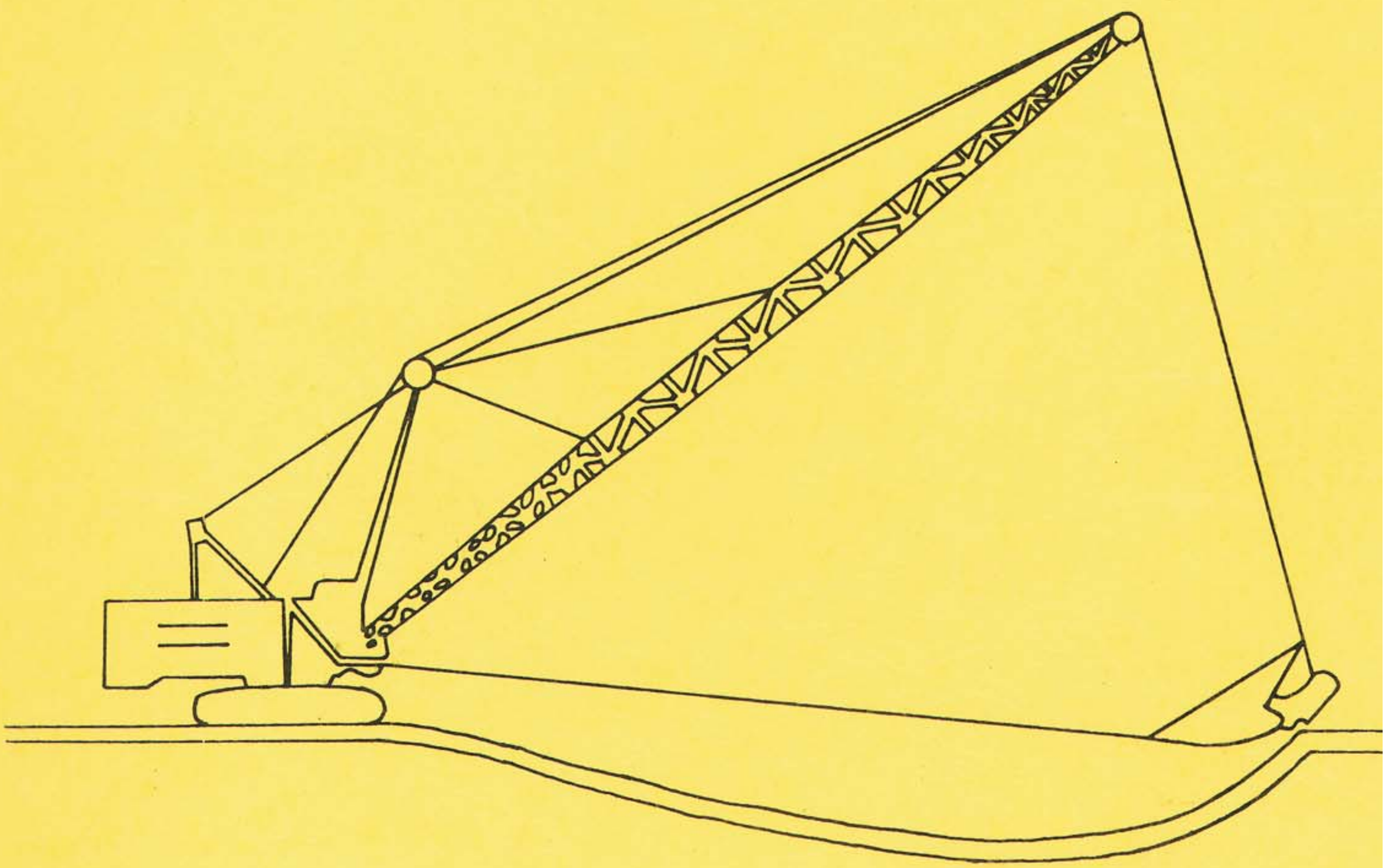
GUIDEBOOK

ASSOCIATION OF MISSOURI GEOLOGISTS

30TH ANNUAL FIELD TRIP AND MEETING

SEPTEMBER 23-24, 1983



GEOLOGY OF NORTHWESTERN RANDOLPH COUNTY, MISSOURI WITH EMPHASIS ON THE COAL INDUSTRY

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30TH ANNUAL MEETING AND FIELD TRIP

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ASSOCIATED ELECTRIC COOPERATIVE, INC.
NEMO COAL, INC.

PREFACE

On Friday afternoon, we shall tour the Thomas Hill Energy Center of Associated Electric Cooperative, Inc. This coal fired electric generation facility is located in the northwestern part of Randolph County, Missouri next to the Middle Fork of the Chariton River and Thomas Hill Reservoir and near the Village of Thomas Hill, Missouri.

Saturday morning we will board buses and visit the Nemo Coal, Inc. and Associated Electric Cooperative, Inc., coal mining and reclamation operations. Personnel from these host companies will acquaint us with their operations, reclamation procedures and experience with the Pennsylvanian and Pleistocene sediments in the area. Charlie Robertson and John Whitfield, Division of Geology and Land Survey of the Missouri Department of Natural Resources, and Richard Gentile, of the University of Missouri - Kansas City, who have made extensive studies of the area, will give us some insight to the geology of this coal producing region of Missouri.

The opportunity to visit the Associated Electric Cooperative, Inc. and Nemo Coal, Inc. operations and facilities and their cooperation and assistance with the field trips is gratefully appreciated. Thanks are expressed also to those who have contributed to the success of the meeting and field trips. Kimery Vories of Associated Electric and Larry and Mary Nuzum of Nemo Coal, Inc. Charlie Robertson and John Whitfield of the Division of Geology and Land Survey of the Missouri Department of Natural Resources. Richard Gentile of the University of Missouri - Kansas City. Glenn Golson and James Jensen of the A.P. Green Refractories Co. for their efforts and work on the guidebook. George Long and Kenneth Via of the Missouri State Highway Department for their efforts in lining up buses for the Saturday field trip, making arrangements for the banquet and meeting on Friday evening, and obtaining information concerning accommodations.

INTRODUCTION

Missouri is truly one of the states that has helped make our country and nation prosper and thrive. Missouri's resources are numerous as is evidenced by the various commodities produced within its borders. Foremost has been the development and use of natural resources such as lead, zinc, fireclay, iron, barite, etc.

This year we will have as our topic: Coal. Missouri is not a major producer of this natural resource in comparison to other states. Coal, however, due to its abundance in our nation and due to economic considerations, will undoubtedly play a more important role as an energy resource in relation to other sources of energy. Thus, this year, it is being given further consideration.

Most of Missouri's coal lies in the north central and western parts of Missouri. The north central part of Missouri is being visited this year as the largest coal mining operations are presently being conducted in this part of the state.

HISTORY OF COAL MINING RANDOLPH COUNTY

Coal mining came to Randolph County with the building of the railroads. Although the early history of coal mining in Randolph County is not well documented it is thought that mining began soon after the founding of Huntsville in 1831. This initial activity was by slopes into the hillsides, with the large underground mines being developed sometime after the Civil War.

Up until the introduction of large scale surface mining operations in 1932, production in Randolph County was from a few large underground mines. Access was by shafts or slopes from 50 to 185 feet deep. Mining of the high quality Bevier Bed was almost exclusively by the room and pillar method.

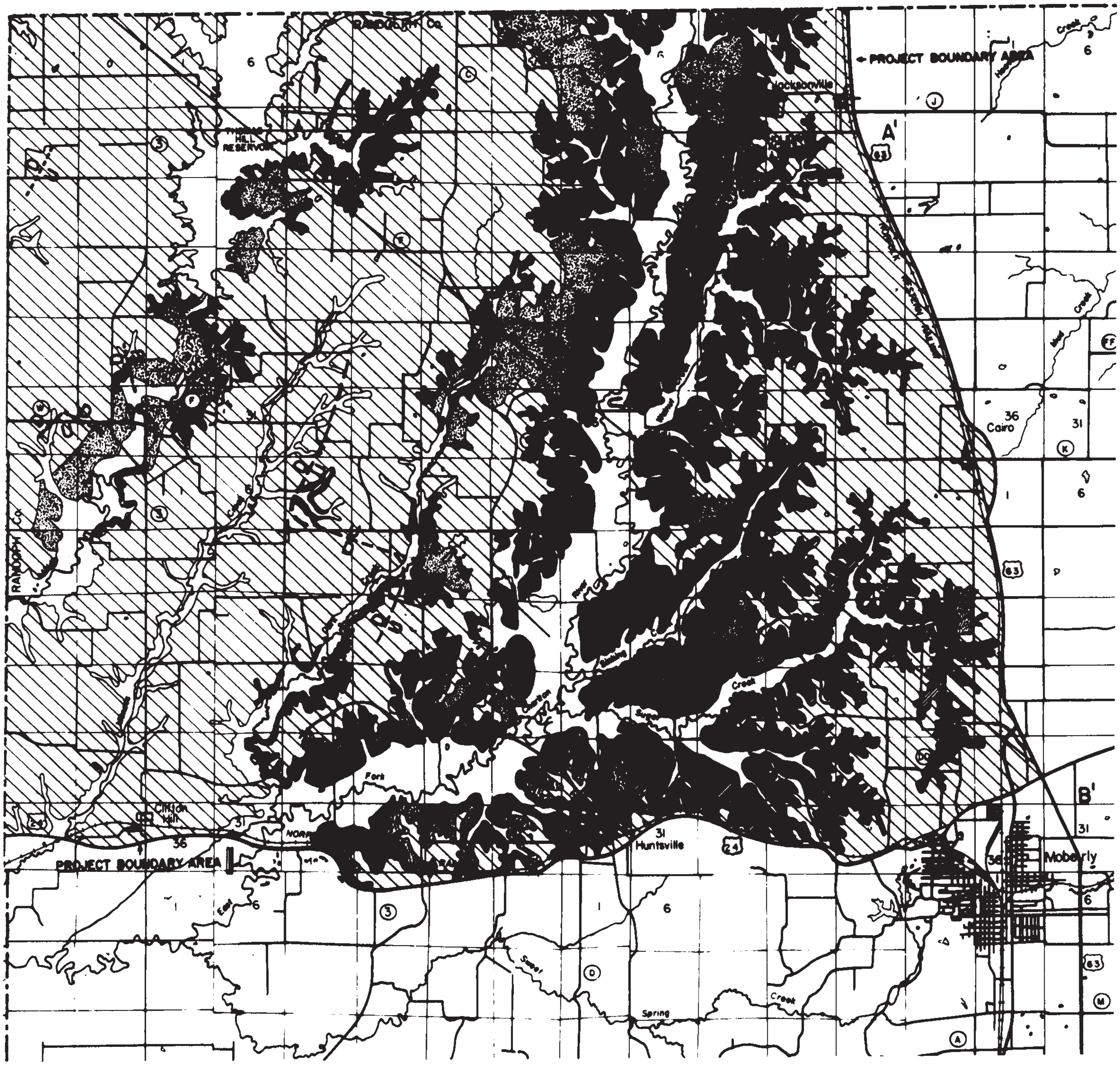
Early underground miners encountered very unstable roof rock above the Bevier coal. In most mines sandy shale or cross-bedded sandstone tended to spall or slice off. In others a carbonaceous shale roof tended to ignite by spontaneous combustion. Much of the

Bevier coal strip mined in later years was avoided in the earlier underground operations because of the glacial drift too close to the coal, making mining very unsafe. The Bevier underclay also caused problems having a tendency to heave where it is thickest and making it difficult to place roof supports.

After World War I, coal mining gradually declined until large scale surface mining methods were introduced to Randolph County in 1932. Since then, 90 percent of the coal production in Randolph County can be attributed to surface mining.

Areal Distribution of Exposed Stratigraphic Units

In Prairie Hill Area, Randolph County, Missouri



LEGEND

PLEISTOCENE

PLEASANTON GROUP

MARMATON GROUP

CHEROKEE GROUP

GEOLOGY

GENERAL

Many of the ridges in the northwestern part of Randolph County are covered by Kansan and Nebraskan age glacial drift. The drift is primarily composed of mixed clays with isolated channels of sand, gravel and boulders. Throughout the area Pennsylvanian age strata underlie the glacial drift outcropping along stream valleys. The Pennsylvanian strata of interest are contained within the Cherokee and Marmaton Groups of the Desmoinesian Series. For the most part the Cherokee and Marmaton Groups consist of a repeated series of limestone, shale and coal.

There are five (5) coal seams of interest in northwestern Randolph County. These are, from oldest to youngest, the Croweburg, Wheeler, Bevier, Mulky and the Summit seams. The Croweburg Coal seam ranges from 1.0 to 1.5 feet in thickness. The Wheeler and Bevier Coal seams are usually considered one seam. These two (2) coal seams are generally separated by a thin shale parting ranging in thickness from 0.1 to 0.6 feet. The Wheeler Coal ranges from 0.0 to 1.0 feet and the Bevier ranges from 1.0 to 4.0 feet in thickness. These two combined seams are dominant in the area. The Mulky Coal seam is also important as it covers the majority of the area. The average thickness of the Mulky is 1.3 feet. The youngest coal seam is the Summit. This seam averages 0.8 feet thick and covers approximately 55% of the area.

STRATIGRAPHY

The general stratigraphy for this section of the county was established using drill logs and field observations of outcrops and existing highwalls. General stratigraphic sections are included in the road log. Some lateral lithologic changes occur throughout the area. The following is a general description of the strata containing important coal seams.

THE CHEROKEE GROUP

- The oldest formation in the Cherokee Group in the area is the Croweburg Formation. This formation consists of, from bottom to top: fossiliferous limestone; black, massive shales grading into silty shale; gray, micaceous siltstone; sandstone; and underclay topped by the Croweburg Coal seam. The Croweburg Formation averages 25 feet in thickness.

- The Verdigris Formation lies directly above the Croweburg Coal. This formation averages 28 feet in thickness. The composition from bottom to top is as follows: massive dark gray mudstone; black grading to gray, fossiliferous shale with phosphatic concretions; gray to light gray, jointed, fossiliferous limestone with some calcite lined vugs; gray, silty shale; medium to dark gray underclay with coal fragments present; and the Wheeler Coal.

- The Bevier Formation within the area consists only of: thin parting of gray shale and/or a dark gray underclay; and the Bevier Coal seam. The Bevier Formation averages 3.5 feet thick.

- The Lagonda Formation averages 14 feet in thickness. This silty or sandy shale has localized areas of white to reddish-brown, medium to fine grained, crossbedded sandstone.

- The Mulky Formation has an average thickness of 2 feet. This formation normally contains a dark gray underclay and the Mulky Coal seam.

- The Excello Formation is the uppermost formation of the Cherokee Group in the area. The Excello Formation averages 5 feet in thickness and is entirely composed of black friable shale with thin gray laminations and cobble size phosphatic, fossil bearing concretions.

THE MARMATON GROUP

- The oldest formation in the Marmaton Group in the area is the Blackjack Creek Formation. The average thickness of this formation is 15 feet. From the bottom up, it consists of: brown, laminated shale; a hard, gray crystalline, massive limestone; light gray sometimes silty shale; topped by a brown to buff, nodular, highly jointed, weathered limestone which is not always present.

- The Little Osage Formation is the youngest formation of the Marmaton Group present. Its thickness ranges from 0.5 to 14 feet. From the bottom up, it consists of: gray, silty, friable shale; a gray to almost black underclay; black to dark brown, fractured coal (the Summit Coal seam); black calcareous, laminated shale; and a gray, highly jointed, fossiliferous, weathered limestone topping this formation.

GLACIAL DEPOSITS

- Glacial till ranging in thickness from 5.0 to 80.0 feet covers the Little Osage Formation. The glacial material is mostly composed of mixed clays with isolated occurrences of sand and gravels.

STRUCTURE

The geologic structure found in northwestern Randolph County is very simple. In almost all portions of the area the strata lies horizontal with a gentle dip of 1 degree to the southwest. A small anticlinal and synclinal structure exists striking northeast-southwest through the lands surrounding the Nemo Coal, Inc. office buildings. The limbs of the structure dip about 2 degrees. Other gentle folding occurs in the area but poses no problem to mining.

PLEISTOCENE GEOLOGY OF THE PRAIRIE HILL AREA

JOHN W. WHITFIELD

Strip pits at the Nemo Coal, Incorporated Mine No. 1, NE ¼, Sec. 7, T. 54 N., R. 14 W.; and Associated Electric Prairie Hill Mine, Center, Sec. 3, T. 54 N., R. 16 W., Randolph County, Missouri, penetrated pre-Illinoian glacial drift to reach several commercially productive coal beds in the Cherokee Group of the Pennsylvanian System. The pits provide an excellent opportunity to examine the vertical sequence, composition, and structure of glacial drift.

The preglacial surface in the area of the two strip mines comprises rolling hills, capped by several feet of hard Higginsville limestone, and wide valleys. Exploratory borings at the Nemo Coal strip mine encountered valleys estimated to be several hundred feet wide (1). In places, the valleys cut as far down as the Verdigris shale and Croweburg coal (2). Work and Others (2) describe the preglacial topography as "gently undulating hills and dissected plains of less relief than the present Ozark topography to the south". Nuzum (1) also mentioned an anticline and syncline structure within the Pennsylvanian formation at the Nemo mine.

All these features-the rolling land surface, wide river channels, and the presence of bedrock-influenced the distribution of glacial drift.

While an individual pit may not show much variation in drift thickness, a comparison of pits on the Nemo and Associated Electric properties does show the thickness varies. For example, one pit reveals forty feet of drift overlying Pennsylvanian sediments, whereas in another, the drift is missing and Wisconsinan loess rests directly on bedrock.

Variable drift thickness may be partly due to postglacial erosion, but the diversity in elevation of the rolling preglacial landscape undoubtedly influenced glacial deposition. Land surfaces not covered by drift were either high enough in elevation during pre-Illinoian times to avoid glacial encroachment (i.e. they were nunataks) or pre-Wisconsinan erosion removed glacial sediments. Possibly the structure of the advancing glacier was not a uniformly monolithic ice mass but a ragged, uneven ice front with lobe-like protrusions.

Small areas remained undisturbed between the protrusions and eventually formed windows of nonglaciated land surface (e.g. nunataks) as the glacier advanced toward its southern terminus.

NEMO COAL INC., MINE NO. 1

A hypothetical sequence of glacial events can be inferred from drift distribution as exposed at the Nemo strip pit, Mine No. 1. Figure 1 summarizes particle-size and stratigraphic data from mine samples.

The first recognizable phase of glacial approach is an outwash layer of silt, containing rounded to subangular chert and limestone pebbles, lying directly on thin-bedded, sandy, Lagonda shale. Overlying the pebbly silt are several feet of dense, compact silt that probably represents a period of glaciolacustrine or glaciofluvial deposition in front of the advancing ice mass.

Immediately above the compact silt is a two-foot layer of varved silt representing an ice-marginal pond or lake. If, as conventionally assumed, a year is represented by a pair of contrasting varves, or laminae, one lamination formed by summer sedimentation and the other by winter sedimentation, the length of time the lake existed can be approximated.

An average of two laminae per inch were counted in the two-foot layer of varved silt, indicating the lake persisted for 20 to 25 years.

The lake was probably small, perhaps confined to a single valley on the rolling prelgacial land surface. No other varved layers were found in drift examined at other pits on the Nemo and Associated Electric properties.

Allen and Ward (3) encountered a three inch thick varve layer at the Deeker Clay Pit in Montgomery County, Missouri. The varve layer rests on a thick paleosol that developed on a lag gravel. The authors mention the varve layer in connection with an ice marginal lake and described it as "the first recognized phase of Pleistocene deposition in this area".

Howe and Heim (4) describe several feet of silt containing laminations of sand and clay in a stratigraphic section near Booneville, Missouri. The authors explain "that these deposits represent remnants of lacustrine deposits formed during a period(s) of blockage of the Missouri River valley by glacial advance.

The varved silt layer, at the Nemo Mine No. 1, maintains a fairly uniform thickness but dips to the northwest. The reason for the dip is not understood, but some of the deformation may have resulted from differential settlement caused by water being forced out of the water-saturated silt layer underlying the varved sequence. The weight of the overlying till gradually squeezed the water out and compressed the silt into a hard, compact layer.

Overlying the varved silt is a thin layer of silt that grades vertically into glacial till. The glacier continued to advance and eventually covered the ice-marginal lake. Approximately 45 feet of glacial till were deposited on the varved silt.

Particle-size analysis of the till indicates possibly two sequences of till deposition. The upper till is 32 feet thick and is composed of fairly consistent amounts of sand-silt-clay; in the lower, which is 12 feet thick, there is significant fluctuation in the sand and silt fraction. Although there is no recognizable paleosol developed on the lower till, there is a sharp increase in the clay fraction at a depth of 34 feet, which may indicate the remnants of a truncated paleosol. Over this clay-rich layer is a thin layer of flat, subangular limonitic fragments that may have formed in what was then a developing soil.

One to two feet of Wisconsinan loess caps the glacial till. Stripping and grading work at the mine has removed some of the loess. The Yarmouth-Sangamon Paleosol is developed in most places on or near the top of the till and at this location occurs in approximately the top four feet of till. This poorly developed paleosol is primarily recognizable by its red color. Poor development of the paleosol was probably due to the sloping Kansan land surface; where developed on a flat surface, it is six to ten feet thick, consisting of gray sticky clay. Where excavations have exposed vertical bluffs of gray paleosol, the clay dries into an easily identifiable columnar structure.

ASSOCIATED ELECTRIC COOPERATIVE INC., PRAIRIE HILL MINE

Between 40 and 60 feet of pre-Illinoian glacial drift, including lacustrine sediments, glacial till and loess, overlie Pennsylvanian bedrock at Associated Electric Prairie Hill Mine, A Pit. Till in A Pit is 30 to 60 feet thick. Several feet of loess and till were excavated on the surface during clearing for strip mine operations (5). Figure No. 2 is a profile of Pleistocene stratigraphy in A Pit.

The basal portion of the glacial drift consists of more than fourteen feet of lacustrine-fluvial sediments composed predominantly of fine sandy silt. This material rests on Pennsylvanian limestone and shale. Rounded pebbles of granite, quartzite, and limestone are scattered throughout the sandy silt. Sand lenses and what appear to be remnants of small point bars of sand are also present in the sandy silt.

The thick sandy silt layer indicates a lake existed during early stages of the glacial advance. Granite and quartzite pebbles in the sandy silt signify the lacustrine-fluvial sediments were glacial in origin. The lake was probably formed by glacial blocking of a pre-existing river channel.

The total thickness of the lacustrine-fluvial layer could not be determined, because excavation for the drag line shelf had destroyed the upper portion of the layer.

Overlying the lacustrine-fluvial sediments are 34 feet of jointed glacial till, the lower portion of which is composed of dark gray, unoxidized, unleached till grading upward to brownish-yellow, oxidized, leached till.

Large irregularly shaped sand inclusions, several feet in diameter and with thin iron-oxide rinds, occur within the oxidized till. Joints within the till contain secondary deposits of gypsum and calcite.

Several feet of Wisconsinan loess cap the till, but surface clearing and grading have removed it in places.

On the surface of the till, a welded Yarmouth-Sangamon paleosol has developed. It has a massive to columnar structure and is mottled gray when moist. When it dries, the color fades and the paleosol is not easily recognizable. The soil structure, however, is visible evidence of a paleosol.

SUMMARY

The sequence of Pleistocene events is not clear in that portion of A Pit that was examined. Drift lithology indicates the presence of a single till, in contrast to Nemo Mine No. 1, where two tills are present. In A Pit, however, a lower till is probably represented by the glaciofluvial-lacustrine sediments, which filled an existing channel or valley on the preglacial surface.

In other portions of A Pit, which is over a mile long, both tills are probably present. They resemble each other, making visual identification difficult, and there is no discernible paleosol between them.

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4. Howe, W.B. and Heim, G.E., 1968, The Ferrelview Formation (Pleistocene) of Missouri, Report of Investigation No. 42, Missouri Department of Natural Resources.

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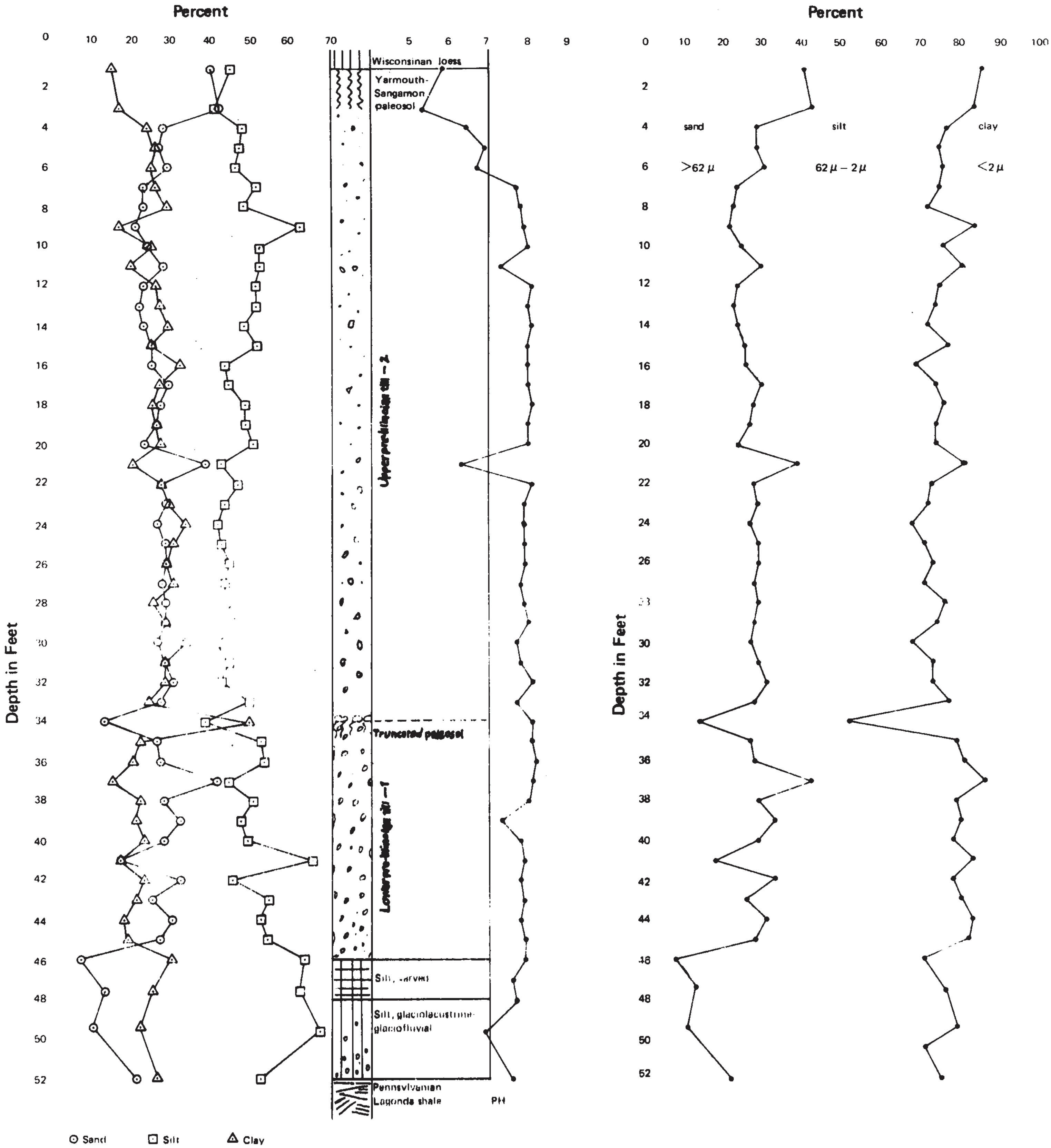
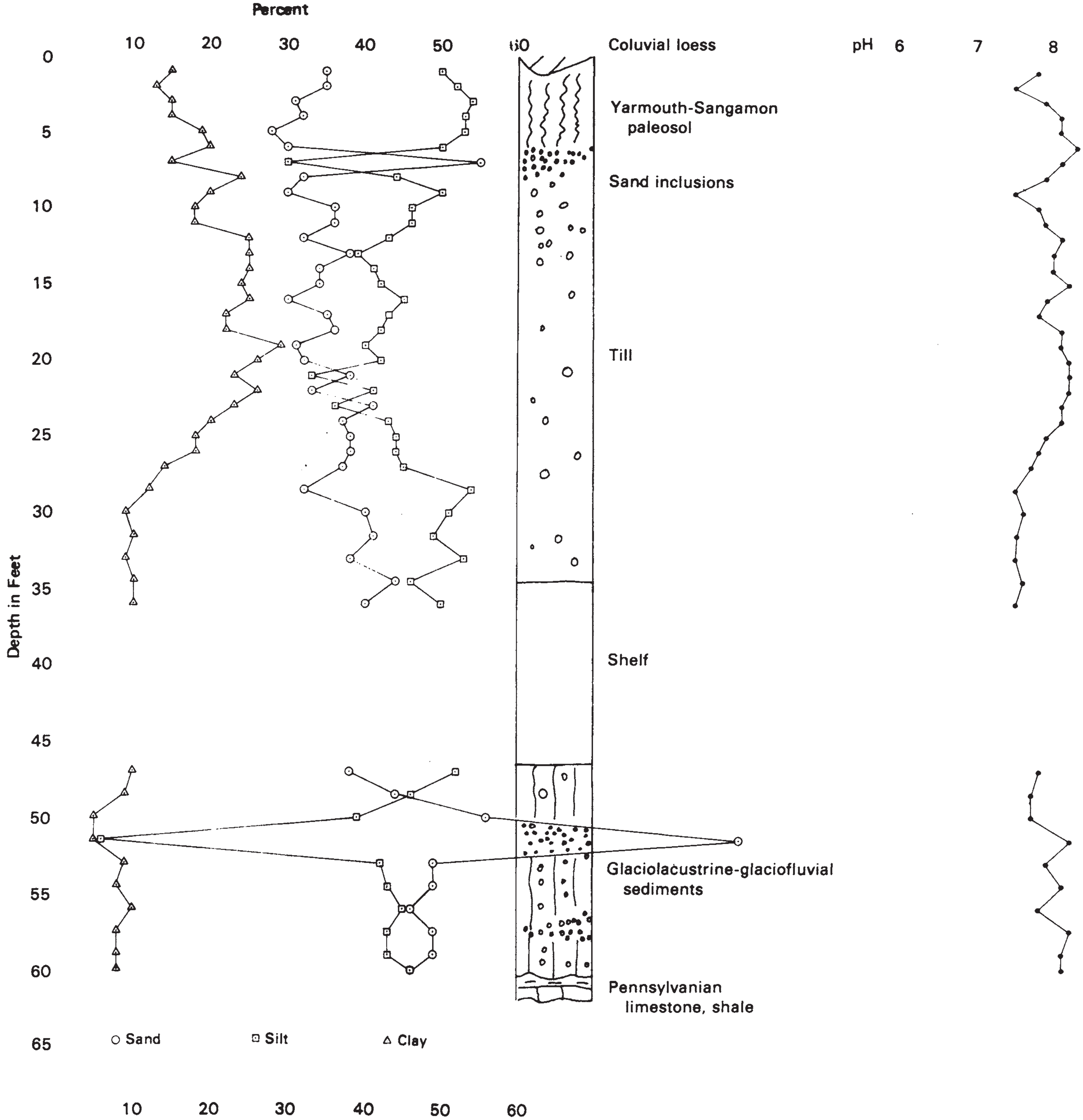


NEMO Coal Inc. Mine No. I

Randolph County, Missouri

Figure 1



ASSOCIATED ELECTRIC COOPERATION
A Pit
Randolph County, Missouri

Figure 2

ROAD LOG

Junction of U.S. Highway 63 and 24 in Moberly to Nemo Coal, Inc. pit and A.E.C.I.'s Prairie Hill Mine.

	Miles
Start: Junction of U.S. Highways 63 and 24 in Moberly, Mo.	0.0
Proceed North on U.S. 63. This extremely flat area is known locally as the "Grand Prairie" and is an undissected remnant of a glacial plain developed on a thick blanket of Kansan and Pre-Kansan drift which fill preglacial valleys and depressions. Post-glacial loess deposits 4 to 8 feet thick mantle the till, and formed the substrate for native tall grass prairies which have now been replaced by crop and pasture land.	
Junction U.S. 63 and County Road Z - Turn left on Z and proceed west through the village of Cairo. Caution-Railroad Crossing.	4.8
Western edge of "Grand Prairie"; from here westward the prairies are broken and eroded by tributaries of the East Fork of the Chariton River. Pennsylvanian bedrock is exposed in road ditches.	7.1
Junction County Roads Z and DD. Nemo Coal Company mine is dead ahead. Land in left foreground has been reclaimed. Turn left on DD and proceed south.	8.1
Houx limestone (Marmaton) exposed in road ditch.	9.0
Pleasant Hill Baptist Church. Turn right on gravel road.	9.0
STOP NO. 1 - Entrance, NEMO Mine	10.1

The Nemo Coal Company mine is located six miles northwest of Moberly. The mine employs 180 people with a payroll of about $7 million.

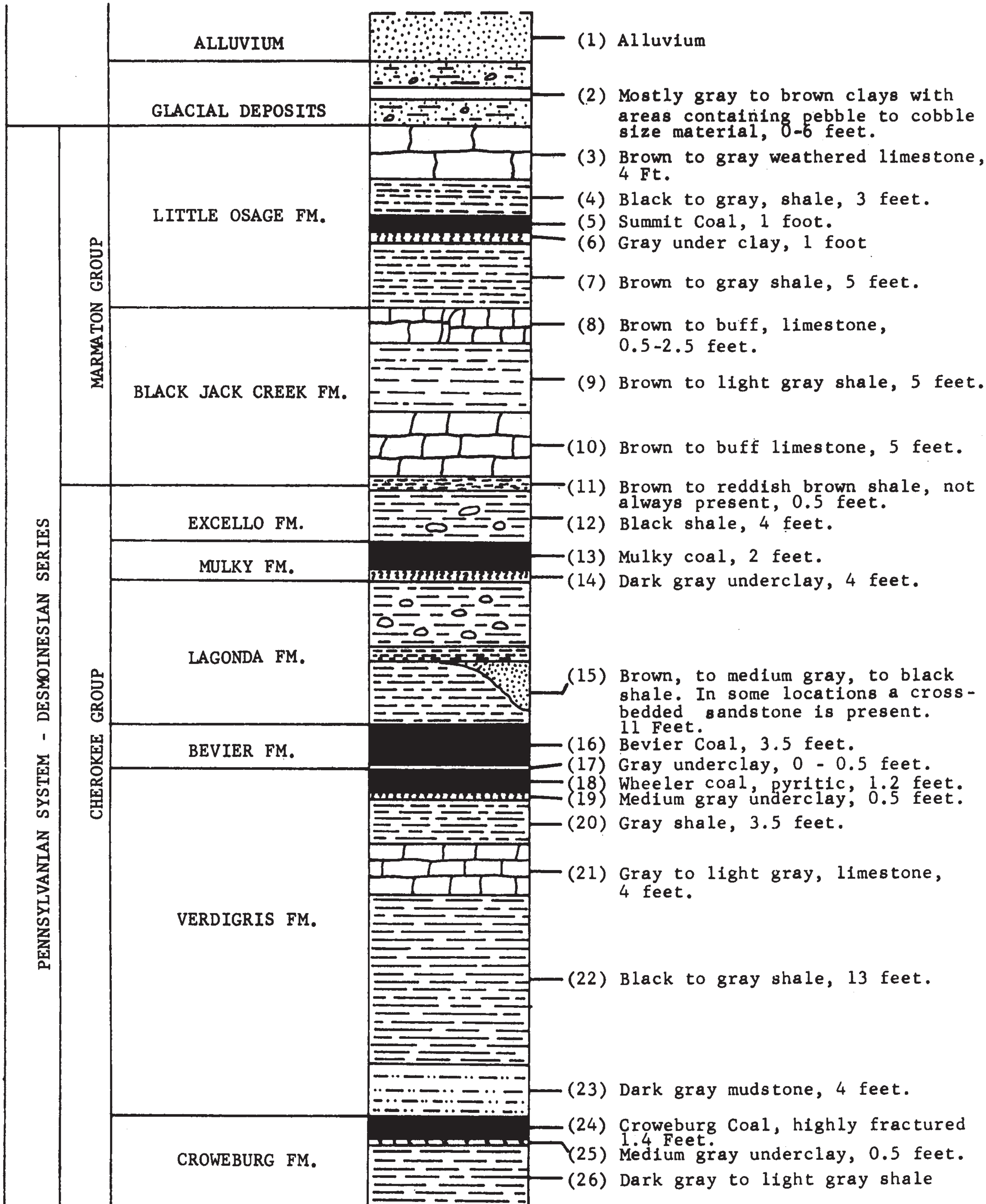
Coal is recovered primarily from the Bevier and Mulky seams which average about 48 and 22 inches respectively in the mine area. The Mulky lies about 12 feet above the Bevier. Minor production is from the Summit seam which lies above the Mulky and from the Croweburg seam which underlies the Bevier.

STOP NO. 1 (Continued)

Overburden is stripped by three draglines, the largest of which is equipped with a 30 yard bucket. Associated Electric's Thomas Hill Energy Center is the primary market although some coal is shipped to small municipal power plants at Chillicothe and Marshall, and to the plants at the University of Missouri at Columbia and Rolla.

In 1981, 645,000 tons of coal were produced at this mine.

STRATIGRAPHIC COLUMN
NEMO COAL INC.
MINE AREA



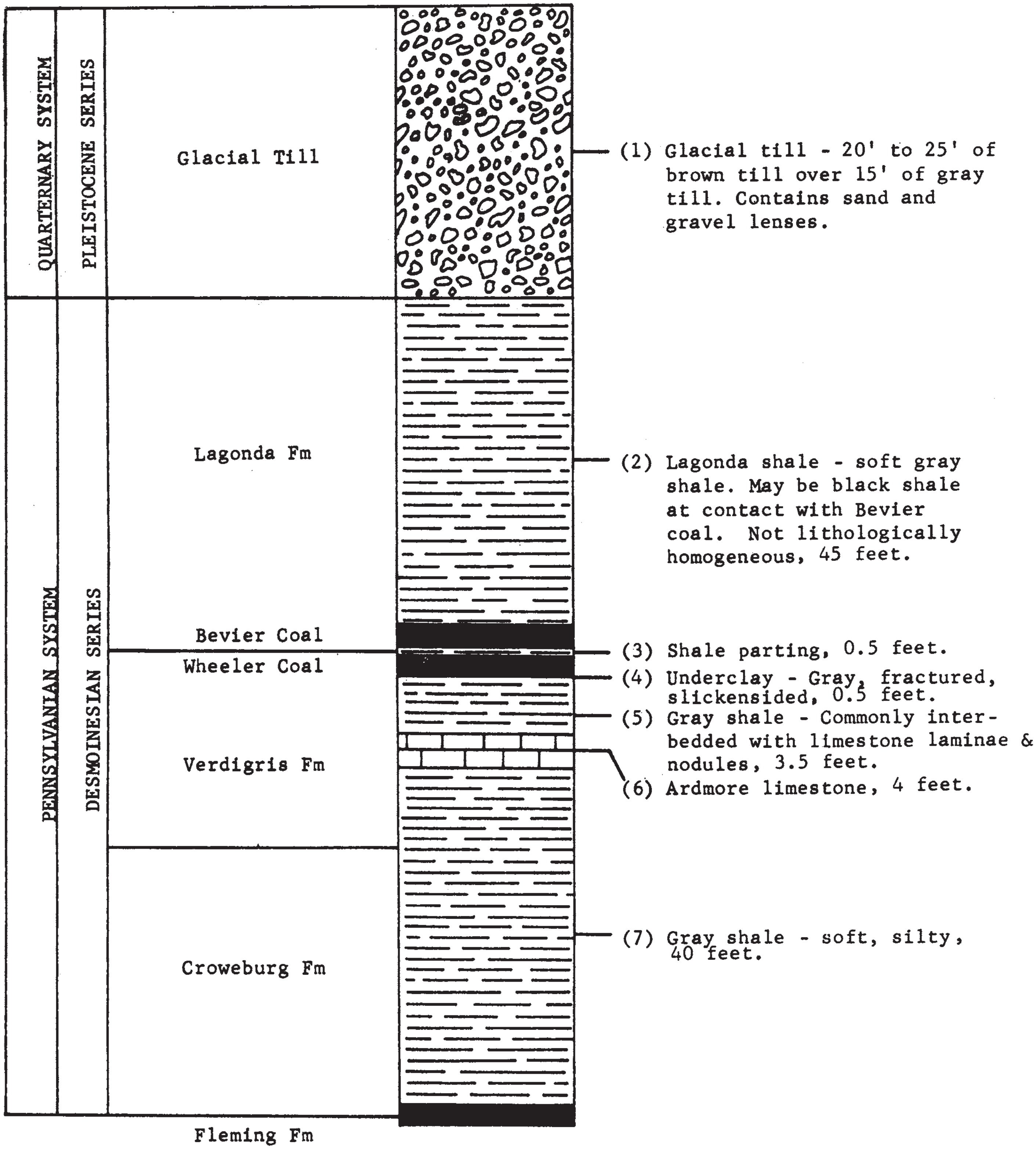
	Miles
Crossing East Fork of the Chariton River. The flood plain here is nearly one mile wide.	11.0
Continue on County Road Z.	11.5
Old Pre-Law Reclamation on Left. Pine trees are the result of aerial seeding in the 1940's. A good mixture of the spoil with glacial drift and loess materials accounts for the relatively good vegetation.	12.5
Junction County Roads Z and C. Turn right on C. Reclaimed stripped land on both sides of road.	13.1 15.7
Junction County Roads C and F. Turn left on F. Take Blacktop road to AECI's Thomas Hill power plant. The prairie Hill mine adjoins the plant.	17.5 21.1

STOP NO. 2 - Entrance, AECI Mine

The Prairie Hill Mine was operated by Peabody Coal Company until Associated Electric took over operations in 1980. In 1982, Associated's mine delivered 1,174,082 tons of coal to the Thomas Hill power plant. At the end of 1982 the mine employed 359 persons.

Ultimately the mine should produce 3 million tons of coal annually. Production is primarily from the Bevier coal seam which averages about 4 feet thick in the mine area. Some future production is expected from the thinner seam which lies approximately 30 feet below the Bevier. The Mulky seam which lies above the Bevier, and which is produced at the NEMO mine is thin to absent in the Prairie Hill area. Overburden, which is as much as 120 ft. thick, is removed by three large draglines, each of which carries a 90 yard bucket at the end of a 360 foot boom.

STRATIGRAPHIC COLUMN
ASSOCIATED ELECTRIC COOPERATIVE, INC.
PRAIRIE HILL MINE



FUTURE OF COAL MINING IN THE FIELD TRIP AREA

With a demonstrated combined reserve of deep and strippable coal amounting to 217 million tons, the greater field trip area could support a sustained annual coal production of more than 7 million tons for 30 years. Geologic evidence indicates that exhaustion of the demonstrated reserve base would not deplete the total coal resource base of the area but that additional reserves remain to be proven by exploration.

Current markets and contracts indicate that an annual production rate of 4 to 4½ million tons per year is assured for the next two or three decades. Additional mine developments depend on many complex factors including economics and environmental regulations. Any further tightening of federal sulfur emission controls or possible strict acid rain legislation would tend to stifle further development in the area. On the positive side, development of a coal conversion plant, such as a coal gasification plant, would allow utilization of the area's high sulfur coal with essentially no harmful effects on the environment.

REFERENCES

List of Missouri Geological Survey Publications (Selected MGS reports of interest)

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"Mineral Commodities of Macon and Randolph Counties" by Richard J. Gentile, 106 p., 3 plates, 16 figures, 7 tables, 1967. Price: $2.00.