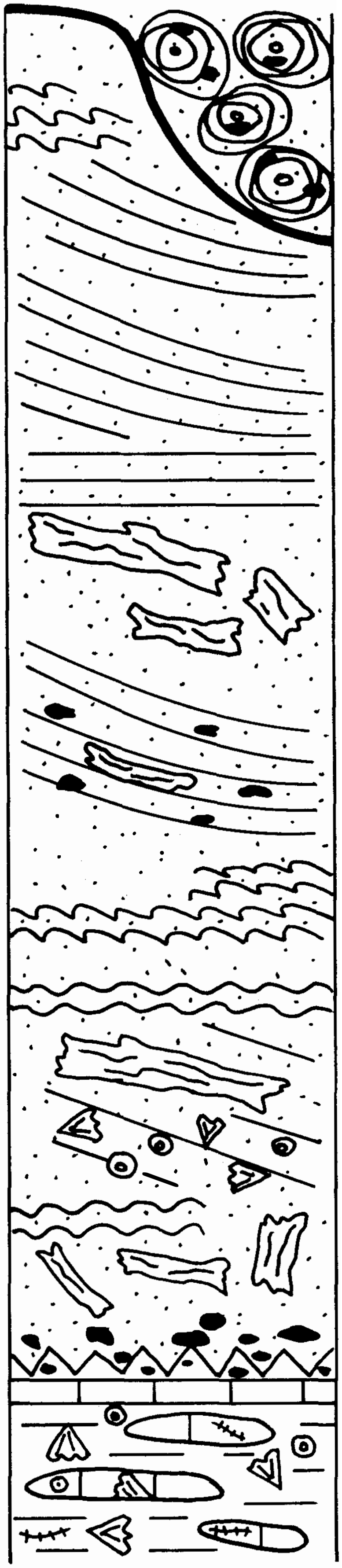
Geological Survey

Delta Environments of the Lower Chesterian (Mississippian) in Southern Illinois

Beverly Seyler

Illinois Geological Society
Illinois State Geological Survey



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Field trip
April 27, 1982

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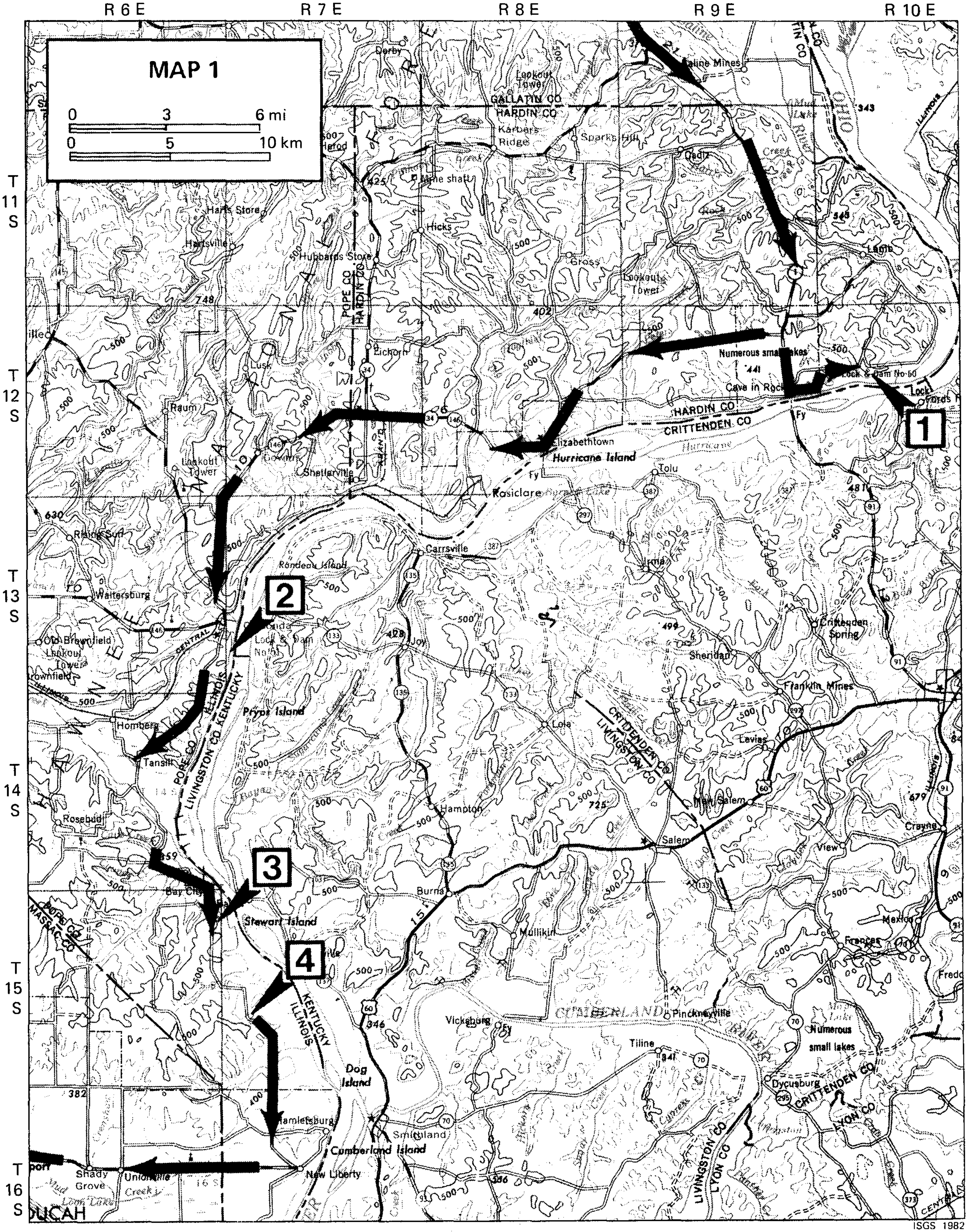
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1
2
3
4
Derby
Lookout Tower
GALLATIN CO
HARDIN CO
Karbers Ridge
Sparks Hill
Saline Mines
Herod
Mine shaft
Oadiz
Harts Store
Hartsville
Hubbards Store
Hicks
Gross
Lookout Tower
Lamb
POPE CO
HARDIN CO
Lickorn
Lusk
Raum
Lookout Tower
Golconda
Shetlerville
Elizabethtown
Hurricane Island
Rosiclare
Numerous small lakes
Cave in Rock
Lock & Dam No 50
HARDIN CO
CRITTENDEN CO
Fy
Tolu
Rising Sun
Waltersburg
Old Brownfield
Lookout Tower
Brownfield
Carrsville
Rondeau Island
Irma
Lock & Dam
Joy
Crittenden Spring
Sheridan
Franklin Mines
Golconda
Pryor Island
Lola
CRITTENDEN CO
LIVINGSTON CO
Levias
Hamburg
Tansill
POPE CO
LIVINGSTON CO
ILLINOIS
KENTUCKY
Rosebud
Hampton
Marion
Salem
Crayne
View
Bay City
Burna
Stewart Island
Mullikin
Mexico
Frances
Fredonia
POPE CO
MASSAC CO
Vicksburg
Pinckneyville
CUMBERLAND RIVER
Numerous small lakes
Tiline
Dog Island
KENTUCKY
ILLINOIS
Dycusburg
CRITTENDEN CO
LYON CO
LIVINGSTON CO
LYON CO
Hamletsburg
Smithland
Cumberland Island
New Liberty
Shady Grove
Unionville
PADUCAH
OHIO RIVER

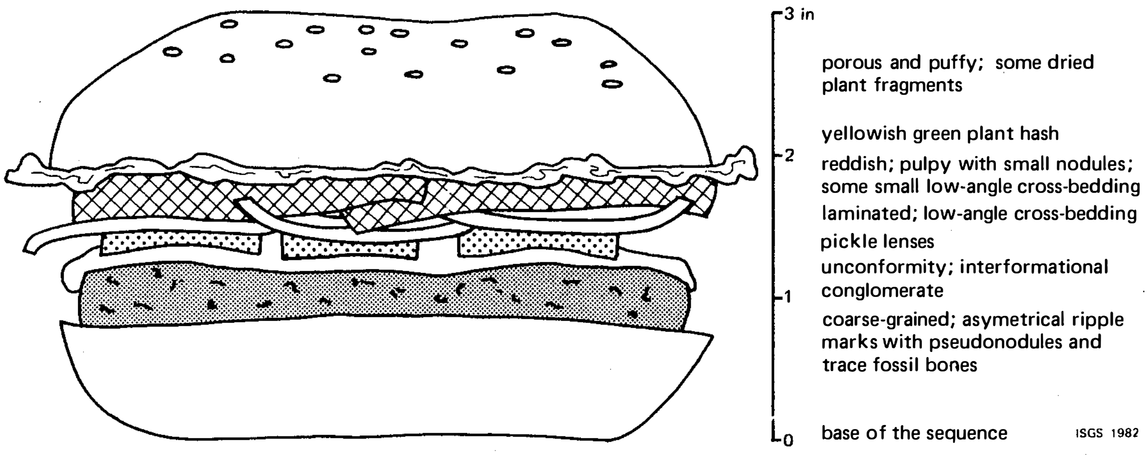
ISGS 1982

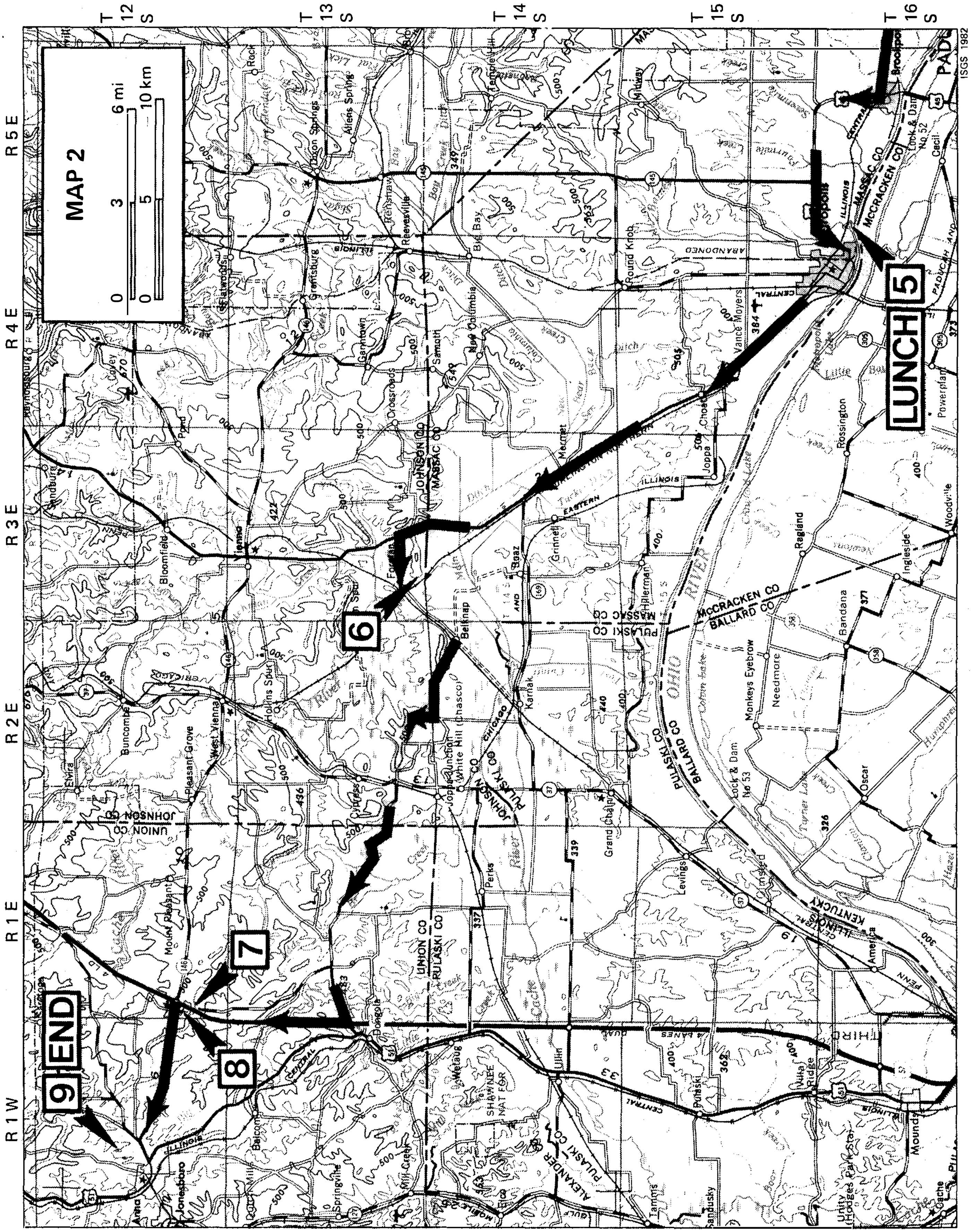
ROAD LOG

Miles to next point	Miles from starting point	
0.0	0.0	Leave Cave in Rock State Park (where pavement ends).
.9	.9	TURN RIGHT onto section road.
.6	1.5	☐ STOP 1—TURN RIGHT at MISSISSIPPI PORTLAND CEMENT QUARRY entrance.
.3	1.8	Stop at office and check in.
.3	2.1	Return to entrance. TURN LEFT onto section road.
.6	2.7	TURN LEFT at intersection.
.9	3.6	Enter Cave in Rock State Park. Observe the cave in Ste. Genevieve Limestone along the bluff of the Ohio River.
.5	4.1	Leave Cave in Rock State Park.
.2	4.3	TURN LEFT at United Methodist Church. Proceed to flashing red light.
.1	4.4	STOP SIGN. Flashing red light. TURN RIGHT (north) onto IL Route 1.
1.8	6.2	TURN LEFT (west) onto Route 146.
4.1	10.3	Outcrop of Bethel Sandstone on north side of Route 146.
.1	10.4	Pass picnic rest area.
1.2	11.6	Outcrop of St. Louis Limestone.
1.0	12.6	Hardin County School.

Miles to next point	Miles from starting point	
.6	13.2	Outcrop of Ste. Genevieve Limestone.
.5	13.7	Enter Elizabethtown.
.7	14.4	STOP SIGN.
1.0	15.4	Outcrop of St. Louis or Ste. Genevieve Limestone.
1.4	16.8	Junction, IL 34 and 146, CONTINUE AHEAD.
1.2	18.0	Outcrop of Clore Sandstone.
1.5	19.5	Outcrop of Aux Vases Sandstone.
.3	19.8	Outcrop of Ste. Genevieve Limestone.
.3	20.1	STOP SIGN. Junction of 34 and 146. CONTINUE AHEAD.
.2	20.3	STOP SIGN.
2.1	22.4	Sandstone outcrop (Hardinsburg).
6.3	28.7	Sandstone outcrop (Hardinsburg).
.3	29.0	Enter Golconda.
.2	29.2	CAUTION. Railroad Crossing.
.2	29.4	Levee on both sides of road.
.2	29.6	TURN LEFT onto Main Street (Golconda).
.2	29.8	Golconda Courthouse.
.1	29.9	Road curves to right up levee
.6	30.5	☐ STOP 2—CYPRESS SANDSTONE (Lock and Dam #51).
.2	30.7	Leave Stop 2. Turn around in parking lot, and retrace steps.
.7	31.4	Turn to left off levee. Enter Golconda main street.
.4	31.8	STOP. TURN LEFT onto Adams Street.
.8	32.6	Outcrop of Cypress Sandstone. Observe cross-bedding.

Miles to next point	Miles from starting point	
3.8	36.4	Outcrop of Cypress Sandstone.
2.8	39.2	Outcrop of Cypress Sandstone.
.8	40.0	STOP. TURN LEFT onto Cave Springs Road.
1.8	41.8	Outcrop of Glen Dean Limestone.
.8	42.6	☐ STOP 3—Cypress Sandstone. Park along road.
2.6	45.2	Leave Stop 3. Outcrop of Cypress Sandstone.
1.5	46.7	☐ STOP 4— Cypress Sandstone and Ridenhower Shale.
5.5	52.2	Leave Stop 4. STOP SIGN. TURN RIGHT onto Hamletsburg Road.
5.4	57.6	STOP SIGN. CONTINUE STRAIGHT AHEAD.
3.9	61.5	Pass levee.
.1	61.6	STOP SIGN. CONTINUE AHEAD.
.4	62.0	STOP SIGN. TURN RIGHT onto Route 45.
4.3	66.3	Intersection with Route 146. Stay on Route 45.
.1	66.4	Intersection with I-24. Stay on Route 45.
2.6	69.0	☐ STOP 5. LUNCH. FORT MASSAC STATE PARK.




MAP 2
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T 12 S
T 13 S
T 14 S
T 15 S
T 16 S
LUNCH 5
6
7
8
9 END
ISGS 1982
OHIO RIVER
KENTUCKY
ILLINOIS
JOHNSON CO
MASSAC CO
UNION CO
PULASKI CO
ALEXANDER CO
MCCRACKEN CO
BALLARD CO
Vienna
Metropolis
Joppa
Karnak
Belknap
Grand Chain
Dongola
Ullin
Jonesboro
Anna
Tamms
Mounds
Pulaski
Olmsted
Mound City
Brookport
Paducah
SHAWNEE NAT FOR

Miles to next point	Miles from starting point	
—	—	Leave Stop 5. Follow Route 45 signs through Metropolis.
1.2	70.2	STOP SIGN. TURN RIGHT onto Route 45N. Continue on Route 45.
.4	70.6	STOP SIGN. TURN LEFT. Continue on Route 45.
8.4	79.0	Mermet Conservation Area.
1.2	80.2	Pass Roadside rest and picnic area.
.5	80.7	Enter Mermet.
1.6	82.3	JUNCTION, Route 169. CONTINUE AHEAD on Route 45.
4.0	86.3	TURN LEFT onto Belknap Road.
1.4	87.7	TURN LEFT onto Johnson County Road. (Froman Church and Heron Pond Nature Preserve are on the right side of Belknap Road).
.8	88.5	☐ STOP 6—Indian Point.
.3	88.8	Leave Stop 6. Turn around and retrace route on Johnson County Road.
1.0	89.8	TURN LEFT onto Belknap Road.
.3	90.1	CAUTION. Railroad crossing.
1.0	91.1	Cross bridge over Cache River.
.7	91.8	Belknap Quarry on right. Observe Ste. Genevieve-Bethel succession.
.5	92.3	STOP SIGN at Belknap and Main Street. TURN RIGHT (northwest).
.2	92.5	CAUTION. Immediately cross RR tracks.
.8	93.3	BEAR LEFT (west) at Y intersection. Stay on paved road.
1.0	94.3	Intersection. PROCEED STRAIGHT (west).
.2	94.5	Y intersection. BEAR LEFT (south).
1.4	95.9	Intersection on left.

Miles to next point	Miles from starting point	
.4	96.3	TURN LEFT (west) onto T intersection. Cypress exposed at top of Turner Bluff.
1.6	97.9	Intersection on right.
.2	98.1	STOP SIGN. Intersection of Dongola Road with Route 37. CONTINUE AHEAD on Dongola Road.
.1	98.2	CAUTION. RR tracks.
.3	98.5	Intersection, gravel road.
.6	99.1	Intersection. Bethany Church on right (north).
.7	99.8	Cross bridge over Cypress Creek.
.3	100.1	Cross second bridge over Cypress Creek.
1.4	101.5	Cross bridge over Adds Branch of Cypress Creek.
.3	101.8	Intersection on left. CONTINUE AHEAD.
.7	102.5	Intersection and second bridge over Adds Branch of Cypress Creek.
1.3	103.8	Intersection on right.
.1	103.9	Intersection on left.
.8	104.7	Cross bridge.
.9	105.6	TAKE ENTRANCE RAMP to I-57 North on right.
2.0	107.6	Milepost 27. Ste. Genevieve Limestone and Aux Vases Sandstone outcrop.
1.0	108.6	☐ STOP 7—Outcrop at Milepost 28 on Interstate, I-57, just north of Vienna-Anna 1-mile warning Interchange sign.
.9	109.5	Leave Stop 7. EXIT I-57 AT EXIT 30 (Vienna-Anna) onto Route 146.
.4	109.9	STOP SIGN. TURN LEFT onto Route 146 toward Anna.
.4	110.3	TURN LEFT onto secondary road (just west of Shell Station).

Miles to next point	Miles from starting point	
.7	111.0	☐ STOP 8—CYPRESS CREEK and Roadcut outcrop just beneath I-57 overpass. Type locality of Cypress Sandstone.
.7	111.7	Leave Stop 8. Return to Route 146 intersection. TURN LEFT (west) onto Route 146 toward Anna.
4.3	116.0	Intersection with Route 51. TURN RIGHT (north) onto Route 51.
.9	116.9	Pass Anna Quarries, Inc. Quarry Ste. Genevieve Limestone.
.5	117.4	☐ OPTIONAL STOP. Ste. Genevieve Limestone and Aux Vases Sandstone (fig. 24).
.2	117.6	TURN RIGHT (east) onto dirt road.
.2	117.8	BEAR LEFT at Y in Road. Cross wood bridge over Cache River.
.3	118.1	Cross cattle guard and small wood bridge.
.1	118.2	Cross small wood bridge.
.3	118.5	☐ STOP 9—Cypress Sandstone and Ridenhower Shale exposed in stream bed at low water.

Return to Route 51 — END OF TRIP!

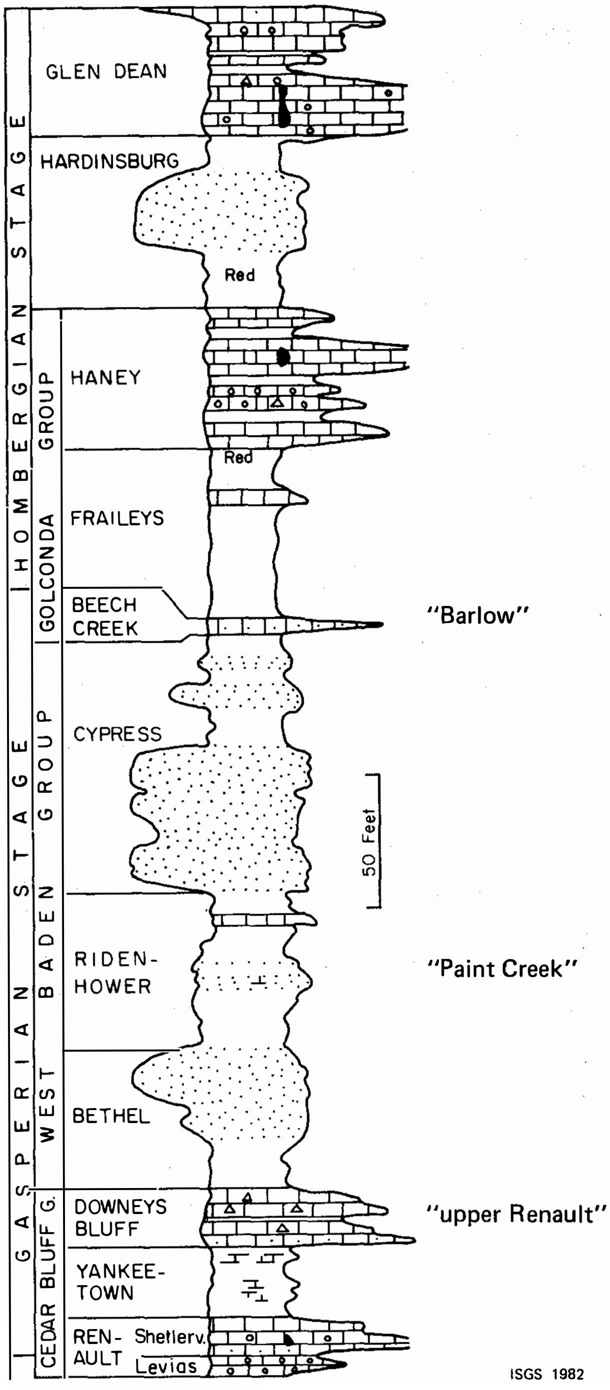


FIGURE 1. Typical electric log pattern of the lower part of the Chesterian Series. Stratigraphic units seen in outcrops at Stops 1-9 are located between the Downeys Bluff ("upper Renault") Limestone and the Beech Creek ("Barlow") Limestone and usually include the Cypress and/or Bethel Sandstones (from ISGS Bulletin 95).

INTRODUCTION

Recent studies of the Lower Chesterian (Mississippian) in southern Illinois, which concentrated on the Cypress and Bethel Sandstones, have shown that these sediments were deposited in deltaic environments primarily under the influence of fluvial and wave processes.

This field trip includes nine stops at Lower Chesterian outcrops in extreme southeastern and south-central Illinois. Stratigraphically, these units are between the Downeys Bluff ("upper Renault") Limestone and the Beech Creek ("Barlow") Limestone (fig. 1). In this report we will describe each outcrop and discuss the delta facies it represents. We will also compare the deltaic depositional environments found at the outcrops with those in the region of the La Salle Anticlinal Belt in the subsurface.

Included in this publication is a review of the literature on deltaic sedimentation pertinent to the deltas formed during the early Chesterian in the Illinois Basin. This information is presented to develop a deltaic model for petroleum exploration that will aid in understanding the environments of deposition and the resultant sandstone reservoirs that have been prolific oil producers in Illinois.

REVIEW OF DELTAIC DEPOSITION

A system of fluvial and distributary channels and their associated prodelta, delta front, distributary mouth bar and interdistributary bay deposits constitutes a delta lobe (fig. 2). The various shapes and patterns occurring in a delta lobe are dependent on whether the major processes acting upon them are fluvial, wave, tidal, or a combination. Deltas are usually classified as fluvial-, wave-, or tide-dominated, and each type has its own distinguishing characteristics. The outcrops of Cypress and Bethel Sandstones are deposits consisting primarily of fluvial-dominated deltas with some influence from wave and tidal processes.

A delta complex can be divided into two basic zones: the first contains sediments deposited in a terrestrial environment and the second contains sediments deposited in a subaqueous environment. Figure 3 shows an idealized electric log pattern for sediments and the various facies found in each zone. The Lower Chesterian sandstones of extreme southern Illinois were deposited primarily in the subaqueous environments and the lower portion of the terrestrial environment. We will discuss the basic components of each zone to provide background information necessary for establishing a deltaic model of deposition in the Lower Chesterian of the Illinois Basin.

The most landward of the delta complex environments is the upper delta plain (fig. 2), which contains point bars deposited in meandering river channels. Other sediments associated with these channels are levees; overbank deposits; spill-over or crevasse splays, which are deposited when rivers breach their levees during floods; filling-in of oxbow lakes; and thin localized coals. Immediately seaward of the upper delta plain environment is the lower delta plain, which contains distributary channel and interdistributary bay deposits

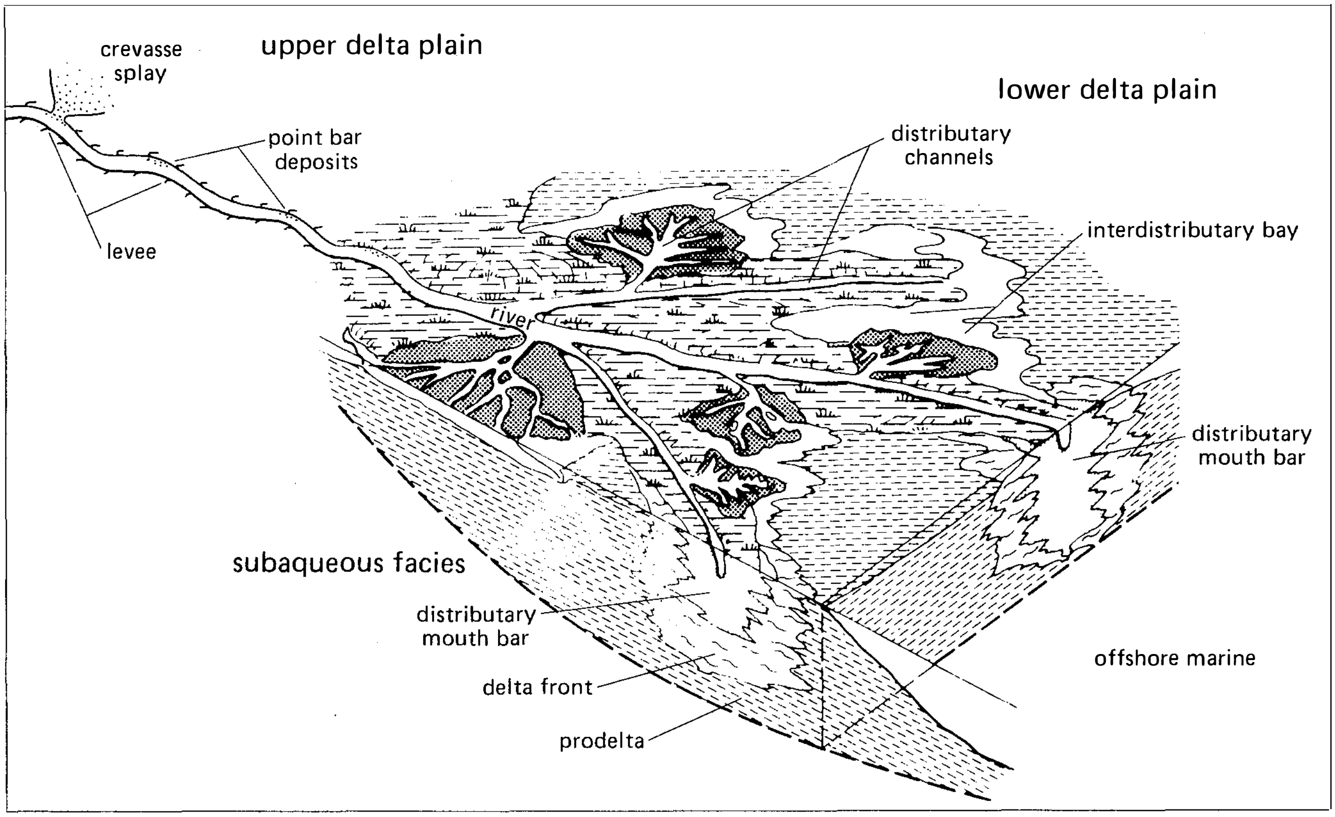


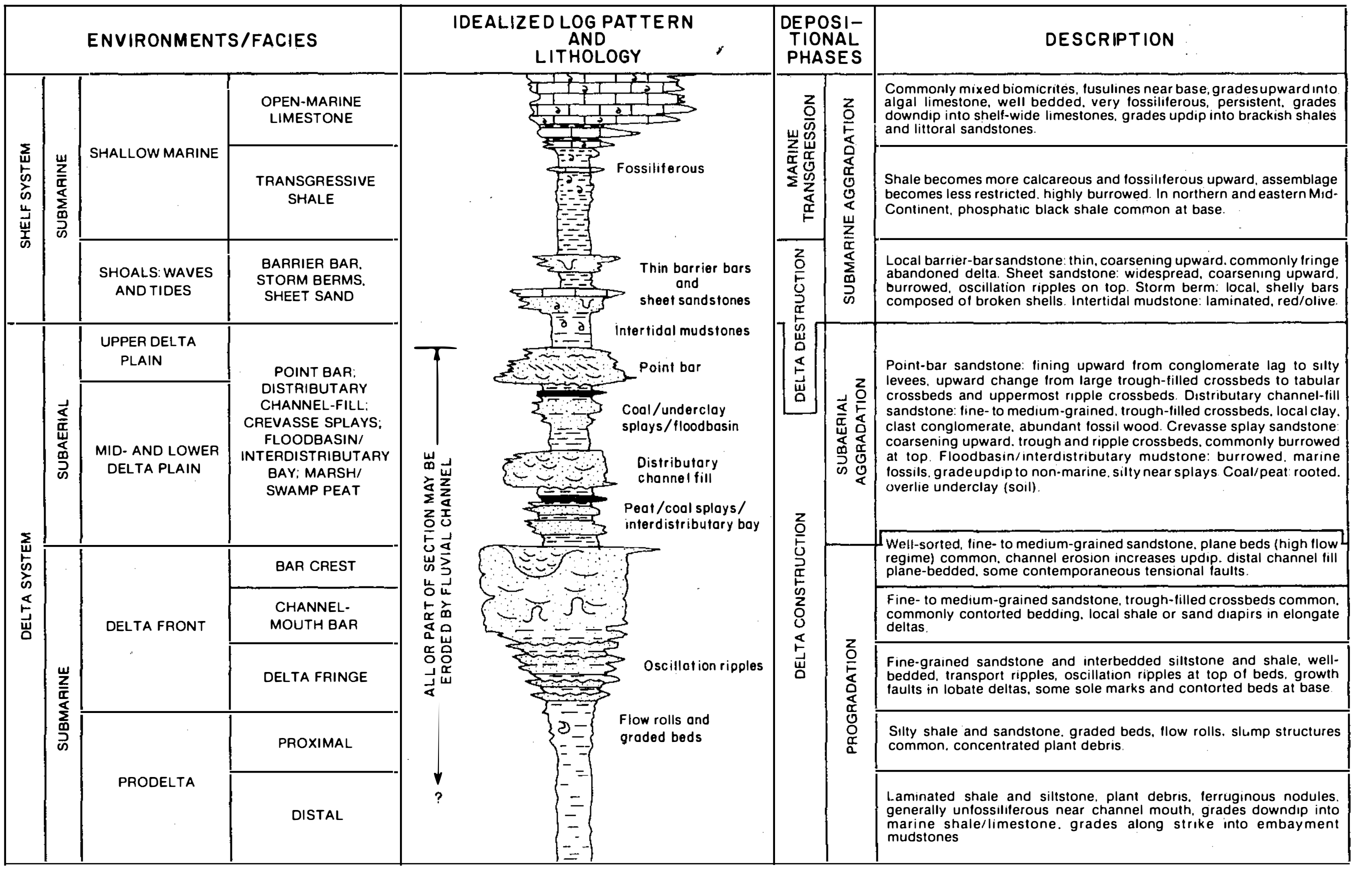
FIGURE 2. Deltaic facies found in an ideal delta lobe. The upper delta plain contains deposits associated with river channels, including point bars, levee sediments, crevasse splays caused by deposition of sediments transported through a break in a levee, and coals formed in low-lying areas of the flood plain. The lower delta plain includes the system of distributary channels and their associated interdistributary facies, including crevasse splays of distributary channels, swamps, and marshes where coal may be formed, and interdistributary bays (fringing on the marine offshore facies) that contain a brackish fauna of pelecypods, gastropods, and brachiopods. Distributary mouth bars, delta fronts, and prodelta shales constitute the subaqueous part of the delta. (Adapted from Elliot, 1978)

that include swamps and marshes (e.g., thin coals). Below sea level and seaward of the lower delta plain are distributary mouth bars, delta front, and prodelta deposits. The stacked vertical sequence and idealized log pattern of this constructive phase of terrestrial and subaqueous deposits of a delta complex are shown in figures 3 and 4.

The coarsening upward sequence of prodelta, delta front, and distributary mouth bar is easily recognized in outcrop as well as in SP log patterns (figs. 3 and 4). The prodelta is the most offshore part of the delta complex and fringes on marine shales; it is the site of suspension deposition of clays and silty clays that commonly contain a hash of carbonaceous plant fragments washed in from terrestrial areas. The clay is laid down in fine laminae. Often no marine fossils are associated with the fine sediment of the prodelta environment.

During the Chesterian, delta sequences were much thinner than many found in modern complexes; therefore, a closer association of marine fossils with terrestrial sediments sometimes occurs. For instance, at STOP 2 in Golconda at Lock and Dam #51, Archimedes, crinoid stems, and brachiopods are abundant in siltstones and fine-grained sandstones of the delta front.

The delta front is more of a nearshore environment than is the prodelta, and therefore receives coarser-grained silts and very fine-grained sands. The



ENVIRONMENTS/FACIES				DEPOSITIONAL PHASES		DESCRIPTION
SHELF SYSTEM	SUBMARINE	SHALLOW MARINE	OPEN-MARINE LIMESTONE	MARINE TRANSGRESSION	SUBMARINE AGGRADATION	Commonly mixed biomicrites, fusulines near base, grades upward into algal limestone, well bedded, very fossiliferous, persistent, grades downdip into shelf-wide limestones, grades updip into brackish shales and littoral sandstones.
			TRANSGRESSIVE SHALE			Shale becomes more calcareous and fossiliferous upward, assemblage becomes less restricted, highly burrowed. In northern and eastern Mid-Continent, phosphatic black shale common at base.
		SHOALS: WAVES AND TIDES	BARRIER BAR, STORM BERMS, SHEET SAND	DELTA DESTRUCTION		Local barrier-bar sandstone: thin, coarsening upward, commonly fringe abandoned delta. Sheet sandstone: widespread, coarsening upward, burrowed, oscillation ripples on top. Storm berm: local, shelly bars composed of broken shells. Intertidal mudstone: laminated, red/olive.
DELTA SYSTEM	SUBAERIAL	UPPER DELTA PLAIN	POINT BAR; DISTRIBUTARY CHANNEL-FILL; CREVASSE SPLAYS; FLOODBASIN/ INTERDISTRIBUTARY BAY; MARSH/ SWAMP PEAT	DELTA CONSTRUCTION	SUBAERIAL AGGRADATION	Point-bar sandstone: fining upward from conglomerate lag to silty levees, upward change from large trough-filled crossbeds to tabular crossbeds and uppermost ripple crossbeds. Distributary channel-fill sandstone: fine- to medium-grained, trough-filled crossbeds, local clay, clast conglomerate, abundant fossil wood. Crevasse splay sandstone: coarsening upward, trough and ripple crossbeds, commonly burrowed at top. Floodbasin/interdistributary mudstone: burrowed, marine fossils, grade updip to non-marine, silty near splays. Coal/peat: rooted, overlie underclay (soil).
		MID- AND LOWER DELTA PLAIN				
	SUBMARINE	DELTA FRONT	BAR CREST		PROGRADATION	Well-sorted, fine- to medium-grained sandstone, plane beds (high flow regime) common, channel erosion increases updip, distal channel fill plane-bedded, some contemporaneous tensional faults.
			CHANNEL-MOUTH BAR			Fine- to medium-grained sandstone, trough-filled crossbeds common, commonly contorted bedding, local shale or sand diapirs in elongate deltas.
			DELTA FRINGE			Fine-grained sandstone and interbedded siltstone and shale, well-bedded, transport ripples, oscillation ripples at top of beds, growth faults in lobate deltas, some sole marks and contorted beds at base.
		PRODELTA	PROXIMAL			Silty shale and sandstone, graded beds, flow rolls, slump structures common, concentrated plant debris.
			DISTAL			Laminated shale and siltstone, plant debris, ferruginous nodules, generally unfossiliferous near channel mouth, grades downdip into marine shale/limestone, grades along strike into embayment mudstones

FIGURE 3. Idealized electric log pattern of delta sequences, descriptions of principal facies, and constructive and destructive phases of delta development (from Brown, 1979, reprinted with permission of the Tulsa Geological Society).

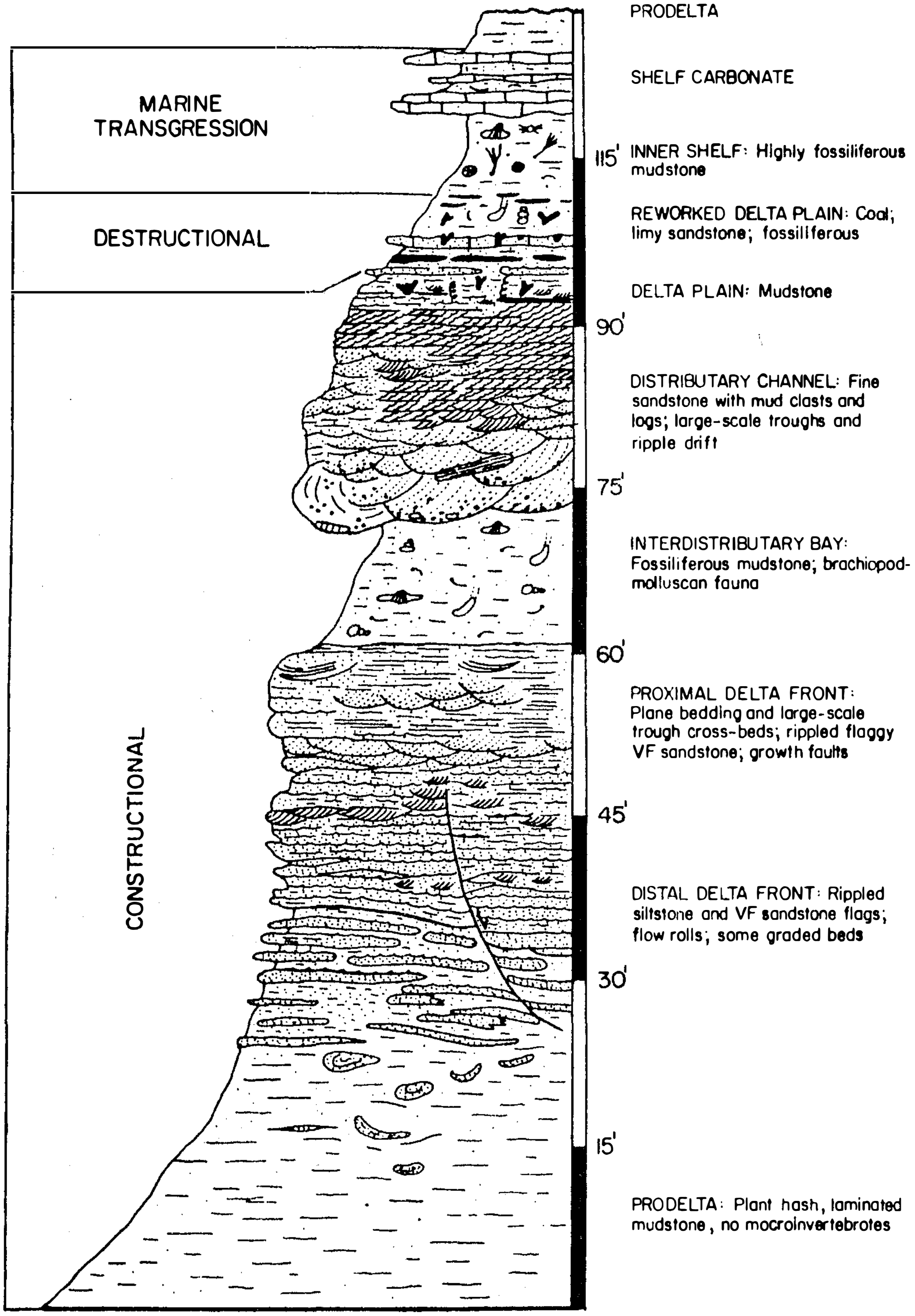


FIGURE 4. Vertical succession of facies in a progradation of a delta lobe, with subsequent abandonment and destruction of the delta complex (from Brown, 1979). (Reprinted with permission of the Tulsa Geological Society)

delta front contains interbedded siltstones, very fine-grained sandstones, and mudstones (shales) and is an extensive sheet deposit.

Lenses of rolled, distorted siltstones and very fine-grained sandstones (fig. 4) often occur in the upper portion of the prodelta. This transitional zone from prodelta to delta front is marked by an influx of horizontally bedded fine-grained sandstone and siltstones. Other features include few very low-angle trough cross-beds, rippled sandstone and scattered shale clasts. The delta front may be topped by a distributary mouth bar or distal bar consisting of medium-grained sandstone and large-scale trough cross-bedding. The distributary mouth bar is the sediment at the mouth of a distributary channel often referred to as a bar finger sand.

Expected nearshore sediments of a delta lobe include barrier bars, and offshore bars of redistributed and reworked mouth bar sediments. Because finer sediments of clay and silt have been removed, these features provide ideal petroleum reservoirs.

It must be kept in mind that since deltas are dynamic systems, any single delta lobe—or its components—is relatively short-lived. In the modern Mississippi delta an individual lobe has a lifespan of approximately 100-150 years from the onset of progradation to the final abandonment phase.

Most familiar to geologists is the constructive phase of a delta's life, in which coarser sediment transported through the distributary channels is deposited at the channel mouth; finer sands and silts are carried a greater distance and deposited in the delta front; and the finest clays and silts are transported in suspension, the greatest distance from channel mouths to be deposited in the prodelta environment. A continuation of this mode of deposition through time will cause a build-up or progradation of a delta lobe. If a channel is cut off and sediments are diverted, a new delta lobe will be constructed and the old abandoned delta lobe will be destroyed by marine reworking.

In the Illinois Basin many petroleum reservoirs were enhanced by reworking and redistribution of sediments deposited at the mouths of distributary channels. Reworking by waves, long shore currents, storm activity, and other forces winnowed out finer clay and silt particles, thereby increasing porosity. The log pattern shown in figure 3 is typical of Cypress producing zones in Lawrence and Crawford Counties.

The delta abandonment phase, however, is just as important as the constructive phase. Abandonment usually occurs during flood stage when the breaching of a levee somewhere along a fluvial or distributary channel cuts off the supply of sediment from the former channel and shifts the direction of flow to a new area. This leaves the cutoff delta lobe open to destructional agents such as waves and tides. Marine reworking of sediments in an abandoned delta lobe will remove the finer clays and silts leaving behind cleaner, more porous, sandstone reservoirs.

SUGGESTED GENERAL REFERENCES ON DELTAIC SYSTEMS

The following publications have good information on delta systems and are particularly pertinent to petroleum exploration in the Illinois Basin.

1. Hyne, Norman T., [ed.], 1979, Pennsylvanian sandstones of the mid-continent: Tulsa Geological Society Special Publication No. 1., Tulsa, OK. The third chapter, "Deltaic Sandstone Facies of the Mid-Continent" by L. F.

Brown, p. 35-64, provides a very succinct review and update of delta systems. Although the emphasis is on Pennsylvanian deltas, the discussion and description of deltaic facies (especially prodelta, delta front, lower delta plain, and shallow marine transgressive sequences) are very applicable to the Lower Chesterian of the Illinois Basin.

2. Broussard, Martha L., [ed.], 1975, Delta models for exploration: Houston Geological Society, Houston, TX. A good, detailed, overall review of delta systems written for the petroleum geologist, this publication includes many examples of modern deltas in fluvial, wave, and tidally dominated environments and ancient deltas representing many basins and time periods.

3. Klein, George deVries, 1980, Sandstone depositional models for exploration for fossil fuels: CEPCO Division of Burgess Publishing Company, Minneapolis, MN. This is an excellent, readable treatment of sandstone deposition including chapters on fluvial, beach barrier, tidal, deltaic, and deep-sea turbidity deposits. The section on deltas is of particular interest to those working in the Illinois Basin because it contains a discussion of electric log patterns associated with deltas and delta-destructive systems associated with reworking and redistribution of distributary mouth-bar sands. These types of sandbodies produce much oil from the Cypress Sandstone along the La Salle Anticlinal Belt.

4. Reading, H. G., [ed.], 1978, Sedimentary environments and facies: Elsevier, New York. A general text providing a review of sedimentary environments beginning with the most terrestrial and ending with the most marine deep sea facies. The chapter on deltas presents some ideas not found in the other texts and gives a good account of delta construction and destruction with some very good illustrations.

ISGS PUBLICATIONS ON SOUTHERN ILLINOIS OUTCROPS

The following Illinois State Geological Survey Circulars, which describe the bedrock geology of southern Illinois, will be helpful to persons wishing to locate other Lower Chesterian outcrops not included in the field trip. They also provide comprehensive discussions of structural and bedrock geology.

Baxter, J. W., P. E. Potter, and F. L. Doyle, 1963, Areal geology of the Illinois Fluorspar District. Part 1—Saline Mines, Cave in Rock, DeKoven, and Repton Quadrangles: Circular 342.

Baxter, J. W., and George A. Desborough, 1965, Areal geology of the Illinois Fluorspar District. Part 2—Karbers Ridge and Rosiclare Quadrangles: Circular 385.

Baxter, J. W., G. A. Desborough, and C. W. Shaw, 1967, Areal geology of the Illinois Fluorspar District. Part 3—Herod and Shetlerville Quadrangles: Circular 413.

Ross, C. A., 1964, Geology of the Paducah and Smithland Quadrangles in Illinois: Circular 360.

Field trip guide leaflets prepared by the ISGS Educational Extension Unit provide very useful discussions of the general geology of specific regions in

Illinois. They contain detailed road logs, maps, and descriptions of each stop, and are written in fairly nontechnical language. Guide leaflets are available on the following outcrop areas of southern Illinois: Elizabethtown, Cave in Rock, Golconda, Metropolis, Vienna, Alto Pass, Jonesboro, Thebes, and Cairo.

REFERENCES

Bristol, H. M., 1968, Structure of the base of the Mississippian Beech Creek (Barlow) Limestone in Illinois: Illinois State Geological Survey, Illinois Petroleum 88.

Brown, L. F., 1979, Deltaic sandstone facies of the mid-continent, in Pennsylvanian Sandstones of the Mid-Continent, Norman J. Hyne [ed.]; Tulsa Geological Society, Tulsa, OK.

Elliot, T., 1978, Deltas, in Sedimentary Environments and Facies, H. G. Reading [ed.]; Elsevier, New York.

Klein, G. deV., 1980, Sandstone depositional models for exploration for fossil fuels: CEPCO Division, Burgess Publishing Company, Minneapolis, MN.

Ross, C. A., 1964, Geology of the Paducah and Smithland Quadrangles in Illinois: Illinois State Geological Survey Circular 360.

Shlemon, R. J., 1975, Subaqueous delta formation—Atchafalaya Bay, Louisiana, in Deltas Models for Exploration, Martha L. Broussard [ed.]; Houston Geological Society, Houston, TX.

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1 Bethel Sandstone, Missouri Portland Cement Quarry. Located 2.5 miles east of Cave in Rock, Illinois, E½, Sec. 17, T. 12 S., R. 10 E., Cave in Rock and Repton 7.5-minute Quadrangles.

The upper level of the quarry contains the best exposure of Bethel Sandstone in southern Illinois. The quarry management has been very cooperative and permits anyone with a legitimate reason to study any of the units in the quarry. Please be careful. An accident may jeopardize the cooperative relationship between the management of the quarry and geologists.

Because some of the walls of the Bethel are actively quarried, it is not possible to be certain prior to a visit exactly what features will be visible. The sandstone (Bethel) is approximately 70 feet thick at the highest point and thins to less than 10 feet along the north wall of the quarry. Distinguishing features observable at this locale (fig. 5) include:

- Numerous pieces of petrified woody stems and trunks, some identified by previous researchers as *Lepidodendron*. Some of them are the size of logs and most are iron-stained and/or carbonized (fig. 6).
- Large-scale, low-angle, cross-bedding.
- Asymmetrical ripple marks resulting from unidirectional currents (fig. 7).
- Interference ripple marks caused by multi-directional currents.
- Intraformation conglomerate lags of flat, rounded, iron-stained shale clasts (fig. 8).
- Zone of marine fossils including fenestrate bryozoa, brachiopods, and crinoidal columnals in loosely consolidated, limonitic, coarse-grained sandstone approximately 10 feet above the Downeys Bluff Limestone contact.
- Primarily fine- to medium-grained, rounded, well-sorted sandstone, except for previously described marine zones.
- Unconformity between Bethel and Downeys Bluff ("upper Renault") Limestone. Contact contains a conglomerate of large flat rounded shale clasts,

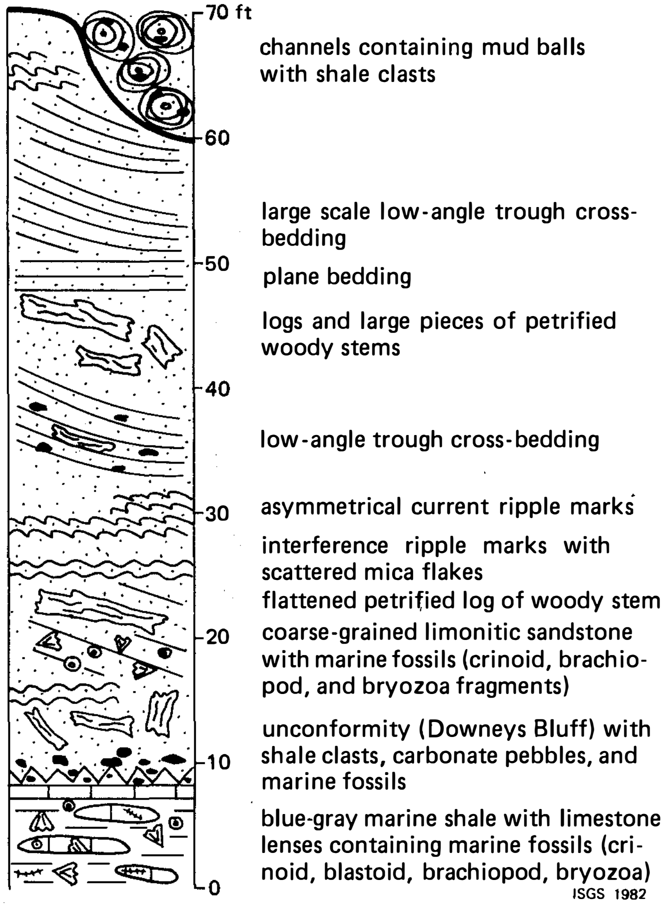


FIGURE 5. Vertical section of the sandstone (Bethel) and Downeys Bluff ("upper Renault") Limestone. The Bethel is a distributary channel mouth bar deposited in the subaqueous part of a delta lobe; it unconformably overlies the Downeys Bluff Limestone, an offshore, fossiliferous shallow-marine unit.

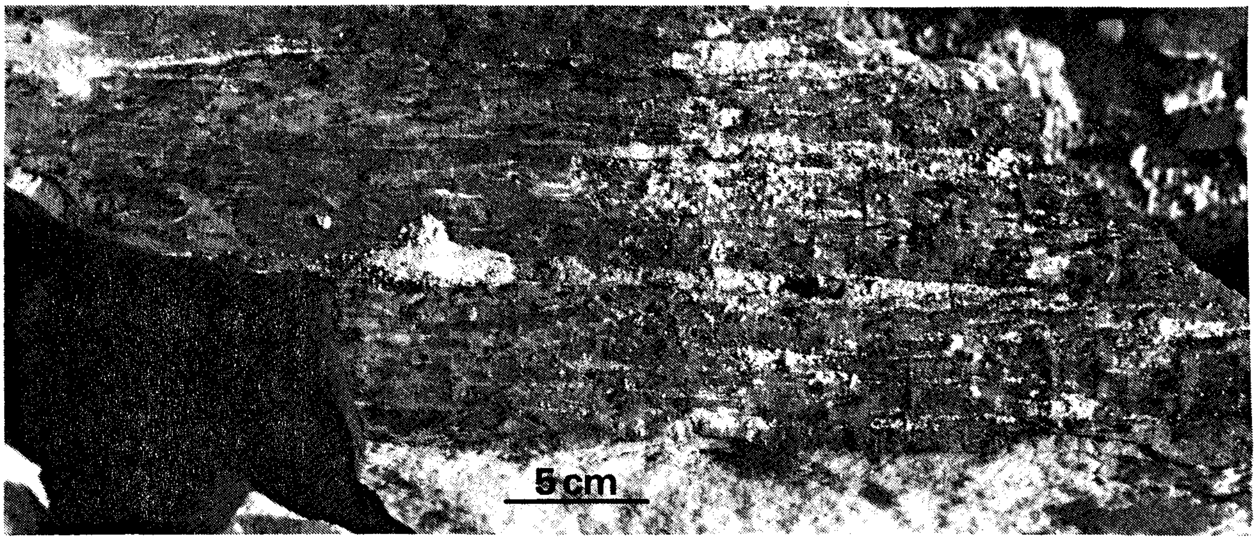


FIGURE 6. Piece of limonitic and carbonized woody stem in Bethel Sandstone at Stop 1.

FIGURE 7. Bethel Sandstone at Stop 1. Asymmetrical current ripples sometimes associated with medium-scale, low-angle, trough cross-bedding.

rounded carbonate pebbles, and marine fossils (*Archimedes* and *Pentrimites* calyces).

- Mica flakes commonly found with interference ripples are also present in other portions of the sandstone.
- Channels—cut into the upper portion of the outcrop—filled with mud balls in which iron-stained shale clasts are scattered.

These characteristics fit the description of an idealized distributary mouth bar deposit described in figure 4. The large logs and pieces of petrified woody stems and trunks of *Lepidodendron* were transported from marshes and swamps of the delta plain. Some pieces may have been partly preserved in peat marshes and coal swamps before final deposition in the distributary mouth bar. The marine fossils were transported from a marine shelf environment, possibly during a storm. These sediments were undoubtedly deposited in an environment where open marine shelf and fluvial influences were juxtaposed. The distributary channels of the Lower Chesterian in the Illinois Basin deposited their sediment load as their waters entered a shallow epicontinental sea. The mouth of each distributary channel is the site of deposition of terrestrially derived sediment. These deposits at the fringe of the sea were subject to marine processes that reworked and redistributed them by longshore and other currents.

The vertical sequence found in this locale deviates from the idealized delta system because prodelta and delta front sediments are missing here. The distributary mouth bar sediments of the Bethel Sandstone directly and unconformably overlie the open marine shelf carbonates and shales of the Downeys Bluff ("upper Renault") Limestone. One possible explanation for the sudden influx of sand into a marine shelf environment requires a diversion of a large distributary or fluvial channel caused by upstream breaching of a levee. This would probably occur during a flood and would result in a channel diversion to a different area and abandonment of the former delta to marine reworking.

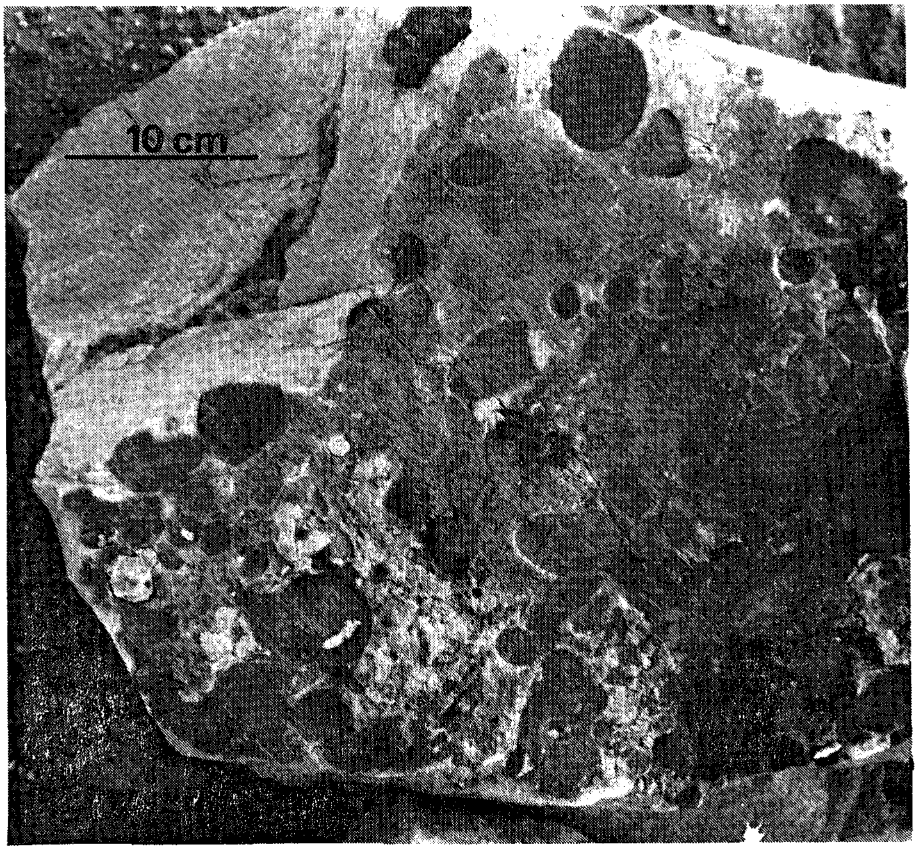


FIGURE 8. Bethel Sandstone at Stop 1. Channel lag consisting of a conglomerate of flat, rounded iron-stained shale clasts and limonitic and carbonized woody stems and trunk.

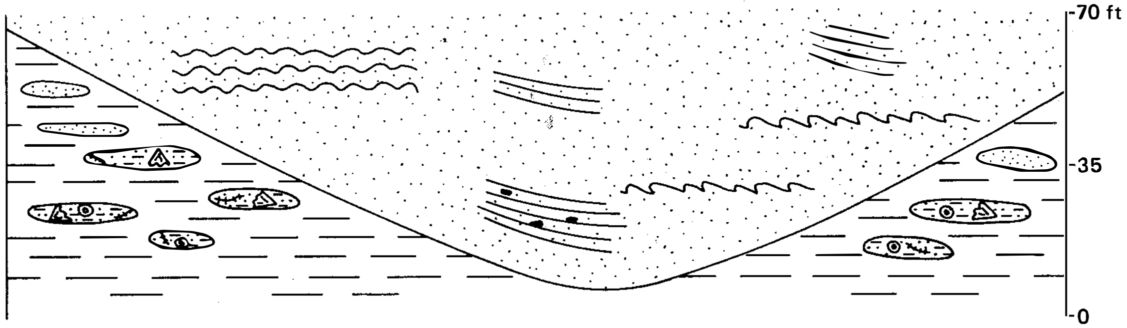
The upper portion of the Bethel contains channel scours filled with mud balls. These are cut-and-fill channel structures typical of distributary channels.

2

Cypress Sandstone and Ridenhower Shale. Located at Lock and Dam No. 51, Golconda, Illinois, Sec. 30, T. 13 S., T 7 E., Golconda 7.5-minute Quadrangle.

This is an exposure of approximately 70 feet of sandstone (Cypress) and shale (Ridenhower) along the bluffs of the Ohio River. The Cypress Sandstone rapidly thins and pinches out at the ends of the bluff. Figure 9 shows the distinctive features of this outcrop. The Cypress is underlain by Ridenhower Shale, which contains thin lenses of fine-grained sandstone and siltstone, some with marine invertebrates such as *Archimedes,* brachiopods, crinoids, and blastoids. These thin lenses are all horizontally bedded and are interbedded with thinly laminated gray shale containing carbonized plant hash. Although the Cypress Sandstone has ripple marks and low-angle trough cross-bedding, few sedimentary features are easily visible on the cliff face. However, the overall geometry of the Cypress Sandstone and the transitional character of the underlying Ridenhower Shale suggest that this outcrop represents an ancient prodelta, overlain by an extremely thin distal delta front topped by a thick distributary channel-mouth bar deposit.

This sequence is unusual in that there is a neglible amount of delta front sediments and the distributary channel cuts into a thin sequence of prodelta shales. This suggests a shallow epicontental sea with a very broad, gently sloping shelf where the course of fluvial channels and delta lobes were not much influenced by gradient or paleoslope. Distributary channel courses were



Ridenhower Shale ("Paint Creek" shale)
thin prodelta and delta front sequence with marine influence; largely shale with fine-grained sandstone and siltstone lenses, some containing marine fossils (Archimedes, brachiopods, and crinoid fragments); shale has large amounts of carbonaceous plant hash.

Cypress Sandstone
massively bedded, medium- to fine-grained, well indurated sandstone with low-angle cross-bedding; interference ripple marks with scattered mica flakes; shale clasts imbricated along bedding planes

Lateral geometry of Cypress Sandstone and association with prodelta and delta front deposits indicates that the sandstone was deposited in a distributary channel-bar environment. ISGS 1982

FIGURE 9. Schematic diagram of the Cypress Sandstone and Ridenhower ("Paint Creek") Shale at Stop 2. The Cypress Sandstone represents a distributary channel mouth bar deposit cutting into the prodelta and distal delta front sediments of the underlying Ridenhower ("Paint Creek") Shale.

diverted often, shifting the areas of delta progradation; this has resulted in thin, deltaic sequences with delta-front sediments commonly missing.

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3 Cypress Sandstone. Located south of Bay City, Illinois, Sec. 1, T. 15 S , R. 6 E., Smithland 7.5-minute Quadrangle.

Approximately 20 feet of fine-grained sandstone is deposited in delta front and interdistributary environments here (figs. 10,11). Stacked layers of thin, interference rippled sandstone beds containing muscovite mica flakes are interbedded with more massive beds 1.5 to.5 feet thick. These beds occasionally have small-scale, low-angle, trough cross-beds with shale clasts aligned along the bedding planes. Iron-stained, petrified, woody stem fragments are scattered throughout much of the sandstone. The base of the sandstone is marked by concentrations of coalified plant fragments consisting largely of *Lepidodendron* woody stems (figure 10).

Directly underlying the sandstone is a zone of flaser bedding consisting of rippled interlaminations of sandstone and shale caused by intervals of bed-load deposition of sand ripples and subsequent lower-energy suspension deposition of clay that filled in the troughs in the underlying sand. Flaser bedding is often attributed to ebb and flood tidal deposition; however, flaser bedding may be produced in any environment where there are alternating episodes of bed-load and suspension deposition.

Beneath the flaser beds there are some lenses of very fine-grained sandstone and siltstone that are underlain by approximately 10 feet of horizontally laminated light gray to dark gray shale possibly deposited in a prodelta environment. Concentrations of carbonaceous plant fragments are found throughout the shale. These fragments have either been transported some

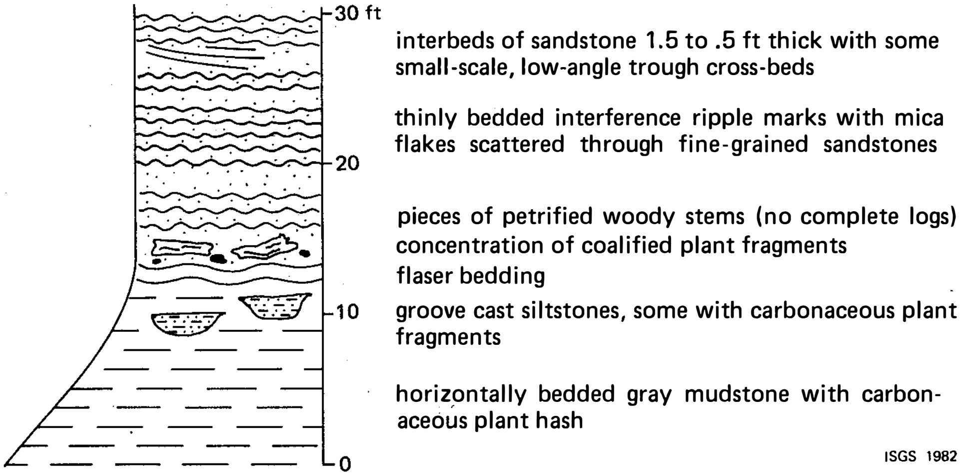

FIGURE 10. Vertical section of Cypress Sandstone and Ridenhower ("Paint Creek") Shale at Stop 3. The base of the sandstone has a concentration of pieces of carbonized woody stems; the sandstone has characteristics of both crevasse splay and delta front facies. The sandstone (Cypress) appears to thin at the north end of the outcrop, indicating a crevasse splay—a type of overbank deposit—rather than a delta front facies, which is a more continuous sheet sandstone deposit.

FIGURE 11. Thin-bedded Cypress Sandstone overlying Ridenhower ("Paint Creek") Shale. (A) Stacked layers of interference ripples of micaceous sandstone; (B) interbedded with sandstone layers (1.5 to .5 ft thick) that occasionally contain low-angle, small-scale, trough cross-beds with shale clasts imbricated along bedding plains; (C) concentrations of carbonized woody stem pieces; (D) Ridenhower ("Paint Creek") Shale with carbonaceous plant hash. Prodelta and possibly distal delta front environment are represented in the shale. Note lateral thinning of the sandstone. Grooved siltstone load casts are found in the shale.

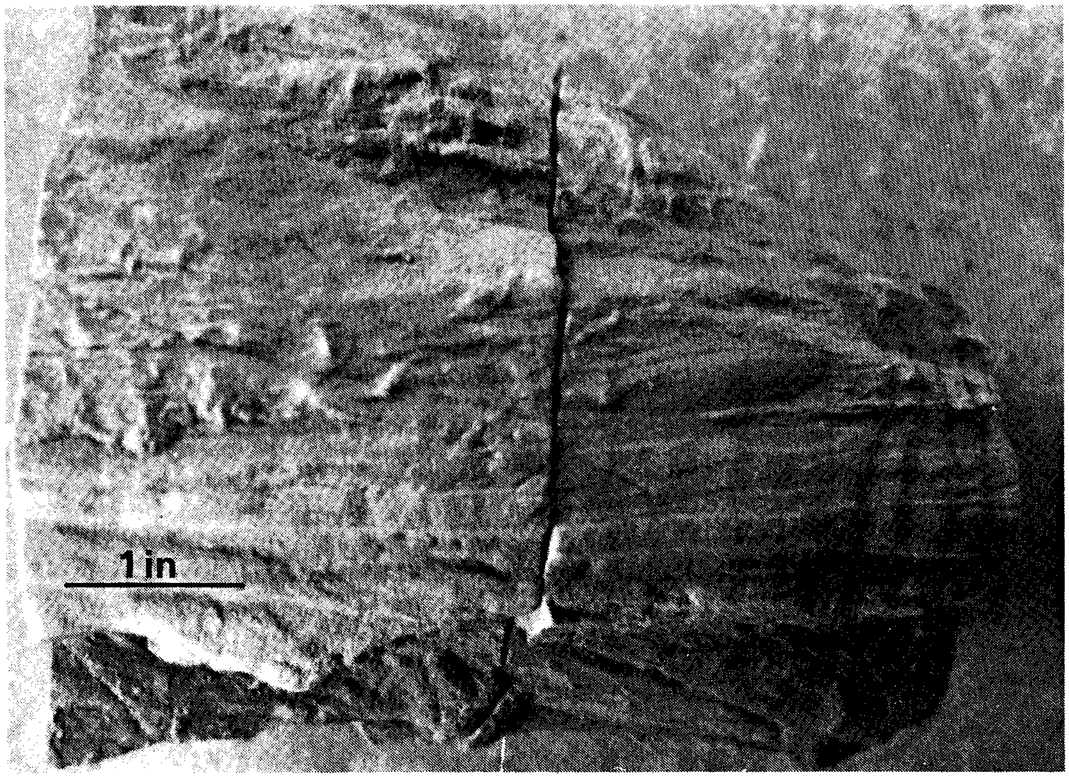

FIGURE 12. Underside of grooved siltstone load cast in shale at Stop 3.

distance from the delta plain or are more locally derived from interdistributary bay swamps and marshes. Grooved, siltstone load-casts containing plant hash (fig. 12) are scattered through the shale; these are excellent indicators of paleocurrents and transport directions. The grooves on the load-casts are oriented east-west, from which an eastern source is inferred.

The Cypress at this locale has characteristics of both crevasse splay (localized deposits of sediments carried over the banks of a channel during flooding) and delta front facies. Micaceous rippled sandstone, concentrations of carbonized and limonitic woody stems and trunks from *Lepidodendron*, iron-stained clasts, flaser bedding at the base of the sandstone, grooved siltstone load casts, and lateral thinning of the sandstone all suggest an overbank crevasse splay facies. Rippled sandstone with shale clasts aligned along bedding planes, and low-angle cross-bedding are also characteristic of the more laterally extensive delta front facies.

Horizontally bedded laminae of gray shale with carbonized plant hash, plant remains no larger than fragment size deposited directly over the upper part of the "Paint Creek" limestone containing marine fossils such as *Archimedes*, *Pentrimites*, and brachiopods are all features of a prodelta shale. In a typical constructive delta lobe, a delta-front facies would overlie prodelta shales. Given the negligible amount of delta front sediments at Golconda Stop 2, it is possible that an interdistributary crevasse splay directly overlies the fine-grained suspension deposits of the prodelta.

4 Cypress Sandstone. Located on New Liberty Road, Sec. 19, T. 15 S., R. 6 E., Smithland 7.5-minute Quadrangle.

Units in this outcrop, identified as Cypress Sandstone by Ross (1964), dip about 30 degrees to the south-southwest and appear to be on the flanks of a small southwest plunging anticline. In figure 13, a schematic diagram of

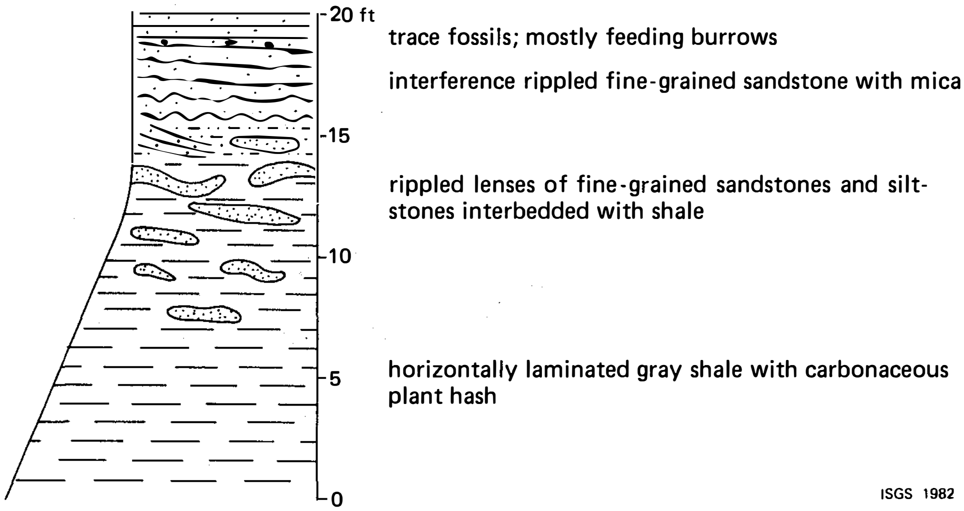

FIGURE 13. Vertical section of upper 20 feet of outcrop of sandstone and shale of the Cypress is roadcut. The facies represented here are probably a prodelta, distal delta front sequence, or an interdistributary swamp or marsh environment.

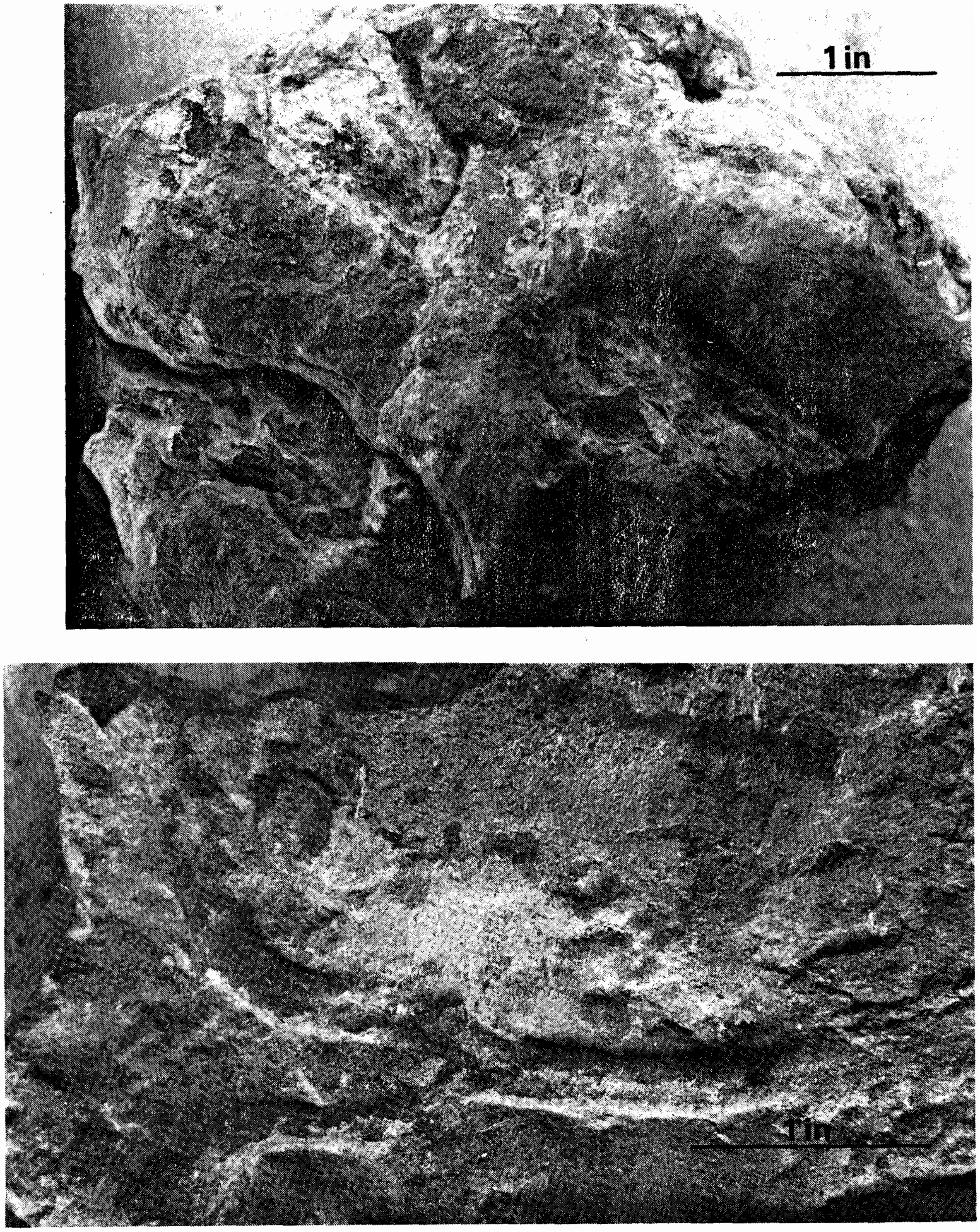

FIGURE 14. Two types of feeding burrows found in the Cypress Sandstone at Stop 4. These are casts of the actual burrows made by organisms feeding on the nutrients in the bottom sediments. The burrows were formed in the sandlayers underlying the casts.

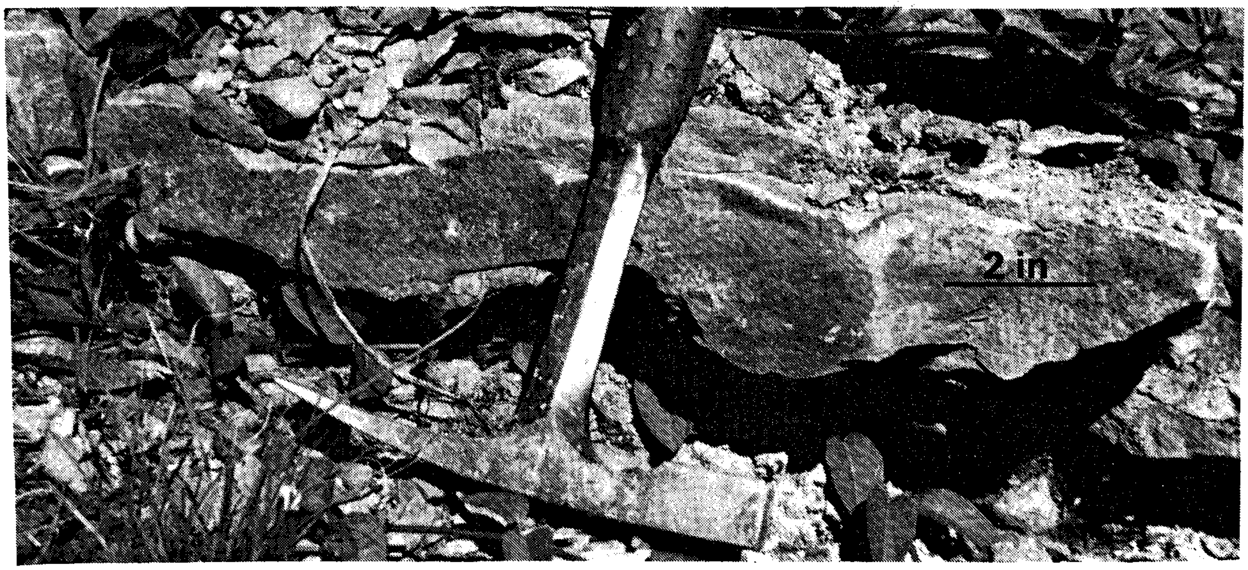

FIGURE 15. Rippled, fine-grained Cypress sandstone lenses interbedded with shale and siltstone at Stop 4.

part of the outcrop, fine- to medium-grained rippled sandstone is shown interbedded with gray to dark-gray shale containing plant hash.

Several types of trace fossils are found at this locale (fig. 14); they were produced primarily by organisms that fed along the fine-grained bottom sediments. This slightly micaceous sandstone contains layers of interference ripples, indicating multidirectional currents.

There is a 5-foot zone grading upward from horizontally laminated medium- to dark-gray shale with terrestrially derived plant hash containing rippled, rolled and/or distorted lenses of siltstones and very fine-grained sandstones (fig. 15) to fine-grained sandstone. This may represent a transition from a prodelta to delta-front facies in a sequence of delta progradation.

Sedimentary features at this locale suggest deposition in environments exposed to wave activity but juxtaposed to the more terrestrial delta plain facies of a delta system. They probably represent an interdistributary bay, distributary channel fill, or other environments near the fringe of the prodelta.

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5 **Lunch, Fort Massac State Park.**

6 **Downeys Bluff ("upper Renault") Limestone through Cypress Sandstone. Located at Indian Point, 1.5 miles east of Belknap, Illinois, Sec. 32, T. 13 S., R. 3 E., Karnak 7.5-minute Quadrangle.**

This is one of the most complete sections of Lower Chesterian strata in Illinois (fig. 16). The upper part of the Downeys Bluff ("upper Renault") Limestone through the Cypress Sandstone is exposed along the railroad cut or the bluff at Indian Point. Most of the Ridenhower ("Paint Creek") Shale is poorly exposed. Look for gully washes and limestone benches. The railroad cut exposes approximately 10 feet of Downeys Bluff Limestone, a clastic carbonate composed almost completely of disintegrated crinoids and blastoids, including numerous compact *Pentrimites* calyces.

Figure 17 shows the typical composition of the limestone. The bedding is rippled and is similar to the wavy bedding of the overlying Bethel Sandstone (fig. 18). The clastic carbonate with wavy bedding (probably caused by interference ripples) was deposited in very shallow water where multidirectional waves could act upon the sediments. The upper two feet of the Downeys Bluff has a greater variety of fossils than the lower part. These fossils suggest an interdistributary bay assemblage including pelecypods, gastropods (snails), and brachiopods, transported from a marine, subaqueous

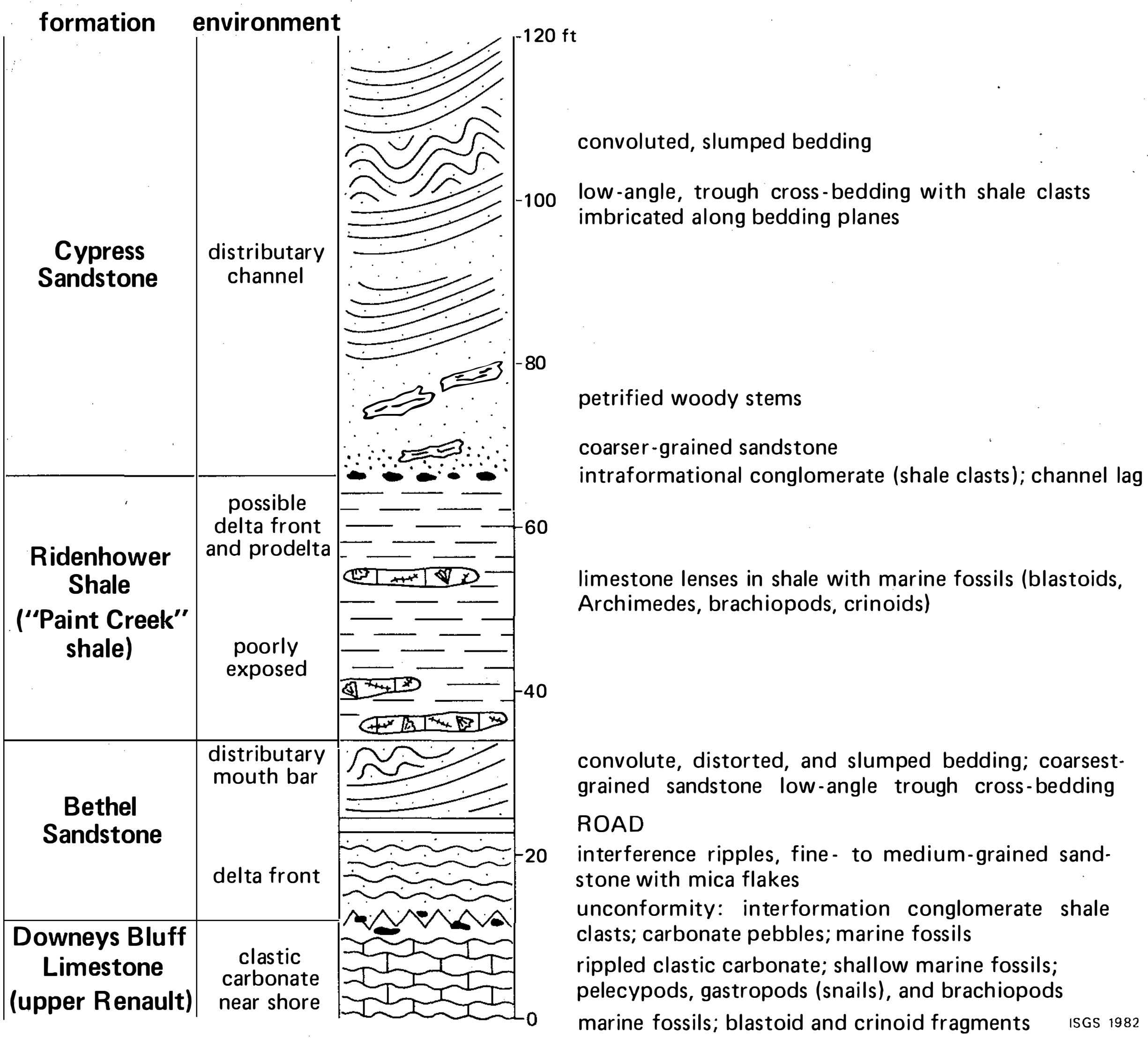

FIGURE 16. Outcrop of Downeys Bluff ("upper Renault") Limestone through Cypress Sandstone, at Stop 6. At this location the mode of deposition in the Bethel Sandstone changed from a delta front facies to a distributary mouth bar; the delta lobe was subsequently abandoned and the marine limestones and shales of the "Paint Creek" were deposited. The contact between the "Paint Creek" Shale and Cypress Sandstone is not visible; consequently, its nature is unknown.

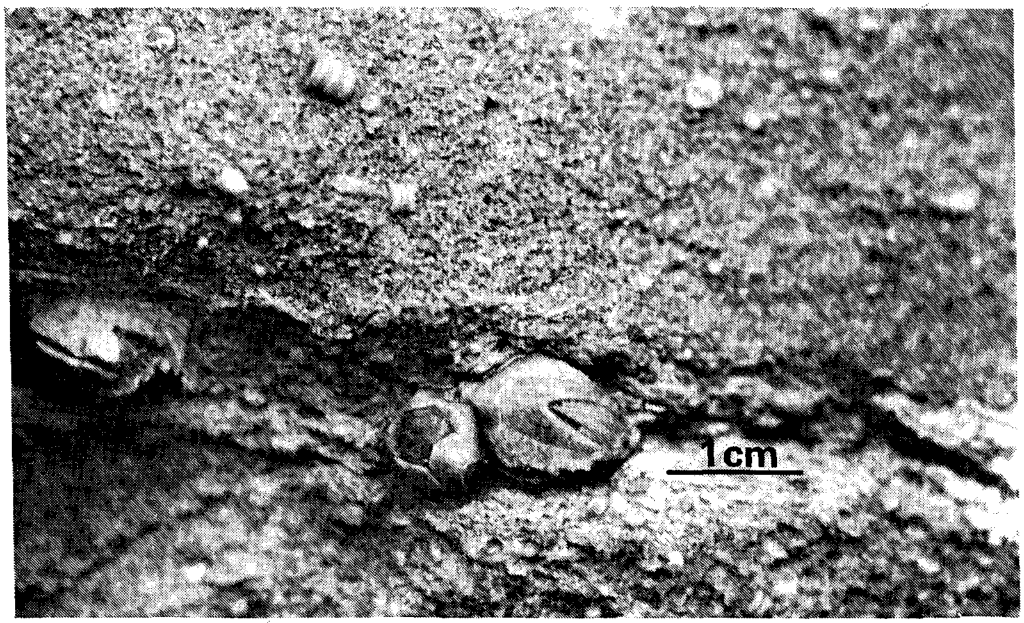

FIGURE 17. Downeys Bluff ("upper Renault") Limestone at Stop 6. Clastic carbonate composed almost entirely of blastoid and crinoid fragments. Pentrimite calyces are intact because their compactness increased their durability, enabling them to withstand transport over greater distances than other segments of the organism.

portion of a delta complex shallower than that which supplied the crinoid and blastoid fragments.

The Bethel Sandstone unconformably overlies the Downeys Bluff Limestone. The unconformity is marked by an interformational conglomerate consisting of shale clasts, carbonate pebbles, and marine fossils. The sandstone (Bethel) exposed along the railroad cut consists of stacked layers of interference ripples in fine-grained sandstone (fig. 18). Weathering has etched the sandstone, revealing the internal structure of cross laminae in individual ripples and shale flakes aligned along bedding planes.

At the top of the railroad cut is a bedding plane exposure of the Bethel offering a three-dimensional view of interference ripples in the sandstone. The mode of deposition of the Bethel Sandstone changes from a shallow marine-dominated delta front environment in the lower 10 feet to a distributary mouth bar environment in the upper 10 feet. The Bethel is topped by marine shales and limestone lenses with many *Pentrimites, Archimides,* brachiopods, and crinoids.

The transition from Ridenhower to Cypress is not exposed. The Ridenhower may represent an abandonment phase of the deltaic front and distributary mouth-bar deposits of the Bethel Sandstone. A marine transgression or cut-off of a distributary channel may have caused a shifting of delta lobes. Whatever the cause, the environment of deposition has changed from distributary channel to marine shelf.

The base of the Cypress Sandstone has an intraformational lag conglomerate of large iron-stained shale clasts that are in relatively coarse-grained sandstone in the lower one foot of the exposure. Fragments of woody stems are commonly found through much of the sandstone. The characteristic sedimentary structures include low-angle trough cross-bedding with shale clasts, and con-

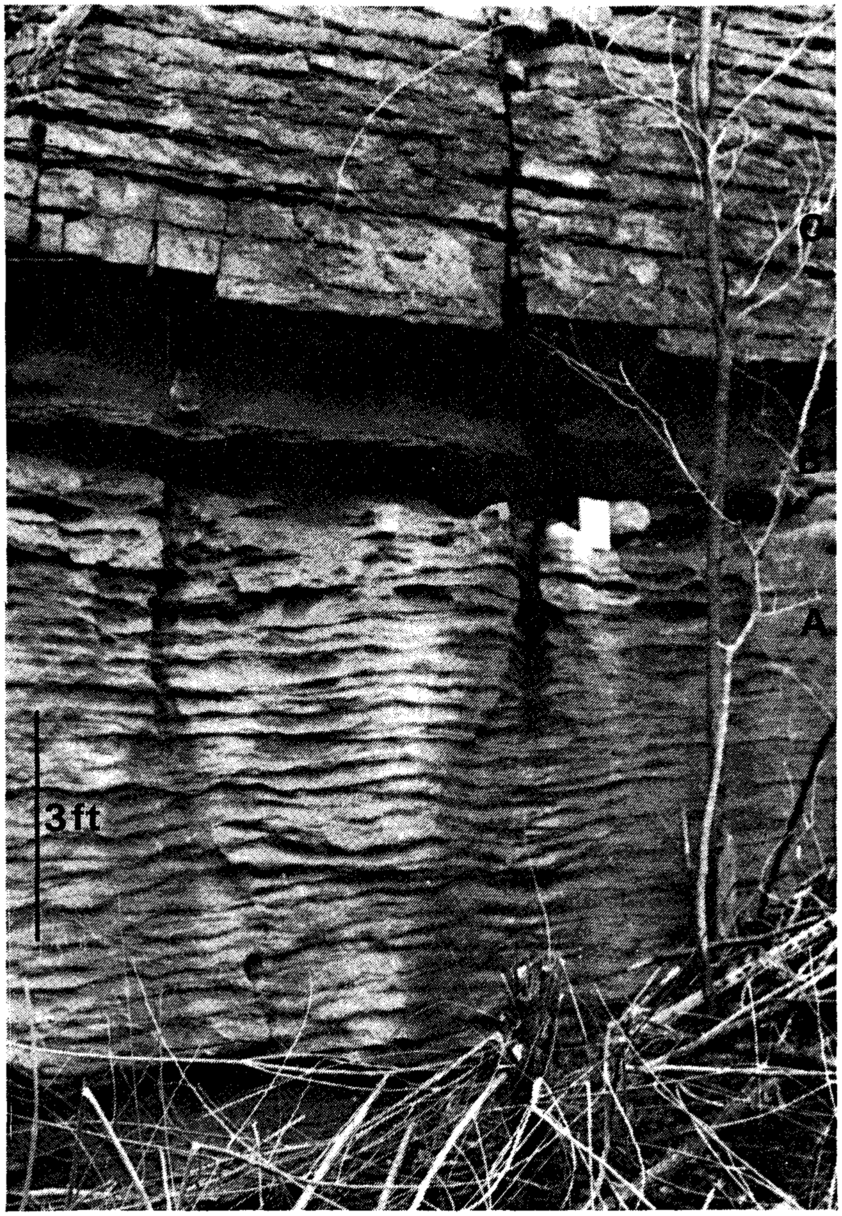

FIGURE 18. Exposure of Downeys Bluff ("upper Renault") Limestone and Bethel Sandstone. (A) Downeys Bluff Limestone is clastic carbonate, consisting mostly of blastoid and crinoid fragments. The upper 2 feet contains a variety of fossils, including pelecypods, gastropods, and brachiopods; wavy bedding is composed of stacked layers of interference ripples. (B) At the unconformity between the two units is a conglomerate of shale clasts, carbonate pebbles, and marine fossils such as *Pentrimites* calyces. (C) Wavy bedding of Bethel Sandstone is caused by stacked interference ripples in fine-grained sandstone with shale flakes aligned along bedding planes.

voluted, distorted bedding caused by slumping and deformation of the sediments before consolidation. These are all features typically formed in a distributary channel- mouth bar environment of a delta complex; they represent a constructive phase of delta lobe progradation at this locale.

7 Cypress Sandstone. Located along Interstate 57 north of milepost 28, Sec. 30, T. 12 S., R. 1 E., Anna 7.5-minute Quadrangle.

Approximately 40 feet of relatively unweathered fine- to medium-grained sandstone (Cypress) outcrops along the I-57 roadcut. This locale is unique because a large bedding plane surface is exposed at the top of the roadcut on the eastern side of the northbound lanes. Contacts with higher or lower units are not visible.

A schematic diagram of the most characteristic sedimentary structures, overall geometry, and lateral changes in lithologies in the Cypress Sandstone is shown in figure 19. These structures include very large-scale, low-angle, cross-beds with iron-stained shale clasts and nodules aligned along bedding planes (fig. 20) superimposed on the very large-scale cross-beds (fig. 20, 21).

When viewed in three dimensions at the top of the roadcut, the medium-scale, low-angle, trough cross-beds reveal a series of shallow depressions or scour pits (fig. 22); they are miniature sand dunes with crests and troughs exhibited in this bedding plane exposure. Asymmetrical ripples and conglomerate lags of flat, rounded iron-stained shale clasts are found along the bedding planes of these trough cross-beds.

The sand bodies thin laterally over a distance of approximately 1,000 feet (fig. 19). Areas between the sand bodies contain gray shale with carbonaceous plant hash.

The sandstone (Cypress) at this location represents a distributary channel-bar environment where the lateral extent of sand bodies can be observed. The poorly exposed areas between the sands may contain sediments typically found in a brackish water, swamp, or marsh environment between distributary channels. Thin, localized coals may also be associated with this lower portion of the delta plain. The interdistributary facies is vulnerable to rapid fluctuations in marine and terrestrial influence. A slight change in conditions, such as a flood-caused diversion of channels or a storm surge, may change the environment of an interdistributary area from a brackish, coal-forming marsh or swamp to an interdistributary bay facies with deposition of gray shale containing shallow-water marine fossils.

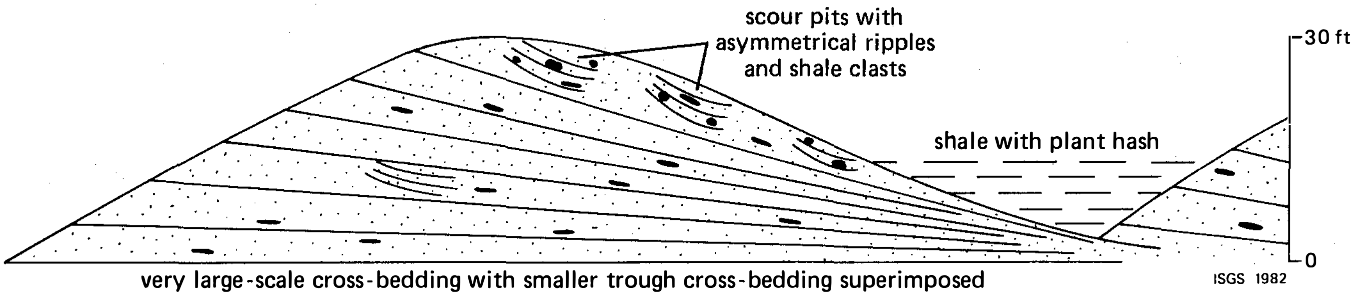

FIGURE 19. Schematic diagram of sandstone (Cypress) at Stop 7. The main feature of this outcrop is the extremely large-scale, low-angle cross-bedding extending across an entire sand body. Small-scale, low-angle trough cross-bedding with shale clasts aligned along bedding planes is superimposed on the large-scale cross-bedding. Gray, horizontally laminated shale with carbonaceous plant hash is found between these sandstone units.

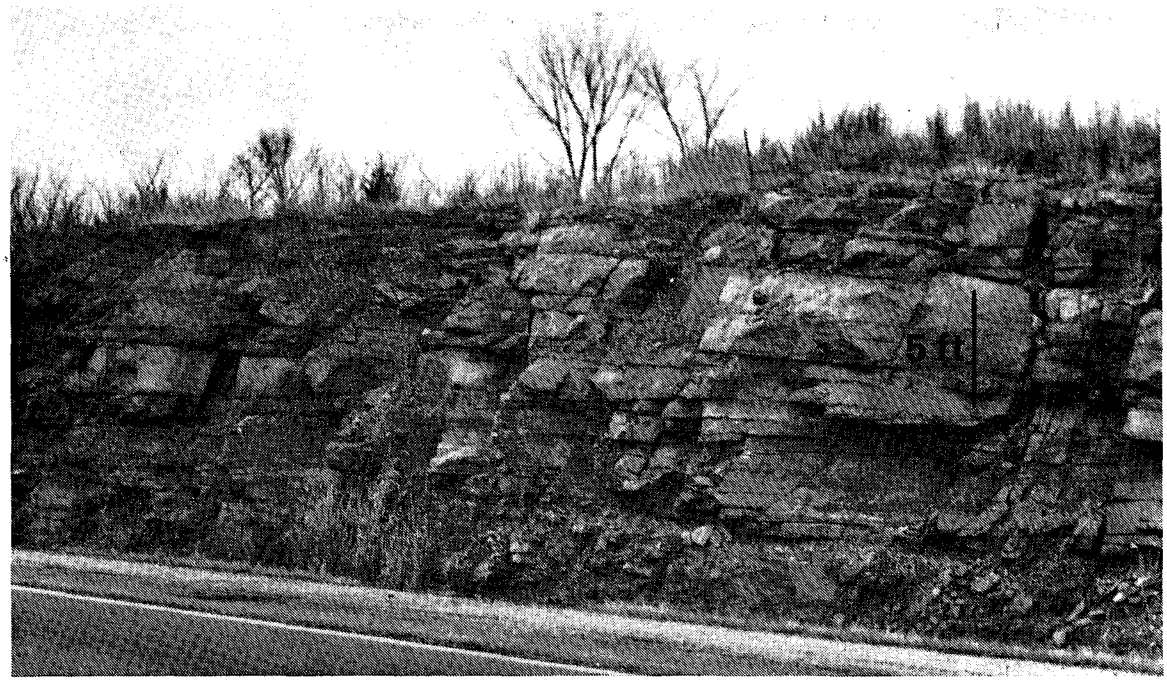

FIGURE 20. Large-scale, low-angle cross-bedding at Stop 7. Maximum thickness of the sandstone (Cypress) is 35 feet. The top of this outcrop has a large area of exposed horizontal bedding planes, offering a three-dimensional view of bedding features.

FIGURE 21. Cypress Sandstone at Stop 7. Fine- to medium-grained sandstone with small-scale, low-angle trough cross-bedding that contains shale clasts superimposed on the large-scale cross-bedding. When seen in three dimensions the trough cross-beds are depressions or scour pits.

FIGURE 22. Exposed bedding plane surface at Stop 7, at the top of the sandstone (Cypress), offering a three-dimensional view of low-angle, trough cross-bedding. The bedding planes of these scour pits have asymmetrical ripples with lags of iron-stained shale clasts and iron nodules aligned along bedding planes.

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8 **Cypress Sandstone. Located at Cypress Creek near Anna, Illinois, Sec. 20, T. 12 S., T. 1 E., Anna 7.5-minute Quadrangle.**

The type section of the Cypress Sandstone is exposed along the roadcut and the bluffs of Cypress Creek. This section is stratigraphically lower than the sandstone at Stop 7 along I-57. The lower contact with the Ridenhower ("Paint Creek") Shale is not visible.

Salient features at this locale are fine-grained sandstone, medium-scale, low-angle, cross-bedding, asymmetrical ripples, convolute bedding caused by distortion of soft sediments, fragments of iron-stained woody stems, and scattered iron nodules (fig. 23).

These features exemplify distributary channel-mouth bar facies near the delta-front environment. The absence of a basal conglomerate such as the one present in the Cypress at Stop 6 and the presence of fewer and smaller woody stem fragments suggests that the sandstone was close to the delta front, and that a more continuous sheet sandstone unit was beginning to form than that found in the Cypress at the other stops east of this location.

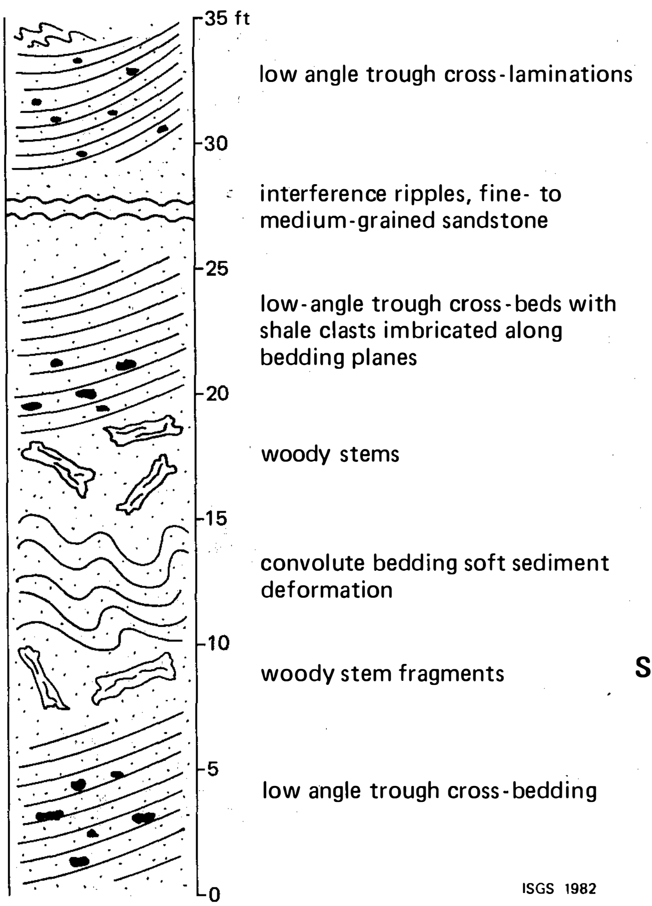


FIGURE 23. Type locality of the Cypress Sandstone along Cypress Creek at Stop 8. This is a combination roadcut and stream bank outcrop. The combination of features found here is indicative of a distributary channel mouth bar facies fringing on the proximal delta front.

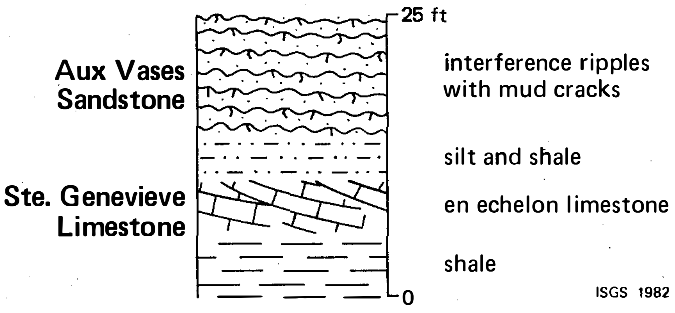


FIGURE 24. Optional Stop. Outcrop of Ste. Genevieve Limestone and Aux Vases Sandstone in roadcut along Rt. 51 north of Anna. The Aux Vases is a fine-grained sandstone consisting of stacked layers of interference ripples. The ripples contain mud-filled cracks that indicate subaerial exposure and perhaps a tidal flat environment. The sandstone conformably overlies the Ste. Genevieve, a shallow marine clastic carbonate. The coarsening-upward sequence of this outcrop represents a regression from a shallow marine environment to a tidal flat environment.

☐ **Optional stop. Outcrop of Ste Genevieve Limestone and Aux Vases Sandstone in roadcut along Route 51 north of Anna.**

9 **Cypress Sandstone. Located 1.5 miles north of Anna, Illinois, NW¼, NW¼, Sec. 9, T. 12 S., R. 1. W., Anna 7.5-minute Quadrangle.**

Approximately 50 feet of Cypress Sandstone is exposed along the bluffs of the Cache River. The Ridenhower ("Paint Creek") Shale is visible in some parts of the Cache River stream bed during periods of low water.

The features seen at this outcrop are very similar to those at Stop 6; they include fine- to medium-grained sandstone, medium-scale, low-angle trough cross-bedding, asymmetrical ripples sometimes associated with the low-angle, trough cross-bedding, and scattered fragments of iron-stained woody stems.

This sandstone, deposited in an environment similar to that of Stop 8, was probably located in the most landward portion of the delta front, where there would have been an influx of terrestrially derived woody plant stems.

☐ **End of trip.**

LOWER CHESTERIAN DEPOSITIONAL ENVIRONMENTS IN THE SUBSURFACE

This is a summary of ongoing research on the depositional environments of Lower Chesterian strata in the subsurface of southeastern Illinois. It is included so that a comparison can be made between the Lower Chesterian depositional environments observed in outcrops in extreme southern Illinois and those found in the subsurface of oil-producing areas of southeastern Illinois. Research to date has shown two basic depositional environments in the Lower Chesterian of southeastern Illinois (fig. 25): The first, present in Area 1, primarily contains prodelta, delta front, and distributary channel-mouth bar facies of the subaqueous part of a delta, similar to those observed in Stops 1-9 of the field trip. The second, in Area 2, was the site of deposition in deeper, more marine water, where the sand bodies were much thicker and more extensive than those in Area 1.

The exact location of the boundary separating the environments of deposition found in Area 1 from those in Area 2 is shown with a solid line off the western flank of the La Salle Anticlinal Belt in Lawrence and southern Crawford Counties (fig. 25). The line is dashed where the boundary is not as well-defined. The western limit of the environment of deposition of Area 2 has not yet been determined; therefore it is marked by a dashed line. However, cross sections of electric logs have shown that sand bodies typical of Area 2 are present from the boundary between Areas 1 and 2 northwest to Louden oil field and southwest to Dale Consolidated field.

Electric logs typical of Area 1 (with SP curves that indicate coarsening-upward sequences representing prodelta, delta front and distributary mouth-bar facies) are shown in the north-south electric log cross section A-A' (figs. 26,27). These facies form the subaqueous part of delta lobes deposited during constructive phases of delta development, occurring when there is a continuous supply of sediment through the same fluvial channel and distributary channel complex for an extended period of time. When coarsening-upward sequences can be traced across the same stratigraphic horizons (e.g., electric logs 3, 4, and 5 in section A-A' (fig. 27), the areal extent of individual delta lobes can be defined. Other partial delta lobes can be identified in logs 1, 2, and 3 in section A-A' (fig. 27). Periods of delta lobe construction were followed by periods of abandonment caused by diversion of fluvial or distributary channels. Abandonment allowed reworking of delta front and distributary mouth-bar sediments by marine processes forming nearshore sand bodies commonly identified in the subsurface.

The thin delta sequences and limited areal extent of the individual delta lobes (fig. 27) indicate short-lived periods of delta construction with

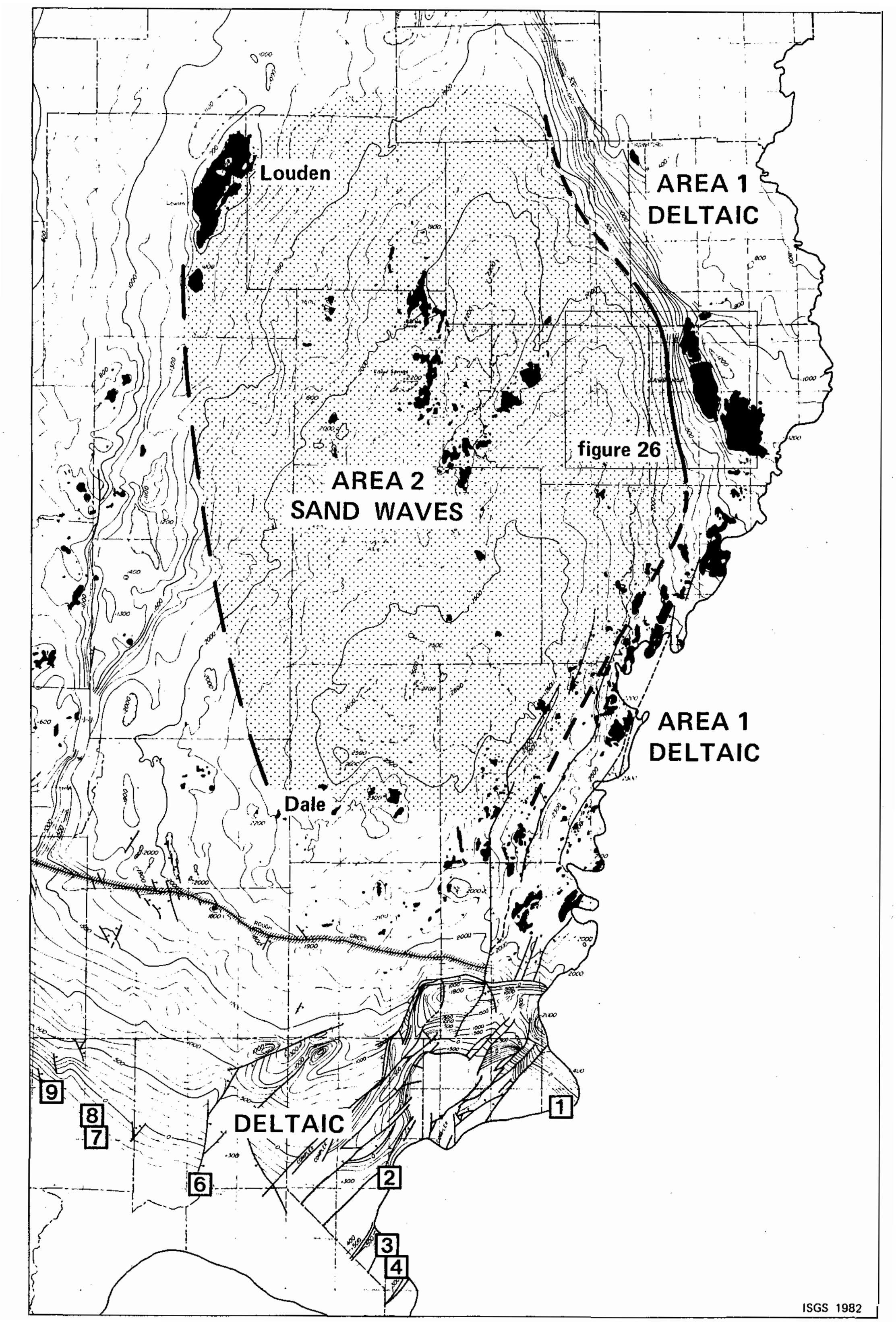


FIGURE 25. Structure map contoured on the base of the Beech Creek ("Barlow") Limestone (Bristol, 1968). Areas of Cypress production are shown in black. Area 1 is the region of deltaic deposition during early Chesterian time. Area 2 contains sand waves deposited in deeper water off the flank of the La Salle Anticlinal Belt. Field trip stops 1-9 are shown at the southern end of the map.

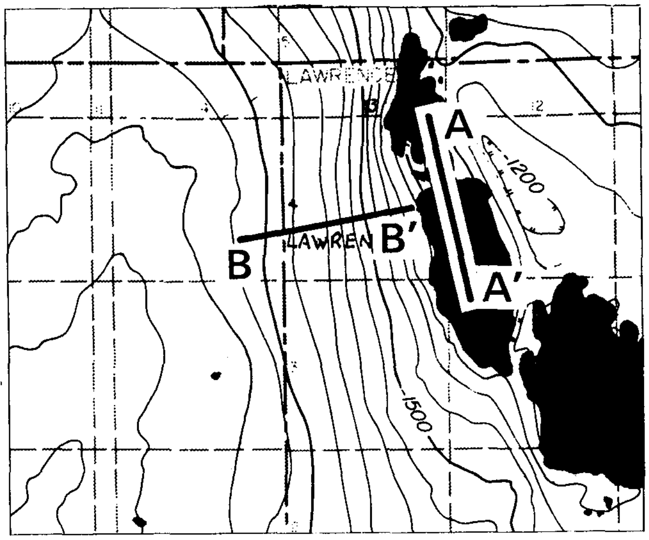


FIGURE 26. Insert from figure 25 showing locations at Sections A-A′ and B-B′ and their relation to the La Salle Anticlinal Belt.

many small fluvial channels entering into the Illinois Basin rather than a single channel constructing a large delta lobe. The mode of deposition of the Lower Chesterian in the subsurface resembles that of the outcrops in extreme southern Illinois. The basic difference between the two areas is due to the significant topographic expression of the La Salle Anticlinal Belt that produced a steep slope along the belt's western flank; this permitted deposition of complete delta sequences, including the most offshore prodelta and delta front facies (fig. 28, logs 8, 9, and 10). The latter two facies are often limited or missing in the Lower Chesterian outcrops that were deposited in a more gently sloping part of the basin.

The Beech Creek Limestone marks a cessation of deltaic deposition in the Illinois Basin. It signifies an extensive marine transgression across the entire basin, possibly due to a eustatic rise in sea level similar to that caused by the melting of continental glaciers in the Pleistocene. The Downeys Bluff Limestone is another relatively extensive marine transgressive unit that may have been caused by a less pronounced eustatic change in sea level.

The submarine sand dune depositional environment of Area 2 (fig. 25) contrasts sharply with the deltaic facies occurring in outcrop and in the subsurface of Area 1 (fig. 25). The thin deltaic coarsening-upward sequences are replaced by blocky SP curves, indicating sand bodies attaining thicknesses of 200 feet. The electric log cross-section B-B' (fig. 28) shows the transition from deltaic deposition at the crest of the La Salle Anticline to the offshore submarine deposition of submarine sand sunes (logs 6 and 7, sec. B-B'). The blocky SP curves indicating an abrupt change from shale to sandstone deposition at the base and top of the sand body are analogous to blocky gamma ray logs of subtidal sand ridges found in the North Sea. The subtidal sand ridges in the North Sea are aligned parallel to the direction of tidal current. Isopach maps of sand bodies in Area 2 show that they are aligned in a north-south direction parallel to the crest of the La Salle Anticline and perpendicular to the probable tidal current direction; therefore, it is suggested that these sand bodies more closely resemble sand waves or submarine sand dunes.

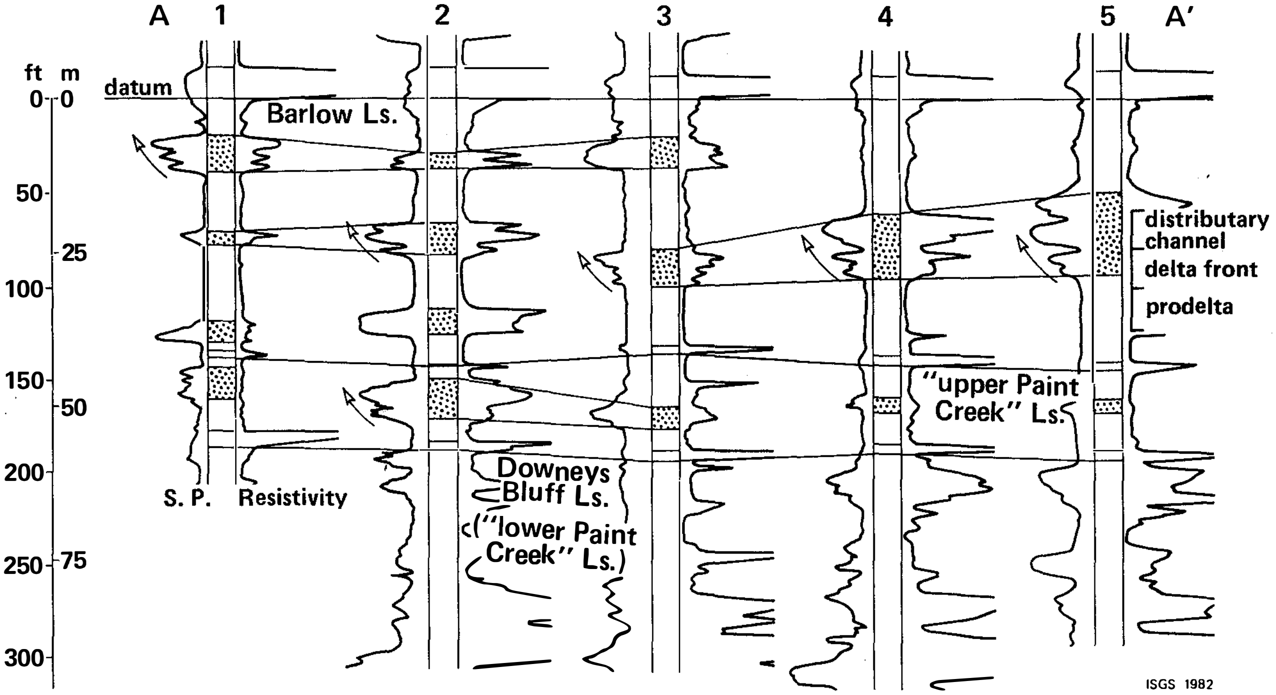


FIGURE 27. Cross section A-A' along the crest of the La Salle Anticline, showing coarsening-upward sequences of prodelta, delta front, distributary mouth bar and channel deposits of delta lobes. The largest is a partial lobe in the Cypress Sandstone (electric logs 3, 4, and 5) where coarsening-upward sequences extend for more than 3 miles. Approximately one mile separates electric logs. Location of cross section is shown on figure 26.

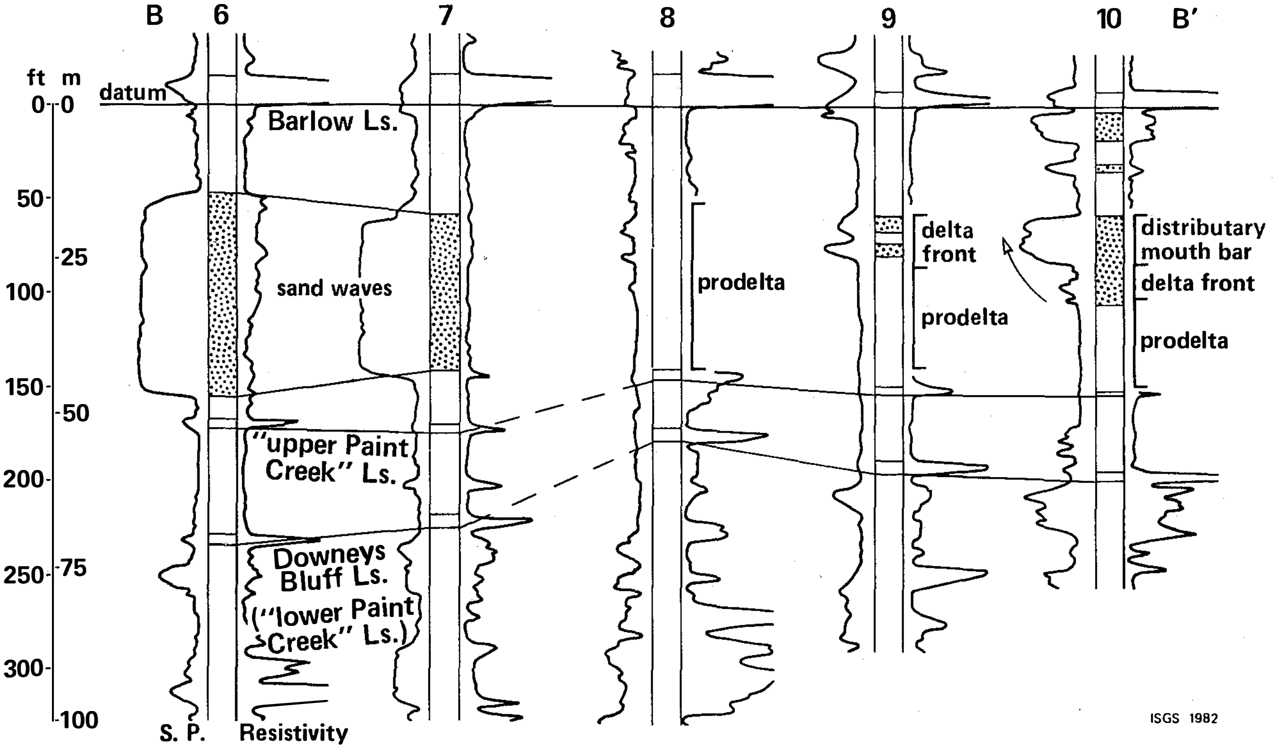
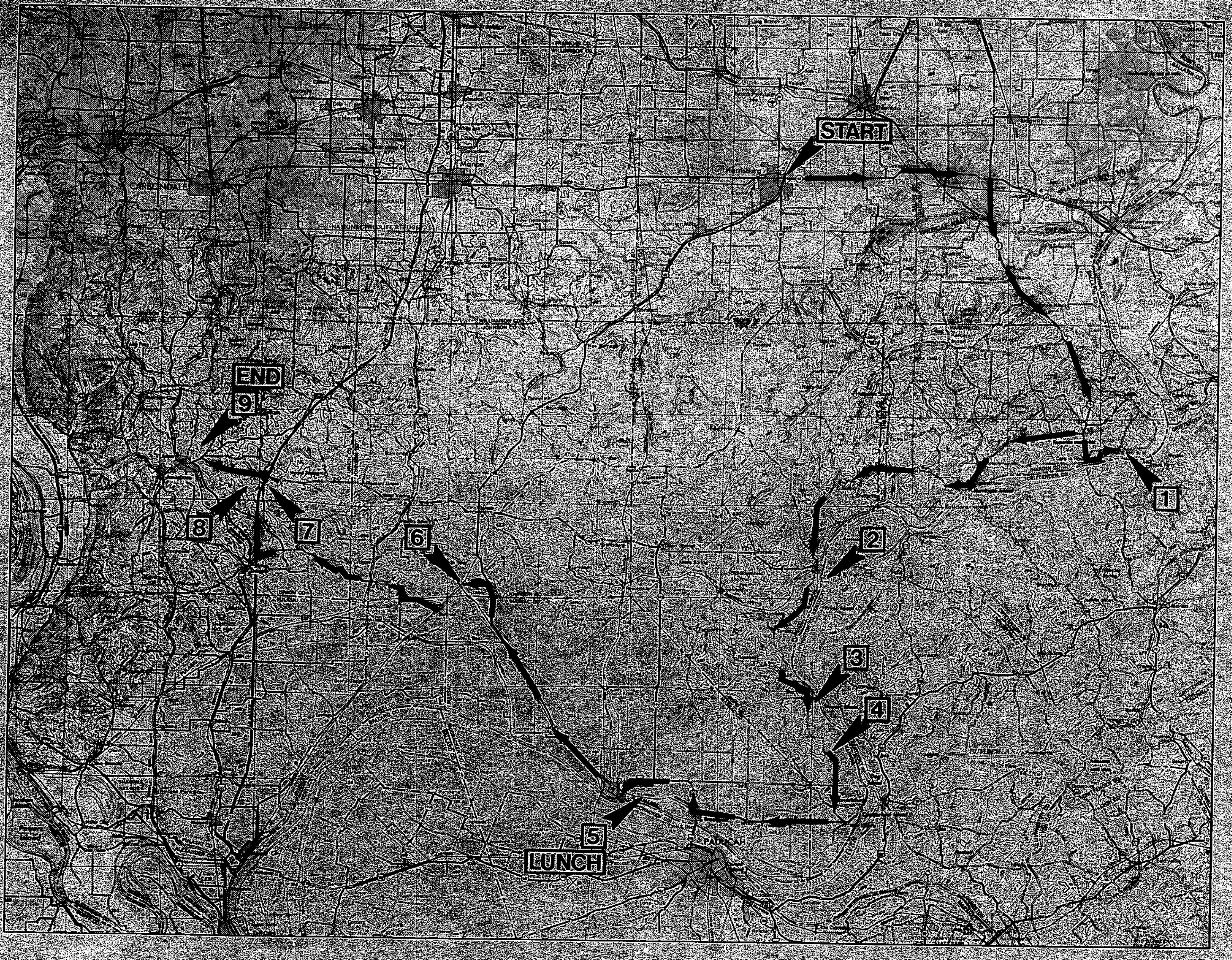


FIGURE 28. Cross section B-B' shows a westward transition from subaqueous delta deposits (represented by electric log 10 with an SP curve indicating a coarsening-upward sequence of prodelta, delta front, and distributary mouth bar deposits at the crest of the La Salle Anticline) to offshore, deeper water deposits of sand waves with blocky SP curves (electric logs 6 and 7). Electric log 9 has little sand, which indicates a prodelta and distal delta front environment. Log 8 is a prodelta shale. Logs are spaced about two miles apart. Location of cross section is shown on figure 26.


START
1
2
3
4
5
LUNCH
6
7
8
9
END