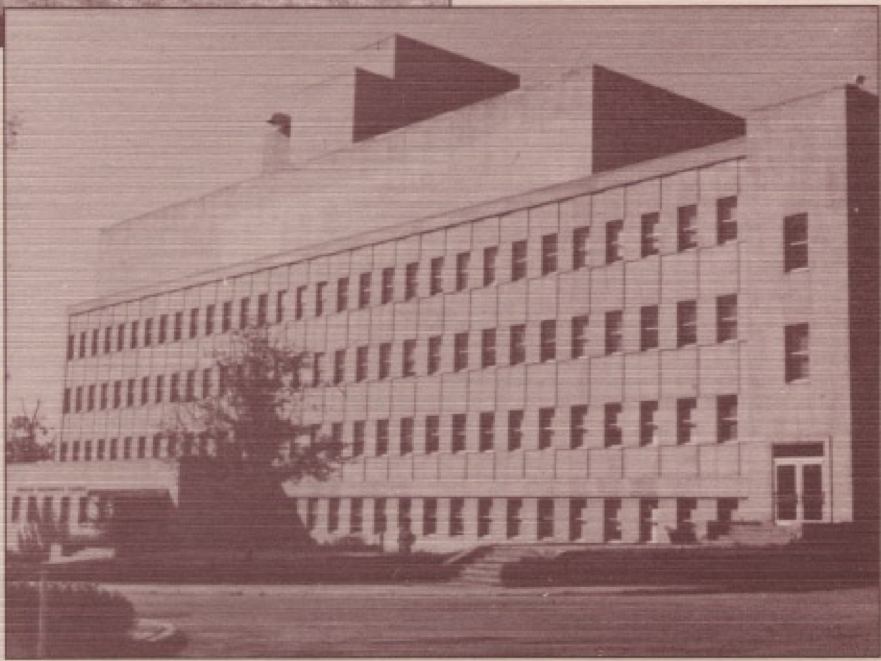
A FIELD GUIDE AND RECOLLECTIONS

THE DAVID DALE OWEN YEARS

TO THE PRESENT



A SESQUICENTENNIAL COMMEMORATION OF SERVICE BY THE GEOLOGICAL SURVEY

State of Indiana Department of Natural Resources

SPECIAL REPORT 44 -c.3

AUTHORS OF THIS REPORT

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FRONT COVER

Two photographs representing earlier days and the present in 150 years of existence of the Geological Survey; top, the fourth David Dale Owen laboratory in New Harmony, construction beginning in the 1850's; bottom, the Geological Survey wing of the Geology Building on the Indiana University campus in Bloomington, construction during 1962 to 1964.

BACK COVER

Three photographs representing the then and now of the Owen family heritage in New Harmony; top, David Dale Owen, 1807-60, Father of the Geological Survey; middle, Richard Owen, 1810-90, second State Geologist; and bottom, Kenneth Dale Owen, 1903-, Houston geologist and oil operator and present keeper of the Owen properties in New Harmony. Photographs through the courtesy of the Indiana University Archives and Kenneth Dale Owen.

A Field Guide and Recollections
The David Dale Owen Years to the Present
A Sesquicentennial Commemoration of Service by the Geological Survey

Edited by ROBERT H. SHAVER

DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY SPECIAL REPORT 44

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By Robert H. Shaver

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A GEOLOGIC ODYSSEY

One hundred and fifty years ago marked the beginnings of a remarkable geologic odyssey funded by the State of Indiana. The legislature of this then pioneer state appropriated less than $2,000 annually for David Dale Owen to conduct a geological survey of the state, which, as one of my neighbors is fond of pointing out, "apparently has never been finished, but why hasn't it?" As it turned out, David Dale Owen accomplished much more than perhaps even the modern state legislature has yet realized. He had been expected, of course, to delineate sources of the raw materials, such as limestone for making burned lime, coal for fuel, stone for building, and clay for bricks and pottery, that would, in time and with discovery of new uses, propel a pioneering region into a modern industrial state. But in the doing he asserted that:

> The Science of Geology, of comparatively modern date, is now universally conceded to be one, not of mere curious inquiry, but of vast practical utility.

True to his belief, Owen made an enormous scientific contribution to geology in North America by successfully transplanting from Europe the geologic ordering of the earth's history, an ordering that was then still in its infancy, that was the makings of modern stratigraphy, and that was hardly more than two decades beyond its inception. Should the reader doubt the efficacy of scientific principle applied to practical, economic geology, let him consider that 150 years ago Owen was able to apply one of the few great geologic principles—nay, he even helped in the continuing discovery of that principle—and say that coal would not be found beyond the western and southwestern confines of the state.

One may appreciate, therefore, and as detailed here especially in the articles by John B. Patton and N. Gary Lane, that David Dale Owen became, through his unsurpassed skill at blending science and practicality in Indiana, in other midwestern states, and as one of the first geologists employed by the United States government, the preeminent "Pioneer Geologist of the Middle West." Surely, the modern Geological Survey is virtually unique among state surveys in the pride of origin to which it points today, and just as surely it is severely challenged to live up to its founding legacy.

The odyssey continued immediately after David Dale Owen's untimely death in 1860 with the appointment of his brother Richard as the second Indiana State Geologist, who carried on the still unfinished geologic work of David Dale. Richard eventually went on to other accomplishments, not directly in our sesquicentennial interests, but including the first offering of geologic instruction at Indiana University and becoming the first president of Purdue University. He is a direct ancestor of Kenneth Dale Owen, the present keeper of the Owen family legacy in New Harmony. (See the back cover.)

As we have seen, the odyssey began with attention to the needs of a pioneer economy, an economy that soon was replaced by that of the Industrial Revolution that had reached Indiana and the nation. As Charles E. Wier's article here portrays, the Geological Survey during the late 1800's and early 1900's occupied itself especially with detailing the geologic occurrence and exploring the uses of potential economic mineral resources. Perhaps no other Survey-sponsored work than that of G. H. Ashley in the Indiana coalfield proved to such an extent the efficiency of David Dale Owen's principle of combined science and practicality.

At the same time, however, another main objective of the Survey was simply to unravel the state's geologic history. Paleontology (study of ancient life) and stratigraphy (historical geology, basically), for example, were their own justification for pursuit and did not require a direct, practically stated objective. After all, this time was the golden era of stratigraphic correlation from region to region and around the world, the golden era of ordering the succession of events in the earth's history. The Geological Survey did admirably fulfill part of its responsibility, therefore, by fostering and publishing the works of several geological scientists whose names were international in their scientific import. It was much of this work that freed the applied geologist from having also to be a generalist, that laid the basis for more efficient use of economic resources, and that even provided the ideas that led to entirely new vistas in exploration. Such exploration had extended, since Owen's day, into the subsurface realm of oil and gas and had made possible an array of stone products unfamiliar to the geologists at New Harmony.

To give but one example, we note that geological scientists Edgar R. Cumings and Robert R. Shrock, who by publishing in 1928 a monographic and thoroughly scientific treatment in a Department of Conservation outlet, unraveled what had been a geologic enigma for the strange fossil structures in Indiana now known to represent ancient reefs. Because they did so, their guiding principles have come to be used repeatedly in treatments of Silurian reefs throughout the Great Lakes area, whether these later citations have been related to the production of special stone products from near-surface reefs or to the production of oil and gas from those reefs that are buried in the subsurface. Does more need to be said of David Dale Owen's assertion as our recollection of the odyssey continues?

This odyssey eventually entered the post-World War II era with its aspirations of a brave new society, an expanded population, and a vastly expanded economy that was born of technologic progress and that featured complexities of interaction never hinted at 50 years before. The Geological Survey, as if in response, was greatly expanded under the tutelage of Charles F. Deiss. The old needs, related to both old and new economic minerals and to especially basic subsurface geology, were still there but in expanded and more complex scopes. Later on, during the John B. Patton administration, the Survey programs began to reflect more and more the concern that the populace felt for the natural environment. "Environmental geology," which referred to activities that the Geological Survey had pursued for many years, finally became a buzz phrase. Simultaneously, the era of specialists came upon us. Geophysics, geochemistry, sedimentology, and paleoecology became the glamorous new frontiers in geology. But many geologically related needs and problems, such as those addressed by geological surveys, are not amenable to solutions wrought by single specialists. The age of *teams* of specialists had also arrived.

The modern Geological Survey, therefore, finds itself at once doing these exemplary kinds of diverse things: writing a geologic account of a proposed Boy Scout campsite that needs to challenge educationally, physically, and imaginatively an impressionable youth (the task of a geologic generalist); deciphering the complex glacial history and deposits of the Kankakee River basin as a basis for the Division of Water's assessment of water resources in that basin (the work of Quaternary specialists); assessing the potentially devastating effects of a major earthquake in areas of earthquake-prone southwestern Indiana underlain by glacial lake sediments (the work of both generalists and specialists); and investigating the fossil-fuel reserves in thick deposits of oil shales (the work of a team of both generalists and specialists).

Almost unexpectedly, it seems, the modern Geological Survey has found itself challenged by so many needs and by so many directions it could take as to suggest program reorientation in itself. Indeed, one of the new expertises needed is in the many and complex sources of funding of practical geologic investigations. The reclamation of coal stripmined lands in southwestern Indiana is just one of many kinds of projects that require a combination of geologic talents rarely possessed by one person, that require technologic-scientific input other than geologic and that also require, therefore, cooperation of other state agencies or institutions, and that, of further necessity, call simultaneously for complex funding.

We may conclude, probably to the chagrin of my neighbor, that the geological survey of Indiana is far from finished and that he would do well to read Norman C. Hester's account of the "The Geological Survey and the Future" (published separately).

The odyssey we have recollected, like so many geologic activities, had a strong field-oriented emphasis, much more so in the Owen years than at present:

I passed down the north side of the Wabash to Lafayette, thence along the Wea to Crawfordsville, thence to Spencer, and the junction of Eel and White Rivers; and returned through Bloomfield, Washington, Petersburgh and Princeton, to New Harmony.

Sesquicentennial celebrants now have an opportunity to sample a bit of that field-oriented emphasis, both by following in a few of the Owen footsteps around New Harmony (stops 2 and 3 of the field-trip guide) and by actually observing one of the practical problems put to the modern Geological Survey (stop 1, assessment of the erosion problem along the Wabash River at New Harmony).

ACKNOWLEDGMENTS

The staff of the Indiana Geological Survey recognizes its many respondents in business and industry, in government agencies, in educational institutions, and among the general populace who have helped in so many ways, whether in asking or giving advice, to make our work seem meaningful. Many of these respondents have elected to help us celebrate our 150 years of existence, and we are both flattered and grateful. We look forward to a continued and improved record of mutual aid. Thanks go especially to those persons who are an integral part of our formal program and who are official representatives of their industry, agency, or organization.

Very special thanks go to the Indiana Limestone Institute, which provided the paperweights fashioned from Indiana Limestone, the official stone of the State of Indiana, to Kenneth Dale Owen, who opened the historic Owen properties in New Harmony to our tours on October 15, and to the several landowners who kindly gave permission for the field-trip visits.

Many persons provided information, photographs, reviews, and publication services for the articles presented here. They include Aline Cook of the Workingmen's Institute Library in New Harmony, Dolores M. Lahrman of the Indiana University Archives, Kenneth Dale Owen of Houston, Lew Trent and James Strange of the Indiana Division of Water, and Gary Gerard and Donald Hatfield of the New Harmony Town Board. We are grateful to these persons and to all the sesquicentennial celebrants for the fond recollections we have and for helping us with the proper focus for this celebration.

We expect in return that they will judge for themselves the efficacy, as related to the modern Geological Survey, of these David Dale Owen words, repeated here:

The Science of Geology, of comparatively modern date, is now universally conceded to be one, not of mere curious inquiry, but of vast practical utility.

THE SESQUICENTENNIAL OF GEOLOGY IN INDIANA — 1987

By John B. Patton

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INTRODUCTION

No doubt exists that a Geologist for the State of Indiana was appointed 150 years ago, but in designating 1987 as the sesquicentennial anniversary for the beginning of geologic *work* in Indiana, I was somewhat concerned by the fact that Willis S. Blatchley, State Geologist 80 years ago and a person for whose accomplishments I have deep respect, was the author of an article published (1917) in the Proceedings for 1916 of the Indiana Academy

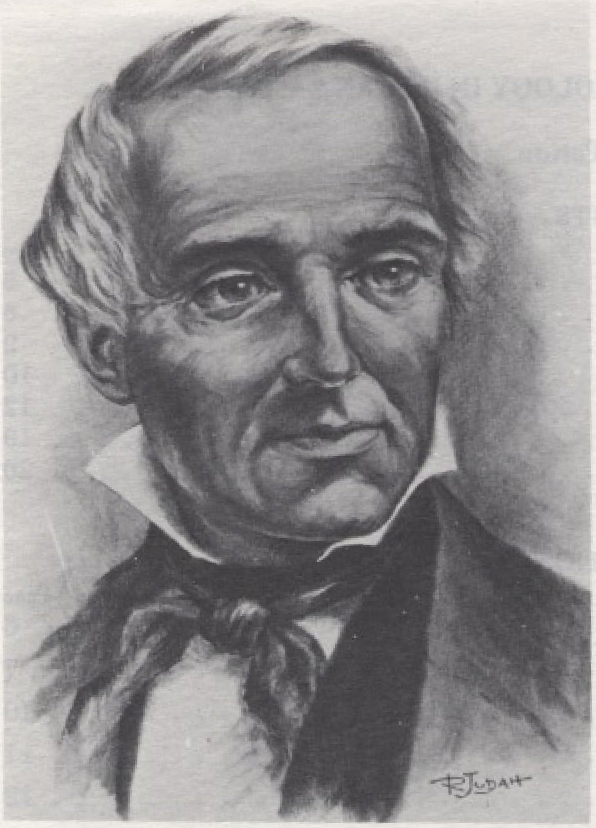

Figure 1. David Dale Owen, Geologist for the State of Indiana, 1837-39; State Geologist, 1859-60.

of Science and named "A Century of Geology in Indiana." Even a person as little inclined toward mathematical approaches as I am known to be recognizes that the century preceding 1916 goes back to the early 1800's, and I set out to determine what early geologic work Blatchley had in mind. These turned out to be William Maclure's (1809, 1818) maps of the then United States; a description, largely nongeologic, of Wyandotte Cave; and topographic reconnaissance, not mapping, for canals, railroads, and turnpikes. I was comforted by Blatchley's words (1917, p. 89) "prior to 1837 there is but little record of work done toward utilizing the mineral resources or determining the geology of Indiana."

A BEGINNING

An act approved by the Indiana legislature on February 6, 1837, began:

Be it enacted by the General Assembly of the State of Indiana, That the Governor be and is hereby authorized and required annually hereafter to appoint and commission a person of talents, integrity, and suitable scientific acquirements as Geologist for the State of Indiana, who shall receive in consideration of his faithful performance of his duties an annual salary not exceeding $1500.00 and necessary expenses not to exceed $250.00, to be paid as the salaries of other civil officers of the State.

Where to find a person of talents, integrity, and suitable scientific acquirements in any sparsely populated frontier state of that era might have proved to be a problem, but Indiana was the home of a person so well fitted for the role that we must wonder whether the position was not created to use his talents. The man was David Dale Owen (fig. 1), one of the sons of Robert Owen, who had purchased the town of New Harmony, on the Wabash River in Posey County, in 1824.

New Harmony was established in 1814 by a group of German extraction led by a man named George Rapp. They had moved from a colony named Harmonie in Pennsylvania, and numerous letters written by them from the new Indiana settlement were datelined Harmonie, Ind. It has been reported that Robert Owen changed the name to New Harmony when he acquired it, but a letter of 1815 from George Rapp to his son Frederick was datelined "Neu Harmony" and used the German spelling "Neu" and ended the word "Harmony" with a "y" instead of "ie" (Arndt, 1975, facing p. 7). The Harmonists, during their 10 years, made no geologic contribution, but they built a physical base of operations in a wilderness, which their successors probably could not and surely would not have done. When Robert Owen, who was a successful industrialist and progressive thinker in New Lanark, Scotland, sought a site in America to test his ideas for social reform, the readymade community of New Harmony was for sale and was purchased.

And how did it happen that David Dale Owen, as well as his brother Richard, became geologists? Surely we must attribute the circumstance in considerable part to the aforementioned William Maclure (fig. 2), a

Figure 2. William Maclure, eminent Scottish geologist and partner with Robert Owen in the New Harmony venture.

Scot who in 1825 became a partner with Robert Owen in the ownership of New Harmony.

Self-trained in geology, Maclure accumulated a fortune in business at an early age and was then able to devote years to his avocations, geology and applied public education, with such success that he has been referred to as the Father of American Geology and the William Smith of America. In fact, the first chapter of G. P. Merrill's "The First 100 Years of American Geology" (1924) is entitled "The Maclurian Era, 1785-1819."

Maclure's reputation was established before he came permanently to North America. His geologic investigations and publications in this country, including some of the first regional maps showing the eastern part of the continent, added to his luster, but this work preceded his investment in New Harmony. In fact, some of it preceded the establishment, under Father George Rapp, of the Harmonists' colony there. Maclure's maps of 1809, before New Harmony was established, and of 1818, after the Harmonist colony was founded, show surficial rocks in Indiana and Illinois Territory to be "Secondary," a name that would place them stratigraphically somewhere within Paleozoic and Mesozoic strata of modern terminology. He continued to publish, mostly on topics of global scale, through 1832, but his work did not emphasize the geology of midwestern North America, although the last two of his American papers were published in New Harmony.

It was Maclure, without doubt, who attracted other eminent geologists to New Harmony and gave the New Harmony cultural and scientific movement a geologic flavor that was unique in the New World. The most lasting impact that Maclure had on American geology may well have been the inspiration that he afforded to the then young David Dale Owen, a person of great talent but without specific direction of interest until after 1835, after Maclure's departure from New Harmony. Maclure himself, his immense collections, and the eminent scientists that he attracted to New Harmony must have been major factors in Owen's decision to become a geologist. For this purpose he entered medical school at Cincinnati and received the M.D. degree, apparently with no intent of becoming a practicing physician but because he regarded medical training as the best method of filling the gaps in his scientific knowledge. He had already some expertise in chemistry, and he thought it necessary to master physiology and anatomy to work with the fossils that were the key to deciphering the geologic record in the Midwest. In 1836, apparently between sessions of his medical training, Owen assisted Dr. Gerard Troost, then State Geologist of Tennessee, in a survey of that state. Troost, a Hollander, had spent a period in New Harmony during 1825 to 1827, when Maclure was there.

In the course of horseback traverses in 1837, Owen determined the stratigraphic succession of the bedrock (Owen, 1838, p.

11-19) and accurately placed the units in relation to the time scale that was evolving for systemic nomenclature in Great Britain. He correctly separated the systems that later became in America the Mississippian and Pennsylvanian, and he distinguished between the rocks that form the present Ordovician and Silurian Systems, even though the Ordovician System was not proposed by Lapworth until 1879. To accompany his report, Owen prepared in 1838 an outline map of the geology of Indiana that was never published but was deposited in the State Library, from which it must have been lost or taken shortly afterward. I am aware of no reference to it except Owen's own in which he described the map in sufficient detail to establish the fact that the boundaries shown must have been essentially the same as those shown on a map printed as part of an Owen paper published in England (1846). To tie the European and American continents together stratigraphically, carrying on precedents set by Maclure and Samuel George Morton, may not seem today to have been a notable accomplishment, but we are speaking of an era in which much of the stratigraphic work was done in a manner that did not offer any correlation of the rocks described with strata elsewhere. Stratigraphic units were most commonly named at the time by their lithologic characteristics, and Owen's were no exception, but their boundaries accorded with those of the classic British systems. His coal formation was the equivalent of the Upper Carboniferous of Great Britain, now the Pennsylvanian System in North America. The map correctly separated British Lower Carboniferous that became our present Mississippian System and the Devonian and Silurian Systems of the time. A boundary that encircled the crest of the Cincinnati Arch delineated the top of the then Lower Silurian that became the Ordovician System. In establishing the time relationship of these units with the classic British type sections, Owen extended traditional stratigraphic treatment into a region more than 6,000 miles from the home base and so furthered the concept of global chronostratigraphy.

The Fenton and Fenton volume "Giants of Geology" (1942, p. 165) commented unfavorably on the tendency for geologists of that time to restrict their interests to the collection and identification of fossils, but they quoted from the first Owen report (1838, p. 4) as follows:

> I have considered it my duty, while surveying a country so new as ours, to remember, that a State just settling, is like a young man starting in life, whom it behooves to secure to himself a competency, before he indulges in unproductive fancies. I have considered it the most important object, to search out the hidden resources of the State, and open new fields of enterprise to her citizens. That object effected, time enough will remain to institute inquiries (which a liberal policy, forbids us to overlook) of a less productive and more abstract character; inquiries which are interesting in a scientific, rather than a commercial, point of view.

The Fentons continued (p. 166), "a sane as well as practical rule, and one which made the man who framed it America's first great economic geologist."

Owen correctly predicted (1838, p. 26) that commercial coal would not be found beneath the uppermost of the limestones that are now classified as Mississippian in age. He called attention to both limestone and sandstone suitable for building stone, to clays and shales usable for ceramic ware, to natural cement rock, to iron ores that would suffice for the small-scale recovery operations of that day, to rock units that could be fashioned into whetstones and rotary grindstones, and to sand and gravel deposits. Owen did not actually discover all of these mineral resources, as most had already been noted and used, but he placed the materials into a geologic order that permitted a scientific approach to their location.

As to the prospect for discovery of certain other types of mineral deposits, Owen observed (1838, p. 30):

> None of the precious metals will ever be found in Indiana, unless in minute portions in boulders * * *.

and (1838, p. 30):

> It is not likely that anthracite coal will ever be found in Indiana * * *.

The Owen survey failed to mention only two of the resources that have contributed in any substantial measure to the mineral economy of the state during the ensuing 144 years: petroleum—and we should remember that his work preceded the drilling of the Drake well at Titusville, Pa., by more than 20 years—and gypsum, which does not appear at the surface and was not recognized as having economic potential until the 1950's.

Political support was strong for continuation of the Indiana survey, but the opposition was also strong. Not until 2 days before the end of the 1839 legislative session was a bill for continuation approved, and it was amended to cover only 1 year instead of the proposed 3 years. Although the bill passed in February 1839, the governor did not immediately appoint Owen for continued service, an action that has been attributed, inconclusively, to political rivalry between the then governor and David Dale Owen's brother Robert Dale. Whatever the cause, reappointment was not offered until June, and by then David Dale Owen was interested in, and was fairly assured of receiving, appointment as a geologist for the federal government. He declined the Indiana appointment. State-supported geologic investigations in Indiana virtually ceased for 20 years, except for employment from 1851 to 1853 of Ryland T. Brown as Geological Agent for the State Board of Agriculture and a single published geologic report (Brown, 1854) that resulted from the assignment.

A HIATUS

Certainly the geologic activities of David Dale Owen and a number of his professional colleagues, including his brother Richard, did not cease, but most of them did not concern Indiana geology. The new federal appointment was as principal agent to explore the mineral lands of the United States beginning July 31, 1839. Since 1807 it had been the policy of the Congress not to sell, but to lease, public lands that contained mineral resources, and to make either disposition of federal lands in the lead-bearing region of Galena, Ill., Dubuque, Iowa, and Mineral Point, Wis., it was necessary to have a geologic appraisal. The House of Representatives called on the President of the United States to communicate to the Congress all information in the possession of the Treasury Department relative to the "location, value, productiveness, and occupancy of public mineral lands," and to cause such further information to be collected and surveys to be made as might be necessary. President Martin Van Buren sent the resolution to the Secretary of the Treasury, who referred it to the Commissioner of the General Land Office. This was James Whitcomb of Indiana, who turned to a fellow Hoosier, David Dale Owen, to carry out the work.

Maclure died in Mexico in 1840, and at the request of Maclure's heirs Owen spent some time classifying the huge Maclure collection, to which he added many items from his own fieldwork. He made a lengthy collecting trip along the Ohio River in 1841, and the resulting two tons of material exceeded the capacity of the building that he was then using as a laboratory, the second in a series. Maclure's sister then gave him a large building (fig. 3), which had been constructed of sandstone and brick by the Harmonists for use as a granary, and which has been called the Old Fort. He remodeled it extensively, and it came to be known as "The Laboratory." It contained storerooms, workrooms, a large lecture hall, and exhibit space. In 1846 the noted British geologist Sir Charles Lyell, with Lady Lyell, was the guest of the Owens, and Sir Charles "spent much time in Owen's laboratory and carefully inspected the fossil and mineral cabinets. In company with Owen he visited various points of geological importance in the neighborhood" (Hendrickson, 1943, p. 69). Soon afterward Owen and Joseph Norwood, who later became State Geologist of Illinois, explored central Kentucky, apparently on their own and without other financial backing.

In March 1847 the Congress created two new land districts and provided for their survey and offer for sale. Owen was appointed in April to survey the Chippewa Land District northeast of the Mississippi River and south of Lake Superior. It was an area the size of the State of New York and mostly without settlements or established transportation routes.

In 1854 the Kentucky Assembly approved a geological survey of that state, and the governor selected Owen to head it. In 1857 the governor of Arkansas offered Owen

Figure 3. Harmonist granary (the "Old Fort"), David Dale Owen's third laboratory and now the property of Kenneth Dale Owen.

appointment as State Geologist for a first survey of that state, and Owen accepted the appointment after arranging with the governor of Kentucky to continue direction of the Kentucky survey without salary. The first report of the Arkansas survey, covering the years 1857 and 1858, was published (Owen, 1858) at a time when the fourth and last of Owen's Kentucky reports was still in preparation.

A RESUMPTION

During the years of Owen's involvement in surveys of the territories and of Kentucky and Arkansas, efforts had continued to resume

Figure 4. David Dale Owen's fourth laboratory, now the New Harmony residence of Kenneth Dale Owen.

state-supported geologic work in Indiana. These efforts were successful in 1859, when the General Assembly authorized a geological survey under the supervision of the State Board of Agriculture and created (anew) the office of State Geologist. The board wished no one but Owen to supervise the work, and Owen accepted the assignment with the provision that his brother Richard would begin the study and pursue it until the Arkansas survey was completed. Richard Owen conducted a 65-day field season beginning in September and returned to New Harmony with 1,000 pounds of specimens. David Dale Owen reported to the State Board of Agriculture in Indianapolis in January 1860 on the progress of the work and plans for the following season, during which Richard Owen concentrated principally on the Coal Measures.

David Dale Owen had in the meantime further complicated his life by undertaking the construction of a new laboratory (fig. 4) in New Harmony to serve the former functions of the old granary. He designed every aspect of the new building and supervised the construction.

Since the 1854 field season in Kentucky he had been in poor health from constant bouts with some fever, and to these miseries were added those of acute rheumatism in October 1860. His biographer, W. B. Hendrickson, recounted (1943, p. 130-131) that Owen was bedfast and dictating the second Arkansas report to two secretaries. His personal physician warned him, "Doctor, if you go on thus * * * you will die in a week." Owen's reply was: "I only want 13 days to finish." He continued dictation until 3 days before his death on November 13, 1860, at the age of 53. J. P. Lesley wrote to James Hall, "Poor Owen is dead, suicide!" which in a sense was

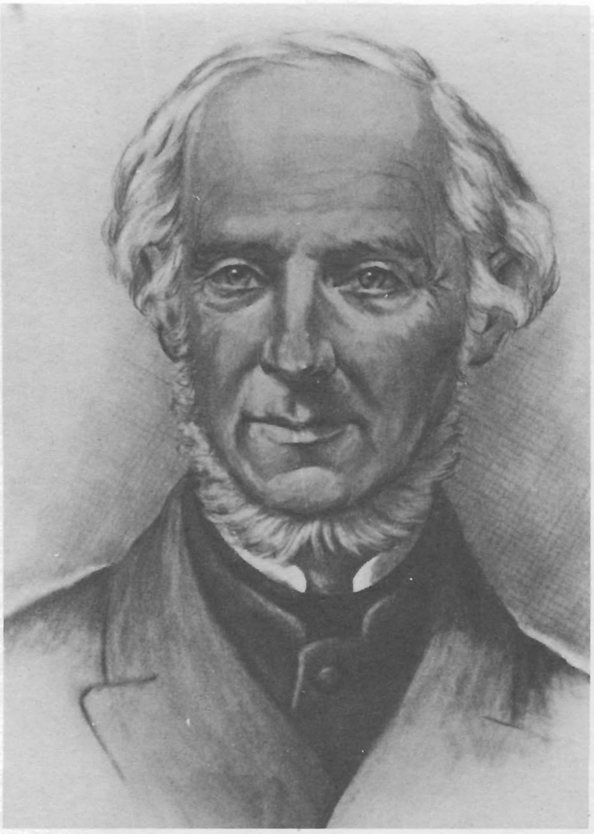

Figure 5. Richard Owen, State Geologist, 1860-61.

true; as Hendrickson observed, "David Dale Owen literally worked himself to death."

The second Indiana survey was completed by Richard Owen (1862 and fig. 5), who was appointed State Geologist succeeding his brother. That the report, except for sections credited to Dr. Robert Peter, Prof. Leo Lesquereux, and Mr. J. P. Lesley, was largely Richard Owen's work is clear, as shown by such entries as a response (1862, p. 184) to an inquiry from Cannelton, Ind., regarding the durability of sandstone for building:

> The freestone of Edinburgh, Scotland, which has stood for centuries unimpaired in buildings and bridges, is from the Coal Measures. And I may add a large granary, erected at New Harmony forty-five years since by the Germans, is from the higher series of the Coal Measures. It seems as substantial as the first day, except at one place where some salted meat by being piled against it, caused some scaling and crumbling.

Kenneth Dale Owen, the great grandson of Richard Owen, and I examined, a few years ago, the sandstone in the building and speculated on its probable source. It seems likely, in view of the transportation facilities of the day, that it came from the locality, a short distance below New Harmony on the Wabash, where a ledge of sandstone forms the rapids that permitted the Harmonists to use waterpower in their mill. Exposures in the adjacent bluff retain no evidence of quarrying, but the stone resembles that used in the building. Whether based on Richard Owen's advice or not, the sandstone from the Mansfield Formation is prominent in the architecture of Cannelton.

The second Owen survey was funded only for the period 1859-61. In May of the latter year, legislation made the State Geologist a member of the Indiana University faculty ex officio, and several published references during the 1860's refer to Richard Owen by that title, although a supporting organization and appropriation did not exist and he was not paid directly by the state.

THE FOUNDING OF A CONTINUING ORGANIZATION

On March 5, 1869, the Indiana General Assembly approved:

> An Act providing for a Geological Survey and for the collecting and preserving of a Geological and Mineralogical Cabinet of the Natural History of this State, and creating the Office of State Geologist, defining his duties, fixing his salary, and appropriating a sufficient sum of money to defray the necessary expenses of said Survey and for the collection and preservation of said Cabinet.

A new organization named the Department of Geology and Natural Science was established under the State Board of Agriculture, and Edward Travers Cox (fig. 6) of New Harmony, a former associate of the Owens in various investigations, was named to head it, which he did for 10 years, turning out 10 annual reports published in seven volumes that contained much information on a wide variety of subjects but in the opinion and words of Blatchley (1917, p. 143) "* * * contained little that was new or impressive." Blatchley attributed this deficiency to the fact that so many of the individual papers

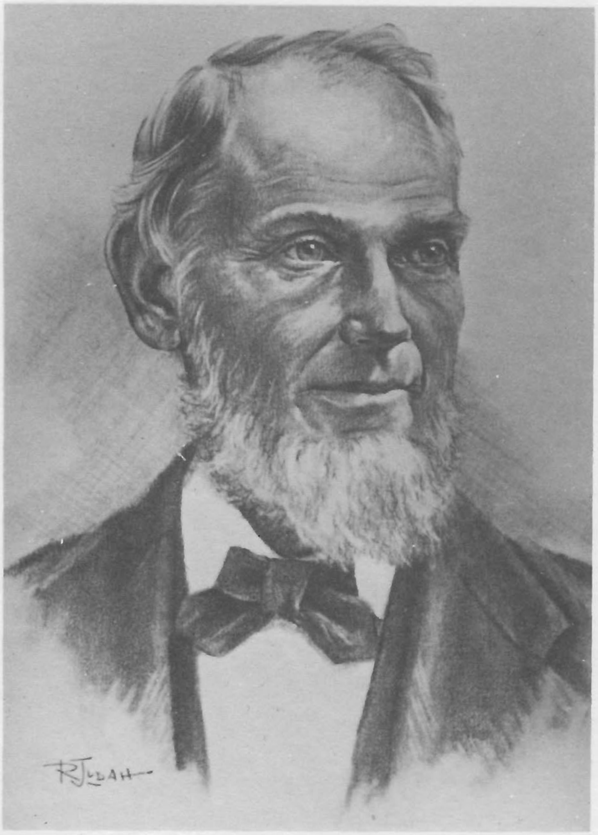

Figure 6. Edward Travers Cox, State Geologist, 1869-79.

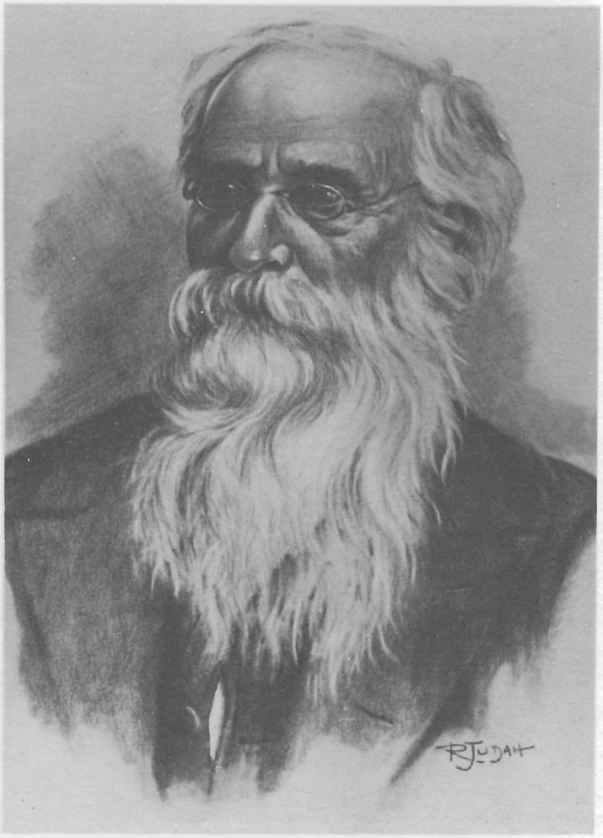

Figure 7. John Collett, State Geologist, 1880-84.

were county reports done by Cox's assistants, with much overlap and repetition of content.

In 1879 legislation replaced the Department of Geology and Natural Science with a Department of Geology and Statistics. The salary of the State Geologist was lowered appreciably, as were the operating funds, and the duties were vastly expanded in nongeologic directions. Cox declined to continue, and John Collett (fig. 7), who had served as an assistant to Cox, was appointed and accepted. The new department lasted only 2 years, and in 1881 a Department of Geology and Natural History was established. The term of appointment for the State Geologist was increased from 2 to 4 years. Collett continued in the position and turned out four annual reports.

Between 1869 and 1884 Cox and Collett were dutifully listed as faculty members ex officio in the Indiana University catalogs without, so far as I can determine, having any involvement with the academic program.

Collett was appointed to a 2-year term by a governor who was a Democrat and to a 4-year term by the next governor, who was a Republican. A Democrat was elected governor in 1884, and apparently unsuccessful in finding a qualified geologist in his own party, he appointed Maurice Thompson (fig. 8), who was a civil engineer and a successful author of fiction. He served only 3 years, from 1885 to 1888. Two annual reports were issued during his tenure, and their geologic high points were new information concerning the thickness and character of the glacial drift, confused misunderstanding on the part of both Thompson and his assistant S. S. Gorby on the Niagaran reefs at the surface in northern Indiana, and the first accounts of the discovery of natural gas.

Thompson resigned before his term was completed but after the election of 1888, and

Figure 8. Maurice Thompson, State Geologist, 1885-88.

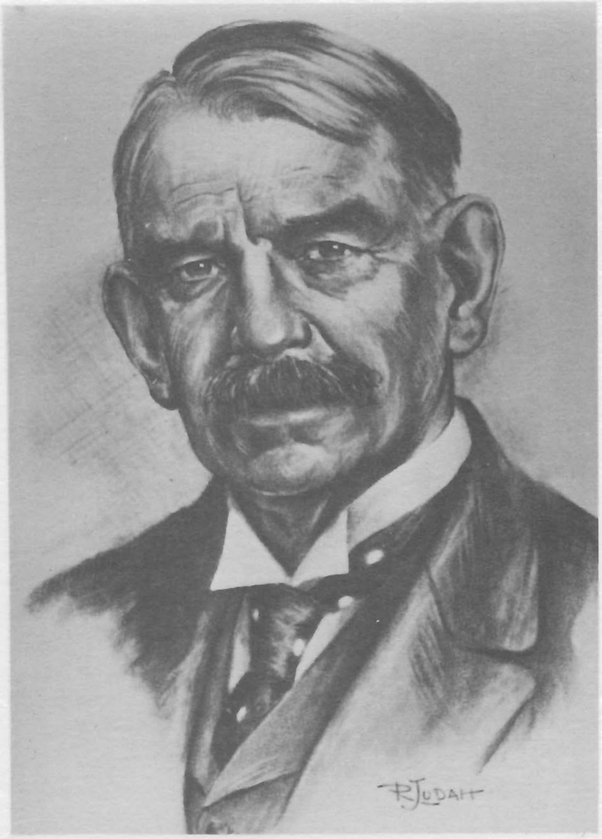

Figure 9. Sylvester Scott Gorby, State Geologist, 1889-94.

the outgoing governor appointed Sylvester S. Gorby (fig. 9) to fill the position. The new governor was a Republican, but the legislature remained firmly in the hands of the Democrats, and they set out to remove the governor's veto, abolished the Department of Geology and Natural History and the appointive office of State Geologist connected therewith, and established a new Department of Geology and Natural Resources, to be headed by a director *elected by the General Assembly*. The legislature then appointed (not elected) Gorby State Geologist. The new governor refused to recognize the act, and in March 1889 he appointed Collett to the post. Gorby declined to give up the office, and Collett apparently did not press the issue. In November the Supreme Court held that the legislature had no power to create an office and then fill it; the choice must be made by the governor or by popular election. Gorby managed to hold on until 1890, when he was nominated by the Democrats and won the election. His 6 years in office were more notable politically than geologically.

The sixth State Geologist of Indiana, Willis Stanley Blatchley (fig. 10), was, in my judgment, the greatest builder of program strength during the first century of the period covered by this study. He served from 1895 to 1910—a longer period than any of his predecessors. Time in office is surely a factor in establishing a program, but from the beginning of his tenure he demonstrated an unusual ability to identify and attract capable scientists, either to work for his organization or to publish the results of their investigations in the annual reports without being paid. The authors of the papers in annual reports issued during the Blatchley years constitute a merit list in geology. To avoid comparison and

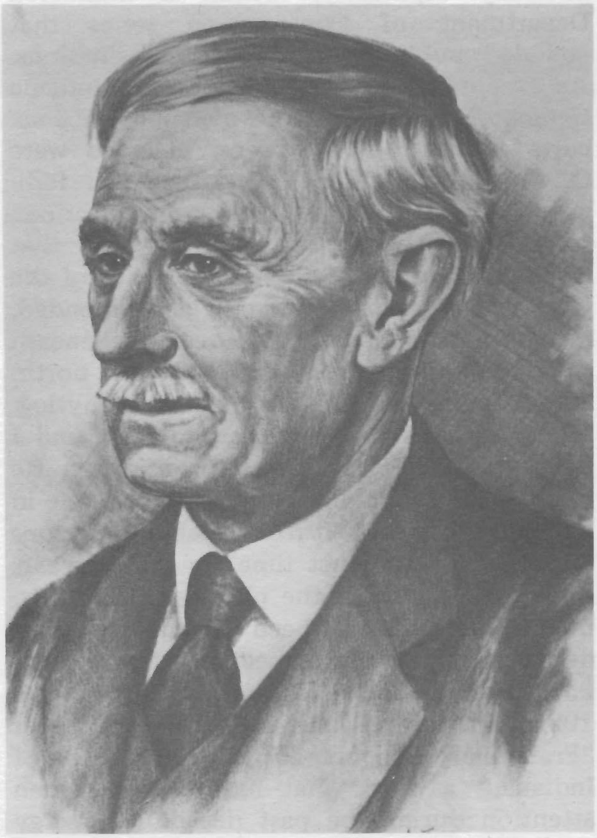

Figure 10. Willis Stanley Blatchley, State Geologist, 1895-1910.

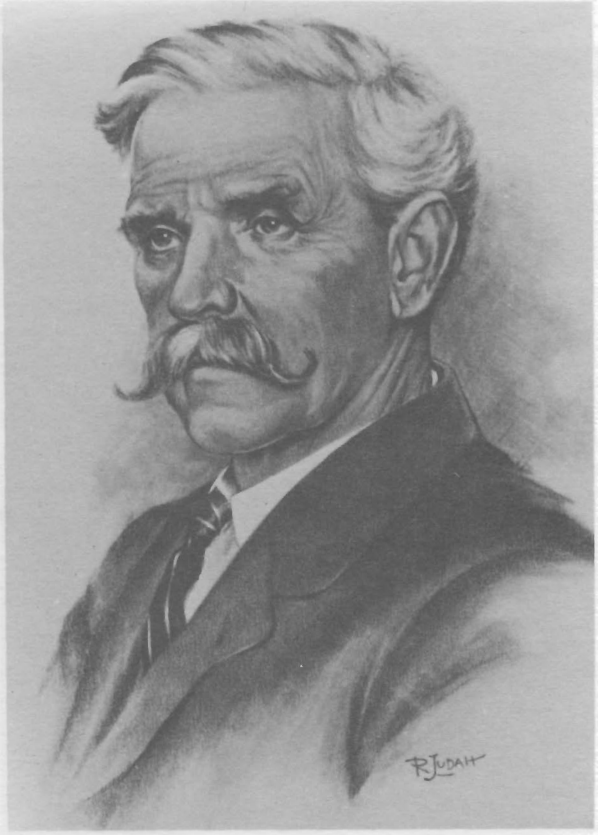

Figure 11. Edward Barrett, State Geologist, 1910-18.

unintentional ranking, I list a few of them in alphabetical order: G. H. Ashley, one of the first and greatest coal geologists; E. R. Cumings, notable for work in Ordovician and Silurian paleontology and stratigraphy; August Foerste, the sage of the Silurian; T. C. Hopkins, author of valuable reports on the geology of the industrial minerals and a turn-of-the-century sedimentary petrologist before the term was used; E. M. Kindle, stratigrapher and paleontologist in the Silurian and Devonian rocks and bibliographer and cataloger of literature and fossils; and C. E. Siebenthal, expert on building stones and cement and the geology of the rock units for both. Blatchley was primarily an entomologist rather than a geologist; he established an enviable record of productivity with meager funds—the sign of an able administrator.

In the election of 1910 Blatchley was defeated by Edward Barrett (fig. 11), who served two 4-year terms during which an increasing proportion of the published work was in the form of county soil surveys, and this concluded a period of 28 years during which the office was elective.

Indiana state government underwent massive changes when a reorganization act was passed early in 1919 and took effect in April of that year. The Indiana Department of Geology and Natural Resources was abolished, and its responsibilities were assigned to a Division of Geology within a newly created Department of Conservation. Because the office of State Geologist was elective, it had to be placed on the ballot in 1918, even though it was virtually certain to terminate. The victor was Louis Roark, who was a new faculty member in the Department of Geology at Indiana University. He never served in the office to which he was elected.

In the new arrangement the division heads

Figure 12. William Newton Logan, State Geologist, 1919-36.

were appointive, and the governor designated William N. Logan (fig. 12), who had joined the Indiana University faculty with the 1916-17 academic year, to head the Division of Geology concurrently with his academic duties. With Logan's appointment there began the closest alliance that has ever existed between the University's Department of Geology and the state program. An office that managed such regulatory matters as drilling permits and plugging of wells continued in Indianapolis, but the office of the State Geologist was on the Bloomington campus. Faculty members and students carried out most of the investigations, many of them through summer field parties. The annual reports that had been issued for so many years and that had included, in single-volume bound form, all the year's publications, became brief administrative accounts of the year's activities; scientific papers were issued, generally separately, within a numbered Department of Conservation series that included publications from other divisions. An exception was the "Handbook of Indiana Geology" (Logan, 1922), which contained six parts and ran to 1120 pages. Included were C. A. Malott's "The Physiography of Indiana," in which Malott named and described seven bedrock physiographic regions that covered all of southern Indiana south of the Wisconsinan glacial boundary and extended, recognizable from subsurface records, beneath the thickening glacial drift to the north. Malott preferred to term himself a physiographer rather than a geomorphologist, and I believe that he was correct in doing so. He had the unusual ability to describe terrane in a manner that made it recognizable to persons seeing it for the first time. In the 65 years since Malott named the physiographic units, no changes have been made in their designation, possibly because Malott described them so well. Another part of the 1922 Handbook is John Robert Reeves' paper "Preliminary Report on the Oil Shales of Indiana," a work that has received much attention during the past decade of energy concerns.

Another example of the Indiana University-state agency cooperative effort to which I refer is Indiana Department of Conservation Publication 75, "The Geology of the Silurian Rocks of Northern Indiana" (1928), one of a triumvirate of papers by E. R. Cumings, chairman of the Department of Geology at the time, and Robert R. Shrock, his graduate student. The three papers were fundamental works on reefs and their environment, and they have joined the ranks of classics. Reef geology, largely neglected during much of the time since Darwin's day, was principally of academic interest at the time of the Cumings and Shrock studies, but its significance to petroleum geology brought it to the forefront in the 1940's.

William N. Logan retired after the 1935-36 academic year, and Ralph Emerson Esarey (fig. 13) became State Geologist and served until 1945. During his tenure in office two external events greatly affected the Survey and its activities. A major new oil play developed in the Illinois Basin and spread to

Figure 13. Ralph Emerson Esarey, State Geologist, 1936-45.

Figure 14. Charles Frederick Deiss, State Geologist, 1945-59.

the Indiana part by the latter 1930's; subsurface information became available at a rate that made it difficult to record and impossible to digest. The Indianapolis office from which the Survey's regulatory functions were administered was hard pressed, and the entry of the United States into the Second World War in 1941 caused constant change, and ultimately diminution, of staff.

Near the end of the Second World War, President Herman B Wells of Indiana University proposed to the Indiana Department of Conservation that the Geological Survey and the Department of Geology be directed by a single head and that the geology faculty constitute most of the professional staff of the Survey. Research associateships and funds for field expenses were to be supplied through the Department of Conservation budget. The search for a new head resulted in the selection of Charles F. Deiss (fig. 14), then head of the Department of Geology at Montana State University at Missoula (now the University of Montana), to be chairman and State Geologist. He arrived in 1945 and began immediately to build staff. The Geological Survey grew under his direction to a staff of about 50 in a dozen years. At his request the Survey was freed by legislative act in 1947 of regulatory authority and duties related to the petroleum industry, and a separate Division of Oil and Gas in the Department of Conservation was established.

The plan to use departmental faculty as professional staff for the Survey proved, after about a year, only partly successful, and Charles Deiss moved the organization systematically toward a staff of its own. When I came to the Geological Survey in 1947, the Survey consisted of a Petroleum Section with two professional employees and an excellent drafting and photographic unit. My mission

Figure 15. Geology Building on the Indiana University campus in Bloomington. The Geological Survey occupies the wing in the foreground and extending to the right; the wing to the left houses the Indiana University Department of Geology.

was to establish a program in industrial minerals and to head a new section with that name. We set up geochemistry laboratories in 1948 and gave section status to the field of geochemistry in 1952. A publications office, a Coal Section, and a Geophysics Section were established at the beginning of the 1950's.

The name of the organization was changed, by act of the General Assembly, from the Division of Geology to the Geological Survey in 1951.

Paleontology and Glacial Geology Sections were established during the 1950's and fused into a Geology Section in 1959. The rapid expansion of both the Geological Survey and the Department of Geology during the latter 1940's and the 1950's posed imperative space needs to which Indiana University responded valiantly. The two organizations were occupying parts or all of 11 buildings when consolidation into the present quarters (fig. 15) took place in 1962 for the Department and 1964 for the Survey.

At the beginning of the 1965-66 fiscal year the Survey's parent organization, the Department of Conservation, was fused with the Indiana Flood Control and Water Resources Commission into a new Department of Natural Resources that was divided into two bureaus, and the Geological Survey became a division of the Bureau of Water and Mineral Resources. With each expansion of the chain of command, a unit such as the Geological Survey was farther removed from top management of state government.

When Charles F. Deiss died in 1959, I became Director and State Geologist (fig. 16). The Coal and Industrial Minerals Sections were joined into one section in 1975. I retired at the end of June 1986, and Norman C. Hester (fig. 17) succeeded me.

Figure 16. John Barratt Patton, Director and State Geologist, 1959-86.

Figure 17. Norman Curtis Hester, Director and State Geologist, 1986-.

EPILOGUE

In retrospect we might contemplate how a frontier state established in 1816 turned so early in its history to geology as an avenue to economic progress and a vital part of its system of higher education, and I should say that it was fortuitous rather than a result of planning. That fortuity began on the banks of the Wabash (fig. 18) when George Rapp decided to sell New Harmony, when Robert Owen bought the community, and when William Maclure became a partner in the venture. George Browning Lockwood (1902, p. 17) commented:

> While the Rappite regime is less interesting, and vastly less important, than the Owenite period, it affords a strong background for the later experiments, the failure of George Rapp's success standing out in vivid contrast to the success of Robert Owen's failure.

The Harmonist colony was materially productive, so much so that departure and a new start elsewhere became necessary to preserve their objectives, and their legacy was a material one. The Owen experiment foundered in its formative months, but it left a legacy of science, culture, and education that is identifiable more than a decade after its sesquicentennial anniversary.

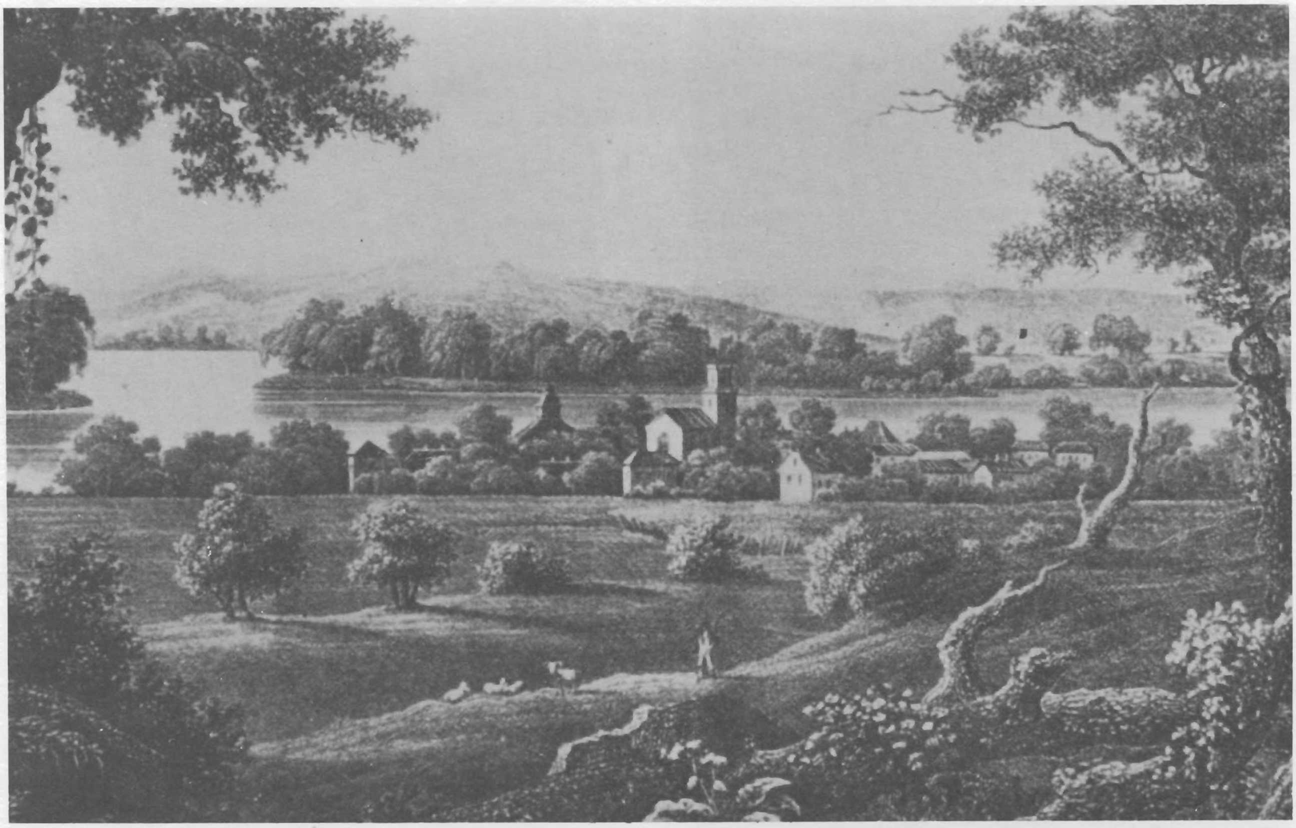

Figure 18. New Harmony in the 1820's. From an old print.

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EARLY STRATIGRAPHIC PRACTICES BY DAVID DALE OWEN IN THE MIDWESTERN UNITED STATES

By N. Gary Lane

CONTENTS

ABSTRACT

The writings of David Dale Owen (1807-60), the Father of the Indiana Geological Survey, exemplify the changing concepts of stratigraphic principles as practiced by early American geologists. Owen began his work with many aspects of the Wernerian system of stratigraphic classification. As new research was published in western Europe, especially in Great Britain, he adapted these new ideas to the strata he was studying in the Midwest. He very early recognized the utility of fossils for biostratigraphic correlation in Paleozoic rocks. He soon adapted the Devonian and Silurian Systems of Great Britain to American rocks. By 1843 he had recognized the Cambrian System as well. He therefore recognized the time equivalence of strata across the North Atlantic. Recognition of European systems was based largely on fossil content of the rocks as the fossils became gradually better known and more fully described and illustrated on both sides of the Atlantic. By the close of his career the time scale that he used and the rock subdivisions that he recognized had a distinctly modern aspect and with relatively minor refinements provided the basis for our present stratigraphic classification in the Midwest.

INTRODUCTION

It is especially appropriate that we meet here in New Harmony to observe the 150th anniversary of the Indiana Geological Survey. We would not be meeting in New Harmony were it not for our recognition of the central role played by David Dale Owen (1807-60) in the early understanding of the geology of Indiana and also of the entire Midwest. Owen can truly be called the Father of the Indiana Geological Survey.

Today we generally agree on stratigraphic practices and rules for correlation. Fossils are especially used for biostratigraphy to match up rocks in time from one area to another. We recognize distinctive sequences of formations as important within basins of deposition, and new methods of correlation, including seismic stratigraphy and magnetostratigraphy, are used on a regular basis.

Suppose we turn to the 1830's in New Harmony, where David Dale Owen was preparing to conduct the first geological survey of Indiana. What was the geologic milieu in which he made these preparations?

There was no geologic time scale as we know it today. A clear distinction between time equivalence of rocks and correlation by lateral continuity was unknown. The use of fossils for biostratigraphic correlation was not yet clearly recognized. Despite William Smith's (1815) demonstration of their utility for this purpose in the Mesozoic rocks of Great Britain, this method had hardly been applied to older, Paleozoic, rocks (Arkell, 1933). The theory of evolution did not yet provide a rational basis for sequential changes in fossils through time. Systems of rock older than the Carboniferous System had barely been named or were yet unnamed. There was no Paleozoic Era then classified as such. There was no demonstrable equivalence between rocks known from western Europe and those being newly discovered in the United States.

How was Owen to proceed, then, to unravel the strata of Indiana? What principles guided his studies? What would he use as a basis for subdividing the rock column, for naming the rocks that he found, and for correlating them with rocks in other areas?

In 1836 when Owen was undertaking his fieldwork there was only one theory for correlation of rocks. This was Abraham Werner's theory of formations (Greene, 1982). Today we think of Werner's theories as largely disproved by James Hutton's ideas on igneous rocks. Werner had proposed that all crystalline rocks were deposited from ocean waters, this being the principal idea of the Neptunist school of thought. Hutton proposed that many crystalline rocks, especially unstratified ones, were originally molten, this being a principal idea of the Vulcanist school of thought. Despite the fact that we now universally accept that igneous rocks were once molten and that metamorphic rocks were subjected to heat and pressure of burial, many other of Werner's ideas were influential for several decades into the 19th century and have colored our modern practices in stratigraphic geology. Although Werner published little, his students spread his doctrines, and a good many early American geologists were influenced to a greater or lesser degree by his ideas (Ospovat, 1960). Hutton and his followers never did formulate a theory that would account directly for the origin and distribution of stratified sedimentary rocks.

Werner's classification included a Primary Epoch of massive, unfossiliferous, and unstratified crystalline rocks and Transition and Secondary Epochs of stratified, fossiliferous, and in many places clearly water laid sedimentary rocks. Besides these major divisions there were suites of rocks consisting of several formations. Our present use of the rock-unit term "formation" ultimately stems from this concept of Werner's. Therefore, there was a limestone suite ranging from massive crystalline limestone formations of the Primary Epoch to soft earthy marls of the Tertiary Epoch. These epochs were time related, the Primary being the oldest and the Tertiary the youngest. Tertiary formations were generally flat lying, Secondary rocks were commonly tilted, and Primary rocks occupied the cores of mountain ranges. Formations were distinguished by very careful study of the physical characters and the mineralogic composition of the rock. As an example, color was considered an important character, and 10 different colors of red were recognized (Greene, 1982). Some formations were thought to be universal or worldwide in distribution. Clearly, if such formations could be recognized by careful study on other continents like North America, this would constitute evidence for contemporaneity in time and in conditions of formation—in other words, a basis for intercontinental correlation.

Several early American geologists were strict proponents of the Wernerian system. Amos Eaton's (1820) early studies in New York State are a good example. He attempted to correlate various red sandstones in the northeastern states by physical characters and mineralogy. He equated these with the European Old Red Sandstone of Werner. Therefore, he matched what we now know as Devonian sandstones of the Catskill Mountains with Triassic sandstones of the Connecticut River valley. It became obvious that physical characters alone could be misleading and not indicative of time relationships.

In moving away from this overemphasis on Wernerian thought, the geologists of the early New York Geological Survey went to the other extreme and used only local names, establishing the Taconic and New York Systems of rock. They abandoned Werner's Primary, Transitional, and Secondary classification. Ultimately, British-based systems of rock, especially the Silurian and Devonian Systems, came to be used in North America. The Cambrian System was not generally recognized until the 1850's, however, because of the dispute between Sir Roderick Murchison and the Rev. Adam Sedgwick and the former's widely regarded authority in stratigraphic matters.

OWEN REPORT OF 1837

How did Owen's first geologic report of Indiana (1837) fit into this background? Owen clearly derived several of his first ideas about stratigraphy from the Wernerian system. Owen recognized a sequence of rock units that he called, in part, formations. All of the units were named according to physical characteristics (freestone, black slate, and so on) (Owen and Gray, 1987). These features were typical of the Wernerian approach to stratigraphy. He used concepts of Secondary and Tertiary rocks typical of the Wernerian scheme. Finally, at the base of the section elsewhere, but not in Indiana, he recognized the Grauwacke Series, a prominent unit of the Transitional Epoch in the Wernerian classification.

Owen used two European terms in his initial stratigraphic column. He used "Mountain Limestone," a British term for Lower Carboniferous carbonates, for Paleozoic limestones below the Coal Measures. Owen introduced one new term, "Subcarboniferous," for Carboniferous limestones below coal-bearing rocks.

Superficial deposits covering bedrock were called diluvium and alluvion, the latter referring to Holocene soils and the former to what were widely regarded as flood deposits, now known to be glacial in origin. He also called this the erratic group because of the exotic boulders found in these sediments. The boulders were thought either to be the results of a universal flood or to have been carried by melting icebergs involved in the flood.

Owen clearly had read the geologic literature, especially books by former students of Werner, such as Bakewell (1829). He was well aware of the Wernerian system of formations and correlation, but he applied this system judiciously and with caution in his Indiana studies. He used local lithologic names for the rocks and did not attempt recognition of universal formations in the Wernerian sense.

In the text of his first report, in a general summary of geologic principles, Owen used such Wernerian terms as "primary formation," "transition formation," and "primitive [primary] rocks." He clearly departed from Wernerian principles, however, in saying that the relative ages of stratified formations was best ascertained, not from lithologic characters but from the petrified remains of plants and animals. This clear recognition of the principles of biostratigraphy in 1837 predated the extensive use of fossils for correlation by James Hall in the New York surveys and by other early paleontologists.

Owen recognized that crystalline igneous rocks had consolidated from a molten state and therefore accepted the vulcanist position. With regard to the origin of diluvium he refused to state a cause, saying that the cause was not apparent or was not now in action. He specified that the Grauwacke Series did not occur in Indiana but that these sparsely fossiliferous dipping strata were found in eastern Tennessee and in the Allegheny Mountains.

Therefore, we can summarize this initial report of Owen by saying that he based his stratigraphy largely on local details of the rock sequence, that he divided the section into a series of formations based on lithologic characters, that he was influenced by Wernerian ideas, and that he was well aware of controversies in Europe about basic principles of geology.

OWEN'S IOWA REPORT OF 1840

By the time of Owen's initial report in 1840 on the geology of Iowa, Wisconsin, and Illinois, the old tristate lead-zinc district, he had made several changes in his stratigraphic nomenclature. Some changes took account of continuing developments elsewhere, such as his recognition of the Devonian System, and others resulted from the different rocks that he encountered during his federal survey.

Owen then included in the Secondary Epoch both the "Coal Measures" (which term he used instead of "Carboniferous") and his "Subcarboniferous limestone," also termed the "*Archimedes* limestone." The latter unit was much restricted to limestones of Mississippian age rather than to the entire carbonate sequence below the Coal Measures as it had been in his first Indiana survey. The division between the Primary and Secondary Epochs fell at the top of the fine-grained sandstone that he called Devonian and that is now recognized as siltstone of the Borden Group of Early Mississippian age. The Devonian System had been named only the year before, in 1839, for rocks in Great Britain. His division between Primary and Secondary rocks therefore fell between Lower and Upper Mississippian rocks in modern classifications. At about this same time, John Phillips (1840) in England was proposing that the division between Paleozoic and Mesozoic rocks should be placed at the Magnesian Limestone below (Permian) and the New Red Sandstone above (Triassic). Owen recognized the black slate also as Devonian and below that a Cliff Formation consisting mainly of limestone and lead-bearing rocks that are now known as Silurian and Ordovician in age. The latter system was not named until 1879. Owen recognized Upper Silurian and perhaps part of the Lower Silurian. Lower sandstones and magnesian limestones were placed below the Cliff unit without further designation. These lower rocks are now known to be Late Cambrian in age. Despite the fact that the Cambrian had been named in 1835, very few American geologists had adopted the term.

One of the principal differences between this stratigraphic column and the earlier one for the Indiana survey was the introduction of the British systematic terms "Devonian" and "Silurian" for rocks in the Midwest. His use of Secondary and Primary was still largely Wernerian in concept, and placement of the boundary between these two divisions was based largely on lithologic differences.

OWEN'S 1843 PAPERS IN THE AMERICAN JOURNAL OF SCIENCE

In 1843 Owen published a paper, in two parts, on the geology of the western states (1843b). This was a summary, with some changes, of the reports of his Indiana and Iowa surveys. The stratigraphy outlined in this paper differed in only a few regards from that of the 1840 Iowa report. Owen referred to the Mountain Limestone as both the *Pentremites* and *Archimedes* Limestone. He regarded the two namesake fossils as important in defining the lowest occurrence of coal-bearing rocks and recognized the practical biostratigraphic utility of these fossils. He equated the western black slate, now called the black bituminous shale, with the Marcellus Shale of New York. The former Cliff Formation became magnesian limestone directly correlated with the Wenlock Formation of Murchison's Silurian System. This latter limestone was the chief lead-bearing rock of Iowa and Wisconsin, and Owen stated that the unit bore close resemblance to the lead-bearing scar limestone of northern England, which was Carboniferous in age. He then repudiated correlation based on the physical characteristics of the rocks, as in the Wernerian method, and stated that fossils constituted a "sure test" proving that these widely separated limestones were of conspicuously different ages. He also clearly distinguished, as he had not done before, the highly fossiliferous thin-bedded blue and gray limestones and shales of the Cincinnati region, which he dated correctly as Early Silurian in age (reclassified later as Ordovician).

In another paper in the same volume of the American Journal of Science (Owen, 1843a), Owen wrote on a universal system of geologic colors and symbols for maps and sections. In his summary of symbols he did not use Devonian but instead adopted the Old Red Sandstone. Below the Old Red he recognized the Silurian and Cambrian Systems (his first recognition of the Cambrian) and above the Old Red, the Mountain Limestone, the Millstone Grit, Carboniferous rocks, and on up through Permian and Mesozoic rocks. He used Sir Charles Lyell's divisions of the Tertiary System (Eocene, Miocene, Pliocene). The entire set of symbols was European, and specifically British, in outline. No North American names but local British names, such as "Lias," "Oolite," and "Greensand," were used. This is a radical departure from his earlier reports and illustrates the rapid changes that were taking place in stratigraphic terminology. It seems likely that Owen viewed this sequence of names as representing a relative time scale that could be applied in other areas. Therefore, local names as he had instituted in the Midwest could be equated with a standard set of time names as represented by his list of universal symbols.

OWEN AND NORWOOD ON KENTUCKY GEOLOGY

In 1847 D. D. Owen and J. G. Norwood published a paper on the rocks of central Kentucky. In this paper they used the term "Protozoic" for pre-Carboniferous rocks, a term initially proposed by Murchison and soon to be superseded by Sedgwick and Phillips's term "Paleozoic Era," which had a different definition.

Below the Carboniferous they subdivided the Subcarboniferous into upper and lower parts. The rocks of the upper part were typical of the Barrens areas in Kentucky, and the rocks of the lower part were typical of the Knobs region. Therefore, the siltstones of the Borden Group, originally considered as Devonian in age by Owen in 1843, were then correctly placed in the Mississippian System. The upper division consisted of Middle Mississippian limestones, especially what are now known as the St. Louis and Ste. Genevieve Limestones. The Black Slate was referred to with question to the Devonian, and the so-called "shell bed" of the Falls of the Ohio was placed in the Lower Devonian (now Middle Devonian). The Cliff Formation, originally encompassing a large part of the lower and middle Paleozoic rocks of Indiana, was then restricted to the Upper Silurian and was largely equivalent to what is now the Laurel Limestone. The name "Blue limestone" (then assigned to the Lower Silurian) was given to what are now classified as Upper Ordovician rocks.

This stratigraphic classification was more detailed than were those resulting from previous efforts by Owen. The Subcarboniferous included rocks that are now generally agreed on as Mississippian in age, and the Cliff Formation had become the antecedent of the Laurel.

It is clear that Owen and Norwood relied heavily on fossil content in making these revisions in the regional stratigraphy. They illustrated some of the more common Devonian and Mississippian fossils, especially some from the Knobs region of Kentucky and Indiana, to demonstrate the Carboniferous age of these rocks.

In this paper they also indicated for the first time the southern termination of the Cincinnati Arch and the enclosure of Ordovician rocks in the center of the arch by younger strata in Kentucky to the east, the south, and the west.

This paper was almost surely prompted by the work of the French geologist Edouard de Verneuil, who visited the Midwest in 1846 and went into the field with Owen. The changes in age designation of the rocks and restriction of usage are identical with remarks published in France by de Verneuil after his return to that country (1847a, 1847b). De Verneuil recognized fossils in the Knobstone rocks that he compared with the Carboniferous of Europe. He judged that all rocks above the black slate were Carboniferous in age and that the Cliff Limestone, as then recognized, included rocks of both Silurian and Devonian age.

In 1857 Owen published his final report on the geology of Kentucky. He recognized for the first time a Pleistocene Period and Quaternary deposits. He divided the Coal Measures into upper and lower parts, the latter consisting of the Millstone Grit. He therefore continued to use this British lithologic name. The Subcarboniferous was represented by both limestones and sandstones, and the early named Black Slate was then called the Black *Lingula* Shale because he found this fossil near the base of the black shale in Kentucky. The shale was considered to be Devonian in age. Devonian limestones at the Falls of the Ohio were called grey coralline. The Cliff Formation was further characterized as the chain coral and upper magnesian limestone, and the Blue Limestone of Ordovician age was also termed the "Shell" and "Birdseye limestone."

OWEN'S WISCONSIN AND ARKANSAS REPORTS

In 1848 Owen published his report on the mineral lands of the Chippewa land district. This area of northern Wisconsin included only lower Paleozoic rocks. Owen divided the strata into three formations that he numbered F1, F2, and F3. The lower unit was a sandstone containing trilobites and inarticulate brachiopods, now known to be Late Cambrian in age but unassigned as to age by Owen in this report.

This was succeeded by a magnesian limestone, F2, and by F3, the St. Peter's shell limestone. Both F1 and F2 were subdivided into lettered units, *a* through *f* for F1 and *a* through *c* for F2. This numbering scheme was carried over into Owen's final report on the lead-zinc district that was published in 1852.

Owen's final report on the Wisconsin lead district was published in 1852. In this report he recognized the Silurian and Devonian as periods of time and numbered formations from 1 at the base to 7 at the top (Cretaceous formation). He continued to call the Cambrian sandstones at the base of the section Lower Silurian deposits, and he divided the Silurian and Devonian rocks into several subunits (for example, upper coraloid limestone and shell beds). Otherwise there was little new or updated in this report with regard to stratigraphic nomenclature and its use. The singlemost striking modification of the standard stratigraphic column that he had gradually developed during the previous 15 years was the use of fossils as formal descriptors of the rock units: *Lingula*, coralline, and chain coral.

In Owen's initial report on the geology of northern Arkansas (1858) he recognized three principal formations. The Millstone grit, including shales and conglomerates, was the uppermost unit. It was followed by the Subcarboniferous limestone, which contained chert, shales, and sandstones and also magnesian limestones of the Lower Silurian Period at the base. He commented that the Knob sandstone of Kentucky and Indiana was absent and that black Devonian shales were doubtfully present. The Upper Silurian rocks were not recognized. This sketchy and poorly developed stratigraphic scheme undoubtedly reflects the hurried nature of this initial survey.

INDIANA REPORTS OF 1859 AND 1862

The final report of Owen's that was published in 1859 before his untimely death consisted of very much revised versions of his first and second reports on the geology of Indiana (1859a, 1859b). This was issued shortly before his younger brother, Richard, took over the new survey of the state in 1859 and 1860 and published his report in 1862. This final stratigraphic statement by Owen differs only in modest ways from his Kentucky report. The Cambrian System was recognized as possibly being represented by the Potsdam sandstone. The lower part of the Subcarboniferous was termed the "knob freestone" for the first time, and the Coal Measures were here called the bituminous coal formation. Otherwise the stratigraphic classification remained little changed.

In his report on Indiana geology, Richard Owen published a geologic time scale (1862, p. 14). Here he recognized Paleozoic, Mesozoic, and Cenozoic Eras, something his brother had never done. He mentioned but did not recognize the Cambrian System. He listed the detailed stratigraphy of New York State as equivalents or subdivisions of the systems in the Paleozoic, but he provided almost no local names for Indiana strata, only mentioning the Knob sandstone. His failure to name the local rock units and to refer them solely to the standardized British and New York scheme that he advocated is a step backward from his brother's work in understanding the local stratigraphic succession in Indiana.

SUMMARY

David Dale Owen was the premier pioneer geologist of the Midwest. His work in several states established the stratigraphic framework that, with refinement, we still use today.

In his early years of scientific work he was under the influence of the German school of stratigraphic practice, exemplified by Abraham Werner and his students. Most other

American geologists of the time similarly followed Werner's ideas. Owen's work was closely attuned to that of other geologists, especially those working in Ohio and Pennsylvania. He kept in close contact with the geologic advances of the day through scientific literature, correspondence, attendance at meetings, and field trips with visiting geologists. Owen's contributions to the geology of the entire Midwest were highly original and significant and provided a strong foundation for continuing work to the present.

He made several advances in understanding the vertical succession and time relations of rocks in Indiana, Kentucky, and Arkansas on the south and northward to Iowa and Wisconsin. He gradually made more careful distinction of rock units that he generally referred to as formations, and he came to assign relative ages (Devonian, Silurian, and so on) to these units. He never came to accept completely the Cambrian System, nor did he recognize the great eras of time, the Paleozoic, Mesozoic, and Cenozoic Eras, that ultimately came to be standard. His Subcarboniferous unit, which he came to use as a system of rocks, was eventually replaced by the Mississippian System of Winchell (1869). Nevertheless, he played an important role in the initial deciphering, naming, and dating of the Paleozoic rocks of several midwestern states. He was an early leader in using fossils for biostratigraphy and for regional correlation. The 22 years in which he worked, from 1837 to 1859, were a time of tremendous change in stratigraphic concepts, and Owen's work reflected those changes, some of which he accepted quickly and others of which he never did accept. He began with some reliance on Wernerian rules for stratigraphy and ended using biostratigraphy and the concept of a standard geologic time scale for correlation.

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DEVELOPMENT OF MINERAL RESOURCES IN INDIANA — 1837-1987

By Charles E. Wier

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EARLY HISTORY OF MINERAL DEVELOPMENT

During the time between George Rapp's establishment of New Harmony in 1814 and Robert Owen's purchase of the town in 1824, the development of mineral resources in Indiana was just beginning. By the time the Indiana General Assembly authorized a geological survey in Indiana in 1837, many families of the early settlers had been in southern Indiana for 30 or 40 years and were beginning to use some of the obvious raw materials. Almost from the beginning, the early settlers began digging blocks of sandstone and limestone from the hillsides and used them as foundations for buildings and bridges. In some areas stone was also used as walls and fences.

When David Dale Owen made his geological reconnaissance of Indiana in 1837 and 1838 (1859a, 1859b), he found not only natural outcrops but also a large number of manmade ones. He found small coal mines operating near Troy, Cannelton, and Newburgh, along the Ohio River, and northward through Petersburg in Pike County, Lewis and Farmersburg in Sullivan County, and Seelyville and Terre Haute in Vigo County.

He mentioned burrstone made into millstones near Vernon and the whetstones near French Lick. Limestone near Madison, "oolitic" limestone in Monroe County, and sandstone near New Harmony and Williamsport were used for building stone. Limestone was burned to make mortar and was used in the "works" on the National Road near Indianapolis. Bricks and pottery were made from underclays at Troy.

By 1837 about half a million people lived in Indiana, mostly in the southern part, and all but a few counties were established. The new state capitol was completed in Indianapolis, and Vincennes University and Indiana University were already established as seats of higher learning. Steamboats were making regular runs on the Whitewater, Ohio, and Wabash Rivers, and the canal system was being extended across the state.

Owen began an alternating sequence that connects the economic geologist with those who wish to develop mineral resources. That is, he took the bits and pieces of information that individuals had developed as they exploited the locally available material and evaluated them and put them together in a "big picture" that would help the exploiters expand their efforts. As they continued drilling, excavating, mining, etc., they furnished more and better information for the later geologist to use. Owen did a remarkable job in developing a broad geologic basis for the occurrence of mineral deposits. For instance, he mapped the approximate Mississippian-Pennsylvanian boundary and correctly pointed out that the future development of coal would be restricted to the area west of the line and in those rocks that are now called Pennsylvanian (fig. 1).

After David Dale Owen did his reconnaissance mapping in 1837 and 1838, the results of that information were made readily available to the general public. Both reports were published in several different versions from 1839 to 1859 (Owen and Gray, 1987). These two reports were very useful to later geologists. Meanwhile, the development of our mineral resources began to increase as the population of the area increased. When Richard Owen (1862) made the 1859 and 1860 geological reconnaissances of Indiana, 1.3 million people were scattered across the state and considerably more geologic information had become available.

After the Civil War the Indiana General Assembly established the first permanent office of State Geologist and appointed Edward T. Cox in 1869. By this time some railroad lines had reached the coalfields and the dimension-stone area, and the production of coal and dimension stone was beginning to increase rapidly. Cox and Governor Morton gave a great deal of time to the promotion of Indiana as a potential steel-producing state that would use Block Coal from Clay County (Thornbrough, 1965, p. 408).

During his 10 years in office Cox produced 30 county geologic reports. Later state geologists continued these county surveys, but political controversy, small budgets, and other duties greatly restricted geologic work during the next 15 years. These county reports were useful to local developers. Information on mineral resources was also available at the Indianapolis office. Some of the early state geologists, such as E. T. Cox and John Collett, wrote many promotional articles to encourage the development of Indiana's mineral resources.

In 1894, when Willis S. Blatchley became State Geologist, more than 2 million people lived in Indiana. Although it was still primarily an agricultural state, Indiana was rapidly becoming more industrialized. A fourth of the people lived in towns and cities, and interest was keen in exploiting mineral resources. By this time telephones were common in cities, and larger cities had electric streetcars and lights. One of the first "horseless carriages" had even been built in the state.

The coal and clay industries provided much

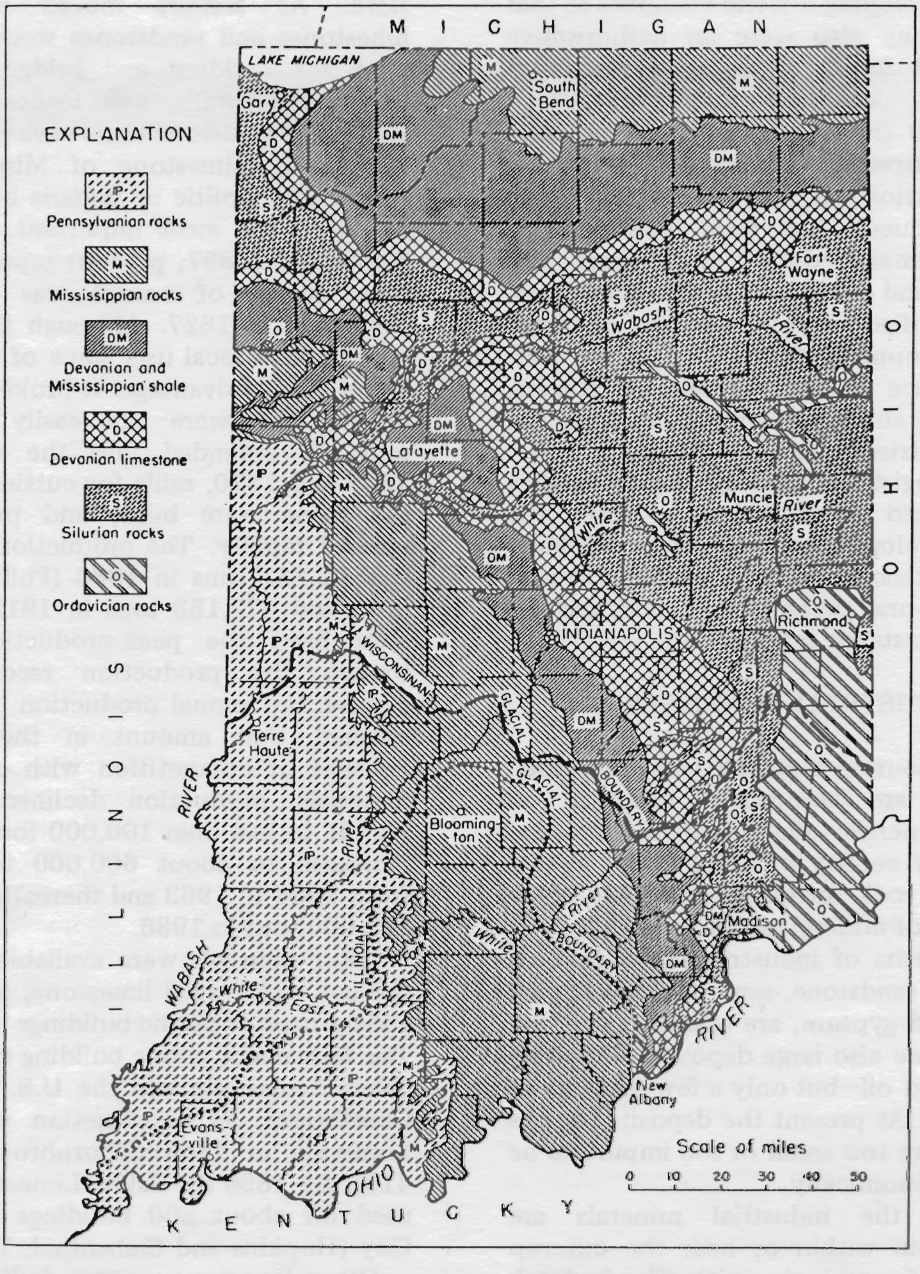


Figure 1. Map of Indiana showing generalized bedrock geology. From Patton (1955).

new information about the geology of the state, and the demand for limestone and sand and gravel for constructing roads and railroads had added its share of new outcrops. The Trenton gas boom in northeastern Indiana was near its peak, and oil production had reached nearly 4 million barrels per year. This was also the time when the last furnace that used Indiana iron ore and coal closed and when a new steel industry that used ore and coal from outside the state began. Blatchley quickly grasped the opportunity. He and his staff began gathering new information and wrote systematic reports on each commodity. Comprehensive reports on coal, oil, mineral aggregates, clays, sandstones, limestones, cements, and mineral waters were published. These reports were useful to the companies that were developing mineral resources at that time, and they also were an authoritative starting point for later geologists who were interested in a specific mineral resource.

Since 1900 the development of Indiana's mineral resources has increased in about the same proportion as the population. The amount produced has been modified by increased demand during war years and reduced demand during recessions. It has been further modified during periods of large internal-development projects. And an overriding influence has been mineral economics, especially the ability to compete with similar mineral industries from other states.

State geologists snd their geological surveys have continued to this time to assist the public in developing mineral resources. Most of this assistance has been in the form of publications, oral presentations, and answers to direct requests for information.

INDUSTRIAL MINERALS

Mineral resources that have been developed in Indiana are commonly classified as industrial minerals, fuels, and the ores of metals. Every county in Indiana and almost every named rock formation have had some development of mineral resources (fig. 2).

Large deposits of industrial minerals, such as limestone, sandstone, sand and gravel, clay and shale, and gypsum, are scattered over the state. There are also large deposits of mineral fuels—coal and oil—but only a few deposits of metallic ores. At present the deposits of ores in the state are too small or too impure to be developed economically.

Many of the industrial minerals are produced from within or near the outcrop area of specific geologic units. The bedrock geologic map (fig. 1) shows the approximate location of companies producing limestone, sandstone, and clay and shale, and the map of unconsolidated glacial materials (fig. 3) shows the areas where peat, marl, and sand and gravel are produced.

DIMENSION STONE

The development of the dimension-stone industry began early in the history of the state. As settlers moved into Indiana, limestones and sandstones were immediately used for building and bridge foundations, tombstones, walls, and fences. Many limestone and sandstone units have been used, but the Salem Limestone of Mississippian age (also called oolitic or Indiana building stone) has been the most important. Hopkins and Siebenthal (1897, p. 340) reported that the first quarry of record was opened near Stinesville in 1827. Although the Salem had considerable local use, some of this limestone had a big disadvantage. It broke into big solid blocks that were not easily handled. As railroads extended into the area between 1848 and 1870, mills for cutting and shaping the stone were built, and production increased rapidly. The production of the stone was 43,631 tons in 1880 (Phillips, 1968, p. 204) and 877,153 tons in 1912, which may have been the peak-production year. Although the production records are not precise, the annual production may also have reached that amount in the mid-1920's. Because of competition with other building materials, production declined after World War II to less than 100,000 tons per year. It increased to about 600,000 tons per year from 1954 to 1963 and thereafter declined to 191,000 tons in 1986.

After railroads were available for shipping the cut and carved limestone, the Salem was widely used in public buildings in most states. The first major public building constructed of Salem Limestone was the U.S. Customs and Courthouse; its construction was begun in Louisville in 1853 (Thornbrough, 1965, p. 410). By 1896 the Salem Limestone had been used for about 300 buildings in New York City (Hopkins and Siebenthal, 1897, p. 413).

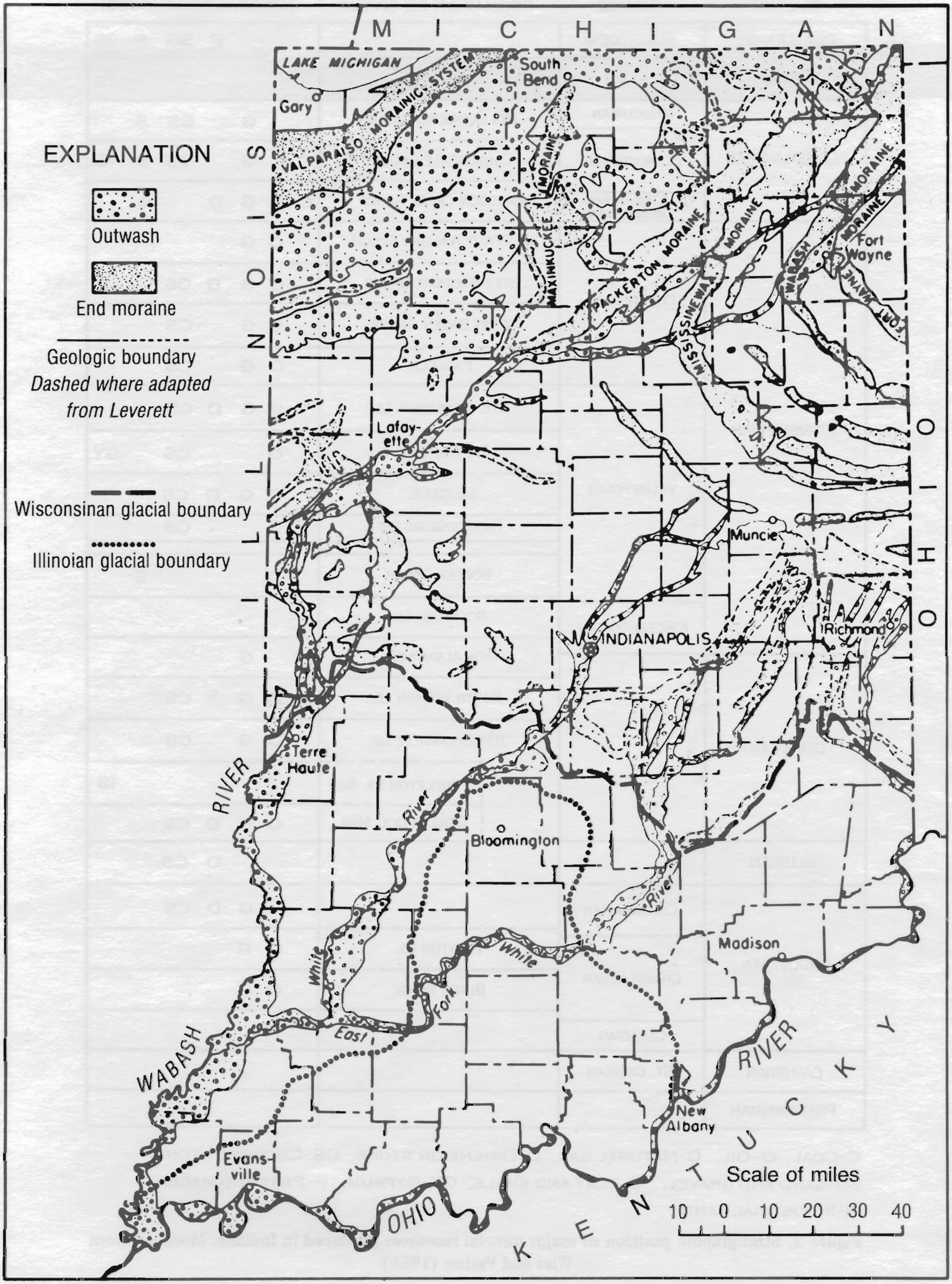
Other limestone units in Indiana that have produced a significant amount of dimension stone are the Laurel Member of the Salamonie Dolomite, the Brassfield Limestone, the Louisville Limestone, and the Geneva Dolomite Member of the Jeffersonville Limestone. These rocks are Devonian and Silurian in age (fig. 1) and crop out in southeastern Indiana (Rooney, 1970b, p. 1).

The sandstones that have commonly been used for dimension stone crop out in southeastern Indiana and are Mississippian

System	Series	Formation or group	Mineral resources
Quaternary	Pleistocene		P SG S IS
Tertiary			IS
Pennsylvanian	Missourian	McLeansboro Group	G CS S
	Desmoinesian	Carbondale Group	C G CS S IS
	Atokan and Morrowan	Raccoon Creek Group	C O G D S
Mississippian	Chesterian	Buffalo Wallow Group	O G
		Stephensport Group	O G D CS
		West Baden Group	O G CS
		Paoli Ls.	O G CS
	Valmeyeran	Ste. Genevieve Ls.	O G D CS
		St. Louis Ls.	O CS GY
		Salem Ls.	O G D CS
		Harrodsburg Ls.	O CS
		Borden Group	O S
	Kinderhookian	Rockford Ls.	
Devonian		New Albany Sh.	G
		North Vernon Ls.	O G CS
		Jeffersonville Ls.	O G CS
		Pendleton Ss. Bed	IS
		Geneva Dol. Mbr.	O G D CS
Silurian			D CS
Ordovician	Cincinnatian		G D CS
	Champlainian	Trenton Ls.	O G
		Black River	O G
	Canadian		
Cambrian	St. Croixan		
Precambrian			

C-Coal, O-Oil, G-Natural gas, D-Dimension stone, CS-Crushed stone, SG-Sand and gravel, S-Clay and shale, GY-Gypsum, P-Peat and marl, IS-Industrial sand

Figure 2. Stratigraphic position of major mineral resources produced in Indiana. Modified from Wier and Patton (1966).


MICHIGAN
LAKE MICHIGAN
South Bend
Gary
EXPLANATION
Outwash
End moraine
Geologic boundary
Dashed where adapted from Leverett
Wisconsinan glacial boundary
Illinoian glacial boundary
ILLINOIS
OHIO
VALPARAISO MORAINIC SYSTEM
MAXINKUCKEE MORAINE
PACKERTON MORAINE
MISSISSINEWA MORAINE
WABASH MORAINE
FORT WAYNE MORAINE
Fort Wayne
Lafayette
Muncie
INDIANAPOLIS
Richmond
Terre Haute
RIVER
Bloomington
River
White
White
Fork
East
Madison
WABASH
RIVER
New Albany
Evansville
OHIO
KENTUCKY
Scale of miles
10 0 10 20 30 40

and Pennsylvanian in age. Over the years quarries have operated from Cannelton on the Ohio River to Williamsport on the middle Wabash River and have had such names as Ferdinand, St. Meinrad, Merom, Mansfield, Hillsboro, and Attica. These sandstone and limestone quarries (other than Salem quarries) have generally been small and have had short lives because their markets have been taken over by the Salem since about 1900. Nevertheless, some of these small quarries have had a modern rejuvenation because of a special demand for their stone as veneer for houses and small public buildings.

For many years Indiana has produced more than 60 percent of the dimension limestone quarried in the United States, but other states have led in total dimension-stone production. Because of a decline in the use of marble and granite produced in other states for dimension stone, Indiana now leads the nation in dimension-stone production. Despite this, dimension-stone value is only about 2 percent of the value of Indiana's total mineral output.

MINERAL AGGREGATES

Indiana is blessed with almost inexhaustible reserves of mineral aggregates. Commercial production consists primarily of sand and gravel and crushed limestone and dolomite. Sand and gravel are concentrated in many places in central and northern Indiana where the state was glaciated and farther south where glacial meltwaters carried and deposited the water-sorted outwash along stream valleys (fig. 3). Commercial limestone and dolomite are found at the surface in large areas where they are not covered by thick glacial deposits. Therefore mineral aggregates were abundantly available to the people in the state in the 1830's when they first became concerned about building all-weather roads. The first significant road-construction project in Indiana was the New Albany-Vincennes road. It was started in 1836 and finished from New Albany to Paoli in 1839. Crushed limestone was used from many quarries along the roadway, especially from Devonian and Mississippian rocks.

The National Road (now U.S. Highway 40), which extends across the central part of the state, was improved in the 1850's by using local gravel deposits. The work was done by county governments and by private companies that operated a toll road in some sections.

Crushed stone was used in constructing the railroad from Madison to Indianapolis that was completed in 1847. This construction was the beginning of 70 years of railroad building that used great quantities of both crushed stone and gravel. By 1880 Indiana had 4,373 miles of railroads (Phillips, 1968, p. 229). Records of production of crushed stone were not kept, but about 250,000 tons per year must have been used during this period. The construction of additional railway lines continued for another 40 years at a reduced rate, and by 1920 7,426 miles of truck had been laid.

The use of aggregates in county roads increased rapidly beginning about 1900 when the state used land-assessment taxes for constructing all-weather roads. Although exact amounts of aggregates are not known for the earlier years, we know the approximate sources of the aggregates because the Geological Survey during the late 1940's and the 1960's located and mapped thousands of abandoned limestone and dolomite quarries and sand and gravel pits. Significantly, many of these are near major railroads and highways.

Before 1900 the individual quarry operator opened a quarry near the market and furnished a variety of products, such as foundation stone, wall stone, tombstones, crushed stone, and whatever else he could sell. Most of the work, even crushing, was done by hand. Gradually, as economic circumstances and production and transportation equipment changed, the operations became fewer, larger, more mechanized, and more specialized. In the 1930's and 1940's many quarries went out of business although demand had

Figure 3 (*on facing page*). Map of Indiana showing moraines and outwash.

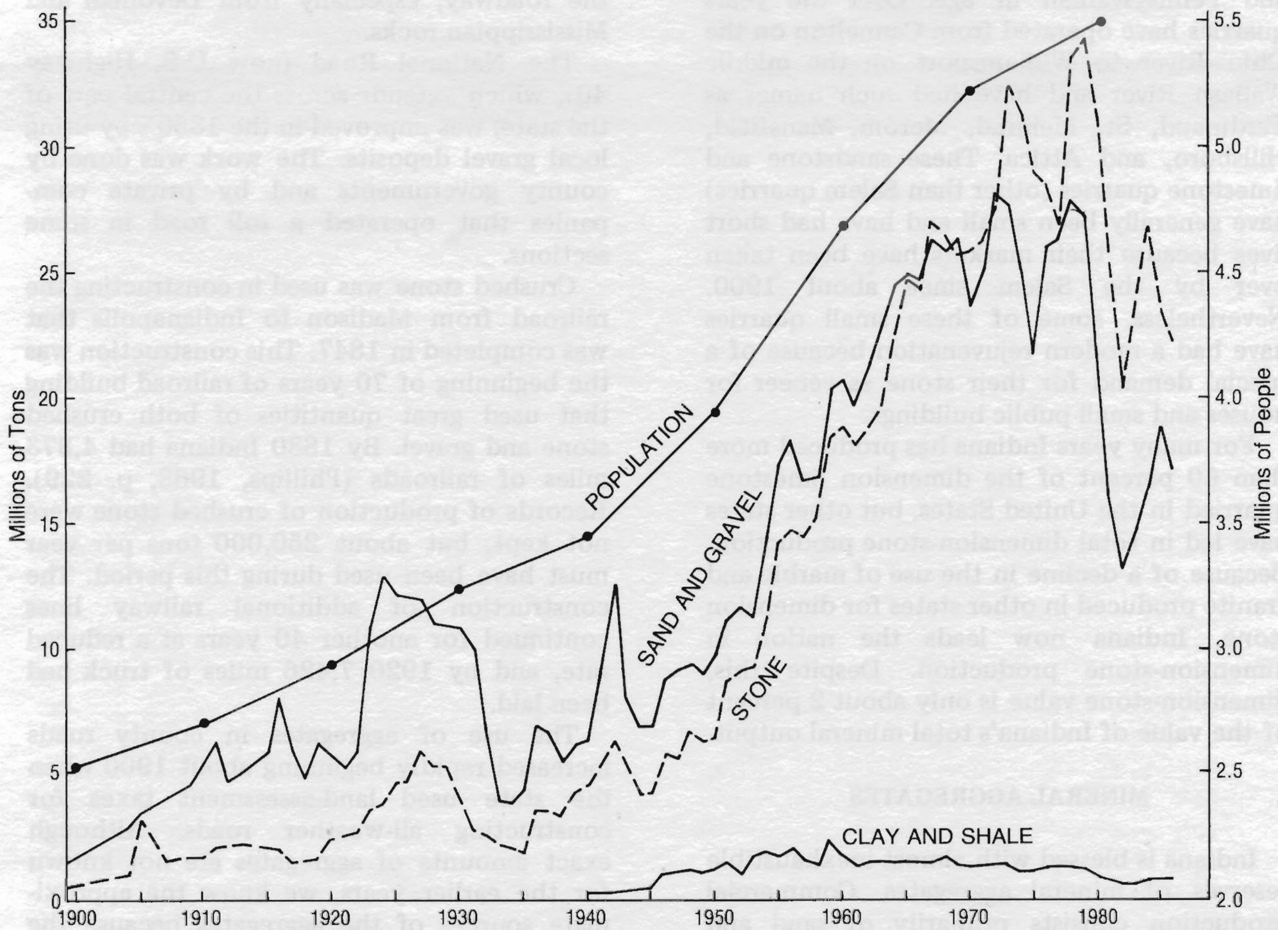


Figure 4. Graph showing production of crushed stone, clay and shale, and sand and gravel in Indiana, 1900-85, as related to population growth. Information from the U.S. Bureau of Mines Yearbooks and preprints.

increased. After World War II, partly because of the new interstate program, highway construction rapidly increased the use of crushed stone, but the trend toward fewer and larger quarries continued.

The use of aggregates since 1900 has been related to population increase (fig. 4) not only because of the need for more roads but also because of the increased use of aggregates in buildings. Crushed limestone and sand and gravel are partly interchangeable in their uses, and transportation costs have encouraged the use of whichever of these commodities has been closest to the market. In the early 1900's sand and gravel were more easily exploited and were much more widely used, but by the early 1970's crushed stone became dominant. Since 1979, with completion of the national program of interstate-highway construction and a general decline in new construction of many kinds, the production of aggregates has continued to decline. Sand and gravel production peaked in 1972 at 27.9 million tons and declined to 16.9 million tons in 1986. Crushed-stone production reached a maximum of 34.1 million tons in 1979 and declined to 22.2 million tons in 1986.

CLAY AND SHALE

Clays and shales are abundant in Indiana, but they vary considerably in their composition and physical properties and, therefore, in their commercial uses. Because both clay and shale are common, cheap, and easy to work, the early settler used locally available material to make pottery and bricks for his own use and for the local market. In general, three different areas of production have developed in accord with somewhat different uses. The largest production comes from shales of Early Mississippian age that crop out from Clark County northwestward to Montgomery County. These shales are used in manufacturing brick, draintile, and lightweight aggregate and as additives to cement. Second in amount produced but probably first in value are the shales and clays (including coal underclays) from the lower and middle parts of Pennsylvanian rocks in southwestern Indiana. Their products include structural tile, sewer pipe, brick, and insulators. The third area is in northern Indiana and includes Pleistocene clay tills and lacustrine clays. Draintile and brick are made from these clays in those areas where they have been leached of calcium carbonate.

An unusual clay (for Indiana) was discovered in Lawrence County in 1874. It is called indianaite or kaolinite and is a high-alumina porcelainlike clay. Although the deposit is not large, it has been used as a raw material for white porcelain ware, paper pulp, high-grade tile, and aluminum sulfate.

In the 1830's and 1840's clays were commonly used for making pottery. During this time large potteries were in operation at Troy, along the Ohio River, and northward through Loogootee and Clay City to Mecca and Bloomingdale in Parke County. During those same years many houses in southwestern Indiana were constructed of brick. The itinerant brickmakers used local clays and shales and used local timber or coal as fuel to fire the bricks at the construction site. Most communities that had suitable clay and shale had their own brickyard.

The ceramic industry developed rapidly in Indiana, especially where high-quality clays (usually coal underclays) were available, and reached its peak about 1910. Clays beneath the Upper and Lower Block Coal Members, the Seelyville Coal Member, and the Colchester Coal Member (Pennsylvanian age) were extensively used in the Brazil to Cayuga area (Clay, Parke, and Vermillion Counties) from the time of the Civil War until after World War II.

Although the products made from clay and shale are worth many times the value of the raw products, the value of the unprocessed clay and shale is only about 0.2 percent of mineral production. In the early 1900's it was about 20 percent. Since 1950 production has ranged from half a million to 2 million tons per year (fig. 4).

OTHER INDUSTRIAL MINERALS

A variety of other uses of limestone and sandstone should also be mentioned. Burned lime was produced from both limestone and dolomite as early as the 1830's and was commonly used for mortar. When portland cement was introduced in the Midwest about 1890, this use dwindled away. The common uses were in concrete mixes, plaster, and flux in steel mills and for chemicals. From 1900 to 1953 the state produced about 100,000 tons per year, but in 1953 commercial lime production ceased.

Both natural cement and portland cement have been made from Indiana limestones. Natural cement was made from the North Vernon Limestone in Clark County before the Civil War. The limestone used for portland cement has been obtained from the Jeffersonville and North Vernon Limestones of Devonian age and the Harrodsburg, Salem, and Ste. Genevieve Limestones of Mississippian age in southern Indiana and from a Silurian limestone in northern Indiana. Indiana produced 12 to 15 million tons per year of portland cement from 1957 to 1970. The production of portland cement declined to about 2.1 million tons in 1986.

Glass sands and foundry sands have been used in Indiana from about 1850 to the present. The demand for glass sand increased greatly when many glass factories located new plants in the area of the Trenton gasfield in the 1890's. Dune sand near Lake Michigan and sandstones in southwestern Indiana from Upper Mississippian and Lower Pennsylvanian rocks were used. A glass sand must be high in silica and have little impurities. Sand deposits with such qualities are not large. Some sands are also used as blasting sand, as an ingredient of scouring powder, and as stone-sawing sand. Others are used for refractory, metallurgical, or chemical purposes. The production of all of these specialty sands from 1960 to 1968 ranged from about 600,000 to 900,000 tons per year (Carr, 1971, p. 5). Since 1968 the production of specialty sands has fluctuated downward but has now risen to about 600,000 tons per year.

An unusual abrasive rock is the Hindostan whetstone. It is a thin-bedded siltstone of early Pennsylvanian age and has been quarried for more than 150 years in Orange County. In the middle 1800's whetstones cut from this siltstone were shipped all over the United States and to some foreign countries. Today, one remaining small plant produces whetstones on demand.

Peat and marl are mined in northern Indiana from bogs of Pleistocene age. Both are used as soil conditioners. In the middle 1800's marl was used as a flux in the early iron furnaces and in both mortar and portland cement.

The production of peat ranged from about 1,000 to 15,000 tons per year in the 1940's and 1950's but increased sharply through the 1960's to 52,000 tons in 1986.

Gypsum is a newcomer to the mineral development of the past 150 years. The two underground mines near Shoals were opened in 1955. Geologists had noted the occurrence of gypsum and anhydrite, but not until the Geological Survey began evaluating gypsum occurrences were the thickness and size of the deposits understood. Although gypsum is present in the St. Louis Limestone in other areas in southwestern Indiana and in the Detroit River Formation (Devonian) in northern Indiana, only the original two mines are operating. Most of the gypsum is used for plaster and wallboard. About 1 million tons of raw gypsum is produced each year.

MINERAL FUELS

In the early 1800's the common fuel was wood, which at that time was abundant. By the 1830's the use of coal had become commplace in southwestern Indiana, where it was readily available. Natural gas and oil were not used in the state until the 1880's. Dried peat from the bogs of northern Indiana has probably been used locally as fuel, but the amount has been insignificant.

COAL

David Dale Owen (1859a, 1859b) noted that the early settlers were mining shallow coal seams along the Ohio River by the early 1830's. At the time of Owen's initial reconnaissance in 1837, the American Cannel Coal Co. was already incorporated and mining near the present town of Cannelton. By 1840 the annual production of coal in Indiana was 9,682 tons with a market value of $5,000. The American Cannel Coal Co. and several smaller mines sold coal to homeowners, blacksmiths, a cotton mill, a chain factory, and a pottery. This early mining was small-scale strip mining that employed horse-drawn scrapers and pick and shovel.

By 1859 and 1860, when Richard Owen (1862) did the second geological reconnaissance, annual production was about 100,000 tons. He noted small drift, slope, and shaft mines from Warren County southward to the Ohio River. Coal was the basic industry along the Ohio River from Cannelton to Newburgh. It was used locally and also was shipped down the river. As the settlers moved northward other coal mines were soon developed in those areas. An important coal-mining center developed near Brazil and Carbon in Clay County in the so-called Block coals. The coal was used locally in blacksmith shops, potteries, and kilns and was also shipped as far away as Chicago.

In 1898 G. H. Ashley (1899) completed the first comprehensive report on the coal industry and coal reserves. Annual production was then about 5 million tons. The estimated total production from the beginning of production to that time was about 70 million tons; the two Block coal members from Clay County accounted for a third of the total production. Ashley and his workers collected a large amount of information on the distribution of coal seams and made it readily available to the developer. No doubt this work helped tremendously in the rapid development of coal mining to a peak production of 30.7 million tons in 1918 during World War I (fig. 5).

Just before World War II a significant change took place in coal-mining methods. The initial production had resulted from clearing dirt and rock from the coal outcrop

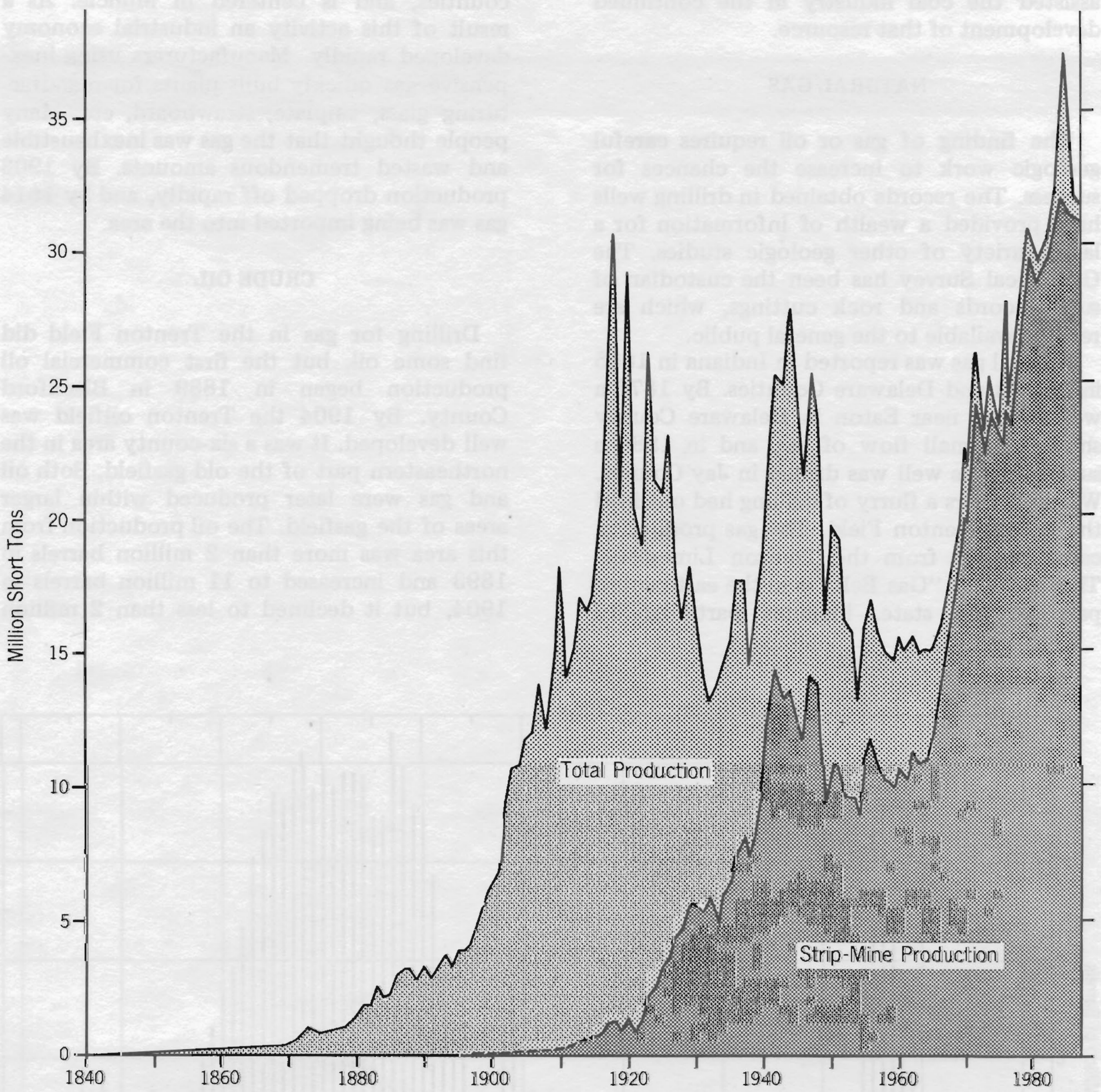


Figure 5. Graph showing total coal production and strip-mine production in Indiana, 1840-1986. Modified from Wier (1973).

and loading out the uncovered coal. But when larger amounts of coal were desired, the miners developed underground mines. By 1915 earth-moving equipment that had been developed for road, dam, and canal building was used to uncover and mine coal. Strip (or surface) mining grew rapidly, especially during World War II when the demand for coal again increased, and since 1970 strip mining has accounted for 90 percent or more of the state's production. A peak coal production of 37 million tons was reached in 1984. The total cumulative production has been 1,790 million tons.

The Geological Survey under the leadership of Charles F. Deiss began a new program on coal reserves in 1949. Published maps and reports and open-file information have greatly assisted the coal industry in the continued development of that resource.

NATURAL GAS

The finding of gas or oil requires careful geologic work to increase the chances for success. The records obtained in drilling wells have provided a wealth of information for a large variety of other geologic studies. The Geological Survey has been the custodian of such records and rock cuttings, which are readily available to the general public.

Natural gas was reported in Indiana in 1865 in Pulaski and Delaware Counties. By 1876 a well drilled near Eaton in Delaware County showed a small flow of gas, and in 1886 a successful gas well was drilled in Jay County. Within 2 years a flurry of drilling had outlined the entire Trenton Field. The gas production came mostly from the Trenton Limestone. This so-called "Gas Belt" is in the east-central part of the state, includes parts of 19 counties, and is centered in Muncie. As a result of this activity an industrial economy developed rapidly. Manufacturers using inexpensive gas quickly built plants for manufacturing glass, tinplate, strawboard, etc. Many people thought that the gas was inexhaustible and wasted tremendous amounts. By 1903 production dropped off rapidly, and by 1914 gas was being imported into the area.

CRUDE OIL

Drilling for gas in the Trenton Field did find some oil, but the first commercial oil production began in 1889 in Blackford County. By 1904 the Trenton oilfield was well developed. It was a six-county area in the northeastern part of the old gasfield. Both oil and gas were later produced within larger areas of the gasfield. The oil production from this area was more than 2 million barrels in 1893 and increased to 11 million barrels in 1904, but it declined to less than 2 million

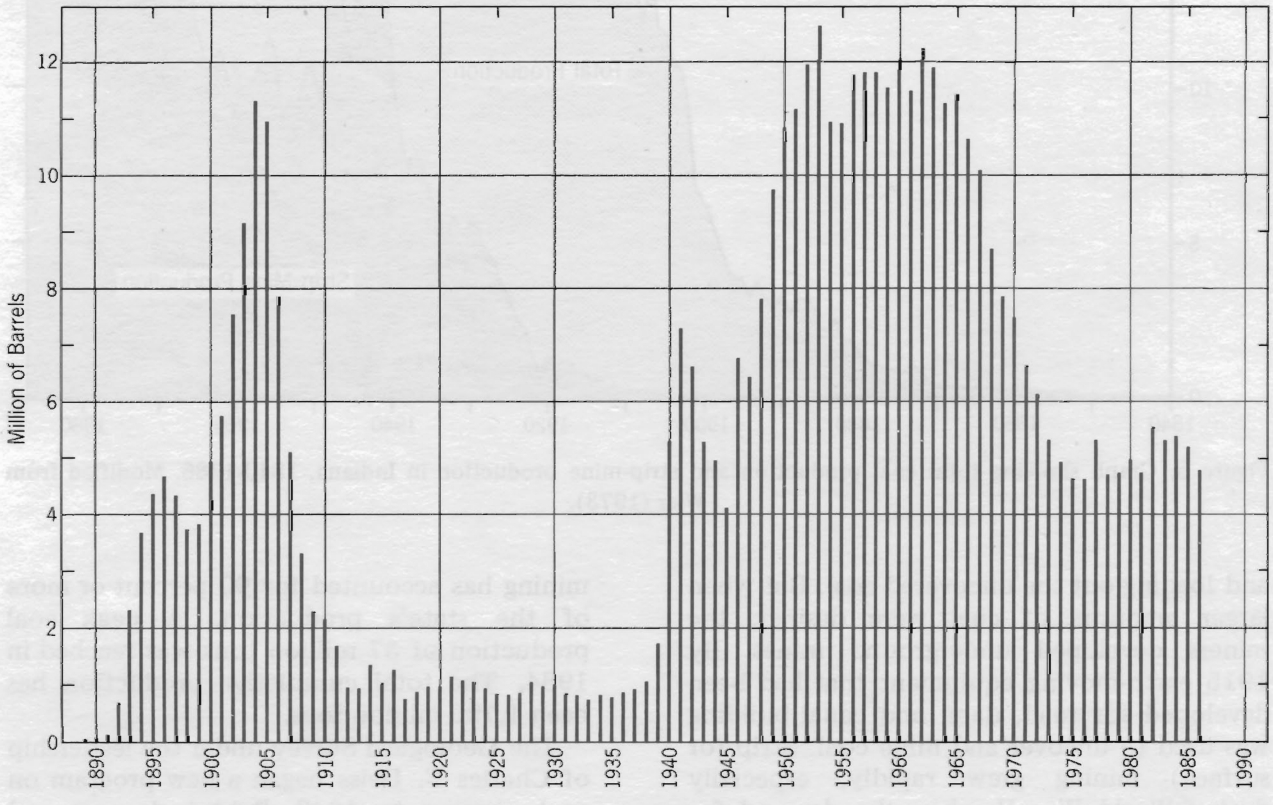


Figure 6. Graph showing oil production in Indiana, 1889-1986. From Keller and Sullivan (1987).

barrels by 1911 (fig. 6). The cumulative production from the old Trenton Field has been about 105 million barrels.

Meanwhile, in southwestern Indiana some exploration was taking place. Oil was found in 1889 in a well in Terre Haute and in 1903 near Princeton, but the fields were slow to develop. The annual production for the state was less than 2 million barrels from 1911 to 1939. Thereafter the production of oil in southwestern Indiana increased rapidly (fig. 6). From 1950 to 1967 the annual production exceeded 10 million barrels. Despite considerable activity in secondary production, the total production of oil declined to about 5 million barrels per year from 1973 to 1986.

In contrast with the Trenton Field, where the production of oil has come from a single field and a single rock unit, the production in southwestern Indiana has come from about 300 separate fields and 20 different formations. Most of the reservoirs are Mississippian in age, but some are Devonian and Pennsylvanian in age. The cumulative production from the fields in southwestern Indiana has been about 400 million barrels.

METALLIC ORES

The production of metallic ores in Indiana has been small. When Richard Owen (1862) made a geological reconnaissance in 1859 and 1860, several blast furnaces for producing iron were operating. Most of these furnaces used sedimentary iron ores from Upper Mississippian and Lower Pennsylvanian rocks. A blast furnace in northern Indiana used bog iron ore. Later, ore from Missouri was imported and mixed with local ores. The Block coals were used as fuel. In 1893 the last blast furnace using Indiana ores was closed. Since that time steel mills in Indiana use not only imported ore but also imported coal.

Finds of gold, silver, lead, and copper have been reported over the years, and some of these finds have been highly publicized. Investigation of these reports has shown that small amounts of these metals transported by ice from north of the Great Lakes area have been found in glacial drift. Most of the known specimens have been found in the water-sorted glacial material in Brown and Morgan Counties.

SUMMARY

The story of the development of mineral resources in Indiana is complex. The timing of the discovery as related to local and national markets and to the development of transportation and technology was a major element in determining the quantity produced. A good example is iron ore. Early state geologists recognized that a healthy iron industry would accelerate industrial development, and therefore they extolled the virtues of using local ore and coal. But Indiana's iron ore and coal were not as suitable as those from other states for making iron and steel. Indiana's steel mills used the better coal and ore as better transportation developed.

Coal was used locally by the early settlers. Many small towns, such as Cannelton (for cannel coal), Coalmont, Coal City, Coal Creek, and Coal Bluff, were named in recognition of local outcrops or mines. Coal was not needed as long as timber was readily available for heating and producing steam for the steamboats, but coal was widely used as wood became scarce and the higher heating value of coal was recognized. The production of coal increased with the increased use of the steam engine and continued in importance as coal was used to generate electricity. Nearly all of Indiana's coal production now goes to electric-utility plants. For the past 75 years the production of coal has been about half or more of the total value of mineral production, even though the annual tonnages have fluctuated from high amounts in war years to low amounts during depressions (table 1). The production of coal in 1986 was 31.9 million tons.

The discovery of natural gas in the late 1880's in the Trenton Field came too early. There were no pipelines to distribute the gas to areas with a larger population, and most people involved did not understand the need to conserve this exhaustible natural resource. Although the boom did result in building many new industries in the local communities (many of which are still there), the gas was

Table 1. Mineral production in Indiana for selected years, 1915-86

[Data from U.S. Bureau of Mines Yearbooks and preprints]

Mineral resource	1915 (pct)	1925 (pct)	1950 (pct)	1975 (pct)	1986 (pct)
Mineral fuels	52.8	56.3	60.7	60.7	74.5
Coal	48.8	54.3	44.1	51.6	68.6
Petroleum	2.2	1.9	16.5	9.0	5.8
Natural gas	1.8	0.1	0.1	0.1	0.1
Industrial minerals	47.2	43.7	39.3	39.3	25.5
Dimension stone	7.9	17.1	7.1	2.0	1.7
Crushed stone	12.2	4.1	11.5	10.7	6.5
Sand and gravel	3.2	6.2	4.2	6.5	4.2
Clay and shale	18.6	0.1	0.9	0.4	0.2
Cement	-------	10.4	10.1[1]	13.9	10.3
Peat	-------	-------	0.1	0.4	0.1
Marl	-------	-------	0.1	0.1	0.1[1]
Gypsum	-------	-------	-------	-------	0.7[1]
Miscellaneous	5.2	5.8	5.6	5.3	1.7
Total value ($1,000)	$38,145	$85,415	$179,500	$541,560	$1,183,486

[1] Estimated value.

exhausted in about 30 years. Since that time the production of gas has been only about 0.1 percent of the total value of the state's mineral production (table 1).

The production of crude oil has been a much more stable industry. After the production of oil declined in the Trenton Field, the total state production was about 1 million barrels per year from 1912 to 1939. Increased activity during and immediately after World War II produced a boom in southwestern Indiana, and the wise use of secondary-recovery methods has continued the production of crude oil at about 5 million barrels per year. The variations in the price of oil have caused drastic changes in its value, but in 1986 the production of crude oil was 4.8 million barrels and accounted for 5.8 percent of the total value of mineral production.

The rock used for crushed stone and sand and gravel occurs in great abundance. These industrial minerals have been developed as they have been needed for various construction projects. Although the amount used has steadily increased, the value of these two aggregates for the past 75 years has been about 15 percent of the state's mineral production. In 1986 the value was 10.7 percent.

The production of dimension stone in the state grew steadily from about the time of the Civil War to peaks in the 1910's and 1920's. During that time the Salem Limestone industry, with its expertise in cutting and carving, greatly affected architectural style in the United States. During the peak-production years dimension stone accounted for nearly 20 percent of the state's total value of mineral production, but for the past 10 years the value has been about 2 percent. In 1986 it was 1.7 percent.

Many small industries use peat, marl, whetstone, special sands, and clay and shale, but the combined production of these industrial minerals accounts for only a few percent of the state's annual value of mineral production. In the 1890's and early 1900's, however, the value of clay and shale may have been as much as 20 percent of the total mineral production in Indiana. The production of gypsum did not begin until 1955. The value of its production in 1986 was about 0.7 percent of the state's total mineral production.

As Indiana's mineral resources have been developed during the past 150 years they have had a significant effect on local communities and the state in general. The annual value of manufacturing in the state is much higher than that of the raw minerals produced. But many of the manufacturing plants are where they are because of one or more mineral resources.

The General Assembly was wise when it authorized the first geological survey of Indiana in 1837. During the past 150 years the geological surveys have collected information about our mineral resources and have continued to reevaluate them. These surveys have been a strong ally of the industries that have developed our mineral resources.

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THE NEW HARMONY COUNTRY OF DAVID DALE OWEN, REVISITED

By Curtis H. Ault, Henry H. Gray, Carl B. Rexroad, and Robert H. Shaver

CONTENTS

ILLUSTRATIONS

INTRODUCTION

Without the combination of David Dale Owen's sensitive artist's temperament but lack of sufficient talent to become a painter, we would not now be following his footsteps in celebration of the sesquicentennial of the Indiana Geological Survey. David Dale was for a while a student of Benjamin West in London before he came to New Harmony and made medicine his second choice as a profession. After he earned his M.D. degree at the Miami Medical College in Ohio, he realized that the sight of physical suffering was too much for his temperament, and he turned to geology. Much of his geologic education came from

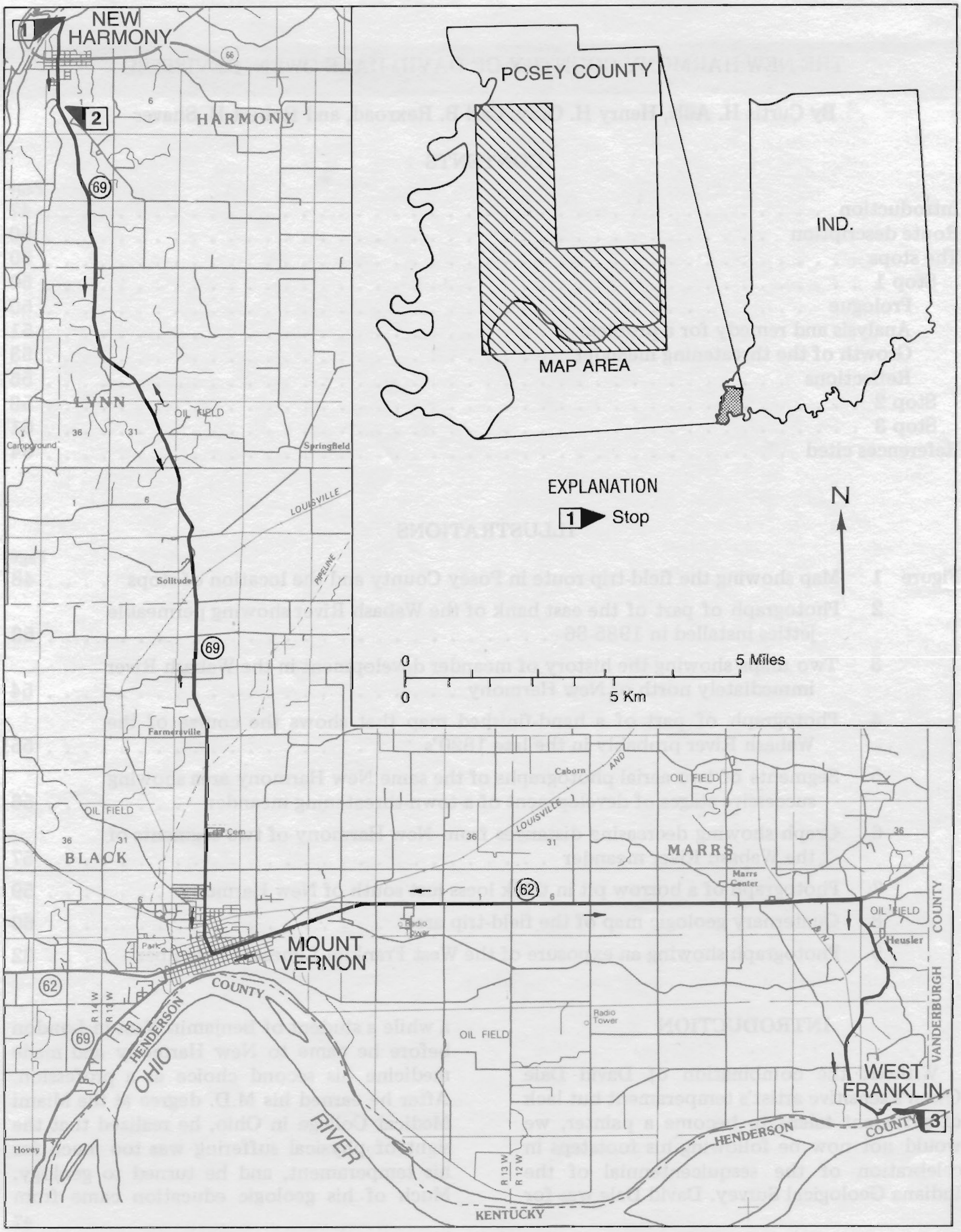


Figure 1. Map showing the field-trip route in Posey County and the location of stops.

studying the collections of William Maclure, Father of American Geology, who arrived at New Harmony on the keelboat *Philanthropist* in 1828 as part of "The Boatload of Knowledge." It also included of special note Thomas Say, zoologist, conchologist, and professor of natural history at the University of Pennsylvania, and Charles-Alexander Lesueur, zoologist and first curator of the Museum of Natural History at Le Havre, France.

David Dale Owen made an initial geological survey of the State of Indiana in 1837, which he continued in 1838, as authorized by an act of the state legislature approved February 6, 1837 (Owen, 1839a, 1839b; 1859a, 1859b). He was appointed "United States Geologist" in 1839 and organized various surveys during the next 17 years.

The Wabash River was familiar to the Rappites, the Owenites, and David Dale and served as an important commercial link for New Harmony, but it is readily apparent at our stop 1 (fig. 1) that, even in the geologic instant of time since 1837, the ever-changing river has shifted course markedly from those earlier days. Nonetheless, the scene that we now view in this corner of Posey County is more closely allied to David Dale Owen's first encounter in 1828 than was his first view in comparison with that of the arriving Rappites only 14 years earlier.

"The Angel and the Serpent" by William E. Wilson (1964) is one of the best sources summarizing the years of building by the religious cult from Germany, the Rappite followers of George Rapp, and the years of the Owenites at New Harmony under the direction of Robert Owen, who founded a much different social experiment that substituted education and aethism for God. Both experiments were communal, although this aspect dwindled under Owen's inept leadership and long absences.

The advance party of Rappites in June 1814, arriving by boat up the Wabash River, met a dense growth of cane across the bottomlands through which they cut a road before reaching higher ground. Although there were scattered open meadows, John Baker wrote (Wilson, 1964, p. 35-36), "The property is covered with heavy timber comprising oaks, beeches, ash, three kinds of nut trees, three to four feet in diameter, with trunks fifty to sixty feet high * * *. Gum trees, hackberry, sycamore, persimmons, wild cherries, apples and plums, also wild grapes of enormous diameter and height, all of which bear fruit. There are also a number of maple and sugar trees * * *. Sassafras trees from two to three feet in diameter and a kind of poplar; * * * while in the lowlands there are very large cypress trees good for the work of the cooper and for shingles." This was a true wilderness when the Rappites arrived. Only a few scattered pioneer log huts dotted small clearings.

When the last of the Rappites left in 1825, the scene was very different. By then New Harmony was a small Indiana town in an agricultural setting. Today New Harmony is still a small Indiana town in an agricultural setting.

As one approached overland by the wagon road from Mount Vernon, the forest opened on cleared land about a mile south of a flourishing town laid out along four streets running toward the river and six at right angles. The many log and frame houses were unpainted and dull, but the white wooden church, the new large red-brick church, the three-story dormitories, and some 40 brick houses brightened the scene. Indicative of the Rappites industry were one large three-story waterpowered merchant mill, an extensive factory of cotton and woolen goods, two sawmills, one oil and hemp mill, two large distilleries, one brewery, one tanyard, one store, a large tavern, a stone warehouse, two large granaries, and six frame buildings used as mechanics' shops. All in all, as one looked out across more than 2,000 acres of highly cultivated land, it was a prosperous scene.

Admittedly, this is not a precise description of New Harmony today, and the wagon road to Mount Vernon has become a black-topped state highway. Even so, the bank of loess and its environs at our stop 2 on the south edge of town would surely still seem familiar to David Dale if he could join us. This stop would surely be the spot where he would be closest to us in spirit, for his grave lies in the cemetery near the top of the hill where some will have a chance to go during the second stop.

David Dale Owen's 1837 survey of the

geology of Indiana obviously started in New Harmony. From there he worked eastward in the counties bordering the Ohio River to Dearborn County; then he irregularly zigzagged over much of the southeastern quadrant of the state. He included forays into the northern part of the state and two trips to Indianapolis as well. From the latter city he worked his way westward to Terre Haute and from there down along the Wabash River to Posey County. It is the second published part of his report that includes county by county descriptions of this traverse, however, and so it is in the latter report that we realize that David Dale visited the limestone outcrop along the upper bluff of the Ohio River at West Franklin that is our stop 3.

Much of the difference between the site then and now must be imagined. We realize, of course, that the summer cottages, cars, and tractors were not part of David Dale's picture, and the then undammed Ohio River must have stood at a much lower level. Nonetheless, we can imagine the rest of the scene as we see it as not really being too different from the day in 1837 when David Dale Owen examined this section, perhaps with his younger brother, Richard, who was his first field assistant. Each of us with only a small bit of imagination at stop 3 and on the entire trip should be able to turn back the clock to absorb the mood of an 1837 countryside in southwestern Indiana, even though a comfortable bus is a far cry from the wagons, horses, and foot power that provided locomotion 150 years ago.

ROUTE DESCRIPTION

The route that we follow in our bus (fig. 1) to stop 1 starts from the parking lot of the New Harmony Inn. From the lot turn left (west) and go less than 0.1 mile to the first street, North Broadway. There turn right and go as far as possible, almost 0.3 mile to the end of the road at a bridge. We will walk a short distance north to the bank of the Wabash River to consider the problems of erosion.

To continue the trip reverse direction and follow the road southward. At Broadway the street name changes to South Main Street and also is Indiana Highway 69. At 1 mile pull off into the parking area on the right below the cemetery for stop 2. We will walk across the road to the east, up a slight embankment, and across a small field southeastward to a barrow pit exposing a historically interesting section of loess. A vehicle will be available to take interested persons up the hill to the graves of many members of the Owen family, including David Dale.

Leave the parking area and continue southward 13.4 miles on Highway 69 to the junction with Indiana Highway 62 in the middle of Mount Vernon. Mount Vernon was a thriving Ohio River port in the early and middle 1800's, and many of the early visitors to New Harmony from the east disembarked here and went overland to their destination rather than continuing down the Ohio and then up the Wabash by boat.

Turn left (east) on Highway 62 at its junction with Highway 69, go 9.6 miles on Highway 62, turn right (south), and follow the black top for 1.25 miles. Take the right fork of the road, continue another 4 miles into West Franklin, and go through town along the river to a bluff exposing the West Franklin Limestone Member (Pennsylvanian) of the Shelburn Formation. Disembark for the third and final stop of the trip.

THE STOPS

STOP 1

This stop is about 0.25 mile north of the northern boundary of New Harmony and on the south bank of the Wabash River, SE¼SW¼NW¼ sec. 36, T. 4 S., R. 14 W., New Harmony Quadrangle.

PROLOGUE

The south cutbank of a large meander has advanced to this point over a distance of about 0.8 mile during 67 years and threatens, therefore, the very existence of the historic town of New Harmony. The field-trip group will consider the history of meander development in this area, the studies that were undertaken to assess the danger, and the remedial measure that was installed not yet 2 years ago.

ANALYSIS AND REMEDY FOR A PROBLEM

When the Rappites arrived in southwestern Indiana in 1814, they had the foresight to locate their Harmonie townsite on a remnant of the Maumee Terrace along the southeastern valley wall of the Wabash River. This terrace and its colluvium represent the flood plain of the river when it carried the overflow of ancestral Lake Erie (that is, glacial Lake Maumee). The terrace is a scant 10 to 15 feet above the modern flood plain, but that is sufficient to prevent all but the rarest and highest of frequent overbank floodwaters from reaching the streets of the town.

These waters, of shallow depths and of much reduced velocities, did not pose real dangers to the town, and probably neither the Rappites nor the Owenites realized that the Wabash River could pose another and very real kind of danger. Rivers then needed to be respected, of course, but they were valued means of transportation and sources of water, power, and food. And they yielded new layers of silt periodically to replenish the fertility of soils that nourished man's life-sustaining crops. No, these early religious, social, scientific, and agricultural pioneers who came to New Harmony beginning 173 years ago did not know that not even the Maumee Terrace could stand in the way of the river that could erase the townsite by the very process that created their thousands of breadbasket acres distributed from valley wall to valley wall. If the river were to do so, the channel bottom would slice laterally some tens of feet below the foundations of the town.

That the Wabash River could wreak such havoc was not realized by the New Harmony townspeople until more than a century and a half had passed, when, in the 1970's, they noted that to the north the annually rampaging floodwaters of great velocities were now much closer to the town and that croplands were being destroyed rapidly as the first overbank floodwaters dumped a foot of sand on formerly tillable fields. Within living memories three buildings and 2,000 feet of the road leading northward out of New Harmony had disappeared. (See the 1959 edition of the U.S. Geological Survey 7½-minute topographic map of the New Harmony Quadrangle and compare it with the figures here.)

Jane Blaffer Owen, a noted New Harmony philanthropist, was among the foremost citizenry to ask for a study. Representative of local citizenry concerns is this quotation from another citizen: "I have been on the river 40 years, and I have seen more change in the last five than all the rest * * *. Five years ago a man had a house on a point out there. He had to move it when the river took more than 60 feet of bank" (Ben Helfert, The Indianapolis News).

The community voiced its growing concerns to then Lieutenant Governor Robert D. Orr of Indiana and to the Department of Natural Resources. The Geological Survey, a division of the Department, was asked to take a look at a time (March 23, 1978) when high water had nearly isolated the town and when loss of cropland through both sand dumping and erosion was a major concern. For example, in 1979 Posey County lost an estimated 35,000 acres of corn and beans to flooding and a much smaller amount to erosion (Posey County Soil & Water Conservation District Newsletter, September 1979). Levees to hold back floodwaters from the fields and from the town itself were popularly assumed to be an obvious remedy.

Studies by the Geological Survey resulted in five open-file reports (Shaver, 1978, 1982, 1984, 1985, and 1986) and one published report (Shaver, 1979) for popular consumption. These reports emphasized not loss of cropland and construction of levees but the danger to the very foundations of the town posed by a meander that was rapidly advancing southward. Along some measured lines the river advanced more than 150 feet in 1 year. It appeared that the leading edge of the meander would be at the northern boundary of the town within a mere two decades.

News of this warning was first published in The New Harmony Times (June 15, 1978) and was soon picked up in city newspapers, the national press and television networks, and even in the slick British Geographical Magazine (Wintsch, 1984). New Harmony is virtually unique in American history. It is too rich in historic, cultural, and scientific resources to be ignored in its peril. The state-appointed New Harmony Commission, the local organization known as Historic New Harmony, Inc., and the New Harmony Town Board took interest. Indiana representatives in the U.S. Congress became informed and added their concern. The director of the Department of Natural Resources and the governors of Indiana and Illinois focused these concerns by asking the Louisville District of the U.S. Army Corps of Engineers to further "define the nature and scope of the problem, the most probable nature and consequences of the further development of the meander in the absence of any corrective measures, and the nature and cost of appropriate corrective action" (correspondence dated June 16, 1982, by Director James A. Ridenour of the Department of Natural Resources).

The Corps of Engineers completed its study in 1983 (U.S. Army Corps of Engineers, 1983) and reconfirmed the peril to New Harmony of which Shaver (1978-82) had warned. Its study included boreholes that revealed no bedrock impediment buried shallowly within the alluvium that could effectively obviate the danger to New Harmony. The Corps mentioned eight different plans to stop the erosion that variably would cost from $1.4 to $4.1 million (Louisville Courier-Journal, October 8, 1983). The Corps seemed to favor a method that would use more than 7,000 truckloads of quarry stone and cost nearly $4.0 million initially and more than $300,000 annually for maintenance (The Evansville Press, December 13, 1983, and The Indianapolis Star, October 7, 1983).

But a remedy emplaced by the Corps would require an act of the U.S. Congress and perhaps years to consider and then to effect a remedy. As viewed by the New Harmony Town Board and officials of the State of Indiana, however, both time and less money were of the essence (Donald Hatfield, chairman of the Town Board, personal communication, May 28, 1987). New Harmony, for example, had no such funds within its jurisdiction for either remedy or maintenance.

In efforts coordinated by Lieutenant Governor John M. Mutz, the Indiana legislature appropriated more than $800,000 to the Department of Natural Resources. A bid from the Houston-based firm ERCON was accepted to construct permeable jetties along 6,100 feet of the east and south riverbank in secs. 25 and 36, T. 4 S., R. 14 W., north of New Harmony. Construction began during the fall of 1985, but unusually high water and an early winter blast in December forced a delay in completion until the spring of 1986. Also, the unexpected severe conditions combined with the postponement of completion required some initial repair work before the job was even completed (Donald Hatfield, as cited above).

The jetties in the New Harmony jetty system were installed at a cost of $838,000 and are positioned at 40-foot intervals along 6,100 feet of the riverbank (fig. 2). Each jetty consists of two to six steel-pipe pilings, 10 inches in diameter, spaced 16 feet apart, driven vertically into the streambed at right angles to the bank, and extending at least 15 feet above the streambed. A woven mat consisting of seat-belt material, 12 feet high by 16 feet long, is attached to the pilings and spans each space between them. These mats were designed to slide down the pipe and therefore to maintain contact with the stream bottom. The success of this system is warranted for 10 years and is checked during annual inspections by ERCON and the Department of Natural Resources. (This information was supplied through the courtesy of Lew Trent, Indiana Division of Water, June 10, 1987.)

The New Harmony Town Board at this time is guardedly optimistic about the success of the installation and is pleased with the role of the Department of Natural Resources. As recorded in his report of July 18, 1986, and after his inspection a few days earlier, Shaver thought that the remedial "principle did seem to be working well." A much reduced current coursed nearshore within the jetty system in contrast with the "fairly swift and angry-looking current" that swept by 50 feet or more from the cutbank and offshore from the jetties. Plant growth on slumped and river-deposited sediment in the spaces between jetties and also the beginning of a modestly

Figure 2. Photograph of part of the east bank of the Wabash River showing permeable jetties installed in 1985-86 by ERCON, Houston, Tex., as preventative of further bank erosion north of New Harmony. Photograph by Shaver (1986).

inclined bank in contrast with the nearly vertical bank of the year before were already evident. An inspection team of DNR and Geological Survey officials examined the installation in September 1986. Reaction was guardedly favorable. Headward erosion in a few places was noted, however, where runoff from the fields, including that generated from the winter and spring overbank floods, had been severe enough to leave the jetties in those areas standing well off the still-recessing cutbank. No such measure as was installed should be considered as permanent and as requiring no watching, maintenance, or repair.

GROWTH OF THE THREATENING MEANDER

After acquisition of the Northwest Territory by the United States during the late 1700's, perhaps the first accurate surveying records of the Wabash River at New Harmony were made in 1806 (fig. 3A). After leaving the great looping meander surrounding Bull Island, 2.5 miles north of New Harmony, the river coursed southwestward in a gentle westward curve past the west edge of the town before it entered another great looping bend surrounding what is now an abandoned meander core called Ribeyre Island.

A hand-finished map (fig. 4), which is reposited in the New Harmony Workingmen's Institute Library, and which is believed to have originated in the 1820's within the Owen and Maclure social-scientific community at New Harmony, reveals no unusual changes in the river 20 years later. Nor does an artistically rendered but upside-down map prepared by the famed naturalist Charles-Alexander Lesueur and labeled 1834 reveal any impending peril to New Harmony by a meandering Wabash River (Hamy, 1968).

By 1900, however, the westward-directed inertia of the current in section 25 had caused the channel to migrate well westward in that section and nearly beyond the confines of section 36. Along the line of maximum shift, the average annual advance was about 14 feet. This was but an immature meander bend in section 25, but it narrowed the neck of Illinois land extending into the great Bull Island meander.

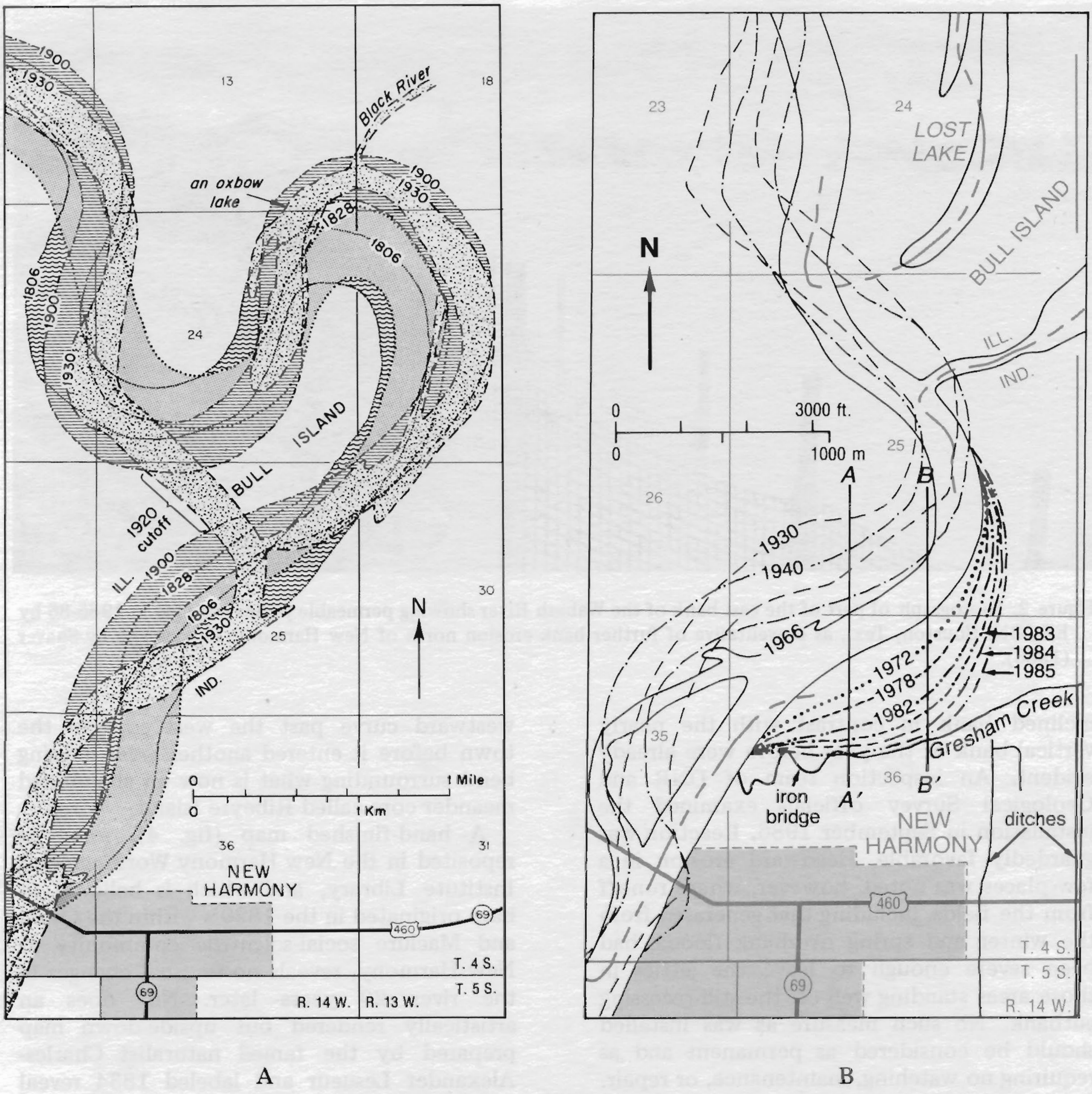


Figure 3. Two maps showing the history of meander development in the Wabash River immediately north of New Harmony. A, From 1806 to 1930, including the 1920 cutoff event for the Bull Island meander; B, 1930 to 1985, including the cutting off of the lower reaches of Gresham Creek. From 1966 on in figure B, the developmental history is traced only for the east and south bank and only in sections 25 and 36. Collate with figure 5A. Modified from Shaver (1978 through 1985).

Indeed, by 1920 the Bull Island neck had become so narrowed by southeastward and northwestward encroachment that the river abruptly negotiated the remaining distance during the spring flooding in 1920 (The New Harmony Times, spring of 1920; fig. 3A here). From that time began the peril to New Harmony. What had been a southwestward-

Figure 4. Photograph of part of a hand-finished map that shows the course of the Wabash River probably in the late 1820's. The map is not identified by author or by date but is believed to derive from the early scientific community that occupied New Harmony in the late 1820's. The map is on file in the Workingmen's Institute Library in New Harmony; photograph through the courtesy of Aline Cook.

moving force in 1919 had abruptly shifted 90° to become a southeastward-moving force in the center of section 25.

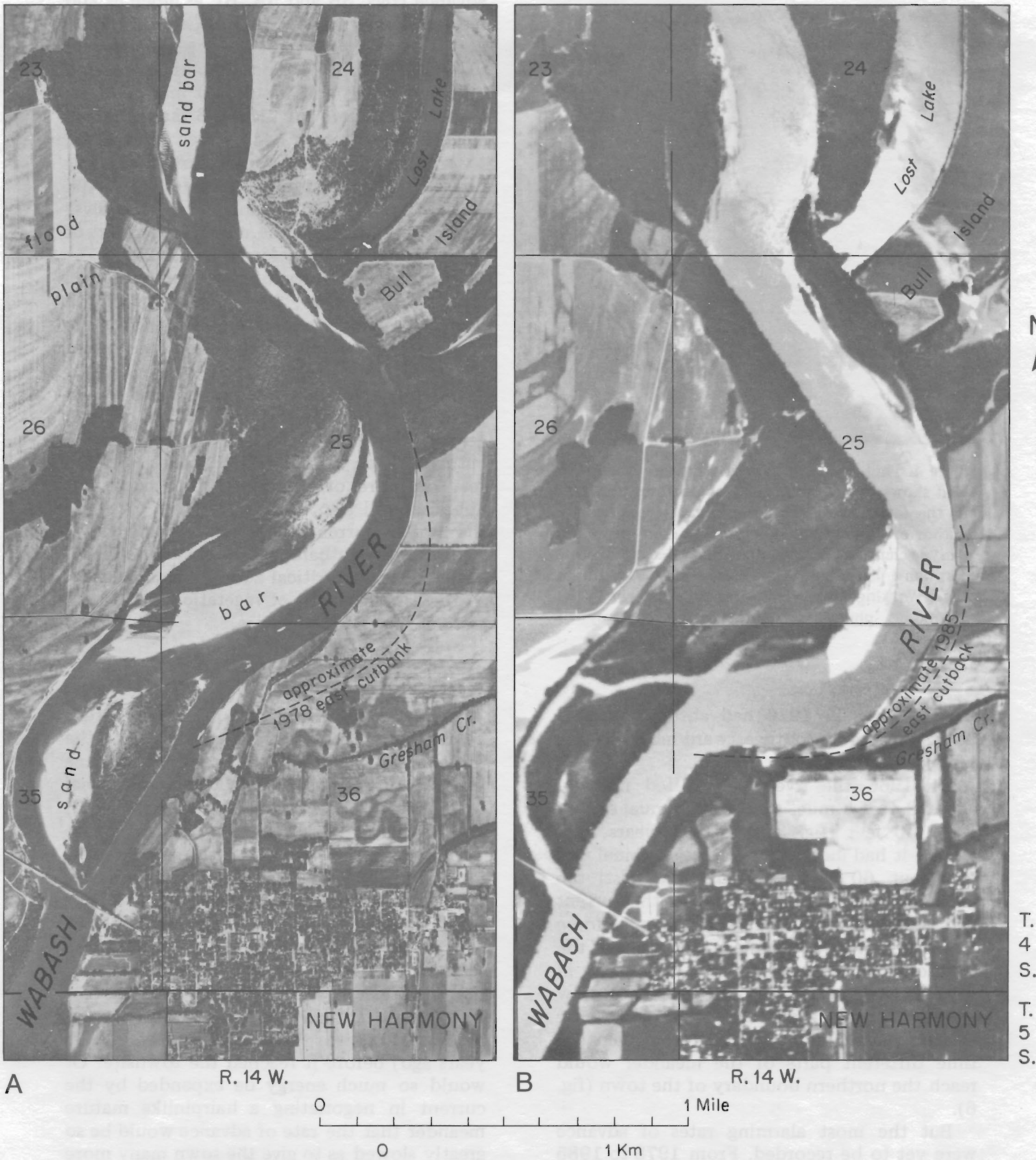
By 1966 the river had shifted laterally about 0.4 of a mile, an average annual rate of some 40 feet (fig. 3B), and 12 years later (1978) it had increased its average annual rate to about 60 feet. The die was cast; the meander was maturing, although the current had yet to develop its maximum inertial force to be directed at blunt angles against the southeast cutbank, which then was partly in section 36 and half a mile closer to New Harmony (figs. 3B and 5A). A curve could be plotted that would predict at what calendar time different parts of the meander would reach the northern boundary of the town (fig. 6).

But the most alarming rates of advance were yet to be recorded. From 1978 to 1985 and along some tape-measured lines of advance (figs. 3B and 5A, B), as much as 200 feet of alluvial flood plain had calved into the river in a year's time. The average annual rate of advance along the most rapidly advancing lines, however, was about 120 feet, and the hand-fitted curve of figure 6 had become steeper. The meander had by then approached to within 1,600 feet of the town and had pirated the upper reaches of Gresham Creek (figs. 3B and 5B). If unchecked, the river would perhaps reach the northeastern part of New Harmony even before the year 2000.

That is the history of meander growth to the year 1985. Now, 2 years later and after 2 years of winter and spring flooding since construction of the permeable jetty system, sesquicentennial field trippers may judge for themselves just how effective this sytem promises to be. The distalmost (from channel center) pilings were driven at or near the cutbank. Even by 1986 some jetties stood 10 feet or more off the flood-plain edge, but appraisal will also need to be given to where the swifter current glides by, to the angle of repose of the cutbank, to the accumulation of sediment in the critical zone for stabilization, to the establishment of vegetation, and to the state of repair of the jetties.

REFLECTIONS

A few experienced persons could hardly believe the rapidity of advance of the threatening meander. Was it a normal advance for a maturing meander? Was it even normal for a meander developing off a new (in 1920) cutoff that gave a relatively straight chute over an abruptly steepened gradient (considering the course that had been shortened by more than 3 miles)? Why did the west end of the meander nearest the northwest corner of New Harmony migrate but little, acting as a fulcrum as it were, for a writhing advance of the upstream meander segment (fig. 3)? Would an eventually fully matured meander be cut off (as was the Bull Island meander 67 years ago) before it reached the townsite? Or would so much energy be expended by the current in negotiating a hairpinlike mature meander that the rate of advance would be so greatly slowed as to give the town many more than 15 years to make a final decision?


23
24
sand bar
Lost Lake
Island
flood
plain
Bull
26
25
bar
RIVER
approximate
1978 east cutbank
Gresham Cr.
sand
35
36
WABASH
NEW HARMONY
A
R. 14 W.
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T.
4
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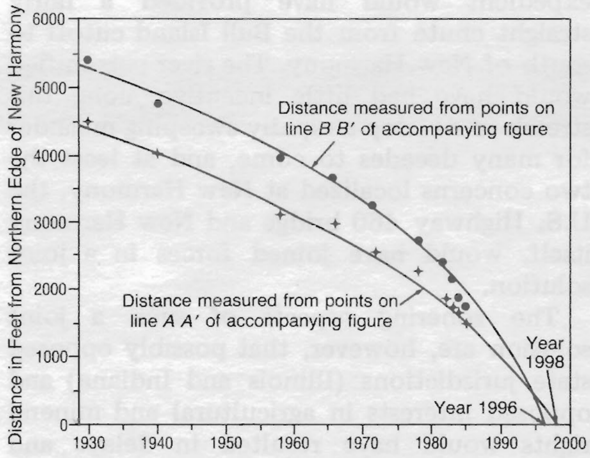

Figure 6. Graph showing decreasing distances from New Harmony, 1930 to 1985 and projected to 1995 and 2000, of two segments of the Wabash River meander immediately north of the town. See figure 3B, in which lines AA′ and BB′ are the data base for construction of the graph.

In his 1985 report to the Department of Natural Resources, Shaver noted that the alluvially composed island in the eastern part of the NE¼ sec. 35 (fig. 3B) appeared not to be affected during his period of observation, even though it stood square in the line of current emerging from the meander segment in section 36. Apparently this island had been armored by highway engineers as a matter of protection of the U.S. Highway 460* bridge connecting New Harmony to Illinois. Could this obstruction, as it were, have caused such a slowing of the headlong-rushing current and such a backward-roiling effect, thereby, as to bring about spectacular erosion even half a mile upstream? If so, the upstream-directed effect would have increased in magnitude as the current, emerging from the evolving meander, approached the armored island evermore head on. If so, would this effect, an unnatural one as the river personified would judge it, have brought the river, surely and soon, to the New Harmony doorstep?

As was noted in 1985 (Shaver), this island, seemingly standing resolute for years in the face of an increasingly head on current, was losing at last its protective armor to the river, which by then had penetrated the armor in places and had produced concave scallopings in the alluvium behind the armor. Plans were then underway, however, to replace the armor and therefore to continue protection for the U.S. Highway 460 bridge. If these plans to rearmor the island were good for the bridge, so to speak, were they nevertheless inimical to the security of New Harmony?

To be sure, two geologists of repute expressed some skepticism about Shaver's prediction of the time when the leading edge of the meander would arrive at the outskirts of the town. They were Robert V. Ruhe, professor of geology at Indiana University, who cited studies along the Missouri River (personal communication, June 1983 and 1984), and Richard L. Powell, senior geologist for Geosciences Research Associates, Inc., Bloomington, Ind. Powell said, for example, "It seems possible that the river may never reach the town. The cost of constructing breakwaters or of rip-rapping the bank may be more severe than what the river will do naturally. It may not be worth the cost" (The Indianapolis News, June 17, 1983). And Ruhe referred to scare tactics and nonscientific prognostication on the part of Shaver.

The tape measure did not lie, however, and

*What is referred to in the text and in some of the figures as U.S. Highway 460 is now Indiana Highway 66.

Figure 5 (*on facing page*). Segments of two aerial photographs of the same New Harmony area, taken in 1953 (A) and 1982 (B), showing successive stages of development of a town-threatening meander in the Wabash River. Figure A also shows an approximate surveyed position of the east and south bank of the meander in 1978 (Shaver), and figure B shows the surveyed position in 1985 (Shaver) and the cutoff by the river of the lower reaches of Gresham Creek. Figure A is U.S. Department of Agriculture aerial photograph QU-5M-159; figure B is a montage of two photographs taken from the Indiana Department of Natural Resources plane.

in the recent decade of critical observation the advance of the meander had been hastened and had approached to within a dashman's sprint of the New Harmony Inn. The threatening meander had not nearly become accentuated into a hairpinlike form that would expedite its own cutoff like the upstream Bull Island cutoff of 1920 and the Grayville cutoff of 1985, nor would it before reaching New Harmony (Shaver, 1985). Public and state opinion had crystallized, and the threshold for action had been crossed. As Jane Owen summed up, "The time has come for the state to act—if not because of New Harmony's historical significance, then because of its contribution to state coffers. New Harmony is a jewel in the crown of the state. I can't think of a greater loss to the state than if it lost New Harmony" (USA Today, August 9, 1983).

To conclude our reflections, we may ask ourselves how well man has acted in this case history to live in harmony with the river, which he cannot control completely. Has he been fully aware in effecting the present local remedy that a price may be paid elsewhere along the river? After all, man should have learned by now that anything he does affecting the regimen of the river is not accepted by the river without exacting a price elsewhere that may or may not prove to be acceptable to man. This principle has applied to man's having built dams and levees and having practiced deforestation, intense agriculture, and artificial channelization throughout the watershed. And in paying the price at New Harmony, has he been aware that he may be paying a price exacted because the river has been tampered with elsewhere, for example, at the island in section 35 (fig. 3) that has been armored by highway engineers as a protective measure for the U.S. Highway 460 bridge?

In 1978 and again in 1985, Shaver mentioned, as did the U.S. Army Corps of Engineers (1983), that one solution for the New Harmony problem would be to divert the channel through the western part of section 25 and the northwest corner of section 35 and from there to rejoin the present channel at the northern approach to the U.S. Highway 460 bridge (fig. 3). This expedient would have provided a fairly straight chute from the Bull Island cutoff to south of New Harmony. The river personified would have had little incentive along this stretch to develop a rapidly sweeping meander for many decades to come, and at least the two concerns localized at New Harmony, the U.S. Highway 460 bridge and New Harmony itself, would have joined forces in a joint solution.

The sobering aspects of such a joint solution are, however, that possibly opposed state jurisdictions (Illinois and Indiana) and opposed interests in agricultural and mineral rights would have resulted in delays and higher costs beyond what the patience of New Harmony-oriented groups could withstand. Besides, what new problem would be created downstream, given increased velocity and erosive power in that direction?

Again, field trippers have an opportunity to decide for themselves whether the newly installed expedient is a reasonable compromise—the river permits nothing but compromise—or whether modern man in this example should still have learned much more than he has about riverine processes and the compensating toll they take when these processes are artificially altered.

STOP 2

This stop features a loess section in a borrow pit east of Indiana Highway 69 at the south edge of New Harmony in the NW¼SW¼ sec. 1, T. 5 S., R. 14 W., Solitude Quadrangle. A visit up the hill to the gravesite of David Dale Owen and the many other members of the Owen family buried here is an alternative or an additional stop for those who wish. The following description is of the borrow pit; Survey members will be present in the cemetery in the area occupied by members of the Owen family. Included in the family plot is the grave of Rosamond Dale Owen Oliphant Templeton, who owned 10,000 acres near Haifa that included the site of Solomon's stables and the presumed site of Armageddon.

Recognition of loess as an extensive and important surface deposit in southern Indiana came rather uncertainly. The term itself does not appear in any of David Dale Owen's

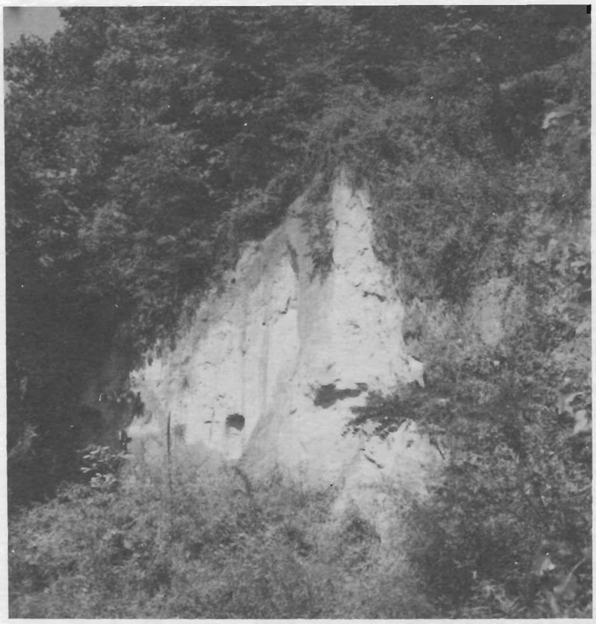

Figure 7. Photograph of a borrow pit in thick loess just south of New Harmony on Indiana Highway 69. Stop 2.

geologic reports on Indiana, although he mentioned the "erroneously called *chalk-banks* of the Mississippi" (1839a, p. 23) as a source of ceramic materials and discussed a "bed of marl" that extends "universally over the upland" (1839b, p. 6) near New Harmony. In the expanded 1859 version of his 1838 report (1859b, p. 5) he described fresh-water shells from this "fine, siliceous marl."

Richard Owen (1862, p. 190-191) then observed that the "vast bed of quaternary marl" in Posey County "is probably of the same age as the 'loess' of the Rhine," but it remained for Collett (1871, p. 226-227) to first apply the term "loess," in Sullivan County, to "obscurely stratified *marly clays* of a reddish brown color, at the base, but becoming [upward] almost pure sand of a yellowish brown or gray-ash color." Collett went on to say that "this bed has been determined by Sir Charles Lyell as equivalent to the 'Loess of the Rhine,'" and it is only in this way that we learn that the loess near New Harmony was apparently first recognized as such by Lyell when he visited Owen in the spring of 1846.

It is likely that this stop is one of the very sites visited by Owen and Lyell, although this borrow pit (fig. 7) postdates their visit by some 100 years. The first published description here is that of Thornbury (1937, p. 86, fig. 17). The site has been restudied many times since, most recently by Olson (1977, p. 17-25, figs. 2-5; Ruhe and Olson, 1978, p. 28-30), whose description is summarized below.

	Thickness (m)
1. Brownish-yellow nonstratified calcareous silt containing calcareous nodules and fossil shells; oxidized and unleached loess	5.1
2. Yellowish-brown to yellow nonstratified calcareous silt in alternating oxidized and deoxidized bands	2.9
3. Gray, strongly mottled with red and yellowish brown, nonstratified calcareous silt containing tubules of iron oxide; deoxidized loess	2.3
4. Yellowish-brown, faintly mottled nonstratified noncalcareous silt loam containing root casts	0.7
5. Strong-brown to dark-brown silt loam with subangular blocky structure and containing a few small pebbles; A2b horizon of paleosol, gravelly stone line at base	0.5
6. Strong-brown to dark-brown to reddish-brown noncalcareous silt loam with strong blocky structure; Bb horizon of paleosol in till	0.2

Loess blankets large areas in southern Indiana (fig. 8) and adjacent states to a depth of 1 m and more. It is an important surficial material and soils across much of the Midwest owe their fertility to the "loess cap," yet despite decades of research it remains enigmatic and controversial. (See Smalley, 1975, for a history of loess research.) Even

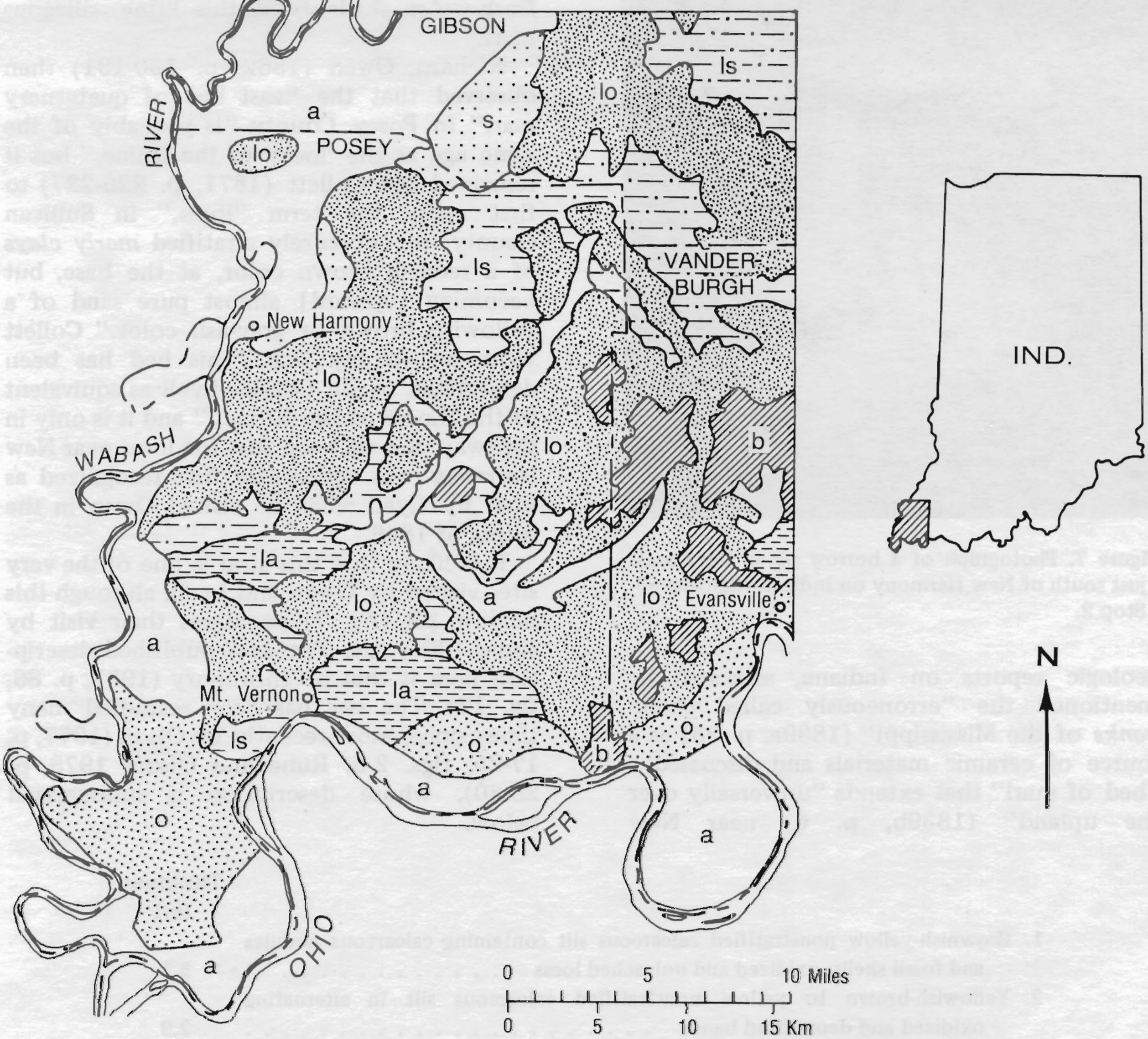

Figure 8. Quaternary geologic map of the field-trip area, generalized from Gray (in preparation). a, alluvium; s, dune sand; lo, loess; la, lacustrine deposits; ls, lowland silt complex; o, outwash sand; b, bedrock. All deposits mapped are Late Wisconsinan in age except alluvium, which is Holocene, and bedrock, which is Pennsylvanian.

the name is pronounced in many different ways. An early insight into some of the reasons that loess has been assigned widely different origins by different authors may be seen in a paper by Fuller and Clapp (1903), who attempted to distinguish "common loess" from "marl-loess." Their descriptions are not quite adequate to establish with certainty just what they had in mind. They appear to have been trying to distinguish between the nonstratified silt that blankets the uplands and that forms bluffs where sufficiently thick and the valley-filling fossiliferous and calcareous stratified silt that stands as terraces where it is entrenched by present streams. The former is thought by many geologists to require an aeolian origin and is regarded as true loess; the latter is possibly more complex.

True loess is nonstratified and is calcareous at depth where sufficiently thick. It lies as a blanket across the rolling uplands of southern Indiana, and it diminishes regularly in thickness away from the Wabash and Ohio Rivers. Over most of southern Indiana it has a maximum uneroded thickness of about 1 m. Where thickest—as here—the loess includes not only the Peoria loess of Late Wisconsinan age (units 1, 2, and 3 in the section above) but also the somewhat older Farmdale loess (unit 4), and in a few localities beyond the glacial boundary it includes the Loveland loess of Illinoian age.* The distribution and mineralogy of the loess are consistent with an aeolian origin. Sources of the windblown silt were valley-train deposits, principally along the Wabash but secondarily along the Ohio River. During glacial episodes the surfaces of these sand and gravel outwash deposits were dry and barren in winter, and the silt was lifted by the wind and carried significant distances.

The greater part of the stratified calcareous valley-filling silt is lacustrine and is in a slackwater deposit the lateral and temporal equivalent of the valley-train deposits mentioned above. In many areas, however, the lacustrine silt is capped by 1 to 4 m of noncalcareous nonstratified silt that is indistinguishable from loess except by topographic position. This loesslike lowland silt overlies not only the stratified calcareous lacustrine silt but also other valley-fill materials, notably outwash of pre-Wisconsinan age and sandy alluvium of local origin. This silt may be aeolian material directly deposited in an alluvial-paludal environment, it may be loessial material that has been eroded from the upland and reworked and redeposited in an alluvial-paludal environment, or it may be a complex involving both processes and possibly more. Because its morphology is distinct and its distribution is readily observed, it is mapped as a "Lowland silt complex" on the most recent Quaternary geologic map of Indiana (Gray, in preparation).

*These three loess units were considered members of the Atherton Formation by Wayne (1963).

STOP 3

This stop is an outcrop of the West Franklin Limestone Member of the Shelburn Formation (Pennsylvanian) at West Franklin, Posey County, in the NW¼SE¼ sec. 24, T. 7 S., R. 12 W., West Franklin Quadrangle.

West Franklin has seen more exciting days. This quiet hamlet of a few homes and vacation cabins on the Ohio River was originally said to have received its name to distinguish it from a man named East Franklin, who was living nearby. The origin of that story is unknown (it may be just as well), but it is known that an early settler, Jacob Winemiller, lived at the site in 1807 and that the town was laid out in January 1837 by John B. Stinson. The town was growing by this time, and a ferry across the Ohio River was bringing settlers into Posey County from Kentucky, Tennessee, and North Carolina. The town thrived from the mid-1800's into the early 1900's and had at times two physicians; a schoolhouse with students who were taught for awhile by James B. Campbell, a long-time county superintendent; a Methodist church, which had to be rebuilt at least once (at a cost of $800) because of flood damage; a general merchandise store; a blacksmith shop; and to balance out the community, a saloon. Things started downhill when the Louisville and Nashville Railroad went through Caborn to the north, and West Franklin dwindled because of the loss of the traveling trade and never regained its past glory.

Before or during the boom David Dale Owen examined the best of the few bedrock outcrops in Posey County, which included a limestone exposed along the bluff behind West Franklin and eastward to past the present Vanderburgh County line (fig. 9). David Dale Owen wrote of "* * * the limestone at West Franklin, in the south-east corner of Posey County," (1859b, p. 9), which was the first published mention of the

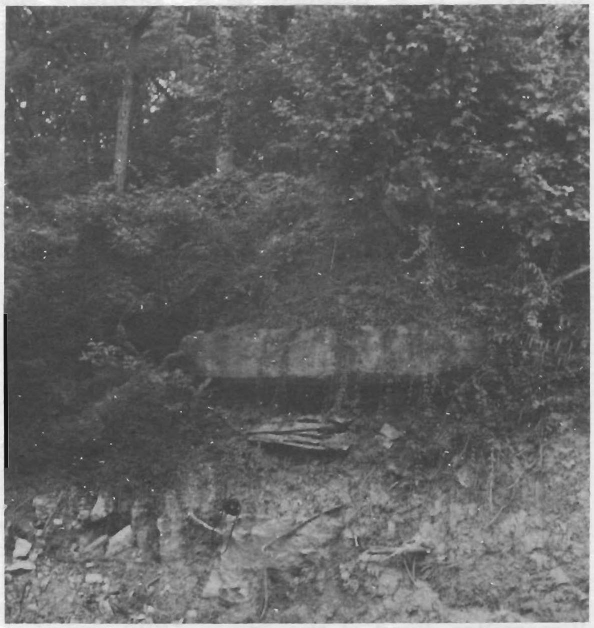

Figure 9. Photograph showing an exposure of the West Franklin Limestone Member along the Ohio River bluff in West Franklin.

West Franklin Limestone Member of the Shelburn Formation, although it was not formally named until later.

The town was still thriving when Richard Owen (1862, p. 296) described the rocks exposed in the bluff on the east side of town:

At West Franklin, the Ohio River is bordered by high banks of limestone, sandstone and shales, exposed and quarried a little above the town. The limestone is in two banks, separated by black shales, containing sometimes a thin coal, six to eight inches thick. The upper bank is of a fine, smooth fracture, hard, compact and fossiliferous. The lower bed is yellowish, less compact, sometimes nodular and also fossiliferous.

This description, made during the early days of geologic study in Indiana, could well be used today. The type section for the West Franklin, described by Shrock and Malott (1929, p. 1306) and modified by Wier (1965), adds little to Richard Owen's description. Richard Owen was also prophetic when he said in the same publication (p. 297):

But there is, concerning these coal strata [referring in part to the thin coal between the two West Franklin limestone beds], a far more important question, viz: that of their exact place in the Coal Measures; in order to ascertain if coal of a greater thickness can be reached in Posey county, and at what depth from the surface.

A modified composite section of rocks cropping out from the east edge of West Franklin along the Ohio River to near the county line between Posey and Vanderburgh Counties (Wier [1965] as modified from Shrock and Malott's type section [1929, p. 1306]) is given below.

	Thickness (ft)
Patoka Formation	
Inglefield Sandstone Member, 40 ft exposed	
1. Sandstone, yellow, massive, soft, micaceous	20
2. Sandstone, yellowish to gray, laminated, hard	10
Unnamed member, 10 ft	
3. Shale, gray, sandy	10
Shelburn Formation, 86 ft exposed	
West Franklin Limestone Member, 17.5 ft	
4. Limestone, gray to yellow, massive, crystalline, fossiliferous	5
5. Shale, gray; contains a thin coal and black, thinly laminated shale with *Derbya crassa*	5
6. Limestone, gray, brecciated, fossiliferous; thins and becomes nodular in places	7.5

	Thickness (ft)
Shelburn Formation—Continued	
Unnamed member, 68.5 ft exposed	
7. Shale, light-gray	2.5
8. Sandstone, massive at top; ripple marked	8
9. Shale, gray; contains nodular sandstone masses and changes laterally to laminated sandstone	8
10. Shale, blue-gray; contains layers of iron carbonate concretions; shale extends to low-water level in the Ohio River	50
Total	126

When subsurface exploration for coal began, it soon became evident that the limestone at West Franklin was one of the best marker beds for coal drillers, geologists, and others searching for the deeper thicker coals, those that would prove to have great commercial potential in much of southwestern Indiana. Although there has been no underground coal mining in Posey County and only minor mining of outcrops of coal in the 1800's, the importance of the future reserves of deep coal for fuels and other uses increases as the surface reserves become exhausted in other parts of Indiana. Much of the test drilling for evaluating coal reserves in Posey County and other nearby areas uses the West Franklin limestone as a marker bed because the limestone is shallow in many places, is easily reached by the drill, and is easily recognized by drillers because of its hardness. When the drilling bit reaches the limestone, there is a jumping and a clattering of the drill string in small rigs, and unmistakable limestone chips come up in the drill cuttings. From this bed an estimate of the depth to deeper coal horizons can be made.

The West Franklin Limestone Member exposed at the Ohio River bluff also had a great part to play in the search for petroleum, large reserves of which were discovered in Posey County beginning in the early 1900's and continuing at a high rate through the mid-1900's. More than 6,000 holes have now been drilled in the county for petroleum. Several marker beds were used by petroleum companies to map the structures in the county, including the extensive faulting of the Wabash Valley Fault System. Of these beds, the shallow West Franklin was ideal for exploration because it gave an indication of deeper structures, and as in coal exploration, it was easily recognized by drillers. The subsea elevation of the West Franklin gave many oil hunters their first good indication of whether they were "high" on a structure or whether fortune had not smiled and they were "low."

Many geologic and structure maps published by the Geological Survey have used the West Franklin Limestone Member as a marker bed. The first detailed Regional Geologic Maps of southwestern Indiana (for example, Gray and others, 1970) included the outcrop and the subcrop of the West Franklin Limestone Member. A bedrock geologic map of Indiana (Gray and others, 1987) also shows the trace of the West Franklin in southwestern Indiana.

Richard Owen mentioned in 1862 that the West Franklin limestone was quarried near West Franklin, and it was quarried in other places along its outcrop in Vanderburgh County for small amounts of burned lime, used in the 1880's for mortar and agricultural fertilizer. From those days until as late as 1965, the limestone was quarried in small amounts in southern Indiana for crushed stone and agricultural limestone. The lack of large near-surface reserves of the thin limestone, however, limited its use, and the crushed stone from the small quarries was replaced by stone shipped to Evansville by barge and by sand and gravel dredged from the Ohio River at Evansville.

The somewhat unimposing limestone beds of the West Franklin now command widespread recognition in the geologic community. Recently use of the name "West Franklin" was extended throughout the Illinois Basin in northwestern Kentucky, southwestern Indiana, and much of central and southern Illinois (Jacobson and others, 1985). David Dale and Richard Owen would probably not be surprised.

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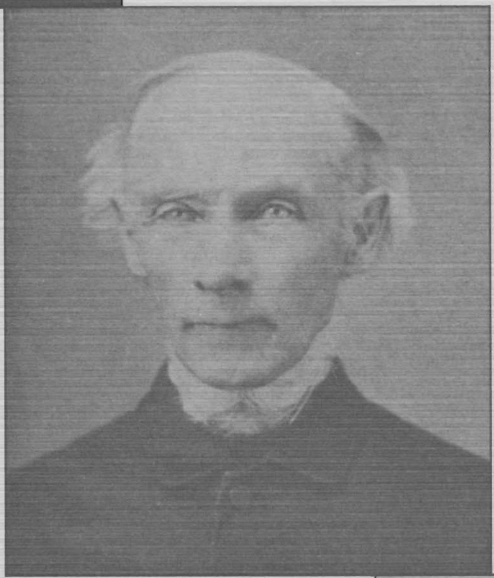
David Dale Owen
1807-1860



Richard Owen
1810-1890

Kenneth Dale Owen
1903-