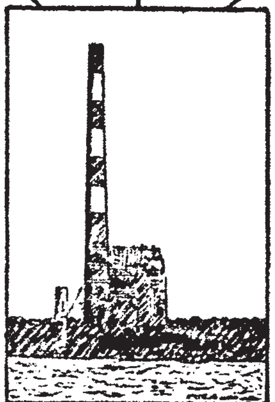
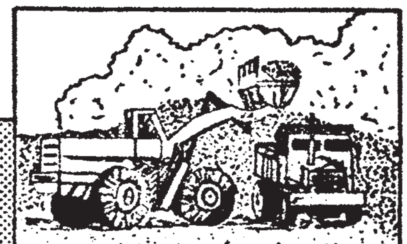
ASSOCIATION OF MISSOURI GEOLOGISTS

GUIDEBOOK

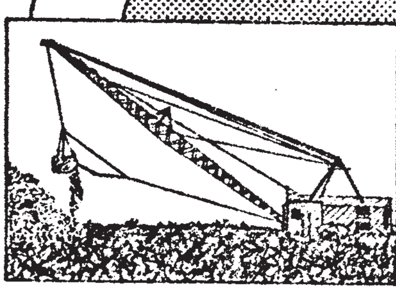


TH ANNUAL FIELD TRIP

SEPTEMBER 29 & 30 1978



energy environment geology in BATES COUNTY



ASSOCIATION OF MISSOURI GEOLOGISTS

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Field Trip Leaders

Friday - Richard Gentile

Gomer Jenkins

Bob McMillen

Saturday - Coordinated by Waldemar M. Dressel

Dedication

to

THOMAS R. BEVERIDGE

(1918 - 1978)

This guidebook is dedicated to Thomas R. Beveridge. Tom was a charter member of the Association and served as its president in 1965. Tom was the Missouri State Geologist from 1954 until 1964 when he became a member of the faculty of the University of Missouri at Rolla. Each of us who knew T.R. have reasons to remember him.

ASSOCIATION OF MISSOURI GEOLOGISTS

25th ANNUAL MEETING AND FIELD TRIP

PREFACE

The 25th Annual Field Trip includes a structural geology trip in the southern part of Kansas City on Friday afternoon and a trip to an operating coal mine and limestone quarry in western Bates County and a power generating plant in Kansas on Saturday.

The Friday afternoon trip will be along Highway I-470 in south Kansas City and will show a complex system of faulting in the Bethany Falls Limestone and associated strata.

The Saturday trip to Bates County will take us to Gulf's Pittsburg-Midway Coal Mine, the Bates County Rock-Division of Ash Grove Cement Company limestone quarry and the Kansas City Power and Light facility at La Cygne, Kansas. The coal mined for burning in the power plant, the limestone mined for use in the stack gas scrubber and the power plant are adjacent to each other.

ACKNOWLEDGEMENTS

We wish to acknowledge the efforts and hospitality of the following individuals and the companies they represent.

F. L. "Toby" Brumback, Bates County Rock-Division of Ash Grove Cement Company

Cliff McDaniel, Kansas City Power and Light Company

Jim Garnett and John Schocke, Pittsburg & Midway Coal Mining Company

This field trip would not have been possible without their help.

We also express our gratitude to members of the Graphics Section of DNR-Geological Survey. Sue Dunn designed the cover and Randy Rinehart, Gary Clark and Bill Ross prepared the figures for the guidebook.

FIELD TRIP: FAULT COMPLEX, RUSKIN HEIGHTS,
SOUTHERN JACKSON COUNTY, MISSOURI

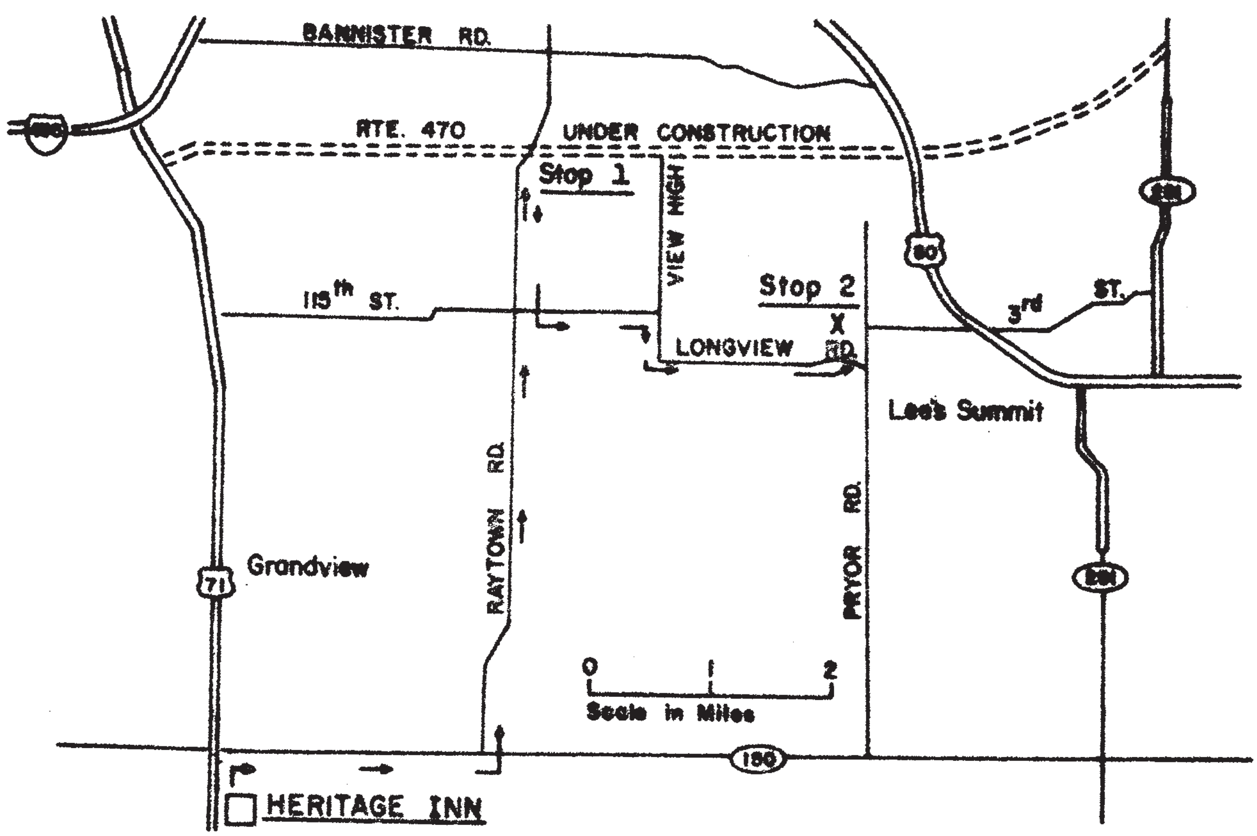
Leave north end Heritage Inn parking lot, Hwy. 71, Grandview, at 1:00 p.m. The total distance of trip is about 20 miles. Participants urged to share ride.

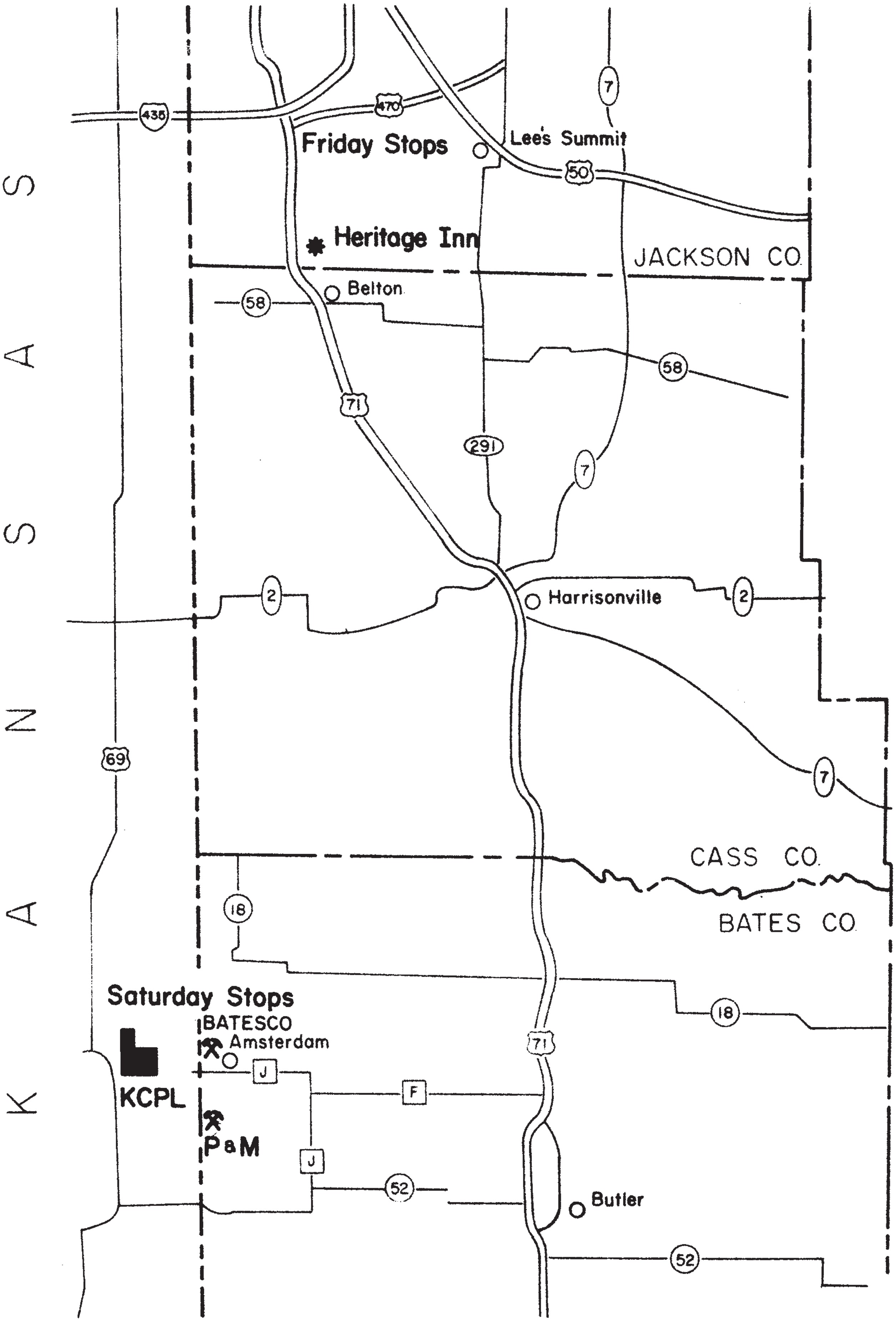
Leaders: Dick Gentile (University of Missouri-Kansas City), and Gomer Jenkins and Bob McMillen (Missouri State Highway Department). Preliminary paper on the fault complexes of west-central Missouri will be handed out.

This trip is an opportunity to study and debate the type and cause of the faulting that appears to be widespread in west-central Missouri. The area visited is a downdropped block of about 3 square miles in extent and named the Ruskin Heights fault complex. Pennsylvanian-age strata, including the Bethany Falls limestone that is extensively mined in the Kansas City area, have been disturbed by a series of high angle normal faults. Of major concern is the engineering geology considerations that should be given to proposed sites of underground construction and mining in the Kansas City area.

STOP NO. 1. Walk along I-470 (under construction) for about 1/2 mile to discuss some of the 10 or more northwesterly striking, high angle, normal faults with displacements of several feet. These faults are located on the northwest edge of the Ruskin Heights fault complex. Jenkins will point out some of the engineering geology problems associated with highway construction.

STOP NO. 2. Pryor Road (under construction) and Chicago-Rock Island and Pacific Railroad. This high angle normal fault first described by McCourt in 1917 is exposed by recent construction along the embankment of the railroad. It is located on the southeast edge of the Ruskin Heights fault complex.





KANSAS
435
470
Friday Stops
Lee's Summit
7
50
Heritage Inn
JACKSON CO.
58
Belton
58
71
291
7
2
Harrisonville
2
69
7
CASS CO.
BATES CO.
18
18
Saturday Stops
BATESCO
Amsterdam
J
KCPL
F
71
P&M
J
52
Butler
52

FAULTING OF THE BETHANY FALLS LIMESTONE AND ASSOCIATED STRATA AT KANSAS CITY

Richard J. Gentile, University of Missouri-Kansas City, Missouri has prepared a comprehensive report entitled "Faulting of the Bethany Falls Limestone and Associated Strata at Kansas City, Missouri--A Preliminary Report". The following was taken from his unpublished report.

ABSTRACT

"The Pennsylvanian-age bedrock of west-central Missouri has been fragmented along a complex system of faults that form polygonal, rectangular, and triangular shaped structures of a few square miles in areal extent. The strata within the faulted areas have been downdropped in places over 100 feet. The Belton fault complex in Cass County and a recently recognized fault complex, the Ruskin Heights in southern Jackson County, appear to have been formed by a similar type of fracturing. The strata have moved downward along high angle, normal faults. The downdropped block is fragmented into a series of smaller blocks by predominately northwesterly striking faults. The fault complexes occupy small, sharply delineated, synclinal areas adjacent to prominent small anticlines and synclines implying a horst and graben structural setting. The stream drainage patterns have been influenced by the orientation of fault and joint systems. The two most likely causes for the faulting are (a) fracturing and subisdence of the Precambrian basement rocks, or (b) collapse of strata into solution cavities developed in Paleozoic-age carbonate rocks. Faulting has not been observed to extend into the soil profile and for this reason it is concluded that movement of rocks associated with the faulting has not taken place in Recent times. Among the stratigraphic units affected by faulting is the Bethany Falls Limestone Member, a rock unit that is being exploited commercially by underground mining methods at an increased rate as Kansas City expands into undeveloped areas. Local structure should be taken into consideration when determining the subsurface geology at proposed mine and construction sites."

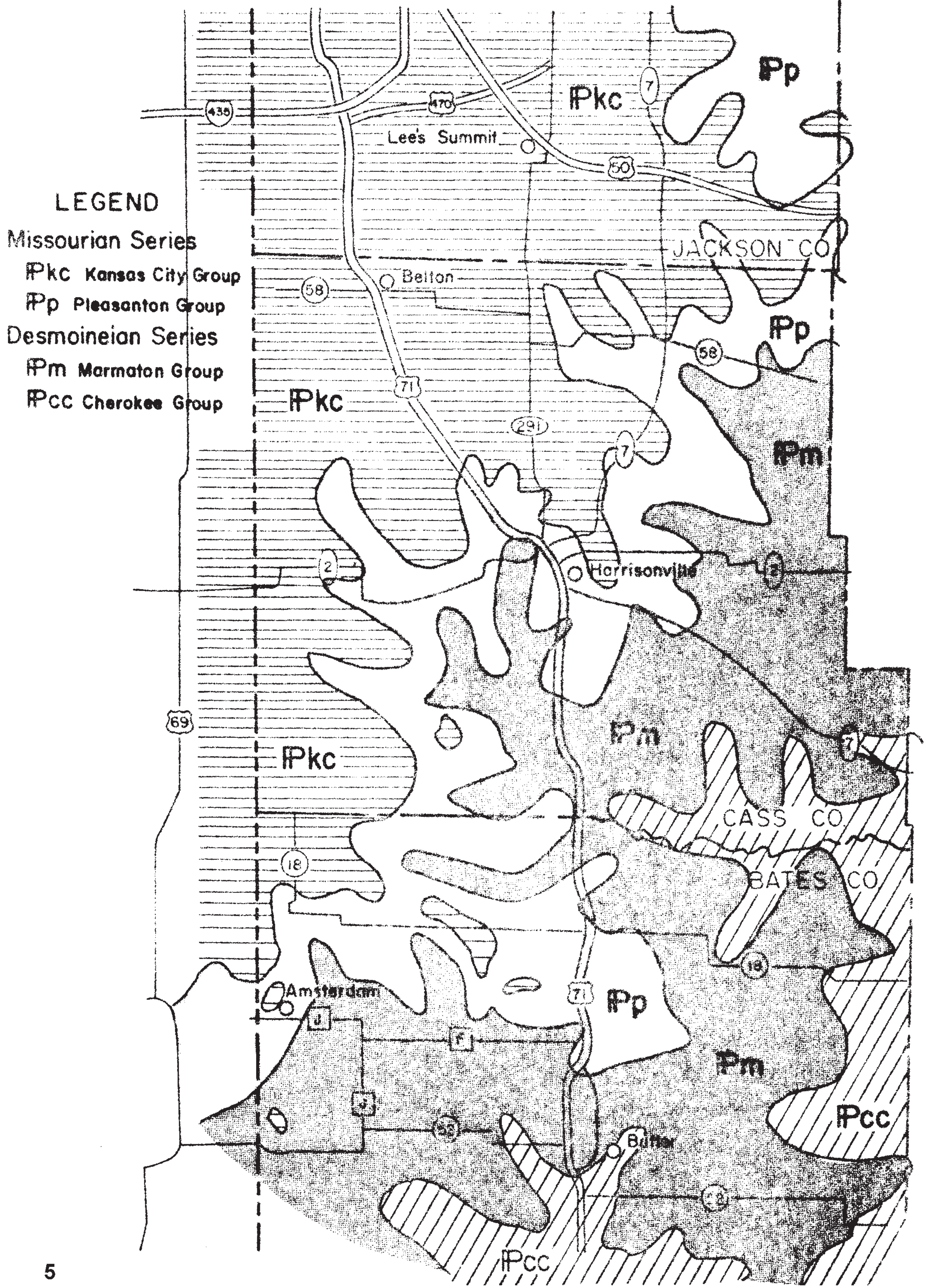
EXCERPT FROM INTRODUCTION

In some areas crustal movements have resulted in stresses of sufficient magnitude to cause the rock sequence to rupture by faulting. These faults are usually hidden under a cover of vegetation, soil, and weathered rock debris in the Kansas City area and are difficult to recognize by conventional field mapping techniques. "Unfortunately, the presence of faulting has been recognized in most places only after these ruptures have been exposed in artificial excavations of the bedrock units. This need not always be the case. Faulting may be anticipated if the proposed site is closely investigated to determine if the following geologic conditions prevail: (a) The strata are dipping in excess of 3°. The dips of folded strata have been observed not to be in excess of 1° or 2°. Strata inclined more than 3° are in most places associated with faulted structures. (b) The presence of a fault may be anticipated by recording, in areas where the strata are essentially horizontal, differences in elevation using a key stratigraphic unit as a datum."

"In addition, areas where faulting has occurred may be anticipated by close scrutiny of the stream drainage patterns displayed on 7-1/2' topographic maps because in many places the drainage has been modified by the orientation of faults and joints systems in the underlying bedrock."

Highway construction oftentimes offers an excellent opportunity to observe the effect of faulting. In the fall and winter of 1976, construction for Interstate Route 470, an east-west circumferential segment of the Federal Highway System, exposed ten northwesterly striking, high angle faults along a one-mile segment of the route, several miles southeast of downtown Kansas City. The faulted area is located on the northeast edge of the Kansas City suburb of Ruskin Heights and is here named the Ruskin Heights fault complex. Based on a preliminary study of drill hole data, interpretation of stream drainage patterns on topographic maps, and field investigations, the Ruskin Heights fault complex is a rectangular shaped downdropped block about 3 miles long in a northwest-southeast direction and 2 miles wide in northeast-southwest dimension. The Ruskin Heights fault complex is divided into several small blocks by a series of northwest trending, high angle normal faults with displacements along individual faults of a few inches to over 10 feet.

GENERALIZED GEOLOGIC MAP



GENERAL GEOLOGY OF BATES COUNTY

The following is the abstract from the Missouri Department of Natural Resources-Division of Geology and Land Survey Report of Investigation No. 59, 1976, entitled "The Geology of Bates County, Missouri" by Richard J. Gentile.

ABSTRACT

Bates County is one of the tier of counties that forms the western boundary of Missouri. It lies about 60 miles south of Kansas City and consists of an area of 841 square miles, making it sixth in size among Missouri counties. Bates County has a small rural population that is mainly engaged in agriculture.

Exposed Pennsylvanian-age rocks, belonging to the Atokan, Desmoinesian and Missourian Series, have an average thickness of about 750 feet. The Pennsylvanian is underlain by about 2,000 feet of Mississippian-, Ordovician-, and Cambrian-age sedimentary rocks which rest on the Precambrian igneous and metamorphic complex.

The Pennsylvanian-age rocks consist of thin but, for the most part, relatively persistent beds of shale, sandstone, limestone and coal that are repeated in cyclic sequences. Shale and sandstone units over 40 feet thick are uncommon and most limestone beds are less than 20 feet thick. The coal beds are less than 6 feet thick. Most of the limestone and coal beds in the Pennsylvanian above the Croweburg coal are persistent across the county and beyond.

Beds tentatively assigned to the Atokan Series are exposed in a limited area in the southeastern part of the county and consist of about 75 feet of sandstone, shale, coal and conglomerate which rests on Mississippian-age limestone.

The combined thickness of the Cherokee and Marmaton Groups, which compose the Desmoinesian Series, is about 450 feet. The Cherokee contains numerous coal beds alternating with shale, sandstone and a few limestone beds. The Marmaton Group is almost as thick as the Cherokee and consists of several escarpment-forming limestone units interbedded with shale, sandstone and coal.

The Pleasanton Group, the lowermost group of the Missourian Series, is predominantly shale and sandstone and is about 100 feet thick. Channel-filling sandstone has filled two north-south-oriented channels eroded into the older Pennsylvanian-age rocks. Some of the channel-filling sandstones are believed to be late Marmaton in age.

The Kansas City Group of the Missourian Series underlies the higher elevations in the northwestern part of the county and consists of shale, sandstone and several prominent limestone units. Resistant limestones of the lower part of the Kansas City Group form the upper part of high mounds in other areas of the county.

Patches of terrace gravels of Pleistocene age are found about 400 feet above the valleys of the major rivers, but terrace gravels also occur near the tops of the high hills in the southeastern part of the county. Several feet of recent gravels underlie the floodplains of the larger rivers.

The general dip is toward the northwest at a few feet per mile, but this has been modified by the broad, low Schell City-Rich Hill anticline that enters the county, plunging beneath younger Pennsylvanian strata near the Missouri-Kansas boundary.

About two dozen coal beds underlie the county and two of these beds, the Mineral and Mulberry, have been exploited commercially on a large scale. Significant reserves of Mulberry coal underlie large areas in the northwestern part of the county and are being mined to supply fuel at the mine-mouth steam generating plant at La Cygne, Kansas.

Limestone is quarried from two beds, the Higginsville and Bethany Falls, each about 20 feet thick. The quarried product is used in the production of concrete aggregate for construction purposes and as agricultural lime. The county possesses large reserves of limestone.

Oil, too heavy to be pumped, impregnates several sandstone and limestone beds throughout the sequence of Pennsylvanian rocks. Asphalt occurs in outcrops of sandstone in the lower Cherokee and Pleasanton Groups. Minor amounts of gas and oil have been obtained from structural traps in former times from several zones in the Pennsylvanian. A few deep tests which penetrated the Mississippian, Ordovician, Cambrian, and Precambrian rocks were dry.

Thick beds of clay and shale, those of the Legonda Formation, Holdenville Formation, and Lower Pleasanton Group in particular, are suitable for making low-grade ceramics.

Shallow wells drilled into the Pennsylvanian-age sandstones produce a few gallons of water per minute. The water has a high iron content. Yields from deep wells are somewhat larger but the water is highly mineralized. Isolated deposits of terrace gravels along the major streams are mined in open pits and used for road construction.

KANSAS CITY POWER AND LIGHT

LA CYGNE STATION UNIT NO. 1

(Extracted from a report prepared by Clifford F. McDaniel, Superintendent of Air Quality Control, La Cygne Station, Kansas City Power and Light Company for presentation at Utility Scrubber Conference held in Denver, Colorado, March 29-30, 1978.)

LA CYGNE STATION UNIT NO. 1

WET SCRUBBER

The 820-megawatt La Cygne No. 1 Unit began commercial operation on June 1, 1973, as a joint project of Kansas Gas and Electric Company and Kansas City Power and Light Company. The companies share equally in ownership and output and the unit is operated by KCP&L. The 630-megawatt No. 2 Unit, in service since being declared commercial May 15, 1977, operates under an identical arrangement.

The plant site is located about 55 miles south of downtown Kansas City, one-half mile west of the Missouri State line, and was selected based on locally available coal, water, and limestone. Construction of No. 1 Unit began in 1969 and erection of the Air Quality Control System was initiated in mid-1971.

Water for cooling purposes is furnished from a 2,600-acre reservoir constructed adjacent to the plant site. Fly ash and spent slurry from the AQC system is piped to a 160-acre settling pond located east of the reservoir.

Coal is delivered to the plant in off-the-road 120-ton trucks from surface mines operated by the Pittsburg & Midway Coal Mining Company. The nearby coal deposits are estimated to contain 70 million tons. The fuel is low grade sub-bituminous with an as-fired heating value of 9,000 to 9,700 Btu/lb, and an ash content of 25 percent and sulfur content of 5 to 6 percent (Exhibit A).

Limestone is obtained from nearby quarries (Bates County Rock) and delivered to the plant in off-the-road 50-ton trucks.

The boiler for No. 1 Unit is a cyclone-fired, supercritical, once-through, balanced-draft Babcock & Wilcox unit, with a rating of 6,200,000 pounds of steam per hour, 1,010 degrees F, 3,825 psig at the superheat outlet. The turbine-generator was supplied by Westinghouse and is rated at 874 MW gross output with five percent overpressure and 3,500 psi throttle pressure. Three auxiliary, oil-fired boilers are used for plant start-up or for powering a 20-megawatt house turbine-generator. The net plant output is 820 megawatts, adjusted to include 24 megawatts used by the AQC system and 30 megawatts by plant auxiliaries.

PROCESS DESCRIPTION

The AQC system consists of eight two-stage Venturi-absorber scrubber modules (Exhibit B) designed to treat the boiler flue gas flow of 2,760,000 ACFM (34,000 ACFM per module at 285 degrees F.). The ductwork design does not provide for flue gas bypass of the system. Also, the plant does not have an alternate or secondary fuel supply. Each module can be isolated for maintenance by individual dampers. On-site limestone grinding and slurry storage facilities provide up to 1,000 tons of slurry per hour. The unit has a balanced draft system with three 7,000 hp forced-draft fans and six 7,000 hp induced-draft fans located between the AQC system and the 700-foot stack. There is a common plenum at both the scrubber inlet and outlet. Spent slurry and fly ash are removed from the module recirculation tank through rubber-lined pipes to the settling pond at the rate of 3,500 tons of solids per day. Clear make-up water is pumped from the pond and the loop is closed by recycling ball mill and module make-up water back into the system.

In abbreviated terms, as the hot flue gas enters the Venturi (Exhibit C), it is sprayed with slurry from 48 spray and 32 wall wash nozzles resulting in up to 99 percent of the particulates agglomerated to the sump below. The gas continues through the sump making a 180-degree turn up through the absorber section. In the reaction chamber, the SO_2 is removed as the gas is forced through a limestone slurry solution sprayed on stainless steel sieve trays. The chemical reaction in part combines the calcium carbonate, water and sulfur dioxide to form two relatively insoluble calcium salts, calcium sulfate and calcium sulfite, which also fall to the sump. The cleaned gas passes through demisters to remove moisture and then is reheated to avoid deposits on the fans and provide buoyancy from the stack.

LA CYGNE STATION
COAL AND ASH ANALYSIS

COAL

Proximate

Volatile	28.63
Fixed Carbon	37.94
Ash	24.36
Moisture	9.07
	100.00

BTU/lb. 9421

Grindability 59.59

Ultimate

Moisture	8.60
Carbon	51.93
Hydrogen	3.43
Nitrogen	0.94
Chlorine	0.027
Sulfur	5.39
Ash	24.36
Oxygen	5.33
	100.007

ASH

Analysis

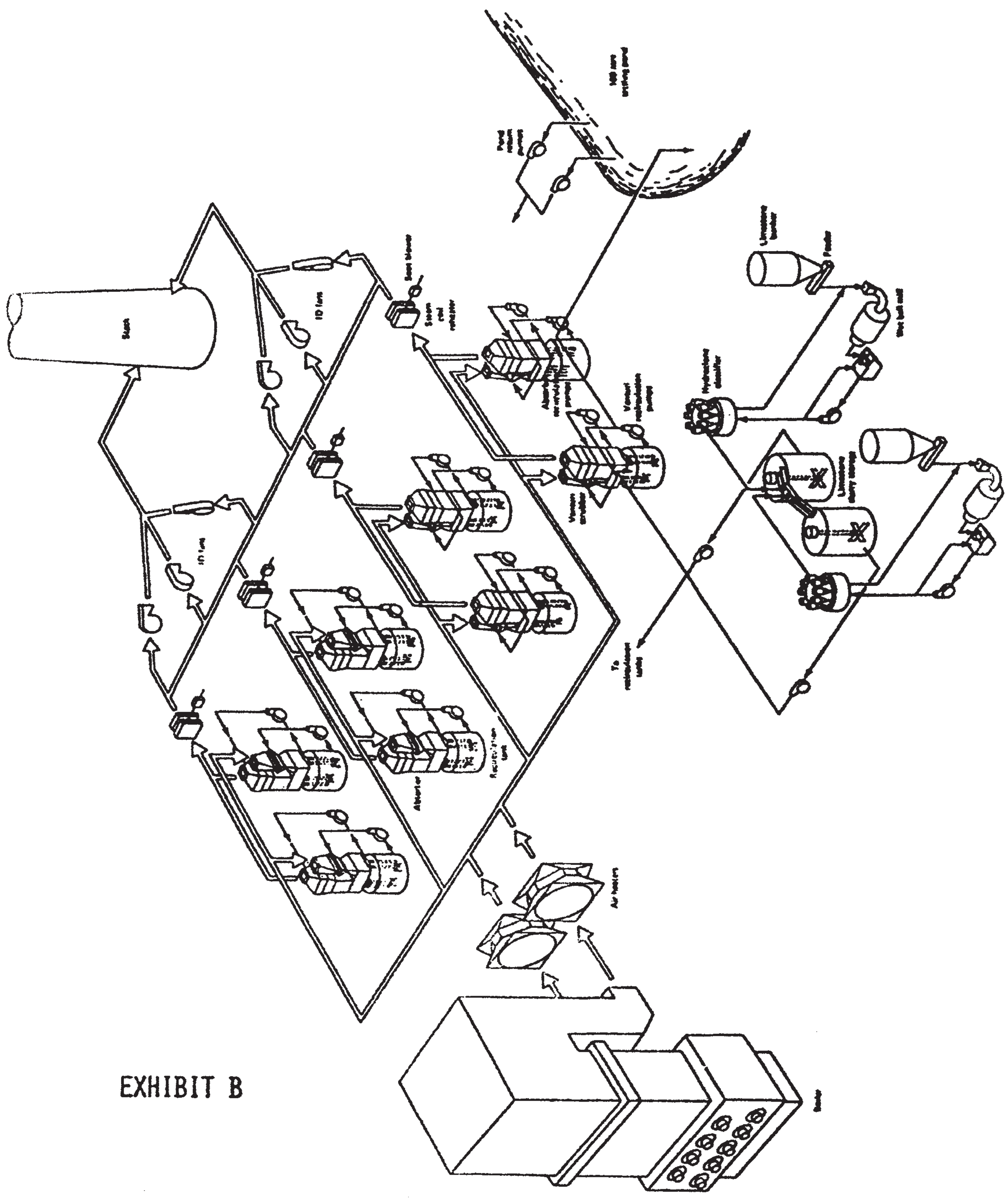
Phosphorous Pentoxide	0.15
Silica	46.05
Ferric Oxide	19.23
Alumina	14.07
Lime	6.86
Magnesia	1.02
Sulfur Trioxide	7.85
Potassium Oxide	2.48
Sodium Oxide	0.60
Titania	1.02
Other	0.67
	100.00

Fusion Temperature

Reducing I.D.	1957
Soft (H=W)	2045
Soft (H=W/2)	2169
Fluid	2321
Oxidizing I.D.	2156
Soft (H=W)	2338
Soft (H=W/2)	2415
Fluid	2520

EXHIBIT A

EXHIBIT B



La Cygne limestone wet scrubbing system

FIGURE 1 - LACYGNE FGD MODULE

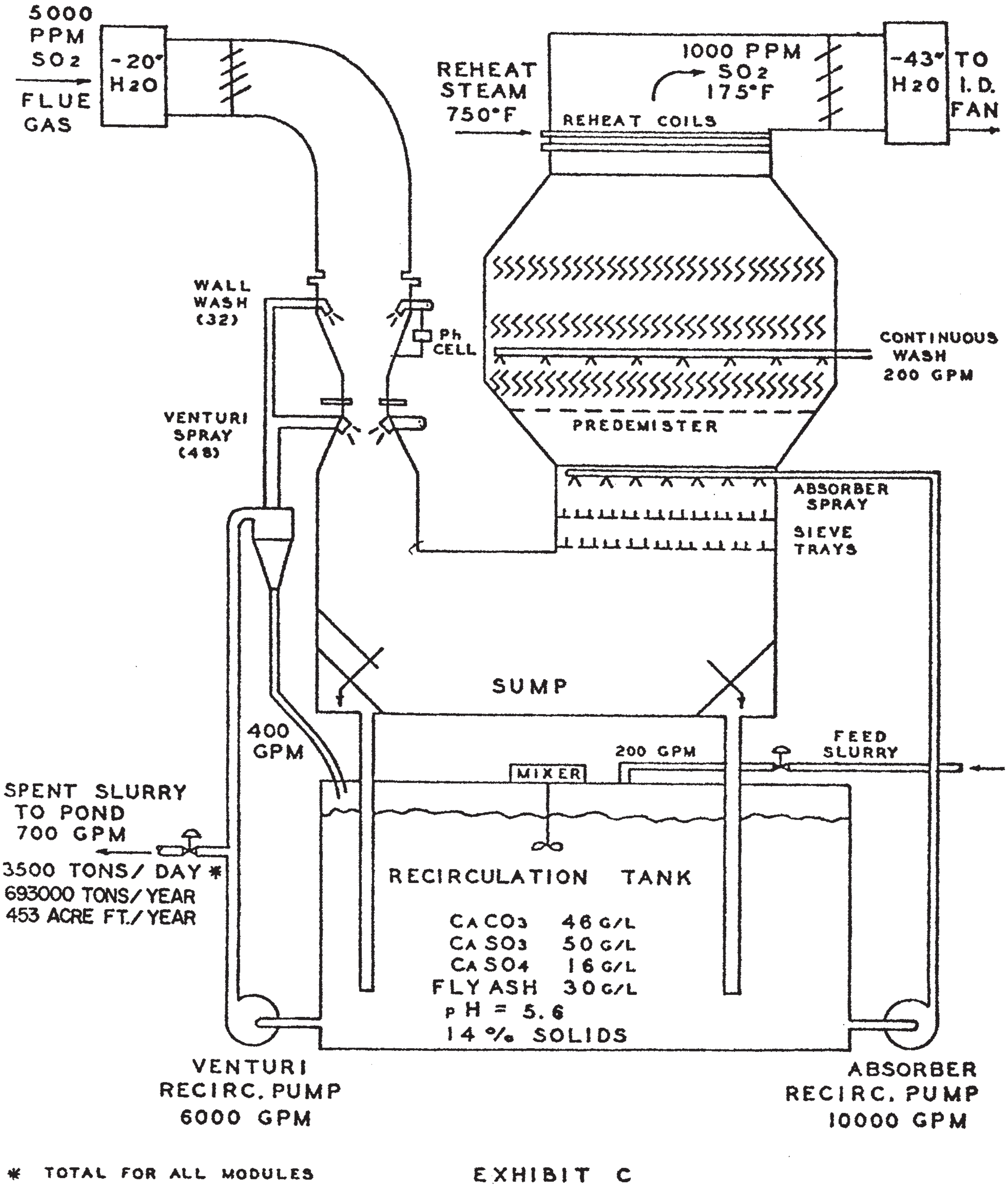


EXHIBIT C

PITTSBURG-MIDWAY MINE

(Description of Geology of Midway Mine Supplied by Pittsburg & Midway Coal)

The Pittsburg-Midway Mine on the Missouri-Kansas line south of the town of Amsterdam began operations in 1972. Although the deposit extends into Kansas present mining activities are confined to Missouri. Production records, since operation began, reported by the State Division of Mine Inspection show the following:

Year	Coal Production Tons
1972	102,769
1973	969,121
1974	974,314
1975	1,476,054
1976	1,452,570
1977	1,718,769

Stripping is done by a 110-yard and a 73-yard dragline. The 100-yard machine is being used in an area where the overburden is in the order of 45 feet and the 73-yard dragline is removing an average of about 75 feet of overburden.

The mine began operations after enactment of Missouri mine land reclamation laws and all land mined up until this year were reclaimed or will be reclaimed in compliance with these laws. Under the Missouri law the affected lands will be or have been graded to a rolling terrain and seeded. More stringent reclamation rules have been put into effect with the advent of the Federal Surface Coal Mine and Reclamation Act of 1977. Insufficient time has elapsed to determine the difference in results of reclamation under the Federal law vs. under the State law.

Approximately 380 acres were affected by mining during 1977.

TOPOGRAPHY

Most of the area in the vicinity of the Midway Mine is a gently rolling prairie with local relief of about 100 feet. This surface, however, is punctuated by several relatively steep mounds which rise abruptly as much as 150 feet above the surrounding plain. These mounds are usually less than one square mile in size, tend to be flat-topped, and are capped by one of the limestones of the Kansas City Group. Surface elevations in the mine area range from a low of around 750 feet on the principal stream, the Marais Des Cygnes River, to between 800 and 860 feet for most of the prairie to as much as 1,040 feet on top of the highest mound. Several relatively large, named mounds (including Summers, Spy, and Graves) as well as un-named mounds, occur in the immediate vicinity of the Midway property. These mounds are outliers of an irregular east-facing cuesta which is formed by the northwest dipping Kandas City Group limestones. In general, this cuesta trends northeast-southwest and is located a few miles to the west in Kansas.

REGIONAL GEOLOGIC SETTING

The Midway Mine area is part of the Western Interior Coal Basin which includes the bituminous-coal-bearing portions of Iowa, Missouri, Kansas, Oklahoma, and Arkansas. In western Missouri and eastern Kansas, the rocks have a regional dip to the northwest off of the Ozark Dome and into the Forrest City Basin of northwestern Missouri, northeastern Kansas, and southwestern Iowa. This dip averages about 20 feet per mile. However, in the immediate vicinity of the Midway Mine, many local interruptions in the regional dip occur; and it is not uncommon to find local dips as much as 10° to 15°, and dips of as much as 30° have been reported. The Midway Mine is located in the general area of a broad, gentle anticlinal structure with a northwest-southeast axial trend.

REGIONAL STRATIGRAPHY

The general distribution of surface outcrops in this part of Missouri and Kansas is one of older rocks on the surface to the east and southeast passing through successively younger rocks to the northwest. Rocks of the same age crop out in irregular bands trending about N30°E-30°W. Mississippian-age rocks occur on the surface in the counties east of Bates County, Missouri, and Pennsylvanian rocks are at the surface throughout all of Linn County, Kansas, and essentially all of Bates County.

The Pennsylvanian System in the area of the mine is about 500 feet thick. Very few wells have penetrated the entire Pennsylvanian; but near Merwin, located several miles northeast of Amsterdam, the base of the Pennsylvanian was found at 497 feet (Hinds, 1912). The Mulberry Coal was at 70 feet making the remaining Pennsylvanian 427 feet. Hinds, 1912, also reported the base of the Pennsylvanian at 438 feet below the Mulberry in a water well drilled at Amsterdam. Another well drilled 2 miles south indicated 435 feet. Below the Pennsylvanian, these wells encountered Mississippian limestones. Thick limestones are characteristic of the Mississippian System throughout this part of the country.

Surface rocks in the general area of the mine belong in ascending sequence, to the Marmaton, Pleasanton, and Kansas City Groups which form a part of the Pennsylvanian System in this area. The Marmaton Group consists of a succession of shale, limestone, clay, sandstone, and coal beds and includes the Mulberry Coal - the coal mined at the Midway Mine. The Pleasanton Group differs somewhat from the Marmaton in that there are fewer limestones and much more sandstone and shale and an occasional thin coal. These rocks crop out primarily on the higher portions of the plains area and on the slopes of the hills and mounds. The Kansas City Group, composed primarily of limestone and shale beds, forms the cap of the higher hills and the mounds. Limestones form a larger portion of this group than either the Marmaton or Pleasanton.

The normal stratigraphic sequence, as exposed in the highwalls and in the exploration drill holes in the Midway Mine area, is depicted in Figure No. 1. The underclay, Mulberry Coal, and the calcareous (limey) shale above the coal constitute the Bandera Formation. Above this is the Altamont Formation, consisting of the Amoret Limestone Member at the base, the Lake Neosho Shale Member in the middle, and the Worland Limestone Member at the top. Throughout most of the mine area, all these can be recognized essentially everywhere except for the Amoret Limestone, which apparently has pinched out from the south or which was gradually graded into the upper part of the calcareous shale unit. Above the Altamont Formation, the formational units were not differentiated, but as much as 80 or 90 feet of additional Pennsylvanian rocks, constituting the upper part of the Marmaton Group and perhaps the lower part of the Pleasanton Group, are present.

(a) Underclay - About 4 feet of light gray claystone, which is relatively soft and plastic, is found under the coal. Only the top several inches is readily visible; but in sump pits, occasionally dug to collect water, the entire section down to the top of the underlying Coal City Limestone Member of the Pawnee Formation can be seen.

(b) Mulberry Coal - This coal is a normally banded bituminous coal with abundant impurities in the form of clay partings and intrusions, pyrite masses and fracture filling, and calcite fracture fillings. It ranges in thickness from zero to as much as 3 feet or more.

(c) Calcareous Shale - This unit, which carries no formal name, averages about 15 feet in thickness. It is composed of variable amounts of light gray shale and hard, calcareous shale which may grade into impure limestone. It contains numerous small irregular limestone nodules usually no more than a few inches in diameter. Marine fossils are abundant, and they indicate open marine conditions. Brachiopods are the dominant form observed.

(d) Amoret Limestone - The Amoret Limestone was not positively identified in the area of the Midway Mine. It has been reported in outcrops in the southern part of the area near Amoret. Its position is at, or near, the top of the calcareous shale unit. Where developed, it is composed of fossiliferous beds of limestone and calcareous shale, which attain a maximum thickness of about 5 feet.

(e) Lake Neosho Shale - This unit is very distinctive and easy to recognize. It consists of 3 to 4 feet of calcareous, fossiliferous, greenish-gray shale which contains a zone of dark gray shale containing small spherical phosphatic concretions an inch to two in diameter. Brachiopods are the dominant fossil form observed, but several other groups of marine organisms are represented. The Lake Neosho is not distinguished in the driller's logs of exploration holes, being lumped with the underlying calcareous shale unit. The Lake Neosho is quite visible in the highwall, being of a different color and being much softer than the calcareous shale unit below.

(f) Worland Limestone - This limestone makes a very prominent persistent marker occuring 15 to 20 feet above the coal. It is usually 3 to 4 feet thick and has a faint pinkish cast. It is a coarse-textured limestone, for the most part, and is normally described as "crystalline". It contains marine fossils. The driller's log always indicates this unit as it is very hard and easily recognized by its drilling characteristics.

(g) Undifferentiated Strata - Above the Worland is a sequence of classic rocks, mostly gray shale with some siltstone and sandstone, and an occasional limestone bed. No attempt was made to determine the proper stratigraphic names for these units. They constitute the upper part of the Marmaton Group, and where the maximum highwall is attained, where as much as 100 feet of highwall is present, the lower part of the Pleasanton Group may be present.

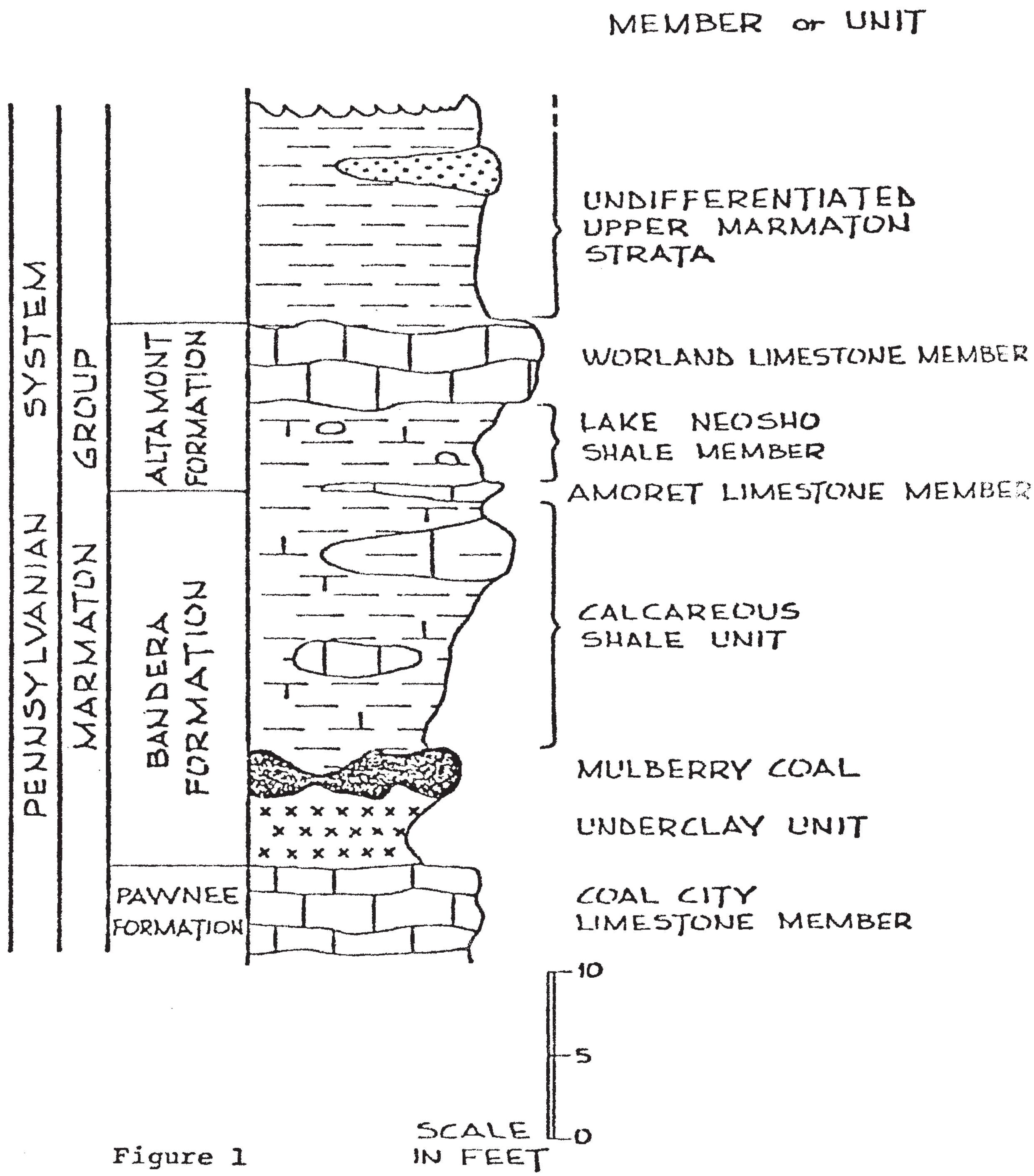

MEMBER or UNIT
PENNSYLVANIAN SYSTEM
MARMATON GROUP
ALTAMONT FORMATION
BANDERA FORMATION
PAWNEE FORMATION
UNDIFFERENTIATED UPPER MARMATON STRATA
WORLAND LIMESTONE MEMBER
LAKE NEOSHO SHALE MEMBER
AMORET LIMESTONE MEMBER
CALCAREOUS SHALE UNIT
MULBERRY COAL
UNDERCLAY UNIT
COAL CITY LIMESTONE MEMBER
10
5
0
SCALE IN FEET

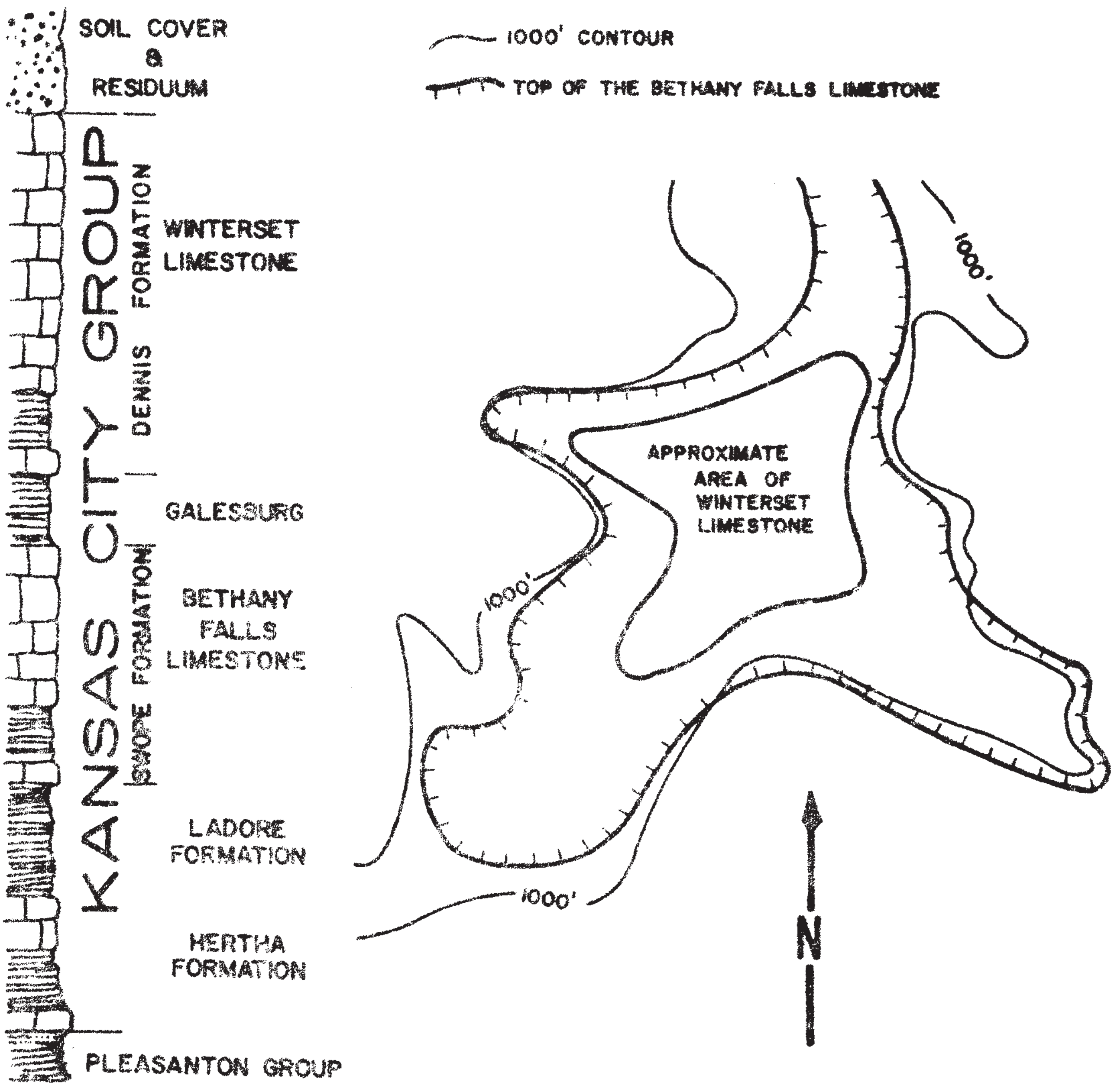
Figure 1

BATES COUNTY ROCK #6 - AMSTERDAM QUARRY

NW$\frac{1}{2}$ Sec. 20 & NE$\frac{1}{2}$ Sec. 19, T. 41 N., R. 33 W., Amoret Quad.

The quarry is located on the top of one of a number of "mounds" present in northwestern Bates County which rise 75 to 150 feet above the surrounding countryside and vary from a few to over 100 acres in extent. The tops of these mounds are relatively flat and are capped by Hertha, Bethany Falls and on a few the Winterset limestones. The slopes are comprised of Pleasanton shales and sandstones. The attitude of the bedrock on the Amsterdam mound was roughly saucer-shaped with upwards of 25 feet of Winterset limestone in the center.

GENERAL SECTION



The following is from an article by Walter E. Trauffer entitled "New 500-tph Crushed Stone Plant Built to Supply Limestone for Pollution Control Needs of New Power Plant on Mo-Kans. Border" published in Pit & Quarry/February, 1977 p. 48-53.

Bates County Rock No. 6 Quarry is on relatively high land overlooking the town of Amsterdam, Missouri. It consists of two ledges both suitable for the special use by the KCP&L power plant. The overburden averages 8' in thickness. Next is a ledge of Winterset limestone 4 ft. to 24 ft. thick. Under this is a shale bed which averages 10 ft. thick, and then the 12-ft. to 14-ft. bed of Bethany Falls limestone. These four layers are mined progressively, with the overburden and the shale being pushed into the worked-out quarry by a Caterpillar D8H bull-dozer with tilt and ripper.

Both limestones fall within the limits specified in the contract with the power company -- a minimum of 85% $CaCO_3$ and a maximum of 2½% $MgCO_3$. Both average 90 to 92% $CaCO_3$. Some of the Winterset stone is not usable for this purpose, due to vertical clay seams, and this is used for road base, surfacing stone, etc.

The two limestone ledges are drilled with a Gardner-Denver HDCF crawler drill, with a Gardner-Denver SP600K compressor. The 3½" blast holes are spaced on a 9' x 10' pattern. Bulk AN/FO explosives are used whenever possible. This is discharged from a 45-ton overhead bin, which loads the explosive into a Sudenga bulk distributing body mounted on a Ford F600 four-wheel drive chassis with an automatic transmission. The explosive is elevated by an auger and flows through a chute into the blast hole. Dupont Watergel and electric caps are also used. In wet holes Dupont Watergel is used in 2" x 16" cartridges. Most shots have 60 holes in 6 rows and a V pattern, using 8- or 9-millisecond delays. The shale is also drilled and blasted using a wider -- 14' x 14' -- pattern and lighter explosive loadings.

In the quarry, two front-end loaders -- a 10-cu. yd. Wabco 1200 and a Caterpillar 988 with an extended lip on its 6-cu. yd. bucket -- load the stone into trucks. The fleet of four 50-ton rear-dump quarry trucks -- 3 Wabco Haulpaks and an Euclid R-50 -- haul the stone about 7,000 feet to the plant. The haul is mostly downhill to a long earth-fill ramp with a 5% grade to reduce gear shifting.

The trucks dump the rock into a 70-cu. yd. rock box from which a 52" x 19'5" Cedarapids vibrating grizzly feeder with 3" longitudinal openings discharges the plus-3" rock into the primary crusher. This is a Cedarapids 5348 single-impeller impactor, which is driven by a 300-hp General Electric motor. An Allied Steel stone breaker was recently installed at the primary crusher. This has a 25' boom and a Model 81 hammer, and is hydraulically and electrically operated. The minus-3" material through the grizzly drops on a short second deck with 3/4" screen cloth. The minus-3/4" rock through this deck drops on 30" x 28' reversible belt conveyor C2. When a quarry material is considered clean enough, the stone is discharged from one end of conveyor C2 onto 30" x 88' conveyor C3, which, in turn, discharges on 36" x 204' stacker conveyor C8. This discharges to the main product stockpile, which is 65 ft. high and has a capacity of 28,000 tons.

When scalping of material from the quarry is being done, both the 3" to 3/4" and the minus-3/4" from the grizzly are discharged onto conveyor C2. This then discharges from the other end to a commercial circuit for making 3", 1½" or 1"-minus base material. A 30" x 40' belt conveyor (C10) discharges on a 5' x 16' Hewitt-Robins vibrating double-deck screen. The product is discharged on 30" x 100' conveyor C11 and then to 30" x 100' radial stacker C12, which discharges to the base material stockpile. Screen cloth changes allow various sizes of this product.

The two larger sizes from this screen -- 3" to 6" and minus-3" sizes -- are carried on 30" x 40' conveyor C13 to 36" x 178' conveyor or C4 to the covered surge pile. This is 55' high and has a capacity of 15,374 tons.

When not scalping, the minus-3" to 0 material from the crusher, and when desired, the 3" to 3/4" rock from the grizzly go on 36" x 40' conveyor C1 to conveyor C4 and the surge pile.

The surge pile has a live storage capacity of 2,500 tons, reclaimable by two Syntron F450 Vibra-Flow feeders rated at 500-tph each. These discharge on 36" x 220' reclaiming belt conveyor C5 in the 10' dia. Armco corrugated metal and concrete tunnel under the pile. This conveyor is inclined to discharge to a pair of 5' x 16' Cedarapids horizontal screens with 2", 1½" and 3/4" wire cloth on their three decks utilizing the top and second decks for relief of the control deck. The three sizes retained on the decks of these screens are chuted to a pair of Cedarapids 5040 hammermills, each driven by a 400-hp General Electric motor. The crusher product, about 1½" to 0, is returned on 30" x 72' parallel conveyors C6 and C7a to the screens.

The minus-3/4" material through the bottom decks of these screens goes to 36" x 204' conveyor C8 which discharges to the 28,000-ton main product stockpile, which is also covered.

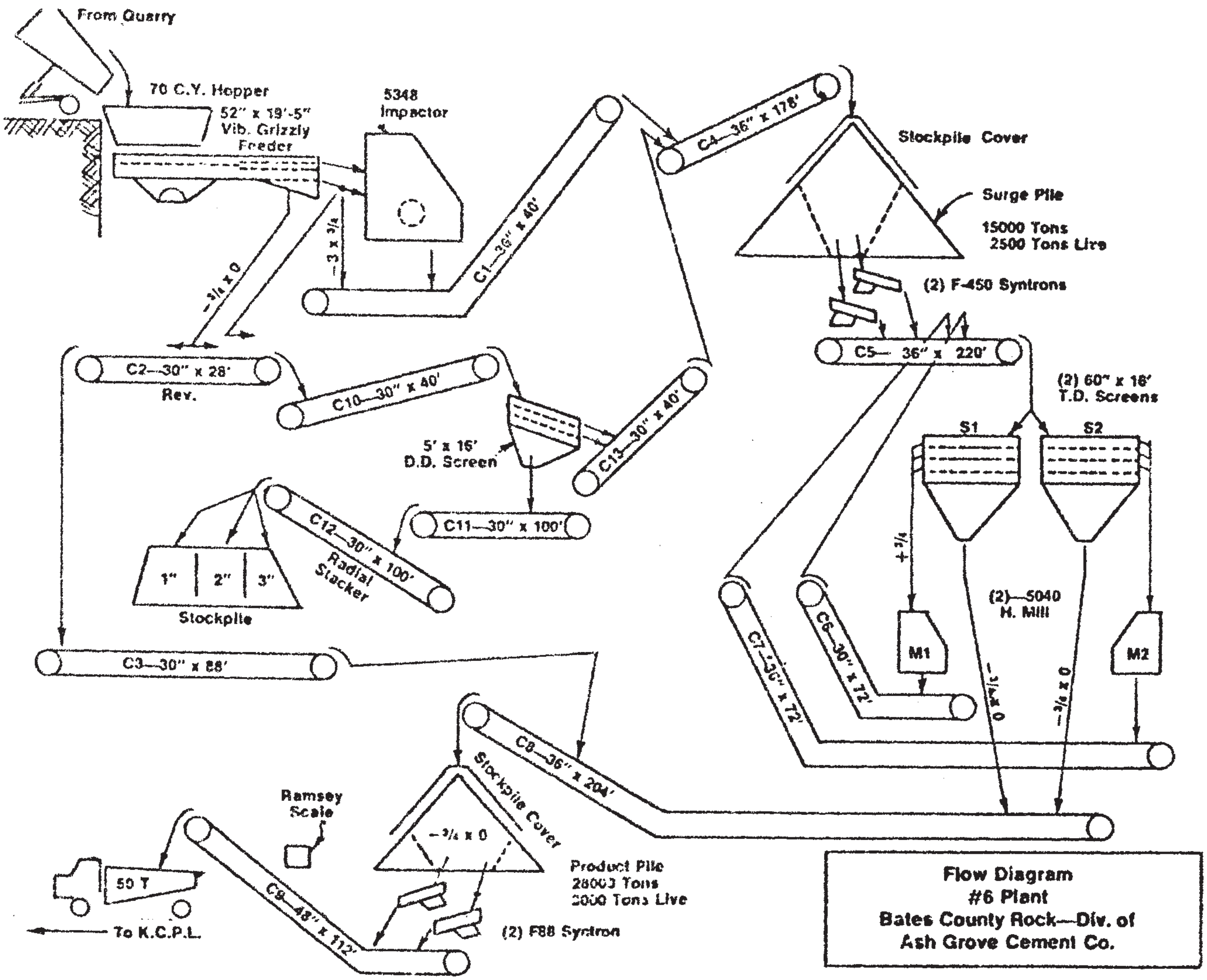
Material is reclaimed from the pile, which has a live storage capacity of 3,000 tons, by two Syntron F-88 Vibra-Flow feeders rated at 1,000 tph each. These feed to 48" x 112' belt conveyor C9 in the 10'-dia. Armco corrugated steel reclaiming tunnel. This has a concrete bunker for the feeders.

This conveyor is inclined to discharge direct to 50-ton trucks for delivery to the power company. Loading is automatically controlled by a Ramsey Engineering Model 10-14 scale on the conveyor, which records and prints out the weight of the truckload, and the date, hour and minute, at a console in the main control room at the primary crusher. A duplicate recorder has been furnished to the Kansas City Power & Light Company for installation in their field yard office. This system can load a 50-ton truck in 90 seconds.

For quality control there is a Bower Industries sampler at the main product stockpile. At the discharge end of 36" x 204' conveyor C8, a pan is passed at regular intervals through the stream of stone being discharged to the pile. The pan discharges the stone to a collecting hopper, from which it is discharged through a pipe to a sample splitter in a concrete house alongside the pile. At intervals, a 20-lb. sample is drawn, in the presence of a power company representative, and each company gets half of this for testing.

Connected with the crushing plant is a new maintenance shop with an office wing, eating room and rest room. Separated is a scale house for commercial

...ales and a 35-ton Thurman scale. A Cat. 950 loader is used for loading out of stockpiles, and a Case 1737 Skidsteer loader is used for plant utility.



Flow Diagram
#6 Plant
Bates County Rock—Div. of
Ash Grove Cement Co.

The minus-3/4" product can either be delivered to a receiving hopper at the La Cygne power plant or to stockpiles. The haul to the hopper is about one mile over a private haul road. Due to limited clearances at the power plant during the construction of the second unit, the 50-ton trucks could not be used during most of 1976 and delivery was temporarily done with commercial dump trucks. The Babcock-Wilcox system for processing the rock includes two wet ball mills. These pulverize the rock to 98% through 200 mesh, and slurry it for cleaning the emission of both particulate and sulfur pollutants.

This modern limestone processing plant is notable for its design and efficient operation, as well as its safety features and the high degree of pollution control. The entire operation is controlled by a single operator from the air-conditioned and pressurized control room alongside the primary crusher. From here the operator can see the entire operation from the trucks dumping to the crusher to the loading out from the main product stockpile. There is a main control console, individual controls for the breaker at the primary crusher and the vibrating feeders, and the electronic loadout scale.

Also contributing to the safety and dust control of this plant is the fact that all belt conveyors have sheet metal rain covers. There is also a company-designed spray bar dust inhibitor system to hold down dust in processing and handling. Water with added wetting agent is applied to the material through sprays at the crusher feed, transfer points, screen, etc. All the water lines for this system are insulated and heat-traced with electric cable units. The water comes from a 10,000-gallon tank buried in the ramp fill. A similar system is used on the company's portable plant.

Another feature that keeps the product dry for the customer and also prevents a dust loss is the conical metal covers over the two main stockpiles. These were designed by Mike Lutz, Assistant Division Manager, and were fabricated and assembled on the job. Each cover is 103 ft. in diameter, 40 ft. high, and slopes at the 37-degree angle of repose of the rock in the pile. Each cover is made of 24-gauge corrugated steel assembled in 16 pie-shaped sections and lifted into place. Each section is supported on a steel joist, which is supported by 6" pipe columns on the outside. The cover is supported at the center on a 42"-diameter pipe column. This has 3-ft. square openings cut in it to act as a stone ladder to distribute the material and to reduce attrition and keep dust down.

One of the safety features of this plant is the use of 4-ft. diameter emergency escape tunnels on the two reclaiming tunnels under the main stockpiles. The conveyors all have safety pull cords. A Safety interlock system automatically shuts down all operations from the point of trouble back to the grizzly. A horn also blows for 20 seconds prior to plant or individual conveyor startup.