

A Birdfoot Delta in the Subsurface Pennsylvanian of Sullivan County, Indiana

JOHN B. DROSTE, N. GARY LANE AND CHRISTOPHER G. MAPLES*

Department of Geology, Indiana University
Bloomington, Indiana 47405

Introduction

We here describe a small, birdfoot delta of fluvial sandstones and mudstones deposited contemporaneously with and between marine embayments of the Alum Cave Limestone Member of the Dugger Formation, uppermost unit of the Middle Pennsylvanian in Sullivan County, Indiana. During the Pennsylvanian Period Indiana was situated in low southern latitudes near the paleoequator (5 to 15 degrees South) and north of the paleosoutheast Tradewind Belt (1). The preserved record of Pennsylvanian rocks indicates that Indiana was the locus of deposition of predominantly terrigenous sand and mud in valley flat and delta plain environments. Coal-forming environments prevailed during short intervals, and scores of named and unnamed coals are laterally and vertically distributed throughout the sequence. Only about five percent of the preserved rocks record deposition in marine to marginal marine settings, and it is our purpose to interpret the general patterns of sedimentation that occurred during one of these marine episodes in Sullivan County (Figure 1).

Stratigraphy

Pennsylvanian rocks of the Illinois Basin are characterized by many close-spaced vertical and lateral changes in lithology, and local and regional rock unit correlations are made primarily on the position of major coal beds and partly on the position of moderately persistent limestone units.

One of the most exploited and widespread coals of the Illinois Basin, the Springfield, or No. 5, coal, marks the top of the Petersburg Formation in Indiana, near the middle of the Desmoinesian Series. The Alum Cave Limestone Member and associated rocks that directly overlie the Springfield Coal form the base of the Dugger Formation in Indiana. The Alum Cave of Indiana correlates with the St. David Limestone Member of the Carbondale Formation of Illinois and is known by miners in Kentucky as the Pennywinkle rock. The type section of the Alum Cave is near the site of the former town of Alum Cave, Sullivan County (2). Although limestone beds of the Alum Cave are not everywhere present in the subsurface of Sullivan County, their stratigraphic position and laterally equivalent rocks are recognizable throughout the county.

Studies along the outcrop belt in Indiana described marine, marginal marine, and lower delta nonmarine environments in which Alum Cave rocks were deposited (3). A typical section above Springfield Coal in Sullivan County is approximately 1 to 8 feet of brackish-water black shale that marks the onset of marine deposition and then 1 to 5 feet of limestone with or without interbeds of richly fossiliferous gray shale that record the full development of marine environments. A highly bioturbated transition unit of calcareous gray shale 1 to 2 feet thick is situated between the underlying black shale and the overlying limestone. At some places above the coal and laterally equivalent to the marine sections sands and muds were deposited in fluvial environments.

The well-developed coal and limestone beds generally have characteristic electric-log signatures and are correlated easily from well to well. The thick fluvial sandstones generally have characteristic electric-log signatures, but these bodies are not as persistent as are the coal and limestone. Well samples are needed usually to distinguish between fluvial shales and marine shales that are not interbedded in limestone.

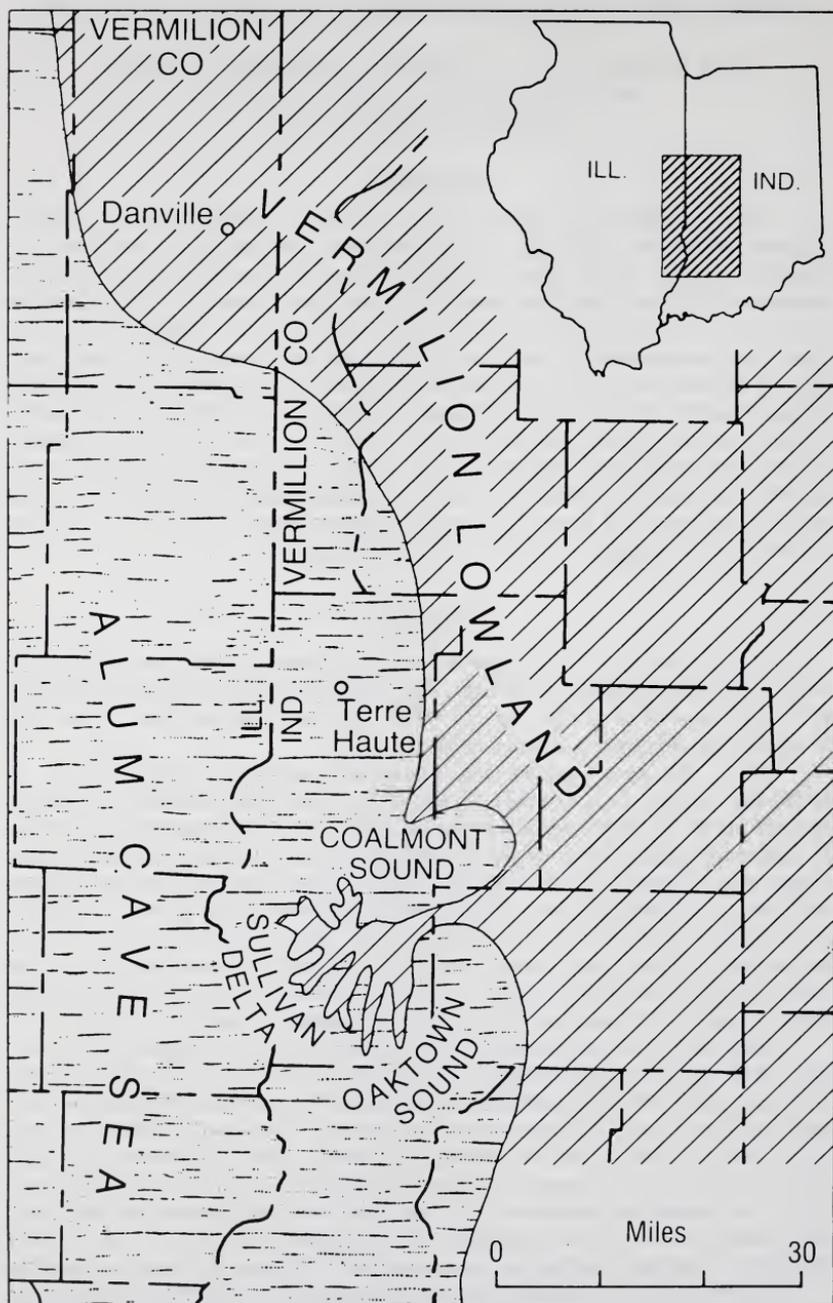


FIGURE 1. Map showing Sullivan and adjacent counties in Indiana and sedimentary facies above Coal 5 in Sullivan County.

Well records for Sullivan County on file in the Petroleum Section, Indiana Geological Survey provided the data for this study. No coal company mine maps and core logs were used. A total of 250 wells provided information in the form of well samples, electric logs and well samples, or only electric logs. The 10 to 20 feet of rocks directly above Coal 5 record the events resulting from flooding of the coal swamp by the sea. Most drillers in Sullivan County have taken samples at 10-foot intervals so at least two samples are available for interpretation.

Alum Cave and Associated Rocks

The swampy environment in which the Springfield Coal formed was very extensive, perhaps the most extensive of all Illinois Basin coal swamps. Here and there streams flowed across the swamp, and fluvial deposits, especially channel sands, accumulated at the same time as the peaty vegetation. Two channel sandstone systems have been identified in Sullivan County as having accumulated at the same time as the Springfield Coal peat (4). These streams entered the county from the east and flowed southward out of the county. As marine waters invaded, the streams aggraded, the water table rose, and less sand was delivered to the lower part of the distributory system. As the plants died the lowest topographic sites in the swamp became the locii of deposition of organic-rich black muds in poorly oxygenated, brackish water.

Marine waters deepened, became more widespread, and better circulation provided a habitat in interdistributory bays for a marine fauna dominated by brachiopods, bryozoans, and echinoderms. The most distal parts of the distributory system were drowned, and fluvial sedimentation as channel and overbank deposits was restricted to near-channel loci (Figure 1). Lobes of a small birdfoot delta separated adjacent bays in Sullivan County. The delta occupied parts of eight townships in Sullivan County (Figure 1). Individual delta lobes were narrow and elongate, ranging from one-half to two miles in width and two to eight miles in length. In other areas where streams were larger, their higher discharges and loads reduced the size of the bays, and marginal marine and nonmarine sedimentation prevailed. Eventually the fluvial regime became widespread throughout the Illinois Basin.

In studies of surface rocks by Maples (3), the macroinvertebrate and trace fossil faunas of inner and outer bays and estuaries can be differentiated. We postulate that in these subsurface rocks interdistributory bay waters became less saline toward the delta apex and increasingly saline distally.

The shape and size of the birdsfoot delta indicates that sandsize terrigenous clastics were in relatively short supply, being confined to narrow strips along distributory channels. This limited distribution probably indicates that the stream supplying the delta had a low gradient and a distant sand source. The delta is strongly asymmetric, with long lobes on the south side and short lobes to the north. This asymmetry may be due to relative supply of sand to the two sides by a generally southwest-flowing river. Alternatively, this difference could be due to differences in strength of waves, currents, or tides on the two sides of the delta. We note that the delta was situated within a large area of marine rocks to the west that represents a marine embayment along the west edge of the Illinois Basin.

The regional subaerial delta plain herein is named the Vermilion Lowland (Figure 2) after Vermilion County, Illinois, and Vermillion County, Indiana where extensive nonmarine strata throughout the stratigraphic interval between Coal 2 and Coal 7 have been described (6). The small delta built seaward in Sullivan County, Indiana, is named the Sullivan Delta. The Sullivan Delta is bounded on the north by the Coalmont Sound, named for Coalmont, Greene County, Indiana, which is the town (figure 1) nearest to the Alum Cave type section. The Sullivan Delta is bounded on the south by the Oaktown Sound, named after a town (Figure 1) in northern Knox County, Indiana.

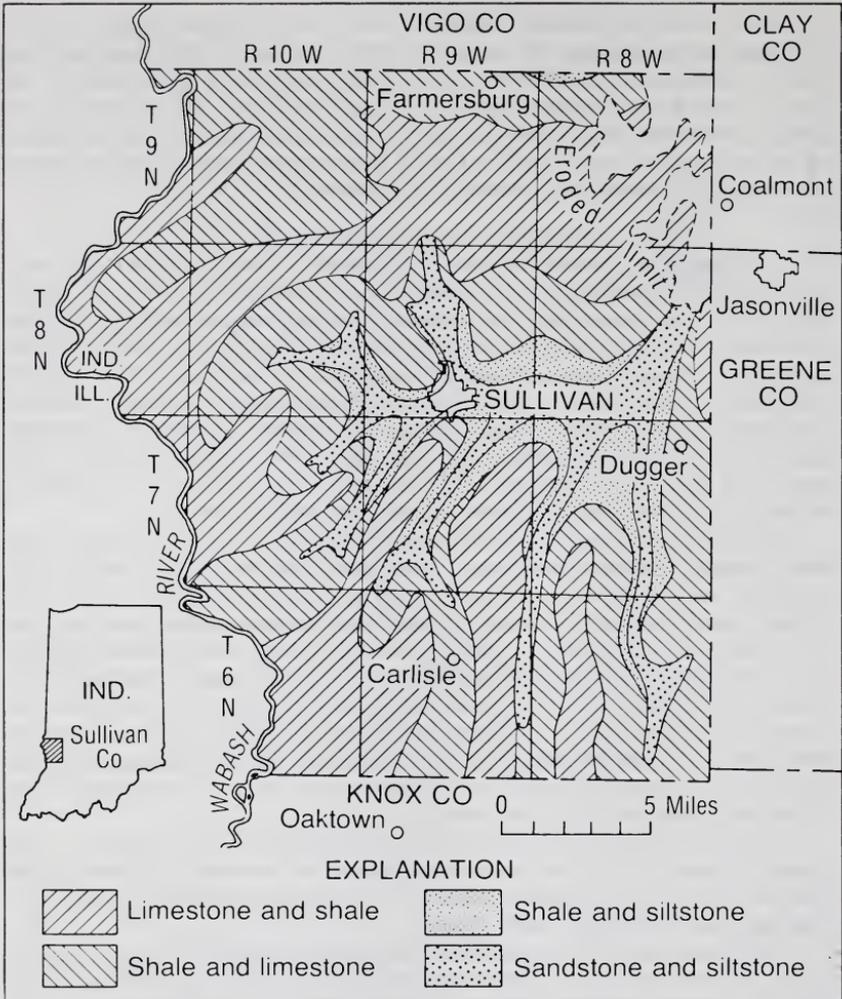


FIGURE 2. Map showing paleogeography in Alum Cave time.

Finally, we suggest that the Springfield coal that underlies the freshwater distributary delta lobes may have a lower sulfur content than does the coal underlying the marine interdistributary bays.

Acknowledgments

Donald L. Eggert and Denver Harper, geologists in the Coal Section, Indiana Geological Survey, discussed stratigraphic and environmental interpretations with us during the study. Harper kindly allowed us to use his recent unpublished map of Sullivan County showing the structure on top of the Springfield coal.

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