28th ANNUAL TRI-STATE GEOLOGICAL GUIDEBOOK

ILLINOIS
IOWA
WISCONSIN
1933

Charles Collinson

Illinois State Geological Survey

Guidebook Series 6

WESTERN ILLINOIS

October 17 and 18

Quincy, Illinois

ACKNOWLEDGMENTS

One person cannot successfully prepare a field trip such as this and the author is deeply indebted to many persons. Foremost are H. B. WILLMAN and JAMES BAXTER who provided indispensable advice and criticism during preparation of the road log.

LOIS SCHOONOVER KENT and CYNTHIA ROSEMAN WRIGHT dealt with numerous, frequently difficult, details of preparation. Lois concentrated on housing and land access problems. Cynthia took charge of reservations and equipment preparation.

MARIE LITTERER, assisted by JAMES KEEL, prepared most of the illustrations.

GERRY JAMES, BILL NORTH, and RICH MICKLIN assumed responsibility for traffic control.

We are also grateful to GRAY QUARRIES, INC., and the GARDNER-DENVER COMPANY for kind permission to visit their properties.

DRIVER INSTRUCTIONS

A very large convoy is anticipated for the conference and close adherence to basic rules of road safety and courtesy are prerequisites for a smooth and safe trip.

At several stops the caravan must park along the highway. Although flagmen will be posted at front and rear of the column, great caution should be exercised when unloading autos. Wherever possible, unload on the shoulder side of the car.

Flagmen will direct parking at several stops. Please follow their directions promptly so all cars can be accommodated. Once your car has taken a position in the convoy at Stop 1 please maintain that position. On the open highway autos should maintain intervals large enough to allow non-conference autos to pass. All conference cars will be identified by windshield stickers. In urban areas, please close up the convoy so it may pass through as one unit. Flagmen will guard intersections which have lights or stop signs.

If you have mechanical or other difficulty, give a hand signal and pull to the side of the road. An Illinois Survey vehicle following the convoy will stop to assist you. If you have a full tank of gas at Stop 1 it should be sufficient for the entire trip.

GENERAL INFORMATION

Please unload as quickly as safety allows at each stop. A brief discussion will be given at the beginning of each stop and then the group will be given time to explore the site. A whistle will be blown to indicate the end of a stop and the signal to load autos. An Illinois Survey vehicle will wait five minutes after the convoy has departed in order to pick up stragglers.

LUNCH ARRANGEMENTS, SATURDAY -- Participants must either provide their own box lunches or plan to drive into Warsaw, Hamilton, or Keokuk. There should be ample time for those who wish to purchase lunches. There are no large cafes in Warsaw. Hamilton has a small cafe on Highway 96 near the river and at least one in the business district. Keokuk has good cafes two or three blocks east of the Mississippi Bridge. The two Chuck Wagon Cafes are fast and reasonable.

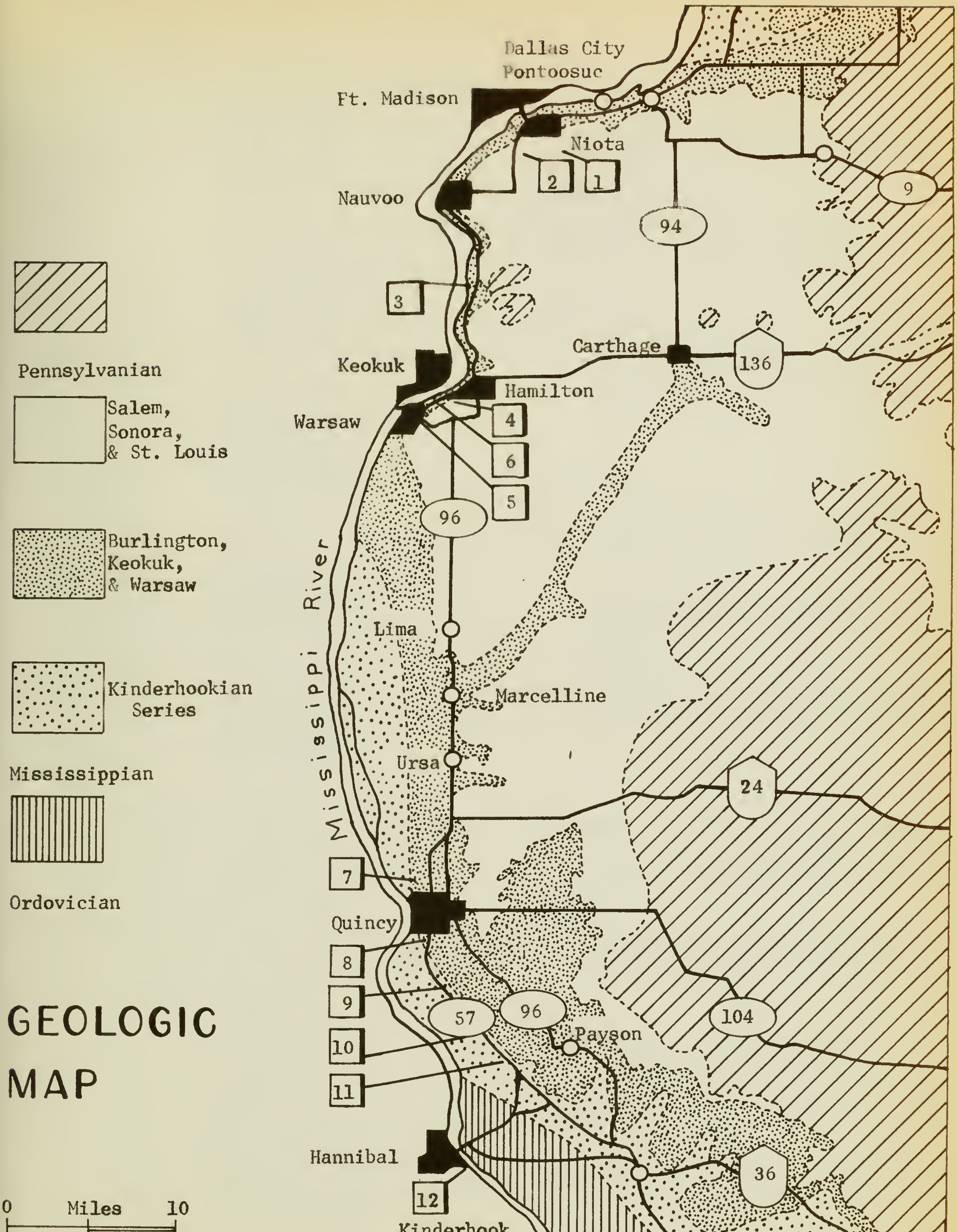
The lunch stop will be in Geode Glen Park in Warsaw where 10 or 11 picnic tables, running water, and toilets are available. Coffee will be provided. The first stop after lunch will be held in Geode Glen so the party will be parked there for about two hours.

DINNER ARRANGEMENTS, SATURDAY -- At Stop 1 each participant will receive a name tag which will identify him as a member of Tri-State and admit him to both the Flamingo and Black-Angus restaurants. If you have not yet made dinner or breakfast reservations, we will appreciate having them by Stop 4.

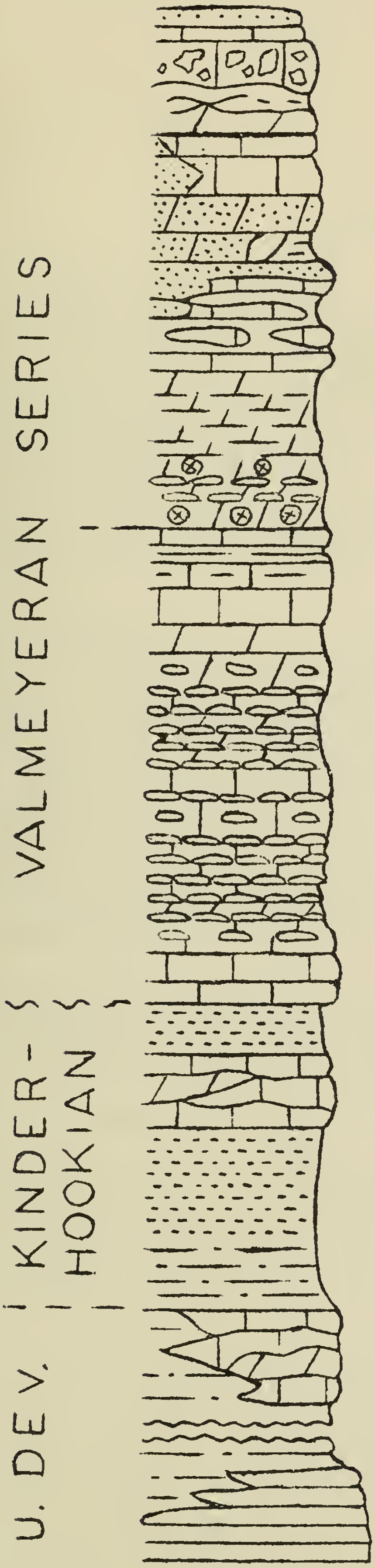
Dinner ($1.75) will be smorgasbord style at Durst's Flamingo in Quincy (see Quincy map at the end of Saturday's road log.) Upon arriving at the Flamingo, 408 N. 24th Street, enter the center vestibule facing 24th Street and enter the door on the right. A Tri-State sign will mark the entrance. Tickets will be sold for $1.75 just inside the door. From 7:15 P.M. until 8:30 P.M. members may go into the adjacent dining room and serve themselves. Bread, a drink, and desert will be brought to the table. No special seating will be observed and members should begin eating when served. A brief business meeting will begin around 8:15 P.M. Professor Jack Hayes of the State University of Iowa, who has spent considerable research effort on the mineralogy of the Warsaw geodes, has kindly consented to discuss their origin and mineralogy shortly after 8:30 P.M. We hope to have you snug in your beds soon after 10:00 P.M.

BREAKFAST ARRANGEMENTS, SUNDAY -- The Black Angus Restaurant, 809 Maine - a few blocks east of the Lincoln-Douglas Hotel, will open at 6:30 A.M. to serve a set breakfast for the price of $1.00. They will continue to serve until 8:00 A.M. Conference participants will be admitted by the conference badge. Upon entering the restaurant go immediately to a table and be served. Payment will be made at the cash register in normal fashion.

ASSEMBLY POINT FOR SUNDAY -- The assemble point is on the Gardner Expressway just south of the Gardner-Denver plant. The expressway is a southward extension of Third Street which runs north-south through the hotel area. EIGHT O'CLOCK is the meeting time.



GEOLOGIC MAP



0' - 1'	Ste. GENEVIEVE? FM. Sandstone, brown.
5' - 20'	ST. LOUIS FM. Limestone, gray, fine grained; Limestone breccia and gray shale.
0' - 30'	SALEM FM. Limestone, brown to buff, calcarenitic.
0' - 70'	SONORA FM. Dolomite, buff, sandy, or sandstone buff dolomitic.
55' - 70'	WARSAW FM. Shale, blue gray to buff, dolomitic with gray limestone, buff to gray sandy dolomite and sandstone lenses Geodes in lower part. Archimedes in upper part.
60' - 85'	KEOKUK FM. Limestone, gray to dark gray, crinoid calcarenite, with gray shale beds and gray chert. MONTROSE MBR. Very cherty buff dolomite and limestone.
5' - 75'	BURLINGTON FM. Limestone, light buff or gray, crinoid calcarenite with white and buff chert nodules.
0' - 20'	PROSPECT HILL FM. Siltstone, buff.
0' - 40'	McCRANEY FM. Limestone gray, interbedde with brown dolomite.
20' - 80'	HANNIBAL FM. Siltstone, buff to blue-gray and blue-gray silty shale.
0' - 40'	LOUISIANA FM. Limestone gray, irregularly interbedded with brown dolomite.
40' - 90'	SAVERTON FM. Shale, green-gray, silty in upper part.
20' - 200'	GRASSY CREEK FM. Shale, black, fissile.

GENERALIZED GEOLOGIC COLUMN
FOR FIELD TRIP AREA.

(less Pleistocene & Pennsylvanian)

TWENTY-EIGHTH ANNUAL TRI-STATE GEOLOGICAL FIELD CONFERENCE

SATURDAY MORNING, OCTOBER 17, 1964

INTRODUCTION TO ROAD LOG

The bluffs and tributary valleys of the Mississippi River in the Nauvoo-Keokuk-Warsaw area of western Illinois and southeastern Iowa is perhaps the best known in the classic Mississippian region. The geodes, the fossils and type sections of the Keokuk and Warsaw Formations have attracted geologists and paleontologists for generations beginning with David Dale Owen, James Hall, and Amos Worthen in the first half of the 19th century, continuing to C. R. Keyes, Francis Van Tuyl, Stuart Weller, and E. O. Ulrich early in this century and followed by Lowell Laudon, Raymond C. Moore, and Marvin Weller in recent years. Most of the present generation including such folks as Al Spreng, Brad McCurda, Jack Hayes, and Stan Harris are here today.

Paleontologically, the result of these efforts has been that dozens, perhaps hundreds of species, especially brachiopods and echinoderms, have their type localities in this area. Geologically, it has left us with a number of unresolved problems of correlation and interpretation. Foremost is the interpretation of the relationships of the Salem, Sonora, and Warsaw formations which has given rise to a long standing disagreement over the number of series to be recognized in the Mississippian and the location of the boundaries between them.

Another remaining problem is the origin of the St. Louis breccia which is still obscure and may be related to proper interpretation of the underlying Sonora and Warsaw clastics.

The nature and origin of the geodes which has fascinated geologists for years has recently been systematically explained by Jack Hayes of the State University of Iowa who will discuss the details at the evening meeting.

All of these problems are open for as much discussion as time will allow.

THE FIELD TRIP AREA -- Most of the field trip area is underlain by the Keokuk, Warsaw, Sonora, and St. Louis Formations but to the north and south the Burlington and the several formations of the Kinderhookian Series are brought to the surface by anticlines. The youngest bedrock is sandstone of the Pennsylvanian-Abbot Formation which occurs in small out-liers south of Nauvoo.

The total thickness of the Mississippian rocks in this area is only 300 feet due to the fact that it is situated on the crest of the broad Mississippi River Arch which separates the Forest City Basin (of the Iowa-Missouri-Oklahoma tri-state area) from the Illinois Basin to the southeast. Superimposed on the arch are a number of minor structures but most of our route lies in a broad shallow N.W.-S.E. trending syncline which lies between a westward extension of the Media Anticline on the north, which brings the Burlington Limestone to the surface about 10 miles northeast of Stop 1, and a westward extension of the Pittsfield Anticline

on the south, which brings the Burlington to the surface just north of Quincy at Stop 7. In between these major structures, our route also passes over the flank of the small but well known Warsaw Dome which is centered just northeast of Warsaw.

Thick Pleistocene deposits overlie the bedrock over most of the field trip area. The uplands consist of an Illinoian till plain mantled by loess which ranges up to 50 feet in thickness. The Illinoian till is relatively thin, however, so the bulk of the Pleistocene deposits other than loess consists of Kansan till, sand and gravel. Many Pleistocene buried bedrock valleys are known and present valleys commonly are located in sags in the glacial materials filling the buried lows. The Mississippi River flows on top of buried Pleistocene valley fill over much of its course but because it was temporarily diverted to a channel farther west in Illinoian time it flows over a shallow bedrock surface near Keokuk known as the "lower rapids."

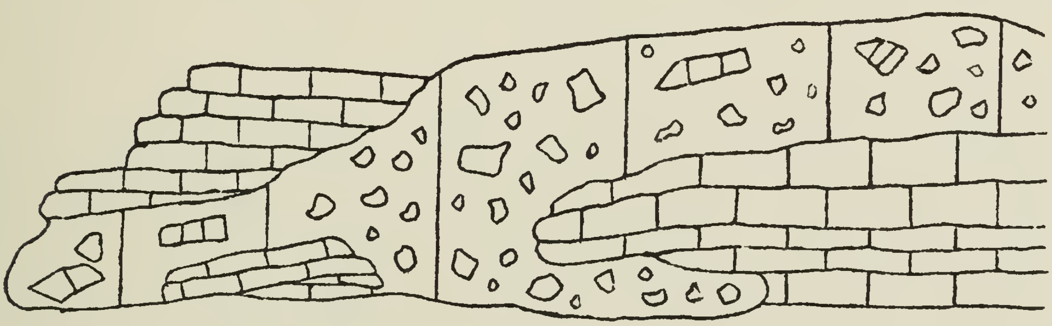


FIGURE A -- DETAIL OF ST. LOUIS BRECCIA, STOP 1.

STOP 1 -- JACKSON CEMETERY, stream cut along highway northeast of Jackson Cemetery, SE¼ NW¼ Section 14, T. 7 N., R. 8 W., Hancock County, Fort Madison Quadrangle.

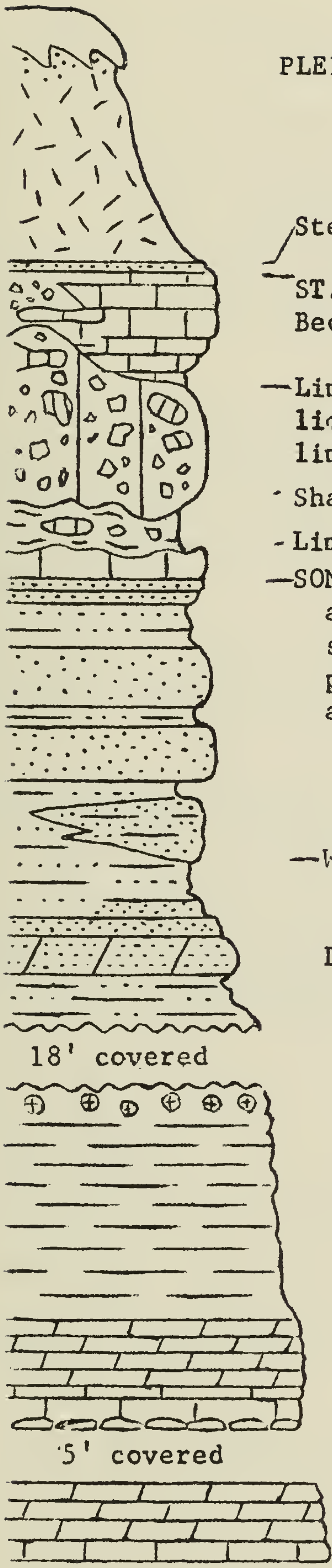
The section is best studied from the top down. The upper part of the bedrock section is at the west side of the road at the top of the hill where the upper part of the St. Louis Breccia as well as cavity fillings of Ste. Genevieve can be seen as a level surface on the shoulder of the highway. The various fabrics of the breccia are etched in relief on this surface and the sharp corners, wedge-shaped cracks filled with matrix and tiny flakes of angular gray limestone can be observed. These tiny flakes are abundant in the sandstone of the Ste. Genevieve. Some blocks in the breccia are fractured and the many pieces are recemented, virtually in place, to form natural mosaics. Nodules of pink chalcedony, with gray lithographic limestone attached, occur at random in the breccia as do gray lithographic, algal and finely calcarenitic blocks of limestone. The matrix is most commonly a fine grained light gray limestone.

Downhill, vertical sections through the breccia may be seen. Twenty yards north of the culvert and next to the highway, horizontal beds can be traced eastward where they have collapsed downward and are both over- and underlain by breccia. These beds apparently lead to a collapse sink into which later St. Louis limestone was deposited in horizontal beds (see Figure A.)

In the cliff section along the stream and beneath the main breccia bed, 2 to 3 feet of shale containing blocks of limestone lie on the uneven surface of a basal dolomitic limestone. Some authors, notable Van Tuyl (1925), attribute the brecciation to violent wave action and regional deformation. The present author doubts the effects of either of these agents and favors the suggestion that the breccia, which occurs over an area of more than 5000 square miles in Iowa, Illinois and Missouri, is the result of anhydrite deposition and subsequent alteration of the anhydrite to gypsum which was disolved either by fresh waters or the returning seas which deposited the upper part of the St. Louis. Extensive occurrence of gypsum and anhydrite in the middle and lower parts of the St. Louis Formation throughout the Illinois basin suggest such as origin as do the fresh angular surfaces of the breccia fragments and the common occurrence of clay associated with the breccia which might be interpreted as residue from dissolved evaporites.

The occurrence at many localities of a limestone bed in the lower St. Louis which exhibits the kind of distorted bedding which is commonly associated with gypsum tends to support this intepretation. On the other hand no gypsum has ever been found at any of the St. Louis outcrops.

Beneath the St. Louis more than 20 feet of argillaceous and dolomitic cross-bedded sandstone alternate with sandy shale. Because of the predominance of sandstone, the beds have been referred to the Sonora Sandstone, a name originally proposed by Keyes in 1895 but supressed by Van Tuyl in 1925 as a synonym for the Spergen Formation (Salem of Illinois). In recent years the need for a name for beds of this lithology which occur widely in the subsurface has caused the Illinois Survey to resurrect the name. The unit is essentially the same age as Salem and upper Warsaw beds with which it interfingers laterally and intergrades stratigraphically.



PLEISTOCENE -- Kansan till overlain by weathered zone, gravel and loess.

Ste. GENEVIEVE FM. -- Sandstone, buff, calcareous.

ST. LOUIS FM. -- Limestone, light buff, dolomitic. Beds brecciated in places.

—Limestone breccia, blocks of lt. gray lithographic limestone and finely calcarenitic gray limestone in lt. gray fine grained limestone matrix.

- Shale, greenish gray, calcareous with limestone blocks.

- Limestone, light buff, dolomitic.

—SONORA FM. -- Sandstone, light buff, dolomitic and argillaceous, fine grained with shale, greenish gray, sandy. Lower sandstones cross-bedded and coarser with pebbles up to 1 mm. Sandstone grades to shale laterally and vice-versa.

—WARSAW FM. -- Shale, bluish gray, silty.

Dolomite, brownish gray, finely silty.

Shale, dolomitic, weathered buff. Lag concentrate of small geodes.

- Dolomite, buff, argillaceous, silty.

- Limestone, light buff, fossiliferous with buff chert nodules.

- Dolomite, buff, slabby.

—KEOKUK FM. -- Limestone, gray fossil calcarenite.

Scale 1" = 10'

STOP 1 -- JACKSON CEMETERY

The Sonora is differentiated from the Salem by its quartz sand and pebbles and predominance of dolomite. Stop 3 will be at the type locality.

The interesting elements of the Sonora here are (1) the cross-bedding (which in general indicates currents flowing toward the south), (2) the lateral variation in the beds, (3) the fact that the shales in both the upper part of the Warsaw and the Sonora, although composed mainly of illite and chlorite, contain small amounts of kaolinite (Hayes, 1963) which increase upward in the section. Hayes interpreted the kaolinite as strong evidence for a retreating sea and many other factors such as increase in quartz clastics upward in the section are in harmony with this interpretation.

The contact between Sonora and St. Louis has been considered to represent a major unconformity by many geologists mainly because in central Iowa the younger formation overlaps onto Kinderhookian beds. Studies of conodonts from the Keokuk, Warsaw, Salem, Sonora, and St. Louis by Rexroad and Collinson, however, indicate that faunas are transitional up to the main breccia bed which apparently represents a major break in time.

The Warsaw at this section is partly covered but both upper and lower boundaries can be observed. The Warsaw-Keokuk boundary is exposed about 1/8 mile down hill in a large road cut.

Pleistocene sections can be seen at both upper and lower ends of the hill. Toward the lower end (north) a large road cut on the east side exposes more than 35 feet of Kansan till upon which a Sangamon weathering profile has been developed.

On the east side of the road at the top of the hill a more complete section is exposed. At the top is 2 to 3 feet of Peorian loess under which 12 to 15 inches of questionable Roxana silt are exposed: Below, a Sangamon weathering profile, associated with sandy Wisconsinan outwash, lies on Illinoian till.

Mileage	
0.0	Leave Stop 1.
0.5	Keokuk and Warsaw in large roadcut on right.
1.1	Stop sign. Junction with Routes 96 and 9. Turn left into Niota.
1.3	Junction of Highways 96 and 9. Continue straight ahead on 96. Highway 9 goes to right.
1.4	Stop sign. Flagmen will protect the convoy.
2.4	Warsaw outcrops in small stream on both sides of highway.
2.6	Bridge across Tyson Creek. Warsaw exposed on both sides of road. This is the Creek whose tributaries have yielded most of the petroliferous geodes collected in this area.

Mileage

2.8 STOP 2 -- TYSON SOUTH, along small tributary of Tyson Creek on both sides of highway 96, SW¼ SW¼, Section 15, T. 7 N., R. 8 W., Hancock County, Fort Madison Quadrangle.

Park on right hand shoulder. Petroliferous geodes are exposed in a small tributary of Tyson Creek where thirteen feet of lower Warsaw shale and dolomite are exposed. The petroliferous geodes are restricted to a zone of buff to gray argillaceous dolomite about 4 feet thick approximately 10 feet above the top of the Keokuk. The same horizon is exposed at a number of localities in this region but it yields geodes with petroleum in only a very restricted area.

The geodes containing the bitumen are in other respects normal indicating that the carbonaceous matter was entrapped after development of the geode. Many geodes are hermetically sealed and will squirt petroleum when punctured. The petroleum stains clothing so take care when breaking them.

The source of hydrocarbon is unknown but could have been derived from surrounding shales or from the Keokuk below. Nevertheless many of the oil-bearing geodes are surrounded by unstained matrix. Thickness of the shell or internal crystals apparently has no relation to oil occurrence. Geodes of almost solid quartz have been found to contain it.

Mileage

5.1 We are now traveling over the Galesburg Till Plain which is Illinoian in age but heavily mantled by Wisconsinan loess.

5.4 Nauvoo High School -- note the unusual design. The unusual windows depict wine goblets with triangular spaces between windows representing a wedge of cheese, a reminder of the annual Nauvoo "Wedding of the Wine and Cheese" festival.

6.0 Highway 96 turns sharply right.

7.0 Outcrop of Peorian Loess on right.

8.9 Historical marker "Historic Nauvoo. In 1839 the Mormans or Latter Day Saints settled Nauvoo and made it their chief city. During their residence its population reached 15,000. After long friction with non-Mormans the Mormans were expelled in 1846. Three years later, French communists called 'Icarians' established a society here which lasted until 1857."

9.6 S curve left.

10.0 Curve right.

10.1 Nauvoo city limits.

10.2 Hotel Nauvoo on left. This hotel has been beautifully restored and enlarged. There is a handsome antique shop behind the hotel.

Mileage

11.0 Nauvoo Information Center on right. St. Mary's Academy enrolls 200 to 300 girls.

Nauvoo was formerly the capital of the Mormans and is one of Illinois' most interesting historical spots. It was acquired by the Mormans in 1839 after they had been driven out of Missouri with much loss of property and lives. They named their city "beautiful place" (Hebrew) and it grew rapidly. At one time it had twice the population of Chicago or Alton. Anti-Morman feeling likewise grew rapidly largely because of great political activity which brought them many special priviledges. By backing first the Whigs and then the Democrats they controlled elections but became hated by both parties.

By 1843 anti-Morman meetings were being held in surrounding communities and in that year Joseph and Hyrum Smith were arrested and later murdered by a mob that stormed the County jail in Carthage 15 miles away. There followed a series of organized disturbances in which settlers were killed or driven from their farms. In that crisis Brigham Young assumed the Morman leadership and when conditions worsened led his followers on their march to Utah.

In 1849, the Icarians, a band of French communists, came from Texas and unsuccessfully attempted to establish a permanent colony. Although the colony soon failed the Icarians began a wine industry which flourishes to the present day.

The great Nauvoo Temple stood on what is now Academy grounds. The temple was built in 1841, stood 160 feet high, and was reported to be the largest building west of the Allegheny Mountains. Ten thousand persons attended the cornerstone laying. On October 7 and 8, 1848 the temple was burned by Joseph Agnew. The ruins were later totally leveled by a tornado in 1850. The enormous pile of rock was distributed throughout the state. Some went into the Galena post office, some to a church in Moline.

Mileage

11.1 Route 96 curves left follow road.

11.2 Turn right off of highway entering Morman part of town. Vineyards on left.

11.4 Turn left.

11.6 Church of Latter Day Saints on right.

11.7 Home of Johnathan Browning on left. Morman newspaper "Times and Seasons" on right along with home of John Taylor.

12.0 Joseph Smith's Mansion House on left. On right ahead is his homestead where he, his wife, and brother Hyrum are buried. The Tour Center and the unfinished hotel are ahead on the left.

12.05 Turn left toward highway.

12.3 Turn right on Highway 96.

12.8 Upper Keokuk outcrops extend along the river for the next few miles. For many years these roadside outcrops were good fossil collecting sites but now are much picked over and the best sites are up the stream valleys. The Iowa Village of Montrose, type locality for the Montrose Chert, lies directly across the Mississippi. The Mississippi at this point is exceptionally wide due to ponding behind Lock and Dam No. 19 at Keokuk. Before the dam was built there was a 45 foot fall in the river between Montrose and Keokuk known as the "lower rapids" or "Des Moines rapids" named for the mouth of the Des Moines River just below Keokuk. The rapids flowed entirely on the Montrose Chert which underlies the foundation of the Keokuk dam. The river channel here is very shallow because it was abandoned during Illinoian time when the ice sheet displaced it westward into Iowa.

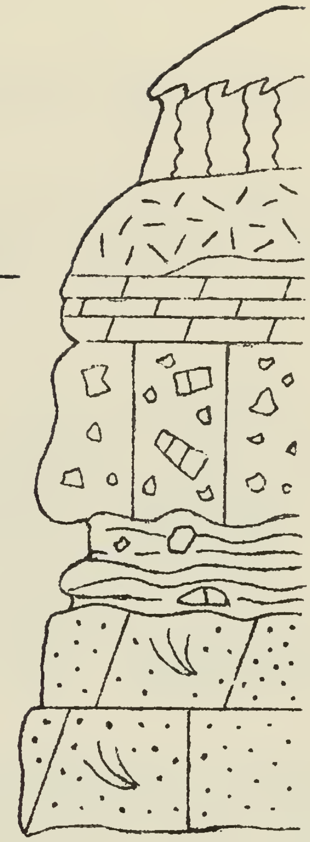
13.2 Curve left around mouth of Riley Creek and right again. Not far ahead on left is a small park where well preserved brachiopods can still be collected. The park development is partly due to the fact that we are traveling on the Great River Road, a parkway planned to extend from the source of the Mississippi to its mouth at New Orleans.

17.8 STOP 3 -- MT. MARIAH, two old quarrys on east side of Highway 96, SE¼ NW¼ Section 31, T. 6 N., R. 8 W., Hancock County, Keokuk Quadrangle.

Park in small parking area on right side of road. Outcrops are on the opposite side of road so please LOOK BOTH WAYS BEFORE CROSSING.

This is the type section of the Sonora Sandstone which was extensively quarried for building stone early in this century and supplied stone for many buildings at Keokuk, Iowa. The name was applied to these beds by Keyes (1893) who took the name from the now extinct village of Sonora about a mile to the north. The stone is about 20 feet thick here although only about half is now exposed. The name Sonora Sandstone is very nearly a misnomer here because much of it is actually a porous sandy cross-bedded dolomite. However, as was seen at Stop 1, the lithology is quite variable and in these quarries grades from sandy dolomite to porous dolomitic sandstone. At Rand Park in Keokuk the formation consists of 8 feet of gray cross-bedded sandstone. Here mudflakes and shale partings are found commonly associated with cross-beds. Much of the rock was a sandy bryozoan calcarenite before dolomitization. Van Tuyl (1925) considered it a facies of the Salem but as J. M. Weller noted in 1941, it possesses neither the lithology nor the fauna of the Salem and more properly should be considered a distinct formation. At the old Fort Madison penitentiary, 13½ miles northeast of Stop 1, the formation is more than 60 feet thick and stands in a massive cliff. At the other extreme it is only two to three feet thick in the Warsaw area. The unit can be traced laterally into the shaly *Archimedes* beds of the Warsaw and when followed southward into Adams County can be traced into the cross-bedded calcarenite of the Salem.

Above the Sonora the St. Louis breccia is developed much as at Stop 1 although some of the exposure is obscured by loess washed from above. At the north end of the line of outcrops, a brown Pennsylvanian sandstone is sometimes exposed and the author has collected excellent examples of *Lepidodendron* from it.



PLEISTOCENE - Loess and till

ST. LOUIS FM. - Breccia composed of light gray limestone and buff dolomite cobbles, slabs and blocks; up to 10"x20" in diameter. Matrix of upper part gray to buff dolomite and limestone. Matrix of lower part is distorted gray shale.

SONORA FM. - Dolomite, buff, very sandy, cross-bedded. Sand fine with few grains up to ¼ mm. Lower few feet represent dolomitized sandy calcarenite.

STOP 3 - MT. MARIAH.

Mileage	
18.4	Cross Larry Creek. An inaccessible but well exposed section to left on north side of Creek. The uppermost part of the Keokuk and the lower half of the Warsaw are exposed.
19.5	Bridge over Wagoner Creek.
20.5	Powerhouse of Lock & Dam No. 19 can be seen at 1 o'clock along with the Keokuk boat shops.
21.2	Bridge across creek.
21.6	Lake View Club. Sweeping S-curve near north edge of Hamilton, Illinois.
22.2	Bridge over Chaney Creek whose lower reaches were flooded by dammed water.
22.3	Hamilton, Illinois.
22.7	Y Intersection with U. S. Highway 136. Keep to right NO STOP.
23.1	Dadant beekeeper's supply house on right. Cafe on left.
23.2	Leave Highway 136. Go straight ahead on bluff road to Gray's Quarry. Highway 136 curves to right toward Keokuk.
23.5	Cross railroad tracks and take crushed stone road climbing hill in gradual curve to left.
23.8	Turn sharp right into gate onto stripped upper surface of Gray's Quarry. Convoy will circle in order to be able to leave by same gate.

STOP 4 - GRAYS QUARRY, SW¼ NE¼ Sec. 31, T. 5 N., R. 8 W., Hancock County, Keokuk Quadrangle. All geode collectors out!!

The upper part of the quarry is not directly connected to the lower part so this stop is mainly for collecting and observation of geode occurrence. This is probably the continuously most prolific collecting locality in Illinois and is visited almost daily by collectors during Fall and Summer.

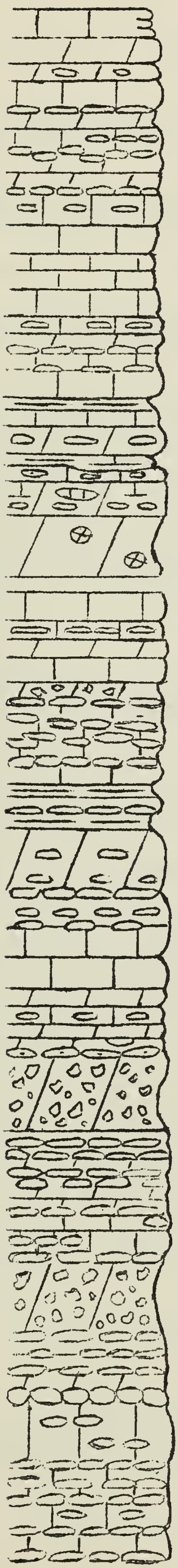
The main quarry exposes all but the lowermost few feet of the Keokuk and now serves as the best reference section for the formation in the type area. Its freshness however makes it a rather poor spot for fossil collecting. Fish teeth and representatives of "Orthotetes" keokuk, "Spirifer" keokuk and Brachythyris suborbicularis are fairly common in the upper part of the quarry. The giant Marginirugus magnus, which is restricted to uppermost Keokuk, is occasionally found. A number have been collected in a railway spur not far south of the quarry. Conodonts are common in almost every limestone bed in the Keokuk and are abundant in beds halfway between the main floor and the top of the quarry. Gnathodus texanus predominates.

The lower level of the quarry is in the Montrose Chert member of the Keokuk which will be observed at Stop 6. It is characterized by brecciated and mottled dolomitic chert in great abundance and will be closely examined at Stop 6. Above the Montrose the Keokuk is a gray to dark gray crinoid and bryozoan calcarenite with interspaced buff dolomite beds. Gray chert occurs throughout the section. The formation becomes increasingly shaly upward and grades into the argillaceous dolomite of the overlying Warsaw. The uppermost significant calcarenite bed is usually picked as the top of the Keokuk. The boundary is about 12 feet below the upper lip of the quarry.

Almost the entire thickness of Warsaw geode beds is preserved here but only the lower geode horizon is well exposed. The upper geode horizon is expressed by a lag concentration of small geodes just below the Pleistocene deposits. An excellent cut through the geode beds can be seen on the quarry road leading along the edge of the quarry toward the west.

Hayes (1961) has established that (1) geodes are virtually confined to the lower Warsaw (2) are specifically associated with argillaceous dolomites and dolomitic mudstones (3) occur in zones or beds (4) were initially round in shape and (5) are conformable with laminations in the containing rock. He also indicates that there is the tendency toward size uniformity within a zone and that pyrite distribution is related to geode distribution. The rest of the story will be presented this evening. Geodes usually consist of a chalcedonic shell and an inner layer of crystals which (if all reports are correct) range from quartz and calcite to pyrite, ankerite, magnetite, hematite, kaolin, aragonite, millerite, chalcopyrite, sphalerite, limonite, smithsonite, malachite, gypsum, fluorite, barite, marcasite, goethite and pyrolusite. Such a variety is not available here but excellent calcite and quartz geodes are common.

On top of the Warsaw a short Pleistocene section is especially well exposed at the north edge of the property.



UPPER KEOKUK --

WARSAW --

Dolomite, buff to brown, argillaceous; and dolomitic shale containing abundant geodes.

Limestone, gray, crinoidal with gray chert nodules. Some light gray to buff dolomite beds with few scattered geodes. Dark gray shale beds become increasingly numerous in upper part of section.

Scale 1″=10′

MONTROSE MEMBER -- Dolomite, buff to light gray, fine-grained; contains mottled white, buff, and blue gray chert nodules and brecciated chert masses in abundance. The dolomite is interbedded with light buff to gray crinoidal limestone which contains numerous buff, white and gray chert nodules.

STOP 4 -- GRAYS QUARRY

23.8 Turn left upon leaving gate at Gray's Quarry.

23.9 Turn left on steep road down to Gray's Quarry then half right toward new Warsaw-Hamilton highway.

NOTE: THOSE WHO WISH TO PURCHASE LUNCH SHOULD PULL OUT OF CONVOY AND REJOIN IT AT GEODE GLEN IN WARSAW. PARTY WILL BE THERE FOR MORE THAN 1½ HOURS.

24.1 Turn left on new highway.

25.5 Road cut in upper part of Keokuk on left. A well preserved pyritized ostracode fauna has been collected from shale zones in this section.

25.7 Concrete bridge at mouth of Crystal Glen. Although on private property, this glen has been the source of many fine geode specimens containing a variety of minerals. We are crossing the northern flank of the Warsaw Dome which is about 5 miles in diameter. The crest is centered a half mile to the southeast. It is elongate N.E.-S.W., covers about 50 square miles in area and has a closure of about 30 feet. Shows of oil were found in the Devonian Hoing Sand at a depth of about 600 feet but no commercial production resulted. Perhaps this represents a source for the oil-filled geodes at Stop 2.

26.2 Passing mouth of Cedar Glen where nearly entire Keokuk is exposed. From here for half a mile ahead the Keokuk and Warsaw is well exposed.

27.8 Warsaw shale on left.

28.1 St. Louis breccia on left.

28.5 Warsaw Brewing Company on right.

28.9 Enter Warsaw. Point of bluff on right was site of Fort Edwards, built in 1814 by Zachary Taylor. Warsaw was a busy shipping point during the early part of the 19th Century but declined after the advent of the railroad. Until this highway was recently built, Warsaw was not on any through road.

30.1 Stop sign at Main Street. Turn left.

30.3 Turn left at Warsaw Grade School. Cars will be circled in the parking lot of the school and on both sides of the road. This will be both STOP 5 and LUNCH STOP.

STOP 5 - TYPE WARSAW, GEODE GLEN, NW¼ Sec. 10, T. 4 N., R. 8 W., Hancock County, Keokuk Quadrangle.

After lunch, assemble in the lower park area along the creek west of the stone bridge.

This is the lower end of the type section of the Warsaw. In former years Soap Creek at the south edge of town was considered an important part of the type sections but exposures here have continued to improve and those south of town to worsen.

ST. LOUIS FM. -- Limestone breccia; limestone, light gray, dense, crenulated bedding.

SONORA FM. -- Dolomite, light buff, very sandy.
WARSAW FM. --
Shale, greenish gray.
Limestone, buffish gray, calcarenitic; some sandy beds.
Shale, greenish gray, sandy in places.
Sandstone, buffish gray, calcareous, pyritic.
Shale, gray to bluish gray.
Sandstone, buffish gray, calcareous.

Limestone, gray, calcarenitic; numerous fenestellids.

Sandstone, buffish gray, calcareous, pyritic.
Shale, gray to bluish gray.
Limestone, gray to bluish gray, calcarenitic.
Shale, bluish gray.

Sandstone, pyritic, bluish gray.
Limestone, lt. gray, crinoidal calcarenite; cross-bedded, pyritic.

Shale, bluish gray; numerous fenestellids.

Limestone, gray, dolomitic, cross-bedded.

Shale, buff, dolomitic.

Dolomite, buff, forms ledge.

Dolomite, buff, soft, argillaceous. Numerous geodes.

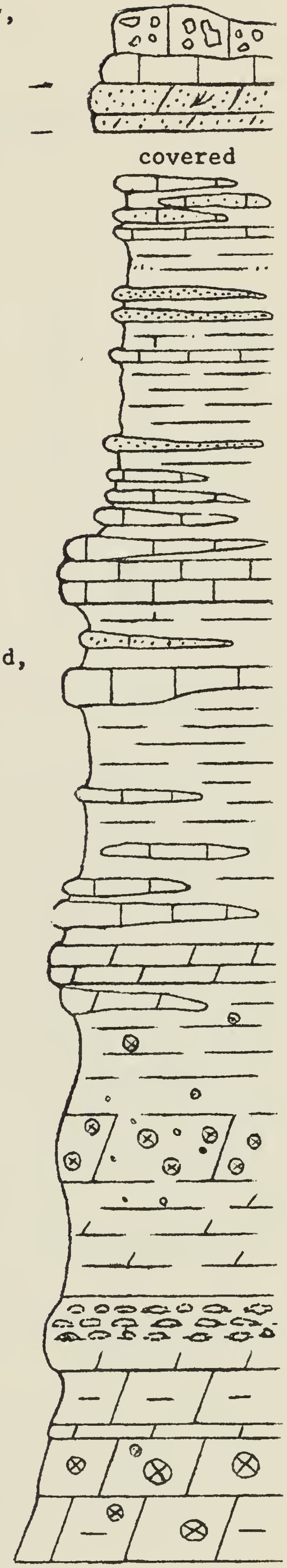
Shale, buff, dolomitic.

Dolomite, brown to gray; brown chert.

Dolomite, buff, weak, argillaceous.

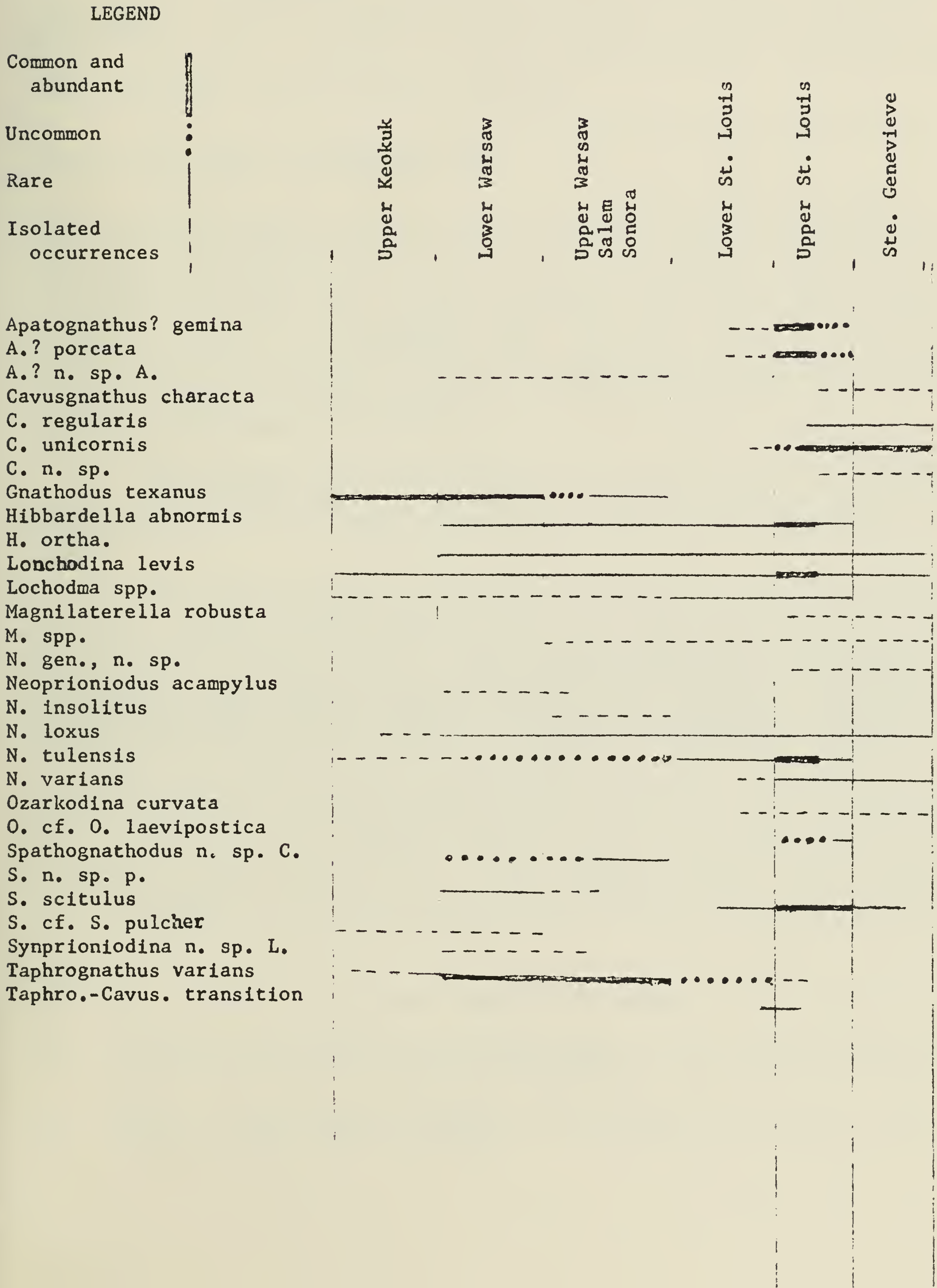
Dolomite, buff, weak, argillaceous. Numerous large geodes up to 12" diameter.

Scale 1" = 10'



STOP 5 -- TYPE WARSAW

VALMEYERAN CONODONT RANGES IN WESTERN ILLINOIS
(Tabulated by C. B. Rexroad and C. Collinson)



We will examine the geode beds at the lower end first and then work eastward along the creek to the Archimedes beds a third of a mile to the east. We will then return by the same route.

The name Warsaw was first applied by Hall (1857) to the shale and limestone beds overlying the geode beds which then were referred to the Keokuk. Later (1858) he included everything between St. Louis and the geode beds but in 1908 Stuart Weller recognized the sandy dolomite or dolomitic sandstone at the top of the section as Salem and removed it from the Warsaw. Later Van Tuyl (1925) included the geode beds with the Warsaw.

The section divides naturally into the lower Warsaw or geode beds and the upper Warsaw or Archimedes beds.

Sedimentationally the upper unit is relatively sandy and pyritic. Hayes (1963) has shown that kaolin appears along with the normal chlorite-illite clays in the upper Warsaw and increases in percentage upward. Several thin calcareous or dolomitic sandstone beds are found in the upper Warsaw and it is our interpretation that these represent stringers of the Sonora which is actually a lateral equivalent of the Archimedes beds. The two or three feet of fine dolomitic sandstone or sandy dolomite, which immediately underlies the St. Louis and was referred to the Salem by Weller, is referred to the Sonora by us. Above the Sonora a normal St. Louis section occurs and the basal bed exhibits the crenulate bedding mentioned previously.

The Archimedes beds are exceedingly well exposed and a few specimens can still be collected. That any remain is a testament to their original abundance inasmuch as this has been a favorite collecting spot for more than a century.

Many new fossil species not known in the Keokuk appear in the Warsaw and, when differences in lithology are taken into account, such changes are not unexpected. Bryozoa dominate the Warsaw with Leioclema, Rhombopora, Fenestella, and Archimedes as the main genera. Echinoconchus alternatus, E. biseriatus, Camarotoechia mutata, Spirifer tenuicostatus, Spirifer pellaensis, Brachythyris subcardiformis, Reticularia setigera, and Eumetria verneuliana are the most common brachiopods. The corals Triplophyllum dalei and Monilipora beecheri are also common. The fauna of the Sonora is smaller but similar with fewer recognized bryozoan species and the same brachiopod fauna. C. B. Rexroad and the author have made a detailed study of Warsaw, Salem, and Sonora conodonts in western Illinois and have concluded that the faunas from the upper Warsaw, the Sonora and the Salem are identical. At this section, conodonts are found in almost every bed but average only 1 or 2 per kilogram of rock. The beds which form a low waterfall a short distance upstream from Geode Glen Park contained the best conodont faunas in the section.

Mileage

30.3 Leave Geode Park by turning right on Main Street.

30.5 Turn right onto Hamilton-Warsaw road which is also Great River Road and repeat route back to vicinity of Cedar Glen.

32.8 STOP 6 -- CEDAR GLEN and ROADCUT, S½ NE¼ Section 2, T. 4 N., R. 9 W., Hancock County, Keokuk Quadrangle.

We will begin the stop by examining the Montrose Chert in Cedar Glen and then working southward up the road cut to the Warsaw-Keokuk boundary. This is the best and most accessible exposure of the Keokuk in the type area. Use the diagram of Gray's Quarry for reference.

The Montrose is characterized by abundant mottled and brecciated chert in buff dolomite interbedded with light buff crinoidal limestone.

A secondary origin for the chert seems to be indicated by inclusions of host rock, silicified fossils and remnants of bedding which pass through nodules. On the other hand, however, the brecciation might be explained by dessication and cracking due to hydration of silica gel on the sea floor. The Montrose is a relatively well defined member and can be traced in surface outcrops nearly to Quincy.

Between road cut and the cliff exposed at the mouth of Cedar Glen less than 10 feet of section is covered.

The upper part of the Keokuk is exposed in the road cut and displays the characteristic gray to dark gray coarse calcarenite lithology. Note that the unit has broad zones which more cherty than others and several dolomitic zones which look as if they could be correlated from section to section. We have made detailed descriptions of Soap Hollow in Keokuk, Grays Quarry, Cedar Glen as well as this road cut and find that the zones carry through only in a very broad way.

Note that most of the chert is gray and that there are several fish tooth beds. One is a 3 inch dark gray calcarenite about 8 feet above the lowest beds of the road cut. It also contains abundant brachiopod and crinoid remains. The best crinoids are found in the dark shale partings between beds. "Orthotetes keokuk" is the most easily recognized common brachiopod in the section. Also common are Productus setigerus, Echinoconochus alternatus, Rhipidomella dubia, Spirifer cf. s. keokuk and Reticularia pseudolineata. Agaricocrinus americanus is the most common crinoid and Triplophyllum dalei the most common coral.

Notice how the upper part of the section differs from that of the Gray's Quarry section where there is more chert and abundant geodes. A few Archimedes can be found at the top of this section.

From Stop 6 we will continue ahead north toward Gray's Quarry.

35.1 Turn right on gravel road leading due east toward the quarry.

35.2 Half turn left and up hill.

35.3 Turn right at top of hill on gravel road and continue eastward past Stop 4.

36.2 Road goes half left.

36.4 Intersection with Highway 96. Turn right.

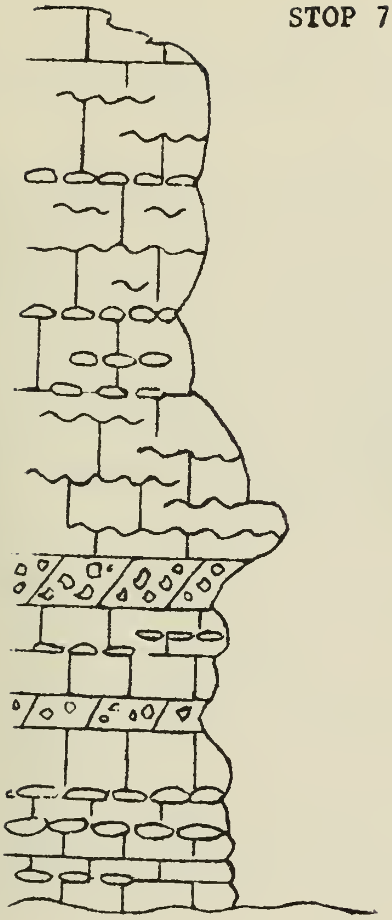
38.9 Turn left at Y and continue to follow Route 96. Prepare for long ride to Quincy.

49.4 Road to Tioga on left.

50.4 Leave Hancock County. Enter Adams County.

51.6 Village of Lima. We are now on the Mendon Quadrangle.

STOP 7 -- SPRING LAKE FALLS



BURLINGTON FM. --

Limestone, white, coarsely crinoidal.
Glauconitic with numerous brachiopods.

Scale 1" = 10'

Limestone, white, coarsely crinoidal; numerous styliolites.

Chert, white, and buff with dolomite.
Limestone, white, coarsely crinoidal, and white chert.

Dolomite, buff, and brecciated chert.
Limestone, white, coarsely crinoidal, and chert, white, dolomitic mottling.

Limestone, lt. brown, fine, dolomitic.

53.4 Bears Creek Valley ahead. Upper Keokuk limestone forms the bluffs of the valley.

54.1 Bridge over Bear Creek.

55.1 Enter village of Marcelline.

58.9 Enter village of Ursa. The Montrose Member of the Keokuk is exposed in Mississippi River bluffs one mile to west.

59.3 Intersection with Highway 61 approaching from left rear (northeast). Burlington railroad crossing. No stop sign.

59.7 Keokuk limestone in Ursa Creek.

60.5 Two miles to the east an excellent Salem section of cross-bedded calcarenite is exposed in an abandoned quarry.

60.9 Keokuk and Warsaw in Creek.

63.4 Begin divided highway at junction with Highway 24, which joins from left. Curve right.

64.3 Highway 96 goes half left. Continue straight ahead on Highway 24.

65.5 Turn half right on concrete road to west.

65.7 Concrete road turns left. Continue straight ahead on black top road.

66.4 STOP 7 -- SPRING LAKE, SW¼ SE¼ Section 11, T. 1 S., R. 9 W., Adams County, Quincy Quadrangle.

Park along black top road. The section is on the left at end of short trail leading through the trees.

This exposure probably represents the upper member of the Burlington Limestone, recently named the Cedar Fork Member by Harris (1964). It is a relatively pure light gray calcarenite with relatively little chert in it. The beds in the upper half of the section are glauconitic. The section is probably referable to Laudon's Dizygocrinus and Pentremites zones. Spirifer grimesi is abundant on the bedding surfaces. Rhipidomella burlingtonensis, Spiriferella plena, Lepetopsis capulus, Pentremites and Dizygocrinus rotundus are the common fossils in this member. Conodonts are common in the beds above the falls. In the glauconitic beds the conodonts are considerably abraded and are referable to the Bactrognathus - Taphrognathus zone of Collinson, Scott, and Rexroad (1962).

Mileage

66.5 Turn sharply left at bottom of hill.

66.7 Rusty iron bridge.

67.5 Quarry on left, largely obscured by small trees, is in upper Burlington limestone.

68.0 S curve sign. Curve to right.

69.1 Cross railroad tracks and continue south.

69.2 Abandoned limestone mine in lower Burlington on left.

69.6 Sid Simpson State Park on right. Camping grounds are available here although no water has been piped to the camp as yet. Water may be found at fountain in the city park uphill to left.
Cross railroad tracks.

70.3 Cedar Street Underpass on left. Monogram Industries on right. Illinois Soldier and Sailors Home can be reached by going east on Cedar Street approximately 11 blocks to 12th Street (Highway 24) and then left (north) 5 blocks.

70.8 Quincy Park District Harbor on right.

71.1 Cross tracks and continue uphill on Broadway two blocks to Third Street. Then turn right and continue south on Third Street for two blocks. This is the heart of the hotel district. Holiday Inn is ahead on right. Hotel Lincoln-Douglas is one block to left.

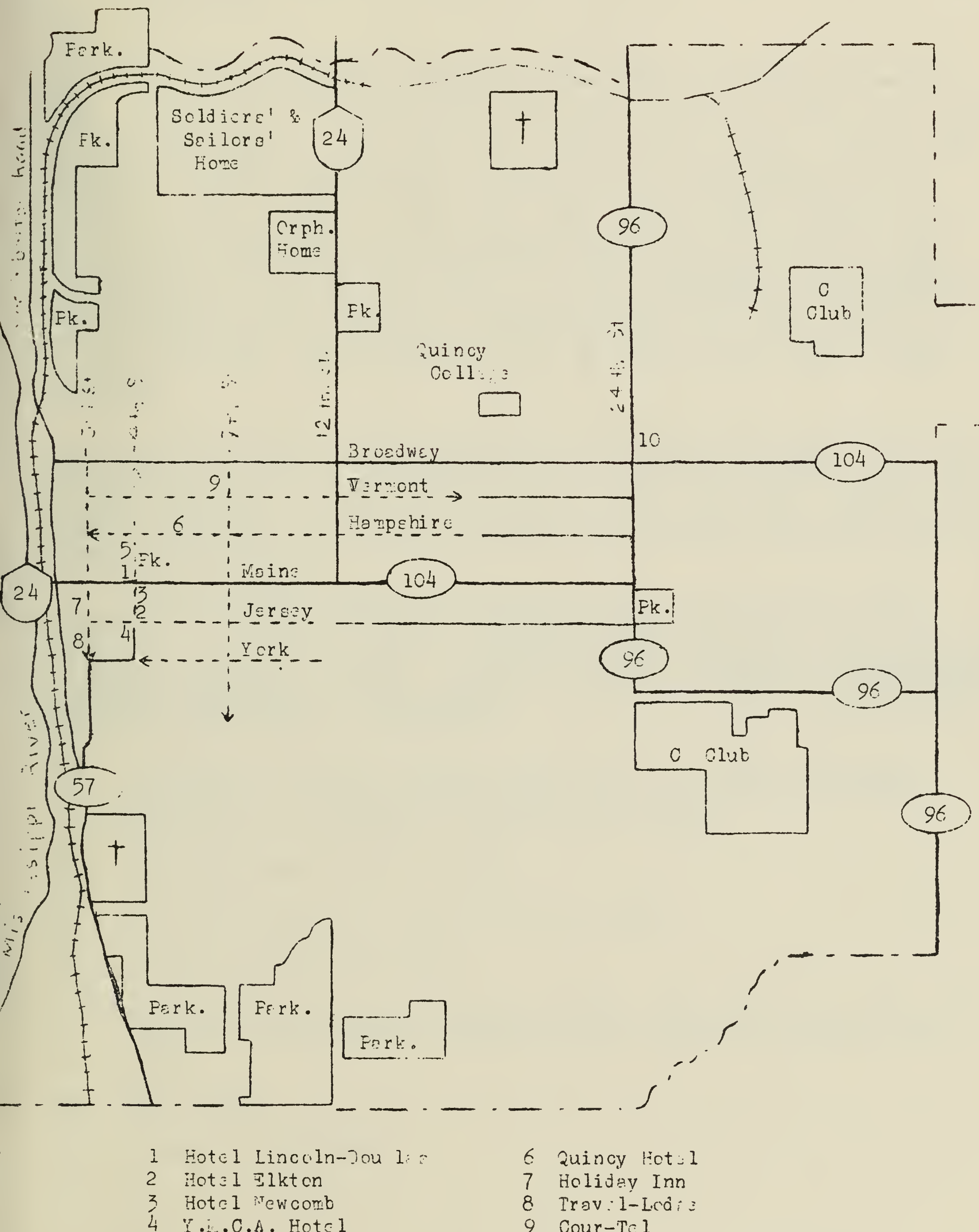
Quincy (44,935 pop.) is an All American city and is the main manufacturing center of westernmost Illinois. It is the only river town between Alton and Rock Island that has continued to prosper through the years. The city was named for John Quincy Adams and was founded only as recently as 1825. The city has more than 800 acres of well kept parks as well as fine boat and docking facilities. The Erroke Indiana Museum in South Park, 5th and Van Buren, is a special attraction for geologists.

SEE YOU AT DINNER AT FLAMINGO
(408 N. 24th St. - just north of Broadway)
BETWEEN 7:15 P.M. and 8:15 P.M.

STREET MAP OF QUINCY

SHOWING LOCATION OF HOTELS AND MOTELS

——— main streets - - - - - - - → one way streets



1 Hotel Lincoln-Douglas
2 Hotel Elkton
3 Hotel Newcomb
4 Y.M.C.A. Hotel
5 Park Hotel
6 Quincy Hotel
7 Holiday Inn
8 Travel-Lodge
9 Cour-Tel
10 Durst's Flamingo Dining Room

Mileage

00.0 STOP 8 -- ASSEMBLY POINT FOR SUNDAY MORNING, 8:00 A.M.; GARDNER-DENVER QUARRY on Gardner Expressway just south of the Gardner-Denver Plant. Park cars on side road leading to Lock and Dam No. 21 just south of plant parking lot.

The coarse crinoidal Burlington limestone is the most prominent formation in the bluffs from Quincy southward to near Alton, a distance of some 80 miles. It caps the bluff at most places and forms the divide between the Illinois and Mississippi Rivers. Its prominience is partly attributable to the fact that the middle Burlington is very cherty and, as weathering proceeds, residual chert accumulates forming a resistant cap. In this area all three members of the Burlington occur: an upper, rather thin, chert-free glauconitic member (the Cedar Fork of Harris, 1964); a thick very cherty middle member (Haight Creek of Harris); and a chert-free, pure lower member (Dolbee Creek of Harris). These members probably correspond respectively to Laudon's Pentremites, Physetocrinus, and Cactocrinus zones. The lower member, for years referred to as the "Quincy beds," is the basis for a high-purity limestone industry here just a quarter of a mile to the south. The Burlington is 70 to 80 feet thick here and continues to thicken southward. In Calhoun County some 60 miles to the south it is 200 feet thick.

About 15 feet of "Quincy beds" are exposed here and contain much more chert than is characteristic--the reason why the quarry is abandoned. As we pass the limestone mines to the south you will see the same beds virtually chert free. Actually, the industry utilizes about 25 feet of lower Burlington. The lowermost 9 feet are dolomitic and are used for agricultural limestone. The beds above are burned for chemical lime.

This has been a favorite collecting place for years so it is well worked over. Nevertheless examples of Spirifer grimesi are still relatively abundant and occasional specimens of Leptaena analoga, Rhipidomella burlingtonensis and Athyris lamellosa are found. Crinoids can still be collected with Batocrinus, Dorycrinus, Cactocrinus, and Platycrinus, the most common forms. Cryptoblastus melo was once very common in the quarry.

00.4 From here on south for nearly a mile there is an almost continuous succession of quarries and limestone mines in the bluff to the left. Kilns of three companies are located on the right.

1.0 Black and White Limestone Company.

1.2 Lower Burlington well exposed on left in mine.

2.3 Menke Stone and Lime Company.

8.5 Plant of Marblehead Lime Company on right. This plant has at times made rock wool from a mixture of Prospect Hill Siltstone and McCraney Limestone.

8.6 Mill Creek.

8.8 Village of Marblehead.

Mileage

9.8 Burlington Limestone low in bluff to left.

10.9 Harkness Creek. Turn left immediately beyond the creek bridge onto a gravel road.

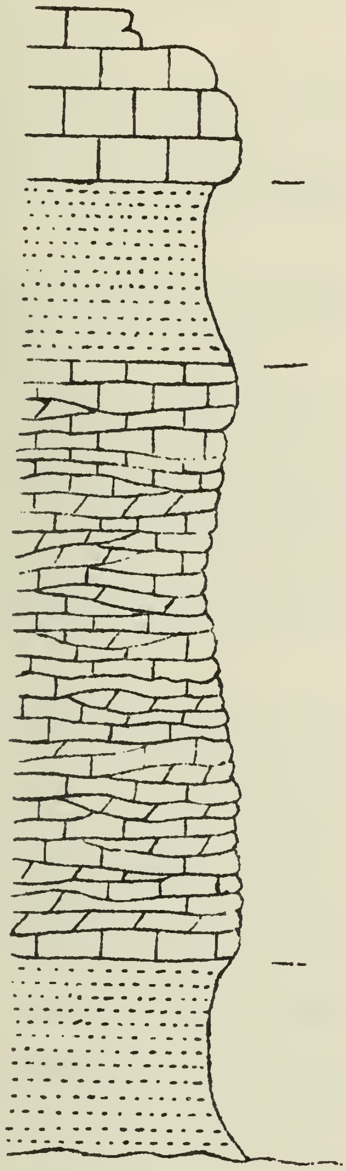
11.2 STOP 9 -- ZION CHURCH, SE¼ SE¼ Section 9, T. 3 S., R. 8 W., Adams County, Quincy Quadrangle.

One of the most recent developments in Pleistocene research in this area is the description by Frye, Willman, and Glass (1964, Ill. Geol. Survey Circ. 364) of extensive Cretaceous deposits which previously had been assigned to the Pleistocene and Tertiary. These deposits, which consist of sand, clay, and gravel, occur over an area of more than 80 square miles in a roughly linear discontinuous belt extending from NW of Pittsfield (30 miles SE of here) to south of Mendon (18 or 19 miles NE of here). Unfortunately, since these deposits lie outside the field trip area, they could not be included in the itinerary. However, as part of the Cretaceous study, this fine Zion Church bluff section was described (p. 28) and provides the unusual opportunity to see, in one section, deposits from all four of the major glacial stages of the Pleistocene.

Description of Section

PLEISTOCENE SERIES	Feet
WISCONSINAN STAGE	
Woodfordian Substage	
Peoria Loess (below surface soil)	
Loess, gray and yellow-tan, calcareous	20.5
Altonian Substage	
Roxana Silt	
Loess, pinkish-tan to brown, leached	4.0
ILLINOIAN STAGE	
Loveland Silt	
Silt, sandy, clayey, gray-tan, leached; 3-foot B-zone of Sangamon Soil at top	8.0
KANSAN STAGE	
Till, tan to brown, leached; 4-foot B-zone of Yarmouth Soil at top in east part of exposure is partly trucated to west	25.0
Till, gray and tan, calcareous	5.0
Silt, gray, calcareous, few snails	6.0
NEBRASKAN STAGE	
Gravel, reddish brown, leached	4.0

STOP 10 -- SEEHORN CREEK



BURLINGTON FM. -- Limestone, white to buff, coarsely crinoidal.

PROSPECT HILL FM. -- Siltstone buff, calcareous, massive.

McCRANEY FM. -- Limestone, light gray, sublithographic, interbedded with dolomite and dolomitic shale partings: irregularly bedded. Few crinoid columnals and brachiopods. Microcrinoids common in shale partings.

Scale 1" = 10'

HANNIBAL FM. -- Siltstone, buff, massive.

Mileage	
11.3	Turn around in vicinity of church yard.
11.8	Junction with Highway 57. Turn left.
14.7	Fall Creek. Three-fourths of a mile up this stream valley the Prospect Hill Siltstone can be seen beneath the base of the Burlington. It crops out in the stream bed below the falls.
17.5	Turn left on gravel road. Seehorn Hollow.
17.8	STOP 10 -- SEEHORN HOLLOW, SW¼ NE¼ SW¼ Section 31, T. 3 S., R. 7 W., Adams County, Quincy Quadrangle.

The section occurs along Seehorn Creek on the right. A pasture fenced by an ELECTRIC FENCE lies between road and outcrop but the section can be reached by going to the bridge, a short distance to the east, and then following the bank of the stream.

Here we will see the major unconformity at the base of the Burlington. It is evidenced by the absence of the Starr's Cave Formation. Southeastward, at Stop 10, the Burlington overlaps the Prospect Hill Formation. Further south the McCraney is also overlapped and the Burlington lies directly on the Hannibal.

This section represents the thickest surface exposure of the McCraney and, because of its thickness and similar lithology, has been considered equivalent to the Louisiana by many authors.

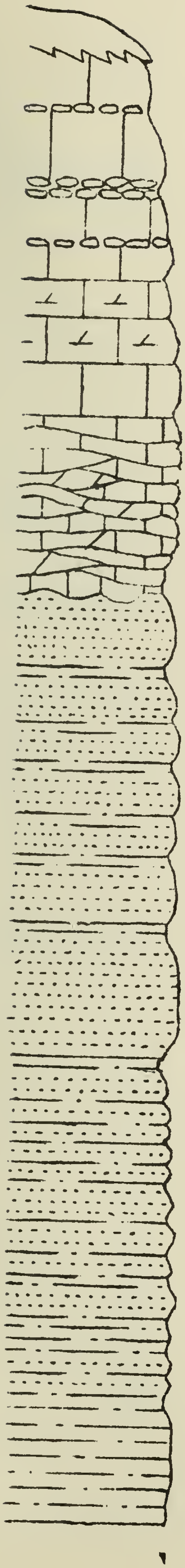
Several interesting faunas have been collected from the McCraney here even though they are relatively scarce. Fay & Koenig (1963, Okla. Geol. Notes) only recently described a new blastoid genus, Pentremoblastus, from this outcrop. The genus is of special interest inasmuch as it is the only representative of the pentremited blastoids in the North American lower Mississippian. A number of microcrinoids and small brachiopods have been collected from the argillaceous dolomite beds between the irregular limestone beds.

Mileage	
17.8	Turn around and return to highway.
18.1	Turn left on Highway 57.
18.3	Leave Adams County, enter Pike County.
20.0	Bridge across Pigeon Creek.
22.5	Junction with Highway 96 entering from left. Continue straight ahead.
23.1	STOP 11 -- McCRANEY NORTH, NE¼ NE¼, Section 15 and SE¼ SE¼ Section 14, T. 4 S., R. 7 W., Pike County, Illinois.
24.9	Y intersection with Route 36. Curve to right. OBSERVE STOP SIGN. Continue toward Hannibal.
26.0	Hull, Illinois.
35.0	Mississippi River.
35.2	Hannibal, Missouri.

To reach Stop 12, Lover's Leap, turn left at end of bridge onto Third Street. Follow Third Street for one and a half blocks to the junction with Highways 61 and 79 which enter from the left. Go left one block, then right, following Highway 79 until it has a T junction with Birch Street (State Road AA). Turn left following State Road AA to Lover's Leap which is opposite the C. B. & Q. Railroad yards.

STOP 12 -- LOVER'S LEAP, SE¼ SE¼ Section 28, T. 57 N., R. 4 W., Marion County, Missouri.

STOP 11 -- McCRANEY NORTH.



BURLINGTON FM. -- Limestone, light buff, massive, coarsely crinoidal; chert, light buff to white, scattered.

Scale 1" = 10'

McCRANEY FM. -- Limestone gray to brownish gray, lithographic to sublithographic, weathers very light gray, irregularly interbedded with dolomite, buff, silty.

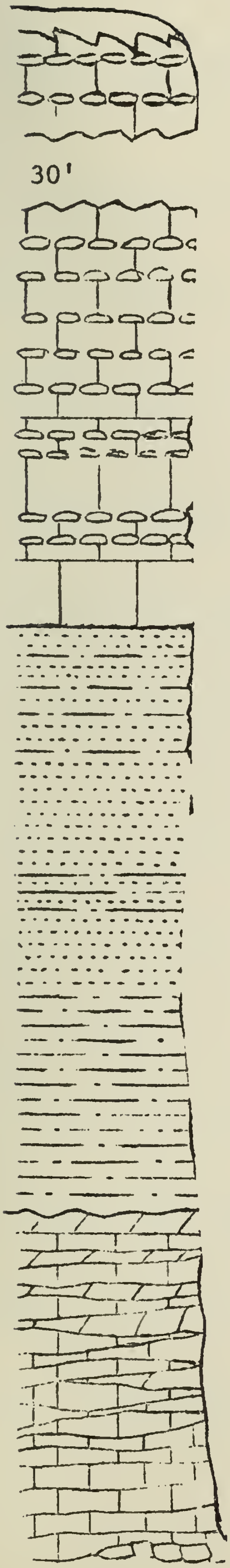
HANNIBAL FM. -- Siltstone, blue gray to buff, argillaceous, indistinctly alternating with silty shale beds. Forms lower part of exposure on south side of gulley.

Siltstone, very massive, bluish gray to buff, upper 3 inches marked by bluish gray zone. Lowermost 3 feet vermicular, pyritic and fossiliferous. Casts of brachiopods and pelecypods.

SAVERTON FM. -- Siltstone bluish gray to buff, argillaceous, indistinctly alternating with silty shale beds. Forms lower part of exposure on south side of gulley.

Shale, greenish gray, very silty, pyritic. Poorly exposed intermittently on slope below main outcrop. Better exposed on south side of gulley.

STOP 12 -- LOVER'S LEAP



BURLINGTON FM. -- Limestone, very light gray to light buff, coarsely crinoidal calcarenite with bands of white to light buff chert nodules.

HANNIBAL FM. -- Siltstone, greenish gray, argillaceous, massive, vermicular with discontinuous shale zone and occasional greenish gray very silty shale beds.

Shale, greenish gray, very silty, slightly calcareous, vermicular in lower part.

LOUISIANA FM. -- Limestone, gray lithographic, pure, irregularly interbedded with dolomitic clay partings and buff to brown saccharoidal dolomite. Beds thin in upper 10 feet, increasing in thickness downward. Beds of dolomite most numerous in upper part. Capped by thick dolomite bed with irregular upper surface.

Scale 1" = 20'

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