PENNSYLVANIA GEOLOGY

THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 15/5

COMMONWEALTH OF PENNSYLVANIA
Dick Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Nicholas DeBenedictis, Secretary

OFFICE OF RESOURCES MANAGEMENT
Patrick J. Solano, Deputy Secretary

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: Northwest view from Route 15 overlook near Williamsport, Lycoming County. Loyalsock Creek (at right) joins West Branch of Susquehanna River. Broad flood plain area (center of photo) is underlain by thick river-borne sand and gravel deposits. Allegheny Plateau forms the skyline in the photo.

PENNSYLVANIA GEOLOGY is published bimonthy by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

VOL. 15, NO. 5 **OCTOBER, 1984**

FROM THE DESK
OF THE
STATE GEOLOGIST

"OIL IS FOUND IN THE MINDS OF MEN"

A major benefit of attending professional meetings is to learn of the interests voiced by colleagues active in our profession. This helps to guide the activities and direction of our Survey along paths for which there are demonstrated needs.

So it was stimulating to see an unexpectedly heavy turnout in Pittsburgh, early this month, where nearly 500 geologists attended the American Association of Petroleum Geologists' Eastern Section Meeting. Representing most of the major oil and gas companies, and coming from as far as California, Texas, and Colorado, the major item of interest on the three-day program appeared to be a series of technical discussions detailing the geologic conditions associated with deeper (e.g. Trentonian) formations of Pennsylvania and adjacent Appalachian states.

It is noteworthy that while this 1984 meeting of the petroleum society fell on the 125th anniversary of the successful completion of the Drake Well at Titusville (North America's first oil well), the thrust of the recent Pittsburgh meeting was directed towards the future of this Appalachian region.

The title of this article is borrowed from a famous quotation uttered many years ago by an illustrious petroleum geologist, Dr. Wallace E. Pratt, who eventually became President of the Standard Oil Company of New Jersey. The title exemplifies the creativity and optimism which was demonstrated by the petroleum geologists attending the Pittsburgh meeting. It bodes well for the future of Appalachian oil and gas production.

With sophisticated new exploration techniques and with exciting new concepts and interpretations of the structure and stratigraphy of the largely untested deep formations under Pennsylvania, it appears that petroleum geologists from throughout the country share our optimism for potential new oil and gas discoveries within our borders. Such reactions have helped to support and justify the investigations by our Oil and Gas Geology Division, based in Pittsburgh and dedicated to providing new insight to Pennsylvania's still untapped oil and gas resources.

Arthur A. Socolow

AN OUTSTANDING MINERAL PRODUCER

Martin Stone Quarries, Inc.

Located in eastern Berks County between Boyertown and Bechtelsville in Colebrookdale Township (Lat. 40°21′37″N, Long. 75°37′46″W), Martin Stone Quarries, Inc., is a unique southeastern Pennsylvania aggregate producer whose selective mining fills various product niches. Aspects of "Martin Stone" which make it a most interesting mining operation include: 1) a small, family owned and operated business, 2) the only active producer mining Precambrian age Reading Prong crystalline rocks in the Commonwealth, 3) one of a limited number of sources in southeastern Pennsylvania for high-friction coarse aggregate which is vital for safe roads, and 4) a source of economical clay-rich landfill cover and lining material for local municipal waste-disposal sites.

Harvey Nester first produced screened sandstone from this site in 1897 (Figure 1) at which time a buckboard load of "gravel" cost 25¢ (Glenn Martin, personal communication, 1984). Henry and Dorothy Martin first leased and produced stone from this site in the mid 1950's. Today, family holdings include about 200 acres and Henry's sons manage daily operations (Figure 2). However, Dorothy Martin still cheerfully greets all visitors and is a very active corporation secretary and treasurer.

Geologically, the surrounding terrain is complex. The folded and faulted Cambrian age Hardyston Formation nonconformably caps most of the higher elevations and also forms the underlying bedrock of some hills in the area (Buckwalter, 1959). Relief of this unconformity is unknown and complicated by even more complex geology of the older, underlying Precambrian age gneisses, which form the cores of large-scale, complex fold (alpine-type nappe) structures (Drake, 1978).

Clay-rich overburden (regolith and saprolite) on top of both the quartzite and gneiss, is used for infield sand on ball diamonds, cover and base liners for area landfills, and is a local source of general fill material.

The Cambrian age Hardyston Formation, characterized as a light-colored, locally feldspathic quartzite and sandstone, historically was

Figure 1. A 1912 photograph of the former Harvey Nester operation now owned and operated by Martin Stone Quarries, Inc. Notice the screening operation in the center of the photo. Original photograph courtesy of Glenn L. Martin.

Figure 2. Would Harvey Nester recognize his operation 72 years later? Primary crusher is located to the right and quartzite face to the left.

the principle rock type mined. This quartzite is crushed into PennDOT-approved fine and coarse aggregate. The coarse aggregate produced from this quartzite is the only "approved" bedrock material mined in southeastern Pennsylvania that meets PennDOT's highest skid resistance level designation which is needed for surfacing bituminous roads with high traffic volumes. Because of the low number of alternative sources for this type of material, it is trucked to the Philadelphia market, a straight line distance of about 40 miles. This same quartzite is also used as an ingredient in mineral wool insulation produced from slag at Hellertown.

The Precambrian gneiss is the major rock type currently being mined. The exposed rock is characterized as a dark-colored hornblende-plagioclase gneiss containing accessory biotite. Similar rocks elsewhere have been designated amphibolite (Drake, 1984). These rocks, when crushed, also produced a good high-friction aggregate, but unlike the quartzite their use is restricted to roads with lower traffic counts. Minor lenses and discontinuous veins (up to 2½") wide) of white and pink barite contain minor calcite, trace amounts of pyrite, chalcopyrite, galena, and quartz.

Selective mining techniques have stretched the total reserves of this operation and conserved rock types for their highest end-use products. Recognizing the need to plan for future generations, this family owned corporation is currently involved in seeking zoning approval to mine a contiguous property. This issue should be resolved in such a way as to maximize the continued use of these valuable resources and have little or no adverse environmental impact. All parties certainly agree on the need for a source of the safest possible highway surfacing material available.

REFERENCES

Buckwalter, T. V. (1959), *Geology of the Precambrian rocks and Hardyston Formation of the Boyertown quadrangle,* Pennsylvania Geological Survey, 4th ser., Atlas 197.

Drake, A. A. (1978), *The Lyon Station-Paulins Kill nappe—the frontal structure of the Musconetcong nappe system in eastern Pennsylvania and New Jersey,* U.S. Geological Survey Professional Paper 102, 20 p.

Drake, A. A. (1984), *The Reading Prong of New Jersey and eastern Pennsylvania: an appraisal of rock relations and chemistry of a major Proterozoic terrane in the Appalachians, in* Bartholomew, M. J., ed., *The Grenville event in the Appalachians and related topics,* Geological Society of America Special Paper 194, p. 75-109.

THE LARGEST LANDSLIDE IN PENNSYLVANIA

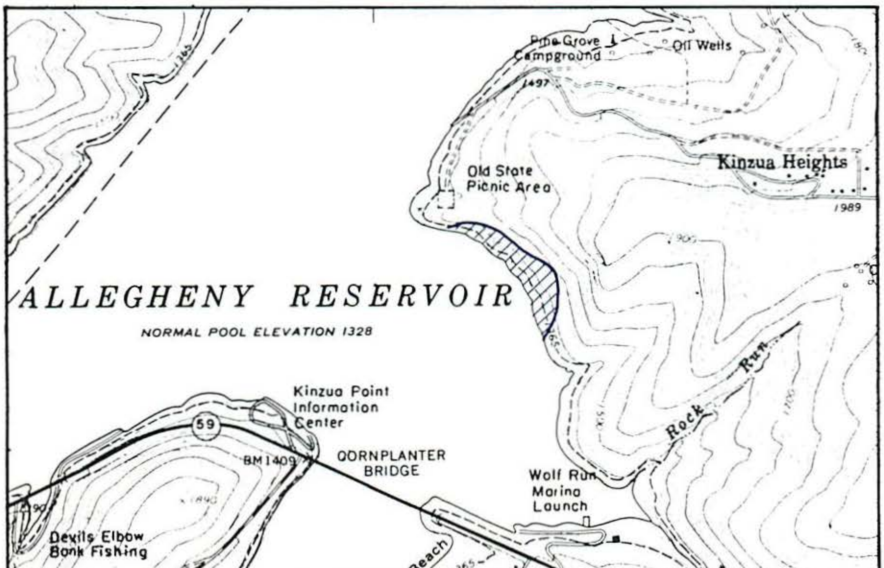
by Thomas K. Collins and Ruth D. Seeger
Allegheny National Forest

We offer a friendly challenge to the readers of PENNSYLVANIA GEOLOGY: find the State's largest landslide.

A landslide may be "large" in different ways: longest, widest, deepest, most volume of slide mass, most surface area. Subsurface investigations to determine depth and volume of slide mass usually are not available. But all readers have the opportunity to measure the surface of a landslide. So, we suggest three categories of "large":

1. surface area (measured by acres).
2. length (measured by maximum downslope distance from main scarp to the toe of the landslide).
3. width (measured by maximum distance, along elevation contour, between lateral scarps).

We also suggest the search be limited to *active* landslides. Active landslides show clear evidence (such as fresh scarps) of ground movement in recent years. The size or surface area of an active land-



slide usually is readily identifiable by the main scarp and by the border of the moving slide mass. In contrast, the recognition of old, inactive landslides and their boundaries can be subject to more interpretation.

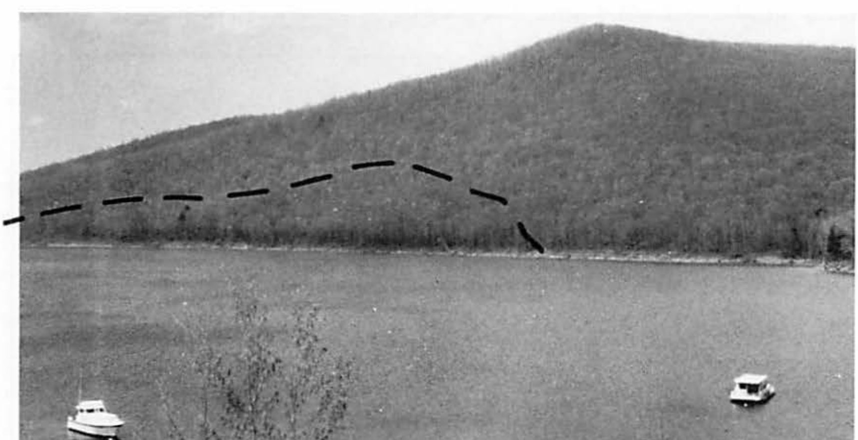
Our nominee for the largest landslide in Pennsylvania is the Kinzua landslide along the east shore of the Allegheny Reservoir in Warren County. To start the contest, we nominate the Kinzua landslide in all three size categories:

1. Its surface area is 14 acres.
2. Its downslope length is at least 560 feet.
3. Its width is 2,000 feet along the shoreline of the Allegheny Reservoir.

The main scarp of this landslide encompasses a zone of active slope movements, including several smaller landslides.

Viewed from a distance, the Kinzua landslide appears just like any other forested slope along the shore of the Allegheny Reservoir. But when walking through the area, one can see recent scarps, tilted trees, and fresh ground cracks.

The Kinzua landslide appears to be a reactivated, old landslide. The lower part of the slide mass is influenced by the fluctuating levels



North view to Kinzua landslide along shore of Allegheny Reservoir. Active slope movements are occurring in the forested slope in the center and left shoreline areas. Main scarp outline shown in color. May 1983.

Recent scarp and tilted trees on Kinzua landslide. May 1983.

of the Allegheny Reservoir. Due to periodic saturation of the toe caused by reservoir fluctuations, slope movements at the Kinzua landslide may be expected to continue, and possibly increase, in future years.

The bedrock at the Kinzua slide site is Upper Devonian Venango Formation. The landslide, however, involves clay-rich colluvium, presumably derived from siltstones, sandstones and shales of the overlying Mississippian and Devonian Shenango through Oswayo Formations. Thick deposits of colluvium accumulated on most lower slopes in this area during the Pleistocene Epoch. These are believed to be related to intense weathering associated with a harsh periglacial climate which affected areas near the ice margin.

THE BALD EAGLE FORMATION A SURPRISINGLY GOOD GAS RESERVOIR

by John A. Harper
Pennsylvania Geological Survey

One of the best kept "secrets" in Pennsylvania is the production of the Texaco-Marathon #1 Pennsylvania State Forest Tract 285 well in Grugan Township, Clinton County (Figure 1). This well, the second deepest ever drilled in Pennsylvania, gained a lot of attention while it was being drilled (see *Pennsylvania Geology,* v. 12, no. 5, 1981), and during the time that the operators searched for a potential producing horizon within the 19,365 feet of penetrated section. Although other companies have looked at the data on the well, its high production has not stimulated much apparent general interest or attention since being completed in December, 1982. Probably less than 10 calls in reference to this well have been made to the Survey's Oil and Gas Geology Division in Pittsburgh since that time. No information requests have come from Clinton County home owners, reporters, or Commonwealth officials. This general lack of attention is surprising to us because this particular well is presently one of the best natural gas producers in the state.

The original target of the Texaco-Marathon cooperative drilling effort was a faulted structure in the Cambro-Ordovician carbonates. The well bottomed in the Middle Cambrian Pleasant Hill Formation (Figure 2) without much promise of production from the deeper limestones and dolomites. Although several large shows of gas were encountered during drilling, all were in intervals shallower than the Middle Ordovician. These intervals were not initially investigated. When the original target zones were unsuccessfully tested and essentially dismissed as potential gas reservoirs, the companies decided to evaluate some of the shallower zones.

A reported large flow of gas at about 8,000 feet came from the Marcellus Formation, a black shale unit in the Middle Devonian Hamilton Group (Figure 2) that is notorious for its large initial flows of gas. These flows typically result from "bubbles" of gas which are created where the gas has leaked slowly from the rock into natural fractures (joints and faults) in the formation over the years. Most drillers are familiar with the Marcellus—regardless of the amount of gas first encountered in drilling, they all report that one can't produce economical quantities of gas from the shales. A driller therefore ignores the Marcellus, cases through it, and continues drilling to deeper, potentially more productive horizons. Such was the case with the Texaco-Marathon well.

The Late Ordovician Bald Eagle Formation at 13,000 feet (Figure 2) also had a show of gas, and it was large enough to attract attention. Although the operators did not submit specific information on the natural open flow from the formation on the official drilling report, the mud log on the well submitted to DER's Bureau of Forestry reported a large enough show such that the gas analyzer went off scale during logging. Also, the gas continued to be flared at the surface during subsequent drilling even though the well bore was heavily mudded (Gene Frund, personal communication). The approximate interval of this gas "show" (12,900 to 13,030 feet) was perforated and acidized. The subsequent flow of gas, gauged at 3,847 thousand cubic feet of gas per day (Mcfgpd), was large enough, however, that fracturing was deemed unnecessary. This open flow is not, in and of itself, particularly large; many shallower Paleozoic formations, such as the Upper Devonian sandstones, provide an occasional open flow of this volume, typically after hydraulic fracturing. Drillers report that even the tight Medina Group (Lower Silurian) of northwestern Pennsylvania commonly has after-treatment open flows of this size

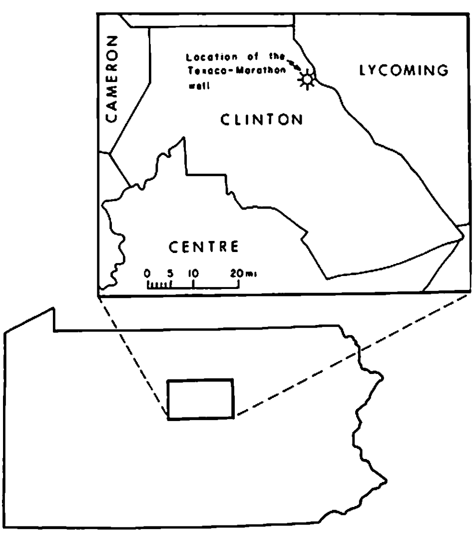


Figure 1. Location map of the Texaco-Marathon -1 Pennsylvania State Forest Tract -285 in Grugan Township, Clinton County.

in certain areas. Most of the wells in these formations, however, rarely go on to produce gas anywhere near the quantities gauged during the initial testing phase. The Texaco-Marathon well is rare in that it, unlike most wells, produced an astounding 307,966 Mcf between late August and December 31, 1983, averaging over 2,000 Mcf of daily production. During the first four months of 1984, the well produced an additional 249,776 Mcf, for an average daily production of 2,081 Mcfgpd, despite some shut-in time in January and April for well-testing purposes.

Because the Bald Eagle Formation is a new reservoir in Pennsylvania, not much is known about its geological characteristics in the subsurface. In outcrop, southeast of the Texaco-Marathon well, the Bald Eagle consists of about 750 feet of very fine- to coarse-grained or conglomeratic sandstones with some interbedded shales and silt-siltstones, especially near the upper and lower formational contacts (Faill and Wells, 1977). The sandstones, which are considered to be graywackes and subgraywackes, are typically medium to thick

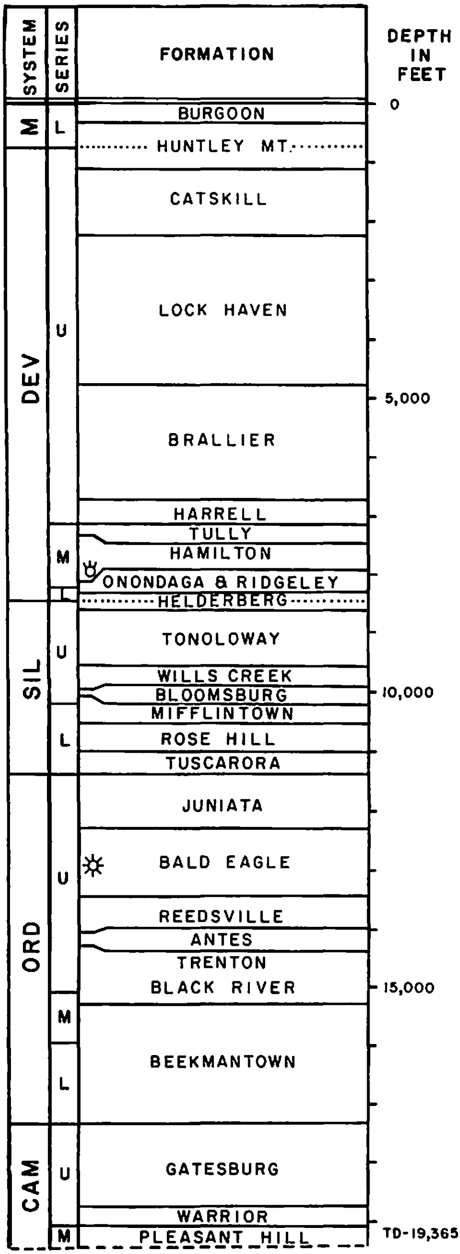


Figure 2. Stratigraphic column representing the formations and depths penetrated by the Texaco-Marathon well. The formation tops and bottoms shown were picked from submitted logs. Well symbols are used to indicate the show (Marcellus) and production (Bald Eagle) encountered in drilling the well.

bedded, often cross bedded. The conglomeratic beds contain assorted quartz pebbles and metamorphic rock frag-ments. The formation is a prominent ridge-former through- out the folded Appalachians of central Pennsylvania. Probably the best exposure of the Bald Eagle is in the spectacular "Big Cut" on Interstate 80 in Clinton County. At this locality the Bald Eagle can be seen grading into the red-colored Juniata Formation.

In the Clinton County well the Bald Eagle Formation consists of 1,215 feet of poorly sorted, calcareous fine- to medium-grained sandstone, siltstone, and shale. A preliminary lab report submitted by the well operators indicates the clastic fraction of the sandstones comprises quartz, feldspar, hornblende, chert, and pyrite. The grains are cemented with calcite and subsidiary dolomite. Authigenic clays (chlorite and mixed-layer illite-smectite) are also present. The rock is so tightly cemented with carbonate cements that intergranular porosity is extremely low, generally less than 2 percent (estimated) as determined by thin section analysis of the well cuttings. Because of the nature of the rock, with its tight matrix, the production of natural gas must be due to fractures in the formation. The high volumes of gas also suggest this.

The Texaco-Marathon well is a surprisingly good producer, and the Bald Eagle Formation is a surprisingly good reservoir. The few wells in central Pennsylvania that have penetrated the Bald Eagle section have had an occasional show of gas in the rocks, but never before has there been enough to attract the operator's attention. More drilling needs to be done in the area to establish whether the Clinton County well is a fluke or the Bald Eagle is "the Big One" that operators have been looking for since the 1950's. Thus far, only a small handful of companies have shown interest in the Texaco-Marathon well and its reservoir. Should one of these companies decide to risk the money necessary to drill another Bald Eagle well (estimated at about $5 million), and should such a well produce in the fashion of the Texaco-Marathon well, Pennsylvania could very well see a major explanatory and drilling boom develop in the north-central counties. Such a boom can only be of benefit to the citizens of the Commonwealth.

REFERENCES CITED

Faill, R. T., and Wells, R. B. (1977), *Bedrock geology and mineral resources of the Linden and Williamsport quadrangles, Lycoming County, Pennsylvania,* Pennsylvania Geological Survey, 4th ser., Atlas 134ab, 66 p.

A NIAGARAN (MID-SILURIAN) PATCH REEF NEAR ALLENWOOD, UNION COUNTY

by Jon D. Inners
Pennsylvania Geological Survey

Coral reefs in the geologic record range from great barrier reefs hundreds of feet high and many miles in extent down to small, patchy buildups several feet high and a few tens of feet in diameter. In order to technically qualify as reefs, however, these structures must possess two attributes: topographic relief and the ability to maintain growth within the wave zone (Heckel, 1974). In Pennsylvania and nearby states of the Appalachian region, fossil coral and related organic reefs are most commonly developed in carbonate rock sequences of the mid-Silurian (Lockport and Mifflintown Formations) and Middle Devonian (Onondaga Limestone). All of the mid-Silurian organic buildups appear to be small patch reefs that had limited relief above the sea floor. Within the fold belt of central Pennsylvania, the only such reefs previously known to outcrop occur in the Mifflintown Formation 1.5 miles southeast of Lock Haven, Clinton County (Cuffey and Davidheiser, 1979; Hoskins and others, 1983) and at Lakemont, Blair County (Swartz, 1935). Recent geologic mapping in Union County, 25 miles to the east of the relatively large reef at Lock Haven, has resulted in the discovery of a similar, albeit smaller, patch reef at approximately the same stratigraphic position near the village of Allenwood.

The newly found patch reef crops out in a small quarry on the south side of L.R. 627–59039 at the entrance to the White Deer Treatment Center, 1.3 miles west-southwest of Allenwood in Gregg Township (Lat. 41°06′09″N/Long. 76°55′27″W, Allenwood quadrangle; Figure 1). SINCE THE QUARRY IS LOCATED ON PROPERTY OF THE WHITE DEER TREATMENT CENTER, IT SHOULD BE VISITED ONLY FOR SCIENTIFIC PURPOSES. OBTAIN PERMISSION TO ENTER THE PROPERTY AT THE TREATMENT CENTER OFFICE.

Stratigraphically, the reef lies within the upper part ("McKenzie Limestone") of the Mifflintown Formation and is middle Niagaran (late Early Silurian or early Late Silurian) in age (Figure 2). The Mif-

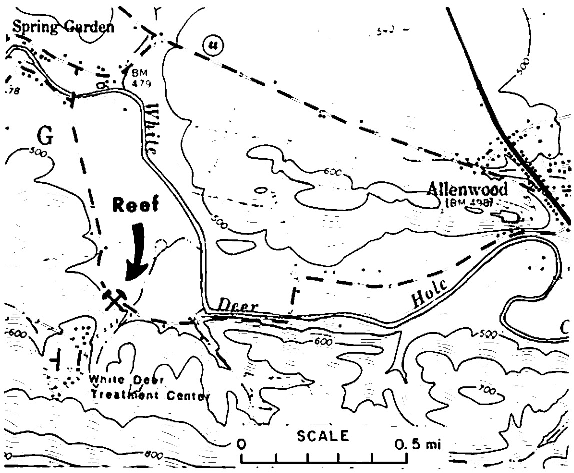


Figure 1. Location map.

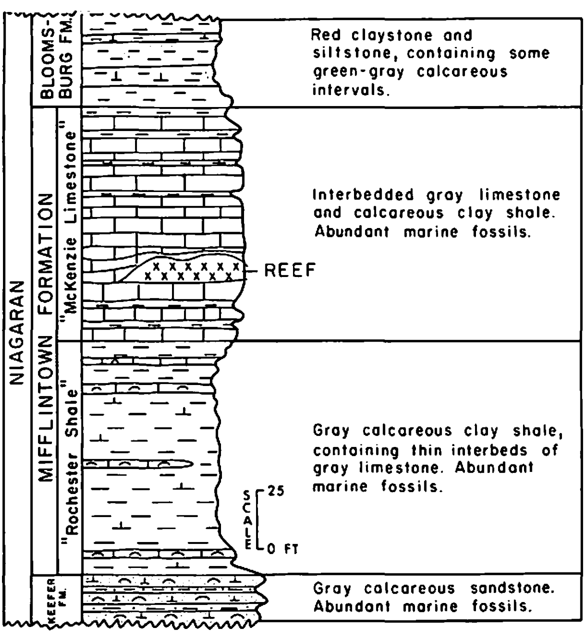


Figure 2. Stratigraphic column of mid-Silurian rocks in the Allenwood area, showing position of patch reef.

flintown Formation in this area is approximately 200 feet thick, and the reef occurs about 125 feet above the base. Directly overlying and underlying the reef are thin to medium beds (mostly 2 to 12 inches thick) of medium dark gray, fossiliferous, silty limestone typical of the upper Mifflintown. The exposed portion of the patch reef is 5 feet thick, at least 15 feet long in a north-south direction, and at least 10 feet wide in an east-west direction. Except for these minimum dimensions, the exact size of the reef is unknown. No fragments of coralline rubble (so common on the quarry floor) were found on the hillslope to the west. However, a few fragments of coral occur in a shallow pit 50 feet east of the main quarry.

The reef consists of poorly bedded, medium dark gray, medium crystalline coralline limestone in irregular subspherical to ellipsoidal masses 2 to 3 feet in diameter (Figure 3). Subspherical to club-shaped coralla of a favositid ("honeycomb") coral constitute the overwhelming bulk of the reef rock. Judging from the small diameter (1 to 2 mm) of the individual corallites, this coral is probably *Favosites niagarensis* Hall (Figure 4). Scattered brachiopod valves and rare, solitary "horn" corals are the only other fossils that were observed within the reef mass.

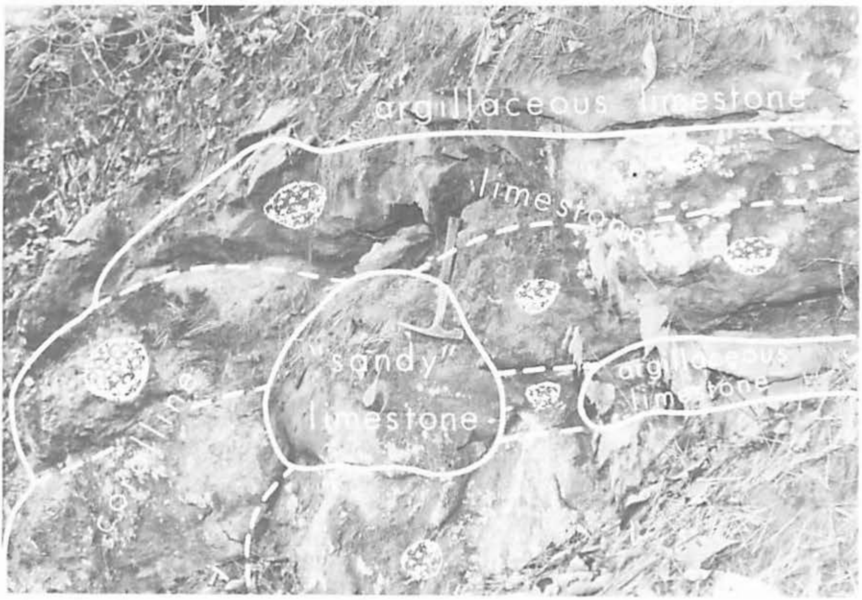


Figure 3. Exposure of Allenwood reef on east side of quarry at Allenwood Treatment Center. Bedding dips about 25 degrees to the north. Hammer is 11 inches long.

Because of poor exposure, direct evidence of wave action—such as the fragmental flanking beds that surround the Lock Haven reef (Cuffey and Davidheiser, 1979)—is lacking for the coralline buildup at Allenwood. The matrix of the reef rock is argillaceous, silty limestone that originated from the fine grained sediment trapped between the coral colonies. A pocket of medium crystalline, sandy

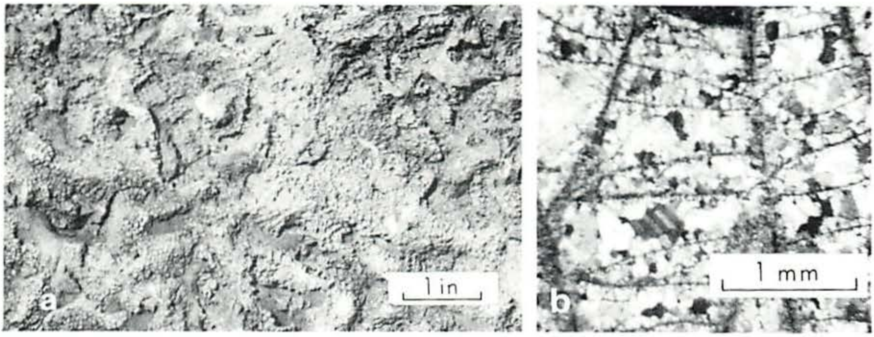


Figure 4. *Favosites niagarensis* Hall from Allenwood reef. a. Large block of coralline limestone, showing small size of corallites; b. Photomicrograph of thin section of favositid colony, showing corallites and tabulae (i.e., platforms which supported individual coral animals during growth of colony).

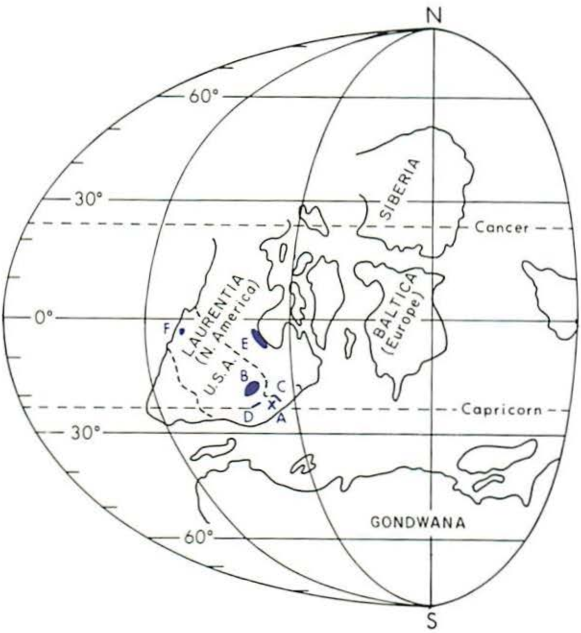


Figure 5. Niagaran (mid-Silurian) paleogeography. Note that most of North America was located within the tropic zone. Reef areas (color) are as follows: A. Allenwood, Lock Haven, and Lakemont reefs; B. Great Lakes region; C. western New York; D. West Virginia; E. Hudson Bay region; and F. central Nevada. (Base map from Scotese and others, 1979).

limestone, possibly formed from broken and wave-washed skeletal material, does occur within the main exposure on the east side of the quarry (see Figure 3). The overall evidence indicates, however, that the Allenwood reef formed in relatively quiet water barely above wave base, perhaps at a depth of several tens of feet.

The Niagaran Epoch witnessed the most extensive proliferation of reefs in North America during all of geologic time (Lowenstam, 1957). Significant reef tracts developed in the Great Lakes region, western New York, West Virginia, the Hudson Bay region, and central Nevada. The widespread occurrence of organic reefs in North America at this time was the result of (1) the expansion of shallow seas over much of the continent and (2) its geographic location within the Earth's tropic and subtropic climatic zones (Ziegler and others, 1979). As shown in Figure 5, the Allenwood, Lock Haven, and Lakemont reefs apparently formed on or very near the mid-Silurian Tropic of Capricorn (23 1/2°S Lat.). In the 420 million years since Niagaran time, the North American continent has moved at least 5,000 miles "northward" to its present position. As a result of this great plate-tectonic movement, the Allenwood reef and its many American contemporaries are now located well outside the climatic zones most hospitable to ancient and modern reef corals.

The author thanks Leslie T. Chubb for his assistance in describing and measuring the Allenwood reef. Dwight H. Rhodes, Williamsport, Pa., generously donated several excellent color photographs of the reef taken in the late summer of 1983.

REFERENCES

Cuffey, R. J., and Davidheiser, C. E. (1979), *Paleoecologic zonation within a mid-Silurian (Rochester Shale) patch reef near Lock Haven, central Pennsylvania,* Geological Society of America Abstracts with Programs, v. 11, p. 9.

Heckel, P. H. (1974), *Carbonate buildups in the geologic record: a review, in* Laporte, L. F., editor, *Reefs in time and space—selected examples from the recent and ancient,* Society of Economic Paleontologists and Mineralogists, Special Publication No. 18, p. 90-154.

Hoskins, D. M., Inners, J. D., and Harper, J. A. (1983), *Fossil collecting in Pennsylvania,* third edition, Pennsylvania Geological Survey, 4th ser., General Geology Report 40, 215 p.

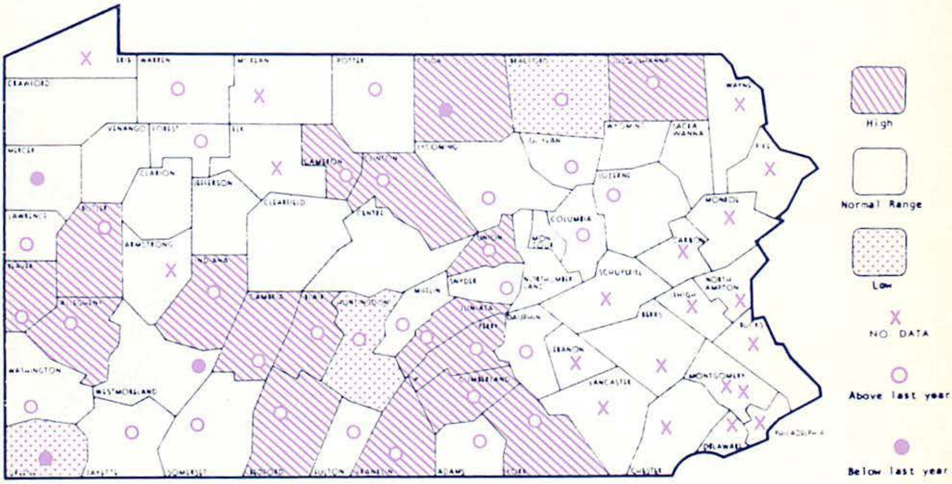
Lowenstam, H. A. (1957), *Niagaran reefs in the Great Lakes area, in* Ladd, H. S., editor, *Treatise on marine ecology and paleoecology,* Geological Society of America Memoir 67, v. 2, p. 215-248.

Scotese, C. R., Bambach, R. K., Barton, Colleen, Van der Voo, Rob, and Ziegler, A. M. (1979), *Paleozoic base maps,* Journal of Geology, v. 87, p. 217-277.

Swartz, F. M. (1935), *Relations of the Silurian Rochester and McKenzie Formations near Cumberland, Maryland, and Lakemont, Pennsylvania,* Geological Society of America Bulletin, v. 46, p. 1165-1194.

Ziegler, A. M., Scotese, C. R., McKerrow, W. S., Johnson, M. E., and Bambach, R. K. (1979), *Paleozoic paleogeography,* Annual Review of Earth and Planetary Sciences, v. 7, p. 473-502.

GROUNDWATER LEVELS
FOR
SEPTEMBER—1984



Bureau of Topographic and Geologic Survey
Dept. of Environmental Resources
P.O. Box 2357
Harrisburg, Pa. 17120

Bulk Rate U. S. Postage PAID Harrisburg, Pa. Permit No. 601

Address Corrections Requested