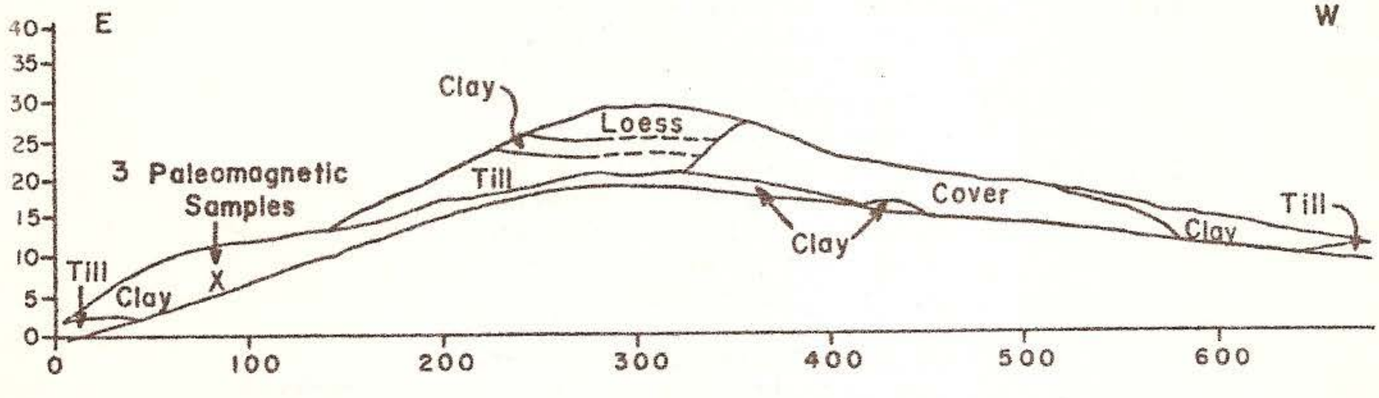
Note: Alternate stops may be visited along the Coal Mine Road for next 3/4 mile; sections are given below.



Mt. Hope Church East Section

NE 1/4, NW 1/4, NE 1/4, SEC. 23, T49N, R12W, BOONE COUNTY, MO

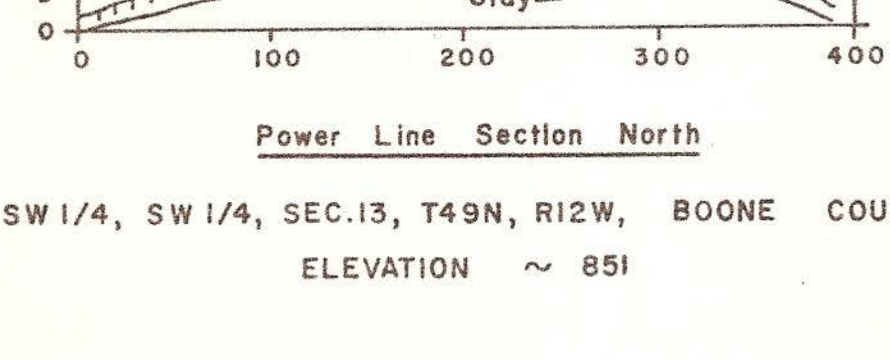
ELEVATION ~ 853



Power Line Section South

SE 1/4, SW 1/4, SW 1/4, SEC. 13, T49N, R12W, BOONE COUNTY MO.

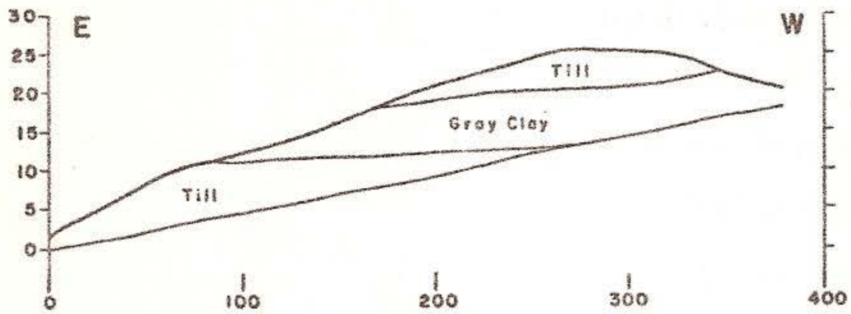
ELEVATION ~ 853



Power Line Section North

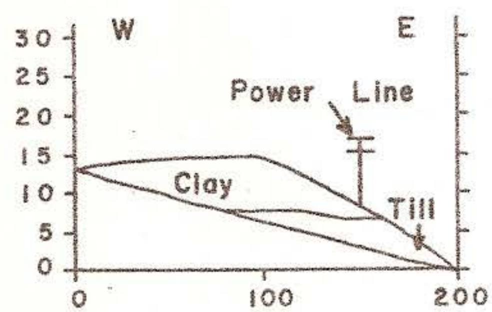
SE 1/4, SW 1/4, SW 1/4, SEC. 13, T49N, R12W, BOONE COUNTY MO.

ELEVATION ~ 851



Powerline SW Section

NE 1/4, NE 1/4, NE 1/4, SEC. 23 T49N, R12W, BOONE COUNTY, MO.
ELEVATION ~ 849



Power Line NW Section

NE 1/4, NE 1/4, NE 1/4, SEC. 23, T49N, R12W, BOONE COUNTY MO.

ELEVATION ~ 846

26.5	Left (east) on Coal Mine Road.
26.8	Hard right (west) on Coal Mine Road.
28.3	Recross County Road.
29.3	Recross Hinkson Creed bridge.
30.4	Recross railroad and turn left (south) on Route B.
30.9	Cross railroad.
34.5	Cross railroad.
35.1	Stoplight (shopping center on left).
35.4	Turn right (west) on Business Route 70.
35.7	Cross railroad.
36.0	Stoplight
36.2	Stoplight - turn right (north) on Business Route 63 N
36.5	Underpass.
36.6	Turn right (east)
36.8	Turn right (south) into Ramada Inn Parking Lot.
	END OF TRIP

SUMMARY OF PEBBLE LITHOLOGY OF NEBRASKAN AND KANSAN TILLS IN NORTH-CENTRAL MISSOURI

Lloyd J. Schmaltz
Western Michigan University

The glacial drift in central Missouri north of presently conducted field trip area was deposited by Nebraskan and Kansan ice sheets. Nebraskan drift was greatly eroded before and during the advance of Kansas ice, therefore, recognizable outcrops are few. An exceptional exposure 20 feet thick did show a well-developed Aftonian soil. Kansan till is much thicker and some roadcuts which expose 50 feet or more of section show a complete sequence from soil horizon to unleached, unoxidized till. During post-Kansan time a thick soil has formed on the Kansan till and abundant exposures can be found throughout the undissected parts of the Kansan till plain in north-central Missouri.

Lack of criteria for distinguishing the drifts has presented a major problem in mapping, and understanding Pleistocene history in northern Missouri. Only the occurrence of the soil between the tills has permitted the separation of the two drift sheets, with any confidence. Exposures of this type are rare.

A study of the pebble lithology of the two tills has provided additional information for their separation. A summary of the study follows:

1. Nebraskan till in north-central Missouri can be distinguished from Kansan till by the high average per cent (42.4) of clastic lithologies. These were derived mostly from local Pennsylvanian bedrock and show a regional pattern of increasing abundance southward.

2. Dolostone, quartz, and mafic igneous rock pebbles in the tills, which are derived from northern source areas, show a decrease in abundance from north to south.

3. Metamorphic and igneous pebbles are less abundant in Nebraskan till (25%) than in Kansan till (41%).

4. An overall similarity in pebble lithologies in the tills suggests that the source area and direction of ice movement was the same for both ice sheets. The presence of abundant Sioux quartzite in both tills is regarded as indicating ice movement from north to south or slightly northwest to southeast.

SUMMARY OF ENGINEERING GEOLOGY IN NORTHERN MISSOURI

by J. H. Williams

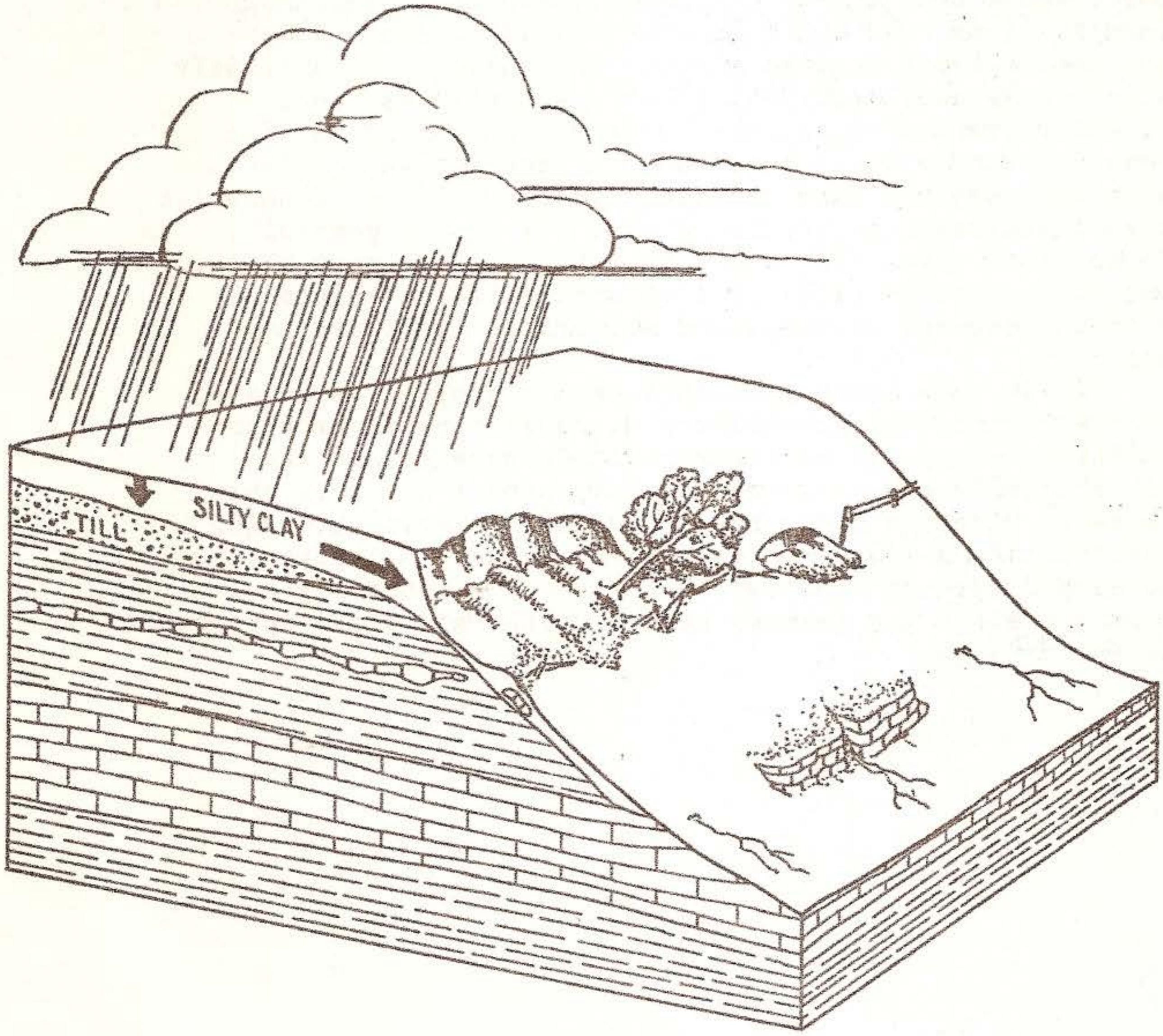
In thinking of engineering geologic projects in northern Missouri, one plans from the beginning to prepare for glacial till related problems. These problems, while at times perplexing, fortunately are offset by the many attributes afforded with sediments made up predominantly of silty clay mixed with scattered stones and having high strength characteristics.

On the problem side of the till question, an investigator considers first, what he must do to avoid foundation cracking and loss of strength due to swelling and wetness. This is an especially serious hazard if the site is located on upland prairies having a modern clay pan soil, underlain by clay rich paleosols showing Yarmouth-Sangamon influences. These soils are generally classified as CH with an AASHO rating of A-7-6 to locally A-6. Here, the investigator anticipates uplift pressures of swelling clays to reach 2.5 to 3 tons per square foot, volume changes upward of 70 percent, and susceptibility to settlement with moisture changes. To avoid this, it is necessary to undercut, perhaps replace with granular base material, possibly use a moisture barrier, and/or design foundation drainage facilities. Prolonged surface wetness characterizes the prairies underlain by clay pan soils. Machinery movement mires to a standstill for months at a time. In wintertime frost penetration reaches 24 inches. Frost heaving in the spring plays hob with secondary roads.

While construction projects on the hillslopes adjoining the prairies may not have the wetness, drainage and swell problems, slope creep and slides reduce the glamour of the more rugged till countryside. Major rotational slides occur where thick gray clay pockets form a portion of a backslope or hillside excavation. Along the southern fringe of glaciation where modified loess and Ferrelview like sediments make up most of the world, rotational slides, generally slipping on underlying shale beds, frustrate the builder especially one concerned with highways. In the north-central section of the state backslopes steeper than 3:1 experience serious slip problems. Rotational movement is minor, but the mass of disturbed soil slipping on the backslope is sufficient to affect the entire slope. Causes of this are not known, but movements seem to be more frequent in cuts with till related or Sangamon related modern soils rather than clay pan soils developed in older modified loess.

The glacial till is normally an over consolidated clay rich soil having 50 to 80% montmorillonite, and 5 to 15% of illite, kaolonite and mixed layered clay minerals. These form a relatively stable, except for slips and slides, impermeable mass of soil excellent for water impoundments, liquid and solid waste disposal sites. Larger valleys, however, are apt to have poorly consolidated floodplain soils underlain by waterbearing sands. Sand pockets and lenses on valley slopes exist locally in sufficient abundance and extent to provide domestic water supplies. These attributes are partly affected by seepage and foundation problems related to dams or pollution hazards associated with waste disposal localities. Thus, foundation exploration must be planned even at the most optimum of sites selected on surface feature evidence. Municipal water supplies can be procured in some areas from buried gravel filled channels, but these are normally at depths greater than most foundation exploration and construction.

Although glacial till sediments are widespread, perhaps no more than 30 percent of northern Missouri has till thicker than 40 feet. Normally shale predominates and affects many projects. Impedence of drainage, slope instability, and some excavation hinderances will adversely affect construction projects across much of central and locally north-central Missouri.



DIAGRAMMATIC INTERPRETATION OF SLOPE STABILITY PROBLEMS

Where glacial till sediments are particularly thin, for example near Kansas City, and north of Columbia and locally around St. Louis, the underlying bedrock is predominantly Pennsylvanian shale. Foundations are seriously affected by swell and loss of strength with wetting. If Pennsylvanian shales are to form the foundation of a construction project, they must be undercut and replaced with well drained base material. Loading of the foundation may be necessary to reduce uplift. If at all possible, foundation sites that would be part till and part shale, should be avoided or if that is not possible replaced by a thick sequence of compacted uniform and well drained material.

While this summary of engineering geology as related to the Pleistocene of northern Missouri appears problem oriented, there are no insurmountable hazards and few exhorbitantly expensive remedial treatment needs in this region. Unfortunately, however, many projects involving construction and waste disposal in northern Missouri have developed serious problems, but the cause generally has been oversight and perhaps even a deliberate blasé approach to the project.

SOILS OF NORTHERN BOONE COUNTY

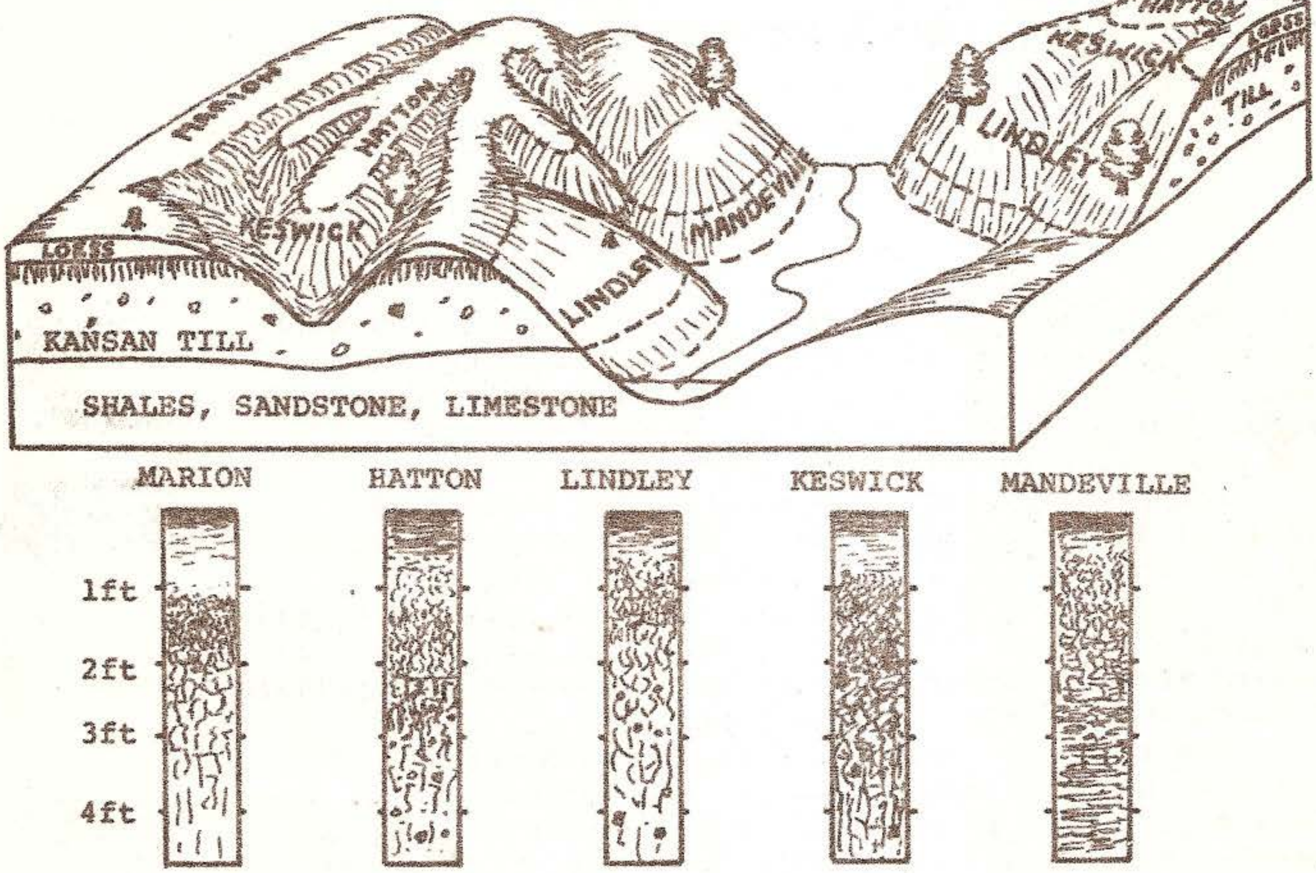
by J. C. Baker

Boone County is centrally located in Missouri near the southern extent of glaciation. Upland soil areas in the northern part of the county are situated on landscapes dominated by Pleistocene deposits; loess, till, and associated materials.

Loess is thickest in the southwest river hills adjacent to the Missouri River flood plain. It thins to the north and east to thicknesses of five to six feet. Underlying the loess are till and reworked materials largely of Kansan age. Within these materials are preserved several former land surfaces. Modern soil patterns reflect these differences in lithology.

Two soil associations describe the major upland units in northern Boone County. The Putnam - Mexico - Gara association is situated on the gently sloping to nearly level, loess dominated, highest portion of the landscape. All the soils belong to the order Alfisols. The Putnam and Mexico have formed in loess under a vegetative cover of prairie grasses. They have silty surface layers and clayey B horizons at fourteen to seventeen inches depth. The Gara soils are positioned on more dissected topography, on steeper slopes, and have formed in weathered till.

The second major soil association is comprised of the Lindley - Keswick - Hatton - Marion soils. This association is of major importance in northeast Missouri and has the largest acreage of any soil association in Boone County.



This block diagram shows the relationship of modern soil landscapes to the major Pleistocene stratigraphic units in North Central Boone County.

The Marion and Hatton soils have formed on ridgetops that are covered with two to five feet of loess. The Keswick soils have formed on side slopes where geologic erosion has exhumed a late Sangamon paleosol. These soils have reddish colored clayey B horizons, commonly have pebble bands somewhere in the B, and in general have inherited many of their characteristics from the paleosol that formed in till.

The Lindley soils have formed on slopes below the Keswick in oxidized Kansan till. They have relatively thin loamy A horizons and mottled yellowish brown clay loam to sandy clay B horizons.

A soil of minor extent is the Sapp. It is situated in landscape positions similar to those of the Keswick but has formed in the gray clayey Ferrelview like material where it is exposed at the land surface.

All the soils of this association are light colored in the surface horizons, have developed under an oak - hickory forest cover and belong to the soil order Alfisols.