General Geology Report 40

1983

FOSSIL COLLECTING IN PENNSYLVANIA

Donald M. Hoskins
Jon D. Inners
John A. Harper

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
OFFICE OF RESOURCES MANAGEMENT
BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

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by Donald M. Hoskins, Jon D. Inners, and John A. Harper
Pennsylvania Geological Survey

Illustrations by John G. Kuchinski, Albert E. VanOlden, and James H. Dolimpio

PENNSYLVANIA GEOLOGICAL SURVEY

FOURTH SERIES

HARRISBURG

First Edition, 1964
Second Edition, 1969
Third Edition, 1983

ISBN: 0-8182-0019-7

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PURCHASED FROM
STATE BOOK STORE, P.O. BOX 1365
HARRISBURG, PENNSYLVANIA 17125

PREFACE

Fossil Collecting in Pennsylvania was originally published in 1964. It was slightly revised and reprinted in 1969 and then reprinted with a newly designed cover in 1973. It was last reprinted in 1976. In the nearly two decades since the original printing, many of the localities have been destroyed through construction, withdrawn from public access, or overcollected such that they no longer yield adequate fossils.

Rather than reprint outdated information, the Pennsylvania Geological Survey decided that a major revision was necessary, and the author, Dr. Donald M. Hoskins, was assigned the responsibility of revising and rewriting the book. He was joined by other Survey members, Dr. Jon Inners, who revisited and redescribed most of the sites, and Dr. John Harper, who contributed descriptions of some sites in western Pennsylvania.

Each site described in the 1964 edition was visited and evaluated to ensure that it was still acceptable for collecting. For those sites found to be unacceptable, suitable replacements were sought. Of the 64 sites listed in the original edition, 22 have been retained. Twenty-two are entirely new, and five are a combination of new and old sites. Many revisits to the older sites revealed new fossils not previously found; these are listed in the revised site descriptions. Eleven counties described in previous editions have been deleted because no adequate sites were found to recommend to collectors.

We hope that the collecting sites presented will provide as much pleasure as did those of the previous edition.

A. A. SOCOLOW
State Geologist

ACKNOWLEDGEMENTS

The authors are indebted to many individuals for their help in locating and describing the fossil-collecting sites compiled in this book. Laurence E. Benander, Samuel W. Berkheiser, Jr., Keith Brady, Richard D. L. Fulton, James M. Gerhart, Alan Saltsmann, James R. Shaulis, Viktoras W. Skema, Robert C. Smith, II, and John H. Way, Jr., supplied us with especially pertinent information. Matthew E. Blauch did a yeoman's job as a field assistant for Inners in the summer of 1981, and Diane M. Nork helped to measure several rock sections in the fall of 1982.

Most importantly, however, we thank the dozens of landowners throughout Pennsylvania, who granted us permission to examine outcrops, quarries, and borrow pits on their properties. Without such cooperation, a book of this type would not be possible.

CONTENTS

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INTRODUCTION

by Donald M. Hoskins

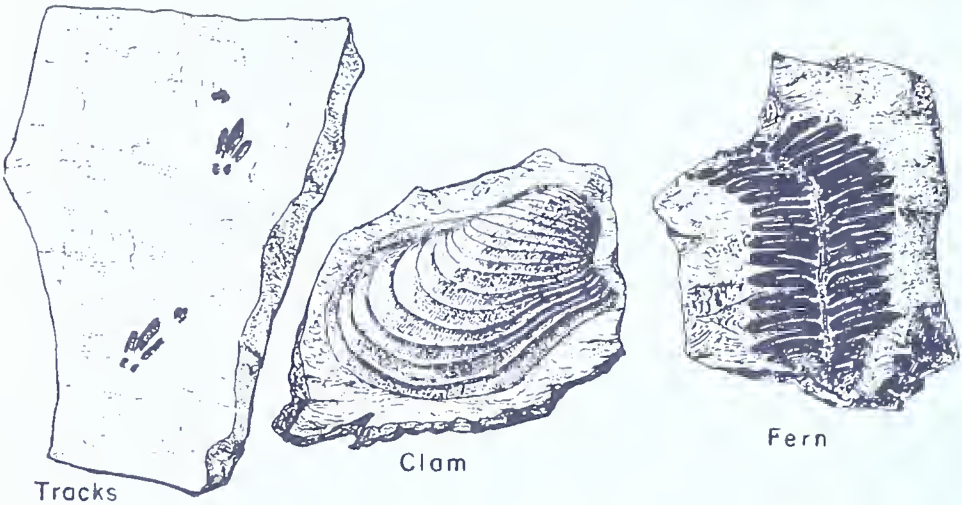
The Pennsylvania Geological Survey frequently receives requests for information on where to collect fossils in the Commonwealth. This book is intended to supply such information; thus the major portion of the book is devoted to a geographic and geologic description of fossil localities, including lists of the fossils to be found at each locality.

Although knowing the location of fossil-collecting sites is important, there is more to fossils than just collecting them. The study of fossils (paleontology) is the lifetime work of many scientists. Their work has given answers to some of the basic questions of the evolution of life and the world we live in. To have a comprehensive understanding of what fossils signify gives the collector a greater appreciation of the hobby in which he is engaged. To enhance this appreciation, the first portion of the book is devoted to the significance and uses of fossils as well as the description of the major groups of fossils that one may encounter when engaged in fossil collecting in Pennsylvania. For those interested in further information on paleontology, references are listed near the end of the book.

WHAT IS A FOSSIL?

Fossils occur in many forms. The footprint or burrow of an animal preserved in rock is a fossil; a clam shell preserved in rock is a fossil; the imprint of a leaf in a rock is a fossil. A fossil is *any naturally formed record of animal or plant life found in rocks* that gives an idea of the appearance of the original organism.

Imagine for a moment a common dweller of today's oceans—the clam. A clam is composed of two shells (called valves) surrounding a fleshy body which contains muscles that open and close the shells. If we examine the various processes that may affect this clam after it dies, we will learn the many ways in which the clam can be preserved as a fossil.



Some examples of fossils.

When the clam dies, the fleshy parts quickly decay and disappear and the shells are left to be washed about on the sea bottom or shore. Because the muscles that held them together are gone, the shells frequently separate. The shells may be destroyed by currents on the sea bottom, or they may be buried beneath sediments, which continually accumulate on the sea floor. *Burial by sediments is the first step in fossilization.*

The sediment surrounding the shell may become compacted and turn into hard rock, and the shell may be preserved with no further changes. But many shells are dissolved by the water in the compacted sediment, leaving a space that becomes a *mold*, which preserves all the details of the shell surface. If other material later fills this space and hardens, the hardened material becomes a *cast*. Both casts and molds are fossils because, although nothing of the original shell is left, we can see what the shell looked like. Since the outside and inside of a shell generally are different, we call molds and casts internal (inside) and external (outside), depending on which part of the shell they represent. Molds are common as fossils, but casts are relatively rare.

Mold and cast of a pelecypod.

If the clam shell escapes being dissolved, it may be affected by other processes as the rock around it hardens. One of these processes is *replacement*. When examined microscopically, most rocks formed from sediments are found to contain many very small pores and spaces. The pores and spaces may be interconnected and may contain water carrying dissolved minerals. Under certain conditions, minerals carried by this water will be substituted for the material of the shell, which is commonly the mineral calcite, so that the shell is gradually replaced by minerals such as quartz or pyrite.

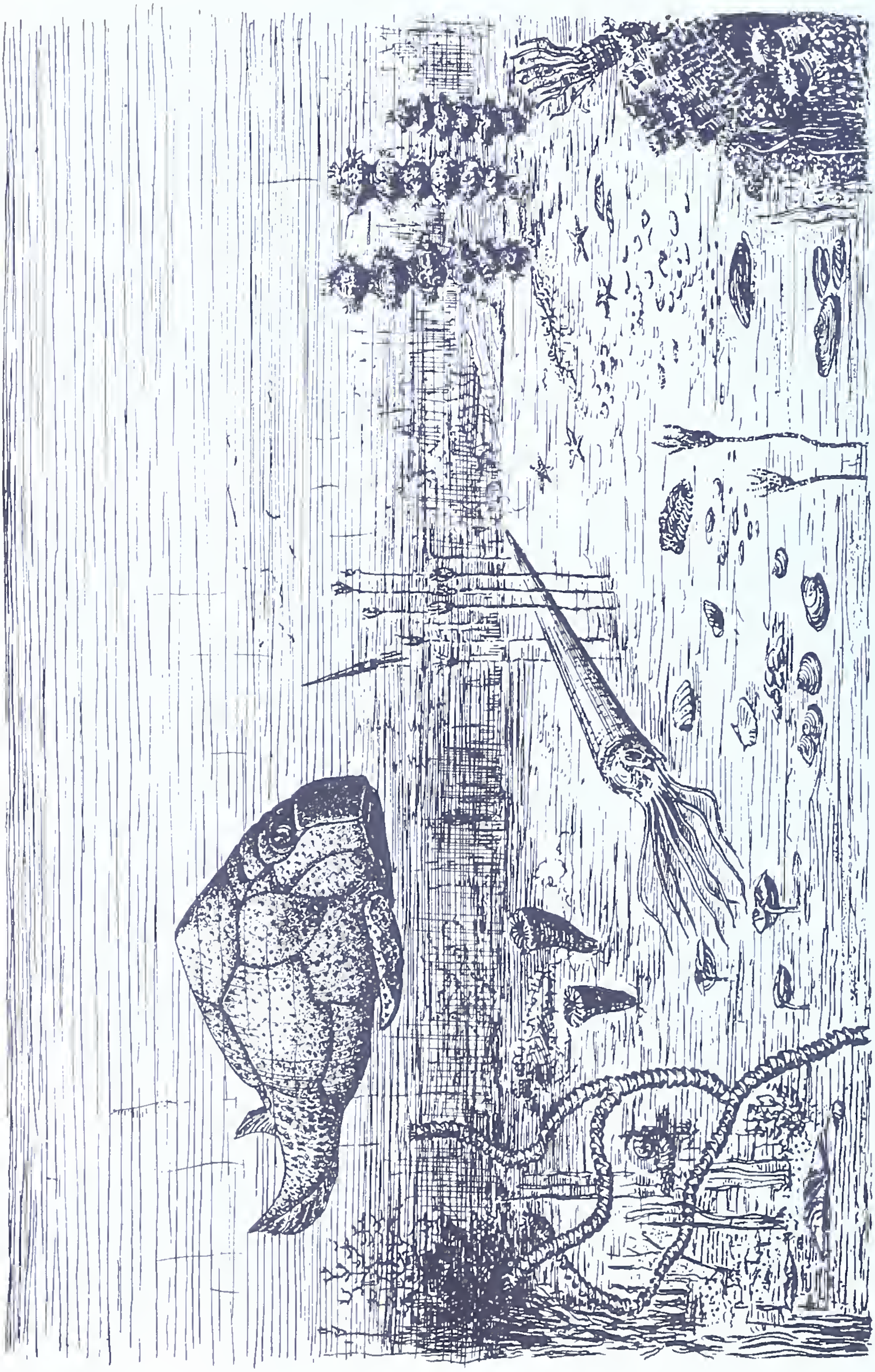
Some animals, such as insects, possess no hard parts (skeleton or shell); their body covering consists of an organic compound called chitin, a material similar to our fingernails. These animals, when buried, are preserved under only the most exceptional circumstances whereby the chitin, through a process called *distillation*, is reduced to a thin carbon film as the sediment is compacted. This film may preserve many of the very fine features of these animals.

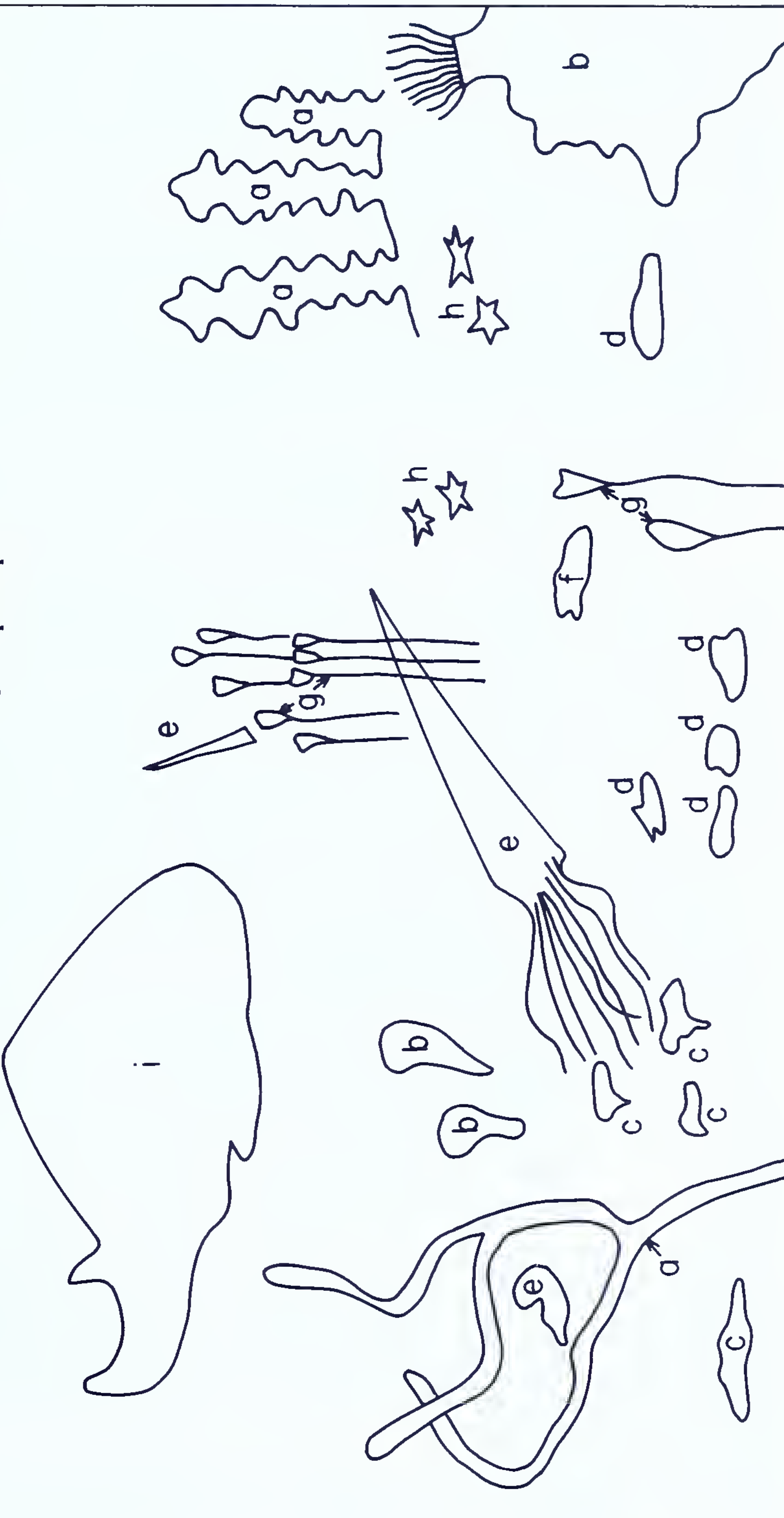
Plants are usually found as two types of fossils. One is the imprint of leaves, ferns, and seeds that have been carbonized by the distillation process discussed above. Limbs, roots, and trunks of trees are many times preserved as casts and molds; rarely, large portions are preserved through replacement of plant tissue and filling of tissue pore spaces by silica and other minerals. This is also called *petrifaction*. The trees found in the Painted Desert and Petrified Forest of the American West are examples of this process.

The track made by the dinosaur as it stopped by a stream to drink and the trail of the crab skittering along the seashore, when preserved in rock, are also fossils because they give us an idea of what the feet of the animal looked like. The burrows and feeding traces of animals are also fossils; tracks, trails, burrows, and traces are referred to as "trace fossils."

Preservation by burial in sediment is one of the most important processes in the formation of a fossil. Many organisms do not die in places where sediment is being deposited and thus have no opportunity for fossilization. The *possession of hard parts* is also very important in the formation of a fossil. Animals and plants live today for which there are no known fossil ancestors. These unknown ancestors lacked hard parts, died where no sediments were being deposited, or were not preserved due to a combination of these two factors. Trace fossils may be the only record we have of many of the animals that did not possess hard parts.

One of the most interesting studies a paleontologist undertakes is the reconstruction of an animal or plant from the fragmentary fossils found. In many cases this is a very difficult procedure because the various parts of an individual animal or plant may have been widely scattered after death, and the skin, muscles, and other soft parts are missing. It is often





A reconstruction of a Devonian sea bottom.

a. "Glass" sponge
b. Coral
c. Brachiopod
d. Pelecypod
e. Cephalopod
f. Trilobite
g. Crinoid
h. Starfish (stelleroid)
i. Armored fish (placoderm)

necessary to refer to living animals and plants to decide how to reconstruct a fossil. Many fossils have been found that cannot yet be totally reconstructed because they have no living relatives to which they can be compared. After reconstruction of a number of different fossils from the same age and environment, scientists often attempt to place them together as they once must have lived. An example of this is the sketch of the Devonian sea bottom shown on page 4.

It is important to remember in collecting fossils that what you collect is usually only a fragment or impression of the original animal or plant, lacking its soft parts and frequently lacking many of its hard parts. It is also important to remember that the fossil organism that you discover is only one of perhaps millions of similar individuals that may have lived.

OF WHAT USE ARE FOSSILS?

Why study fossils? Are they more than just curiosities to collect and place in a display cabinet? The answer is, as you might guess, yes. Fossils are the record of life on the earth through billions of years since the first bacteria lived and the first algae began to form layered mats still recognizable in very ancient rocks. As such they offer clues not only to the history of the development of life, but also to the character of past climates on the earth and to changes that have occurred on the earth's surface and in its seas. Because fossils yield information about the environment in which they lived, they also tell us something about the history of the rock in which they are found. Knowledge of the rock history has practical use in the search for mineral resources such as oil and gas, coal, and limestone.

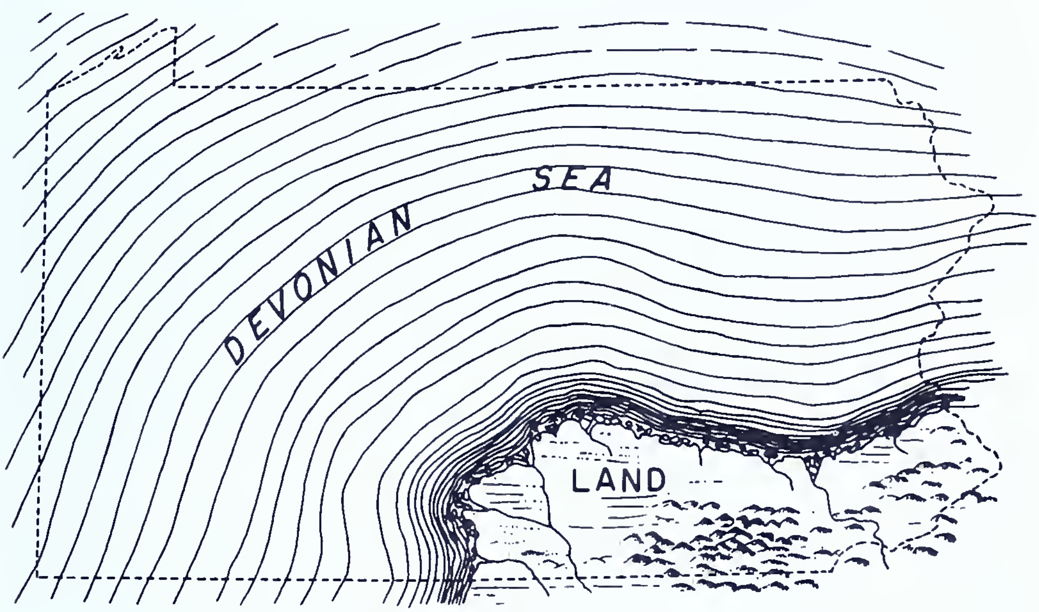
The oldest known rocks of sedimentary origin contain only very primitive fossil animals, such as algae. As younger and younger rocks are examined, we find that the fossils they contain have gradually changed and become progressively more like present-day living organisms. Detailed study of the fossils shows that certain older groups gradually changed (evolved) into younger groups. These changes support the *theory of evolution*, a theory with which scientists are much concerned.

The differences between fossils contained in younger rocks and those contained in older rocks provide a basis for dating and identifying rocks of similar age in widely different areas. For example, if a paleontologist finds rocks in North America and South America that contain the same fossils, he can generally say that they were formed at the same time and thus are of the same age.

A paleontologist working for an oil company does the same thing with fossils, but this paleontologist may use only very small fossils called *microfossils*. The paleontologist may work with rocks that occur only in

Pennsylvania. If the company has fossils from an oil-producing well drilled near Pittsburgh and drills another well in Clearfield County, the fossils may be used to indicate to the driller when the drill is approaching rocks of the same age as those in the Pittsburgh well. This may help in determining how deep one has to drill before intersecting the oil-bearing rocks.

How do fossils help us to unravel the history of the earth? The paleontologist has been able to determine the conditions under which most fossils lived by studying modern life. Corals, for example, today live in the oceans. When a coral is found in a rock, it follows that the rock material must have been deposited on a sea bottom. By collecting a large number of fossils from all rocks of a given age over a large area, those areas occupied by land and sea of that former time can be outlined. For example, the area of land and sea existing in Pennsylvania 380 million years ago has been worked out in this way and is shown below.



Land and sea areas in Pennsylvania during part of Devonian time.

Plant fossils, like animal fossils, also tell their own story. Trees grow on the land surface. Certain assemblages of plants and trees are characteristic of swamps rather than dry land. The coals of Pennsylvania are composed of trees and plants from such assemblages, indicating that during the periods of coal formation extensive swamps existed in Pennsylvania (see page 46).

Fossils may also be used to determine past climates on the earth. Corals, for example, are thought to have lived only in warm waters, as they do today. Corals found in rocks in Alaska indicate that the area of Alaska was at one time an area of warm seas.

Fossils may also be used to identify and date the rocks in which they are found. These fossils are known as *index* fossils. An index fossil generally has a distinctive and easily recognizable shape, occurs commonly over a large area, and is restricted to a short period of geologic time. The best index fossils are from animals that were swimmers or floaters, so that they were distributed widely in the seas and oceans. Some of the best index fossils are graptolites and certain types of cephalopods.

FINDING FOSSILS

Although fossil-bearing (fossiliferous) rocks are present in many areas of Pennsylvania, fossils are not always easy to collect. They are found only in sedimentary rocks, such as limestone, shale, and sandstone, and then only in a small portion of these types of rocks. If you are a beginning fossil collector, you are advised to visit localities described in this book in order to become acquainted with the types of rock that contain fossils and to find out what fossils look like.

In this book fossil localities are described for 52 of Pennsylvania's 67 counties. A map of Pennsylvania showing the location of each of the sites is on page 50. A detailed location map also accompanies each site description. Pennsylvania highway maps and topographic maps may further aid the collector in finding the localities described.

In addition to a description of the fossil sites, we include a list of the generic names of fossils we have found at each site, the type of rock and its geologic age, and other information that may be of interest to the collector. We expect that careful searching at any locality will uncover additional genera of fossils not given in the lists.

For the ambitious collector, the 1980 edition of the *Geologic Map of Pennsylvania* (Map 1 of the Pennsylvania Geological Survey) will be of great aid. This map shows the many rock formations throughout the state. If a sedimentary rock formation is found to contain fossils at one place, it is likely to contain fossils elsewhere. After learning which rock units contain fossils, refer to this geologic map to find other areas underlain by the same rock units. You may then explore these areas for additional localities.

COURTESY IN COLLECTING

Overuse of a site by students and exploitation of a site for commercial purposes have resulted in the closing to the public of two famous localities, as well as several less famous sites, in the past two decades. Please do not do anything that will cause property owners to remove localities described herein from future collecting.

Remember that in almost all cases the site at which you are collecting is on private property. If possible, obtain permission from the owner before you collect. Even roadside exposures within the highway "right-of-way" are private property. If someone questions your presence at a roadside exposure, explain your activity and request permission to continue collecting. Do not destroy fences or other private property and do not leave litter. Other people may want to visit this site, and careless or heedless actions on your part may destroy this opportunity for them.

COLLECTING AND PREPARING FOSSILS

The collector should take to the fossil locality a hammer, scrap paper, and a collecting bag. A hand lens is useful where the fossils are small.

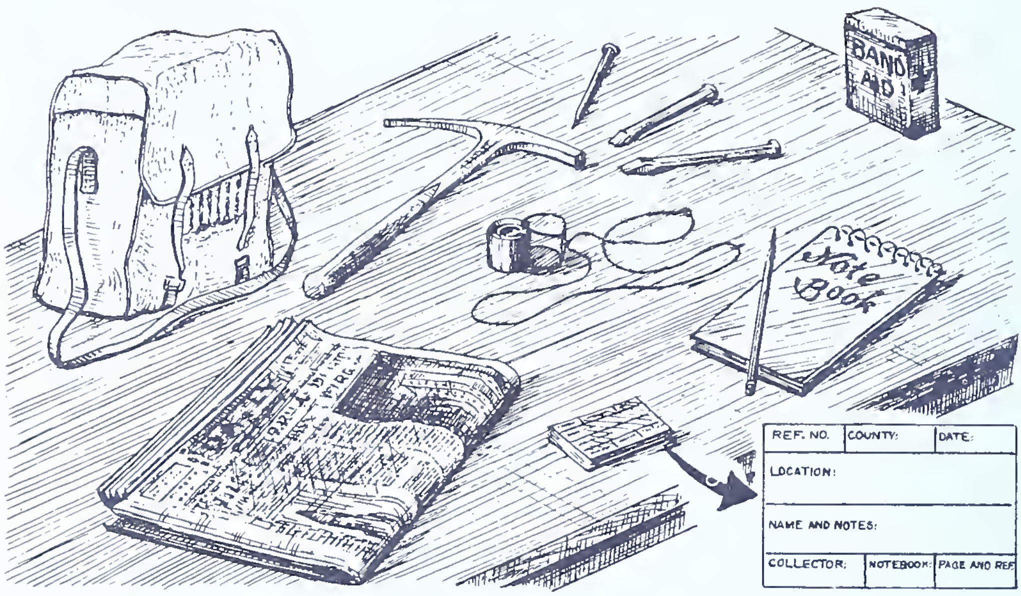
A chisel-edge hammer, such as that used by bricklayers, is most convenient for both breaking rock from the outcrop and for splitting the sample along natural layers. The rock at some localities is weathered so that it is fragile and easily broken, whereas at other localities it may be unweathered and very difficult to break.

Specimens collected in the field should be wrapped in layers of paper to preserve them; it is then most convenient to place them in a collecting bag. It is important that specimens be labeled with the locality and any other pertinent information when they are collected. Labeling at collection time will allow the specimens to be properly identified at a later date. A sample of the label used by the Pennsylvania Geological Survey is shown on the following page.

After the fossils have been collected, it is often necessary to clean them by removing any dirt and rock layers that hide part of the specimen. It is advisable to wash the nonfragile specimens with water and a soft brush and then to work on the rock with various chipping and scraping tools, ranging in size from cold chisels to fine needles, depending on the size and fragility of the fossil. Old dental probes, if you can obtain them, may be sharpened easily into needle and chisel points and make very useful tools in cleaning fossils. Fragile specimens may be protected with a coating of clear plastic spray or clear nail polish.

After individual fossils have been cleaned and prepared, identification labels should be made out for each specimen, giving the locality, the fossil's name, and the name of the collector.

One of the best virtues of a fossil collector is patience. Many of the very best specimens that have been collected come from sitting in one spot at a fossiliferous outcrop and patiently examining each piece of rock for fossils.



Equipment of the well-prepared fossil collector.

IDENTIFYING AND CLASSIFYING FOSSILS

A fossil-collecting expedition is complete only when the fossils found have been given their proper names. All fossil plants and animals can be classified into progressively more limited categories until a generic and a specific name (genus and species) is applied. The first step, a simple one in most cases, is to decide if the fossil is an animal or plant (Kingdom Animalia or Kingdom Plantae). Then the fossil is placed in its proper phylum (plural: phyla) and class. Classes are subdivided into families and families into orders; these are mainly of interest to scientists and are not discussed here. The section of this book entitled "Characteristics of the Major Fossil Groups" (page 14) contains descriptions of the various phyla and classes and will help you classify your specimen in the proper category.

The final refinement of the identification is to determine the genus (plural: genera) and species of the fossil specimen you have found. All individual specimens of the same species may not look exactly alike, but they will have many features in common. This you can see by observing individuals of the species to which you belong (*Homo sapiens*). You can best identify the genus of the fossils you collect by comparing them with pictures of fossils. The sketches at the back of this book illustrate most of the fossils you are likely to encounter at the localities described in the book.

Fossils on these plates are generally not shown at their actual size because of space limitations. The amount of reduction or enlargement is shown under each fossil sketch. The figure "x0.8" means that the picture is eight-tenths the size of the actual specimen. Keep in mind, however, that all specimens of the same genus will not be the same size, just as all *Homo sapiens* are not the same size. Illustrations of fossils not shown on these plates may be found in one or more of the books listed in the "Additional Reading" section near the end of this book. Two of the most useful references are *Index Fossils of North America*, by Shimer and Shrock, and the *Treatise on Invertebrate Paleontology*, published by the Geological Society of America and the University of Kansas.

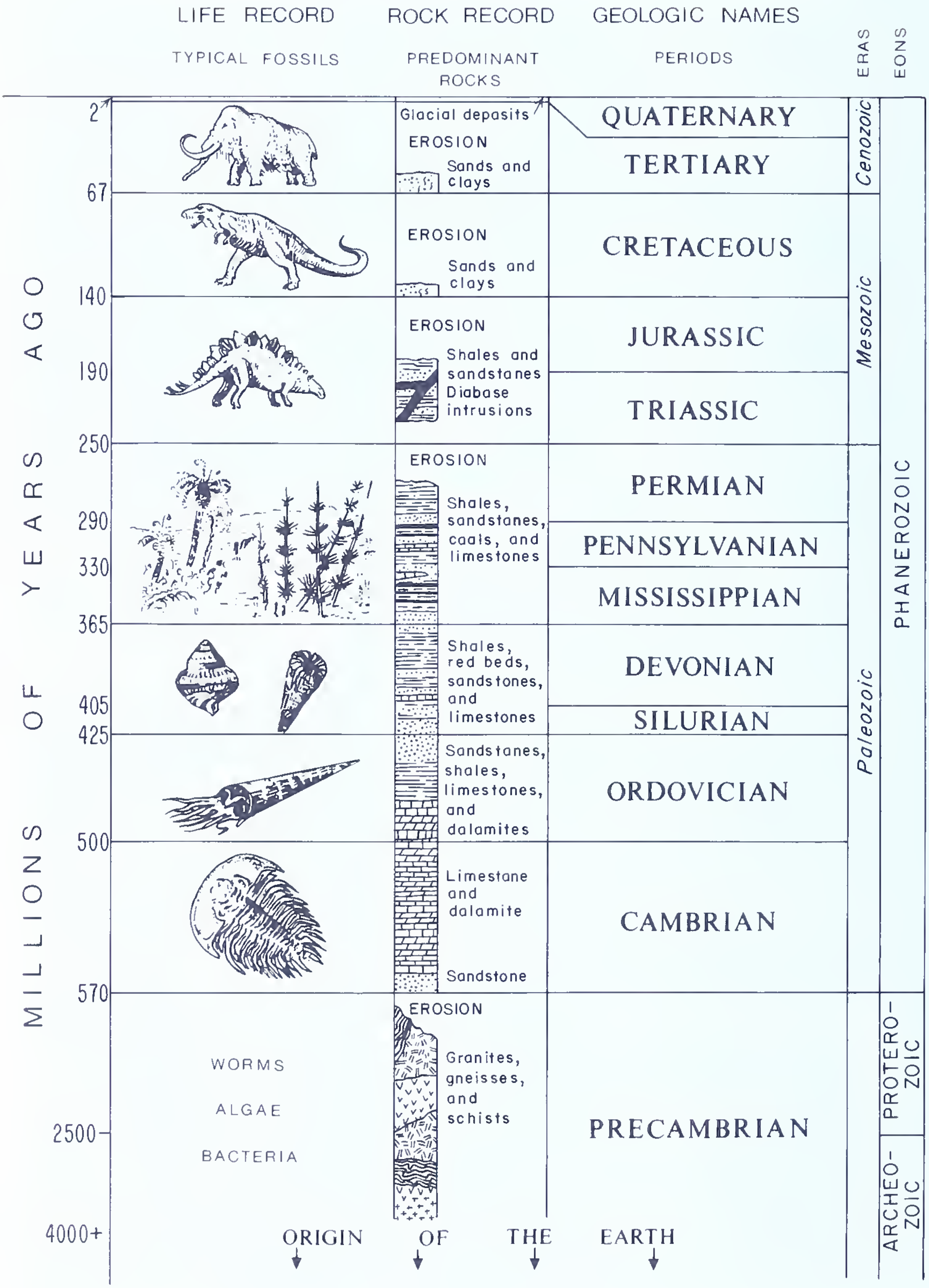
The examples below show how three different organisms are classified into various categories. The names may seem strange because they are based upon Latin and Greek words, but this has been done so that the names may be used and pronounced all over the world in an international system (code) of zoological nomenclature.

Category	*Example 1*	*Example 2*	*Example 3*
Kingdom	Plantae	Animalia	Animalia
Phylum	Tracheophyta	Brachiopoda	Chordata
Class	Gymnospermae	Articulata	Mammalia
Genus	*Pinus*	*Atrypa*	*Homo*
Species	*strobus*	*reticularis*	*sapiens*
Individual	White pine tree	Sea shell	Man

It is common practice to simplify frequently used names by dropping or changing endings. For example, members of the phylum Brachiopoda are called brachiopods; members of the class Mammalia are called mammals. The generic and specific names are not used informally and are always written as you see them above, following rules of the International Code.

GEOLOGIC TIME

The earth has been in existence for over 4,000 million years. To be able to talk about portions of this vast amount of time, scientists have separated it into divisions (called eons, eras, and periods), which are characterized by certain kinds of fossils. In fact, fossils were one of the original means by which the boundaries between these various time divisions were established. The accepted time divisions are shown on the geologic time scale on the following page. The first column shows the times at which the various periods started, in millions of years before the present. The second column indicates some of the characteristic animals and plants that lived in these periods of the earth's history. The third column shows the many types of rocks formed in Pennsylvania during certain periods of time. If you examine the time scale, you will see that during most of the Jurassic and Cretaceous Periods no sediments were deposit-



Geologic time scale.

ed in Pennsylvania. We thus assume that Pennsylvania was mainly a land region during these periods. Therefore we have no fossil record of life during these periods in Pennsylvania. The fourth and fifth columns list the period, era, and eon names that we use for the various divisions of time. As you can see, it is much easier to say that you found a Devonian age fossil than to say that you found a fossil between 365 and 405 million years old. The period names will be used a great deal in later portions of this book.

The geologic time scale is the standard to which scientists refer in dating the various portions of the earth's history. Using this standard, paleontologists can study what occurred all over the world at any one time. The periods and eras represent, in general, times during which major geologic events took place, such as the formation of a range of mountains or the deposition of a certain suite of rocks. Many long and detailed books have been written on the subject of geologic time and the many geologic events that have taken place since the earth began. For those interested in this fascinating subject, references are given in the section on "Additional Reading."

CHARACTERISTICS OF THE MAJOR FOSSIL GROUPS

by Donald M. Hoskins

INTRODUCTION

Living creatures are divided into two main groups—the animal kingdom and the plant kingdom. There is also a group of living and fossil creatures that have some aspects of each kingdom—these are the Protista. Because they cannot be allied with either plants or animals exclusively, the protistans are classified as a separate kingdom.

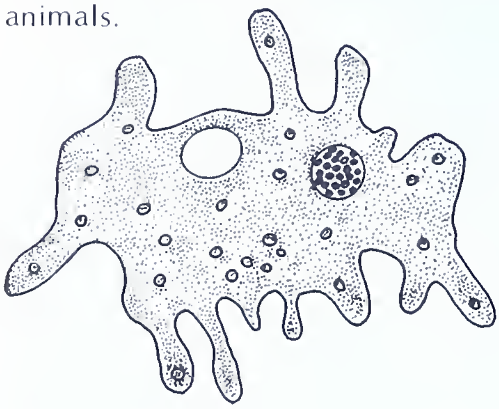
The animal kingdom is divided into 21 separate groups called phyla (singular: phylum). A phylum is a group of organisms assumed to have originated from one common ancestor. Only 9 of the 21 phyla are represented by abundant fossils, and thus these 9 phyla are of great importance to the paleontologist. The other 12 phyla lack hard parts and are rarely found as fossils. The phyla that are important because of their fossils also contain many groups not found as fossils. Only those groups that have fossils will be discussed in this book.

The plant kingdom is composed of four major divisions. The term phylum is not applied to these divisions because they are not defined in quite the same way as are the animal phyla. One division, the Tracheophyta, produced almost all of the fossil plants found in Pennsylvania.

KINGDOM PROTISTA

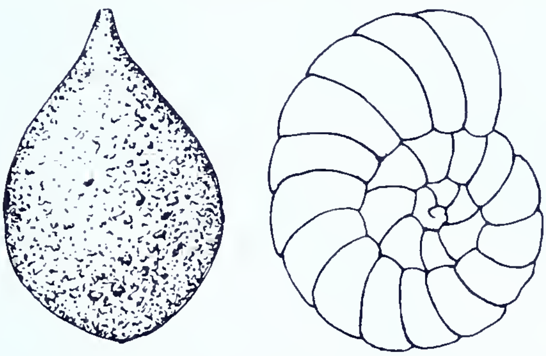
Phylum Protozoa

Protozoans are simple, one-celled creatures that include such forms as the living *Amoeba*. They are found by uncountable billions in our sea water, where they provide much of the food for many other large aquatic animals.



Amoeba **— a living protozoan (x50).**

Only a few groups of the phylum Protozoa are found as fossils because most of the animals in the phylum form no hard parts. The most important of these groups belong to the subphylum Sarcodina, class Rhizopodea, and are called Foraminiferida, or "forams" for short. These microscopic one-celled animals secrete (build) a shell around their body made of chitin (an organic compound similar to a fingernail) or calcium carbonate; some make their shell from sand particles. Large portions of our deep-sea bottoms are covered with the minute shells of these animals.



***Lagenammina* (left) and *Endothyra* — foraminifera genera (x85).**

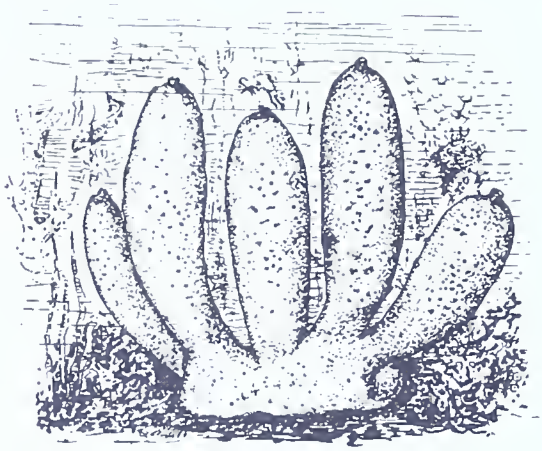
Most of the forams are so small that they can be seen only with a high-power microscope. A few, however, have built a shell up to 6 inches across and are a major part of some rocks. The limestone that was quarried to build the great pyramids of Egypt is made up largely of the genus *Nummulites*, one of the largest forams that ever lived. One family of forams, the Fusulinidae, secreted shells about the size and shape of wheat grains.

Foraminiferida are not common fossils of Pennsylvania, but fusulinids have been found in the Pennsylvanian age Vanport Limestone in the western part of Pennsylvania.

KINGDOM ANIMALIA

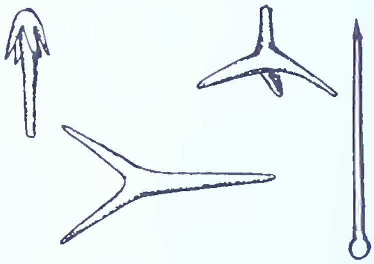
Phylum Porifera

The phylum Porifera (meaning pore-bearing) is the group of simple, many-celled animals we call sponges. Sponges have many shapes, ranging from encrusting to ball-shaped, flask-shaped, and leaflike forms. These animals consist of fleshy material that has numerous pores, supported by a rigid or semi-rigid internal skeleton. The skeleton of most sponges is made up of many very tiny pieces, called *spicules*, composed of calcite or silica, or fibers composed of spongin, a protein compound containing sulfur. The common bath sponge, used until recently replaced by plastic "sponges," is the fibrous spongin skeleton of the genus *Euspongia*. The skeleton of some classes is made of a mass of calcite or aragonite (a mineral whose composition is close to that of calcite), similar to coral skeletons.



Sycon **— a living marine sponge (x2).**

Sponge spicules (x15).



Sponge fossils generally are very rare because the spicules that form the skeleton fall apart soon after the death of the sponge; those without spicules have even less of a chance of preservation because their skeletons of fibers are rapidly destroyed.

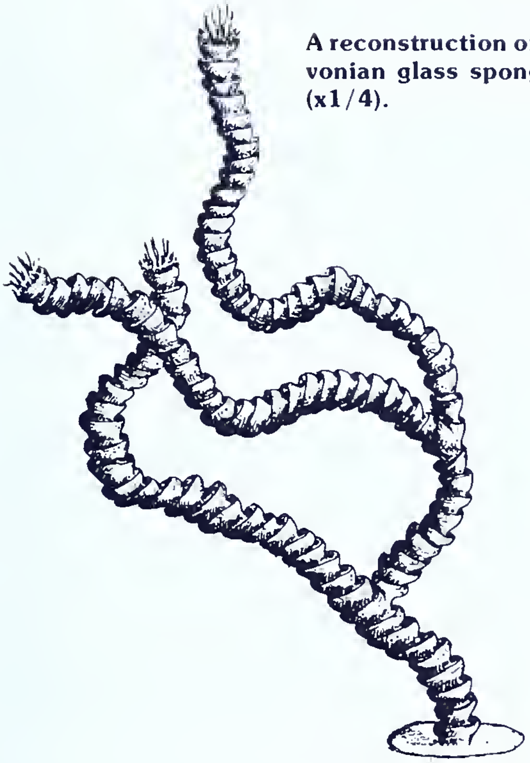
There are five classes of sponges, four of which have fossil representatives. However, most fossil sponges in Pennsylvania belong to two classes: Hyalospongia (glass sponges) and Stromatoporoidea.

Fossils of the class Hyalospongia are rare, but in some areas of northwestern Pennsylvania molds of hyalospongid skeletons showing the characteristic mesh of the spicules are found in Devonian and Mississippian age rocks.

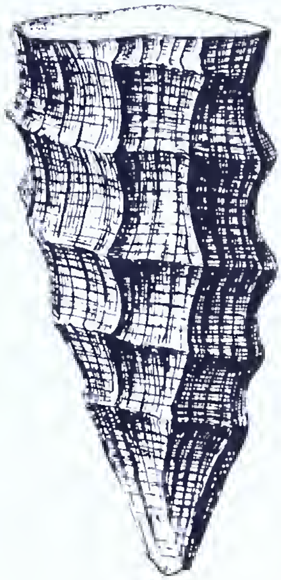
The Hyalospongia have a skeleton composed of an intricate network of siliceous spicules. The skeleton was flask shaped or tubular and covered inside and out with fleshy layers. (See page 4 for a sketch of fossil sponges in a reconstructed scene.) When the animal died, the fleshy material disintegrated and the skeleton was filled and covered with mud. Because the siliceous spicules were strongly interconnected and hard, their shapes were impressed in the mud and were thus preserved as molds. The silica disappeared by dissolution.

The living class of sponges, the Sclerospongia, do not have a skeleton supported by spicules. Instead, they build a skeleton of calcite, which contains many pores and interconnected canals. The fleshy part of the sponge lives on the surface and in the pores and holes.

An extinct class, the Stromatoporoidea, built a skeleton much as the living sclerosponges do. The skeletons consist of ball-, mound-, or twig-shaped masses, which internally are composed of many layers (lamellae)

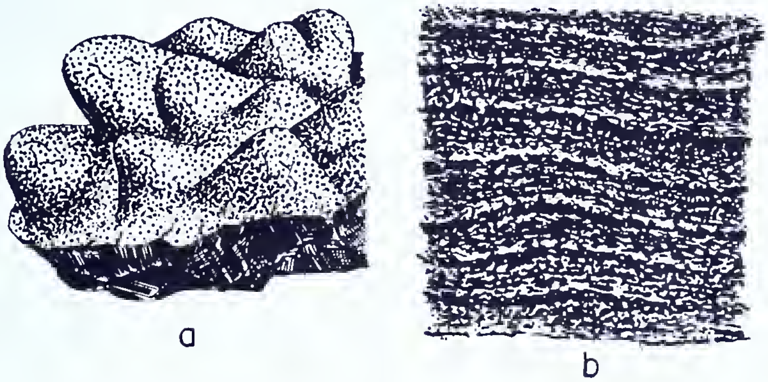


A reconstruction of *Titusvillia*, a rare Devonian glass sponge from Pennsylvania (x1/4).



***Hydnoceras* — a Devonian glass sponge (x1/3).**

that have pores and holes. Stromatoporoids were an important reef builder in the Silurian and Devonian Periods, as were corals. They are often found in some of the limestones of Late Silurian and Early Devonian age in central Pennsylvania.



***Stromatopora* — a fossil sponge.**

a. **Part of a colony (x1-1/2)**
b. **Section through colony showing layers (lamellae) (x3)**

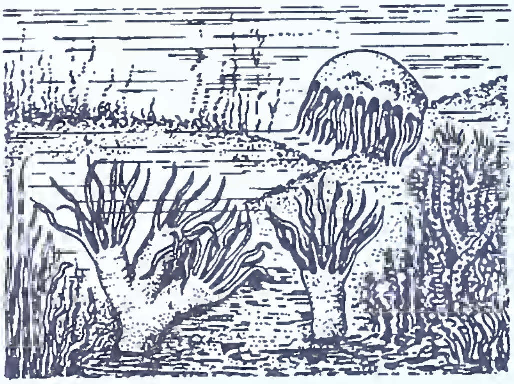
Phylum Coelenterata

The phylum Coelenterata is a large group of animals exemplified by the living corals, which exist mainly in sea water. The phylum includes many forms, both living and extinct, that superficially do not look much alike. Many of the groups within the phylum have almost no fossil record, whereas others have no living representatives.

Corals make up the largest part of the phylum and are well known from the large reefs they make near islands in tropical and subtropical seas. Also included within the phylum Coelenterata are jellyfish, sea pens, sea fans, sea feathers, and a multitude of other forms.

There are two general body types in this phylum. One type, called a medusa, is a rounded, bell-shaped body that floats and is carried about by sea currents. Tentacles hang from its lower edge to catch food. The medusa type of coelenterate is rarely found as a fossil because it has no skeleton. Living jellyfish have this form of body. The other body type is the polyp, which is like a tube that has one end closed and attached to something on the sea bottom. A ring of tentacles is present around the edge of the other end. Coelenterates having the polyp form are mainly responsible for the coral reefs because they secrete a skeleton.

Diagrammatic sea-bottom sketch showing a floating medusa and attached polyps.



Corals are characterized by the colonial mode of life, whereby many individuals join together to grow one large skeleton on which they all live. Some corals, however, are solitary, and their skeletons are grown singly.

In Pennsylvania two classes of this phylum are found as fossils. All genera of these classes are extinct, but because of their similarity in skeletal form to living coelenterates they are placed in the phylum Coelenterata, and reconstructions of what they must have looked like can be made.

Class Scyphozoa

This class of coelenterates includes the free-floating jellyfishes that have the body form of a medusa. However, there is one small group of

Reconstructed Devonian sea-bottom sketch showing attached and floating conulariids (x1/4).

fossils called Conulariida that are placed in this class. Unlike the jellyfish, some of the conulariids were attached to the sea bottom.

The fossil conulariids are generally cone shaped or pyramidal and consist of a thin, flexible chitin outer "skin" that is usually marked with many curved or angular lines. Because some members of this group may have floated like a medusa, and because of other similarities, this unusual group is placed in the class Scyphozoa.

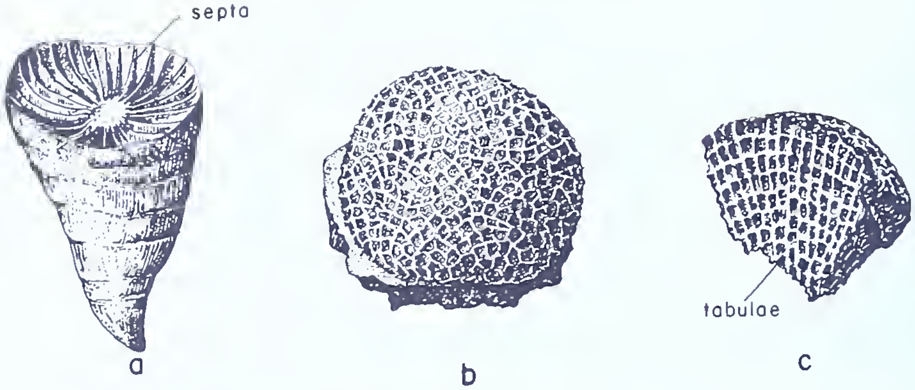
Conulariids have been found in Devonian age shales in central and eastern Pennsylvania.

Class Anthozoa

The anthozoans include most of the corals that build our modern reefs. Only the polyp form of individual occurs in this class and is exemplified by the living sea anemones.

Anthozoan polyps form a tubular, cup-shaped, or horn-shaped skeleton that may be joined with others or be solitary. Each skeleton formed by a group of polyps is called a *corallum*. The individual polyps live mainly in the cup-shaped depression at the upper or outer end of each individual *corallite* and rest on radial partitions (*septa*) that extend the length of the tube, or on plates (*tabulae*) that extend across the tube. As the polyp adds more to the walls of the corallite, it also adds to the septa so that its soft body always remains near the outer end. In those forms that have tabulae, a new tabula is periodically added so that the polyp is not too far down the tube. The polyp can retract itself into the tube in case of danger, but it usually remains outside with its tentacles waving about in the sea water to catch food. (See also page 4.)

Within the Anthozoa are several groups, three of which include most of the corals of the world. The corals of our present oceans belong to the Scleractinia. Corals of this class are also found as fossils as far back as Triassic times, but not in the rocks of Pennsylvania. Pennsylvania corals belong to the Rugosa and Tabulata, two groups that are extinct. Both the Rugosa and Scleractinia have septa, but the septa are arranged in different patterns that readily distinguish the two groups.



Anthozoan corals (x1).

a. A solitary, rugose corallite; the radial partitions are the septa.
b. A colonial, tabulate corallum; each hole housed a polyp.
c. A section through a tabulate corallum showing the transverse partitions, the tabulae, and the vertical walls of each corallite.

The Rugosa built large, massive colonial skeletons and horn-shaped solitary skeletons. Individual corallites are characterized by a rough and ridged outer surface, hence the name Rugosa. Rugose corals also contain septa. The Tabulata are colonial and are characterized by having tabulae, generally without septa. A few tabulate genera have septa, but the septa are usually very small.

Both rugose and tabulate corals are found in the Paleozoic rocks of Pennsylvania. They are relatively common in some of the Silurian and Devonian age rocks of central and eastern Pennsylvania.

Phylum Bryozoa

The bryozoans are a group of exclusively colonial animals that live mainly in sea water. Although some of them build encrusting skeletons that contribute to reefs, most of them secrete delicate skeletons that look much like plants, moss, or seaweed. Because of their delicacy, few are found complete. After death, they are usually scattered about like broken twigs and branches of a tree. Some bryozoans build very thin, delicate, crustlike skeletons on rocks, sea shells, and corals.

Bryozoans as individuals are extremely tiny, and the colonies they form may have dimensions of only about one inch. A hundred or more bryozoans may live in a colony that is an inch or two long. The soft body of the bryozoan looks similar to the polyps of the coelenterates in that the body is tubular and has a ring of tentacles around its outer edge. However, this resemblance is only superficial because the bryozoan body, called the *zooid*, has much more complicated internal organs than does the relatively simple coelenterate polyp.

Each of the zooids secretes a tubular skeleton that may or may not have various cross partitions similar to tabulae. Surrounding the tubes is

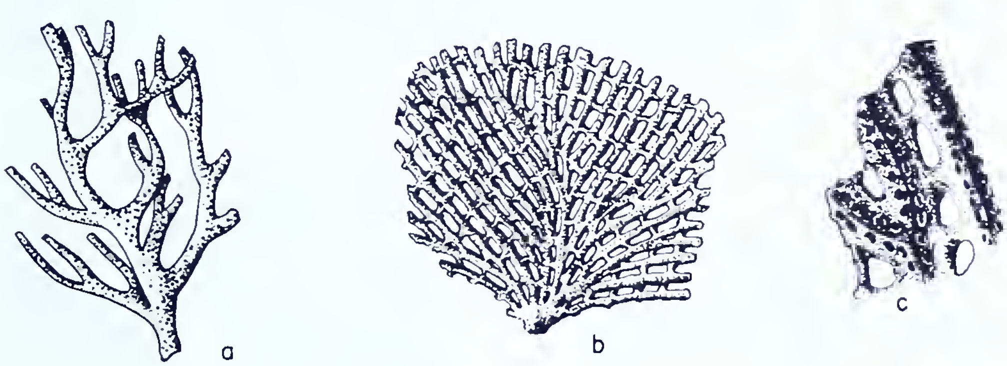
***Bugula*, a living bryozoan (x1). Each of the small sections houses a zooid.**

other skeletal material that binds them all together. A complete colony is called a *zoarium*. By the use of complex muscles, the individual soft body is capable of pushing itself out of its *zooecium* to collect food with its tentacles or to completely retract itself within its skeleton.

Many bryozoans may be identified by their surface character, but positive identification of bryozoans frequently can be made only by microscopic examination of thin, transparent slices cut from the specimen.

Two of the forms of fossil bryozoans that you may find are the twig-, branch-, or mound-shaped form that has zooecia all over its surface, and the ribbon or lacy form that has zooecia on one side or surface and often consists of several long branches connected by short bars, which gives it a lacy appearance. Fossil bryozoans found in Pennsylvania all belong to the class Gymnolaemata.

Bryozoans are found in all of the periods from the Ordovician to the present. They are found most often in Silurian and Devonian age limestones and shales throughout the Commonwealth.



Fossil bryozoans.

a. "*Batostomella*," a branching type (x25).

b. *Fenestrellina*, a lacy type (x1). The black dots are zooecial apertures.

c. Part of (b), expanded to show the zooecial apertures (x15).

Phylum Brachiopoda

Brachiopods are small marine animals that possess two shells (or "valves" as they are most commonly called) that completely enclose the soft body.

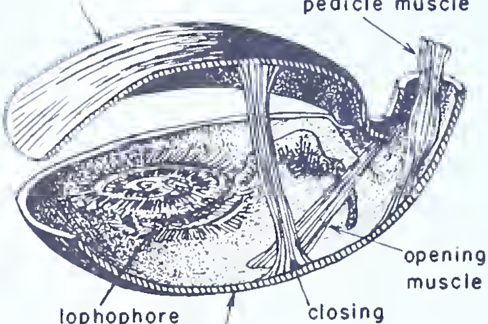
Only a few living representatives of this once-immense phylum are to be found in our present seas. Brachiopods, however, flourished on the bottoms of Paleozoic seas and are one of the most common fossil types found in Pennsylvania. At times they accumulated in large deposits similar to the oyster banks of today.

Brachiopods were animals that burrowed into or were attached to the sea bottom; they were not capable of moving about.

Brachiopods on the sea floor.

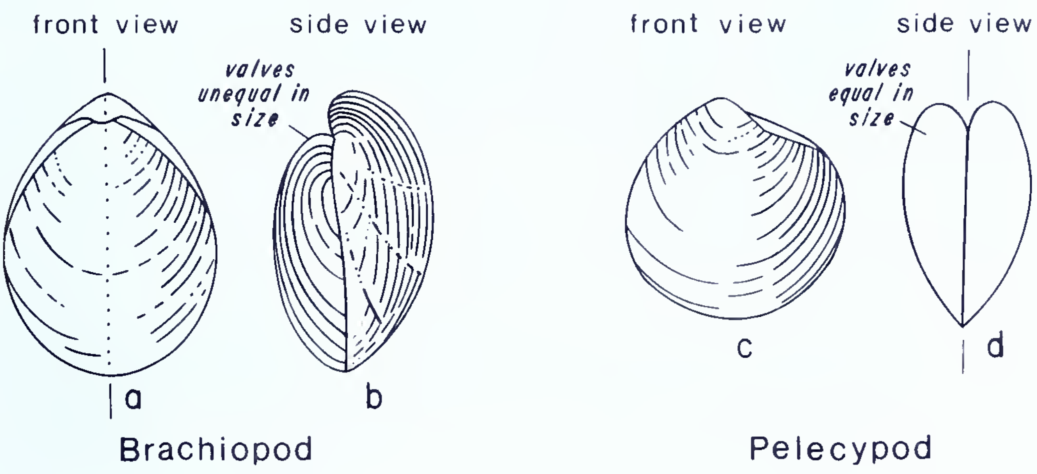
They bear superficial similarities to, and may be confused with, pelecypods (the clams and oysters), which are also marine. They are, however, easily distinguished from pelecypods because both the soft body and the enclosing valves of brachiopods differ very much from the pelecypods. The fleshy parts of pelecypods consist mainly of a large muscular "foot" for digging and moving about, and a set of strong muscles that close the shell. Brachiopod fleshy parts consist mainly of a compli-

Cut-away sketch of an articulate brachiopod, showing the muscle system and the lophophore. Certain other organs are omitted from the sketch.



cated feeding mechanism called the *lophophore* and specialized muscles that both open and close the valves.

The simplest method of determining whether a shell is a brachiopod or a pelecypod is by examination of the valves to determine their symmetry. Brachiopods and pelecypods are both bilaterally symmetrical, which means that the animals may be divided into two equal halves, but the plane of symmetry is different in these two kinds of animals. Brachiopod valves are unequal in size, but each may be divided into two symmetrical halves, as shown by "a" in the drawing below. Pelecypod valves are equal in size but each valve cannot be divided into two equal halves ("c" of the drawing below). The plane of symmetry of a pelecypod is *between* the valves; thus each valve is a mirror image of the other. In the case of a brachiopod, the plane of symmetry is *through* the valves.



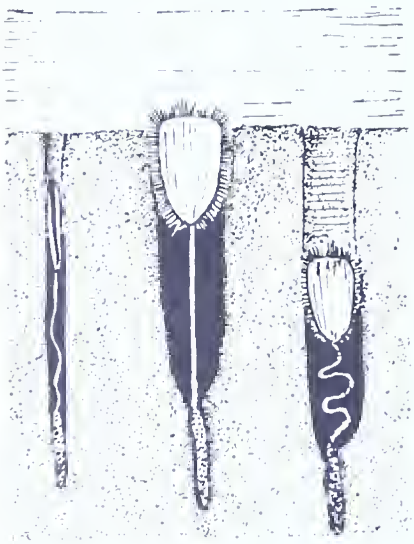
Differences in symmetry between pelecypods and brachiopods.

The larger of the two brachiopod valves is called the *pedicle* valve, because this valve bears the pedicle, a long muscular stalk that is used to attach the shell to the sea bottom. Not all brachiopods used this method of attachment. Some grew long spines all over the valve and rested on these. Others lay loose or burrowed into the muds on the sea floor. Some even cemented themselves to stones or to other animals.

The smaller valve, the *brachial* valve, bears the brachidium, the skeletal support for the feeding organ, or lophophore.

The phylum is divided into two classes, the Inarticulata and the Articulata, which are separated on the basis of the way the two valves are joined together at the hinge. The hinge allows the valves to open and close without having the valves come apart.

The inarticulate brachiopods are characterized by the absence of teeth and sockets near the hinge line; they possess only muscles to hold the two valves together. Their valves are usually composed of phosphatic and chitinous materials. *Lingula*, a modern inarticulate, lives along some seashores and burrows deep into sand, where it is attached by a very long pedicle. Fossil valves of the genus *Lingula* are found in rocks as old as the Cambrian and thus provide one of the best examples known of an animal that assumed its present form over 500 million years ago and has remained the same since then.



Schematic sketch of the burrowing life habits of *Lingula*, a living inarticulate brachiopod (x1/4).
a. Side view showing narrowness of the brachiopod and its burrow.
b. Extended feeding position.
c. Retracted position.

The class Articulata is characterized by having teeth in the pedicle valve and sockets in the brachial valve. The muscle system of the articulates is less complex than that of the inarticulates because it is used only to open and close the valves. The majority of all known fossil brachiopods are articulates.

Brachiopods were very common during the Paleozoic Era (see page 4) but have declined in number since then. Because of their abundance during the Paleozoic and because the various fossil genera evolved and became extinct quickly, the brachiopods are useful in identifying, subdividing, and correlating Paleozoic rocks over the whole world.

Articulate brachiopods, in a variety of shapes and sizes, are one of the most common fossils found in Pennsylvania. They are present in nearly all fossiliferous rocks in the Commonwealth.

Phylum Mollusca

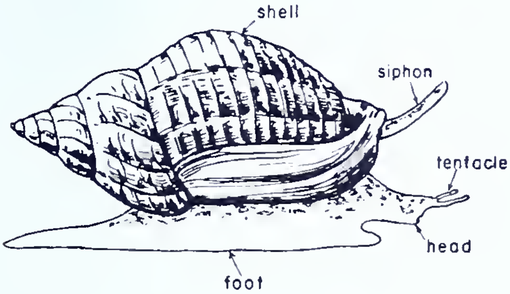
The phylum Mollusca includes a varied group of animals such as the well-known chitons, snails, oysters, clams, squids, octopods, and others. Although they differ greatly in size (from less than an inch to several feet) and shape, these animals are all closely allied. The phylum is divisible into seven classes. Of the seven classes, only four are found as fossils in Pennsylvania, and of these only three are abundant in occurrence. These are gastropods, pelecypods, and cephalopods.

With certain modifications, the soft bodies of the animals in all classes of this phylum are similar. Six of the classes (the cephalopods excluded) contain animals that have a muscular "foot," which is used for moving and burrowing. In the cephalopods (squids and octopods) this foot is modified into structures near the head region which aid in propulsion. Six of the classes also have a well-defined head region with tentacles and a mouth. The Pelecypoda ("clams") is the only class that does not have a definable head. Soft parts of various molluscan animals can be shown to possess many more similarities than those mentioned above.

Class Gastropoda

Gastropods are the most diverse group of molluscans; they live throughout the world both on land and in the sea. Those that have no shells are the slugs; those that carry shells are snails. Snails that live on land have developed lungs; the others have gill structures for living underwater.

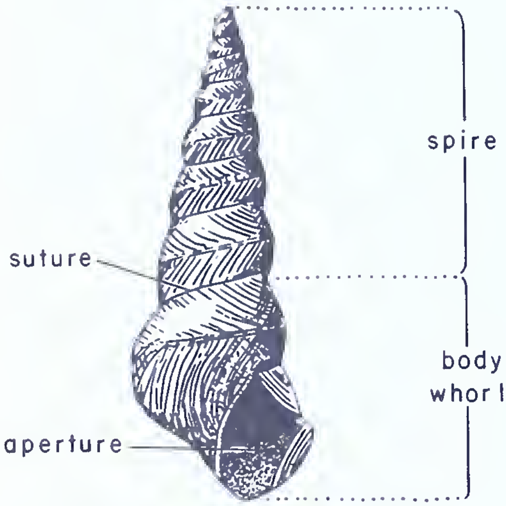
The individual gastropod consists mostly of the muscular foot on which it moves, a head that generally contains a pair of tentacles, and a body upon which is carried a coiled, unchambered shell. In times of danger, the snail withdraws its body into its shell. Some gastropods have evolved an *operculum* or "door" that covers the opening to their "house."



Anatomical parts of a snail.

Starting with a simple coil, gastropods build many very different kinds of shells. Some have complex external structures and ornamentation; some are smooth. Some are coiled tightly, whereas others uncoil as they grow.

The snail shell is divided into two main parts: the *body whorl*, which is the last turn of the spiral, and the *spire*, which encompasses all of the other spiral turns above or behind the body whorl. The opening is called the



The parts of a snail shell.

aperture; the line between the many whorls (turns of the spire) is called the *suture.*

After the snail dies, the shell often fills with mud. If, after fossilization, the shell disappears by dissolution, an internal mold is left. Such molds are called *steinkerns.*

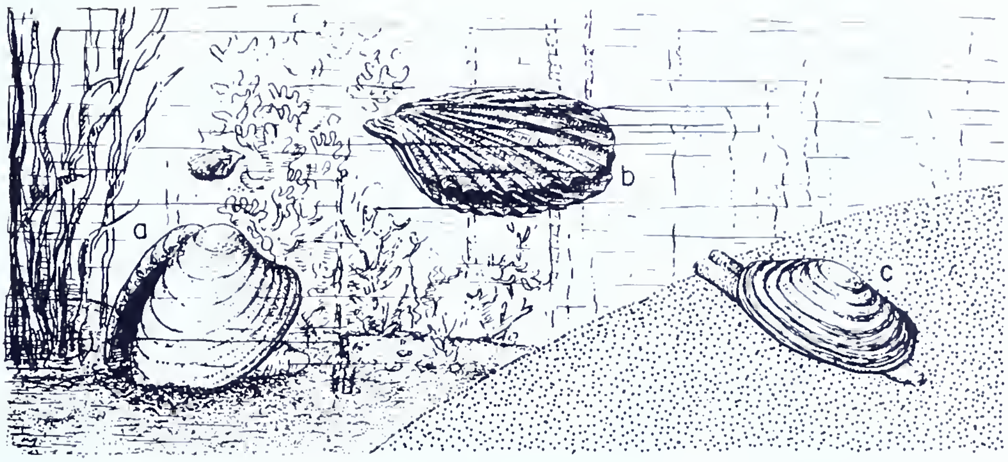
Gastropods, like brachiopods, can be found in almost all of the fossiliferous rocks in Pennsylvania.

Class Pelecypoda (=Bivalvia)

The pelecypods, or bivalves, include many of the organisms we call shellfish—the clams, oysters, and scallops. These are an important food product of the sea. They differ from the other members of the molluscan phylum by their habit of secreting an external skeleton of two valves, as do brachiopods.

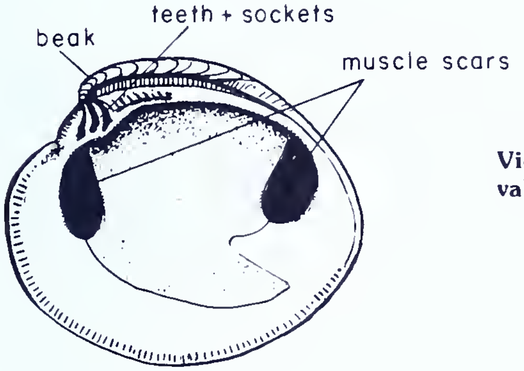
Pelecypods are more varied in their home sites and methods of movement than are other groups of the Mollusca. The snails (gastropods), being nonswimmers, usually dwell on a surface such as the sea, a lake, or a stream bottom. The cephalopods (squids, etc.) are largely made up of swimmers, but some pelecypods dwell on a surface, some burrow, and some swim about. The scallop *Pecten* swims about in the water by strong muscular movement of its valves. Many pelecypods live on the bottoms of bodies of water, where they move by using their foot. They often bury themselves deeply into the mud. Some even bore into rock to find a hiding place. A few of the pelecypods, such as the oyster, cement themselves to the bottom. The oyster is one of those unusual pelecypods in which both valves are not the same size.

The two valves are called right and left valves because many of the pelecypods move about with the foot downward and the beak (the pointed part of the shell) upward. Thus the valves are the "sides" of the ani-



Schematic sketch depicting the life habits of clams (pelecypods) (x1/4).
a. *Venus*, a bottom dweller.
b. *Pecten*, a swimmer.
c. *Mactra*, a burrower.

mal. Both valves have teeth and sockets along the hinge line to keep them attached. Fossils that preserve the interior often show the position of the large muscles that hold the valve closed.



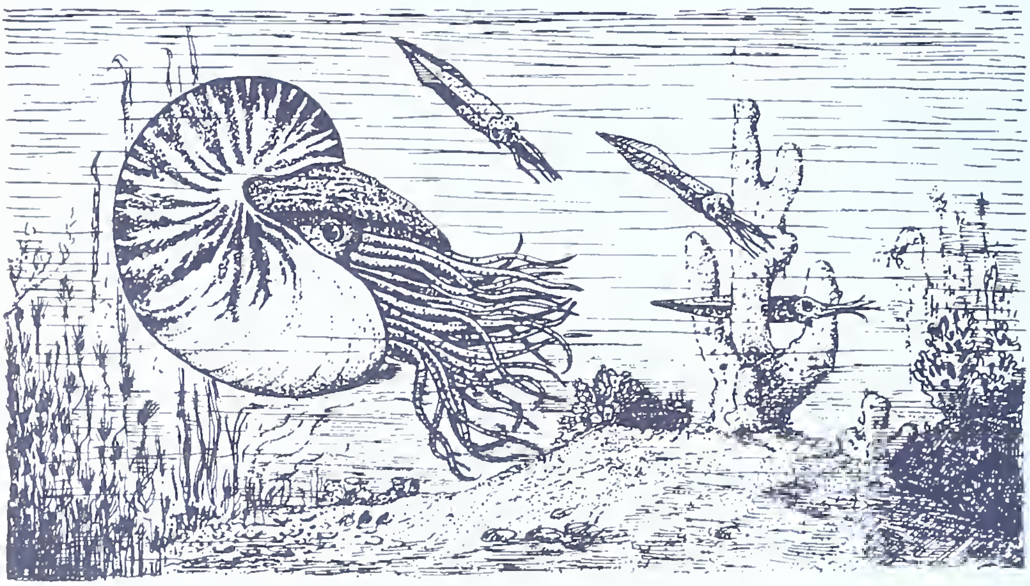
View of the interior of a pelecypod's right valve.

Pelecypods are a common fossil in some of the fossiliferous rocks of Pennsylvania but are found most often in the Middle and Late Devonian age sandstones and shales of central and northern Pennsylvania.

Class Cephalopoda

The class of mollusks called cephalopods, instead of having just an external shell as do "snails" and "clams," may have shells that are either external or internal. Some, such as the modern octopus, have no shell. The cuttle fish *Sepia* has only a very small internal shell called the *rostrum*, often used in bird cages. Most fossil cephalopods, however, possessed a rather intricate external shell.

Only one living representative of the external-shelled group is known. This is the pearly *Nautilus*, which is found in our south seas. From this sole living member of a nearly extinct group, we know much about how many fossil cephalopods must have looked and how they must have lived.

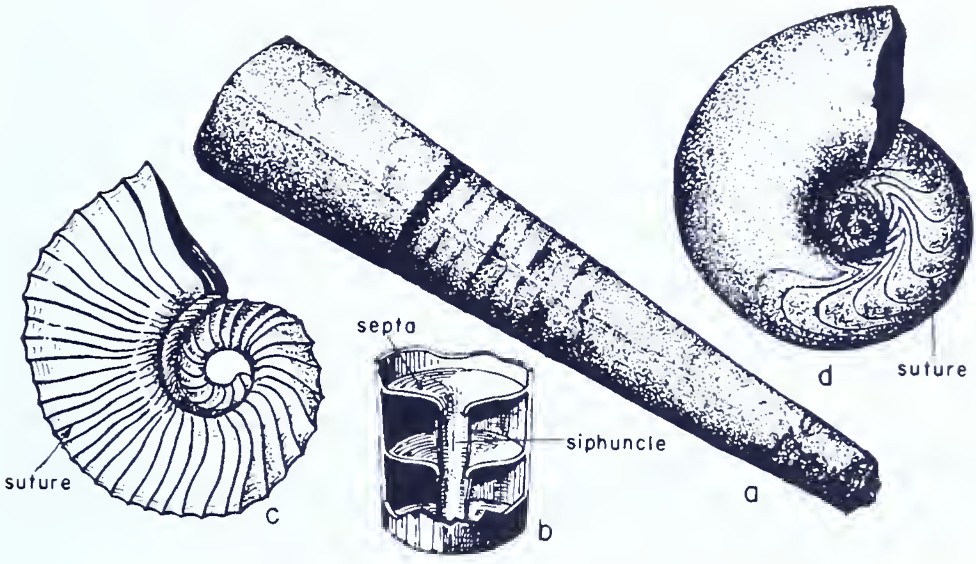


The "pearly" *Nautilus* and its relatives, the squids (x1/4).

Fossil cephalopods built many varied and intricate shells. The simplest type of cephalopod shell is straight and shaped like a cone. Others grew a slightly curved shell, and still others grew completely coiled. The coiling of the cephalopods was generally in one plane rather than spirally as in most snails. A few cephalopods, however, did build a spirally coiled shell.

A major difference between cephalopod shells and the somewhat similar gastropod ("snail") shells is that cephalopods separated their shells into many chambers by building partitions (septa) at regular intervals. The animal itself lived in the last chamber. The septa were perforated by a tube called the siphuncle, through which a fleshy stalk was extended from the bulk of the animal in the living chamber to the tip of the shell.

In a simple cephalopod each partition (septum) was shaped much like a watch glass—a simple, smooth, concave partition. Where the septum is attached to the shell wall, a visible line occurs, called the suture line. More complex cephalopods built septa that were wavy along their edges, thus creating a more complicated suture line. The individual chambers, separated by septa, were filled with gas during life so that the animal could float and swim in the water, yet carry around a strong, heavy shell that provided protection against its enemies.



Types of fossil cephalopod shells (x1/2).

a. ***Michelinoceras*, a simple, uncoiled shell.**

b. **Enlarged portion of (a), showing interior partitions (septa) and the connecting tube (siphuncle).**

c. ***Centroceras*, a coiled shell that has even septa, shown by the even sutures.**

d. ***Manticoceras*, a coiled shell that has wavy septa, shown by the uneven sutures.**

The exterior of the shell was ornamented in some cephalopods. Most had a smooth exterior; others had ridges along or around the cone. A few built spines along their shell. (See page 4 for a reconstruction of the common cone-shaped cephalopod found in Devonian age rocks.)

Cephalopods are not common in Pennsylvania; however, they may be found in many of the Devonian age rocks of central Pennsylvania, particularly in the rocks of the Mahantango Formation. They also occur in some of the Pennsylvanian age limestones of western Pennsylvania.

Class Scaphopoda

The scaphopods are a small living class of exclusively marine molluscan animals. Only two living genera are known. One of these, the distinctive genus *Dentalium*, lives buried in the sea-bottom sediment so that only a small portion of the shell extends above the water-sediment interface. The scaphopod shell is a small, tapering tube open at both ends, similar to a drinking straw.

The foot that extrudes from the larger of the two openings is used to bury the bulk of the shell in the sea bottom in a nearly vertical position. The scaphopod eats small bits of food in the muds, and the currents moving over the exposed end of the shell remove waste products.

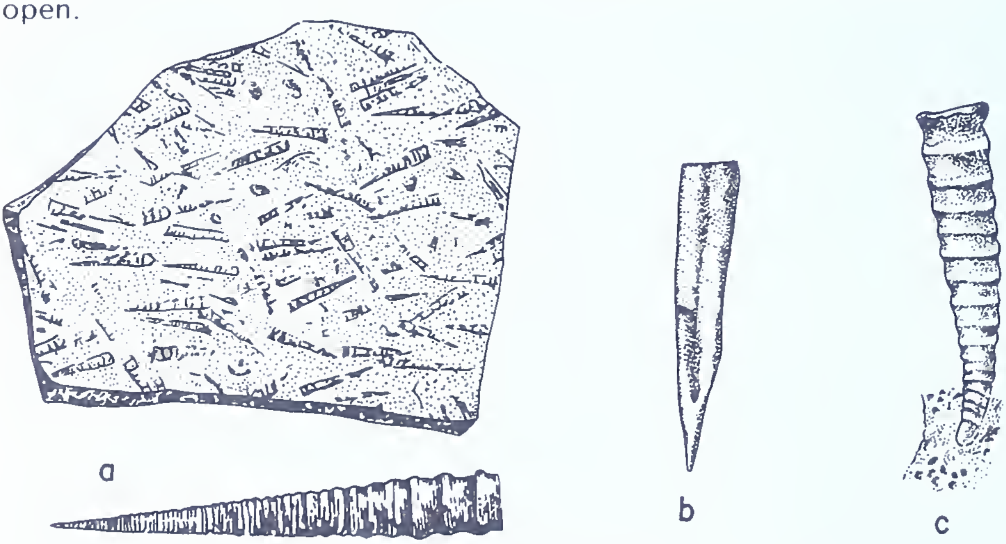
A modern scaphopod in life position, with foot extended.

Fossil shells of the genus *Plagioglypta* occur at some of the localities of Late Paleozoic age rocks in western Pennsylvania. These have transverse wrinkles as ornamentation.

Conoidal Shells of Uncertain Affinity

A few unusual fossils of extinct animals are placed in the class Cricoconarida and assigned to the phylum Mollusca because of some similarities they have to other molluscans. Because they are extinct, it is not known if they truly belong to this phylum.

One of these extinct fossils is *Tentaculites*, which is very small, cone shaped, and needlelike, and has several raised ringlike ridges around its surface. The shell was hollow in life, having one end closed and the other open.



Types of cone-shaped shells.

a. The cricoconarid *Tentaculites*, shown in a rock containing many individuals (x1), and in a closeup view.
b. *Styliolina* (x10).
c. *Cornulites* (x3).

Another is *Styliolina*, which is also small and cone shaped, but which does not have any external ornamentation. Most specimens of this fossil are crushed so that they appear to have a longitudinal groove.

An additional small conoidal shell found rarely in Pennsylvania is *Cornulites*. The phylum and class are not assignable for this fossil, but it is included in this section because of its superficial similarity to cricoconarids. The shell of *Cornulites* may be curved and is much thicker than that of *Tentaculites*.

The types of animals that lived in these shells are unknown. A truly accurate idea of what they looked like in life is impossible to recreate because many very different animals build tubular skeletons.

Tentaculites is a very common fossil in many of the Late Silurian and Early Devonian age limestones of central Pennsylvania. The other conoidal shells are much rarer.

Phylum Annelida

The common earthworm *Lumbricus*, and other similar worms used by fishermen, are the animals included in the phylum Annelida. Annelids are characterized by the segmented nature of their bodies; the body is made up of many ringlike segments (annulae). These worms, since they generally secrete no hard parts or shells, are rare as fossils. However, a few members of this group do have some preservable parts.

Annelid worms.
a. *Lumbricus*, the common earthworm (x1/4).
b. *Spirorbis*, a polychaete worm in its shell (x5).
c. The shell of *Spirorbis* (x10).

A few annelids of the class Polychaeta form tubes of different substances. These tubes are built either of organic material, or of fragments of sand, silt, or broken seashells, cemented together with calcium carbonate. The worm uses the tube as a protective covering and frequently also creates a door (operculum) to cover the opening. Some of the tubes are attached to rocks and other shells on the sea bottom. Some types of worms carry the tube as they move about. Some worms even leave their "house" for a short time to feed and then return to it for protection. The living polychaete *Spirorbis* forms a coiled shell of calcium carbonate, somewhat similar to a snail shell. This type of tube may be found in rocks as old as the Ordovician and is an example of a genus that has evolved little in the formation of the shell during its long existence on the earth.

Fossil annelids, primarily *Spirorbis*, have been found in some Pennsylvanian age limestones in western Pennsylvania; however, they are rare as fossils.

Phylum Arthropoda

The largest of all animal phyla is the phylum Arthropoda. About 75 percent of all living animals (most of which are insects) belong to this extremely varied group. The animals that are placed in the phylum are all characterized by legs that are jointed and a body that is divided into several segments (head, body, abdomen, tail, and other segments). The body is enclosed by a hard external covering (the exoskeleton).

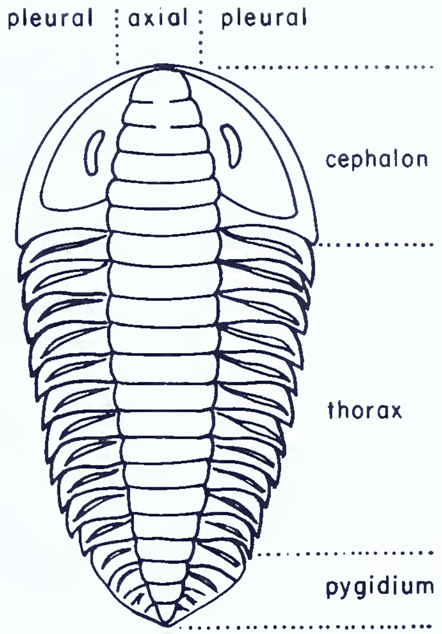
The phylum is divided into several groups, some of which have little superficial resemblance to each other. Only two of these groups are important as fossils in Pennsylvania. These are the extinct class Trilobita, and the class Crustacea, which includes living lobsters, crabs, barnacles, and ostracodes. Some of the other classes placed in this phylum are Hexopoda (all of the many types of insects); Myriopoda (centipedes and millipedes); Arachnida (spiders and scorpions); and Merostomata ("king crabs").

All of these classes have produced fossils but, because of the weakness of the exoskeleton in many of the groups and because many of them dwelled on the land or in the air, their exoskeletons have not been abundantly preserved.

Class Trilobita

Although the trilobites are an extinct group of animals, the similarities of their exoskeletons to those of living arthropods are such that paleontologists can generally reconstruct these fossils as they must have appeared in the past. In addition, some specimens have been found with appendages and other organs partially preserved, thus aiding the reconstruction

The trilobite body is divided into three main sections, each of which is composed of smaller segments. These three sections are the head (cephalon), body (thorax), and tail (pygidium). In the cephalon and pygidium, the smaller segments are fused together; in the thorax, they are separate. Thus, when a trilobite died, the exoskeleton was usually scattered about.



Schematic sketch of a trilobite exoskeleton.

Fossil hunters commonly find the head or tail complete, but the thorax is rarely intact.

Each of the three main sections is, in turn, divisible into three "lobes" by furrows that extend along the length of the animal; hence, the name trilobite. The lobes are marked by indentations and consist of an axial lobe and two pleural lobes; the axial lobe is usually higher than the others. In some genera, a small piece of exoskeleton called the libragenae (free cheek) is attached, but not fused, to the cephalon. Some trilobites also had a long spine at each side of the cephalon. These are the genal spines, which are attached either to the free cheek or to the cephalon.

***Cryptolithus* — an Ordovician trilobite (x4).**

a. **The three major body divisions of *Cryptolithus*.**
b. **Side view of the cephalon showing the libragenae, which fits underneath the cephalon. The genal spines are attached to the libragenae.**

By comparison with living arthropods and by the study of a few fossil specimens that have appendages preserved, paleontologists have determined that each segment in the three main regions had a set of legs or other appendages. In the cephalon the appendages were antennae. Fossil specimens of legs of trilobites have not been found in Pennsylvania.

Trilobites, as well as all other arthropods, shed their exoskeleton periodically as they grew. One trilobite, in its lifetime, produced many exoskeletons, and we assume that many of the fossil specimens of trilobites are these discarded exoskeletons.

These animals were probably dwellers of the sea bottom and crawled around in the mud in search of food, much in the same way as living crabs. (See page 4 for a reconstruction scene.) It is possible that certain trilobites were also swimmers. When in danger, some trilobites were able to roll into a "ball" like some living insects. This protected their soft underside.

Trilobites are a common fossil in many of the Cambrian, Ordovician, and Devonian rocks of central Pennsylvania Rolled specimens are rare but may be found in Devonian rocks of central Pennsylvania.

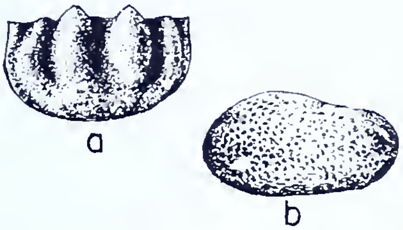
Class Crustacea, Subclass Ostracoda

Ostracodes are such extremely small organisms that one must use a magnifying lens or microscope to see them. Study of living ostracodes in our seas and rivers enables us to place them with other crustaceans because they have jointed legs and other appendages, such as the crabs and lobsters, although ostracodes look nothing like these relatives.

***Cypris*—a living ostracode in the swimming position; view of the right side (x20).**

These small animals look more like a very small pea with a hard exoskeleton composed of two pieces called valves that enclose the soft body. The valves, except for their tiny size, are somewhat like those of the brachiopods and clams. Because their exoskeleton has no resemblance to other crustacean exoskeletons, the soft parts of the ostracodes, specifically the legs, determine their correct placement in the phylum. Ostracodes, like crabs and lobsters, have several sets of jointed legs and antennae, and their internal organs are similar to those of other crustaceans; thus we know that they are definitely a member of this phylum.

Ostracodes use their legs to swim about in the water, and they feed from seaweed and debris on the bottom. The legs retract and the valves close completely when the animal is in danger. The valves that cover the sides of the animal are called left and right valves because ostracodes swim in a vertical position with their legs extended down between the valves.

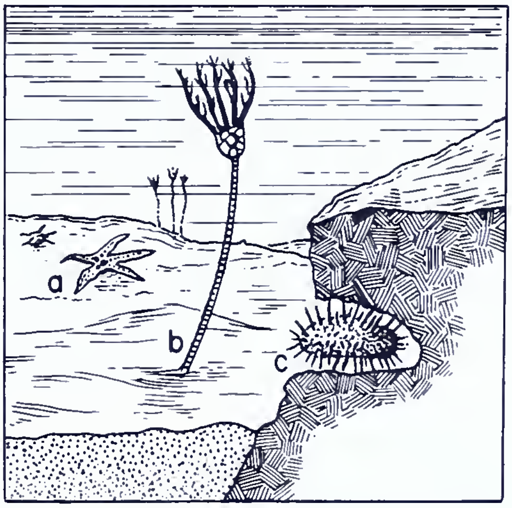


Right valves of fossil ostracodes.
a. *Drepanellina* (x5).
b. *Ponderodictya* (x15).

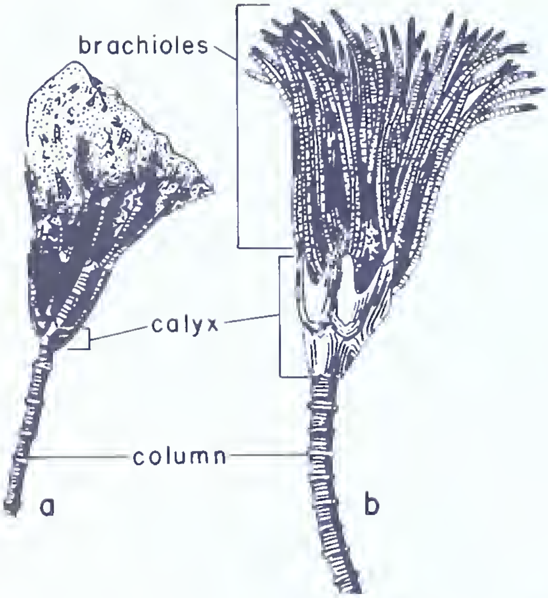
Ostracodes have been found in many of the Silurian and Devonian age limestones and shales of central Pennsylvania.

Phylum Echinodermata

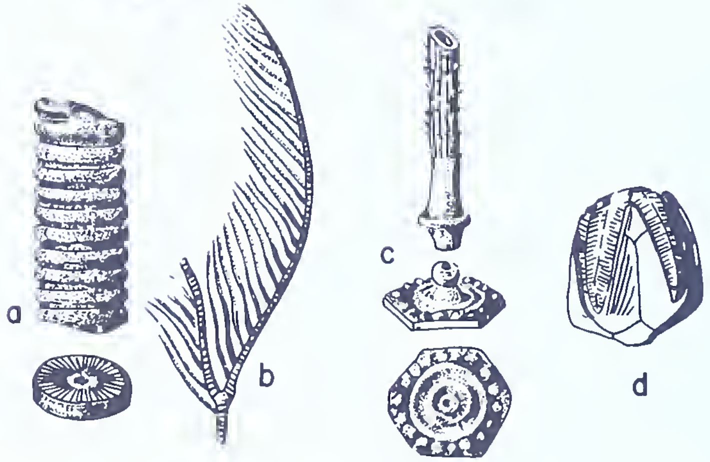
Echinodermata is another phylum containing several familiar and unfamiliar classes that outwardly resemble each other. The common members of this phylum found along the seashore are the starfishes (class Stelleroidea), sea urchins, heart urchins, and sand dollars (class Echinoidea). Living members that are not so well known but important as fossils in Pennsylvania are the sea lilies (class Crinoidea). The phylum also includes some extinct classes.



Schematic sketch of echinoderms in their living positions.
a. Stelleroid (starfish).
b. Crinoid.
c. Echinoid (sea urchin).



Echinoderms, illustrating various parts.
a. *Cupulocrinus* (crinoid).
b. *Orophocrinus* (blastoid) (x1).



Fragments of echinoderms (x2).

a. Portion of a crinoid column; one segment is tilted to show the grooved surface. Many have star-shaped centers.
b. A portion of a crinoid ambulacra with attached pinnules.
c. Echinoid plate (lower figure); tilted plate (middle) shows ball upon which the spine (upper) fits.
d. Calyx of *Pentremites*.

Fossil representatives of the living stelleroid, echinoid, and crinoid classes, and the extinct cystoid and blastoid classes, have been found in Pennsylvania but, except for the crinoids, they are rare.

Class Crinoidea

Crinoids bear resemblance to plants in that most of them have a stalk or stem that attaches the flowerlike body to the sea floor. This stalk is called the *column* or stem and is composed of many small segments that are jointed and allow the stalk to be flexible. Some of the soft body of the animal is enclosed in an exoskeleton called the *calyx*. The calyx is composed of many regularly arranged plates of calcium carbonate held together by skinlike tissue. Many jointed and branching arms (ambulacra) extend from the upper edge of the calyx. These wave about in the sea water and catch the food; they also contain some of the organs of the animal. Extending from the arms in some species of crinoids are many slender *pinnules*. These also aid in food catching by forming a mesh that entraps food particles.

Crinoids are characterized by five-sided (pentameral) symmetry; thus a calyx is made up of five units of plates, or multiples thereof (10, 15, etc.) and of multiples of five arms. This symmetry is not as obvious as in the class Blastoidea.

Because the animal is composed of so many pieces, it is rare to find whole animals. Pieces and parts of the column are common in almost all sedimentary rocks in Pennsylvania; in fact, crinoid columns are perhaps the most common fossil of Pennsylvania. Parts of the calyx and arms are rare but have been found in some localities, notably in the Wymps Gap ("Greenbrier") Limestone of western Pennsylvania. Occasionally, whole calyxes with arms may be found.

Class Blastoidea

Blastoids are an extinct class of echinoderms which superficially resemble crinoids but differ from them in several fundamental characteristics, except for the column. Blastoids have a column and a calyx, as do crinoids, but they have no branching arms extending from the calyx. Instead, they have brachioles, which serve the same purpose as the ambulacra and pinnules of crinoids, yet are very different structures.

Blastoids are characterized by a highly developed and visible five-fold (pentameral) symmetry. The calyx, as viewed from the bottom or top, is generally five sided and contains five structures called ambulacra, to which countless brachioles were attached. These brachioles, however, did not contain internal organs as did crinoid arms.

The individual columnals that made up the stem of a blastoid or crinoid are indistinguishable from each other. The most common blastoid fossil found is the calyx without the brachioles, whereas crinoid calyxes generally occur with at least part of the arms.

Class Stelleroidea

The class Stelleroidea includes two distinct groups of echinoderms. These are the starfish (Asteroidea) and brittle stars (Ophiuroidea), both represented in present marine waters. They differ in that starfish lack a distinct separation of the arms from the central disk, whereas brittle stars have a distinct rounded central disk and slender arms.

The starfish and brittle star of the seashore are composed of many small calcium carbonate plates called *ossicles* that are loosely joined and covered by a leathery, muscular skin that holds the skeleton together. Although these animals do not look much like the crinoids and echinoids, their organ systems, such as the digestive system, are similar, and on this basis these dissimilar classes are grouped with other echinoderms.

Stelleroids are dwellers on and below the sea bottom, where they move about by means of suckers or tube feet which extend from the underside of the arms. These animals are strong and with their suckers can pull apart clam shells to devour the clam.

Stelleroids are rare as fossils because the skeleton is so loosely held together. However, complete molds have been found at the Swatara Gap locality in the Late Ordovician age rocks of Lebanon County (site 29) and at the Franklin County site (21).

Class Echinoidea

Echinoids (sea urchins) are sea-bottom dwellers that are somewhat mobile, although they are not as active as the starfish. The sea urchin uses the many spines on its surface to move about and also to hold itself fast in rocky places when the waves and currents are strong.

Sea urchins have a semiglobular body composed of many ossicles held together by skin. In some species, these ossicles are fused together and form a strong hollow skeleton in which the soft body is housed. The surface of the urchin is studded with many movable spines. In the days when slates were a schoolboy's common companion, some of the pencils used to write on the slate were the long spines of the sea urchin. The base of the spine had a socket that fit on a ball joint on the surface of an ossicle (see lower figure on page 36, part c).

Fossil sea urchins are rare because the skeleton usually falls apart after death. However, spines and some of the ossicles have been found in Mississippian and Pennsylvanian age marine limestones of western Pennsylvania.

Phylum Hemichordata

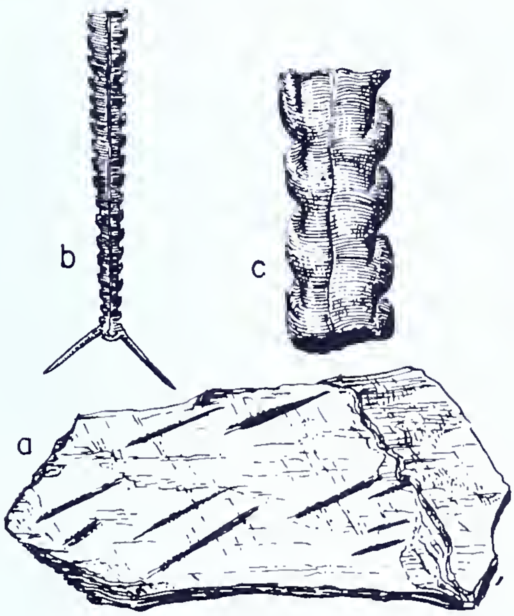
The living hemichordates are small, mostly soft bodied, colonial organisms that have complex organs and growth patterns. Rare specimens of the class Pterobranchia are known as fossils as old as 500 million years (Ordovician Period). They formed a cuticular, tubular exoskeleton.

Cuticle is a hardened material, similar to the human fingernail, made of protein substances. Pterobranchs are important because their tubular exoskeleton is very similar to the exoskeleton of an extinct class, the Graptolithina.

In the tubes built by the pterobranchs live small animals called zooids that are connected to each other by a stalk that can contract. By analogy, similar zooids are assumed to have lived in the tubes built by the Graptolithina.

Class Graptolithina

The extinct graptolites built a chitinous, colonial exoskeleton. Nothing is known of the soft bodies of graptolites, but they may have been similar to those of the living pterobranchs. Each animal is assumed to have lived in a small cup (theca) on the side of a branch (rhabdosome) that looks like a tiny saw blade with teeth on one or both sides. Each "tooth" is a theca.

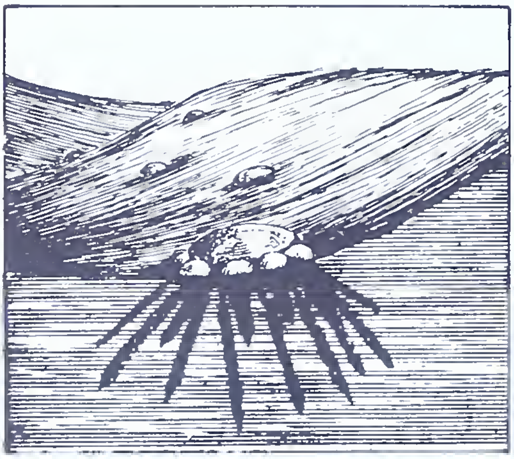


Climacograptus **— an Ordovician graptolite.**

- **a. Rhabdosomes on a rock surface (x1).**
- **b. An enlarged view of a single rhabdosome.**
- **c. An enlargement of part of the rhabdosome to show theca, the holes in which the individuals lived.**

In life the rhabdosome was round and hollow, and each individual was probably connected to another by fleshy material. The rhabdosomes are flattened in most rocks because they were crushed by the weight of the sediment that settled over them after burial. Graptolite rhabdosomes have many shapes and, as suggested in the reconstruction of the colony shown below, may have been joined into a "super" colony that floated on the surface of the sea.

Because graptolites changed (evolved) quite rapidly, the various fossil genera serve as good index fossils, identifying the age and sequence of many sedimentary formations. The Ordovician age shales of central and



A hypothetical reconstruction of a large graptolite colony, which may have floated on the seas much as do living jellyfish.

southeastern Pennsylvania are the rocks in which graptolites are commonly found.

Phylum Chordata

The members of the phylum Chordata are characterized in part by the presence of a *notochord.* The notochord is a cartilaginous rod that provides support to the body of a chordate; it acts as a "backbone." In vertebrate animals this notochord is modified into a bony vertebral column made up of several individual vertebrae.

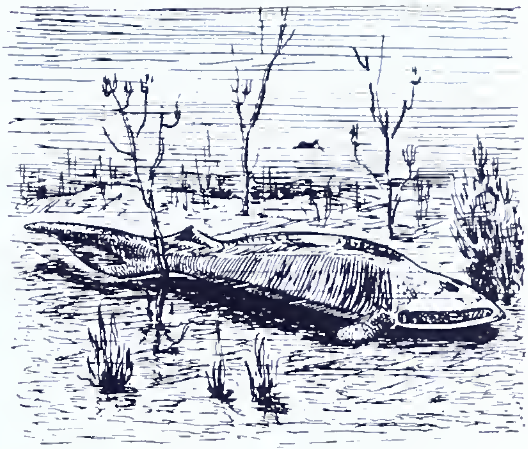
Many familiar animals belong to this phylum—man, whales, dogs, cats, elephants, birds, and fish. It is a large and varied phylum. Because so many of the chordate classes are land or air dwellers, they rarely occur as fossils. Fish are the only chordate fossil that occurs commonly in Pennsylvania.

Class Agnatha

Living agnathids are jawless animals that have a fishlike body and include the parasitic lamprey, the scourge of the Great Lakes. The class is also characterized by the lack of paired fins. The earliest known vertebrates belong to this class and are fishlike animals called ostracoderms (meaning "armored skin") because their upper surface was covered by bony plates. They, too, possessed no jaws.

No complete specimens of agnathids have been found in Pennsylvania, but Silurian age rocks in localities in Fulton County (see site 22) contain broken pieces of the dermal armor that covered this fish.

It is probable that they were freshwater or brackish-water fish that lived on stream and lake bottoms. Some may have lived along the seashores or along streams that emptied into the sea. The pieces of bony ar-



***Hemicyclaspis*— a Silurian-Devonian ostracoderm (x1/3). This primitive fish lived mainly on the food it obtained from sifting the bottom muds.**

mor are characterized by a surface pattern much like a fingerprint pattern, and appear as bluish-white fragments in rock.

Class Placoderma

This class of extinct fishes differs from the Agnatha because its members possess jaws and have definite fins. The placoderms were an armored type of fish similar to ostracoderms, and the fossil remains of this group usually consist of broken dermal plates. Complete specimens are very rare. A reconstruction of *Pterichthyodes*, a Devonian age placoderm, is shown on page 4.

The Late Devonian age rocks of central and northern Pennsylvania are known for the fragments of dermal armor of these fish. Good specimens occur at the Sullivan County site (48).

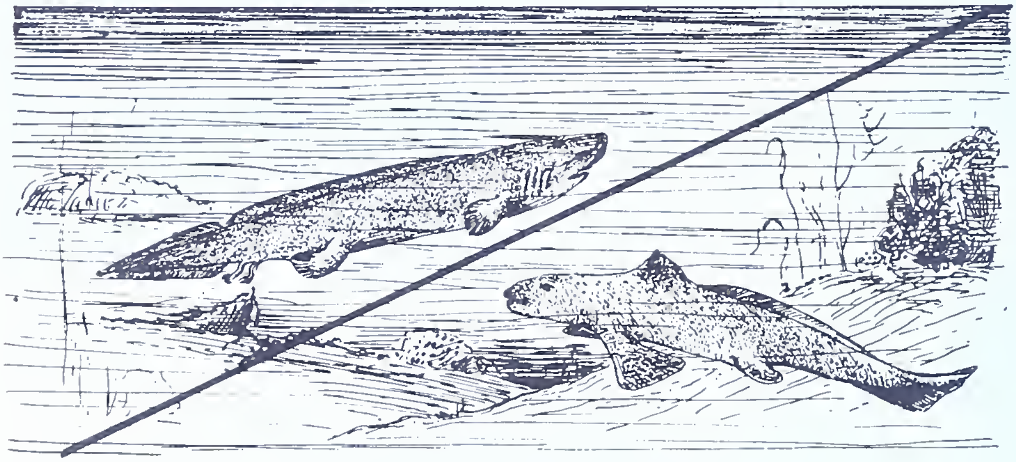
Class Chondricthyes

The living sharks, skates, and rays belong to this class of fish and are characterized by the absence of a bony skeleton. The skeleton of this class of animals is made up of cartilage. Because cartilage is not a resistant skeleton, few complete remains have been found of the fossil sharks and their allies. However, teeth of these fish are resistant and are found in abundance in some areas.

Fossil shark teeth from Pennsylvania are of three general kinds. One kind is from the type of shark (the bradyodonts) that inhabited marine waters and lived on a diet of mollusks. The teeth have a flattened surface, which produced a crushing rather than a biting action. These have been called "pavement" teeth.

The second kind of tooth, composed of two slender prongs, is from a group of sharks called pleurocanths, which are unusual because they lived in fresh water rather than marine.

The third type of tooth has a tall central cusp on a broad base, on which are one or more pairs of smaller cusps or tubercles. These teeth are characteristic of the cladoselachians, and are referred to the form genus *Cladodus*.



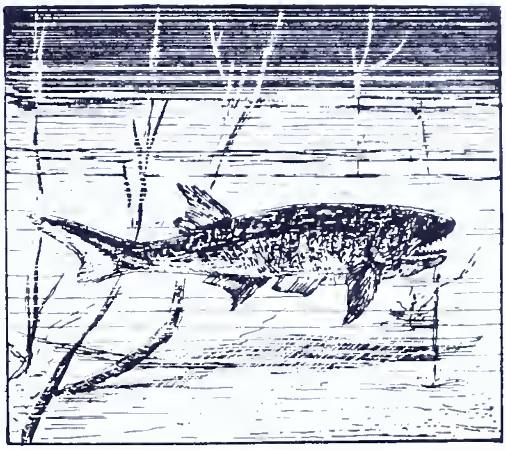
Primitive Late Paleozoic sharks. On the left, *Pleurocanthus*, a freshwater pleuro-canth about 2-1/2 feet long; on the right, *Helodus*, a marine brayodont about 14 inches long.

The three types of shark teeth have been found in marine and freshwater limestones of Pennsylvanian and Permian age in western Pennsylvania.

Class Osteichthyes

This class of vertebrates includes those fish with which we are most familiar, such as trout, perch, and salmon. All of these have bony skeletons. Older members of this class, a group called the paleoniscoids, had well-developed bony scales and teeth. These fish, which were about the size of our herring and minnows, lived in fresh water. Paleoniscoid teeth and scales have been found in some of the Permian age freshwater limestones of western Pennsylvania.

Another ancient group, the Crossopterygians, includes fish that have many bony scales. Some of these fish were very large and lived in fresh waters. The only known living genus of this group of fish is one that now lives in the deep oceans and is related to another rare group, the lungfish. Crossopterygian scales are found in many of our rocks of Late Devonian age, as are the aestivation tubes of the relatives of Crossopterygians, the primitive lungfish. The aestivation tube, essentially a vertical tube, was used by lungfish to hide in (or aestivate) when the lakes or streams in which they lived dried up.



***Cheirolepis*, a primitive bony fish from the Permian Period (x1/4).**

Class Reptilia

The reptiles include many living groups, and also extinct groups such as the dinosaurs and phytosaurs. Fossil specimens of the reptiles are extremely rare in Pennsylvania because these animals lived almost exclusively on land, or in swamps or streams. It was only on very rare occasions that a reptile died and was buried before its bones decayed. The dinosaurs, however, did at times leave their footprints in the sand and mud that bordered the streams from which they drank. Fossil footprints

A Triassic dinosaur, *Anchisaurus*. This animal was probably about 6 to 7 feet in height.

of this type have been discovered in the Triassic age rocks exposed in Adams, York, and Lehigh Counties. From these tracks and additional data, it is possible to reconstruct the dinosaur that roamed over Pennsylvania. This dinosaur was small and was an ancestor of some of the larger plant-eating dinosaurs discovered in other parts of the United States. Although the dinosaur is shown in the accompanying figure as a plant eater, this animal was also probably carnivorous. Rare specimens of the phytosaur, an ancestor of crocodiles, have been found in York County.

KINGDOM PLANTAE

The plant kingdom may be divided into four main divisions (the term phylum is not used with plants): Algae, Fungi, Bryophyta (mosses), and Tracheophyta (vascular plants). The first three of these divisions are relatively unimportant as fossils because they are seldom preserved. Some groups of the algae build a calcareous mat on the sea bottom, and fossil forms of these algae contributed to the formation of Early Paleozoic age limestones.

The tracheophytes include the many types of fossil and living organisms that we most commonly call plants and trees. Of this division, many plant fossils of the Pennsylvanian coal-forming swamps belong to one of the following groups: Lycopsida (fossil scale and seal trees, living club mosses), Sphenopsida (living and fossil horsetail rushes), Pteropsida (living or fossil ferns), and Gymnospermae (seed plants).

Plants, because they are generally land dwellers, are not a common fossil throughout geologic time. For plants to become fossils, special situations that cause them to be buried rapidly must exist; otherwise, the plants decay and merely enrich the soil.

Pennsylvania is fortunate in having large amounts of fossil plants preserved in the coal-bearing rocks. These rocks were formed during a period of time when the unusual requirements for plant preservation were present. This was the period called the Pennsylvanian, so named because of the important coal beds found in our Commonwealth. During the Pennsylvanian Period, large areas of the Commonwealth were covered with large and small swamps in which grew many types of trees, tree-like plants, ferns, and fernlike plants. As the plants died, they collected below the water surface, where decay was slowed sufficiently that they could be covered by sediment before they were destroyed. Most became part of the mat of material that eventually developed into coal.

As with animals, plants break apart after death and become scattered. The leaves, fruit, branches, trunks, or stems and roots of a plant may be completely separated from each other and, when they are buried and preserved, it may be nearly impossible to determine which pieces fit together. This is in large part due to the great size of some fossil plants and the fact that fossils that are recoverable are usually ones that are hand sized rather than tree sized, so that finding a complete plant or tree is extremely rare.

Scientists who study fossil plants (the paleobotanists) apply generic and specific names to many of these separated parts of plants in order to be able to discuss them, realizing that they apply more than one name to the same "real" genus and species. These are called "form" genera so as to separate them from real genera. As work progresses in paleobotany, plants are pieced together, but the old names are retained for the sake of convenience. Thus the leaves, stems, and fruit of the same actual genus and species may bear different names.

Lycopsida

Living lycopsids are the club mosses and ground pines that are used for decoration at Christmas time. They are a low, creeping, many-branched evergreen plant that produces spores.

Fossil lycopsids were tree-like in form and thus do not look like living members of the group. The two most famous lycopsids are the scale and seal trees—*Lepidodendron* and *Sigillaria*. Portions of their trunks are commonly found associated with the coal deposits. The leaves that covered the trunk left small scars after they fell off, making the trunk appear scaly. In *Lepidodendron* the scars are arranged spirally; on *Sigillaria* the scars are in vertical rows and are more elaborate, having the appearance of a fancy seal or stamp.

Sphenopsida

The living horsetail rushes, so called from the similarity of their leaves to a horsetail, are the sole survivors of this class. They are sometimes called scouring rushes because they were used for polishing wood and metal in years past. They have a single, branching, hollow stem divided into sections by prominent joints. Living horsetails belong to the genus *Equisetum*, are small in size, and produce spores instead of seeds.

Fossil rushes belong to the genus *Calamites*, which grew to heights of over 40 feet. These tree-like plants were hollow stemmed and had conspicuous joints. Leaf whorls, called *Annularia*, grew from the joints.

A small rush that grew beside the giant *Calamites* in the Pennsylvanian swamps, and belonged to the same class, is *Sphenophyllum*. This name is applied to both the stem and leaf whorls. *Sphenophyllum* is characterized by having triangular or wedge-shaped leaves on the leaf whorl.

A hypothetical reconstruction of a coal-forming swamp of the Pennsylvanian Period.

a. *Lepidodendron*, the "scale tree."
b. *Sigillaria*, the "seal tree."
c. *Calamites*, a rush.
d. *Psaronius*, a true fern.
e. *Medullosa*, a seed fern.
f. *Cordaites*, an ancestor of the conifers.

Pteropsida

This is the group that contains the true ferns. Living ferns range from the small ferns of northern forests to giant ferns of the tropics. True ferns produce spores, which are found in clusters on the underside or margins of the leaves.

Fossil ferns of the Pennsylvanian Period forests and swamps were of many sizes, ranging up to tree-like ferns over 30 feet in height. The various parts of the fern plant were usually separated after death. Most often found are the fern leaflets, of which there are several form genera, such as *Pecopteris*.

Gymnospermae

Seed ferns belong to the Pteridospermopsida, one of several gymnosperm (meaning seed-bearing) groups. Seed ferns are a group of extinct plants that were very prominent during the Pennsylvanian (more so than tree ferns) and were characterized by their habit of producing seeds rather than spores. They had fernlike leaves and were fernlike in their growth, producing large trees, climbing vines, and other forms. The seed ferns were more complicated plants than true ferns.

Another group of gymnosperms (Cordaitales), together with the seed ferns, made up the majority of seed plants in the Pennsylvanian Period. The cordaitean trees grew to over 100 feet tall and were important contributors to the making of coal. The tree top bore masses of large, spirally arranged, straplike leaves that grew up to 3 feet in length and 2 to 3 inches in width. Cordaitean leaves are a fairly common fossil.

A few other fossil gymnosperms, belonging to the cycad, ginkgo, and conifer groups, have been found in Triassic rocks in some areas of Pennsylvania, but they are, in general, rare fossils.

TRACE FOSSILS

Trace fossils, also called ichnofossils (from the Greek word ichno, meaning footprint or track), are the fossilized tracks, trails, burrows, or borings made by an animal in the sediment or rock in which it lived. Ancient plants also produced trace fossils, notably the molds of roots in the soil in which the plants grew.

Trace fossils differ from the body fossils usually collected because, although they may give some indication of the external shape of the animal's body, they really are fossils that reveal something of the animal's behavior; for example, whether it was a walker or burrower.

In sedimentary rocks that have no preserved body fossils, trace fossils may be the only remaining evidence of the former existence of life. Trace fossils in such otherwise "barren" rocks may have been formed by the activities of either hard-shelled organisms (clams, trilobites, etc.) whose shells were destroyed after the animals died, or soft-bodied wormlike organisms that had no hard parts. Ichnofossils are one of the most reliable clues to environmental conditions at the time the sediment was deposited, because they were formed in-place and not transported by currents, as were many body fossils.

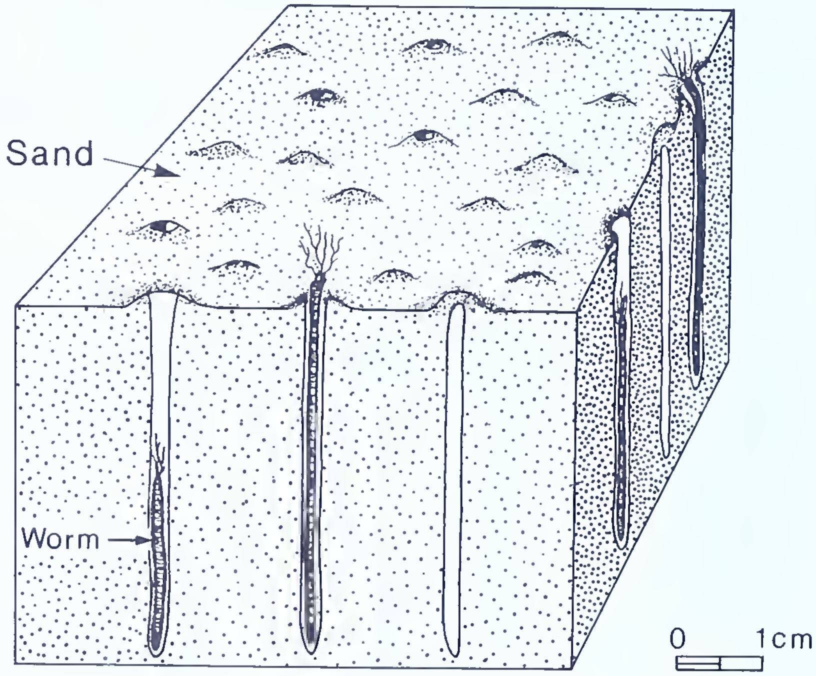
The interpretation of trace fossils is difficult for the following reasons: (1) Nearly identical tracks or burrows may be made by more than one type of animal. (2) The same animal can make different traces, depending on the activity in which it is engaged (for example, walking, feeding, resting, etc.). (3) An animal will make different marks if it moves about on a muddy bottom than if it moves about on a sandy bottom. Trace fossils are also difficult to collect, since they are part of the rock.

Trace fossils are abundant in the rocks of Pennsylvania, particularly in those rocks made up of mud, silt, and sand, which are called clastic rocks.

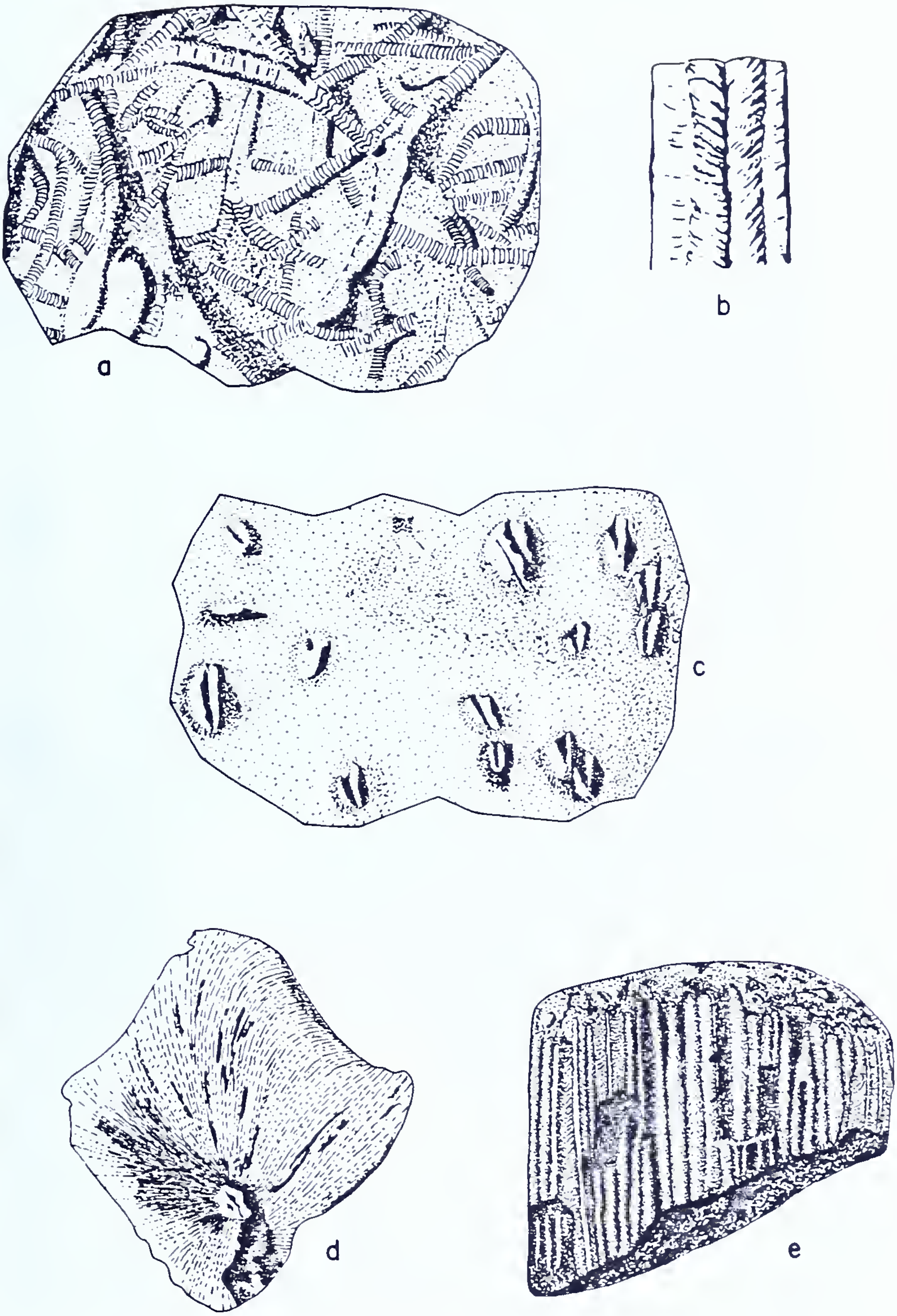
Common trace fossils that occur in Pennsylvania are *Skolithos*, a vertical dwelling tube common in some sandstones, *Arthrophycus*, a lateral and crossing feeding burrow, and *Zoophycos*, a spiral feeding trail.

Rarer trace fossils are the tracks of dinosaurs, and the resting and crawling traces of trilobites, called *Rusophycus* and *Cruziana*, respectively.

Other trace fossils found at sites listed in this book are shown on Plate 19.

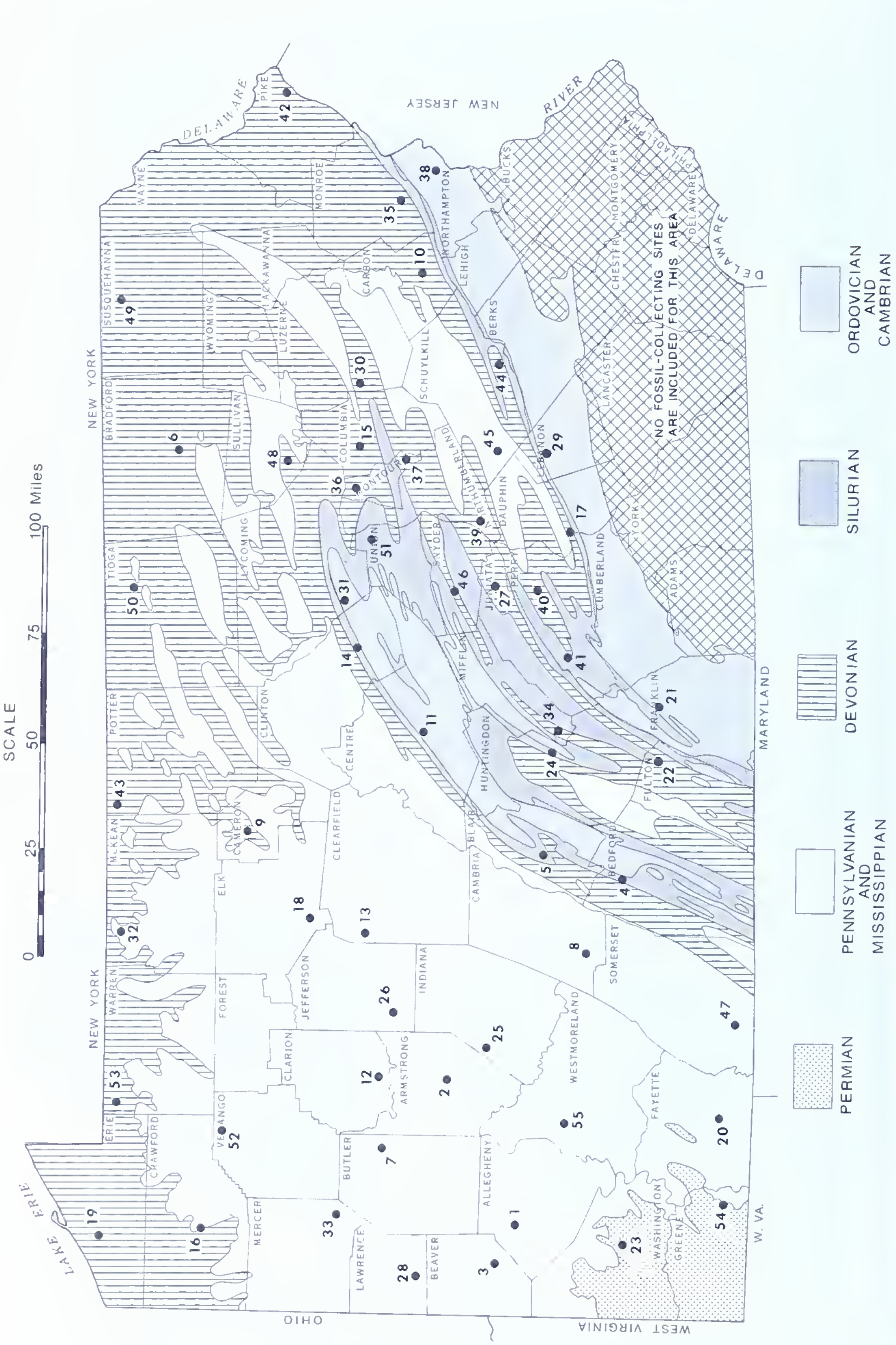


The trace fossil *Skolithos*, interpreted as a worm burrow.



Trace fossils.

a. ***Arthrophycus*** **(x0.3)**
b. ***Cruziana*** **(x0.3)**
c. ***Rusophycus*** **(x0.5)**
d. ***Zoophycos*** **(x0.3)**
e. ***Skolithos*** **(x0.5)**



Generalized geologic map of Pennsylvania showing locations of fossil-collecting sites.

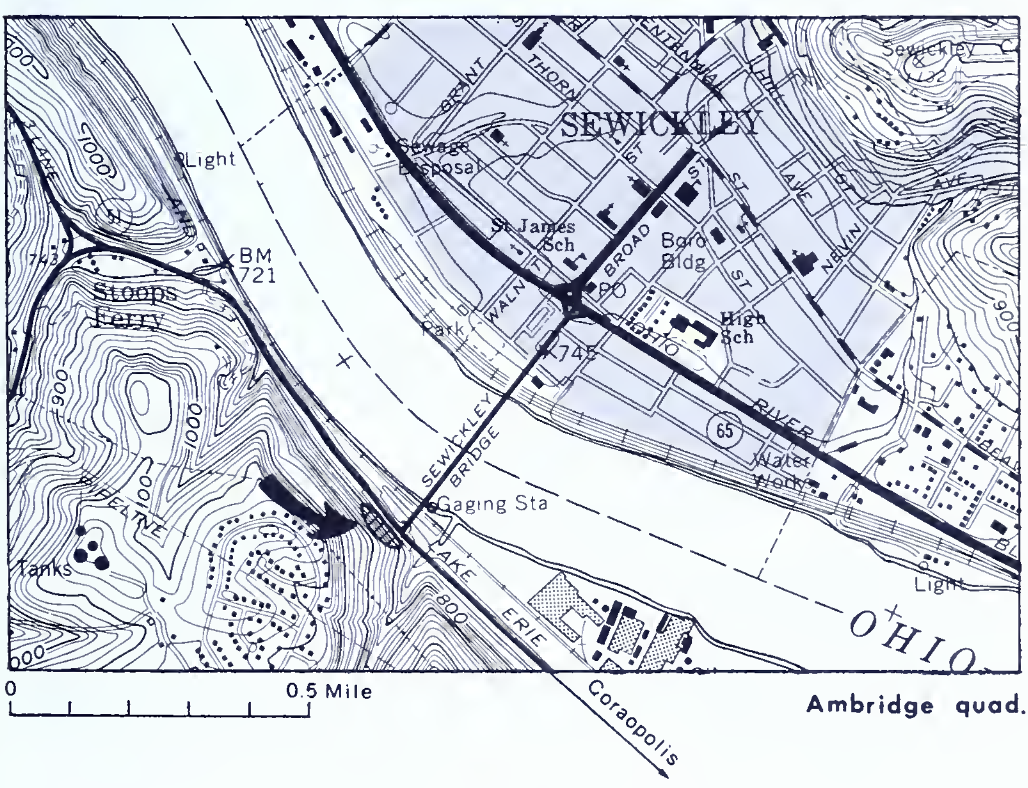
COLLECTING LOCALITIES

by
Jon D. Inners
Donald M. Hoskins
John A. Harper

ALLEGHENY COUNTY

SITE 1—BRUSH CREEK MARINE ZONE AT SEWICKLEY BRIDGE

LOCATION. A very fossiliferous locality in the Brush Creek marine zone is exposed in a roadcut on the south side of the Ohio River in Allegheny County, near the Beaver County line. The exposure is along Pa. Route 51, about 1 mile west of Coraopolis and just across the Ohio River from Sewickley. The best part of the roadcut for collecting fossils is a 200-foot section, the center of which is across the highway from the south end of the Sewickley Bridge. The Brush Creek limestone crops out about 10 feet above ground level at this point and can be reached easily by climbing



the debris slope at the foot of the exposure. Many blocks and slabs of the limestone and associated black shales have fallen or slid to the highway berm, where they are readily accessible for collecting. Parking is available on the same side of the highway about 100 feet southeast of the bridge, at the end of the guardrail. If you reach the locality by driving north on Pa. Route 51 (away from Coraopolis), continue on until you can find a safe place to turn around and come back to the recommended parking area.

WARNING: ROUTE 51 IS A HEAVILY TRAVELED, HIGH-SPEED ROAD DESPITE THE TRAFFIC SIGNAL AT THE BRIDGE. ALTHOUGH THE FOSSIL-COLLECTING AREA ITSELF IS PROTECTED BY A METAL GUARDRAIL, CAUTION SHOULD BE TAKEN BEFORE APPROACHING THE ROAD ON FOOT.

FOSSILS. Fossils of many varieties can be found here in the Brush Creek marine zone. The limestone has a large assortment of crinoid debris as well as brachiopods, bryozoans, and other fossils that lived in open water. However, the hardness of the limestone can be frustrating to even the most ardent collector. It is recommended that collecting be focused primarily on the black shale underlying and overlying the limestone, especially within a foot on either side of it. Here numerous, typically well preserved fossils, many having original shell material preserved, can be easily extracted from the soft, flaky shale. The more common forms are listed below and illustrated on Plates 13 to 17 and 21.

CORAL
- *Stereostylus*

BRYOZOAN
- *Rhombopora*

BRACHIOPODS
- *Chonetinella*
- *Juresania*
- *Composita*
- *Crurythyris*
- *Neospirifer*
- *Punctospirifer*

GASTROPODS
- *Euphemites*
- *Bellerophon*
- *Pharkidonotus*
- *Cymatospira*

GASTROPODS (cont.)
- *Amphiscapha*
- *Trepospira*
- *Glabrocingulum*
- *Worthenia*
- *Shansiella*
- *Phymatopleura*
- *Meekospira*
- *Strobeus*

PELECYPODS
- *Nuculopsis*
- *Phestia*
- *Dunbarella*
- *Aviculopecten*
- *Astartella*

CEPHALOPODS
- *Brachycycloceras*
- *Pseudorthoceras*
- *Metacoceras*
- *Domatoceras*

SCAPHOPOD
- *Plagioglypta*

TRILOBITE
- *Ditomopyge*

CRINOIDS
- Columnals, plates, ambulacra

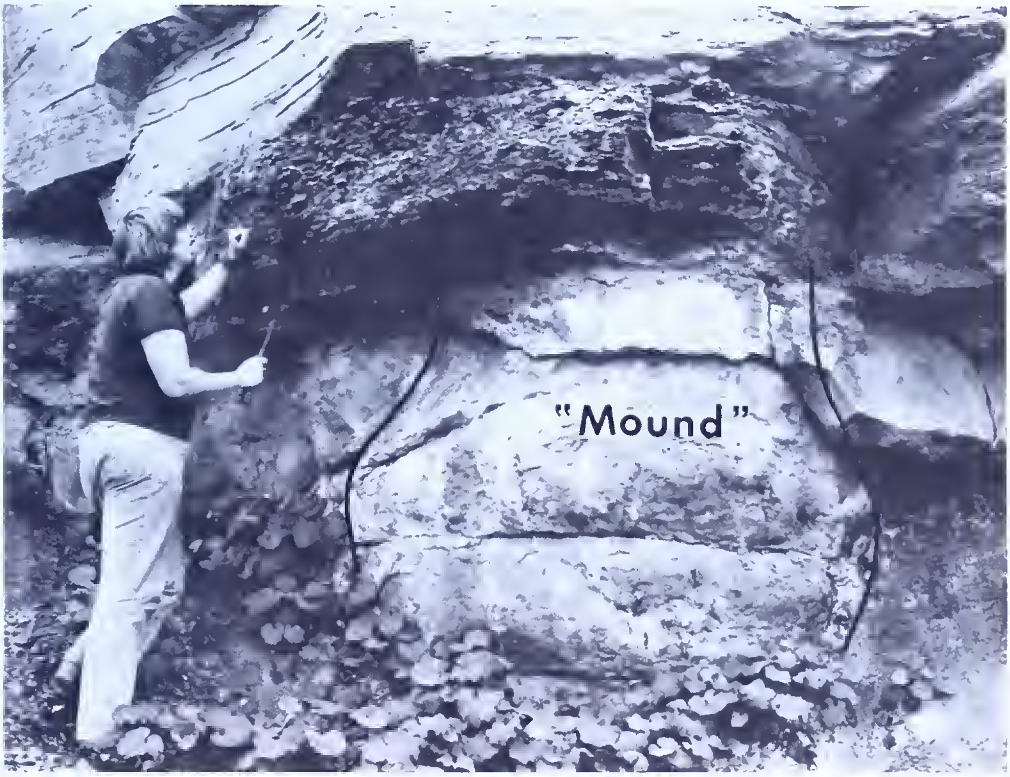
CHORDATE (Chondricthyes)
- *Petalodus*

TRACE FOSSIL
- *Zoophycos*

GEOLOGY. This locality affords an unusual look at an almost complete section of the Glenshaw Formation, a series of sandstones, shales, and marine limestones in the lower half of the Pennsylvanian age Conemaugh

Group. The Brush Creek limestone and associated black shales are the rocks formed from sediments deposited during the earliest of several marine incursions into the predominantly coastal and deltaic systems that prevailed in the Pittsburgh area about 305 million years ago. Also exposed at this roadcut are the Pine Creek limestone, here a very thin, muddy rock containing sparse fossils, about 90 feet above the Brush Creek, and the Ames limestone, which occurs near the top of the roadcut. The Ames can be seen only in float blocks that have slid downslope from their original outcrop position. The numerous thick sandstones and shales exposed at this locality represent river and delta deposits. Many of them exhibit crossbedding, truncation, and other features common to this type of depositional system.

An interesting feature of this locality is a limestone "mound" in the Brush Creek limestone immediately across from the foot of the bridge. This "mound" appears to be at least 8 feet in height and is composed of limestone of the same variety as the main layer. Studies of similar "mounds" at other localities in Pennsylvania and Ohio indicate that they were formed by the activity of multitudes of burrowing animals, possibly shrimplike or crablike crustaceans whose hard parts are not preserved.



Mound in the Brush Creek limestone at the Sewickley Bridge locality.

ARMSTRONG COUNTY

SITE 2—CADET RESTAURANT LOCALITY

LOCATION. The very fossiliferous Brush Creek limestone and associated shale are well exposed in a cliff behind the Cadet Restaurant in Manor Township east of Kittanning. The locality is on the north side of U.S. Route 422, 0.6 mile east of the intersection of Route 422 and Pa. Routes 28 and 66 northbound. The restaurant is of the drive-in variety popular in the 1950's and 1960's and has a large, hard-to-miss sign. The fossiliferous rocks were exposed when the hillside was excavated for the restaurant. The Brush Creek limestone is buff colored and is about 10 inches thick here. It is accompanied by 2 feet of black shale above and 10 feet of black shale below.

Some blocks of the more fossiliferous shale and limestone have weathered from the cliff face and fallen to the ground, where they can be easily broken up. Parking is available in the parking lot of the restaurant.

Kittanning quad. | Mosgrove quad.

0 — 0.5 Mile

FOSSILS. As with most of the Brush Creek localities in southwestern Pennsylvania, the limestone and shale are rich in well-preserved fossils. The black shales, especially those nearest to the limestone, contain the most diverse and potentially collectible faunas. The persevering collector will undoubtedly find many more fossil genera than those few listed below. Illustrations of these fossils are shown on Plates 13 to 16.

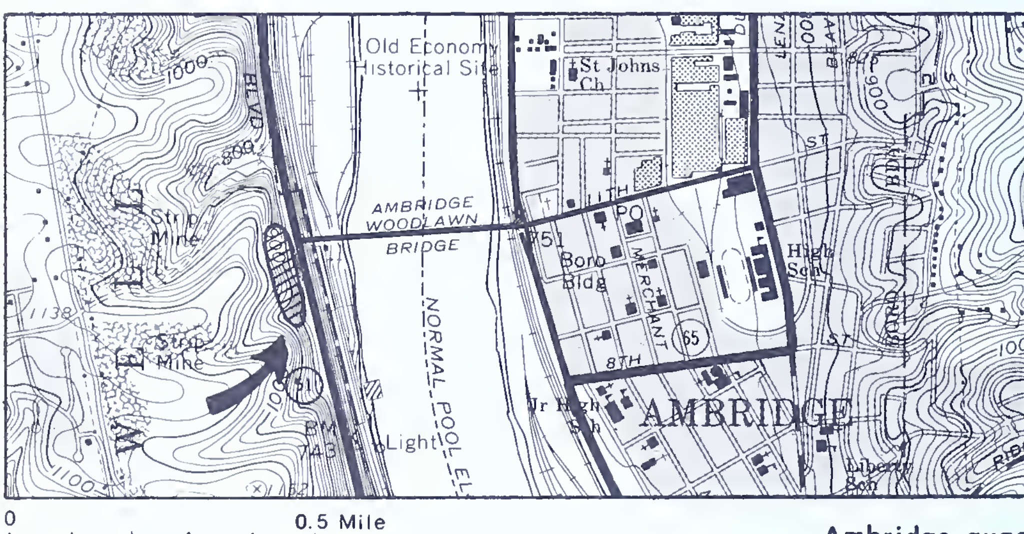
CORAL
Stereostylus
BRACHIOPODS
Chonetinella
Composita
GASTROPODS
Worthenia
Meekospira
PELECYPODS
Nuculopsis
Phestia
CEPHALOPODS
Pseudorthoceras
Metacoceras
Liroceras
Eoasianites

GEOLOGY. The Pennsylvanian age Brush Creek limestone and associated shales represent the oldest of four marine invasions of the coastal and deltaic depositional systems that otherwise produced the nonmarine rocks of the Conemaugh Group. The shales and limestone at this site tell a tale of sea-level rise and fall in western Pennsylvania about 305 million years ago. The lower black shale, about 10 feet thick, was deposited during a rapid rise in sea level. During this time most of the sediment came from the land in the form of clay and silt, which was mixed with organic material and broken and dissolved shells to form a black, organic-rich, calcareous shale. At the time of greatest sea-level rise the Brush Creek limestone was deposited from the calcareous shells of animals living in the open sea. There was very little influx of sediment from the land at this time. Sea level fell relatively slowly after limestone deposition, but only 2 feet of black shales similar to those below the limestone was deposited. The rocks above the black shales are mostly siltstones and shales of nonmarine origin. This whole episode of sea-level rise and fall is estimated to have occurred in the space of 10,000 to 50,000 years.

BEAVER COUNTY

SITE 3—AMBRIDGE PLANT-, INVERTEBRATE-, AND TRACE-FOSSIL LOCALITY

LOCATION. A two-for-one fossil-collecting locality occurs on the west side of the Ohio River in Beaver County south of the borough of Aliquippa. This is a unique site, not because it has two localities in the same area, but because it has two very different rock units that yield their own distinctly different sets of fossils. Both plant and animal fossils, as well as trace fossils, can be collected here. The locality is on the hillside above Pa. Route 51 at the west end of the Ambridge-Woodlawn Bridge, which connects the highway with Ambridge across the river. The best area for collecting is at the south end of the ramp to and from the bridge. Parking is readily available on the wide berm of the highway at this point. It is best to park on the west side of the southbound lane to avoid crossing four lanes of traffic. Northbound travelers can turn around in Aliquippa about 2 miles north of the site.



Ambridge quad.

The best collecting is on the first bench above the highway, a relatively easy climb up the hillside. The rocks on this bench are an assortment of shale, siltstone, and sandstone. Plant fossils are abundant in the easily parted shales, and trace fossils are common in the siltstones and sandstones. Although it is scattered and in small pieces, fossiliferous black shale from the second bench can often be found on the first bench as well. Scaling the hillside to the second bench is decidedly more difficult and more dangerous, but the industrious collector will find a way up. On this bench can be found the fossiliferous black shale in abundance, both as loose material and in actual outcrop. This shale is full of invertebrate and some vertebrate fossils.

CAUTION: PA. ROUTE 51 IS A HEAVILY TRAVELED HIGHWAY. AVOID CROSSING IT AT ALL TIMES. Fossil collectors interested in scaling the cliff to the second bench should be prepared for a minor mountain-climbing experience. The hillside is almost vertical and the ascent is difficult at best.

FOSSILS. The fossils at this locality are of three types—plant fossils, trace fossils, and animal-body fossils. The first two types are abundant in the Mahoning Member of the Conemaugh Group on the first bench. There is not a large variety of plant fossils here, and the trace fossils are almost entirely burrows. But the lack of fossil diversity is clearly offset by the abundance of excellent and readily collectible specimens. The Brush Creek black shales on the second bench typically contain a rather diverse fauna, dominated at this locality by the brachiopod *Chonetinella*. Other forms are listed below. See Plates 14 to 17 and 19 to 21 for illustrations of these fossils.

Mahoning fossils:

PLANTS
- *Lepidophylloides*
- *Pecopteris*
- *Neuropteris*

TRACE FOSSILS
- Burrows
- Feeding traces

Brush Creek fossils:

CORAL
- *Stereostylus*

BRACHIOPOD
- *Chonetinella*

GASTROPODS
- *Cymatospira*
- *Trepospira*
- *Glabrocingulum*

PELECYPOD
- *Pernopecten*

CEPHALOPODS
- *Pseudorthoceras*
- *Domatoceras*

CHORDATE (Chondricthyes)
- *Cladodus*

TRACE FOSSIL
- *Conostichus*

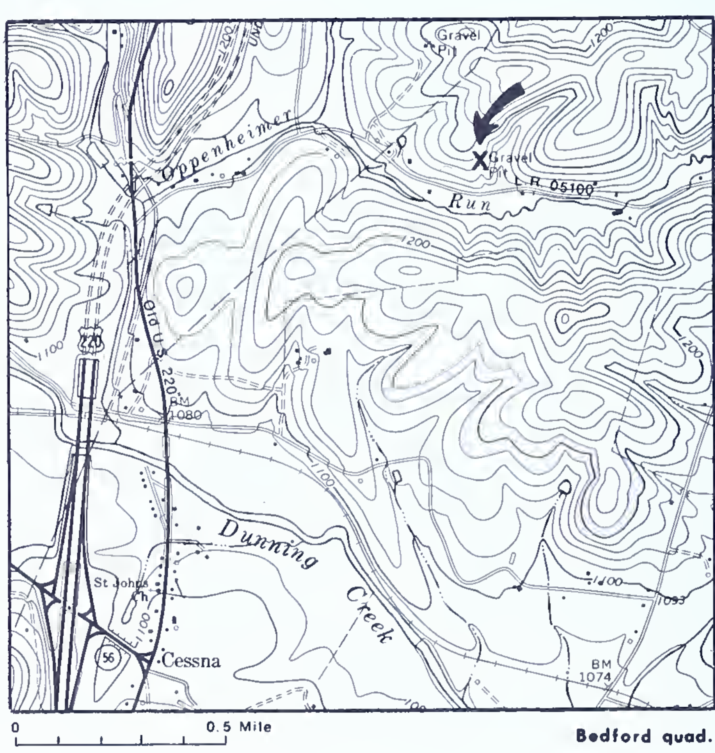
GEOLOGY. The rocks cropping out at this locality include some of the oldest rocks of the Pennsylvanian age Conemaugh Group. The Mahoning Member, partially exposed on the first bench, is typically a sandstone but varies laterally and vertically to siltstones and shales. These rocks were part of the coastal and deltaic systems that dominated deposition in the Pittsburgh region about 300 million years ago. Delta river channels and bars (sandstones) are interspersed both geographically and temporally with levees, swamps, and marshes (siltstones and shales). Careful observation of the rocks cropping out on the hillside will reveal many different types of sedimentary features associated with these depositional patterns, including crossbedding, ripple marks, and channel scour. As sea level began to rise, the marine influence combined with deltaic deposition of clays and silts to form suitable shallow-marine conditions in which a variety of shelled animals could live. The Brush Creek shales represent this change from deltaic to marine conditions.

BEDFORD COUNTY

SITE 4—BRACHIOPODS IN IRON ORE

LOCATION. During the 1800's a great deal of iron ore was "strip mined" from the Early Silurian age Rose Hill Formation in Bedford County. The most important ore was called the "fossil-ore" due to the abundant fossils associated with it. Most of the mines were shallow pits that are now overgrown. Because the pits were opened along the surface outcrop of the folded beds of iron ore, they follow the northeast-southwest trend of the mountain ridges and intervening valleys and are generally inaccessible without hiking across private property.

One locality that is accessible from a road is 4.2 miles directly north of interchange 11 on the Pennsylvania Turnpike at Bedford. To reach the locality, travel north on U.S. Route 220 to the community of Cessna, 3.2 miles north of the turnpike. Follow "old U.S. 220" 1.1 miles north to the second paved road (L.R. 05100). This road, which goes east and then south to Imlertown, follows along the south side of Oppenheimer Run. Continue for one-half mile. On the left (north) side of the road is a pit (indicated on the index map as a "gravel pit") where you may collect fossils from the "fossil ore." The pit is on the property of Mr. F. L. Hoagland, who lives about 0.3 mile east along the road. Please check with the property owner to obtain permission to collect at this site.



FOSSILS. Early Silurian age fossils, mostly brachiopods, can be collected in fairly large quantities at this site. Many of the specimens are weathered free from the enclosing rock and can be picked up loose from the rock surfaces exposed in the pit. Fossils weathered free from the rock can also be collected from the low cut bank extending up the hill and exposing shales overlying the "ore"-bearing rock. Abundant fossils can also be found in the spoil piles, notably at the top of the hill, where there are many large, loose chunks of fossiliferous rock. Illustrations of the fossils listed below may be found on Plates 3 and 6.

BRYOZOAN
Orthopora
BRACHIOPODS
Leptaena
Leptostrophea
Stegerhynchus
Isorthis
CONOIDAL SHELL
Cornulites
CRINOIDS
Columnals

GEOLOGY. The early part of the Silurian Period was a time noted for the deposition of iron ore throughout the Appalachian region. Important ores mined in the 1900's occur in rocks of this age near Birmingham, Alabama, resulting in a large industry in that area. In most areas of the Appalachians, however, the ores were thin layers and could only be economically mined by stripping the weathered surface rock from which much of the calcium carbonate (limestone) had been naturally removed by solution. Where the rock was unweathered, the iron content of the "ore" was too low and the rock too difficult to extract economically. Thus, the "strip" mines were always shallow surface operations.

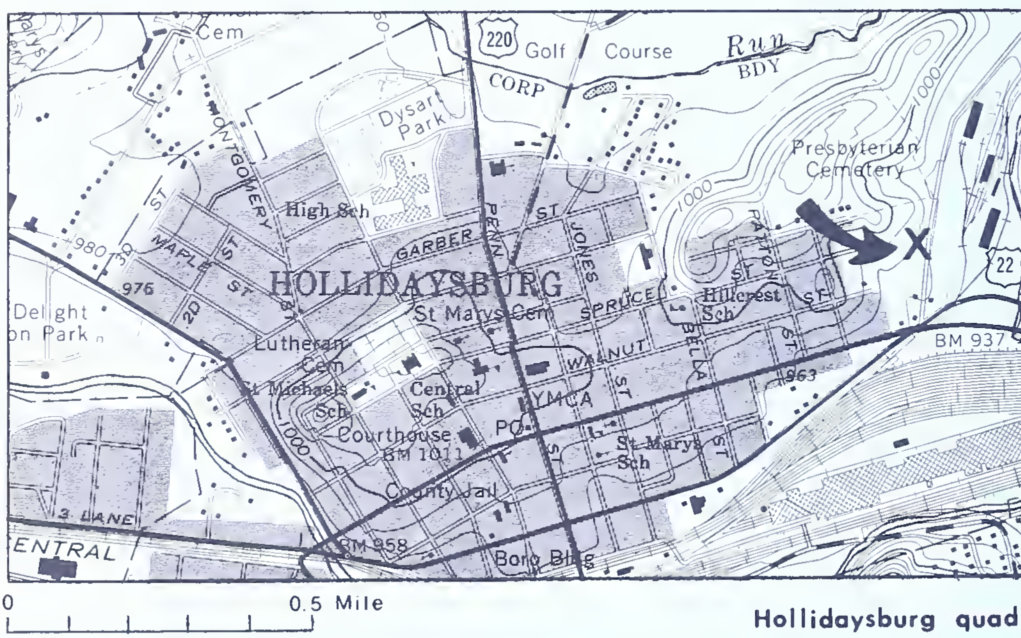
The ores of the Rose Hill Formation were formed in two ways. One was by direct precipitation of iron oxide (hematite) in the form of oolites, small flattened structures about the size of flaxseed. The limestones in which the fossils are found contain oolites in profusion, and they may be seen easily with a 10-power lens. The oolites were deposited on the sea bottom at the same time that the fossils were living. Replacement is the second method by which ore formed. The fossil shells were swept about and broken after the death of the animals, and some of the shells were replaced by hematite in solution in the sea water so that they may, in part or in whole, consist of hematite rather than calcium carbonate.

Some rock specimens containing fossils also contain the mineral hematite in a crystalline form. These crystals appear as black, shiny, metallic-looking specks scattered in the rock. This form of the mineral was created at a later time in the history of these rocks, after the rocks were buried and consolidated and subjected to heat and pressure. Some of the hematite in the oolites was dissolved and then reprecipitated in the crystalline mineral form.

BLAIR COUNTY

SITE 5—HOLLIDAYSBURG SILURIAN LOCALITY

LOCATION. Very well preserved Silurian age fossils can be collected in abundance near Hollidaysburg in central Blair County. The fossil site is a large borrow-pit area from which the soil has been stripped, on the west side of the secondary road that passes the Presbyterian Cemetery near the east end of Hollidaysburg Borough, 0.1 mile due north of U.S. Route 22 and 0.6 mile east-northeast of the intersection of U.S. Routes 22 and 220. Plenty of parking space is available just off the road in the stripped area. A 10-power hand lens is very useful at this site.



Hollidaysburg quad.

FOSSILS. The Hollidaysburg locality is noted for its myriad of small, well-preserved brachiopods. In addition, uncountable thousands of microscopic ostracodes entirely make up some layers of rock. Fossils can be collected either as small specimens completely free of matrix or as beautifully etched out concentrations of shells on thin slabs of limestone. See Plates 3, 4, and 6 for illustrations of the fossils listed below.

CORALS
- *Favosites*
- *Coenites*

BRYOZOAN
- *Rhombotrypa*

BRACHIOPODS
- *Isorthis*
- *Stegerhynchus*

BRACHIOPODS (cont.)
- *Uncinulus*
- *Whitfieldella*

GASTROPOD
- *Hormotoma*

PELECYPOD
- *Leiopteria*

CEPHALOPOD
- *Michelinoceras*

CRICOCONARID
- *Tentaculites*

OSTRACODES
- *Velibeyrichia*
- *Kloedenia*

GEOLOGY. The rock strata exposed in the stripped area are approximately 415 million years old and belong to the upper part of the Mifflintown Formation, of Early to Late Silurian age. They show an irregular alternation of extremely fossiliferous, crystalline limestone (thin beds) and nonfossiliferous shaly limestone and shale (thicker beds). The fossiliferous limestone beds make up only a small percentage of the total rock exposed. Each of the fossiliferous layers marks a time during the deposition of the limestone and shale when abundant marine life was able to flourish. The barren, or nonfossiliferous, beds formed when animals could not live where the sediments were being deposited. Reasons for such alternation from suitable to unsuitable habitats for marine organisms may have been changes in either the salinity of the sea water or the muddiness of the water.

The interbedded limestones and shales of the Mifflintown Formation at this site were probably deposited in a shallow nearshore embayment that was partially protected from strong waves and currents. During periods of reduced salinity (perhaps brought about by inflow of fresh water from coastal rivers), fine-grained clay and lime mud barren of fossils were deposited in the embayment. When salinity approached normal levels, marine larvae (mostly ostracodes and brachiopods) carried in from farther out to sea by tidal currents were able to take hold and proliferate. Periodically storm waves stirred up these more marine waters and concentrated the shells into thin layers. Red, oxidized claystone occurs above and below the limy shales and limestones and indicates that this area did indeed lie close to shore and adjacent to low-salinity lagoons and coastal flats.

In the lower part of the exposure are several layers of red "fossil ore," fossiliferous limestone layers that have been replaced by hematite. During the 1800's similar "fossil ore" beds in the older Rose Hill Formation were a major source of iron ore for the "Juniata Iron" industry of central Pennsylvania.

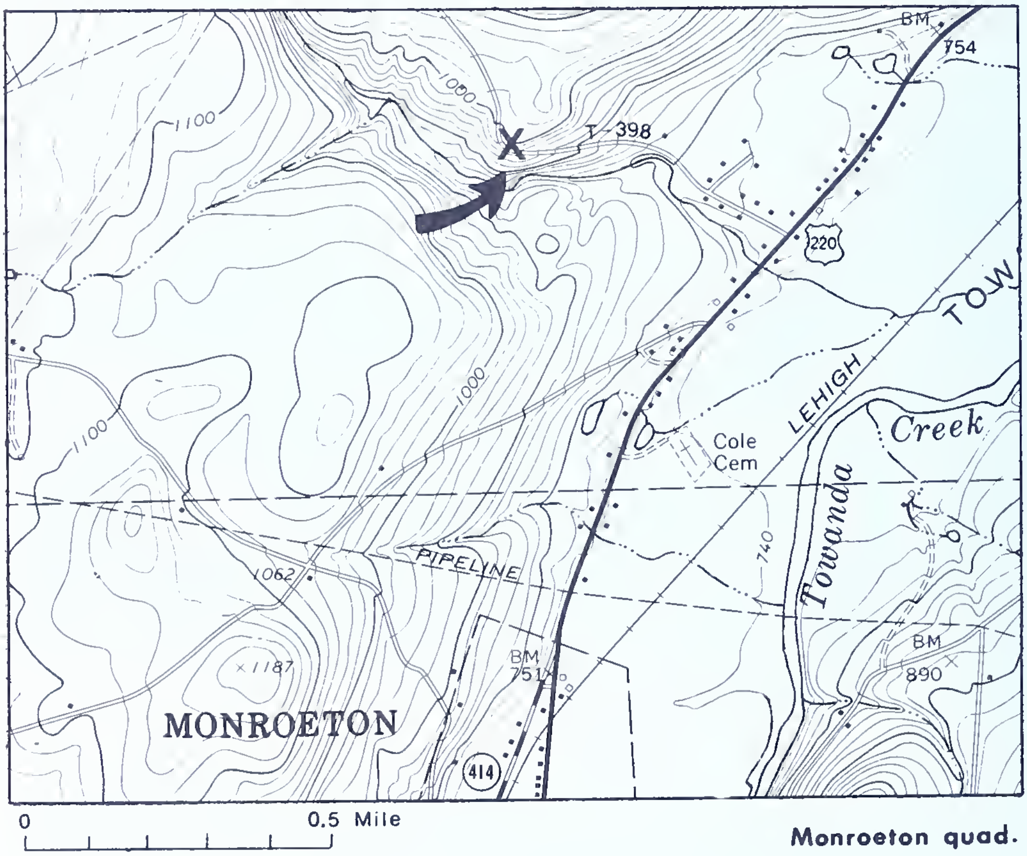
REFERENCE

Hoskins, D. M. (1961), *Stratigraphy and paleontology of the Bloomsburg Formation of Pennsylvania and adjacent states*, Pennsylvania Geological Survey, 4th ser., General Geology Report 36, 125 p.

BRADFORD COUNTY

SITE 6—LATE DEVONIAN AGE FOSSILS

LOCATION. Many fossiliferous exposures occur within Bradford County. The primary locality selected for this description is along Towanda Twp. Route 398, about 4,400 feet north of the Monroeton Borough line. To reach the locality, go 0.8 mile north from Monroeton on U.S. Route 220. Turn left on Route 398 and go 0.5 mile northwest to a small borrow pit on the inside bend of the paved road. This is a good locality because there is ample parking space and little traffic on the road.



Two other nearby localities may also be of interest. The first alternate locality is near the site shown on the map. To reach it, return to Monroeton and continue 4.3 miles west on Pa. Route 444 from the intersection of that route with U.S. Route 220 to the high roadcuts on both sides of the highway. Parking is extremely limited at this exposure and the traffic is heavy. The roadcut is narrow, and vehicles cannot be seen until they are nearly at the exposure. SHOULD YOU VISIT THIS SITE, USE EXTREME CAUTION. A second alternate site is near the borough of Burlington, 10 miles west of Towanda on U.S. Route 6. The site is 0.6 mile east of the intersection at the center of Burlington on the north side of the road. It is a small quarry operated sporadically by Louis Case of Burlington. Permission should be obtained to enter the quarry.

All three of these Bradford County localities occur in the Late Devonian age Lock Haven Formation.

FOSSILS. The characteristic fossils found at these localities are listed below and illustrated on Plates 6, 8, 9, 10, and 21.

BRACHIOPODS
- *Chonetes*
- *Spinulicosta*
- *Ptychomaletoechia*
- *Ambocoelia*
- *Tylothyris*
- *Cyrtospirifer*

GASTROPOD
- *Holopea*

PELECYPOD
- *Grammysia*

CRICOCONARID
- *Tentaculites*

CRINOIDS
- Columnals

TRACE FOSSIL
- *Planolites*

GEOLOGY. The fossil faunas at all of these sites are dominated by brachiopods. At the Burlington site, shells are so numerous that the rock there has been specially named "coquinite." The shelly beds formed as a result of tidal and nearshore currents sweeping the shells into channels and areas near to the shore, where, in some cases, they were mixed with plant material and fish-bone fragments that were being transported out to sea by fresher waters. All of this activity took place near the edges of submarine distributary streams carrying muds, silts, and sandstones from the large delta that was building westward in this part of Pennsylvania during the Late Devonian, approximately 380 million years ago.

For a detailed geologic description and interpretation of the alternate sites, consult the descriptions of Stops 1 and 3 of the guidebook for the 1982 Field Conference of Pennsylvania Geologists.

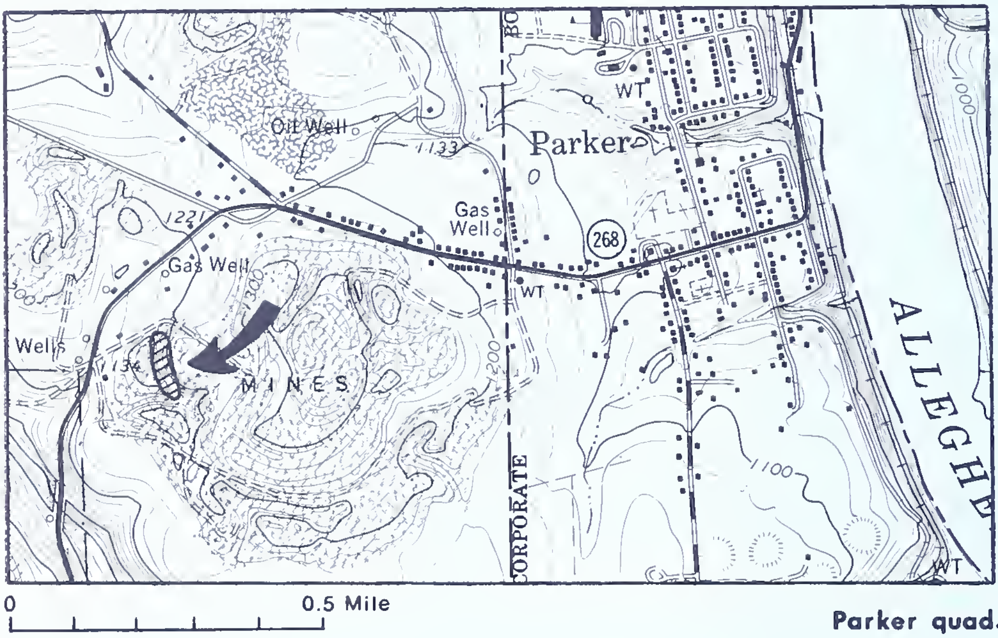
REFERENCE

Berg, T. M., Crowl, G. H., Edmunds, W. E., and others (1981), *Geology of Tioga and Bradford Counties, Pennsylvania*, Annual Field Conference of Pennsylvania Geologists, 46th, Wellsboro, Pa., 1981, Guidebook, p. 105–112 and 118–122.

BUTLER COUNTY

SITE 7—PARKER STRIP MINE (VANPORT LIMESTONE)

LOCATION. Many pre-1965 strip mines in the northeastern corner of Butler County contain exposures of the fossiliferous Vanport Limestone. One of the more accessible of these old strip mines is 700 feet southeast of Pa. Route 268, about 1 mile west-southwest of Parker, Armstrong County. The Vanport crops out near the top of a 30-foot highwall, a remnant cliff of the mining operation. Although the steepness of the highwall makes it dangerous to collect from the in-place limestone ledge, fossils can be collected from the many blocks that have tumbled to the floor of the strip mine. The shale directly underneath the limestone contains fossils that are much easier to extract than those in the limestone.



FOSSILS. Brachiopods are the most common fossils at this locality. Crinoid columnals and the horn coral *Lophophyllidium* are also fairly abundant. The fossils listed below are illustrated on Plates 13, 14, and 15.

CORAL
Lophophyllidium
BRYOZOAN
Rhombopora
BRACHIOPODS
Neochonetes
Dictyoclostus
BRACHIOPODS (cont.)
Hustedia
Anthracospirifer
Phricidothyris
GASTROPOD
Shansiella
CRINOIDS
Columnals
ECHINOIDS
Spines and plates

GEOLOGY. The Vanport Limestone and its associated fossiliferous shales were deposited in a marine embayment which briefly covered western Pennsylvania during the Pennsylvanian Period about 315 million years ago. In the Parker area the marine waters flooded a coastal coal swamp that was preserved as a thin bed of coal—probably the Scrubgrass—8 feet below the Vanport Limestone. Initially much land-derived sediment in the form of silt and clay was deposited on the sea floor directly on top of the drowned swamp. These muddy sediments formed the fossiliferous shale that lies between the coal and the limestone. Abundant siderite (iron-carbonate) nodules in the shale are interpreted to indicate mildly reducing bottom conditions at the time of deposition. Gradually, as the sea deepened and the shoreline advanced eastward out of the area, the water became much less turbid. Invertebrate organisms—especially brachiopods, corals, and echinoderms—proliferated in the warm, well-oxygenated waters of the Vanport sea, and their calcareous shells and hard parts accumulated on the sea floor to become limestone.

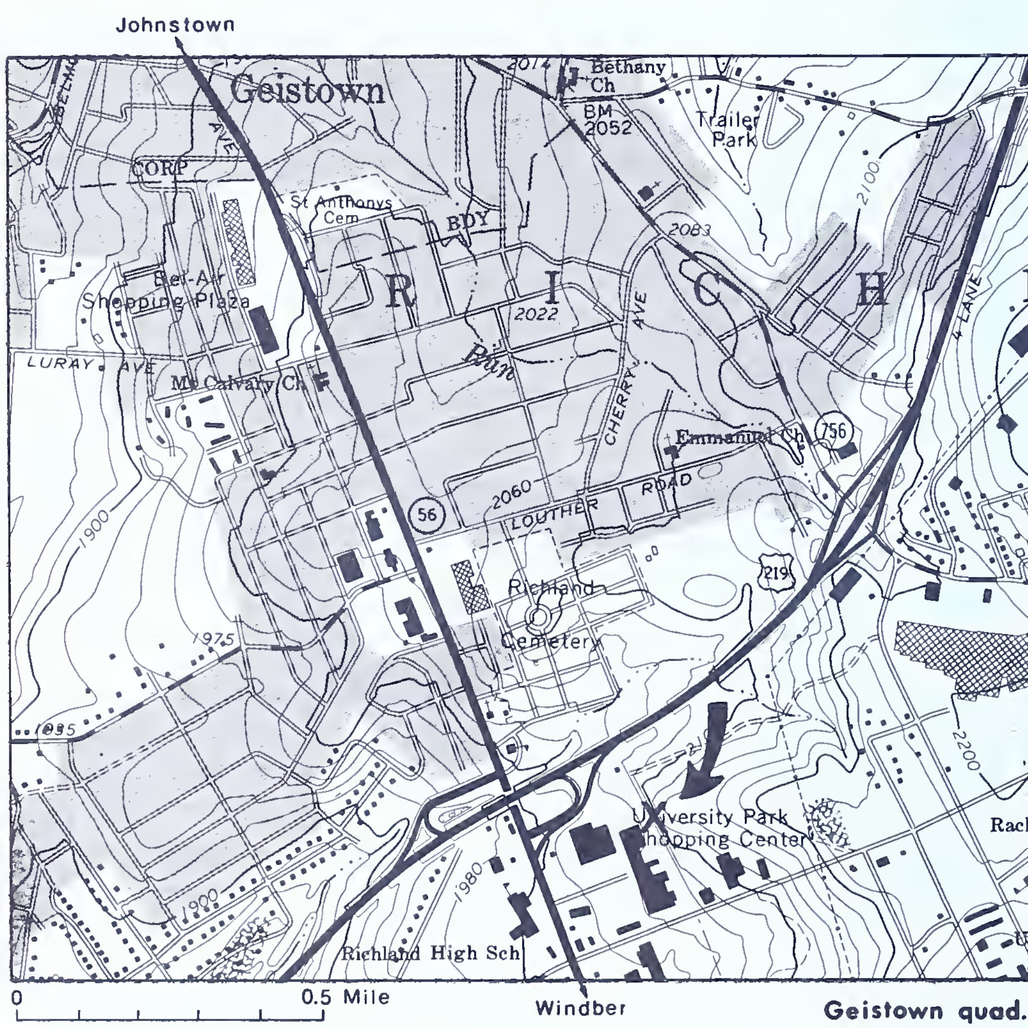
Because it is the only thick, relatively pure, and widely distributed limestone in northwestern Pennsylvania, the Vanport Limestone is of considerable economic importance. It is extensively mined and quarried in Butler, Mercer, Lawrence, Armstrong, Clarion, and Jefferson Counties and used as a source of fluxstone, cement, agricultural limestone, and crushed aggregate. Although the Vanport of northeastern Butler County is too thin for commercial exploitation on its own merits, the limestone is often stripped in combination with the underlying Clarion coal. In the Parker strip mine the Clarion coal apparently occurs 20 to 25 feet below the Vanport, but it is covered by debris at the base of the highwall.

Highwall in an abandoned strip mine near Parker. The Vanport Limestone is about 10 feet thick here.

CAMBRIA COUNTY

SITE 8—BRUSH CREEK FOSSILS NEAR JOHNSTOWN

LOCATION. Over the years Cambria County has been one of the largest producers of bituminous coal in the state. It is especially well known for the smokeless (low-volatile bituminous) steam coal that formerly fueled the locomotives of the steam railroad era and now is used extensively in coal-fired electric power plants throughout Pennsylvania. Cambria County's coal comes mainly from the Allegheny Group, or "lower productive coal measures" of the nineteenth-century geologists. Overlying the coal-rich Allegheny strata is a thick sequence of interbedded sandstones, shales, limestone, and thin coals called the Conemaugh Group, or "lower barren coal measures." Although the Conemaugh contains very few minable coal beds, it does contain several thin intervals of marine limestone



and shale that abound in invertebrate fossils. The lowest and most widely exposed of these marine zones in Cambria County is the Brush Creek "limestone," which occurs about 100 feet stratigraphically above the Upper Freeport coal, a thick, commercially important seam at the top of the Allegheny Group.

A safe and very accessible locality for collecting many typical Brush Creek fossils near Johnstown is at the base of a high cut slope behind the Gee Bee Department Store at the University Park Shopping Center, 1.25 miles south-southeast of Geistown. The shopping center is on the east side of U.S. Route 219, 0.2 mile east of the intersection of that highway with Pa. Route 56, approximately 4.5 miles southeast of Johnstown. Plenty of parking space is available in the lot adjacent to the rock outcrop.

FOSSILS. The Brush Creek limestone and shale at this locality is noteworthy for its many well-preserved gastropods and pelecypods. Spiny brachiopods, horn corals, and crinoid columnals may also be found in some abundance. The fossils occur in the 4 or 5 feet of rock directly above a thin (0.9-foot) coal—the Brush Creek coal. The lower 1 foot of the fossiliferous interval is dark-gray silty impure limestone; the upper 3 or 4 feet is dark-gray limy clay shale. Fossils can be collected from the shale and limestone ledges or from broken slabs of rock that lie at the base of the cut. Except for the gastropod *Worthenia* (which is often 1 inch or more in diameter), most of the Brush Creek invertebrates are quite small. Many are weathered completely free of the rock matrix and can be collected whole. Some of the fossils appear to be replaced by pyrite. See Plates 13 to 16 for illustrations of the fossils listed below.

CORAL
- *Stereostylus*

BRACHIOPODS
- *Chonetinella*
- *Juresania*

GASTROPODS
- *Euphemites*
- *Pharkidonatus*
- *Amphiscapha*

GASTROPODS (cont.)
- *Worthenia*
- *Meekospira*
- *Strobeus*

PELECYPODS
- *Nuculopsis*
- *Phestia*
- *Astartella*

CEPHALOPOD
- *Metacoceras*

CRINOIDS
- Columnals

GEOLOGY. The rock sequence exposed at the Geistown fossil site dates from the middle of the Pennsylvanian Period. It records the following events associated with a widespread sea-level rise in the Appalachian basin approximately 305 million years ago:

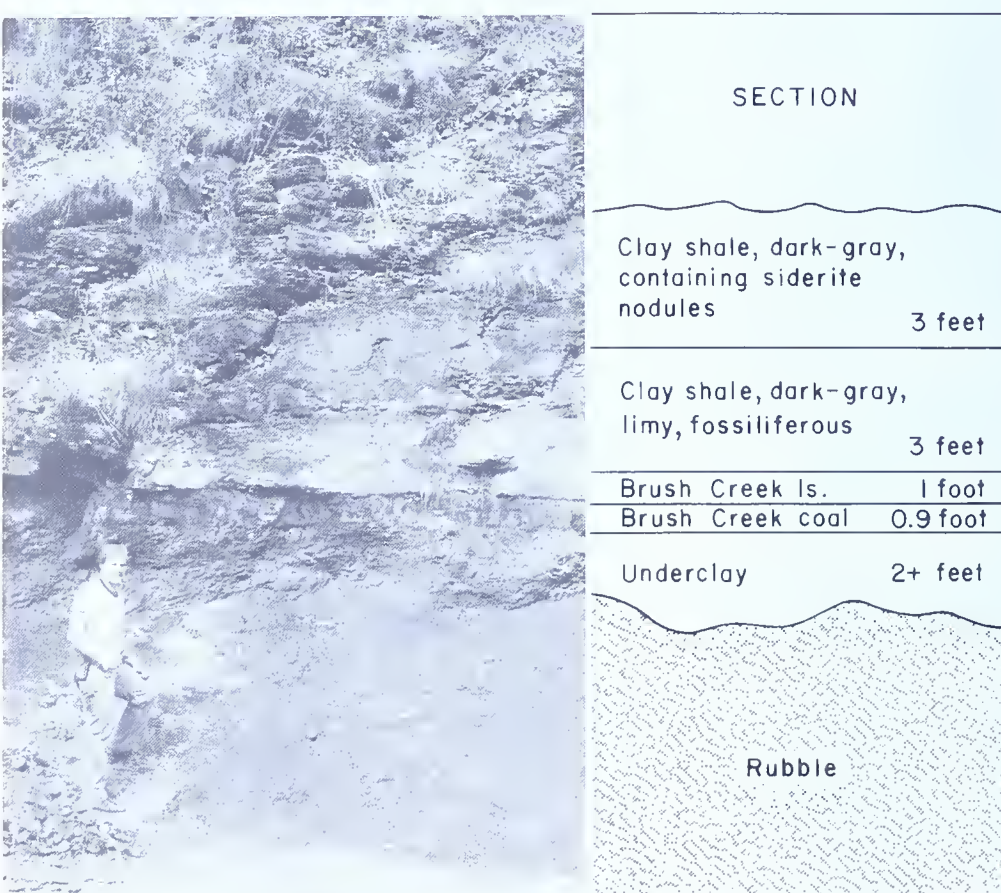
(1) Deposition of sandbars along the seaward edge of a small, local river delta (interbedded shales and coarsening-upward sandstones at south end of exposure)

(2) Growth of a luxuriant coastal swamp (Brush Creek coal and underclay)

(3) Drowning of the swamp during a rapid advance of the sea eastward across the area and deposition of silty, highly fossiliferous limy beds (Brush Creek limestone and shale)

(4) Restriction of open-marine circulation by renewed growth of river deltas westward (siderite-nodule-bearing shales at top of section)

In addition to excellent fossil collecting, this site affords an opportunity to examine a typical banded coal and its underclay. Because it takes approximately 4 feet of well-compacted peat, subjected to natural heat and compression, to form 1 foot of bituminous coal, a thickness of nearly 4 feet of peat was necessary to form the Brush Creek coal. The bright bands in the coal may represent single large tree trunks that were squeezed and carbonized during the process of coal formation. In the thick, slippery underclay beneath the coal can be seen traces of the extensive straplike root systems ("stigmaria") of the large tree-ferns that grew in the ancient coal swamp.

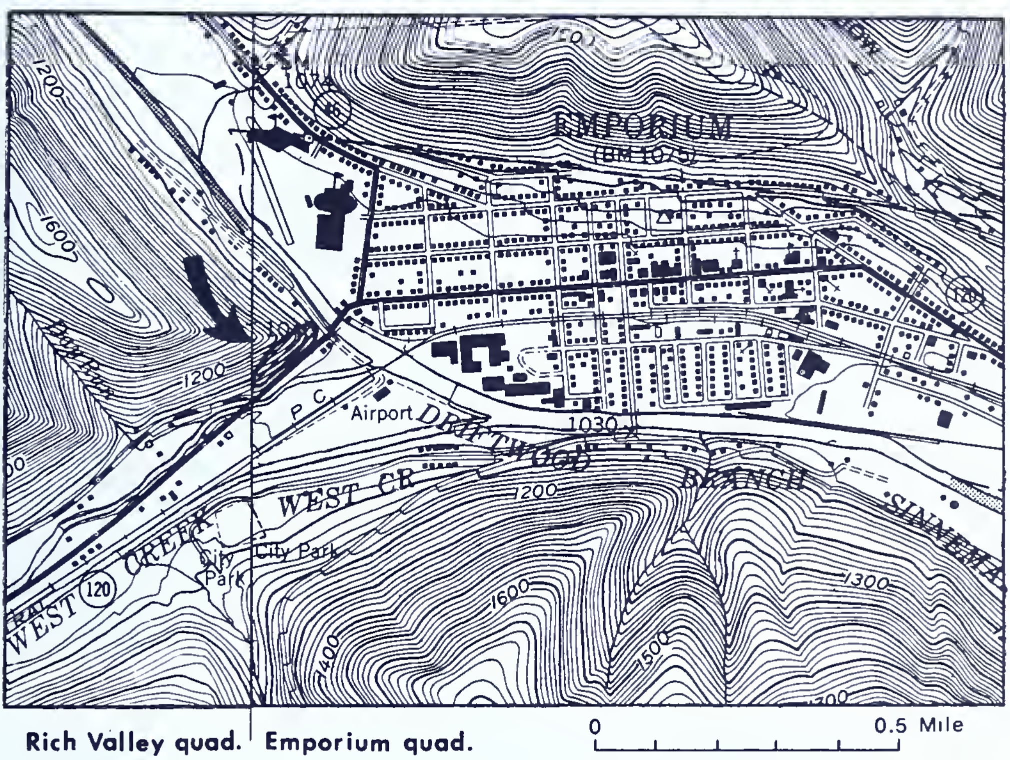


The Brush Creek marine zone and contiguous strata exposed behind the Gee Bee Department Store near Geistown.

CAMERON COUNTY

SITE 9—EMPORIUM SPONGE AND BRACHIOPOD LOCALITY

LOCATION. The oldest surface rock strata in Cameron County occur in the valleys of Sinnemahoning Creek and its tributaries near Emporium. An outcrop of these rocks on the north side of Pa. Route 120, 200 feet southwest of the bridge over the Driftwood Branch of Sinnemahoning Creek at the western borough limit of Emporium, yields an interesting assemblage of marine invertebrate fossils. The exposure is approximately 700 feet long, and fossils can be found on loose slabs or collected from the outcrop itself. Ample parking space is available on both sides of the highway.



Rich Valley quad. **Emporium quad.**

FOSSILS. Invertebrate fossils in the Emporium roadcut include brachiopods, branching bryozoans, cephalopods, crinoid columnals, and siliceous sponges. Brachiopods of several different genera make up the majority of the fossils; a few specimens of the genus *Athyris* are weathered in such a way that the rarely preserved feeding-organ supports (called spiralia) can be seen. Bryozoans are extremely abundant locally and compose nearly 100 percent of some of the thin layers. The most intriguing fossils that occur here, however, are rare fragments of a large siliceous sponge, possibly *Dictyospongia*. Generally the fossils are concentrated in thin fine-grained sandstone beds. Internal and external molds are most common, but some of the bryozoan layers contain original shell material where the rock is not deeply weathered. Fossils found at this exposure are listed below and illustrated on Plates 5 to 8.

SPONGE
- *Dictyospongia*

BRYOZOAN
- *"Batostomella"*

BRACHIOPODS
- *Douvillina*

BRACHIOPODS (cont.)
- *Chonetes*
- *Productella*
- *Ptychomaletoechia*
- *Athyris*
- *Cyrtospirifer*

CEPHALOPOD
- *Michelinoceras*

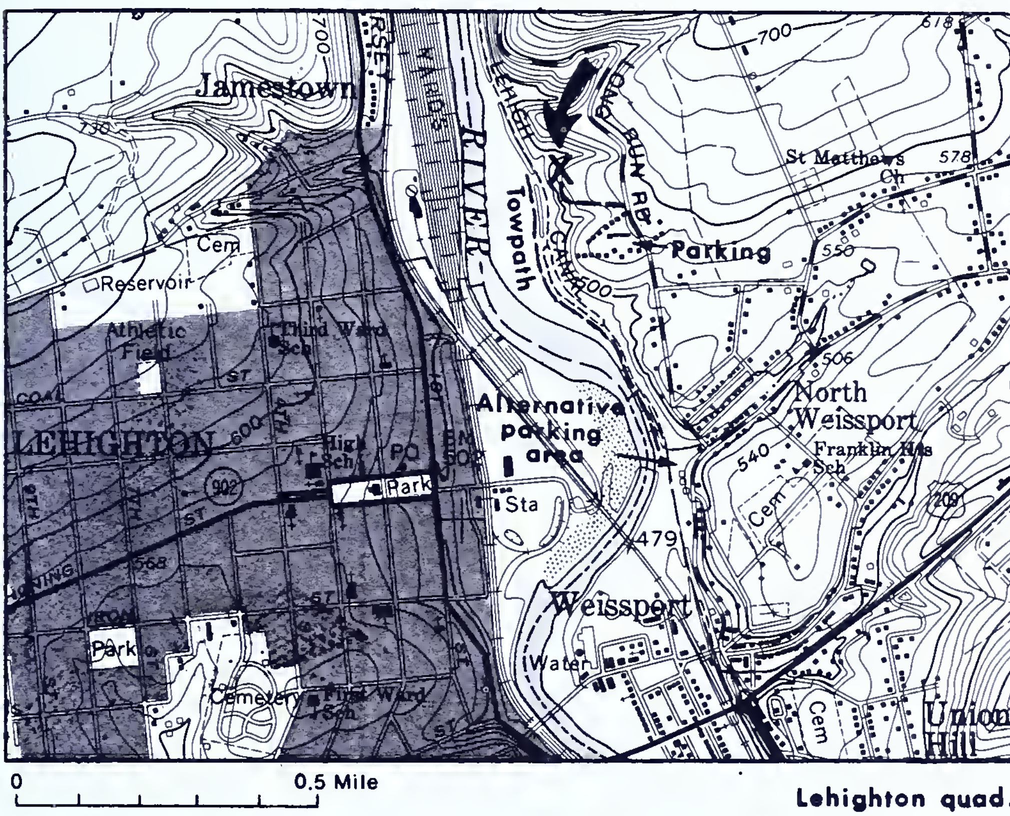
CRINOIDS
- Columnals

GEOLOGY. Cameron County is nearly everywhere underlain by mainly nonmarine rocks of Late Devonian to Pennsylvanian age. In the vicinity of Emporium, the Driftwood Branch of Sinnemahoning Creek has cut down completely through these dominantly nonmarine rocks and exposed, in the lowest part of the valley, the gray, highly fossiliferous marine shales and sandstones seen at the fossil site. These beds are assigned to the Late Devonian age Lock Haven Formation and were deposited under shallow open-marine conditions about 380 million years ago. Except for some minor nearshore marine intervals, the remaining layers of rock above the Lock Haven Formation accumulated in freshwater lakes, swamps, and streambeds. A widespread layer of red shale or claystone that crops out on the hillside about 100 feet above the fossil site marks the change from marine rocks (below) to nonmarine rocks (above).

CARBON COUNTY

SITE 10—CENTERFIELD FOSSIL ZONE ON THE LEHIGH CANAL

LOCATION. One of many good localities for collecting Devonian invertebrate fossils in Carbon County is situated along the old Lehigh Canal on the east side of the Lehigh River, 0.8 mile north of Weissport. Abundant fossils can be found scattered over a broad rubble-covered area just east of the canal and 500 feet west of Long Run Road. The easiest way to reach the site is to park at the entrance to Nathan's Hamlet across from Ray and Shirl's Tavern on Long Run Road, walk 300 feet north along the paved road to a poorly graded dirt road that leads downhill toward the river, and then walk another 700 feet down this road to the excavated area. An alternative route is to park at the north edge of Weissport and walk along the canal towpath approximately 0.5 mile to the site.



Lehighton quad.

FOSSILS. Abundant internal and external molds of a variety of invertebrate fossils, including corals, brachiopods, and gastropods, may be collected at this site. The most interesting fossils, however, are rare complete blastoid calyxes. Not only were these stalked echinoderms relatively uncommon in the Devonian seas of Pennsylvania, but unusually quiet conditions of sedimentation are necessary for preservation of the delicate, easily broken calyxes. (Oddly enough, many of the other fossils at this site are fragmented.)

The fossils listed below are illustrated on Plates 5 to 11.

CORALS
- *Pleurodictyum*
- *"Trachypora"*

BRYOZOAN
- *Fenestella*

BRACHIOPODS
- *Tropidoleptus*
- *Megastrophia*
- *Protoleptostrophia*
- *Douvillina*
- *Devonochonetes*
- *Cupulorostrum*
- *Mucrospirifer*

BRACHIOPODS (cont.)
- *Spinocyrtia*
- *Mediospirifer*

GASTROPODS
- *Bembexia*
- *Palaeozygopleura*

PELECYPOD
- *Cypricardinia*

CEPHALOPODS
- *Michelinoceras*
- *Striacoceras*
- *Spyroceras*

TRILOBITES
- *Trimerus*
- *Phacops*

CRINOIDS
- Columnals
- *Gennaeocrinus*

BLASTOID
- *Pentremitidea*

GEOLOGY. The fossiliferous rubble at the Lehigh Canal site is derived from the "Centerfield fossil zone" of the Middle Devonian age Mahantango Formation. The Centerfield is one of four thin, highly fossiliferous horizons that have been recognized within the 2,200-foot thickness of the Mahantango Formation in Carbon County. Generally these "fossil zones" consist of 20 to 60 feet of limy shale and clayey limestone. They are separated from each other by hundreds of feet of barren to sparsely fossiliferous claystone and shale.

The Centerfield beds were deposited about 387 million years ago on a moderately shallow, well-oxygenated marine shelf. At times the sea bottom resembled a vast undersea "garden," abounding in such plantlike organisms as stalked echinoderms (crinoids and blastoids), branching tabulate corals ("*Trachypora*"), and delicate fanshaped bryozoans (*Fenestella*). Storm-generated currents and waves periodically swept through these flourishing invertebrate communities, uprooting many living organisms and sorting and winnowing shell debris that had accumulated on the sea floor during quiet periods. Following a brief interval of muddy sedimentation, organisms again colonized the sea bottom and built another community several inches above the remains of the earlier one. Each of the fossil zones of the Mahantango Formation records several such cycles of proliferation and destruction of sea-bottom communities.

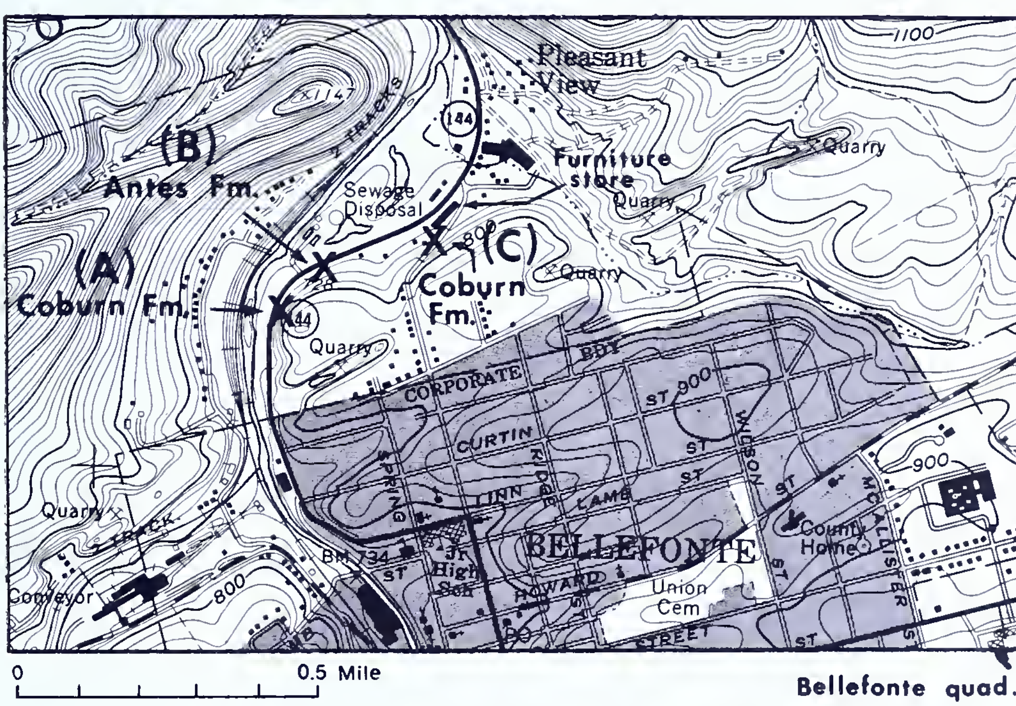
REFERENCE

Epstein, J. B., Sevon, W. D., and Glaeser, J. D. (1974), *Geology and mineral resources of the Lehighton and Palmerton quadrangles, Carbon and Northampton Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 195cd, 460 p.

CENTRE COUNTY

SITE 11—BELLEFONTE ORDOVICIAN FOSSIL LOCALITIES

LOCATION. Several of the Ordovician age limestone formations that underlie Nittany, Brush, and Penns Valleys in Centre County are highly fossiliferous. The best collecting localities are generally in the youngest of these limestones, the Coburn Formation, and in the immediately overlying dark calcareous shales of the Antes Formation. Three good exposures in these two formations are found just north of the borough of Bellefonte. The outcrops are located on the east and south sides of Pa. Route 144, about 0.2 mile north of the Bellefonte Borough line. Fossiliferous beds are indicated on the map as follows: (A) limestones in the northern part of a large roadcut on Pa. Route 144 north of an abandoned quarry; (B) dark-gray shales on the south side of the highway opposite the sewage treatment plant; and (C) limestones in an excavation at the west end of Capperella Brothers Furniture warehouse. Parking for the first two exposures is available on the west side of Route 144 opposite the south end of the roadcut. A large cleared area suitable for parking is present at the warehouse exposure. Groups of more than a few individuals who wish to collect at the warehouse locality should first obtain permission from someone on the premises.



FOSSILS. Well-preserved fossils of several types of invertebrates can be collected at the Ordovician exposures north of Bellefonte. The Coburn limestone abounds in bryozoans, brachiopods, trilobites (*Cryptolithus*), and crinoid columnals, and the Antes shale contains many whole and fragmented specimens of the small trilobite *Triarthus*. Fossils in the limestone beds consist of the original calcareous shell material and are either beautifully etched out on limestone slabs or weathered completely free of the enclosing rock. Whole specimens of the brachiopod *Dalmanella* and the bryozoan *Prasopora* are notably common at the north end of the highway cut. *Triarthus* specimens in the Antes shale occur as yellowish internal and external molds. Plates 1 and 2 illustrate some of the fossils found at this locality.

BRYOZOANS	BRACHIOPODS	TRILOBITES	CRINOIDS
Prasopora	*Dalmanella*	*Triarthus*	Columnals
Hallopora	*Sowerbyella*	*Cryptolithus*	
	Rafinesquina	*Flexicalymene*	

GEOLOGY. The Coburn and Antes Formations are both Late Ordovician in age, or approximately 455 million years old. Whereas the Coburn is predominantly gray limestone containing thin interbeds of dark-gray shale, the overlying Antes is mostly black, brownish-gray-weathered shale containing thin beds of dark-gray impure limestone in the lower part. The upward change in lithology exhibited by the rock section north of Bellefonte indicates equally significant changes in the character of sedimentation and life on the Ordovician sea floor. The older Coburn limestones accumulated in clear water on a shallow, well-oxygenated carbonate bank. Strong waves and currents periodically agitated the sea floor and concentrated the shells of the invertebrate animals living there into thin layers. The younger Antes shale, on the other hand, formed from the fine silt and clay that rivers and streams carried into the sea. This increase in land-derived sediment deposition in Antes time reflects accelerated erosion brought about by the uplift of coastal mountains far to the southeast. Thin yellowish, weathered volcanic ash beds ("metabentonites") interlayered with the Coburn limestones are further evidence of this Late Ordovician mountain-building activity and of the nearness of active volcanoes spewing wind-borne ash into the marine waters.

REFERENCES

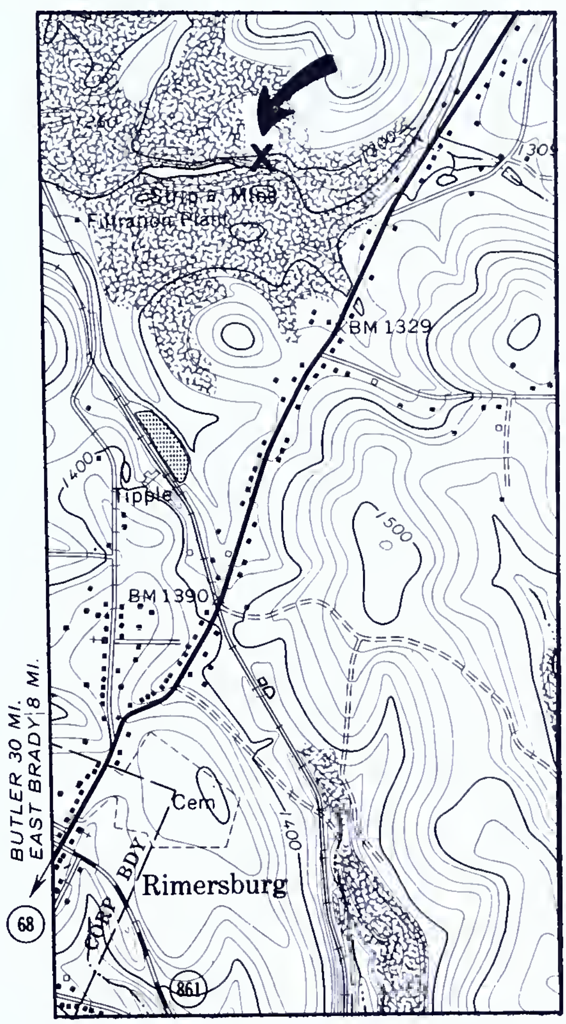
Butts, Charles, and Moore, E. S. (1936), *Geology and mineral resources of the Bellefonte quadrangle, Pennsylvania*, U.S. Geological Survey Bulletin 855, 111 p.

Thompson, R. R. (1963), *Lithostratigraphy of the Middle Ordovician Salona and Coburn Formations in central Pennsylvania*, Pennsylvania Geological Survey, 4th ser., General Geology Report 38, 154 p.

CLARION COUNTY

SITE 12—BRACHIOPODS IN CONCRETIONS

LOCATION. Clarion County is fortunate in having rocks associated with coal-bearing deposits that contain excellently preserved marine fossils. The locality recommended for this county is about 12 miles southwest of Clarion, near the borough of Rimersburg. The exposure of the fossiliferous rock is in an abandoned coal strip mine 1.2 miles north of Rimersburg. The strip mine is about 300 yards west of Pa. Route 68, 1.2 miles north of the intersection of Pa. Routes 68 and 861 in Rimersburg. The areas between Route 68 and the strip mine have been partially planted with evergreens so that the area is becoming overgrown with vegetation. It is best to park vehicles at a convenient spot along the main highway and walk northwestward across the fields, to a small stream that leads to-



Sligo quad.

ward the strip mine. The fossiliferous rocks were originally exposed at the base of the strip-mine wall at the point where the stream enters the mine. Erosion has caused this face to become covered with rock debris falling from the old "high wall." Fossils may be easily collected from the blocks of rock on the immediately adjacent dump pile.

On the spoil piles adjacent to the stream are innumerable pieces of rounded reddish rock. These are iron-rich concretions composed of the mineral siderite (iron carbonate). In these concretions, which are frequently cracked and broken, are many excellently preserved fossil specimens.

FOSSILS. This locality is remarkable because of the extreme profusion of two genera of brachiopods. The genus *Juresania* occurs by the hundreds and may be found in the layer containing concretions, just above the coal bed. Many blocks from this layer are on the dump pile. The genus *Mesolobus* occurs in even greater numbers in the black shales that overlie the iron zone. Blocks of this shale are also common on the dumps. These, plus the other fossils found at this locality, are illustrated on Plates 13 to 16.

BRACHIOPODS	GASTROPODS	PELECYPOD
Lingula	*Euphemites*	*Nuculopsis*
Mesolobus	*Amphiscapha*	CEPHALOPOD
Juresania	*Worthenia*	*Pseudorthoceras*
Linoproductus		

GEOLOGY. The fossiliferous shale and siderite concretion layer at Rimersburg is informally called the Washingtonville shale.

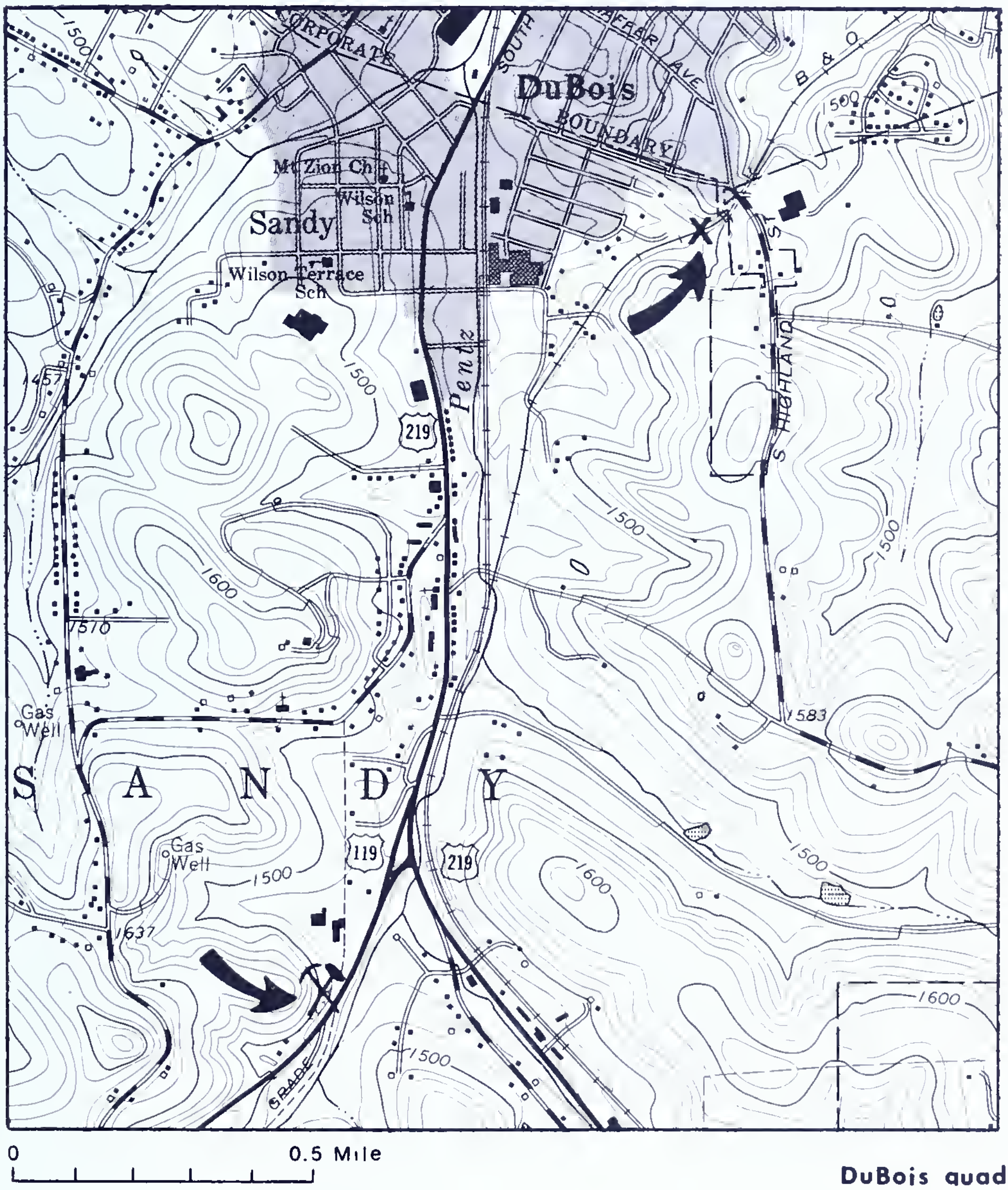
The coal that was mined in the strip mine is the Middle Kittanning coal, one of the many coal seams that record the development of widespread swamps during the Pennsylvanian Period, 330 to 290 million years ago. The coals are part of depositional cycles that were, in part, controlled by rising and lowering levels of the marine seas. The rocks containing the marine fossils were the result of one of the rises of sea level that spread marine waters over the coal swamps. The waters were sufficiently marine to support an abundant fauna of brachiopods, but also had chemical characteristics that contributed to the precipitation of iron carbonate to form the siderite concretions. The fossil shells lying on the sea floor became the site where the iron carbonate precipitated from the water. As more and more material precipitated, the concretion grew, completely covering the fossils so that now they are enclosed in the concretion, which must be broken to see the fossils.

Following the deposition of the fossil-bearing layers, sea level lowered and the marine seas withdrew. Streams then deposited clays and sand to begin another cycle, which led eventually to the formation of a new coal swamp.

CLEARFIELD COUNTY

SITE 13—GASTROPODS AT DU BOIS

LOCATION. Several localities within a short distance of DuBois are replete with Pennsylvanian age gastropods. The locality of easiest access is a borrow pit along U.S. Route 119, 1.5 miles south of the DuBois corporate line. It is 0.4 mile south of the intersection of U.S. Routes 119 and 219, on the west side of the road. The pit contains two levels from which the shales were stripped. The fossil zone, which is the Brush Creek limestone,



DuBois quad.

directly underlies the second level. Fossils are exposed at the surface, weathered free from the clayey matrix, and may be picked up whole.

An additional nearby locality is along the B & O Railroad right-of-way, a few tens of feet south of a tunnel that goes through the hill under South Highland Street, the corporate boundary of DuBois. To get access to the railroad locality, one must approach it from the street that crosses the railroad about 0.3 mile south of the locality, and then walk north to the tunnel.

Two additional localities in the same Brush Creek limestone occur in Jefferson County about 3 miles west and southwest of the U.S. Route 119 pit. All of these localities are located and described in Atlas 64 on pages 36 and 98–99.

FOSSILS. Large and small gastropods are the common fossils at the U.S. Route 119 pit. Listed below are fossils found by the authors at this site. Detailed lists of fossils for each of the localities described above are also found in Atlas 64 (p. 98–99). See Plates 13, 14, and 15 for illustrations.

CORAL	GASTROPODS (cont.)
Stereostylus	*Worthenia*
GASTROPODS	*Shansiella*
Euphemites	*Donaldina*
Cymatospira	PELECYPOD
Glabrocingulum	*Phestia*

GEOLOGY. The Brush Creek limestone at these localities represents a short period of geologic time when sea level rose and saline waters, able to support abundant marine life, spread over an area formerly occupied by coastal swamps and small freshwater streams. The limy shale was deposited over a swamp in which the Brush Creek coal was formed. At the Route 119 locality this coal is absent, as it is over much of the area. Some cores through this sequence of rocks show the coal to be up to 2 feet thick, but it was not observed at any of the localities where the fossiliferous rocks occur.

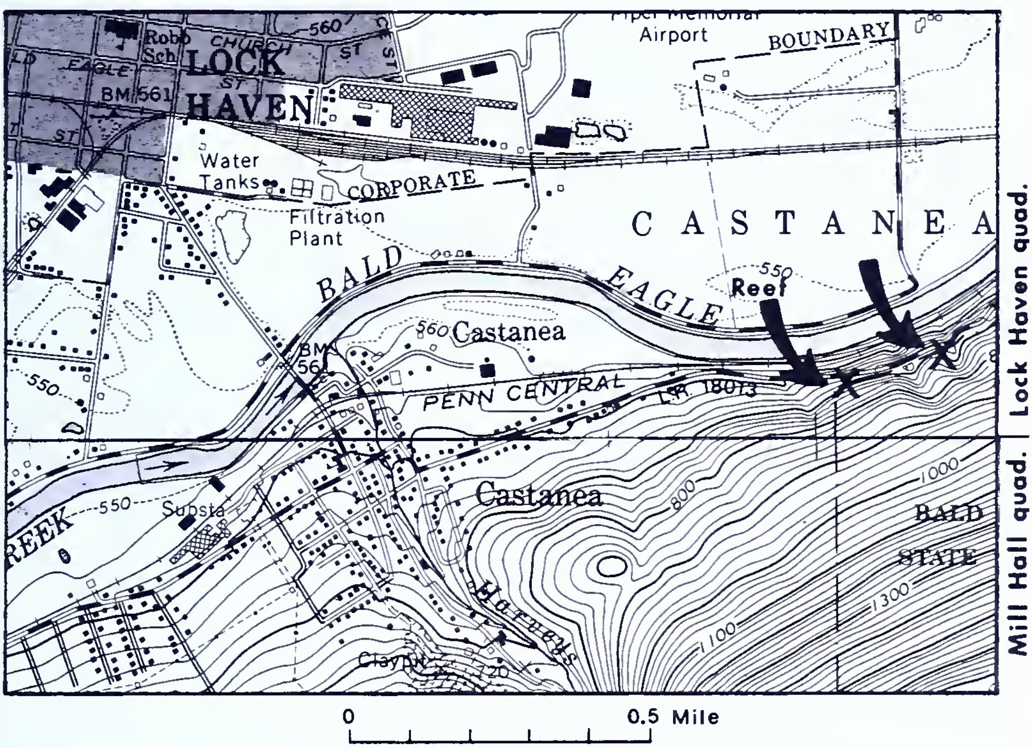
REFERENCE

Glover, A. D., and Bragonier, W. A. (1978), *Geology and mineral resources of the Hazen, Falls Creek, Reynoldsville, and DuBois quadrangles, Clearfield and Jefferson Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 64, 131 p.

CLINTON COUNTY

SITE 14—SILURIAN CORAL REEF NEAR LOCK HAVEN

LOCATION. An excellent site for examining an ancient coral reef and collecting Silurian age corals and brachiopods is situated on the south side of Bald Eagle Creek, approximately 1.5 miles southeast of Lock Haven. The site consists of two adjacent roadcuts in the Mifflintown Formation on L.R. 18013 (the road to McElhatten), 0.8 mile east of the village of Castanea. The western cut exposes the massive reef limestone and some underlying bryozoan- and coral-rich beds; the eastern cut consists of interbedded fossiliferous limestone and calcareous shale. A large parking area lies between the two exposures. (The reef itself crops out about 500 feet west of the parking area.)



FOSSILS. The most interesting fossils at this site are the colonial corals that built the reef. The massive tabulate coral *Favosites* occurs in the reef exposure in masses up to bushel-basket size. Many well-preserved hand specimens can also be collected from the reef rock. The slender branching colonial coral *Coenites* and the massive bryozoan *Monotrypa* are common in the beds exposed just east of the reef. In the exposure east of the parking area, many excellent specimens of brachiopods can be found. These beds also yield small, isolated *Favosites* colonies 1 to 2 inches in diameter. The fossils listed below are illustrated on Plates 3, 4, and 5.

CORALS
Favosites
Coenites

BRYOZOAN
Monotrypa

BRACHIOPODS
Stegerhynchus
Whitfieldella
Howellella

OSTRACODE
Kloedenella

GEOLOGY. Coral reefs of Silurian age are well known in the eastern and central United States. In the Great Lakes region, many of these reefs exceed 1 mile in diameter and 100 feet in thickness. By comparison, the Silurian coral reef near Lock Haven is only about 600 feet in diameter and 30 feet high. Despite its small size, however, the reef at this site exhibits much the same structure as larger reefs elsewhere and contains a massive core (composed mostly of *Favosites*) surrounded by stratified, fragmented flanking beds. Growth of the reef occurred in a warm, shallow sea which covered this area approximately 415 million years ago. In order for the delicate coral animals to have thrived, the marine waters must have been relatively clear but rich in nutrients. Secretions of calcium carbonate by thousands of tiny organisms built up the massive "honeycomb" colonies that characterize the core of the reef. As one colony died off, another grew directly on top of it. Eventually a large, nearly circular mound projected above the sea floor. After several thousands or tens of thousands of years had passed, the sea water became increasingly turbid and land-derived sediment smothered the reef.

Subsurface coral reefs are excellent "traps" for oil and natural gas. For example, in northwestern Pennsylvania and adjacent New York, a modest amount of natural gas is obtained from coral reefs somewhat similar to the one at Lock Haven, albeit of Middle Devonian age. Of much greater importance are the extensive oil-bearing Devonian age reefs of Alberta, Canada.

REFERENCES

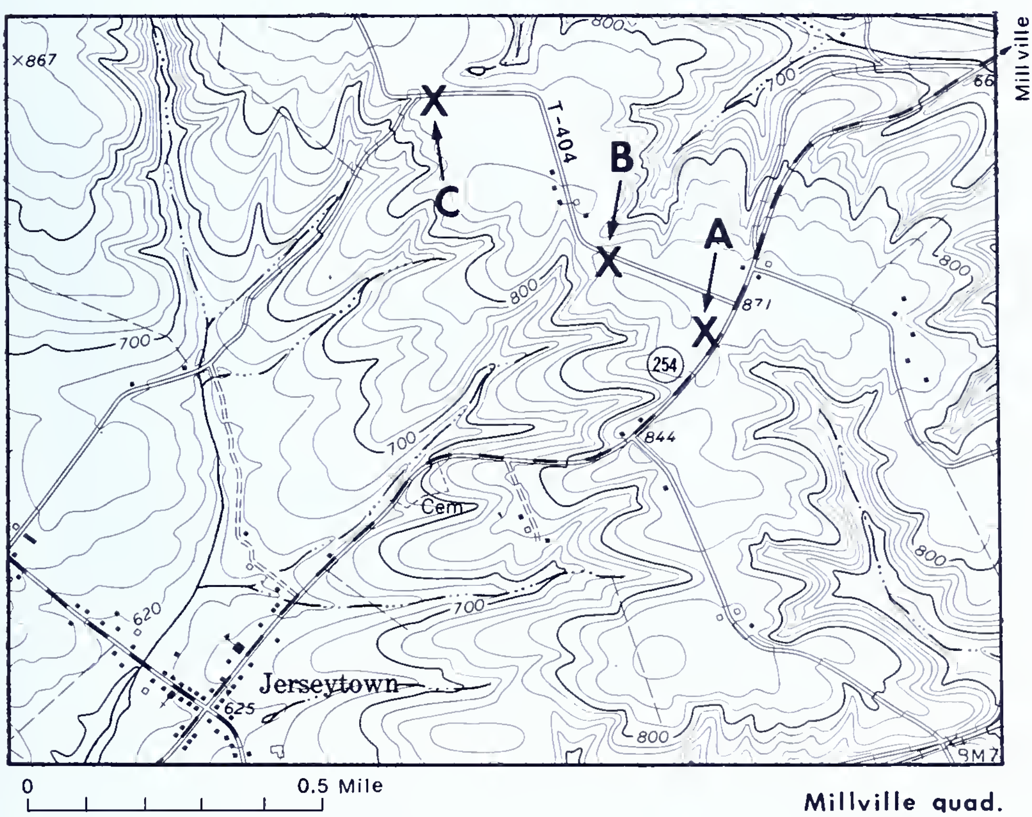
Cuffey, R. J., and Davidheiser, C. E. (1979), *Paleoecologic zonation within a mid-Silurian (Rochester Shale) patch reef near Lock Haven, central Pennsylvania* [abs.], Geological Society of America Abstracts with Programs, v. 11, no. 1, p. 9.

Taylor, A. R. (1977), *Geology and mineral resources of the Lock Haven quadrangle, Clinton and Lycoming Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 124*a*, scale 1:24,000.

COLUMBIA COUNTY

SITE 15—TULLY FOSSILS AT JERSEYTOWN

LOCATION. Several outcrops of the limy Tully Member of the Mahantango Formation in the vicinity of Jerseytown, western Columbia County, yield well-preserved invertebrate fossils. The best localities for collecting are three shallow roadcuts northeast of Jerseytown. These are located as follows: (A) on the northwest side of Pa. Route 254, 1.1 miles northeast of Jerseytown; (B) on Madison Twp. Route 404, 0.2 mile northwest of the first outcrop; and (C) on the same township road 0.4 mile farther northwest. To visit site A, park at the intersection of Route 254 and the township road. Traffic is moderately heavy on the state highway, so be cautious while walking and collecting along the road shoulder. The township road carries extremely light traffic. BECAUSE OVER-COLLECTING COULD QUICKLY DEPLETE THE FOSSIL SPECIMENS, THESE SITES ARE NOT RECOMMENDED FOR LARGE GROUPS.



FOSSILS. The most common fossils at the Jerseytown Tully outcrops are the small horn coral *Heterophrentis* and the spiny brachiopod *Spinatrypa* Specimens of these fossils are typically weathered free of the gray clayey-limestone matrix and can be found loose in the rubble on the road banks. Other fossils, including crinoid columnals and trilobites, are also easily found here. The fossils listed below are illustrated on Plates 5 to 8, 10, and 11.

CORAL
Heterophrentis
BRYOZOAN
Fenestella
BRACHIOPODS
Longispina
Spinatrypa
Ambocoelia
Emanuella
Delthyris
CEPHALOPOD
Spyroceras
TRILOBITES
Phacops
Greenops
CRINOIDS
Columnals

GEOLOGY. The Tully limestone—the youngest Devonian age limestone in Pennsylvania—was deposited near the end of Middle Devonian time approximately 385 million years ago. In north-central and northeastern Pennsylvania the Tully consists of light-gray-weathering clayey limestone and limy shale that differs from the bulk of the Mahantango Formation only in containing distinct beds of limestone.

The fossiliferous beds at the localities near Jerseytown occur near the top of the Tully and accumulated on a moderately shallow, sunlit, well-oxygenated marine shelf. The favorable environmental conditions that allowed the brachiopods, corals, and crinoids to thrive existed for only a brief time, however, as the black, pyritic clay shales of the succeeding Harrell Formation were deposited in stagnant, poorly oxygenated waters that could support little marine life. An outcrop of the black Harrell shales can be seen along the township road at the top of the hill, 0.2 mile northwest of locality C.

REFERENCES

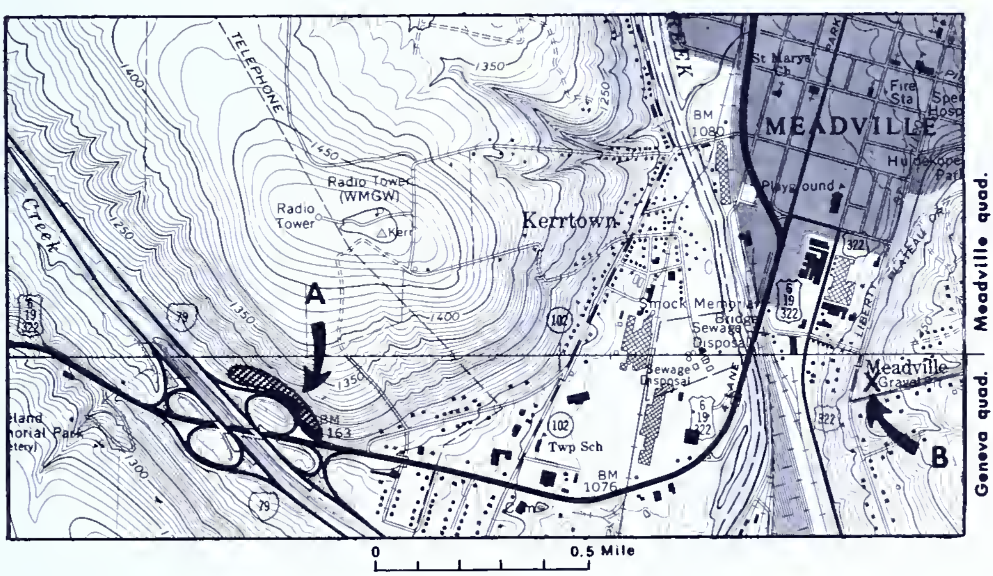
Inners, J. D. (1981), *Geology and mineral resources of the Bloomsburg and Mifflinville quadrangles and part of the Catawissa quadrangle, Columbia County, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 164cd, 152 p.

Way, J. H. (in preparation), *Geology and mineral resources of the Washingtonville and Millville quadrangles, Montour, Columbia, and Northumberland Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 154cd.

CRAWFORD COUNTY

SITE 16—MEADVILLE BRACHIOPOD AND TRACE-FOSSIL LOCALITIES

LOCATION. There are two good localities for collecting fossils in the vicinity of Meadville in Crawford County. Locality A is a roadcut along the northbound entrance ramp to Interstate Route 79 at the interchange with U.S. Route 322, approximately 1.5 miles southwest of Meadville. The locality is best approached by traveling west from Meadville on Route 322. Parking is available at the side of the road near the entrance ramp. Be sure to park far enough off the road to avoid causing unnecessary traffic problems. Fossils can be collected from the hillside at the base of the ramp, and from the outcrop along the east and north sides of the ramp itself. Be careful here because of the high-speed traffic. Locality B is an excavation in the hillside adjacent to the lot of the Micro Tool Company on Liberty Street at the south end of Meadville. This site is located diagonally across the street from the old incinerator near the road up to Neason Hill. Most of the rock here is loose float, but there is plenty of bedrock to collect from as well.



FOSSILS. There are many trace fossils to be found at these localities. Some rocks are literally covered with tracks, trails, and burrows, probably of wormlike animals for the most part, although most animals that crawl on or under the surface of the sea floor will leave some kind of trace. Quick burial of these tracks and trails results in their preservation; however, the physical and chemical processes that change loose sediment into rock, as well as further burrowing of the sediment prior to these processes, normally cause some distortion of trace fossils. In addition to the trace fossils there are numerous body fossils, primarily of brachiopods and pelecypods. The more common invertebrate fossils are listed below and illustrated on Plates 8 and 9.

BRACHIOPODS
Dictyoclostus
Cyrtospirifer
GASTROPOD
Euomphalus
PELECYPOD
Mytilarca

GEOLOGY. The rocks at these two localities represent a transitional sequence from Late Devonian to Early Mississippian rocks. The shales and siltstones of the Devonian age Riceville Formation are the lowest beds exposed here. These rocks grade upward into the Mississippian age Cussewago Sandstone, a unit that attains a great thickness regionally but that is less than 20 feet thick in the vicinity of Meadville. The fine-grained and fossiliferous Cussewago is a lobate delta deposit that spread into northwestern Pennsylvania and northeastern Ohio from a source to the southeast. The Cussewago grades upward into the Bedford Shale and Berea Sandstone. Locality A provides a glimpse of this entire transition, whereas locality B is restricted to the lower portion of the sequence. Most of the invertebrate body fossils occur in light-gray siliceous siltstones of the Riceville Formation.

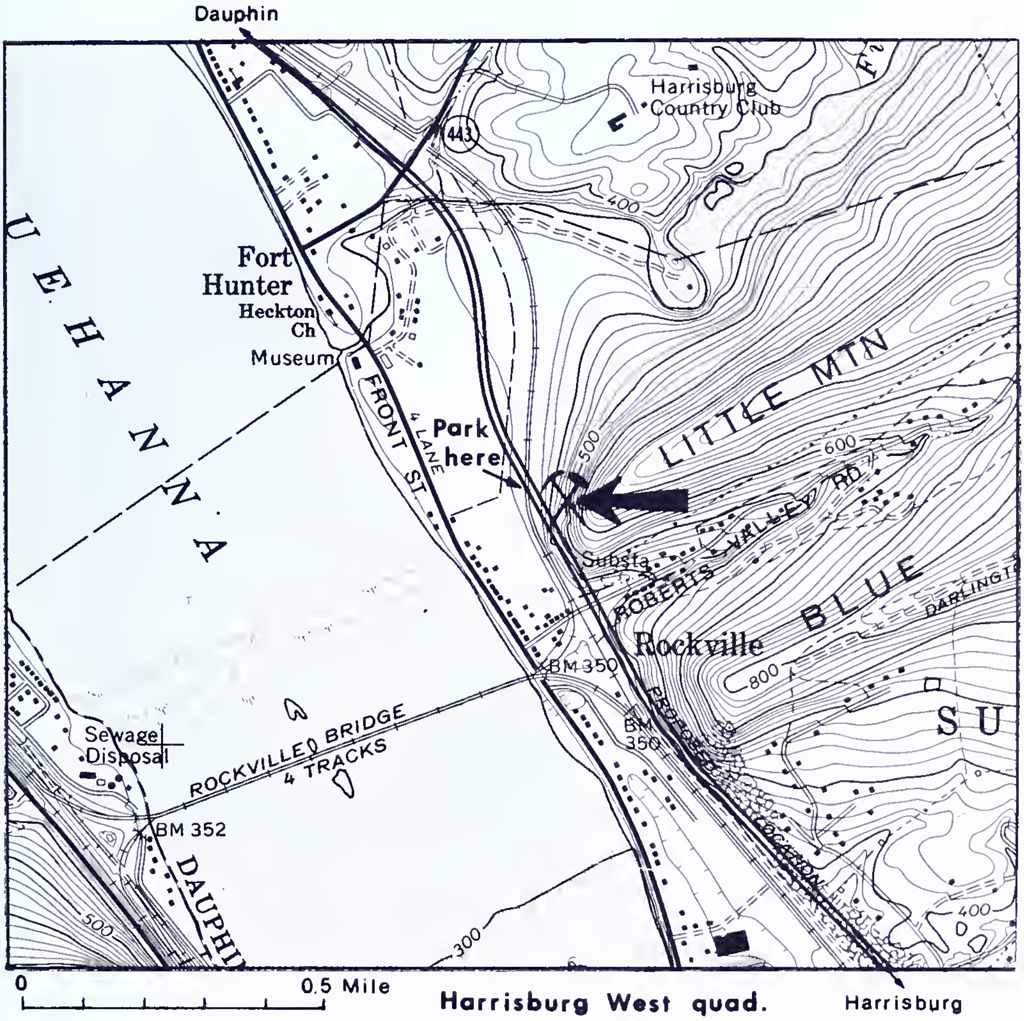
REFERENCE

Caster, K. E. (1934), *The stratigraphy and paleontology of northwestern Pennsylvania—Part 1, Stratigraphy*, Bulletins of American Paleontology, v. 21, no. 71, 185 p.

DAUPHIN COUNTY

SITE 17—ROCKVILLE QUARRY BRACHIOPOD LOCALITY

LOCATION. One of the most productive fossil-collecting sites in central Pennsylvania is located on the east side of the Susquehanna River near the village of Rockville, Dauphin County, approximately 3 miles north of Harrisburg. (Rockville is best known for its magnificent stone-arch railroad bridge, the longest bridge of this construction in the world.) The fossils can be found in an abandoned sandstone quarry in Little Mountain at the north end of a deep rock cut on U.S. Routes 22-322. The quarry lies about 50 feet above road level and can most easily be reached by turning east off Front Street (old U.S. Route 22-322) onto Roberts Valley Road about 200 feet north of the stone-arch bridge. About 0.1 mile to the east,



turn north along the dirt road that parallels the railroad tracks. Park at the highway bridge over the railroad and walk up the hill to the quarry.

Most of the rock exposed at this site is gray, thick-bedded, medium-grained to conglomeratic quartz sandstone in which molds of large, thick-shelled brachiopods are quite common. The most fossiliferous beds, however, are in a 20-foot-thick interval of gray, calcareous, sandy silt shale that juts out from the quarry wall at the south end of the right-of-way fence.

This locality is a relatively safe place to collect if you (1) DO NOT VENTURE NEAR THE EDGE OF THE PRECIPITOUS HIGHWAY CUT THAT EXTENDS ALONG THE WEST EDGE OF THE SITE, and (2) STAY CLEAR OF THE QUARRY HIGHWALL.

FOSSILS. The sandstones and silt shales of the Rockville quarry abound in brachiopods and also contain many pelecypods and trilobites. All of the fossils in the coarse sandy and conglomerate beds are external and internal molds. In the silty, calcareous beds, however, recrystallized original shell material is commonly present.

Perhaps the most unusual fossils at this locality are the many specimens of the brachiopod *Athyris* in which the delicate feeding-organ supports, or spiralia, are preserved. The spiralia consist of fine, spiral ribbons of calcite that are readily seen on broken and abraded specimens. These internal structures are generally broken before burial or otherwise lost as the soft sediment enclosing the fossils is altered to rock. Other interesting fossils in the Rockville quarry are large specimens of the spiny brachiopod *Spinulicosta* and the many well-preserved pelecypods.

Illustrations of the fossils listed below are found on Plates 5 to 11 and 21.

CORAL
- *Aulopora*

BRYOZOAN
- *Fenestella*

BRACHIOPODS
- *Rhipidomella*
- *Tropidoleptus*
- *Schuchertella*
- *Protoleptostrophia*
- *Douvillina*
- *Devonochonetes*
- *Longispina*
- *Spinulicosta*
- *Cupulorostrum*

BRACHIOPODS (cont.)
- *Ambocoelia*
- *Athyris*
- *Mucrospirifer*
- *Spinocyrtia*
- *Mediospirifer*

PELECYPODS
- *Palaeoneilo*
- *Leiopteria*
- *Ptychopteria*
- *Actinopteria*
- *Modiomorpha*
- *Cypricardella*

CEPHALOPOD
- *Michelinoceras*

CRICOCONARID
- *Tentaculites*

TRILOBITES
- *Trimerus*
- *Phacops*
- *Greenops*

CRINOIDS
- Columnals

TRACE FOSSIL
- *Zoophycos*

GEOLOGY. The rocks exposed at this site and in the adjacent deep roadcut on U.S. 22-322 belong to the Montebello Member of the Middle De-

Vertical beds of the Montebello Sandstone in the Rockville quarry. Fossiliferous silt shale rubble can be seen in the foreground.

vonian age Mahantango Formation. The sandy Montebello beds represent the marine portion of a large river delta that was deposited over much of central Pennsylvania approximately 387 million years ago. The predominant crossbedded sandstones and conglomeratic sandstones of the Montebello accumulated in very shallow water where waves and currents winnowed out any silt and clay that was originally present. Few animals lived on these unstable sandy bottoms, but the remains of shelly organisms living in quieter areas nearby were sometimes transported in and concentrated at the base of current-scoured channels.

The beds that contain the greatest number and variety of fossils are conspicuously finer grained than the bulk of the Montebello. These shaly, highly fossiliferous strata were deposited on a somewhat deeper portion of the delta that was less agitated by waves and currents. Invertebrate organisms such as brachiopods and pelecypods found an ideal habitat on such quiet, yet well-oxygenated, bottoms.

At the base of the shaly fossiliferous interval in the southern part of the quarry is a 3-foot layer of black silty shale that contains abundant flattened chamosite (an iron-aluminum silicate) oolites. The oolites are black, shiny, disc-shaped particles that are 1 to 2 mm in diameter. They consist of thin concentric layers of chamosite built up mainly around quartz-sand grains. Such inorganic "pseudo-fossils" can form in slightly reducing marine environments that have a slow rate of deposition and current activity strong enough to agitate sand grains. During the nineteenth century, similar oolitic layers in the Montebello Sandstone of Perry County were mined for iron ore.

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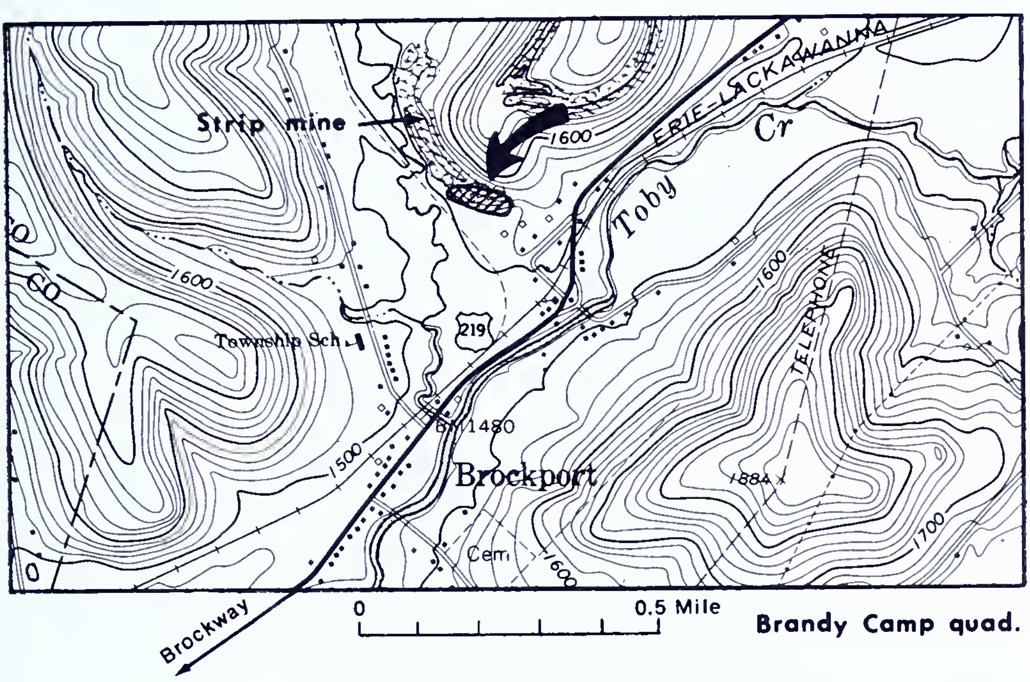
ELK COUNTY

SITE 18—DELICATE BRACHIOPODS AT BROCKPORT

LOCATION. Along the valley of Toby Creek in the southern part of Elk County, Pennsylvanian fossiliferous rocks have been exposed in many coal strip mines. An abandoned strip mine that exposes shales containing abundant marine invertebrate fossils is located in the northern part of the village of Brockport 3 miles east of Brockway (Jefferson County). The site is about 500 feet west of U.S. Route 219 at a point 1.4 miles southwest of the intersection of that highway with Pa. Route 153.

To reach the site follow the L-shaped dirt street that leads southwest off U.S. Route 219 where the highway turns south to cross Toby Creek. Park along the street near the Quinn McLaughlin residence and walk back along the path between the house and a large barn. *Please obtain Mr. McLaughlin's permission to enter the property.*

The fossiliferous strata occur at the southeast end of an old strip-mine highwall. Recent excavation has reexposed a 15-foot section of fossiliferous black shale. Blocks of shale containing well-preserved fossils can also be found scattered over the spoil piles.



FOSSILS. The black shale exposed in the strip mine contains many specimens of the small spiny brachiopod *Mesolobus* and significant numbers of two related spine-bearing brachiopods. One of these, *Linoproductus*, was fairly large and was covered with long, slender spines. The shell of this animal must have been relatively thin because most specimens of *Linoproductus* found are crushed. Aside from the brachiopods, other fossils are relatively uncommon.

The fossils occur as delicate remains of original shell material, and as external and internal molds where the shell has broken away.

Illustrations of the fossils listed below are on Plates 13, 14, and 15.

BRACHIOPODS	PELECYPOD
Mesolobus	*Nuculopsis*
Juresania	GASTROPOD
Linoproductus	*Euphemites*

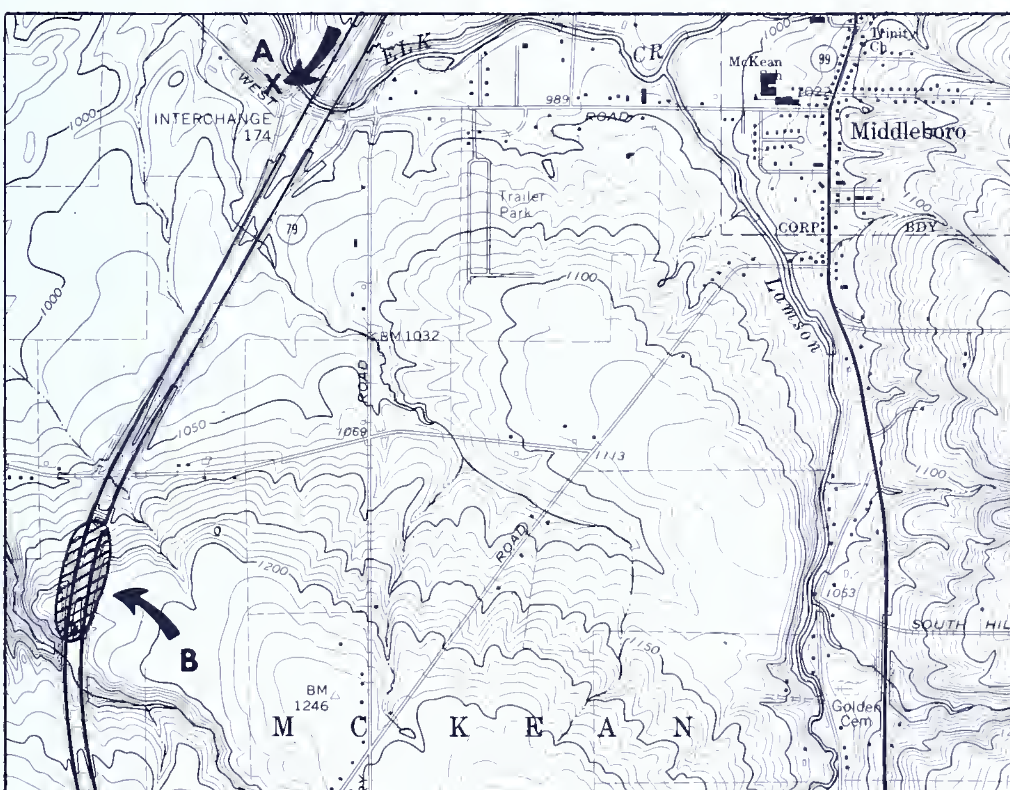
GEOLOGY. The fossiliferous rock at this site is known as the Columbiana shale. It occurs directly above the Lower Kittanning (or "B") coal, the seam that was stripped from the area. The black color of the shale, its fine texture, and the presence of innumerable siderite, or "clay ironstone," concretions indicate that the fossils that occur here inhabited a soft, poorly oxygenated bottom. The spines on the brachiopods kept the shells from being buried in the mud. Fine-grained muds such as this accumulate very slowly, so it is likely that the spines allowed the brachiopods to stay clear of foundering in the mud until they died and were buried.

Fossiliferous shale exposed in the abandoned Brockport strip mine. Note the abundant siderite nodules.

ERIE COUNTY

SITE 19—I-79 INVERTEBRATE- AND TRACE-FOSSIL LOCALITIES

LOCATION. Because the bedrock of Erie County is largely covered by glacial deposits, exposures of fossiliferous rocks suitable for the average collector are relatively rare. Two exceptions where fossiliferous bedrock may be seen are a mile apart on Interstate Route 79 about 8 miles south of Erie. The first locality (A) is situated at interchange 174, where I-79 crosses Elk Creek. The roadcut made for West Road and the interchange exposes layers of gray sandstone rich in trace fossils. The best exposures at this locality are on the north side of West Road at the southbound exit ramp from the interstate, and in the south bank of Elk Creek beneath the highway. The second locality (B) is a roadcut on I-79 approximately 1 mile south of the first locality. The roadcut exposes more gray sandstones and shales which, at this site, are abundantly fossiliferous. Parking is available at the interchange along West Road, but parking is not permitted on the interstate highway itself. Persons interested in collecting from the second locality should prepare themselves to walk the 1-mile



0 0.5 Mile

Edinboro North quad.

distance from the interchange to the collecting site. The abundant collecting makes this locality well worth visiting. An alternative is to be dropped off and picked up at a pre-arranged time by a friend or relative.

WARNING: LIKE ALL INTERSTATE HIGHWAYS, I-79 IS A HIGH-SPEED ROAD ON WHICH THERE IS CONSIDERABLE TRAFFIC. THE SHOULDERS OF THE ROAD AT THE SECOND SITE ARE WIDE ENOUGH TO PERMIT SAFE ACTIVITY, BUT COLLECTORS SHOULD BE AWARE OF THE DANGERS INVOLVED IN WORKING SO CLOSE TO TRAFFIC AND SHOULD NOT STEP ON THE PAVEMENT.

FOSSILS. Except for an occasional internal or external mold of a brachiopod or pelecypod, the fossils at locality A are primarily trace fossils of many varieties. The best place for body fossils seems to be in the rock exposed in the banks of Elk Creek. Locality B has abundant body and trace fossils. The body fossils are not merely molds, but actual three-dimensional representations of once-living organisms. Brachiopods are especially abundant, and pelecypods are almost as numerous. Illustrations of the fossils listed below can be found on Plates 7, 8, and 9.

BRACHIOPODS	BRACHIOPODS (cont.)	PELECYPODS
Lingula	*Cyrtospirifer*	*Palaeoneilo*
Productella	*Ambocoelia*	*Leptodesma*
Ptychomaletoechia		

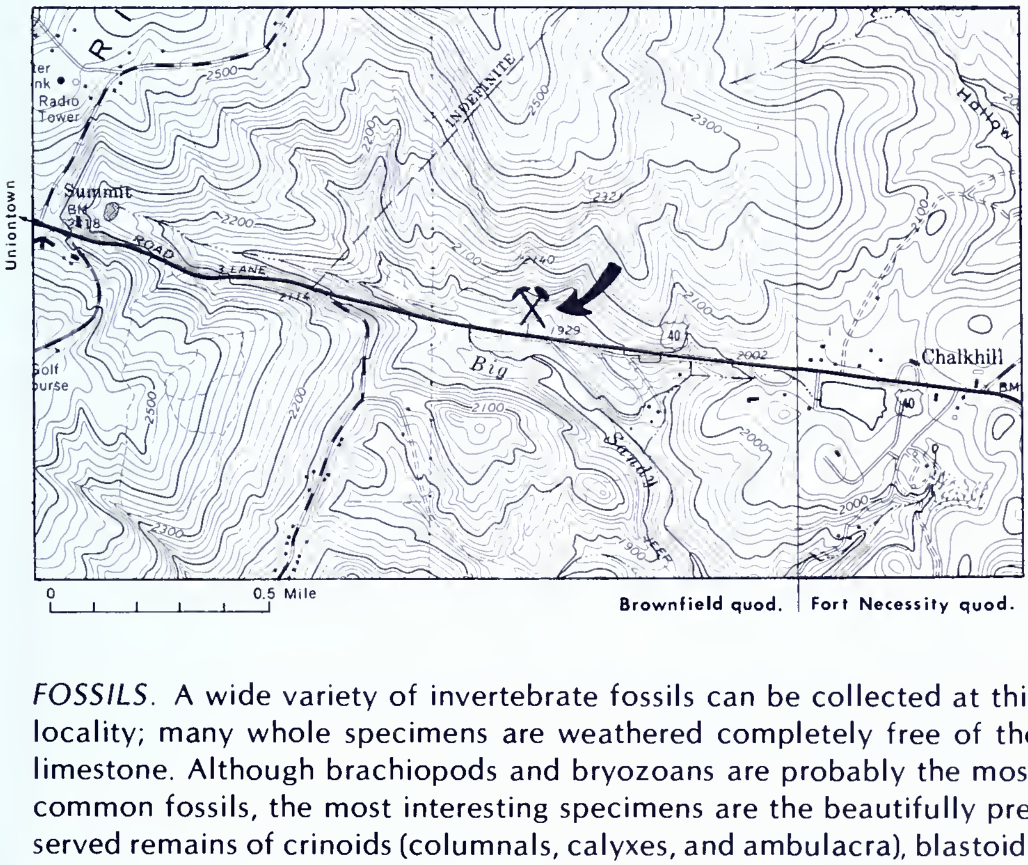
GEOLOGY. The bluish-gray shales and thin-bedded, fine-grained sandstones cropping out at these two localities represent only a small portion of the Late Devonian age Chadakoin Formation. The rocks at locality B (on I-79) are very near the top of the formation, whereas those at locality A are probably from the upper-middle part of the formation. Some of the sandstones in this unit attain a thickness of greater than 20 feet. The Chadakoin sandstones underlie the small rapids and waterfalls seen in the north-flowing streams of northern Erie County, for example, Howard Falls, a rather spectacular waterfall on Falk Run north of Franklin Center about 3.5 miles west of this area. The rocks are the result of deposition of fine-grained sediments from the Catskill deltaic regime that dominated deposition throughout Late Devonian time. The coarser grained sediments carried to sea by the Catskill river systems remained closer to shore, but the finer particles were carried farther seaward before finally settling out on the sea floor. Many species of brachiopods, burrowing pelecypods, and other animals thrived on or in the relatively soft mud that accumulated in this warm, shallow, open-marine environment. Much of Pennsylvania's oil and natural gas, valuable commodities in the state's economy, come from coarser grained sandstones deposited farther to the east and south. Some of these oil- and gas-bearing sandstones are lateral equivalents of the Chadakoin of Erie County.

FAYETTE COUNTY

SITE 20—THOMPSON QUARRY ECHINODERM AND BRACHIOPOD LOCALITY

LOCATION. Many of the best localities for collecting invertebrate fossils in southwestern Pennsylvania are in the marine Wymps Gap ("Greenbrier") Limestone of Late Mississippian age. In Fayette County the Wymps Gap is exposed in numerous active and inactive quarries on the slopes of Chestnut Ridge. One of the most accessible collecting sites in the Wymps Gap is the abandoned J. V. Thompson quarry along U.S. Route 40 on the east flank of Chestnut Ridge approximately 8 miles southeast of Uniontown. The quarry lies several hundred feet north of the highway and is currently being used as a PennDOT (Pennsylvania Department of Transportation) storage area.

Although fossils can be extracted with difficulty from the limestone ledges that crop out around the edges of the quarry, the best collecting is from soil and rubble banks in the southwest corner and against the north wall. Some specimens can also be found on the floor of the quarry in areas that are not covered by piles of PennDOT's shale and stone.



FOSSILS. A wide variety of invertebrate fossils can be collected at this locality; many whole specimens are weathered completely free of the limestone. Although brachiopods and bryozoans are probably the most common fossils, the most interesting specimens are the beautifully preserved remains of crinoids (columnals, calyxes, and ambulacra), blastoids (calyxes and columnals), and echinoids (plates and spines). Some of the crinoid columnals and stem fragments are one-half inch in diameter. The crinoid calyxes may bear a small portion of the lower "arms" (ambulacra), but usually the "arms" are separated. Some ambulacra still have the delicate pinnules attached. The blastoid fossils consist of rare small, exquisitely preserved calyxes. (Many small columnals may also be stem fragments of blastoids rather than crinoids.) The echinoid fragments are slender, somewhat prickly spines and the small six-sided plates to which a single spine was attached. The fossils listed below are illustrated on Plates 12 and 13.

BRYOZOANS
Fenestella
Polypora
Septopora
BRACHIOPODS
Rhipidomella
Orthotetes
Diaphragmus
Composita
Spirifer
Dielasma

GASTROPODS
Bellerophon
Naticopsis
Strobeus

PELECYPODS
Nuculopsis
Phestia
Pinna
Sanguinolites
Wilkingia

CEPHALOPOD
Endolobus
TRILOBITE
Kaskia
CRINOID
Eupachycrinus (columnals, calyxes, and ambulacra)
BLASTOID
Pentremites
ECHINOIDS
Plates and spines

GEOLOGY. The limestone in the Thompson quarry is the Wymps Gap Limestone of the Mauch Chunk Formation. The same limestone is exposed at site 47 in Somerset County, where it is thinner, less pure, and more shaly. The Wymps Gap was deposited approximately 340 million years ago during the Mississippian Period in a marine sea that covered much of West Virginia but only the southwestern counties of Pennsylvania. The water depth in the vicinity of what is now the Thompson quarry may have been 50 feet or more. South of this area the Wymps Gap thickens and becomes the Greenbrier Limestone. North of Fayette County the Wymps Gap Limestone is gradually replaced by the red shales and sandstones of the Mauch Chunk Formation. These "red beds" were being deposited in streams and rivers on land while the Wymps Gap Limestone was being deposited in the sea.

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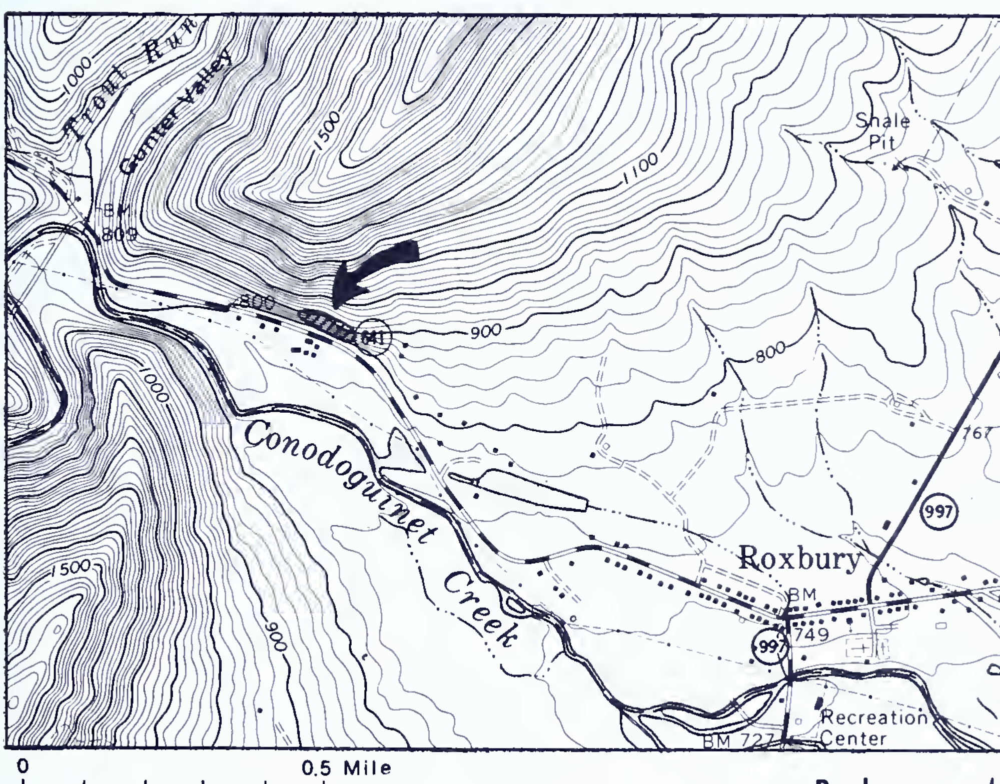
FRANKLIN COUNTY

SITE 21—ROXBURY ORDOVICIAN FOSSIL LOCALITY

LOCATION. Much of Franklin County lies within the Great Valley, a broad belt of easily eroded Cambro-Ordovician limestones and shales that curves across central and eastern Pennsylvania from the Maryland line to the Delaware River. In western Franklin County, thick quartzitic sandstones and conglomerates of Silurian and latest Ordovician age overlie the Ordovician shales that occur at the top of the Great Valley rock sequence. Along the foot of the narrow mountain ridges formed by these erosion-resistant sandstones and conglomerates, road construction has occasionally exposed a series of transitional Late Ordovician age shales and sandstones that locally contain abundant invertebrate fossils.

Probably the best place for collecting fossils from these beds is in roadcuts and abandoned borrow pits on the north side of Pa. Route 641 at the east end of the Conodoguinet Creek gap through Blue Mountain, 1 mile northwest of Roxbury. Roxbury is a village situated at the intersection of Pa. Routes 641 and 997, 12 miles north of Chambersburg. Fossils can be found throughout the entire exposed rock section, extending from



Roxbury quad.

the PennDOT storage area westward along the road to a point opposite Blue Mountain Rink. Adequate parking space exists in abandoned borrow pits at the east and west ends of the site. Between the two parking areas is a roadcut where the shoulder is narrow. BECAUSE TRAFFIC IS MODERATELY HEAVY ON THE HIGHWAY, BE ESPECIALLY CAREFUL IF YOU COLLECT IN THIS INTERVAL.

FOSSILS. Bryozoans, brachiopods, trilobites, gastropods, and crinoid columnals are the most characteristic fossils found at this locality. If you are extremely lucky and observant, however, you may find a specimen of the ophiuroid ("starfish") *Protasterina*. Most of the fossils occur as lenticular concentrations in thin siltstones (eastern part of section) or medium to thick sandstones (western part). The fossiliferous layers may contain fragments of the hard parts of many different organisms, or they may consist predominantly of the remains of one type of organism. Gastropod-rich beds are especially common in the middle of the exposed section. It appears that the rare ophiuroids occur only in the shaly layers exposed at the PennDOT storage area.

Although original (probably recrystallized) shells are preserved in unweathered sandstone beds, most of the fossils that can be reasonably identified are external and internal molds in sandstones and siltstones that have been leached of calcium carbonate. Fossiliferous sandstone blocks typically exhibit friable, brown weathering rinds around cores of gray, calcareous unweathered rock.

The fossils listed below are illustrated on Plates 1 and 2.

BRYOZOAN	GASTROPODS	CRINOIDS
Hallopora	*Liospira*	Columnals
BRACHIOPODS	*Cyclonema*	OPHIUROID
Dalmanella	TRILOBITE	*Protasterina*
Rafinesquina	*Cryptolithus*	

GEOLOGY. The rocks exposed west of Roxbury belong to the upper part of the Late Ordovician age Martinsburg Formation, a thick sequence of dominantly shaly rocks that was deposited about 440 million years ago. The lower part of the Martinsburg (believed to be several thousand feet thick in this area) accumulated in a deep marine basin, and, except for fragments of pelagic graptolites, is largely devoid of organic remains. Only during the deposition of the few hundred feet of interbedded sandstones and shales at the top of the formation were abundant marine invertebrates able to inhabit the sea floor.

The Roxbury section records a gradual shoaling of the Martinsburg sea. In the lower part (PennDOT storage area), clay and silt accumulated mainly from suspension on a moderately deep, well-oxygenated bottom.

Interbedded sandstones and shales of the upper Martinsburg Formation west of Roxbury. Fossils are very common in these beds.

Small crinoids and soft-bodied burrowing organisms were abundant, and a few ophiuroids crawled about on the sediment surface. Gentle currents periodically swept over the sea floor, depositing their loads of fine silt in thin rippled beds. In the middle and upper parts (roadcut and western borrow pit), relatively strong currents deposited medium to thick beds of sand on a relatively nearshore marine shelf that became progressively shallower through time (as shown by the occurrence of numerous 1- to 2-foot sandstone beds at the top of the section). The lenticular layers of fossil shells that occur at the base of many of the sandstone beds may represent in-place communities of organisms subjected to winnowing and short-distance transportation by currents or waves. Alternatively, some of these fossil layers may be composed of skeletal remains transported a fairly long way by high-energy waves and currents.

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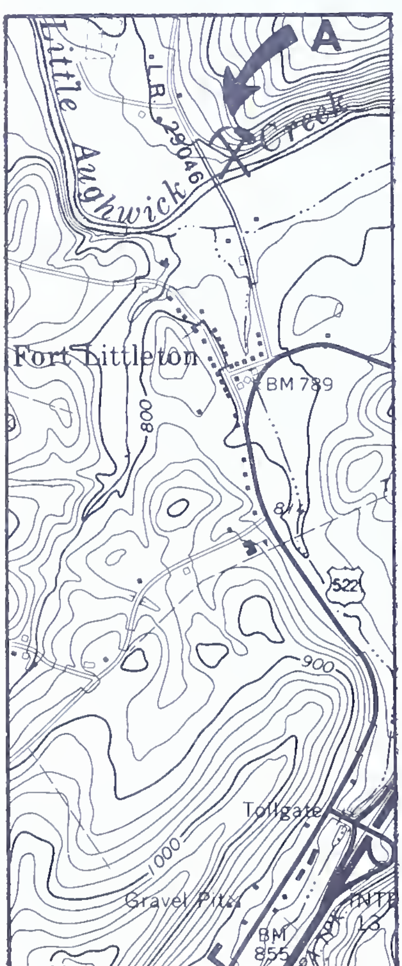
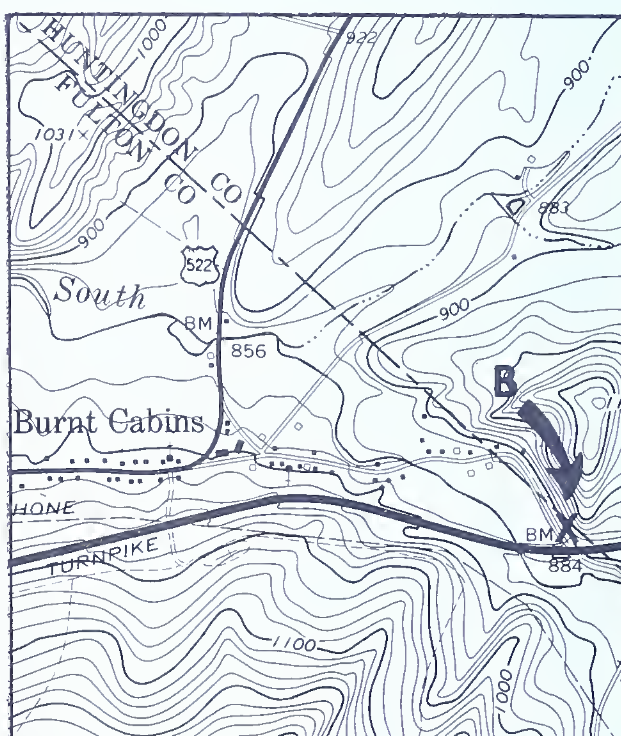
FULTON COUNTY

SITE 22—ROSE HILL OSTRACODES AND TENTACULITIDS

LOCATION. Early Silurian age "microfossils" can be found at two localities in the Rose Hill Formation about 4 miles apart in northeastern Fulton County. At both localities most of the fossil specimens are so small that you need at least a 10-power hand lens to see them.

The better of the two collecting localities (A) is an abandoned borrow pit 1.1 miles north of the tollgate at interchange 13 of the Pennsylvania Turnpike. To reach the locality from the turnpike, travel north on U.S. Route 522 from the interchange three fourths of a mile to the community of Fort Littleton. Then continue north from Fort Littleton on L.R. 29046 about 0.3 mile until you cross Little Aughwick Creek on the new bridge. To your right, on the north bank of the creek, is a borrow pit used to sup-





Burnt Cabins quad.

0 0.5 Mile

ply fill for the bridge abutments. In this pit are many specimens of rocks which contain thousands of tiny fossil ostracodes.

The second locality (B) can be reached from the same turnpike interchange by traveling on U.S. Route 522 north to the community of Burnt Cabins, a distance of 4.4 miles. In Burnt Cabins, leave U.S. Route 522 where it turns to the north and continue through the town for a distance of 0.6 mile, crossing and then recrossing the Fulton-Huntingdon County line. Along the left (northeast) side of the road is a borrow-pit area containing the same kind of rock as seen at locality A. Similar fossils may be found here, although not in as great profusion.

FOSSILS. The Rose Hill Formation in many areas characteristically contains extremely large numbers of the tiny fossil shells of ostracodes. At these localities, you may also find many thousands of impressions of *Tentaculites*, a tiny conoidal shell. This fossil is an enigma because we have no definite knowledge of the animal that formed it. Almost all of the specimens are molds of the animals. See Plates 3, 4, and 6 for illustrations of the fossils listed below.

BRACHIOPODS
Isorthis
Strophochonetes

CRICOCONARIDS
Tentaculites

TRILOBITES
Calymene

OSTRACODES
Bonnemaia

AGNATHIDS
Fish-bone fragments

GEOLOGY. The Rose Hill Formation is largely composed of olive-gray to buff, nonfossiliferous shales containing thin interbeds of fine-grained, iron-rich sandstone. At the eastern end of locality B, close to the abutment of the turnpike bridge, some coquinitic limestone layers near the top of the Rose Hill Formation are also exposed. Although these limestone layers contain a profusion of brachiopod shells, it is difficult to collect any good specimens because the rock is so hard.

The shales and thin sandstones of the Rose Hill were deposited in water that lacked nutrients or was too muddy for most animals. The tiny ostracodes are found in thin zones that have thousands of specimens crowding the exposed surfaces. Such thin fossiliferous layers probably represent "blooms" that periodically occurred when the water could support animal life.

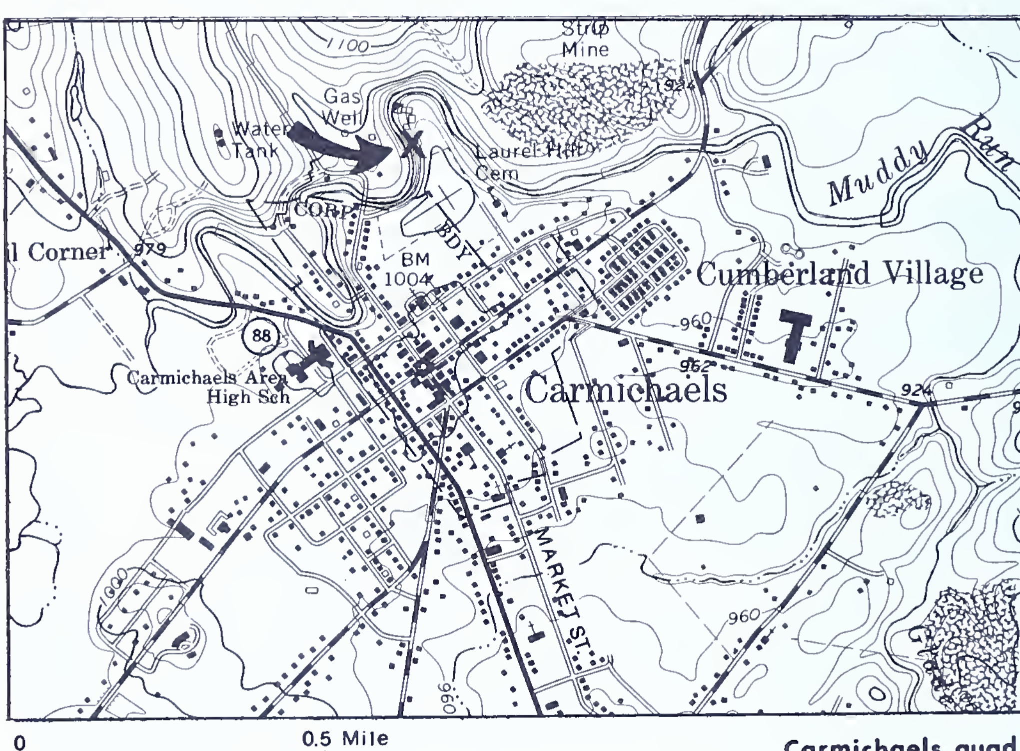
The rarer brachiopod and trilobite specimens may be the remains of animals swept into the generally muddy environment that was the sea bottom at this geologic time. The same may be true of the rare fish fragments that occur as purplish-white specks and fragments in some of the thin sandstone layers.

GREENE COUNTY

SITE 23—CARMICHAELS PLANT-FOSSIL LOCALITY

LOCATION. There are many areas in western Pennsylvania where plant fossils may be collected, particularly in coal strip mines. But because strip mines must be reclaimed, fossiliferous exposures quickly disappear. One very good natural locality not likely to disappear can be found in the bank of Muddy Run at Carmichaels, Greene County, about 12 miles east of Waynesburg on Pa. Route 88. Upon entering Carmichaels turn north on Market Street and drive to the end of town. Turn right before crossing the bridge over Muddy Run, and drive past the cemetery. The paved portion of the road ends at the cemetery, but the track continues down the hill and ends at a group of outbuildings housing a deep-mine ventilation system. Park either at the cemetery or along the dirt track and proceed on foot down the stream bank. The fossiliferous Cassville shales above the Waynesburg coal are best exposed in an undercut portion of the stream bank on the east side of Muddy Run about 50 feet downstream from a small but prominent waterfall.

WARNING: Caution should be exercised in climbing down into the deep Muddy Run gully; the hill is steep and covered with tangling vegetation and rocks capable of causing serious injury. Some of the worn paths



Carmichaels quad.

used by the citizens of Carmichaels are better than others, and the prudent collector will search for the safest means of getting down the bank, keeping this route in mind for future collecting excursions to the locality.

FOSSILS. Many different varieties of plant fossils have been described from the Cassville shales, particularly in West Virginia near the type locality of the formation. The Cassville is also well known for its fossil insect fauna, although these elusive fossils are much more difficult to find. No fossil insects have been described or reported from this locality, but the collector must always be aware of the possibility of such finds. At this locality there are several plant-fossil forms that are more abundant than others. These include leaves of a fossil horsetail rush, *Sphenophyllum*, and the fernlike pteridosperms *Neuropteris* and *Odontopteris*. The lycopsids *Sigillaria* and *Stigmaria* have been collected here as well, though not in great numbers. The avid collector should be able to find more than these few forms, which are illustrated on Plates 19 and 20. The shale has been hacked at and broken from the bank walls by collectors, and has collapsed from undercutting in some places. This provides much easily collected material. The shale breaks very readily, and many excellent fossils can be lost unless adequate precautions are taken. Be certain to have plenty of newspaper or paper towels with which to wrap the fossils before stacking them in a box or putting them in a bag.

GEOLOGY. The Cassville shale attains a thickness of up to 12 feet in parts of Greene County, forming the "roof" of the Waynesburg coal seam. The coal represents a peat deposit of rotted logs, leaves, seeds, and other plant parts from the ancient "swamp forests" typical of the Late Pennsylvanian and Early Permian Periods, 290 million years ago. The Cassville shale originated as an influx of fine mud, which covered the peat and protected it against rapid bacterial deterioration. Plant fragments from nearby "forests" blew or were washed into these sediments and became embedded to form the plant fossils we see today.

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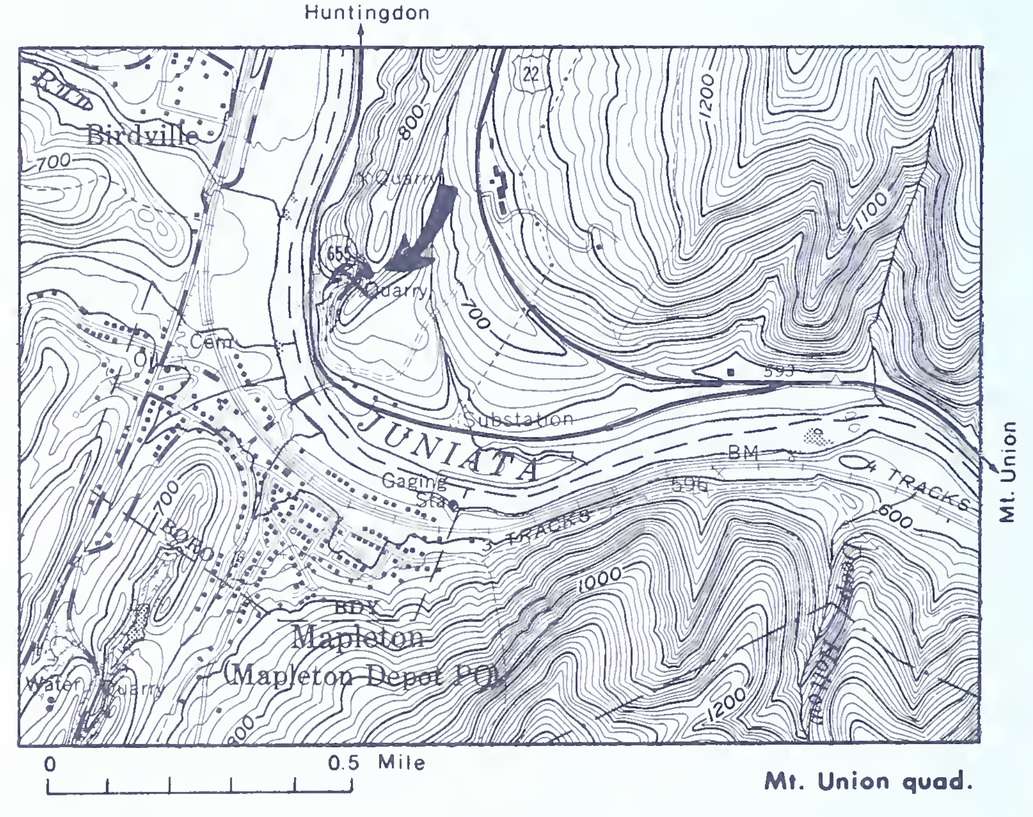
HUNTINGDON COUNTY

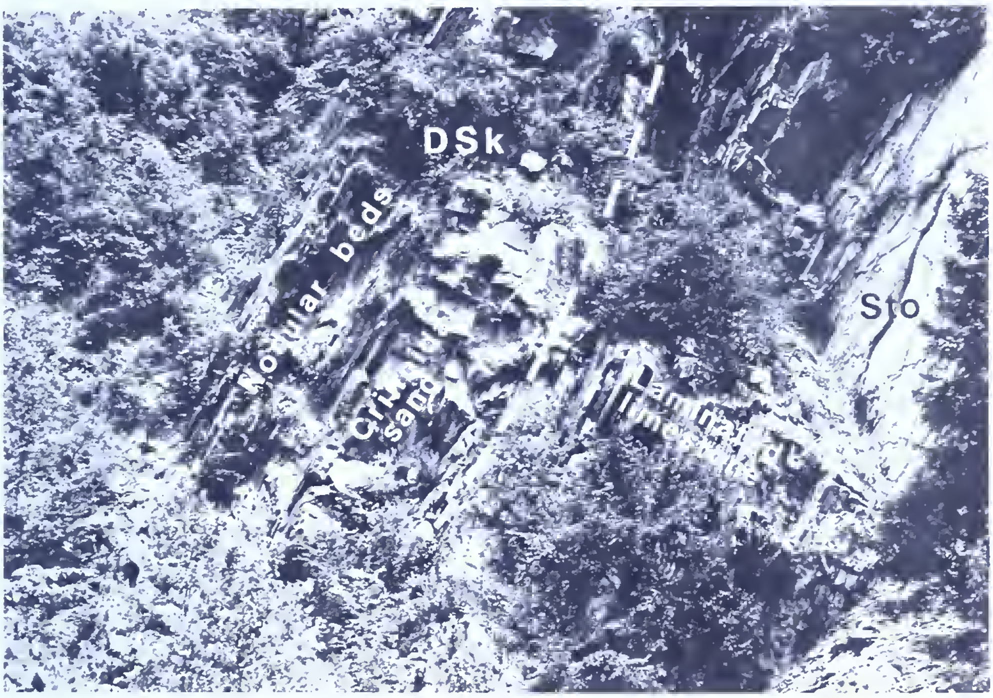
SITE 24—SWOPE QUARRY AT MAPLETON

LOCATION. Both the Tonoloway-Keyser limestones (Late Silurian to Early Devonian in age) and the somewhat younger Ridgeley Sandstone are exposed in many large quarries on the west flank of Jacks Mountain near Mapleton in eastern Huntingdon County. The most impressive of the quarries are those of the Pennsylvania Glass Sand Company in the Ridgeley Sandstone. Although the Ridgeley is highly fossiliferous, access to company property is strictly prohibited. Excellent collecting is possible, however, in the Tonoloway-Keyser limestones of the old I. N. Swope quarry along Pa. Route 655 on the east side of the Juniata River, 0.3 mile north of Mapleton. A few cars can park at the entrance to an overgrown haul road about 0.15 mile north of the Mapleton bridge.

THE ROCK WALLS OF THE QUARRY ARE HIGH AND STEEP. PLEASE EXERCISE EXTREME CAUTION AND BE WARY OF ROCKS DISLODGED FROM OVERHEAD.



FOSSILS. The Keyser limestone at this locality contains profuse well-preserved invertebrate fossils. Most easily collected are the abundant brachiopods that occur in nodular limestone beds near the base of the formation (north wall of quarry). In addition, brachiopods and corals of several different types can be found in weathered slabs on the quarry floor. Many of these fossils are weathered completely free of the surrounding rock. The uppermost beds in the quarry, though rather poorly exposed, occasionally yield large, cabbagelike stromatoporoids.



North wall of the Swope quarry. The dashed lines mark the contact between the Keyser (DSk) and Tonoloway (Sto) Formations. Several key beds are indicated.

The Tonoloway Limestone on the steeply sloping east wall of the quarry is rich in large ostracodes of the genus *Leperditia*. Small lumps on the otherwise smooth bedding planes in the Tonoloway represent algal structures, called stromatolites (not to be confused with stromatoporoids).

Only the most common and characteristic fossils of the Swope quarry are listed below and illustrated on Plates 3 to 6.

SPONGES
- Stromatoporoids

CORALS
- *Favosites*
- *Halysites*
- *Aulopora*

BRYOZOAN
- *Fistuliporella*

BRACHIOPODS
- *Isorthis*
- *Leptaena*
- *Leptostrophia*
- *Cupulorostrum*
- *Uncinulus*
- *Atrypa*
- *Meristina*
- *Howellella*

CRICOCONARID
- *Tentaculites*

OSTRACODE
- *Leperditia*

ECHINODERMS
- Crinoid and cystoid columnals

GEOLOGY. The Keyser and Tonoloway limestones exposed in the Swope quarry are mainly of Late Silurian age. (The youngest beds of the Keyser may have been deposited in Early Devonian time.) Both formations originated as limy sediments deposited in a tropical or subtropical sea that invaded central Pennsylvania approximately 405 million years ago. The laminated limestone of the Tonoloway Formation was once lime mud precipitated in protected shallow lagoons. The thin laminations were formed by films of algae that covered the floor of the lagoon and caused deposition of lime mud by removal of carbon dioxide from the warm lagoonal waters. At the base of the Keyser Formation occurs a thick bed of crinoidal sand, which is interpreted to mark a period of intense wave action that accompanied a rise in sea level. The sea continued to deepen as the lower Keyser limestones were deposited, and nodular impure limestones formed on a well-oxygenated marine shelf that teemed with invertebrate animals.

The beds in the quarry reached their present steep inclination (60 degrees to the northwest) about 250 million years ago when horizontal forces acting from the southeast formed the folded Appalachian Mountains.

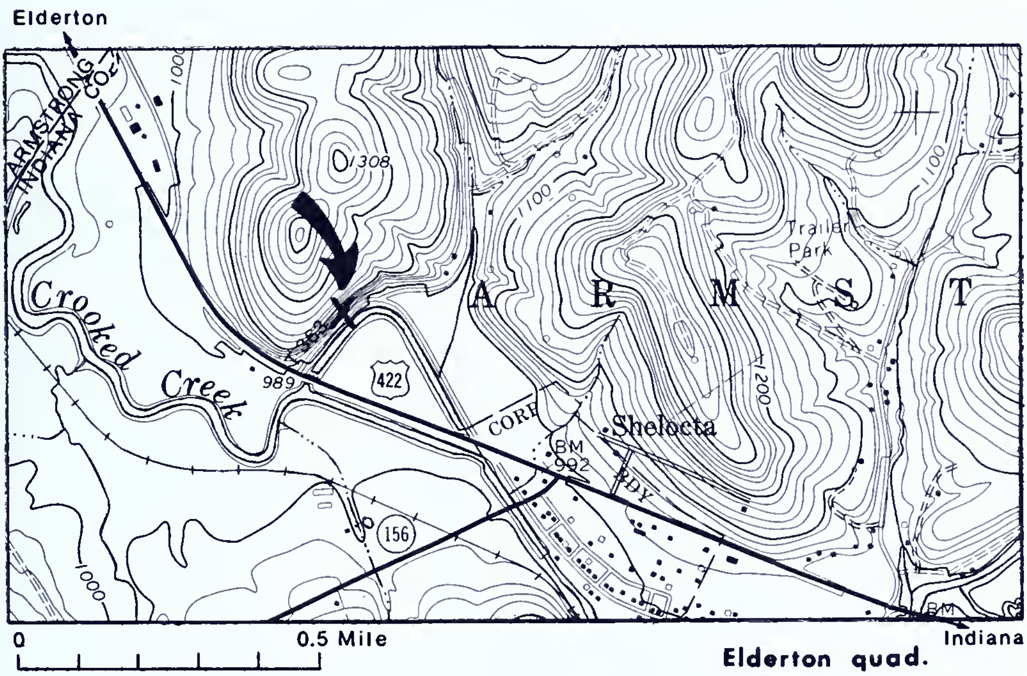
REFERENCE

Miller, C. E., Jr. (1982), *Fossil collecting locality in the Keyser Formation at Mapleton, Huntingdon County, Pennsylvania*, Pennsylvania Geology, v. 13, no. 1, p. 4–7.

INDIANA COUNTY

SITE 25—SHELOCTA GASTROPOD LOCALITY

LOCATION. Fossiliferous marine rocks of Pennsylvanian age are well exposed near the boundary line between Indiana and Armstrong Counties, approximately 9 miles west of the city of Indiana. The outcrop is a long roadcut on Armstrong Twp. Route 363 on the northwest side of Crooked Creek, 0.5 mile west-northwest of Shelocta. The cut extends north along the township road about 700 feet from its junction with U.S. Route 422. Although fossils can be found throughout most of the exposed section, the best specimens are in the dark-gray clay shales that directly overlie the 0.7-foot-thick silty limestone bed 10 feet above road level. Fossils in the limestone itself are difficult to extract.



FOSSILS. The most common fossils at this locality are small gastropods (snails). Many specimens of snails, as well as other fossils, have been weathered free of the rock and can be collected free of matrix in the clay shales above and below the limestone bed. The skeletal material of these organisms has been leached, so that in many cases the shells consist of a whitish powdery residue rather than the original calcium carbonate. Some of the fossils are also preserved as internal molds. See Plates 13 to 16 for illustrations of the fossils listed at the top of the following page.

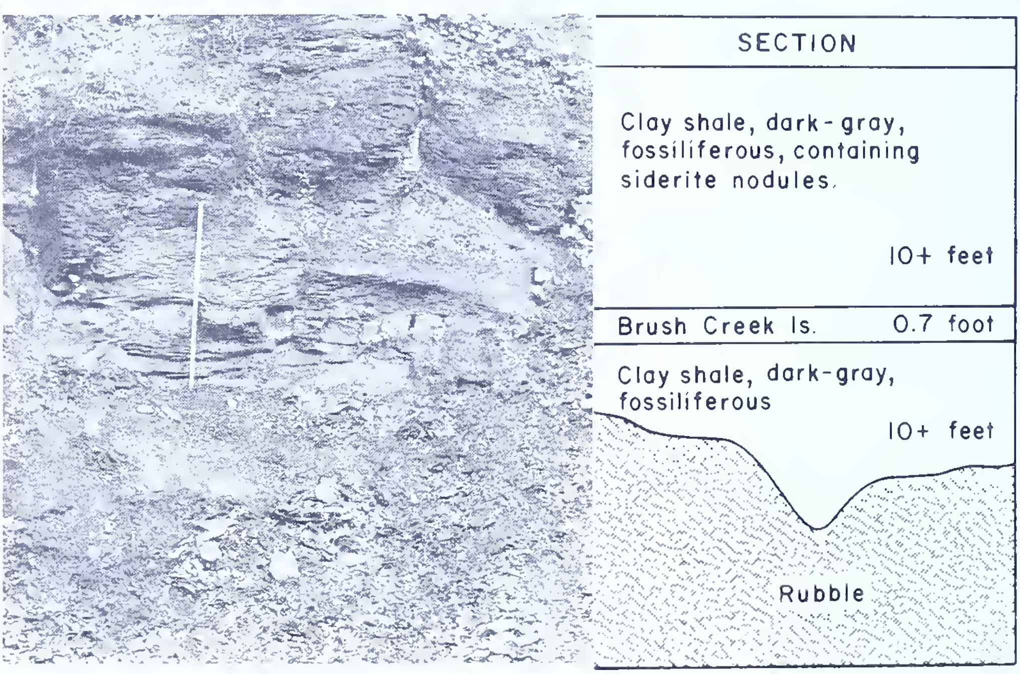
CORAL
Stereostylus
BRACHIOPODS
Chonetinella
Crurithyris
GASTROPODS
Euphemites
Bellerophon

GASTROPODS (cont.)
Pharkidonatus
Amphiscapha
Glabrocingulum
Worthenia
Shansiella
Meekospira
Strobeus

PELECYPODS
Nuculopsis
Astartella
CEPHALOPODS
Pseudorthoceras
Metacoceras
CRINOIDS
Columnals

GEOLOGY. The shale and limestone exposed in the roadcut belong to the Brush Creek marine zone of the Conemaugh Group. These beds were deposited about 305 million years ago during a brief marine incursion that covered much of western Pennsylvania. The thin limestone bed probably records the maximum extent of the marine conditions to the east and north. In the clay shales overlying the limestone bed are numerous hard siderite, or "clay-ironstone," concretions. The dark color of the shales and limestone and the occurrence of siderite nodules both suggest that mildly reducing conditions existed on the sea floor when the sediments accumulated. Many kinds of marine snails apparently were adapted to living in this muddy, low-oxygen environment.

The Shelocta locality is also an interesting mineral-collecting locality. Wurtzite, barite, chalcopyrite, and sphalerite fill shrinkage cracks in many siderite nodules.



The Brush Creek marine zone at Shelocta.

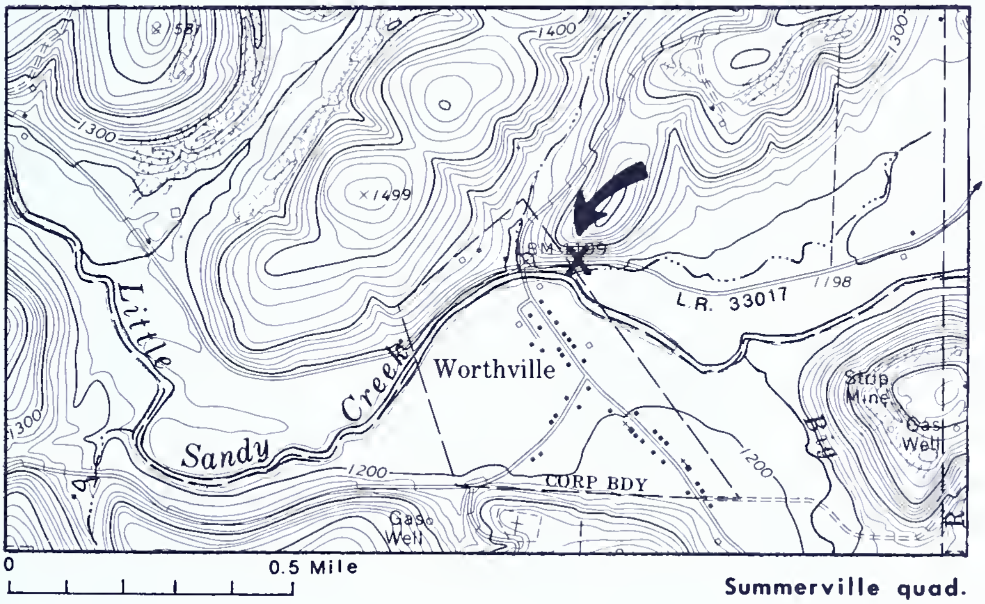
REFERENCE

Geyer, A. R., Smith, R. C., II, and Barnes, J. H. (1976), *Mineral collecting in Pennsylvania*, Pennsylvania Geological Survey, 4th ser., General Geology Report 33, 260 p.

JEFFERSON COUNTY

SITE 26—COLUMBIANA SHALE AT WORTHVILLE

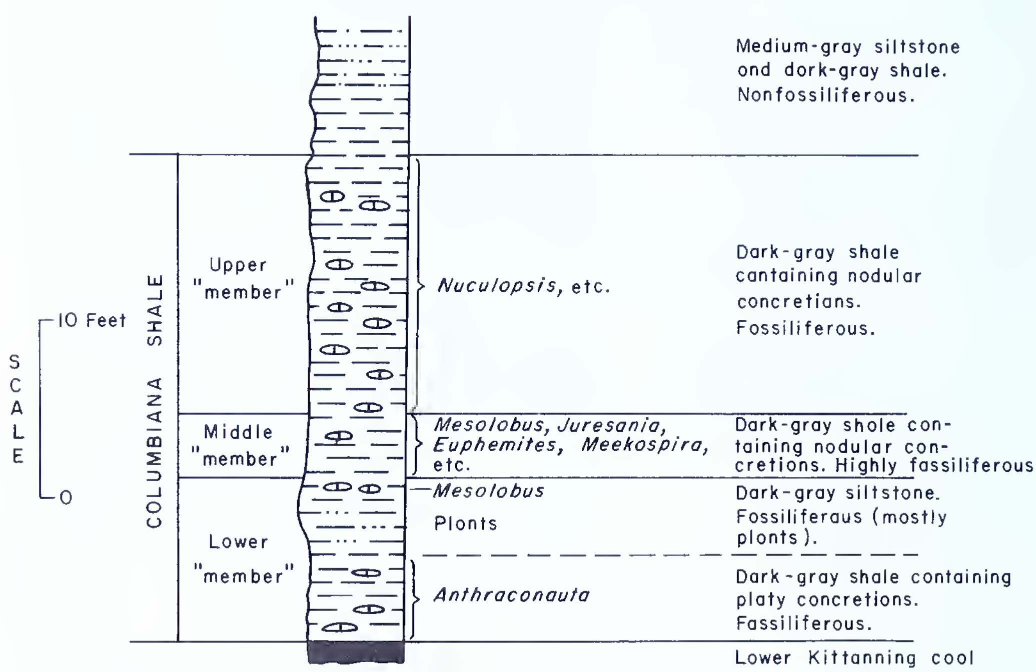
LOCATION. Jefferson County has many localities where Pennsylvanian fossils can be collected. One of these sites contains a fossiliferous, dark-gray to black shale which is readily accessible to the fossil collector. The shale crops out in a roadcut in Ringgold Township adjacent to the village of Worthville, about 10 miles northwest of Punxsutawney. The locality can be reached by traveling north on Pa. Route 36 to Coolspring, then turning west onto L.R. 33017 about 0.5 mile north of the center of the village. Follow the road along the Little Sandy Creek valley for 3.1 miles. The outcrop is on the right-hand side of the road. Parking is available along the side of the little-traveled road, but cars should be pulled off the road as far as possible to avoid potential accidents. The roadcut itself is mostly weathered shale, but there are beds of siltstone which, if undermined, could break away in large chunks. Caution should be taken to avoid being struck by any of these falling rocks. Although many of the shale layers are fossiliferous, the best fossils are found in the darkest shale, about 10 feet above road level. The shale breaks easily with a penknife and can be literally mined without much trouble.



FOSSILS. Although this locality does not contain a very diverse fauna, abundant specimens of a few fossil types, particularly the brachiopod *Mesolobus*, can be collected. Because many of the fossils are small and delicate, care should be taken to protect any collected specimens from damage. Paper towels, napkins, facial tissue, or bathroom tissue are excellent for wrapping and storing the specimens. Be careful—some specimens, especially the brachiopods, have a tendency to come loose from the shale when you least expect it. Collectors interested in plant fossils will find impressions of fossil roots in the blocks of claystone lying on the ground at the foot of the slope. These blocks come from an underclay zone near the top of the outcrop. The fossils are illustrated on Plates 13 to 16.

BRACHIOPODS
Mesolobus
Juresania
Linoproductus
GASTROPODS
Euphemites
Bellerophon
Meekospira
PELECYPODS
Nuculopsis
Anthraconauta
SCAPHOPOD
"Dentalium"
PLANTS
Root impressions

GEOLOGY. The rocks exposed at this locality consist almost entirely of shales and siltstones associated with the Lower and Middle Kittanning coals. The coals themselves are not exposed; the Lower Kittanning coal lies just below the surface at the eastern end of the roadcut. About half of the outcrop consists of the Columbiana shale, a series of rocks comprised of transitional and marine deposits containing abundant siderite concretions. The Columbiana at this locality has been divided into three informal "members." The lower "member," consisting of dark-gray shale



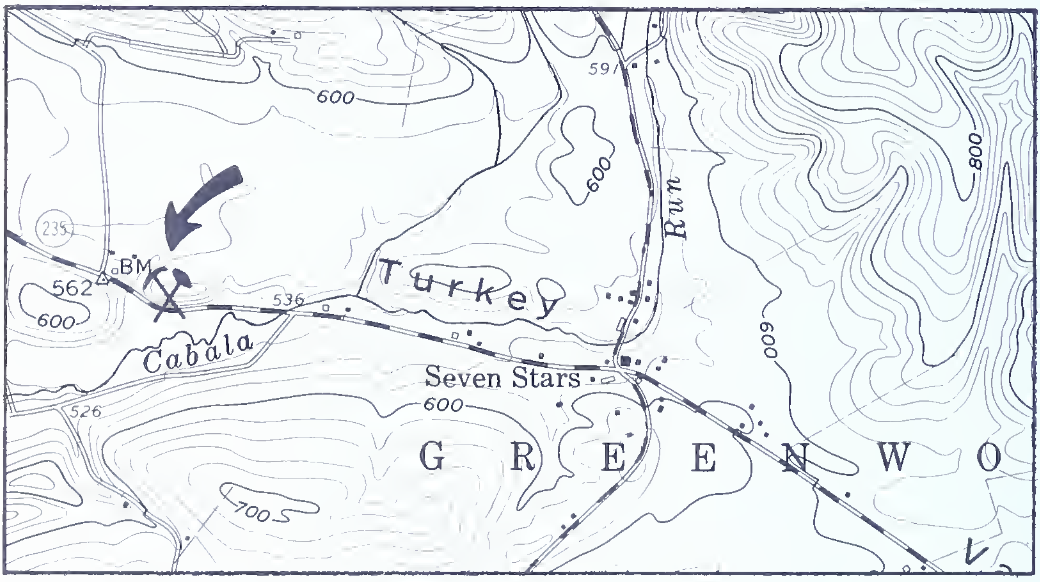
A generalized section of the Columbiana shale exposed at Worthville.

containing platy siderite concretions, a thin dark-gray siltstone, and a few plant fossils, represents a tidal-flat or lagoonal deposit. The middle "member," the most fossiliferous unit at the site, is a dark-gray to black shale containing nodular concretions and represents deposition under open-marine conditions. In many areas of central-western Pennsylvania a thin marine limestone occurs at this level in the Columbiana. The upper "member," a dark-gray shale containing nodular concretions, is also marine in origin but contains fewer fossils than either of the other Columbiana "members." The upper half of the outcrop consists of shales and siltstones, free of siderite concretions, that formed in brackish and fresh waters. The presence and shape of the concretions at the exposure are excellent guides to finding the most fossiliferous part of the outcrop.

JUNIATA COUNTY

SITE 27—SEVEN STARS PELECYPOD LOCALITY

LOCATION. An excellent locality for collecting Middle Devonian pelecypods is an active borrow pit on the north side of Pa. Route 235, 0.75 mile west of the crossroads village of Seven Stars in Greenwood Township, Juniata County. To reach the pit, travel northwestward on Pa. Route 17 from Liverpool. Approximately 1.5 miles outside Liverpool, turn right onto Pa. Route 235 and follow its winding path another 8 miles to the locality. Mr. Chester Strawser of Seven Stars owns the pit. He has given permission for individuals and groups to collect without prior authorization. PLEASE RESPECT THIS PRIVILEGE.



0 0.5 Mile

Reward quad.

FOSSILS. The Seven Stars borrow pit is noteworthy because of the abundance of pelecypod specimens and genera. Especially common are *Nuculites* and *Orthonota*. The latter is similar in shape and living habits to the modern "razor clam." Except for a small species of the brachiopod genus *Devonochonetes*, fossils other than pelecypods are relatively uncommon at this locality.

All of the fossils at Seven Stars are internal and external molds, the original calcium carbonate shells having dissolved away. Because the claystone that encloses the fossils is badly fractured, considerable care must be exercised to collect whole specimens of the larger genera. Plates 6 to 11 illustrate the fossils that occur at this locality.

CORAL
- *Pleurodictyum*

BRACHIOPODS
- *Tropidoleptus*
- *Devonochonetes*
- *Mucrospirifer*

GASTROPODS
- *Crenistriella*
- *Tropidodiscus*
- *Bembexia*

PELECYPODS
- *Nuculoidea*
- *Nuculites*
- *Palaeoneilo*
- *Leiopteria*
- *Modiomorpha*
- *Goniophora*
- *Orthonota*
- *Grammysiodea*
- *Protomya*

CEPHALOPOD
- *Bactrites*

TRILOBITE
- *Trimerus*

GEOLOGY. The rock exposed in the borrow pit is brownish-gray-weathered claystone of the upper part of the Mahantango Formation and is about 387 million years old. Although the dominant particles in the rock are clay sized, as in most shales, the very thin layers characteristic of shale are lacking. Absence of well-defined layering (bedding) in the pit may have resulted from churning of the original soft sediment by burrowing pelecypods.

Similar exposures in rocks of the Mahantango Formation in other counties of Pennsylvania also contain many of these fossils, attesting to a period of time near the middle of the Devonian Period when abundant marine life flourished on the sea bottom. Some differences in the character of the rock and the types of fossils at each exposure, however, show that the environmental conditions varied, even though all of the beds were deposited in a moderately shallow, offshore marine setting.

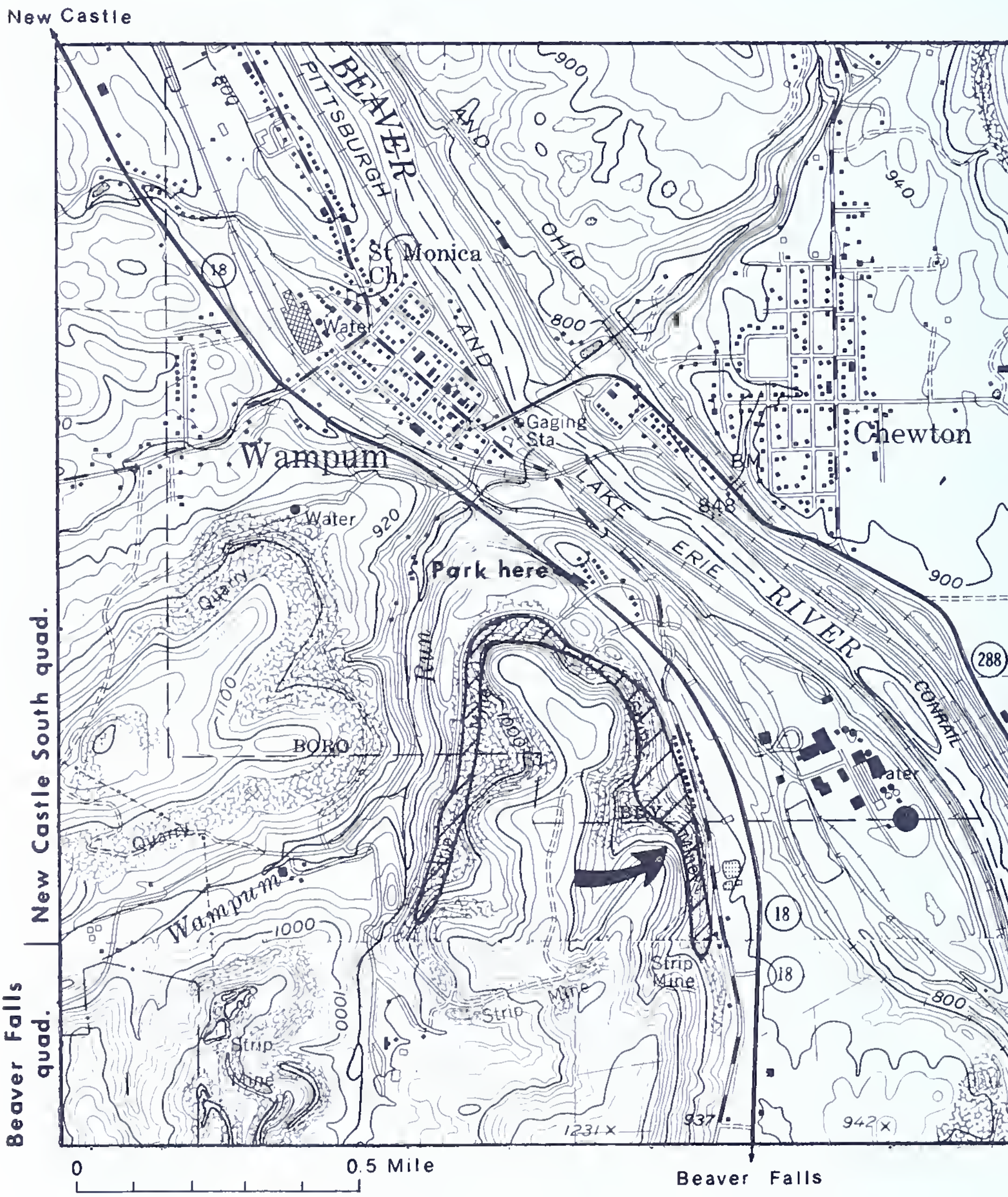
REFERENCE

Faill, R. T., and Wells, R. B. (1974), *Geology and mineral resources of the Millerstown quadrangle, Perry, Juniata, and Snyder Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 136, 276 p.

LAWRENCE COUNTY

SITE 28—WAMPUM QUARRIES

LOCATION. The abandoned Vanport Limestone quarries at Wampum just north of the Beaver-Lawrence County line have been known for many years as good localities for collecting Pennsylvanian age fossils. Wampum can be reached by traveling north from Beaver Falls or south from New Castle on Pa. Route 18. At the south end of Wampum, Route 18 goes under an old concrete bridge, which connects the borough with the largest of the quarries on the hillside to the west. This bridge can be



reached from the highway via a short unimproved road that slants off the highway and services the houses near the east end of the bridge. Parking space is available at the end of the bridge. Because a chain across the bridge entrance prevents parking or driving on the structure itself, it is necessary to walk into the quarry from this point. The old quarry road circles the hillside for about 1.5 miles, and the fossiliferous limestone is exposed along its entire length. Some areas of the quarry are better than others for fossil collecting, but only persistence and repeated trips to the locality will determine where these are. In many areas the limestone has been sufficiently weathered so that the fossils can be collected whole or observed in place in the rock.

FOSSILS. The brachiopod *Phricodothyris* is the most abundant fossil in the limestone at this locality. Also common are columnals of a large species of crinoid, which if it were reconstructed would have a full-grown height exceeding 30 feet. This locality has one of the most diverse faunas collected from the Vanport in western Pennsylvania, including many gastropods, a group of fossils not normally regarded as characteristic of the Vanport. The most common gastropod is *Euconospira*, a cone-shaped shell having preserved shell structure. Most of the other gastropods present in the Vanport are internal molds or external casts created when the shell was dissolved and replaced with lime mud. Collections made during the early 1900's are housed at the Carnegie Museum in Pittsburgh, where they can be examined under supervision of the Museum staff. The fossils listed below are illustrated on Plates 13 to 16.

CORAL
- *Lophophyllidium*

BRYOZOANS
- *Fenestrellina*
- *Septopora*

BRACHIOPODS
- *Hustedia*
- *Cleiothyridina*
- *Composita*
- *Anthracospirifer*
- *Phricodothyris*
- *Beecheria*

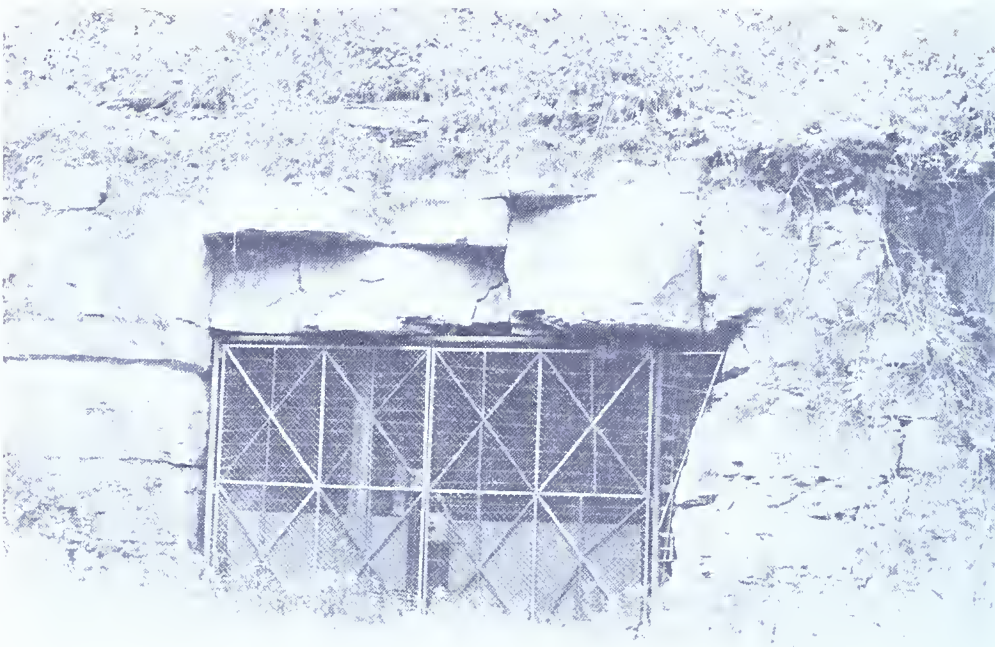
GASTROPODS
- *Amphiscapha*
- *Euconospira*
- *Ambozone*
- *Gosellitina*
- *Orthonychia*
- *Naticopsis*

PELECYPOD
- *Acanthopecten*

CRINOIDS
- Columnals

ECHINOIDS
- Plates and spines

GEOLOGY. The limestone exposed at the Wampum quarries is the Vanport Limestone, a very persistent unit near the base of the Pennsylvanian age Allegheny Group. The Vanport was quarried and mined at Wampum to support the cement and steel industries. Because of its purity, the limestone is ideal for a variety of industrial, agricultural, and construction uses.



Entrance to one of the abandoned underground mines in the Vanport Limestone at Wampum. The Vanport is about 20 feet thick in this area.

The Vanport was deposited about 315 million years ago in a shallow sea which covered most of west-central and part of southwestern Pennsylvania. Since the limestone is relatively free of muddy rocks such as shale or siltstone, the distance to shore (the nearest source of mud influx) must have been considerable. Indeed, as one goes south and east from Lawrence County, toward the ancient shoreline, the limestone becomes thinner and more impure. The abrupt change from limestone to sandstone above the Vanport indicates a rapid change in depositional environment from open marine to nearshore and terrestrial.

REFERENCE

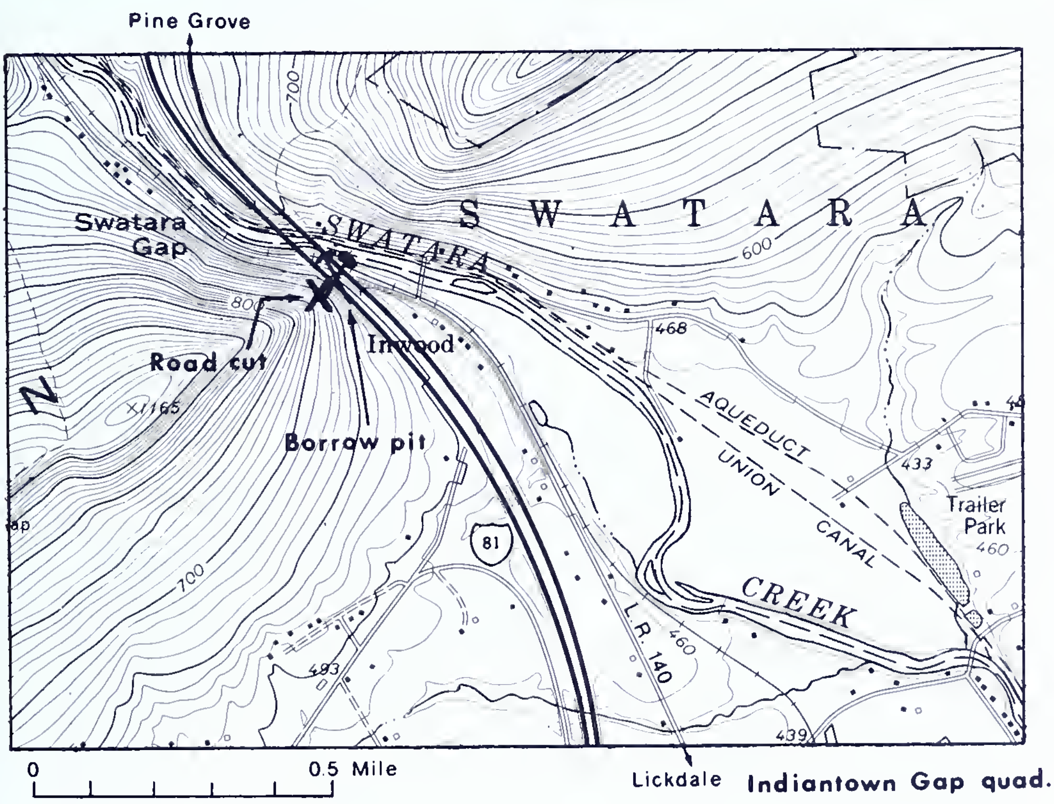
DeWolf, F. W. (1927), *New Castle quadrangle—Geology and mineral resources*, Pennsylvania Geological Survey, 4th ser., Atlas 5, 238 p.

LEBANON COUNTY

SITE 29—SWATARA GAP STARFISH AND TRILOBITE LOCALITY

LOCATION. A popular and nationally known fossil-collecting site is located in northern Lebanon County where Swatara Creek cuts a picturesque water gap (known as Swatara Gap) through Blue Mountain. Fossiliferous Ordovician age shale crops out in an abandoned borrow pit on the west side of L.R. 140 at the Interstate Route 81 overpass, 1.9 miles north of the village of Lickdale. The same shale beds are exposed in a large cut on the southbound lane of the interstate highway above the pit. The State Police prohibit access to the highway cut, however, because of the great amount of debris that collectors have dislodged onto the road shoulder.

Parking for one or two cars is available in a pull-off at the abandoned pit. DRIVERS TURNING THEIR VEHICLES ACROSS THE ROAD INTO THE PULL-OFF SHOULD EXERCISE EXTREME CAUTION, AS SOUTH-TRAVELING MOTORISTS CANNOT SEE AROUND THE BEND JUST NORTH OF THE PIT.



FOSSILS. The Swatara Gap site is famous for the abundance of well-preserved specimens of the trilobite *Cryptolithus* and the occurrence of several types of starfish, the most common of which is the ophiuroid *Protasterina*. Many other types of fossils can be found in the pit, including brachiopods, cephalopods, pelecypods, and several other genera of trilobites. The *Cryptolithus* specimens consist mostly of isolated cephalons and pygidia, but many are complete and articulated (that is, the various parts of the animal are connected as in life). Although starfish are rare, the specimens collected are commonly complete. Some of the starfish are found in burrowing positions.

All of the fossils in the Swatara Gap shale pit occur as internal and external molds of the original shells. Most of these molds exhibit a thin reddish-orange iron oxide film, which was probably deposited by groundwater in the not-too-distant past.

More than 70 genera of fossils are known from the shales in the borrow pit and interstate cut. Only the most common are listed below and illustrated on Plates 1 and 2.

BRACHIOPODS
- *Craniops*
- *Dalmanella*
- *Sowerbyella*
- *Rafinesquina*

GASTROPOD
- *Sinuites*

PELECYPOD
- *Lyrodesma*

CEPHALOPOD
- *Michelinoceras*

TRILOBITES
- *Triarthus*
- *Isotelus*
- *Cryptolithus*
- *Flexicalymene*

CRINOIDS
- Columnals

ASTEROID
- *Mesopalaeaster*

OPHIUROID
- *Protasterina*

GRAPTOLITE
- *Diplograptus*

GEOLOGY. The fossils at Swatara Gap occur in olive-gray shale at the top of the Martinsburg Formation. The fossiliferous shales accumulated on the sea floor in Late Ordovician time, about 440 million years ago. As is also noted in the description of the Franklin County site (site 21), the mass of the Martinsburg is relatively unfossiliferous. Only during deposition of the uppermost part of the formation did environmental conditions promote the existence of abundant marine life.

The fine grain size of the sediment enclosing the fossils indicates that the organisms lived in quiet, moderately deep water below the influence of significant wave and current activity. What currents there were apparently did not scour the bottom sediment, but merely carried in pulses of coarser material to form the numerous thin siltstone beds that are interlayered with the shales. The many articulated trilobites, brachiopods, and stelleroids also imply little wave or current agitation. The relatively high percentage of articulated specimens also suggests rapid sedimentation and quick burial of dead organisms.

At the north end of the I-81 roadcut, coarse sandstones and conglomerates of the Early Silurian age Tuscarora Formation abruptly overlie the Martinsburg shales. It is generally believed that the basal beds of the Tuscarora were deposited several million years after the uppermost preserved beds of the Martinsburg. Such a substantial break, or unconformity, in the geologic record indicates that this part of Pennsylvania was uplifted above sea level and subjected to erosion some time after deposition of the Martinsburg Formation and before deposition of the Tuscarora Formation.

REFERENCES

Cramer, H. R. (1957), *Ordovician starfish from the Martinsburg shale, Swatara Gap, Pennsylvania*, Journal of Paleontology, v. 31, p. 903-907.

Gerhart, Jim (in press), *Trilobites highlight a collection of fossils from Swatara Gap*, Pennsylvania Geology.

Royer, D. W. (1982), *Swatara State Park, Lebanon and Schuylkill Counties—Geologic features and fossil sites*, Pennsylvania Geological Survey, 4th ser., Park Guide 16.

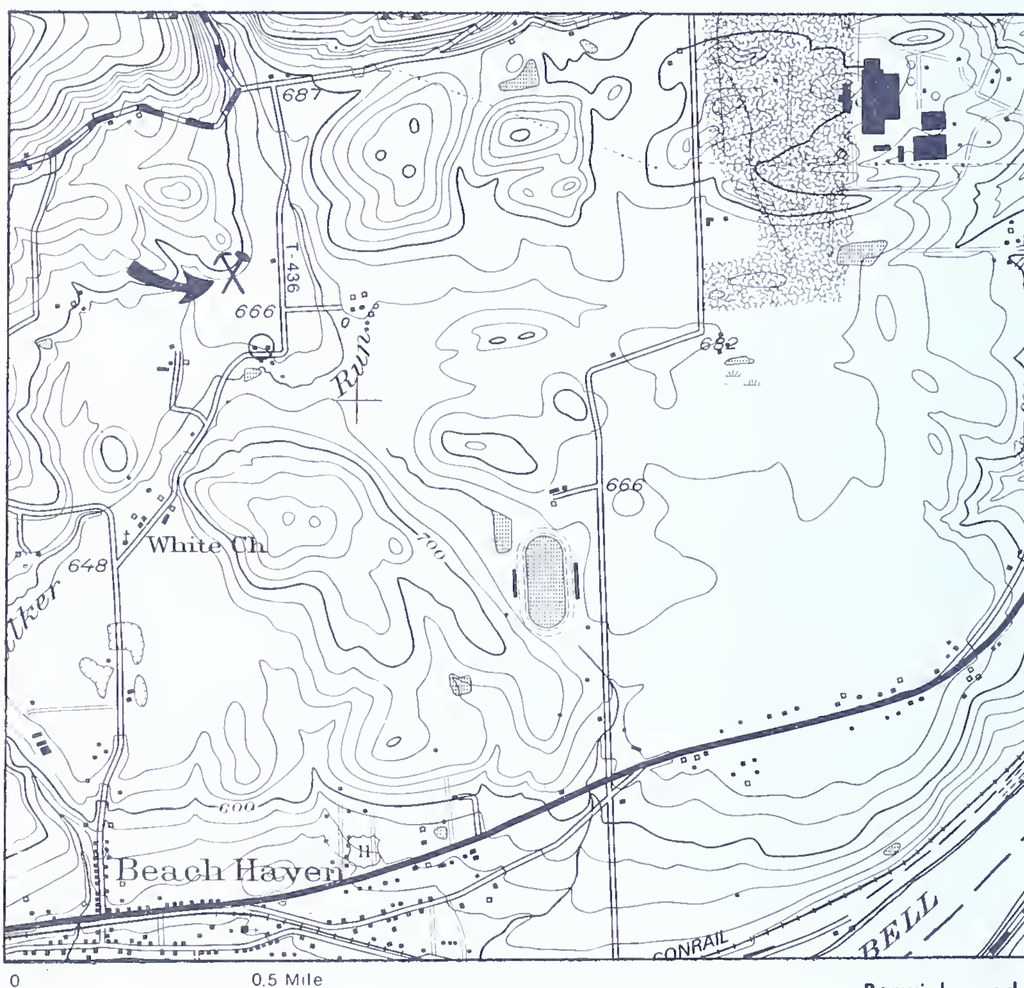
Wright, T. O., Garwood, S. M., and Derstler, Kraig (1977), *The age of the Martinsburg Formation at Swatara Gap, Pennsylvania*, Pennsylvania Academy of Science Proceedings, v. 51, p. 85-87.

LUZERNE COUNTY

SITE 30—BEACH HAVEN CORAL LOCALITY

LOCATION. In Luzerne County fossiliferous marine rocks occur in only two areas, both in the western part of the county. The southern area extends from Salem Township northeastward to Dorrance and Slocum Townships and is occupied mainly by Middle and Late Devonian age shales and siltstones of the Mahantango and Trimmers Rock Formations. Invertebrate fossils can be found in many roadcuts, quarries, and borrow pits throughout this area.

An accessible locality for collecting well-preserved Mahantango invertebrates is a small active borrow pit in Salem Township approximately 4 miles east-northeast of Berwick (Columbia County). The pit is located about 400 feet west of Twp. Route 436, 1.25 miles north of Beach Haven. Mr. Clyde Michael (who lives in the farmhouse circled on the map) owns the property. Please obtain his permission before entering the pit.



Berwick quad.

FOSSILS. The invertebrate fossils that occur at this site consist of corals, brachiopods, and pelecypods. Most abundant and best preserved are specimens of the small- to medium-sized rugose coral *Stereolasma*. The white calcareous exterior skeletons of *Stereolasma* and other corals stand out clearly against the dark-gray bedrock of the pit. The brachiopods and cephalopods exhibit another type of preservation. Remains of these invertebrates are commonly found as soft, orange-brown internal molds formed of the mineral limonite. The fossils listed below are illustrated on Plates 5 to 10.

CORALS
- *Pleurodictyum*
- *Aulopora*
- *Stereolasma*

BRYOZOAN
- *Taeniopora*

BRACHIOPODS
- *Tropidoleptus*
- *Strophodonta*
- *Protoleptostrophia*
- *Devonochonetes*
- *Atrypa*

PELECYPODS
- *Nuculoidea*
- *Cypricardella*

GASTROPOD
- *Palaeozygopleura*

CEPHALOPOD
- *Spyroceras*

GEOLOGY. The claystones of the Michael pit were deposited on the floor of a warm, relatively shallow sea that covered this portion of Luzerne County about 387 million years ago. Because the shoreline of the sea was many miles to the southeast, only relatively fine, land-derived

Michael borrow pit. The cooling towers of the Susquehanna Steam Electric Station are visible in the distance.

sediment (silt and clay) accumulated here. Fine detritus settled out of the sea water slowly, allowing marine organisms to proliferate in shallower, better oxygenated areas of the sea floor.

Although the dominant corals and brachiopods at this site lived on the sediment surface and obtained food directly from the sea water, the activity of burrowing organisms is clearly indicated by the abundance of horizontal tubular markings, several millimeters in diameter, throughout the claystone beds. These traces probably represent the feeding burrows of small, soft-bodied, wormlike creatures that extracted nourishment directly from the sediment.

Note the numerous large, rounded cobbles and boulders in the hedgerow adjacent to the pit. These are glacial erratics carried into the area by the last continental ice sheet about 15,000 years ago. A belt of hummocky, boulder-strewn terrain about 1 mile west of the pit records the maximum southwestward advance of the ice.

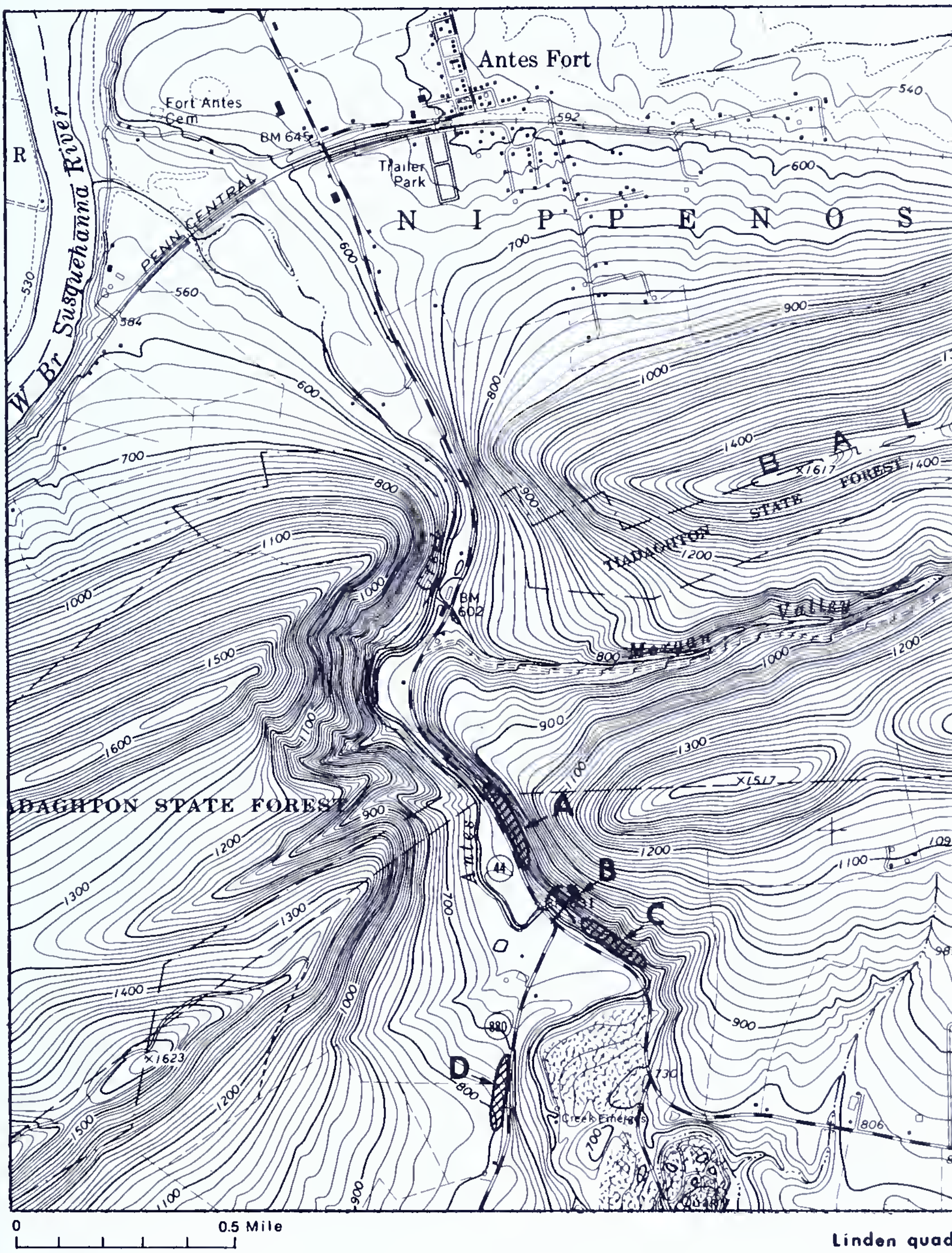
REFERENCE

Inners, J. D. (1978), *Geology and mineral resources of the Berwick quadrangle, Luzerne and Columbia Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 174c, 34 p.

LYCOMING COUNTY

SITE 31—ANTES GAP ORDOVICIAN FOSSIL LOCALITIES

LOCATION. An outstanding area for collecting fossils from a number of Ordovician age geologic formations is at the south end of Antes Gap in southwestern Lycoming County. Antes Gap is a picturesque defile in Bald



Linden quad.

Eagle Mountain through which Antes Creek flows northward out of the Nippenose Valley. Four fossiliferous formations are exposed in the area. The best spots for collecting from each are as follows:

(A) Reedsville Formation—roadcuts on the east side of Pa. Route 44, 1.8 miles south of the village of Antes Fort

(B) Antes Formation—abandoned borrow pit behind a partially completed building on the northeast side of Antes Creek, 200 feet east-southeast of the northern of two highway bridges across the creek

(C) Antes and Coburn Formations—natural exposures on the northeast bank of Antes Creek, beginning 400 feet southeast of (B) and extending along the creek approximately 500 feet to the southern of the two highway bridges

(D) Salona Formation—cut along Pa. Route 880, 0.4 mile south of the intersection of this road with Route 44, 2.3 miles south of Antes Fort

Exposures B and C are on land owned by Mr. John C. Youngman, Sr., of Williamsport. Mr. Youngman has kindly given permission for collectors to visit the localities. Please respect this privilege.

Convenient parking for the first three sites is on the wide east shoulder of Pa. Route 44 north of the downstream bridge. Traffic on this road is moderately heavy. Be especially careful of the large trucks coming from nearby quarries in the Nippenose Valley. Exposure C is accessible only when Antes Creek is relatively low and can most easily be reached by fording the stream.

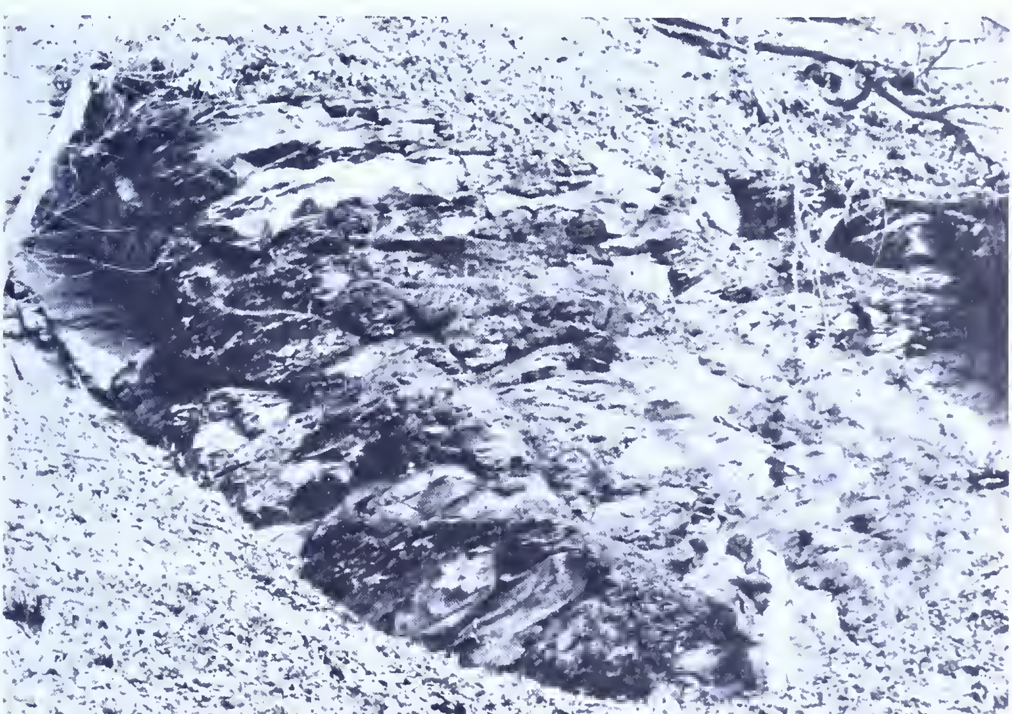
Exposure D is on a narrow winding road, along which there is little room for parking. One or two cars can park in a pull-off area on the east side of the road approximately opposite the north end of the outcrop. Although traffic on this road is relatively light, trucks from a large quarry 1.25 miles to the southwest frequently travel it at a high rate of speed. Motorists coming north on the highway are also not able to see people collecting at the exposure because of a sharp bend and rise at its south end. Only a few feet of shoulder exists between the pavement and the outcrop. BE VERY CAREFUL!

FOSSILS. Invertebrate fossils of many types can be collected at the Antes Gap exposures. Brachiopods and crinoid columnals occur in all four formations; trilobites (mostly fragments) are common in the Antes, Coburn, and Salona; bryozoans are abundant in the Coburn; and graptolites (rare in the Reedsville) abound in the Antes borrow pit.

The manner and state of fossil preservation differ considerably among the four formations. In the limestones (Salona, Coburn, and lower Antes), the fossils consist primarily of original (recrystallized?) shell material. Shell detail is especially good in specimens from the Salona. Graptolites in the Antes shale are preserved as black, carbonaceous compressions that resemble graphitic pencil marks. (This typical mode of fossilization gave rise to the name graptolite—from the Greek "grapho-," to write, and "lith-," stone.) Fossils in weathered Reedsville shale and siltstone are mainly external and internal molds; fresh rock contains original (recrystallized?) shells.

Plates 1 and 2 illustrate the fossils listed below.

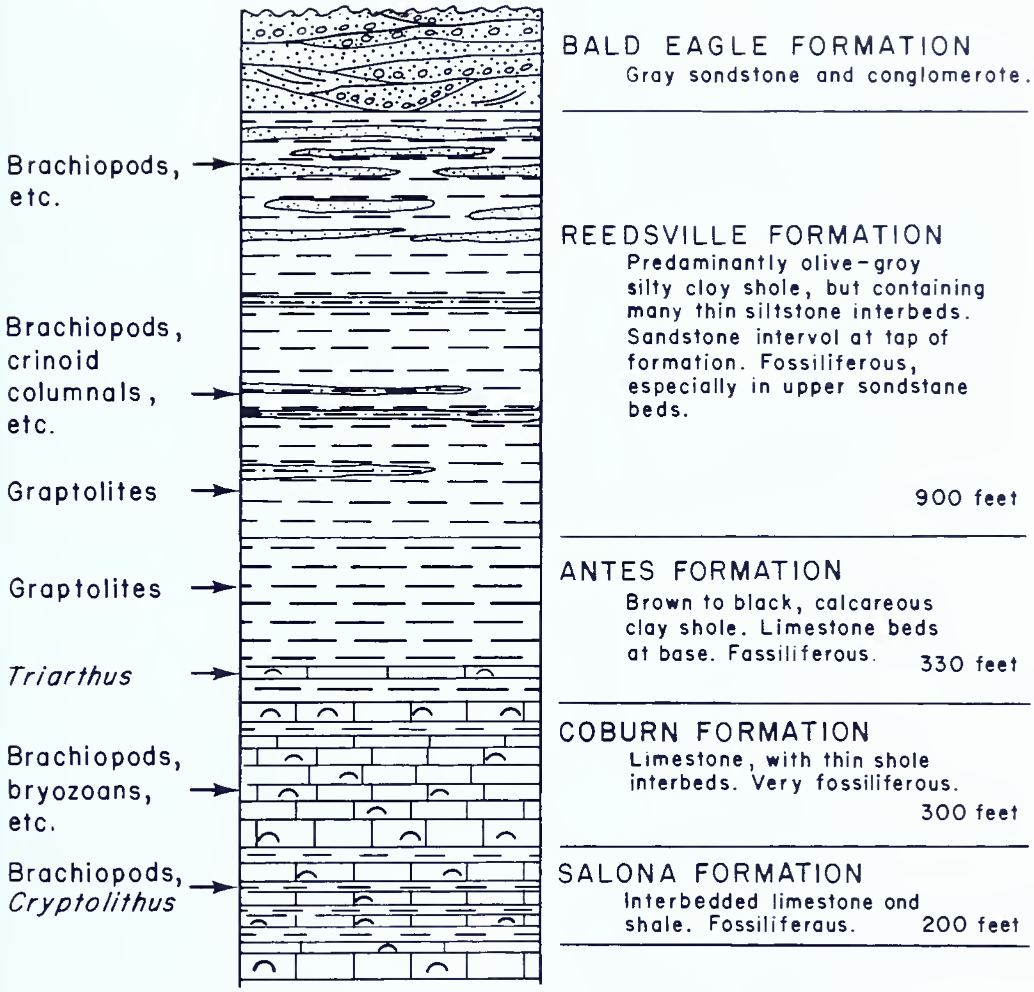
Reedsville Formation:	Antes Formation:	Coburn and Salona Formations:
BRYOZOAN	BRACHIOPOD	BRYOZOANS
Hallopora	*Dalmanella*	*Prasopora*
BRACHIOPODS	TRILOBITE	*Hallopora*
Dalmanella	*Triarthus*	BRACHIOPODS
Sowerbyella	GRAPTOLITE	*Dalmanella*
PELECYPOD	*Dicranograptus*	*Plectorthis*
Ambonychia		*Sowerbyella*
CRINOIDS		*Rafinesquina*
Columnals		TRILOBITES
GRAPTOLITE		*Cryptolithus*
Climacograptus		*Ceraurus*
		CRINOIDS
		Columnals of several shapes



Black, graptolitic shale of the Antes Formation in the abandoned borrow pit behind the unfinished building on the bank of Antes Creek. Shale from this locality was reportedly used as pigment and filler in paint for warships during World War II.

Medium-bedded fossiliferous limestones of the Coburn Formation exposed on the east bank of Antes Creek.

GEOLOGY. The rock formations exposed at the south end of Antes Gap record a succession of tropical marine depositional environments that existed in this area approximately 455 million years ago. From oldest to youngest, these environments are as follows: (1) shallow, well-oxygenated carbonate banks and shoals (Salona and Coburn limestones); (2) deep-water, poorly oxygenated basin (Antes shales); (3) moderately deep water, offshore, deltaic slope (lower Reedsville shales and siltstones); and (4) shallow, nearshore, deltaic platform (upper Reedsville shales and sandstones). The uplift and subsequent erosion of mountains located far to the southeast brought about the profound increase in land-derived sand, silt, and clay deposition that characterizes the younger formations. Other earth movements associated with the mountain building caused a deepening of the sea floor at the same time that more and more land-derived sediment was washed into the sea. As sediment poured into the basin faster than the sea floor subsided, nearshore sandy conditions grad-



A generalized section of Upper Ordovician rocks at the south end of Antes Gap, showing the fossiliferous beds.

ually spread to the northwest, eventually reaching what is now Lycoming County.

A similar, but more abbreviated, sequence of Late Ordovician age rocks can be examined 34 miles to the southwest at Bellefonte, Centre County (site 11). The occurrence of *Triarthus*-rich beds in the lower Antes at Bellefonte, as well as here at Antes Gap, is illustrative of the relatively uniform nature of deeper water sedimentation in the Ordovician seas.

REFERENCES

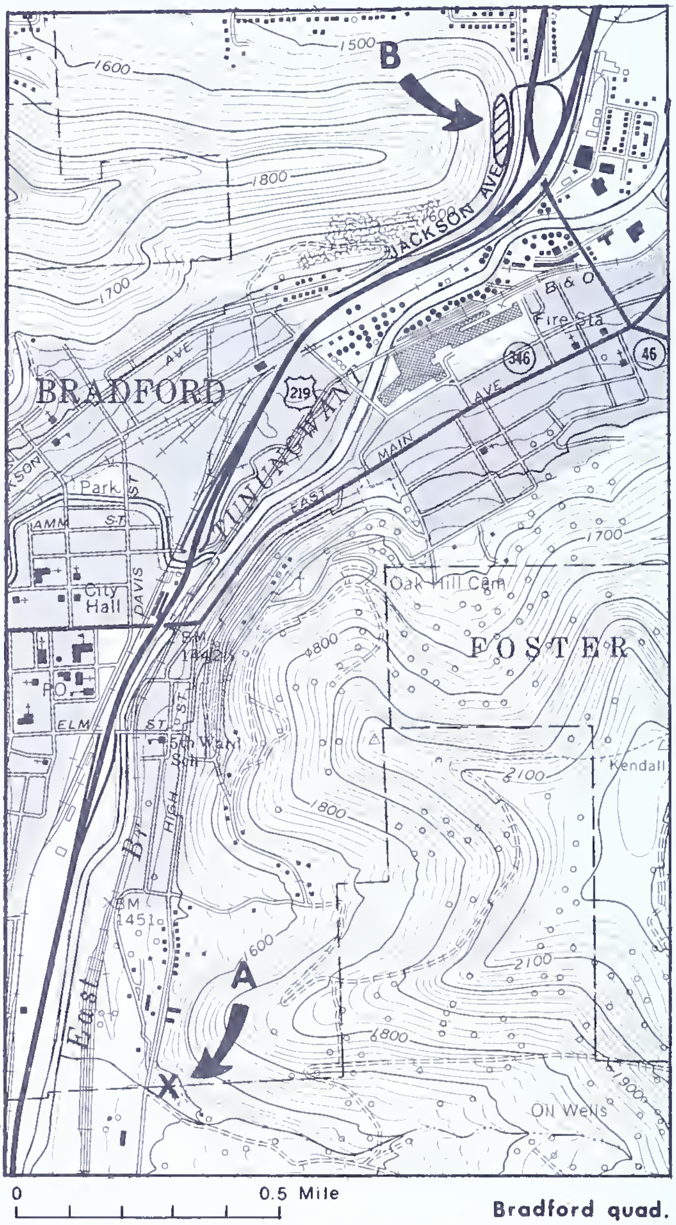
Faill, R. T., Wells, R. B., and Sevon, W. D. (1977), *Geology and mineral resources of the Linden and Williamsport quadrangles, Lycoming County, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 134ab, 66 p.

Thompson, R. R. (1963), *Lithostratigraphy of the Middle Ordovician Salona and Coburn Formations in central Pennsylvania*, Pennsylvania Geological Survey, 4th ser., General Geology Report 38, 154 p.

McKEAN COUNTY

SITE 32—BRACHIOPODS AND PELECYPODS IN OIL COUNTRY

LOCATION. At several localities near Bradford, one of the centers of oil production in Pennsylvania, Late Devonian age fossils occur in great abundance. Several quarries have been operated along the sides of the valley of Tunungwant Creek, and fossils can be found in each one, as well as in some roadside exposures.



Two localities are recommended. The first (A) is a quarry about 0.9 mile south of the intersection of Main and High Streets in Bradford, on the east side of Tunungwant Creek. The quarry extends about 0.1 mile northward, where it serves as a parking area for local businesses.

The second locality (B) is on the west side of Jackson Avenue near where it ends at its intersection with U.S. Route 219 at the north end of the city. Here the cut bank exposes layers of sandstone and shale that weather loose and fall down the slope to make easy collecting. Many of the specimens at this site contain well-preserved molds of pelecypods.

Some of the blocks in the quarry are weathered only at the surface. When these are split, they reveal fossil specimens that have shell material intact. Breaking these specimens is difficult because the calcium carbonate cement binds the sand grains and fossils tightly together.

FOSSILS. See Plates 6, 8, and 21 for illustrations of the fossils listed below.

BRACHIOPODS
Ptychomaletoechia
Cyrtospirifer
PELECYPOD
Leiopteria

TRACE FOSSILS
Planolites
Unidentified trails

GEOLOGY. The rock layers that underlie the slopes of Tunungwant Creek are included in the Chadakoin Formation of Late Devonian age. The Chadakoin consists of alternating layers of sandstone and shale, similar to the overlying Venango Formation. All of these rocks were deposited in marine waters about 370 million years ago.

The sea bottom was constantly changing as sand and silt were swept in by swiftly moving currents, and clay was deposited at times of weak current activity. Periodically the sea bottom was colonized by the young of what must have been fairly robust brachiopods and pelecypods. The lack of a large number of species suggests that only these were adapted to the harsh environment of shifting sands, rapid currents, and intermittent turbidity. The abundance of *Cyrtospirifer* and *Leiopteria* in certain layers suggests that they may have lived in large masses similar to living oyster banks or mounds.

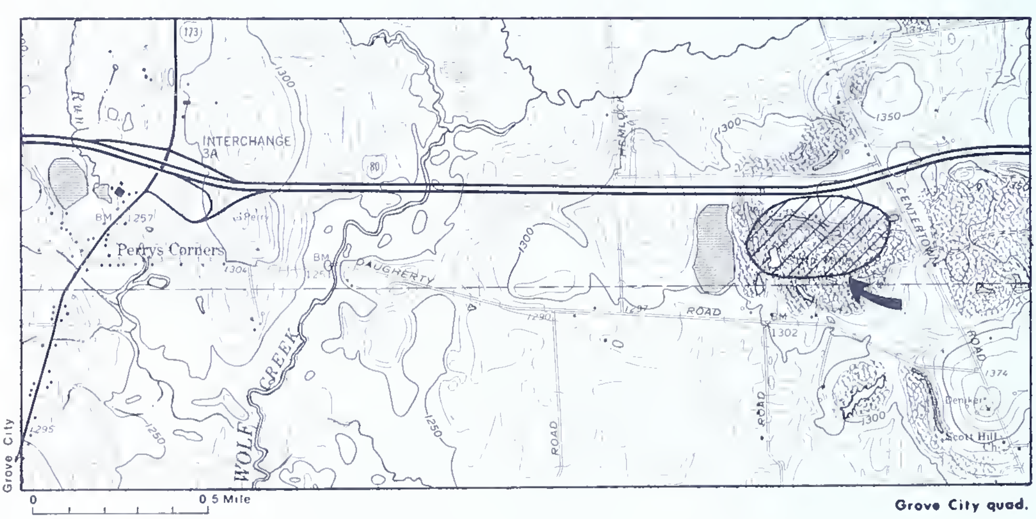
There was also a large fauna of burrowing animals that did not have shells, as seen in the numerous burrows associated with the shelly fossils.

MERCER COUNTY

SITE 33—FUSULINIDS AND BRACHIOPODS IN THE VANPORT LIMESTONE

LOCATION. In Mercer County fossils can be collected from many abandoned coal strip mines that expose the Pennsylvanian age Vanport Limestone. An abandoned strip mine northeast of Grove City is an ideal collecting locality because it is readily accessible. The strip mine was bisected during the construction of Interstate Route 80, thereby reducing the original areal extent of collecting territory, but nearby interchange 3A makes I-80 a good means of getting to the site. From interchange 3A travel south toward Grove City on Pa. Route 173 for about 0.3 mile. Turn left onto Daugherty Road and travel to its end, about 2.5 miles. Turn left on Centertown Road and travel about 0.6 mile north, back toward I-80. About 100 feet before passing under I-80 turn left onto a dirt track that used to serve as the access road to the mine. The mine access road is now impassable to all but off-road vehicles, so those in other vehicles should park at the wide entrance and walk into the mine. The Vanport Limestone crops out low in the walls of the mine pits. Blocks of limestone can also be seen in some spoil piles around the pits.

CAUTION: THE PITS ARE DEEP AND CONTAIN WATER TO AN UNKNOWN DEPTH, AND THE PIT WALLS ARE STEEP. BE PREPARED TO TAKE EXTRA PRECAUTIONS TO AVOID SLIPPING OR FALLING INTO THE PONDS.



Grove City quad.

FOSSILS. Because the Vanport Limestone is massive and very hard, it is not an easy formation from which to collect fossils. It occasionally contains some layers of shale or muddy limestone which are softer and more easily broken. Such is the case at this locality, where an occasional slab of shaly limestone yields a good supply of fossils. As with most Vanport localities, brachiopods are the most common fossil forms. In addition to the usual fauna, however, the limestone at this site contains specimens of "forams" of the family Fusulinidae. "Forams" are one-celled, generally microscopic creatures, but the fusulinids grew to relatively "large" sizes. Here they are normally the size of wheat grains. The fusulinid genus *Fusulina* can be observed on the weathered surfaces of the limestone. These fossils are often partially eroded, and the intricate internal network of chambers and walls can readily be seen if a hand lens is used. The fossils listed below are illustrated on Plates 13, 14, and 15.

"FORAMS"
Fusulina
CORAL
Lophophyllidium
BRYOZOANS
Septopora
Rhombopora
BRACHIOPODS
Anthracospirifer
Phricodothyris
GASTROPOD
Gosellitina
CRINOIDS
Columnals
ECHINOIDS
Spines and plates

GEOLOGY. The Vanport is typically a very "pure" limestone, containing little in the way of clay or silt impurities. It is an excellent commercial limestone having a composition suitable to many uses including cement, fluxing lime, agricultural lime, and road aggregate. The purity of the limestone and the abundant fusulinids and crinoids that it contains indicate that the Vanport was deposited in relatively deep water too far from land to allow an appreciable influx of clay and silt. Minor exceptions to this generalization occur, especially at the contacts of the individual limestone beds, where thin muddy limestones or limy shales separate massive limestone blocks.

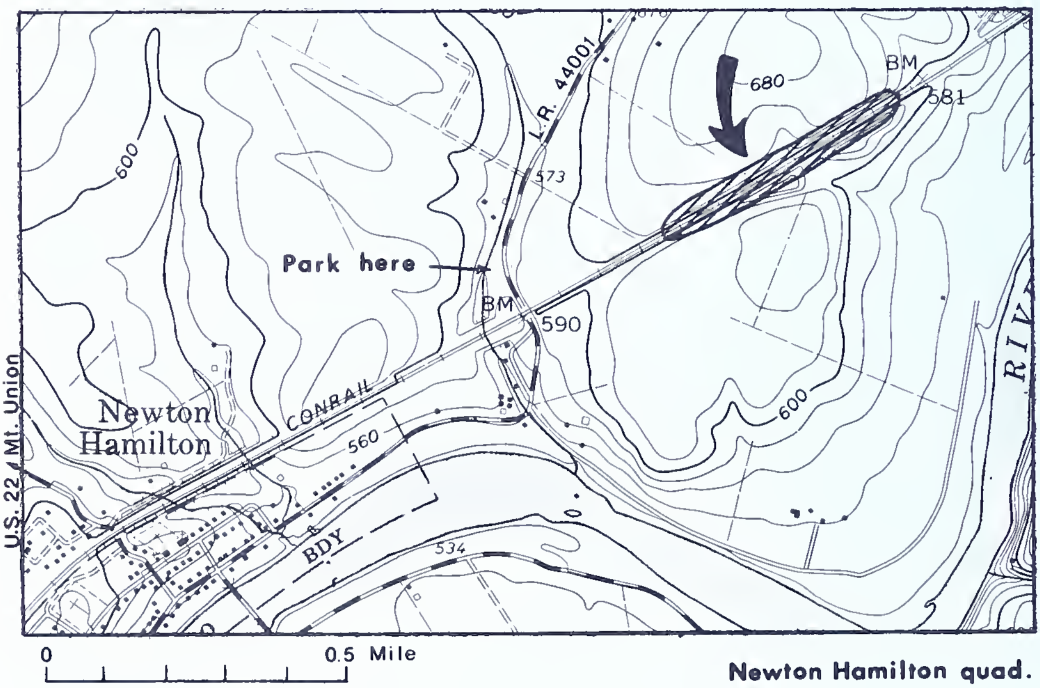
The Vanport Limestone was deposited about 315 million years ago. It formed during one of the few periods that marine waters encroached for any appreciable length of time onto the coastal systems that characterized deposition in the Pennsylvanian Period.

MIFFLIN COUNTY

SITE 34—NEWTON HAMILTON RAILROAD CUT

LOCATION. One of the best spots in central Pennsylvania for collecting fossils from the Early and Middle Devonian age Onondaga Formation is in a deep cut on the Conrail tracks approximately 1 mile northeast of Newton Hamilton. The railroad cut is more than 2,000 feet long and exposes gently dipping, fossiliferous shale and limestone beds that constitute nearly the entire thickness of the Onondaga in this area. The best collecting is in calcareous shales near the middle of the cut, but some very interesting fossils can also be found in the limestone layers in the southwestern part.

Parking space for several vehicles is available on the west side of L.R. 44001 about 500 feet north of a large stone railroad overpass. To reach the collecting locality, climb up the railroad embankment and walk northeastward along the tracks approximately 0.5 mile into the railroad cut. Trains pass through the cut every 20 to 30 minutes; most are slow moving and give adequate warning. There is plenty of room between the tracks and the rock wall on both sides of the cut. BE ON THE ALERT FOR FAST PASSENGER TRAINS. THIS LOCALITY IS NOT RECOMMENDED FOR LARGE GROUPS.



0 0.5 Mile

Newton Hamilton quad.

FOSSILS. The rocks exposed in the Newton Hamilton railroad cut contain an unusual assemblage of fossils, many of which are quite small.

Especially interesting are the inarticulate brachiopods (*Lingula* and *Orbiculoidea*) that are common in dark-gray calcareous shales 850 feet southwest of the 186 milepost and the large trilobite pygidia (*Odontocephalus*) that occur in limestone beds 1,500 feet southwest of the milepost.

Fossils in the cut are preserved in a variety of ways. Many of the brachiopods and trilobites retain the original skeletal material. The gastropods and cephalopods in the shaly beds are commonly replaced by pyrite (iron sulfide). Limestone beds at the very top of the exposed section contain coiled gastropods in which the shell cavities are filled with coarsely crystalline calcite. Internal and external molds of most of the fossils can also be found.

Illustrations of the fossils listed below are on Plates 6 to 11 and 21.

BRACHIOPODS
- *Lingula*
- *Orbiculoidea*
- *Anoplia*
- *Eodevonaria*
- *Pacificocoelia*
- *Ambocoelia*

GASTROPODS
- *Bembexia*
- *Platyostoma*
- *Palaeozygopleura*

PELECYPODS
- *Nuculites*
- *Praecardium*

CEPHALOPODS
- *Michelinoceras*
- *Bactrites*
- *Agoniatites*

CRICOCONARID
- *Styliolina*

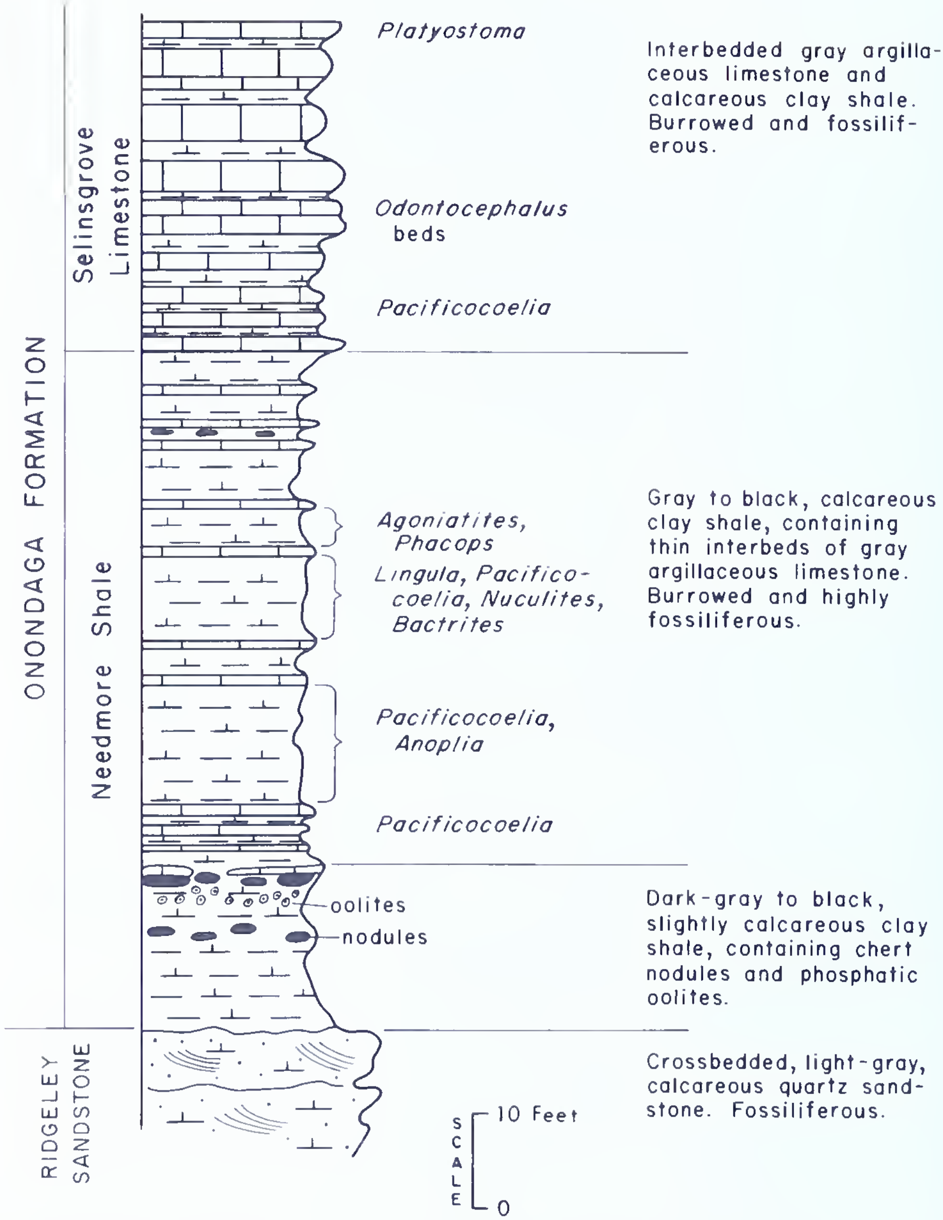
TRILOBITES
- *Phacops*
- *Odontocephalus*

TRACE FOSSIL
- *Chondrites*

GEOLOGY. Nearly the entire 110-foot thickness of the Onondaga Formation crops out in the Newton Hamilton railroad cut. As shown in the columnar section, the lower part of the formation is dominantly shale (Needmore Shale Member) and the upper part is interbedded limestone and shale (Selinsgrove Limestone Member).

The Onondaga shales and limestones formed from limy muds that accumulated in fairly deep water (100 to 200 feet) in a tropical sea about 390 million years ago. Some of the obvious features of these rocks that point to deposition under deep-water, low-energy conditions are the following: (1) fine grain size (silt- and clay-sized particles); (2) abundance of horizontal burrows (*Chondrites*); (3) pyrite (iron sulfide) in many beds; (4) occurrence of small, unbroken fossils; (5) lack of any evidence of the activity of currents, such as crossbedding or layers of broken fossils; and (6) abundance of *Styliolina*, a small, needle-shaped, swimming or floating animal, in the upper limestone beds. The widespread occurrence of pyrite also indicates poor circulation in the sea water and low oxygen levels in the bottom muds. (In marked contrast, the older Ridgeley Sandstone exposed at the northeast end of the railroad cut exhibits many features typical of shallow-water, high-energy deposition, including coarse grain size, crossbedding, and large broken fossils.)

The small, black, BB-shaped phosphatic "oolites" and hard, dark-gray chert ("flint") nodules in the lower part of the Needmore Shale probably formed at a time when little sediment was accumulating on the sea floor.



A generalized section of the Onondaga Formation in the Newton Hamilton railroad cut. Note the fossiliferous beds.

The phosphate was derived from the decay of organic material, and the chert originated in part from the breakdown of silica-rich skeletal fragments (for example, sponge spicules).

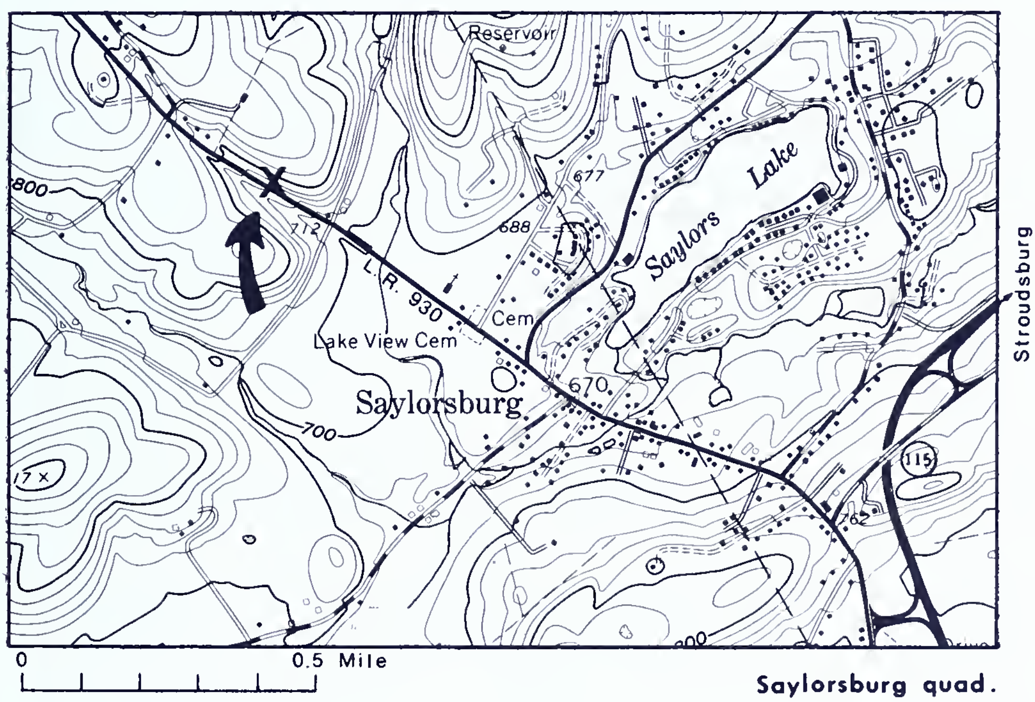
REFERENCE

Inners, J. D. (1979), *The Onesquethaw Stage in south-central Pennsylvania and nearby areas*, in Dennison, J. M., and others, *Devonian shales in south-central Pennsylvania and Maryland*, Annual Field Conference of Pennsylvania Geologists, 44th, Bedford, Pa., 1979, Guidebook, p. 38–55.

MONROE COUNTY

SITE 35—SAYLORSBURG CORAL AND BRACHIOPOD LOCALITY

LOCALITY. Monroe County is one of the "happiest of hunting grounds" for fossil collectors in Pennsylvania. Good collecting localities exist at many places in rocks that range from Late Silurian to Late Devonian in age. The best sites, however, are in the "Centerfield fossil zone" of the Middle Devonian age Mahantango Formation. The preferred locality is a roadcut on the northeast side of L.R. 930 in Ross Township, 0.5 mile northwest of Saylorsburg and 10 miles southwest of Stroudsburg. Parking space for several cars is available across the road from the outcrop.



FOSSILS. The most common fossils at this locality are rugose (or "horn") corals, brachiopods, and bryozoans. Most of the specimens that can be readily collected are fairly well preserved internal and external molds in claystone that has been partially leached of calcium carbonate. Extracting whole calcareous fossils from unweathered rock is somewhat more difficult. The fossils listed at the top of the following page are illustrated on Plates 5 to 9, 11, and 21.

CORALS
Favosites
Pleurodictyum
Cystiphylloides
Heterophrentis
BRYOZOAN
Fenestella
BRACHIOPODS
Tropidoleptus
Rhipidomella

BRACHIOPODS (cont.)
Protoleptostrophia
Spinocyrtia
Mediospirifer
Elita
Athyris
PELECYPODS
Goniophora
Cypricardinia

CEPHALOPOD
Michelinoceras
TRILOBITE
Phacops
CRINOIDS
Columnals
TRACE FOSSIL
Zoophycos

GEOLOGY. The fossiliferous rock at this site is a dark-gray, very limy, silty claystone that weathers to a soft, yellowish-brown "punky" material. In the lower 15 feet of the rock section, the fossils are mostly concentrated into fragmental layers 2 to 12 inches thick separated by intensely burrowed, sparsely fossiliferous claystone. These fossiliferous beds represent skeletal debris winnowed and transported by currents after the organisms had died (that is, each layer is a "death assemblage"). The upper 3 feet of the exposure, however, is a coral-rich biostrome in which many of the fossils are approximately in the same position as they were when they were living (that is, it is a "life assemblage"). This and other Centerfield biostromes in Monroe County formed on sunlit shoals in the marine sea that covered much of Pennsylvania approximately 387 million years ago. Although the sea floor was quite muddy at the time, the water itself must have been relatively clear. Otherwise, excessive turbidity would have resulted in fouling of the elaborate feeding organs of the brachiopods and bryozoans.

REFERENCES

Beerbower, J. R. (1957), *Paleoecology of the Centerfield Coral Zone, East Stroudsburg locality, Monroe County, Pennsylvania*, Pennsylvania Academy of Science Proceedings, v. 31, p. 91–97.

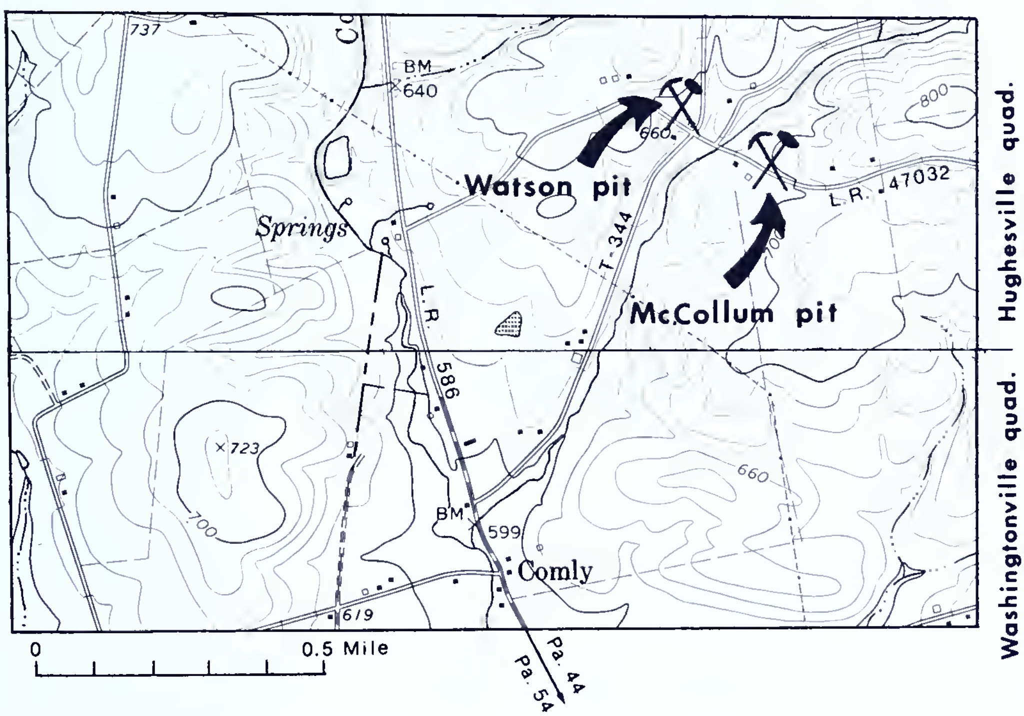
El-Ashry, M. T. (1971), *New Devonian coral reef from Monroe County, eastern Pennsylvania*, Pennsylvania Academy of Science Proceedings, v. 45, p. 5–8.

MONTOUR COUNTY

SITE 36—McCOLLUM AND WATSON BORROW PITS

LOCATION. Abundant and well-preserved Middle Devonian age fossils can be collected in two intermittently active borrow pits in northern Montour County. The pits are located within 1,000 feet of each other near the intersection of L.R. 47032 and Anthony Twp. Route 334, 0.9 mile north-northeast of Comly, a cluster of houses at a road junction 5.7 miles north-northwest of Washingtonville. Mr. Clarence McCollum owns the eastern of the two pits; Mr. Foster Watson owns the other. Please ask the permission of the property owners before entering the pits.

Many borrow pits and roadcuts in the Middle Devonian shales and claystones of the Washingtonville area are highly fossiliferous. Locations of other good collecting sites can be obtained by writing to the Pennsylvania Geological Survey.



FOSSILS. The combined fauna of these two borrow pits consists of more than 25 genera of tabulate and rugose corals, inarticulate and articulate brachiopods, bryozoans, gastropods, pelecypods, cephalopods, trilobites, and crinoids. Most of the fossils occur in several thin shelly layers that are separated by the thick barren shale beds. Many specimens are weathered free of the enclosing rock, but large slabs containing a variety of different fossils can also be obtained.

The fossils are preserved as internal and external molds and as recrystallized original shell material. The calcareous coralla of the tabulate corals seem to be especially resistant to dissolution.

Following is a composite list of the fossils found at these two sites. See Plates 5 to 11 for illustrations.

CORALS
- *Pleurodictyum*
- *"Trachypora"*
- *Stereolasma*

BRYOZOAN
- *Fenestella*

BRACHIOPODS
- *Lingula*
- *Rhipidomella*
- *Strophodonta*

BRACHIOPODS (cont.)
- *Leiorhynchus*
- *Atrypa*
- *Athyris*
- *Mucrospirifer*
- *Mediospirifer*

GASTROPODS
- *Bembexia*
- *Cyclonema*
- *Palaeozygopleura*

PELECYPODS
- *Palaeoneilo*
- *Phestia*
- *Actinopteria*
- *Modiomorpha*
- *Goniophora*
- *Cypricardella*
- *Protomya*

CEPHALOPOD
- *Michelinoceras*

TRILOBITES
- *Phacops*
- *Greenops*

CRINOIDS
- Columnals

GEOLOGY. The highly fossiliferous beds exposed in the McCollum and Watson borrow pits occur in the upper part of the Mahantango Formation. They were deposited in a moderately shallow, open-marine setting approximately 387 million years ago. The alternation of thin, very fossiliferous limy layers and thick, sparsely fossiliferous shales may reflect the existence of well-lighted, aerated shoals that were surrounded by areas of the sea floor too turbid and poorly oxygenated to support life. Communities of diverse marine invertebrates including suspension feeders (bryozoans, brachiopods, crinoids, and some pelecypods), deposit feeders (*Palaeoneilo*), carnivores (corals, gastropods, and cephalopods), and scavengers (trilobites) thrived for brief periods of time in the shoal areas until subsidence or a change in currents brought back stagnant, reducing conditions.

REFERENCES

Faill, R. T. (1979), *Geology and mineral resources of the Montoursville South and Muncy quadrangles and part of the Hughesville quadrangle, Lycoming, Northumberland, and Montour Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 144ab, 114 p.

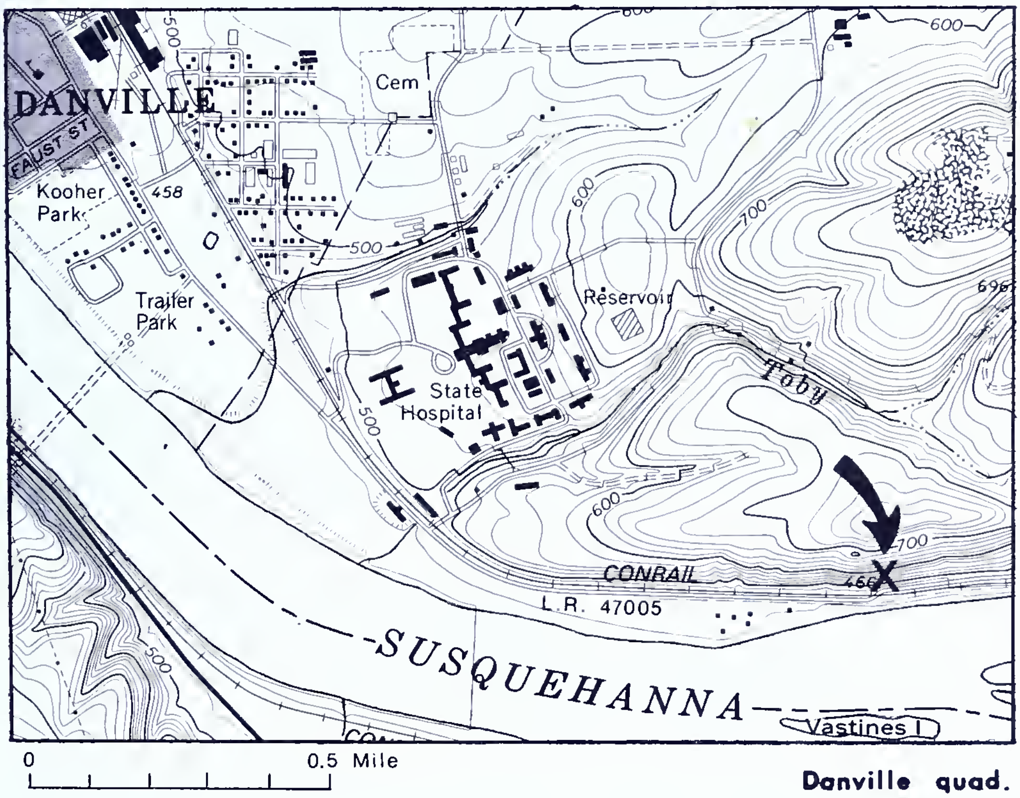
Way, J. H. (in preparation), *Geology and mineral resources of the Washingtonville and Millville quadrangles, Montour, Columbia, and Northumberland Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 154cd.

SITE 37—STONY BROOK BEDS NEAR DANVILLE

LOCATION. One of the most profusely fossiliferous collecting localities in Late Devonian age rocks in Pennsylvania is situated on the north side of the Susquehanna River approximately 2 miles southeast of Danville. The fossil site is an outcrop containing a large rockslide just east of the point at which L.R. 47005 crosses the Conrail tracks 0.75 mile southeast of the Danville State Hospital. Remnants of the old Pennsylvania Canal, North Branch Division, are visible along the river to the south.

Although bedrock ledges crop out at the top and on the right (east) side of the slide, the best collecting is in the fragmented siltstone that covers the steep slope and spills down onto the shoulder of the road. Be extremely careful in climbing around on the rockslide, however, because any disturbance of the angular rubble causes downslope movement.

Several cars can park along the road at the base of the slide. Traffic on L.R. 47005 is light.



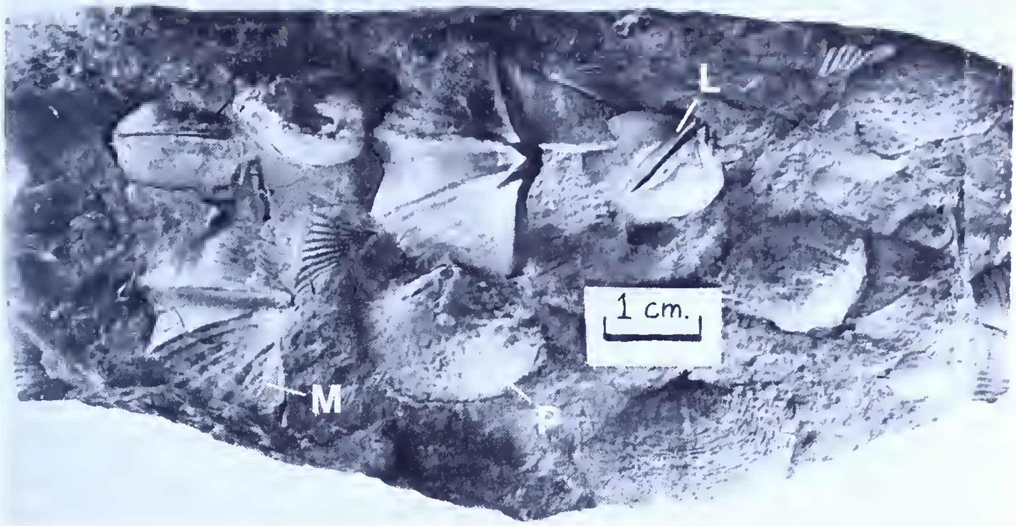
FOSSILS. The Danville Devonian locality sports great numbers of only a few fossil genera (that is, it has high abundance but low diversity). Most of the fossils occur in 1- to 3-inch bands of moderately concentrated

Rock slide in the Stony Brook beds near Danville.

shells. Three kinds of brachiopods occur in profusion, and pelecypods of at least two genera are relatively common. Although original calcareous shells can be found in less weathered rock fragments, most fossils here are external and internal molds. Many specimens show exceptional preservation of such shell features as spines and muscle scars. Illustrations of the fossils listed below can be found on Plates 6, 8, and 9.

BRACHIOPODS	PELECYPODS	CRINOIDS
Productella	*Nuculoidea*	Columnals
Leiorhynchus	*Palaeoneilo*	
Mucrospirifer		

GEOLOGY. The fossiliferous rubble at the Danville locality is derived from fragmentation of medium-gray siltstone beds in the upper part of the Trimmers Rock Formation. Known locally as the "Stony Brook beds," these distinctive fossil-bearing rocks can be recognized at many places in Columbia, Montour, and Northumberland Counties. The Stony Brook beds were deposited in moderately deep marine waters on the outer edge



Internal molds of *Leiorhyncus* (L), *Mucrospirifer* (M), and *Productella* (P) from the Stony Brook beds.

of a great delta that built northwestward across central and northeastern Pennsylvania in Late Devonian time (approximately 383 million years ago). Brachiopods thrived on these outer banks, and weak bottom currents periodically concentrated their shelly remains into thin layers.

Note that many pieces of rock are partly covered by thin "frothy" masses of white travertine (calcite). These mineral deposits are formed in much the same manner as the flowstone of caves. Rainwater slowly leaches calcite from the calcareous, fossiliferous siltstone fragments, becomes saturated, and redeposits the calcite on the surface of the rock.

REFERENCES

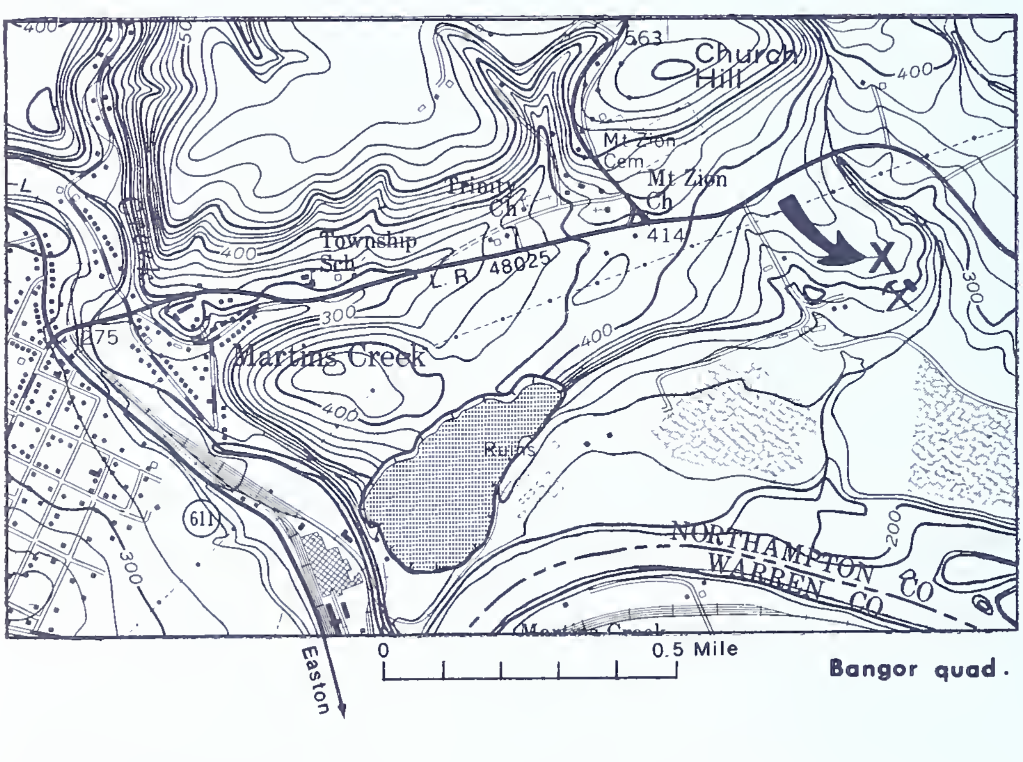
Inners, J. D. (1981), *The fossiliferous Stoney Brook beds (Upper Devonian) of Columbia County, Pennsylvania*, Pennsylvania Geology, v. 12, no. 5, p. 8–13.

White, I. C. (1883), *Geology of the Susquehanna River region in the six counties of Wyoming, Lackawanna, Luzerne, Columbia, Montour, and Northumberland*, Pennsylvania Geological Survey, 2nd ser., Report G7, 464 p.

NORTHAMPTON COUNTY

SITE 38—MARTINS CREEK BRYOZOAN LOCALITY

LOCATION. The best fossil-collecting site in southeastern Pennsylvania is in Northampton County about 6 miles north of Easton. Highly fossiliferous, Late Ordovician limestones are exposed in an inactive quarry of the former Alpha Portland Cement Company 1.25 miles east of Martins Creek. Well-preserved fossils occur in limestone rubble that covers a gently sloping hillside above the old quarry. The hillside was stripped of soil in anticipation of continuing the quarry northward, but unfavorable geologic conditions forced abandonment of the operation. The rubble-covered area is now part of a pasture about 1,200 feet south of L.R. 48025. A posted farm road leading south 0.2 mile east of the junction of L.R. 48025 and U.S. Route 611 provides an approach to the area. Access is also possible via the next lane to the east. Permission should be obtained from Alpha Aggregates Company in Martins Creek (telephone 215-258-2345) prior to entering the property. Also please inform the tenant farmer of your presence. STAY CLEAR OF THE QUARRY HIGHWALL.



FOSSILS. Bryozoans are the most abundant fossils found at this locality. Pieces of the delicate sticklike genus *Helopora* cover the weathered surfaces of many limestone fragments. In addition, hemispherical colonies of the massive bryozoan *Prasopora* 1 to 3 inches in diameter are common in the rubble. *Prasopora* specimens can also be collected from bedrock ledges in the southwestern part of the abandoned quarry. Except for crinoid columnals, other fossils are relatively uncommon at this locality. The fossils listed below are illustrated on Plates 1 and 2.

BRYOZOANS	BRACHIOPOD	TRILOBITE	CRINOIDS
Prasopora	*Dalmanella*	*Cryptolithus*	Columnals
Helopora			

GEOLOGY. The limestone exposed in the quarry and on the adjacent hillside belongs to the lower ("cement limestone") portion of the Jacksonburg Formation. These beds were deposited on the floor of a shallow tropical sea approximately 455 million years ago, or at about the same time as the limestones at the sites in Centre (site 11) and Lycoming (site 31) Counties. Although fossils can be found in the Jacksonburg at many other localities in Northampton County, collecting is generally poor because of structural distortion of the fossils. The Jacksonburg has locally been so intensely deformed that the fossils are entirely obliterated. In the area east of Martins Creek the gentle northward inclination of the limestone beds belies the great structural complexity of this part of Pennsylvania. The rocks in the old Alpha Company quarry occur on the upper limb of a large fold that is lying on its side. Such structures—known as nappes—are typical of the Alps and have been recognized in Pennsylvania throughout the Great Valley from Harrisburg to Easton.

The limestones of the Jacksonburg are of considerable economic importance. The upper portion of the formation (the "cement rock") is impure and locally has the correct chemical composition to make natural cement. In the early days of the cement industry (1830–70) the "cement rock" was simply pulverized and roasted ("calcined") to form cement. Because the chemistry of this natural cement was difficult to control, techniques of mixing limestone and clay in known proportions were developed to produce what is now known as Portland cement. Manufacturers of Portland cement in the local area generally must add some limestone to raw material from the upper Jacksonburg "cement rock" and some clay to raw material taken mainly from the lower Jacksonburg "cement limestone."

Although the Alpha Portland Cement Company no longer quarries limestone in the Martins Creek area, the Alpha Aggregates Company is carrying on a large sand-and-gravel operation on the Delaware River terrace south of the fossil site.

REFERENCES

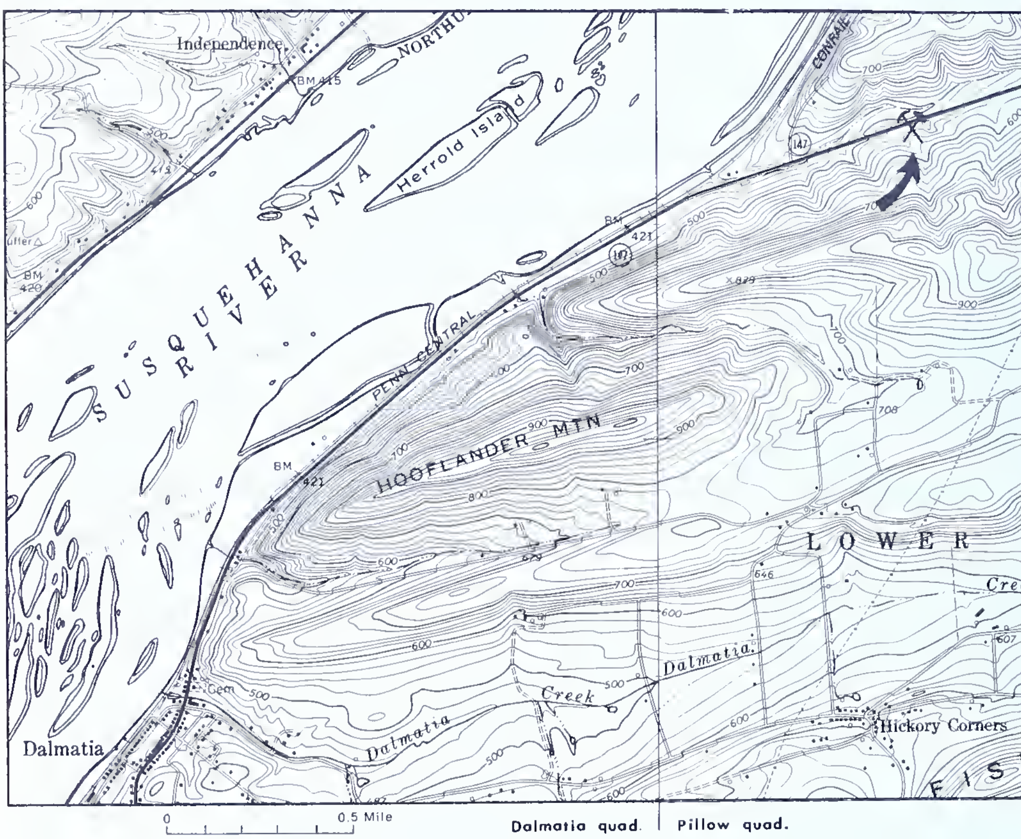
Miller, B. L., Fraser, D. M., and Miller, R. L. (1939), *Northampton County, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., County Report 48, 496 p.

Sherwood, W. C. (1964), *Structure of the Jacksonburg Formation in Northampton and Lehigh Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., General Geology Report 45, 64 p.

NORTHUMBERLAND COUNTY

SITE 39—DEVONIAN FOSSILS NEAR DALMATIA

LOCATION. Northumberland County contains a wide variety of fossiliferous rocks that range in age from Early Silurian to Middle Pennsylvanian. One of the most accessible Middle Devonian localities is a borrow pit on the south side of Pa. Route 147 about 2.5 miles northeast of Dalmatia, Lower Mahanoy Township. The pit is 1.85 miles west of the intersection of Pa. Routes 147 and 225. Ample space is available to park vehicles along the highway at the borrow pit.



FOSSILS. All of the fossils occurring at this locality are external and internal molds; groundwater has dissolved the original calcareous shell material. Brachiopods (especially *Tropidoleptus* and *Devonochonetes*) and crinoid columnals are the most abundant fossils. Pelecypods and trilobites are also fairly common. The spiral, rooster-tail-like markings (*Zoophycos*) in the rock layers throughout the pit are believed to represent the feeding burrows of soft wormlike organisms that left no skeletal remains. The fossils listed below are illustrated on Plates 6 to 11 and 21.

BRYOZOAN
Sulcoretepora

BRACHIOPODS
Rhipidomella
Tropidoleptus
Protoleptostrophia
Devonochonetes
Mucrospirifer
Mediospirifer

GASTROPOD
Palaeozygopleura

PELECYPODS
Palaeoneilo
Leiopteria
Paracyclas
Cypricardella
Orthonota

CEPHALOPOD
Michelinoceras

CRICOCONARID
Tentaculites

TRILOBITES
Trimerus
Greenops

CRINOIDS
Columnals

TRACE FOSSIL
Zoophycos

GEOLOGY. The rocks exposed in the Dalmatia borrow pit are silty claystones typical of the upper part of the Mahantango Formation. The claystones were deposited in a shallow marine sea about 387 million years ago. The very uniform character of the rock in the pit is unusual. Most sedimentary rocks are layered in units of a few inches to a few feet, but at this locality the only noticeable changes are widely spaced fossil concentrations. Examination of these thin fossiliferous bands shows that the layers (beds) are inclined to the north. A slow and even rate of sediment deposition and intense burrowing by organisms may both have contributed to the uniformity of these rocks. As soon as the fine silt and clay settled to the sea floor, burrowers such as the *Zoophycos* organism churned the sediment into mud that later hardened into the claystone we see in the pit today.

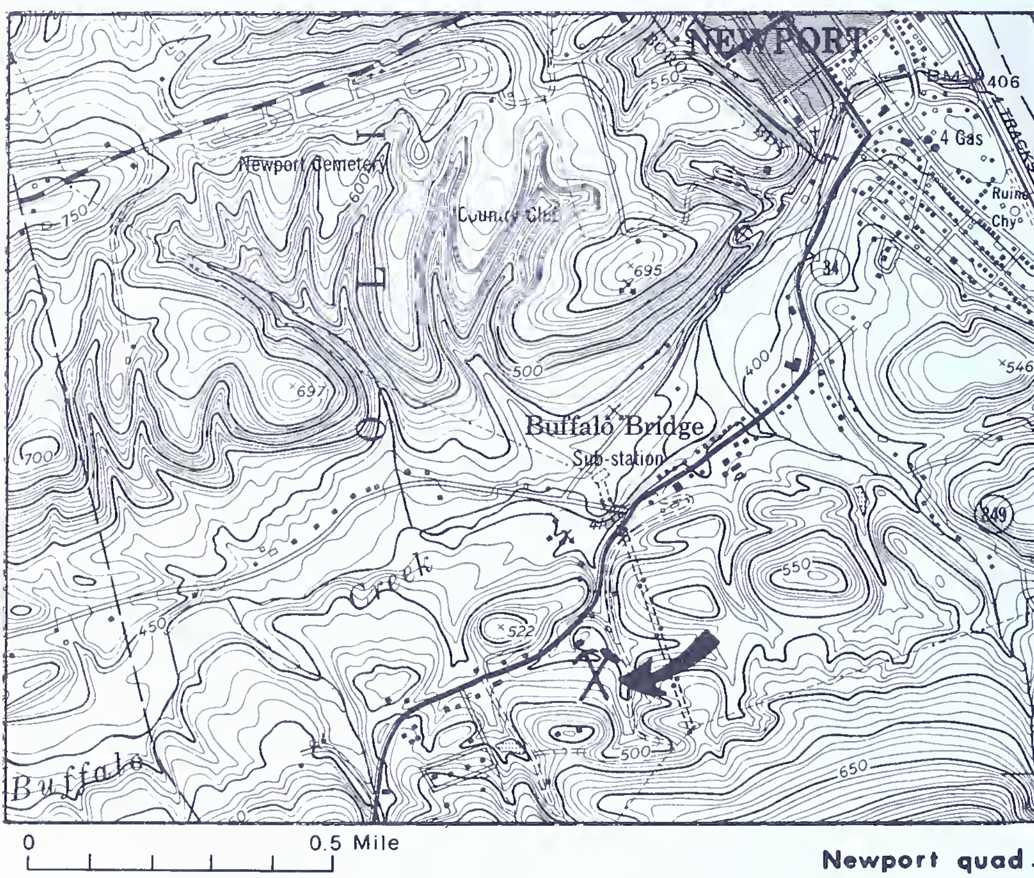
REFERENCE

Hoskins, D. M. (1976), *Geology and mineral resources of the Millersburg 15-minute quadrangle, Dauphin, Juniata, Northumberland, Perry, and Snyder Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 146, 38 p.

PERRY COUNTY

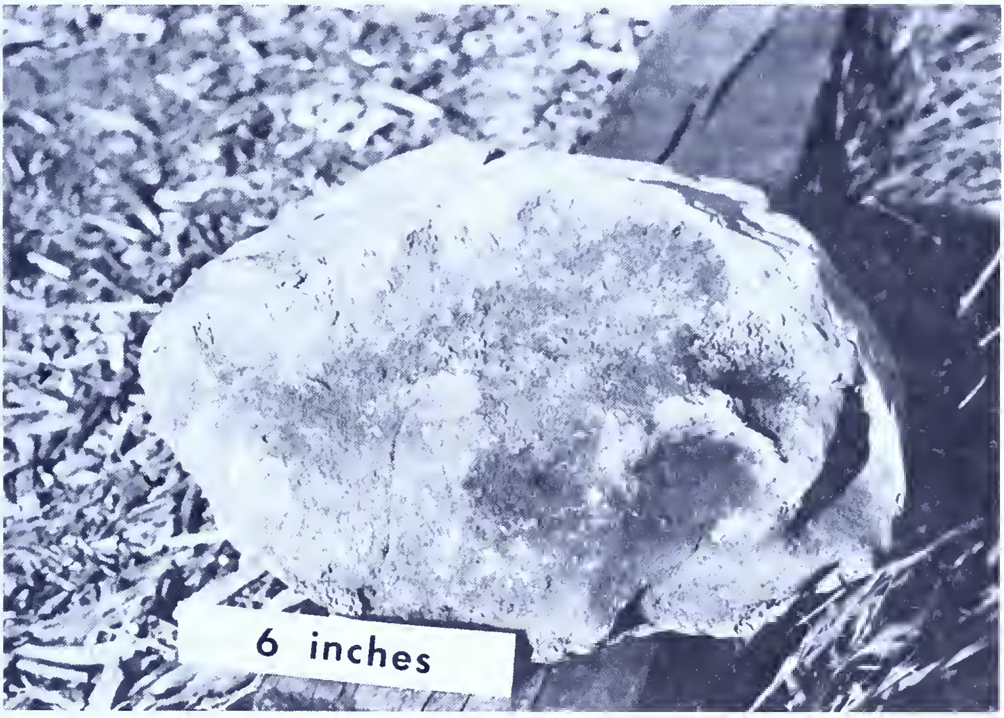
SITE 40—MAHANTANGO FOSSILS AT THE LESH BORROW PIT

LOCATION. More than 40 genera of Middle Devonian invertebrate fossils, including fist-sized and larger colonies of the honeycomb coral *Favosites*, can be found in a shale pit 1 mile southwest of Newport. The pit is located on the southeast side of Pa. Route 34, 500 feet south of Swartz's Car Wash, and exposes beds in the upper part of the Mahantango Formation. The property owner, Mr. Harry B. Lesh, has given permission for individuals and groups to collect when equipment is not operating in the pit.



Newport quad.

FOSSILS. For variety, abundance, and preservation of fossil remains, the Lesh borrow pit is one of the best collecting localities in central Pennsylvania. Representatives of six invertebrate phyla, as well as one easily recognized trace fossil, occur in the claystones, calcareous clay shales, and limestones unearthed in the pit. The most abundant of these groups are brachiopods and bryozoans. Of greater interest, however, are the robust "horn" corals and large "honeycomb" coral colonies common in the southern part of the pit. Many "horn" corals of the genus *Heterophrentis* are 2 inches in diameter and 4 inches long; the "honeycomb" coral colonies (genus *Favosites*) range up to 13 inches in diameter. In the claystones above and below the coral-rich bed can be seen the spiral swirls of the trace fossil *Zoophycos*. These markings are believed to result from the activity of a deposit-feeding, wormlike organism.



A large *Favosites* colony from the Lesh borrow pit.

Fossils in the Lesh pit are preserved both as molds and original shell material. Because of the fine grain size of the rock matrix, many delicate skeletal features are still intact.

The list below includes only the more common fossils to be found at this site. These genera are illustrated on Plates 5 to 11 and 21.

CORALS
- *Favosites*
- *Pleurodictyum*
- *Heterophrentis*

BRYOZOANS
- *Fenestella*
- *Sulcoretepora*

BRACHIOPODS
- *Rhipidomella*
- *Megastrophia*
- *Protoleptostrophia*

BRACHIOPODS (cont.)
- *Douvillina*
- *Longispina*
- *Atrypa*
- *Spinatrypa*
- *Echinocoelia*
- *Pustulatia*
- *Delthyris*
- *Mucrospirifer*
- *Spinocyrtia*
- *Mediospirifer*

GASTROPODS
- *Platyceras*
- *Palaeozygopleura*

PELECYPODS
- *Palaeoneilo*
- *Actinopteria*
- *Modiomorpha*
- *Paracyclas*
- *Grammysioidea*

CEPHALOPOD
- *Bactrites*

TRILOBITES
- *Dechenella*
- *Phacops*
- *Greenops*

CRINOIDS
- Columnals

TRACE FOSSIL
- *Zoophycos*

GEOLOGY. The fine-grained clayey and limy rocks of the Lesh borrow pit were deposited during a brief expansion of the shallow subtropical sea that covered central Pennsylvania in Middle Devonian time (about 385 million years ago). Several million years previously, a large sandy delta complex had spread into this part of Perry County from the south (see site 17). When sandy deposition on the delta ceased, the marine shoreline advanced farther to the southeast, and only fine-grained sediment accumulated on the sea floor in this area.

Marine organisms thrived in the warm, well-oxygenated waters of the late Mahantango sea. The most abundant inhabitants were suspension feeders—brachiopods, bryozoans, and crinoids. Rugose ("horn") and favositid ("honeycomb") corals proliferated on shoals over which the water was sufficiently clear and shallow to allow sunlight to reach the bottom. Beneath the depositional surface, soft-bodied "worms" foraged through the organic mud. Although the sea occupied Perry County for another 5 million years, never again would such a large community of marine organisms colonize the area.

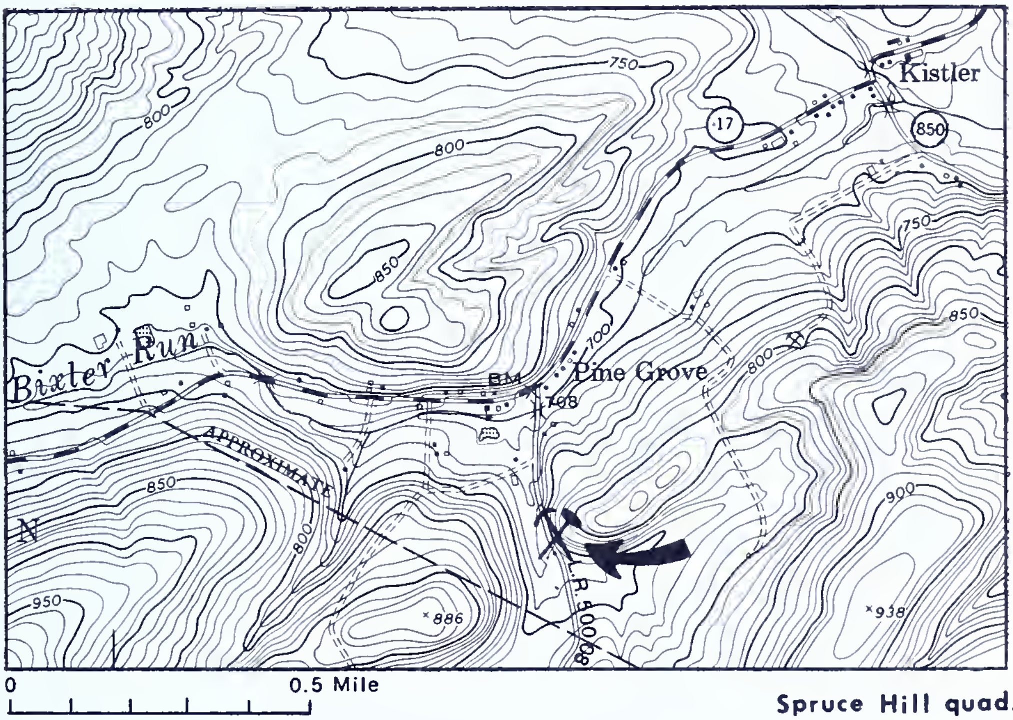
REFERENCES

Dyson, J. L. (1963), *Geology and mineral resources of the northern half of the New Bloomfield quadrangle*, Pennsylvania Geological Survey, 4th ser., Atlas 137ab, 63 p.

Inners, J. D., and Nork, D. M. (1983), *Prolific corals and other fossils of Devonian age at the Lesh borrow pit, Perry County, Pennsylvania,* Pennsylvania Geology, v. 14, no. 2, p. 10–15.

SITE 41—KEYSER FOSSILS AT DE LANCEY'S HOMESTEAD

LOCATION. An excellent locality for collecting fossils from the limestones of the Late Silurian to Early Devonian age Keyser Formation is an abandoned quarry on the east side of L.R. 50008, 0.25 mile south of Pine Grove and 1.0 mile southwest of Kistler, Madison Township, Perry County. Pine Grove and Kistler are crossroads communities situated at the junction of L.R. 50008 and Pa. Route 17 and the intersection of Pa. Routes 17 and 850, respectively, 5 miles northwest of Loysville. The collecting site consists of an abandoned quarry and shallow roadcut that expose more than 100 feet of wavy-bedded to nodular Keyser limestone and about 15 feet of laminated limestone belonging to the underlying Late Silurian age Tonoloway Formation. Vehicles can park on the west side of the road near the monument marking the homestead of Francis DeLancey (1724–1816), a French-born veteran of the American Revolution and aide to the Marquis de Lafayette. Traffic on L.R. 50008 is very light.



Spruce Hill quad.

FOSSILS. The Keyser limestone at this site contains innumerable fossils, including at least a dozen genera of brachiopods. Several types of corals and bryozoans are also very abundant in some layers. At the south end of the exposure, large ostracodes of the genus *Leperditia* can be found in the Tonoloway Formation. Many of the fossils weather free of the rock and can be picked up whole. See Plates 3 to 6 for illustrations of the fossils listed below.

CORAL
Favosites
BRYOZOANS
"Batostomella"
Fenestella
Orthopora
BRACHIOPODS
Craniops
Orbiculoidea
Isorthis

BRACHIOPODS (cont.)
Rhipidomella
Leptaena
Leptostrophia
Cupulorostrum
Uncinulus
Atrypa
Rhynchospirina
Meristina

GASTROPODS
Platyostoma
Palaeozygopleura
CRICOCONARID
Tentaculites
PELECYPODS
Actinopteria
Cypricardinia
CEPHALOPOD
Michelinoceras

ANNELID
Spirorbis
OSTRACODE
Leperditia
CRINOIDS
Columnals

GEOLOGY. The limestones exposed at the DeLancey site were deposited in a shallow subtropical marine embayment that covered central Pennsylvania about 405 million years ago. At least three distinct environments of deposition are represented. The laminated, sparsely fossiliferous Tonoloway limestones accumulated in shallow, protected, very salty la-

Abandoned quarry in the Keyser Formation south of Pine Grove. The conspicuous inclination of the beds toward the left (north) is the result of folding that occurred at the end of the Permian Period approximately 250 million years ago.

goons. The nodular, highly fossiliferous, fine-grained limestone beds at the base of the Keyser Formation formed in normal marine, shallow subtidal to intertidal areas; the irregular, "ropy" bedding in this unit probably reflects profuse organic burrowing when the original lime mud was soft and unconsolidated. The wavy-bedded, somewhat coarser grained, but also highly fossiliferous, limestones at the top of the quarry section show evidence of current and wave agitation and were deposited under higher energy, subtidal conditions. Not exposed at this site are the massive stromatoporoid beds that occur above the wavy-bedded limestones in more complete sections of the Keyser Formation. These distinctive layers composed of masses of cabbagelike coralline sponges can be observed in many abandoned limestone quarries throughout Perry County, particularly near Blain and Landisburg.

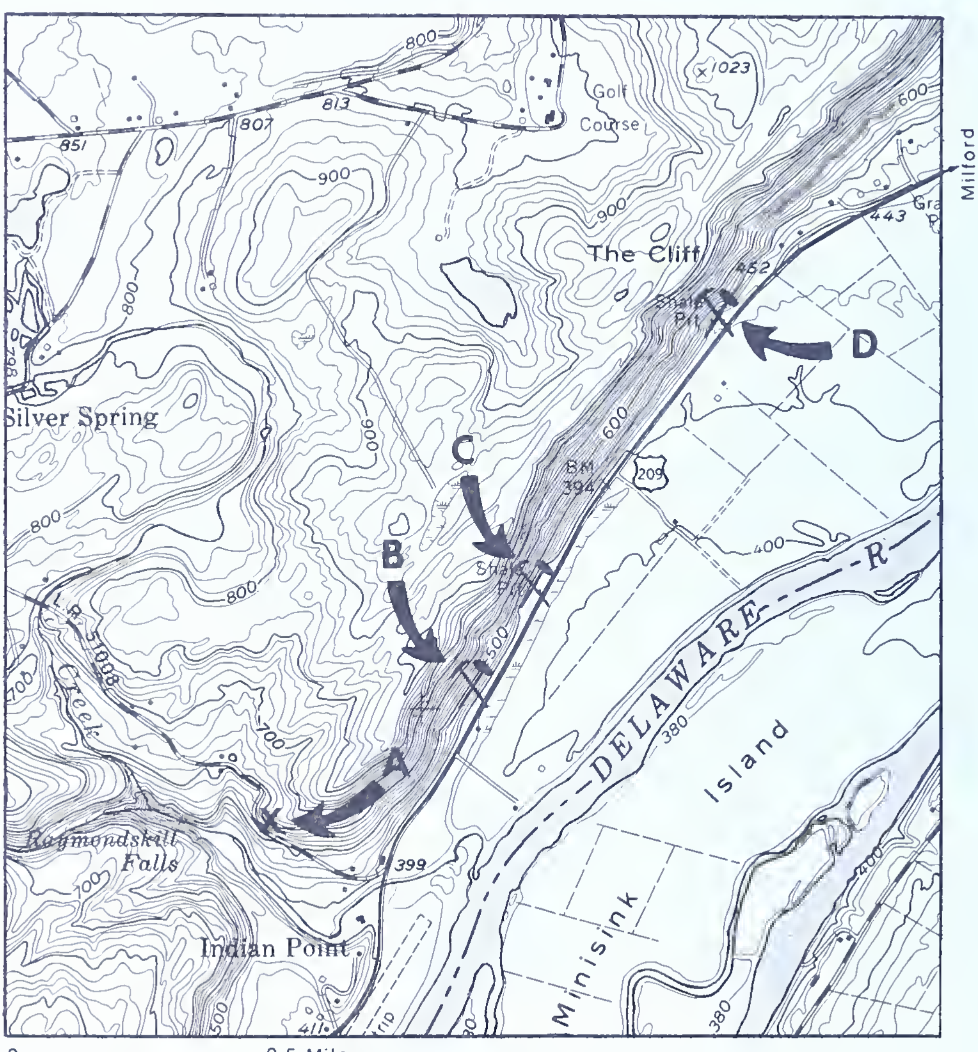
REFERENCE

Miller, J. T. (1961), *Geology and mineral resources of the Loysville quadrangle, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 127, 47 p.

PIKE COUNTY

SITE 42—RAYMONDSKILL BRACHIOPOD AND PELECYPOD LOCALITIES

LOCATION. In southeastern Pike County, marine shales and siltstones of Middle Devonian age form a bold escarpment bordering a 25-mile reach of the Delaware River. Near Milford this rocky precipice attains such prominence that it is known simply as "The Cliff." A string of inactive borrow pits at the base of The Cliff between Raymondskill Creek and Milford provide good fossil collecting. Several road and stream cuts (particularly in the gorge of Raymondskill Creek) also expose fossiliferous



beds. The following four localities in this area are recommended for collecting:

(A) a roadcut at a sharp bend of L.R. 51008 on the northeast side of Raymondskill Creek, 0.25 mile west-northwest of U.S. Route 209, about 3 miles southwest of Milford;
(B) an inactive shale borrow pit on U.S. Route 209, 0.35 mile northeast of its intersection with L.R. 51008;
(C) a second borrow pit 0.25 mile farther northeast; and
(D) a third borrow pit 0.6 mile northeast of the second and 1.7 miles southwest of Milford.

Collecting is best at the southernmost borrow pit (B).

Plenty of parking space is available at all three roadside borrow pits. To visit the outcrop on L.R. 51008, park at the abandoned office at Raymondskill Falls and walk several hundred feet down the road to the locality. Watch out for traffic coming around the bend.

The Cliff, southwest of Milford. Note the sharpstone rubble on the lower part of the slope.

FOSSILS. Brachiopods, pelecypods, and crinoid columnals are the most common fossils found at these Pike County localities. All of the specimens occur as fairly well preserved external and internal molds in hard gray siliceous siltstone. At the L.R. 51008 roadcut, fossils can be collected from outcropping ledges of this fossiliferous siltstone. In the borrow pits, however, the fossil-bearing rock consists of loose, angular siltstone fragments that have moved downslope from rocky cliffs several hundred feet above. A composite list of the fossils that can be collected at the four localities is given below. The invertebrates are illustrated on Plates 5 to 11.

CORAL
- *Aulopora*

BRYOZOAN
- *Fenestella*

BRACHIOPODS
- *Rhipidomella*
- *Tropidoleptus*
- *Protoleptostrophia*
- *Devonochonetes*
- *Cupulorostrum*
- *Leiorhynchus*
- *Emmanuella*

BRACHIOPODS (cont.)
- *Mucrospirifer*
- *Spinocyrtia*
- *Mediospirifer*

GASTROPOD
- *Platyceras*

PELECYPODS
- *Nuculoidea*
- *Palaeoneilo*
- *Leptodesma*
- *Actinopteria*
- *Grammysioidea*

CEPHALOPOD
- *Michelinoceras*

TRILOBITES
- *Trimerus*
- *Phacops*

CRINOIDS
- Columnals

PLANTS
- Stem fragments

GEOLOGY. The Pike County fossils come from interbedded siltstones and shales in the middle of the Mahantango Formation. Because these beds are relatively more resistant to erosion than overlying and underlying shales, they form the rocky crags at the top of The Cliff. As can be seen in the borrow pits along U.S. Route 209, the barren, dark-gray shales that occupy the lower part of the escarpment are largely concealed beneath a thick cover of fossiliferous shale-and-siltstone rubble derived from ledges in the upper part.

The fossiliferous strata in the middle Mahantango southwest of Milford are approximately 387 million years old. A predominance of thick sandy siltstones and the local occurrence of carbonized plant fragments suggest that these beds originated relatively near the marine shoreline. In fact, the sediments were probably deposited offshore of a large river system that emptied into the sea not far to the northeast. The siltstones accumulated in a shallow marine environment, where the water was generally well oxygenated and currents periodically agitated the bottom. The layers of sandy silt on the sea floor provided a firm, relatively stable living surface for abundant brachiopods, pelecypods, and crinoids, and for the gastropods and trilobites that fed on the remains of dead organisms.

The shale and siltstone rubble (locally called "sharpstone") in the borrow pits is an excellent example of a deposit formed by the process of gravitational movement of debris down a slope. Much of this material accumulated 10,000 to 15,000 years ago, shortly after the last continental glacier melted back from the Delaware Valley. Because the extremely cold climate caused frost splitting of the rocky outcrops along The Cliff, countless fragments of siltstone and shale were dislodged to fall and slide down the steep slopes. In this way a vast apron of broken debris collected at the base of the escarpment. This process of rubble formation is still operating today, especially in the late winter and early spring, albeit at a much slower rate. The "sharpstone" rubble of the Milford area is widely quarried for use as readily compacted construction fill. It is also utilized as a free-draining surface material for driveways and unpaved secondary roads.

REFERENCES

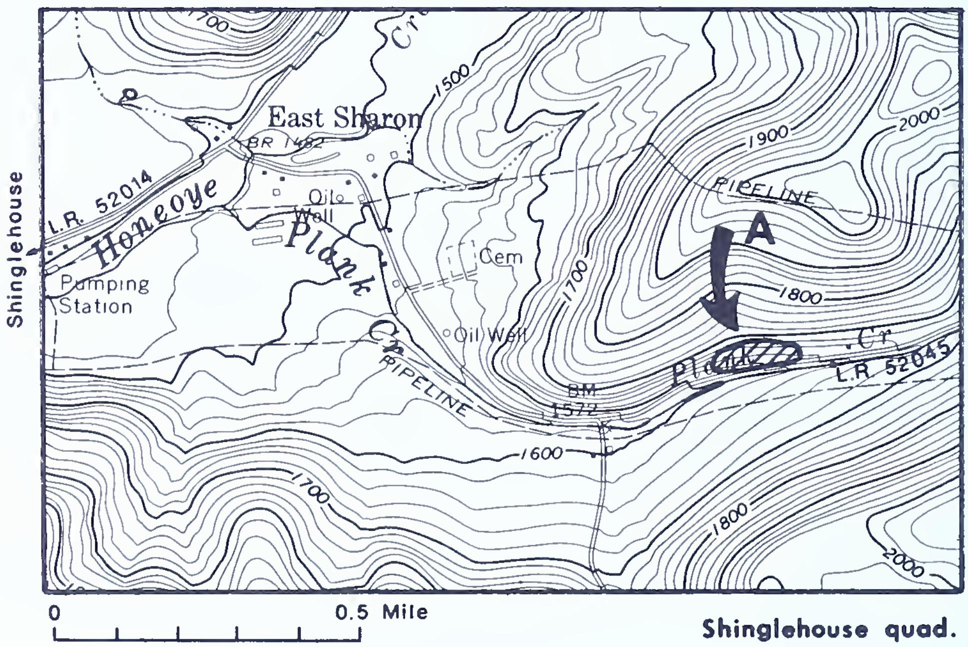
Fletcher, F. W., and Woodrow, D. L. (1970), *Geology and economic resources of the Pennsylvania portion of the Milford and Port Jervis 15-minute quadrangles*, Pennsylvania Geological Survey, 4th ser., Atlas 223, 64 p.

Sevon, W. D., Berg, T. M., Schultz, L. D., and Crowl, G. H. (in preparation), *Geology and mineral resources of Pike County, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., County Report 52.

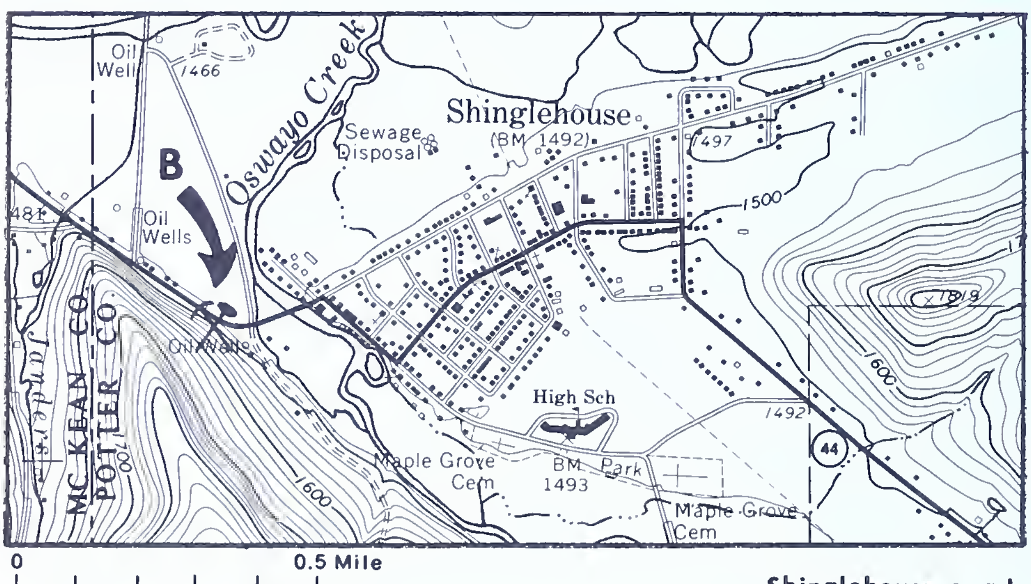
POTTER COUNTY

SITE 43—SHINGLEHOUSE BRACHIOPOD AND BRYOZOAN LOCALITIES

LOCATION. Because the fossiliferous rocks of Late Devonian age in northern Potter County are largely covered by glacial deposits, bedrock exposures are rare. Two localities near the New York-Pennsylvania boundary line, however, expose Devonian age sandstones containing



Shinglehouse quad.



Shinglehouse quad.

marine fossils. The first exposure (A) is along L.R. 52045 about 3 miles east of Shinglehouse. The exposure is a low-sloping bank from which the soil has been removed, revealing blocks of weathered sandstone. Many of these blocks contain fossils. To reach the collecting site, follow L.R. 52014 east from Shinglehouse along Honeoye Creek. At East Sharon, 2.3 miles east of Shinglehouse, turn right (south) onto the paved road (L.R. 52045) leading up Plank Creek. The exposure is 1.1 miles southeast of East Sharon on the north side of the road.

The second exposure (B) occurs west of Shinglehouse on Pa. Route 44. The outcrop is in a small borrow pit 500 feet west of Oswayo Creek at the west end of Shinglehouse. It is 1,300 feet east of the Potter-McKean County line.

FOSSILS. External and internal molds of brachiopods and bryozoans are the most common fossils in these rocks, but these fossils are not very abundant. None of the original shell materials remain except for the bony scales of fish. The fish scales, up to 1 inch in diameter, are recognized by their white color, which stands out in the rusty-brown-colored rock. The fish scales appear porous and composed of lustrous material if viewed under high magnification. Fragments of plants as well as burrows are present. The fossils listed below are illustrated on Plates 5, 6, 8, and 9.

BRYOZOAN
- *"Batostomella"*

BRACHIOPODS
- *Spinulicosta*
- *Ptychomaletoechia*
- *Cyrtospirifer*

PELECYPOD
- *Leptodesma*

CRINOIDS
- Columnals

CHORDATE (Osteichthyes)
- "Fish scales"

PLANTS
- Twigs and bark

TRACE FOSSILS
- Burrows

GEOLOGY. The strata exposed along Honeoye Creek and near Shinglehouse are part of the Chadakoin Formation and were deposited near the end of the Devonian Period, about 370 million years ago. The wide variety of rock types (shale, sandstone, and conglomerate) and fossil groups (plants, fish, marine invertebrates, and burrows) indicate that the original sediments accumulated in a rapidly changing nearshore environment where swift currents swept quartz pebbles into the same area where sand and mud were being deposited. The marine fossils were also probably transported into the area as were, perhaps, the fish fossils.

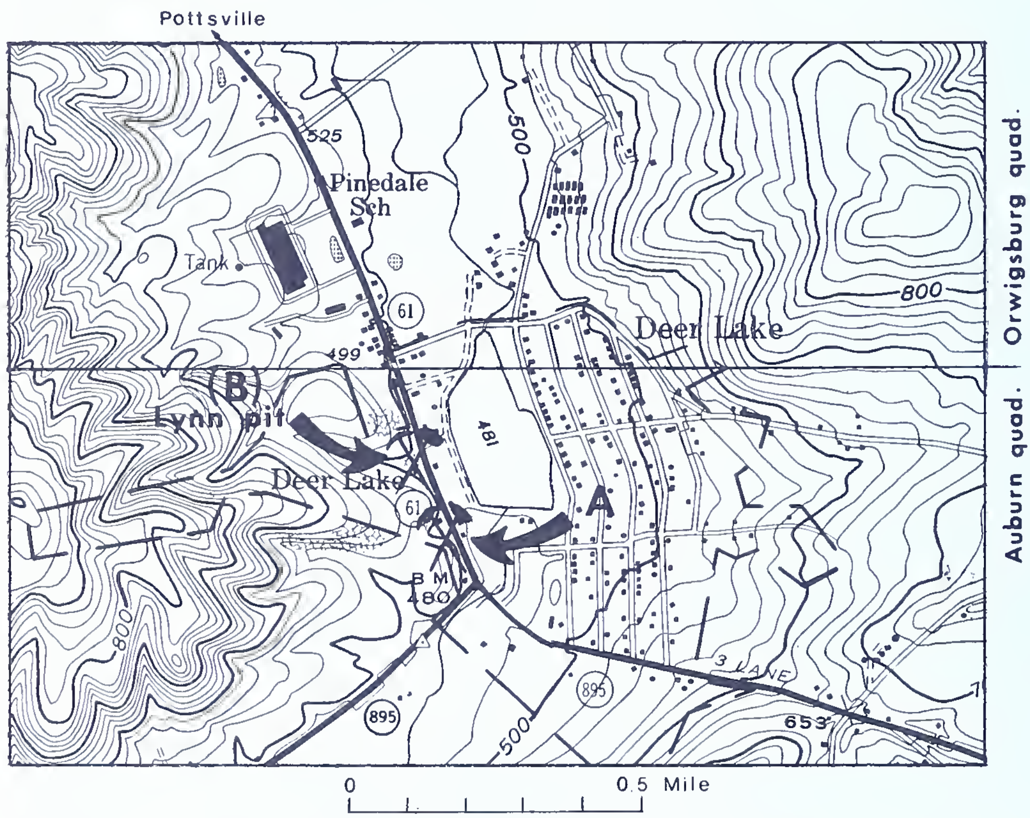
The thickness of the quartz-pebble layers indicates that very fast currents must have occurred in the area for short periods. The fragmentary nature of the plants and fish plates also suggests swift current activity.

After the fossils and sediment were deposited, bottom-dwelling animals burrowed into the unconsolidated material, leaving their passages as trace fossils.

SCHUYLKILL COUNTY

SITE 44—DEER LAKE DEVONIAN MOLLUSK LOCALITIES

LOCATION. Schuylkill County is noted for its many good localities for collecting invertebrate and plant fossils. Two of the best sites for Devonian invertebrates (especially mollusks) are in the borough of Deer Lake, about 11 miles southeast of Pottsville. The sites are as follows: (A) an abandoned borrow pit on the west side of Pa. Route 61, 200 feet north of the junction of Pa. Routes 61 and 895; and (B) an active pit about 0.25 mile farther north, also on the west side of Pa. Route 61. Mr. George R. Lynn of Port Carbon, Pennsylvania, owns the active borrow pit. He permits collecting at any time that his heavy equipment is not operating.



FOSSILS. Although similar fossils are found at the two Deer Lake localities, enough differences exist to make visits to both sites worthwhile. An abundance of genera and specimens of mollusks characterizes the borrow pits. Pelecypods are abundant at both localities, whereas gastropods and cephalopods are more common in the Lynn pit. Particularly interesting at the latter locality are large specimens of one of the earliest known ammonoid cephalopods, *Agoniatites*.

Fossils at Deer Lake occur mostly in poorly defined layers 2 to 4 inches thick. The rock between the fossil-rich beds is sparsely fossiliferous, but locally does contain an abundance of the trace fossil *Zoophycos*. The best fossil specimens are internal and external molds; original calcareous shell material is found only in dense, unweathered rock.

The fossils listed below are illustrated on Plates 6 to 11 and 21.

Abandoned borrow pit (A):

COELENTERATE
Conularia

BRACHIOPODS
Orbiculoidea
Tropidoleptus
Protoleptostrophia
Devonochonetes

BRACHIOPODS (cont.)
Mucrospirifer

PELECYPODS
Nuculoidea
Nuculites
Palaeoneilo
Leptodesma

PELECYPODS (cont.)
Leiopteria
Modiomorpha
Orthonota
Grammysioidea
Protomya

TRILOBITE
Trimerus

CRINOIDS
Columnals

TRACE FOSSIL
Zoophycos

Lynn borrow pit (B):

CORAL
Pleurodictyum

BRACHIOPODS
Lingula
Orbiculoidea
Tropidoleptus
Protoleptostrophia
Devonochonetes
Mucrospirifer

BRACHIOPODS (cont.)
Spinocyrtia

GASTROPODS
Tropidodiscus
Bucanopsis
Bembexia
Cyclonema

PELECYPODS
Nuculoidea

PELECYPODS (cont.)
Nuculites
Phestia
Leiopteria
Modiomorpha
Goniophora
Cypricardella
Orthonota
Grammysioidea

CEPHALOPODS
Michelinoceras
Agoniatites

TRILOBITES
Trimerus
Greenops

PLANTS
Stem fragments

GEOLOGY. The rock strata exposed in the Deer Lake borrow pits belong to the Middle Devonian age Mahantango Formation and are approximately 387 million years old. The dominant lithology in both pits is rather uniform, gray silty claystone. Some thin rippled siltstone beds and calcareous nodules occur in the Lynn pit.

At the time these beds were deposited, the muddy sea bottom must have been an ideal habitat for both deposit- and suspension-feeding pelecypods. The layers of mud accumulated very slowly, and burrowing organisms mixed each new layer of sediment into underlying layers. Many of these burrowers were the pelecypods that occur so abundantly as fossils in the pits. Others were soft-bodied wormlike animals that had no hard parts suitable for fossilization but did leave behind unmistakable traces of their burrows. The feeding burrows of one such creature—the *Zoophycos* organism—resemble rooster tails impressed in the rock.

The pelecypod genera found in the Deer Lake borrow pits are nearly identical to those at Seven Stars, Juniata County (site 27). Local geologic relationships also suggest that the fossil "clam banks" in Schuylkill and Juniata Counties flourished on the sea floor at nearly the same time.

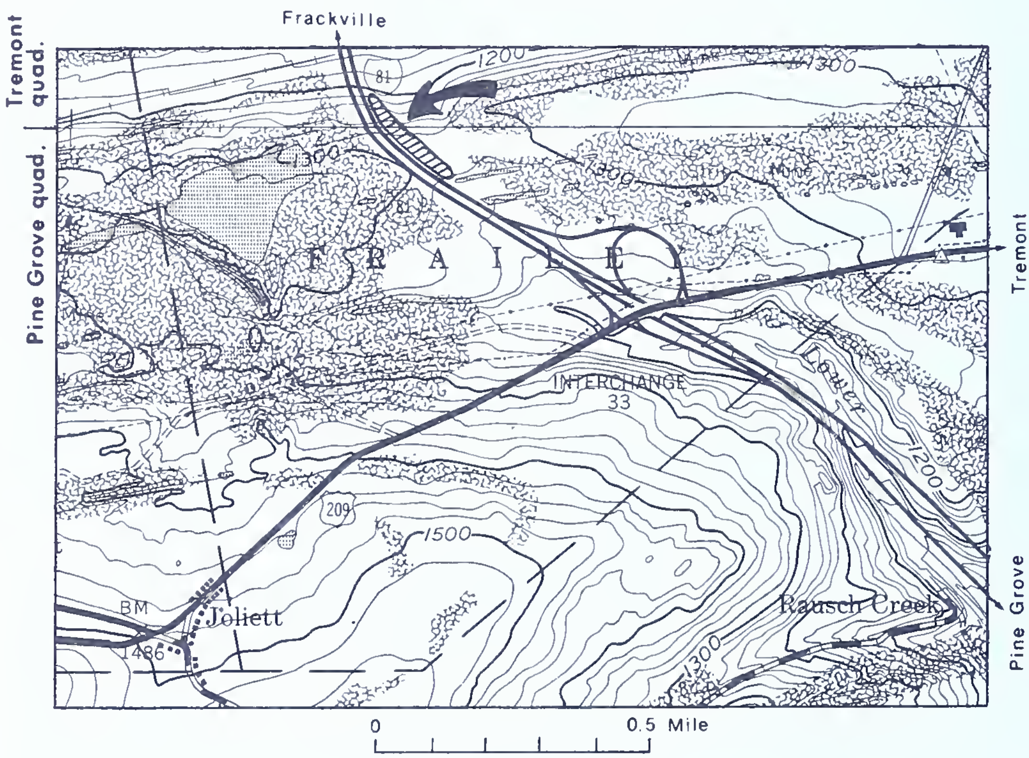
REFERENCE

Palmer, A. C. (1977), *Rare fossils in Schuylkill County*, Pennsylvania Geology, v. 8, no. 4, p. 30–32.

SITE 45—TREMONT SYNCLINE PLANT-FOSSIL LOCALITY

LOCATION. One of the most interesting and productive places to collect plant fossils in the coal-bearing Pennsylvanian age strata of the anthracite fields is located on Interstate Route 81 near interchange 33 (Tremont-Tower City), 2.7 miles west of Tremont. The site is a long, deep roadcut that begins 0.2 mile north of the U.S. Route 209 overpass and exposes a spectacular cross section of a syncline (downfold). Collecting is best on the east side of the interstate (along the northbound lane).

DO NOT PARK ON THE INTERSTATE HIGHWAY! Park at the large pull-off near U.S. Route 209 just east of the interchange. It is a 0.5-mile walk from the parking area to the middle of the cut.



FOSSILS. Not only does this site afford excellent plant-fossil collecting, but it also shows how the fossils occur in the rock record. Plant fossils in the Tremont syncline cut consist of leaves and leaflets (*Annularia, Asterophyllites, Lepidophylloides, Pecopteris,* and *Neuropteris*), stems and trunks (*Calamites, Lepidodendron,* and *Sigillaria*), and roots and rootlets (*Stigmaria*). Each of these portions of ancient plants is found in certain rock types in the cut. For example, identifiable leaves and leaflets occur mainly as compressions and impressions in the shaly beds above the coal seams; large stems and trunks are usually found as coal-rimmed molds and casts in the sandstones; and molds and casts of *Stigmaria* are largely restricted to the underclays beneath the coal beds.

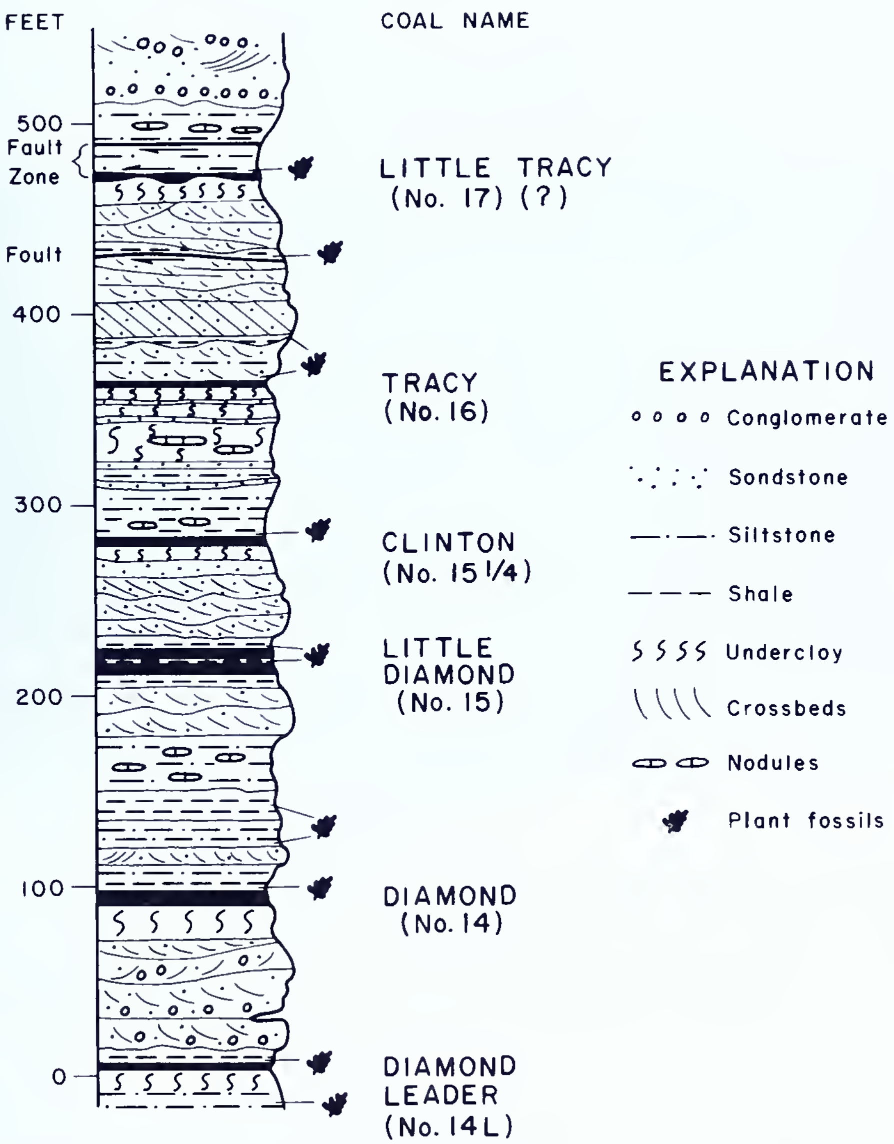
The columnar section shows the horizons at which well-preserved leaves and leaflets occur. The best collecting is in the shales above the Diamond (No. 14), Tracy (No. 16), and Little Tracy (No. 17) coals. Good specimens can be found in the rubble fans that mark the position of each of the coal beds. The plant fossils listed below are illustrated on Plates 19 and 20.

LYCOPSIDS
- *Lepidophylloides*
- *Lepidodendron*
- *Sigillaria*
- *Stigmaria*

SPHENOPSIDS
- *Annularia*
- *Asterophyllites*
- *Calamites*

PTEROPSID
- *Pecopteris*

PTERIDOSPERMOPSID
- *Neuropteris*



A generalized section of the Llewellyn Formation exposed along the northbound lane of Interstate 81 near Tremont. (The lowest beds are exposed at the north end of the cut.)

GEOLOGY. The rock strata exposed in the roadcut are part of the Llewellyn Formation, the younger and more commercially important of the two coal-bearing formations in the anthracite fields. The Llewellyn Formation is composed of river, lake, and swamp deposits that date from the Pennsylvanian Period approximately 300 million years ago. The succession of rock layers in the cut demonstrates the cyclic pattern characteristic of coal-bearing rocks in this part of Pennsylvania. A typical cycle consists (from bottom to top) of underclay, coal, dark-gray shale, shale and siltstone containing siderite (iron carbonate) nodules, and sandstone. Such cycles represent repeated burial of swamps by river deposits. The coal is the compressed remains of in-place accumulations of plant trunks, stems, and leaves in poorly oxygenated swamps.

The rock layers at this locality are bent into a tight downfold known as the Tremont syncline. This structure was formed during the great mountain-building episode that ended the Paleozoic Era 250 million years ago.

Core of the Tremont syncline exposed at site 45.

REFERENCES

Oleksyshyn, John (1982), *Fossil plants from the anthracite coal fields of eastern Pennsylvania*, Pennsylvania Geological Survey, 4th ser., General Geology Report 72, 157 p.

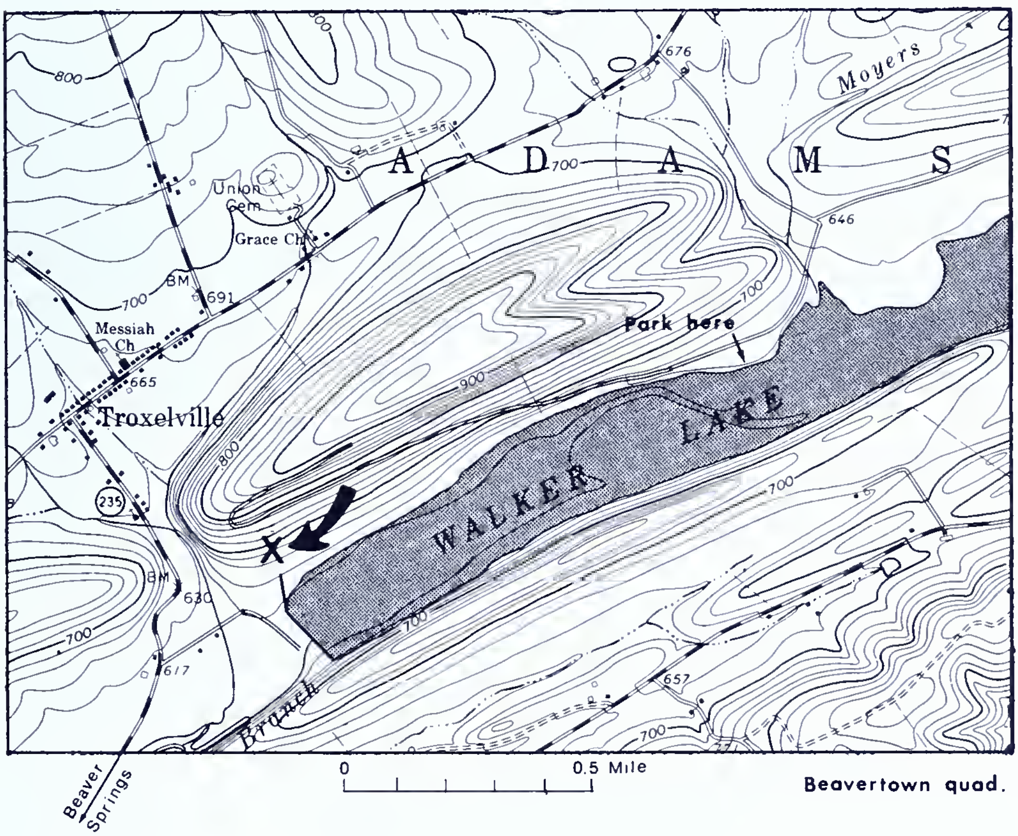
Sevon, W. D., Berg, T. M., Inners, J. D., and Smith, R. C., II (1982), *Geology of the southern part of the anthracite coal fields of Pennsylvania*, Annual Meeting of the American Association of State Geologists, 74th, Harrisburg, Pa., 1982, Guidebook, 41 p.

Wood, G. H., Jr., Trexler, J. P., and Kehn, T. M. (1969), *Geology of the west-central part of the Southern Anthracite field and adjoining areas, Pennsylvania*, U.S. Geological Survey Professional Paper 602, 150 p.

SNYDER COUNTY

SITE 46—WALKER LAKE BRACHIOPOD LOCALITY

LOCATION. A good locality for collecting marine invertebrate fossils that have weathered free of the enclosing rock occurs at the Pennsylvania Fish Commission's Walker Lake dam, 0.5 mile south-southeast of Troxelville, Adams Township. Fossiliferous dark-gray calcareous clay shale crops out on the north side of the deep excavation for the emergency spillway. The locality is accessible from the parking lot at the boat launch area via a 1-mile walk westward along the north shore of Walker Lake. Do not attempt to approach the site from the west! The area to the west of the dam is private property. DO NOT DIG PITS IN THE SPILLWAY CUT; COLLECT ONLY MATERIAL LYING ON THE SURFACE OF THE GROUND.



FOSSILS. The Walker Lake site yields well-preserved specimens of calcareous brachiopod valves and pyritized internal molds ("steinkerns") of brachiopods, gastropods, and cephalopods. Although few genera are represented here, the abundance of individual fossils compensates for the lack of variety. Brachiopods of the genus *Pacificocoelia* commonly occur in thin lenses, which may represent groups of shells that colonized harder ground on the generally soft, muddy sea floor. The fossils listed below are illustrated on Plates 6, 7, 8, and 21.

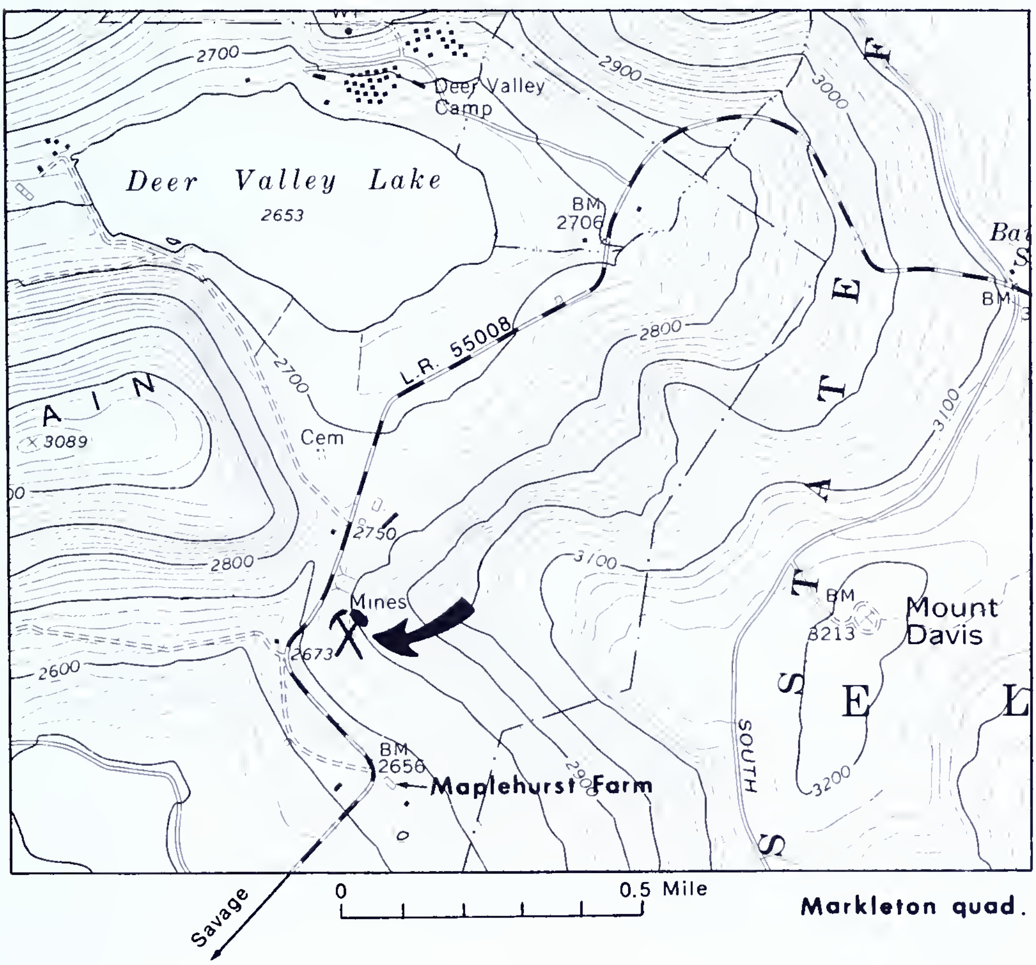
CORAL	GASTROPOD
Stereolasma	*Palaeozygopleura*
BRACHIOPODS	CEPHALOPOD
Orbiculoidea	*Michelinoceras*
Eodevonaria	TRACE FOSSIL
Pacificocoelia	*Chondrites*

GEOLOGY. The spillway cut at Walker Lake dam exposes calcareous clay shales and thin nodular limestone beds of the lower Onondaga Formation. The rock was originally lime-rich mud deposited in a tropical continental sea during Early Devonian time (approximately 392 million years ago). Where these sediments were laid down, the water was too deep (100 feet or more) for currents and waves to significantly disturb the sea bottom. In this quiet environment, however, highly mobile organisms of some kind (probably soft-bodied worms) extensively reworked the sediment, leaving behind a profusion of horizontal burrows (*Chondrites*). The occurrence of pyrite and limonite in the internal cavities of the fossils, as well as in many burrows, suggests that the muds were depleted in oxygen not far below the sediment surface. Pyrite probably crystallized in the shells and burrows shortly after they were buried. Weathering has converted much of the pyrite (iron sulfide) into limonite (hydrated iron oxide).

SOMERSET COUNTY

SITE 47—MT. DAVIS LIMESTONE QUARRY

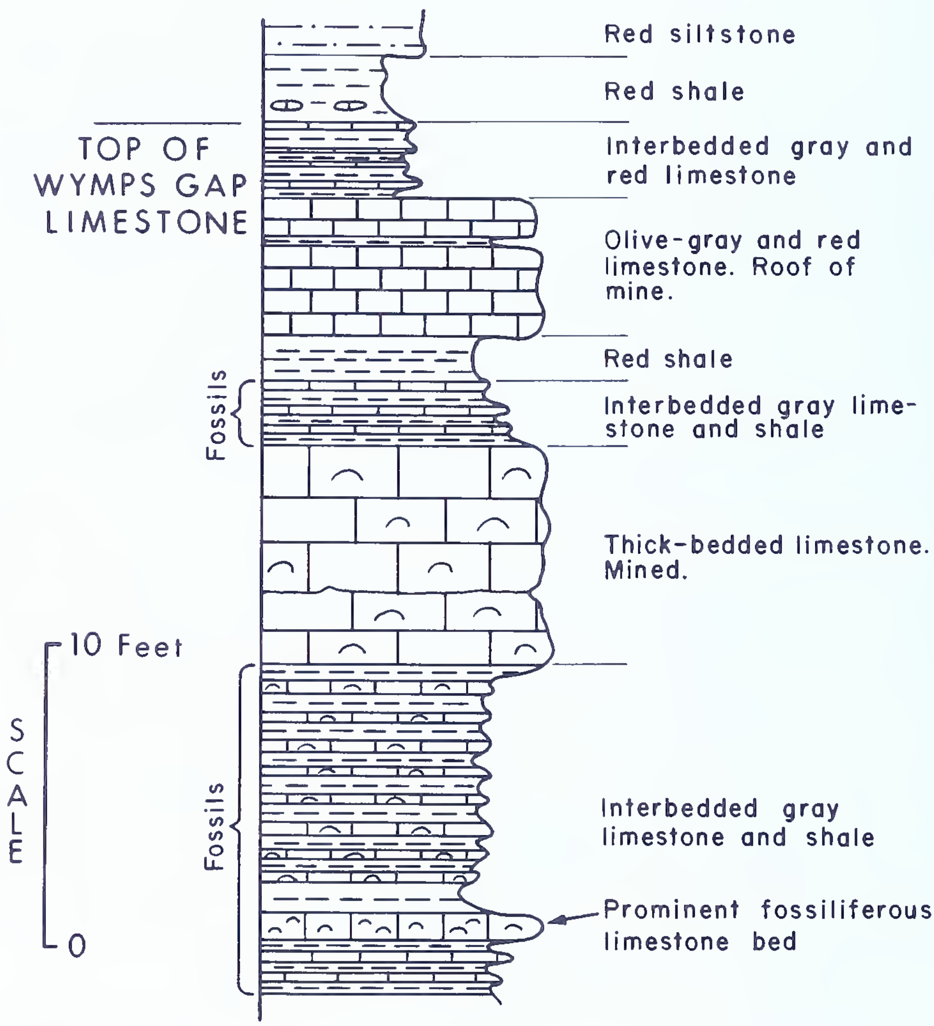
LOCATION. Somerset County is underlain by rocks that range in age from Late Devonian to Late Pennsylvanian. The upper 1,500 feet of this rock sequence consists of bituminous-coal-bearing strata that are temporarily exposed in many strip mines. Some of the shales and limestones associated with mined coal beds contain abundant invertebrate and plant fossils. Because of conservation practices, however, the mines are backfilled as soon as the coal is removed and are thus not available for collecting. Below the coal-bearing rocks in the southern part of the county, a distinctive band of fossiliferous marine limestone of Mississippian age occurs within the dominantly red, shaly Mauch Chunk Formation. Known as the Wymps Gap Limestone, this thin limy unit is a northern extension of the much thicker Greenbrier Limestone of West Virginia. For many years, the Keystone Lime Company mined the Wymps Gap Lime-



stone on the western slopes of Mt. Davis, the highest mountain in Pennsylvania.

An excellent locality for collecting Wymps Gap fossils is in an abandoned quarry at the entrance to one of the old underground mines on a hillside 500 feet east of L.R. 55008 and approximately 0.8 mile due west of the summit of Mt. Davis. The mine and quarry are located in a pasture on the Maplehurst Farm. Please obtain the permission of Mr. John Peck, owner of the farm, before entering the quarry. KEEP OUT OF THE UNDERGROUND MINE.

FOSSILS. The limestone at this locality is full of fossils, mostly brachiopods. Some of the fossils, for example the bryozoans and the brachiopod



A generalized section of the Wymps Gap Limestone exposed at the entrance to the old Keystone Lime Company mine on the Maplehurst Farm. Beds that contain easily collected fossils are marked.

genus *Orthotetes*, are so fragile that few complete specimens are found. However, diligent search should provide good specimens of these plus the rare trilobite genus *Kaskia*. The best collecting is from interbedded shale and limestone above and below the 7-foot mined interval. Many excellent specimens can also be found weathered free on the floor of the quarry. Sketches of the fossils listed below are shown on Plates 12 and 13.

BRYOZOAN	TRILOBITE
Fenestella	*Kaskia*
BRACHIOPODS	CRINOIDS
Orthotetes	Columnals
Diaphragmus	
Composita	
Spirifer	

GEOLOGY. The Wymps Gap Limestone in the Mt. Davis area was deposited about 340 million years ago on the eastern margin of a marine embayment which extended northward from what is now West Virginia into southwestern Pennsylvania. At the same time that marine organisms flourished in the area of Wymps Gap deposition, red shales and sandstones more typical of the Mauch Chunk Formation accumulated on river floodplains farther to the north and east.

The Keystone Lime Company formerly mined the Wymps Gap Limestone at this site for use as construction aggregate and agricultural lime. The commercial-grade beds are free of shale interlayers and are composed of sand-sized calcite grains, most of which are fragments of fossils. The "roof rock" of the mine is a less pure limestone that exhibits conspicuous burrow mottling.

When you visit this locality, include a trip to Mt. Davis, the "top" of Pennsylvania. The massive, erosionally resistant sandstone that caps the mountain is Pennsylvanian in age (320 million years old) and occurs about 450 feet stratigraphically above the Wymps Gap Limestone.

REFERENCES

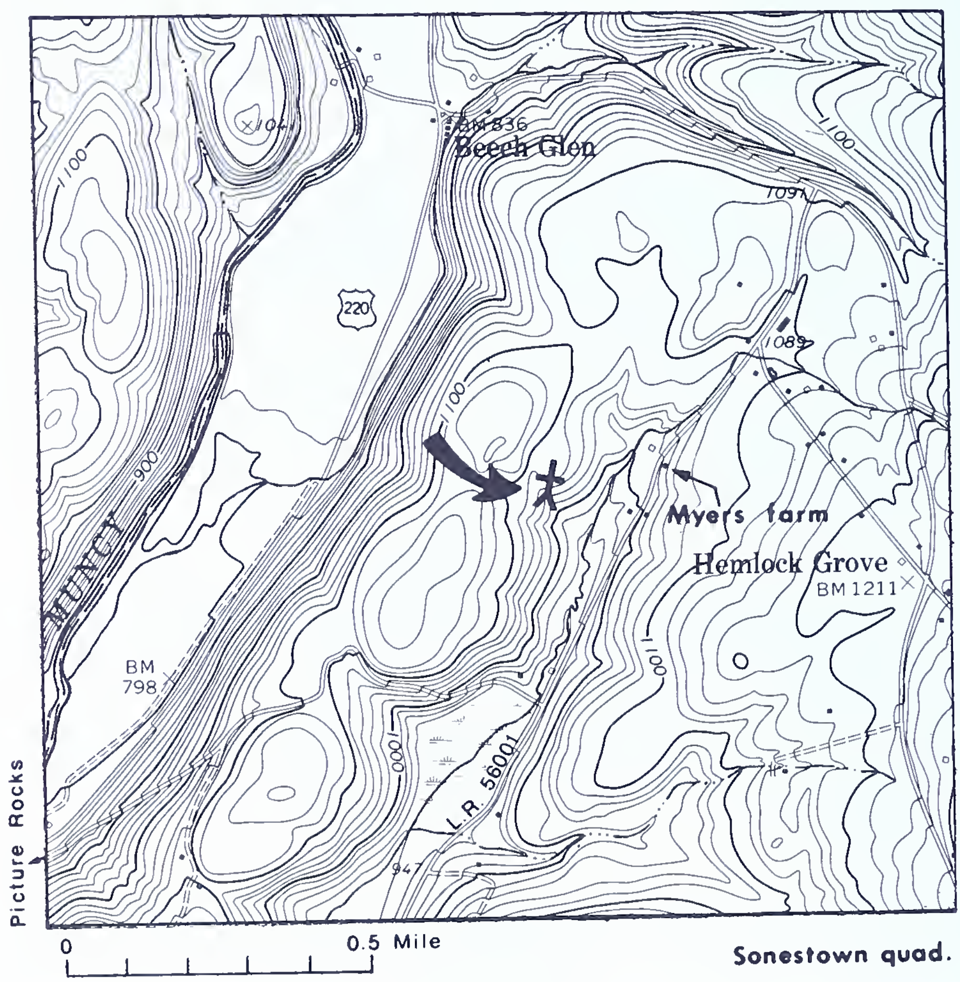
Flint, N. K. (1962), *Stratigraphy, structure, and economic geology of southern Somerset County and adjacent parts of Bedford and Fayette Counties, Pennsylvania*, Annual Field Conference of Pennsylvania Geologists, 27th, Somerset, Pa., 1962, Guidebook, 34 p.

__________ (1965), *Geology and mineral resources of southern Somerset County, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., County Report 56A, 267 p.

SULLIVAN COUNTY

SITE 48—MYERS FARM FISH-SCALE LOCALITY

LOCATION. Outcropping rocks in Sullivan County are entirely nonmarine. Some parts of the county (as near Bernice) contain coal-bearing Pennsylvanian rocks, and in those areas plant fossils may be found associated with the coals. Although the older Devonian "red beds" that underlie much of the county also contain plant fossils, these rocks are best known for yielding occasional vertebrate fossils. One of the best localities for collecting fossil fish remains in Pennsylvania is on the Willis N. Myers farm near Beech Glen in southwestern Sullivan County. The site is a small excavation in a sandstone ledge that crops out in the farm pasture 900 feet west of L.R. 56001 and 0.6 mile south of Beech Glen. The excavation lies in a slight topographic reentrant at an altitude of 1,075 feet on a high, east-facing hillside. PERMISSION MUST BE OBTAINED FROM MR. MYERS BEFORE ENTERING THE PROPERTY.

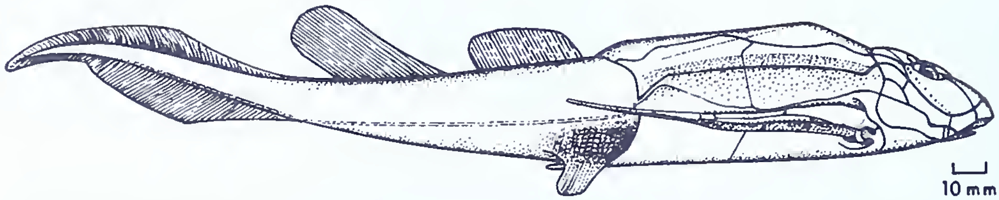


The fish remains occur in the prominent second rock bench on the hillslope. Although fossils have been found at several places along this bench, the largest and most abundant scales and plates are in a few feet of rock at the small excavation.

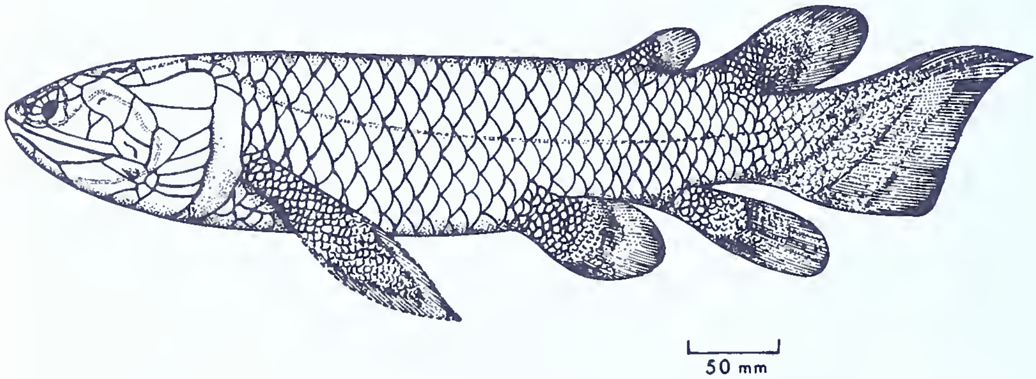
Excavation in sandstone ledge at the Myers farm locality. The arrow marks the fossiliferous bed.

FOSSILS. At the Myers farm site, large fossil fish scales and plates are associated with abundant carbonized plant fragments. The fish fragments are composed of whitish fluorapatite (a calcium phosphate mineral) and stand out clearly against the reddish-brown rock. Remains of the following three types of fish are found at this locality: (1) *Bothryolepis*, an armored fish (class Placodermi) (identified from partial plates); (2) *Holoptychius*, a crossopterygian, or "lobe fin" (class Osteichthyes) (identified from complete scales); and (3) an unidentified crossopterygian (known from complete scales). Some of the *Holoptychius* scales are 1.5 to 2 inches in diameter, suggesting that the fish itself was several yards in length.

Whereas the armored placoderms constituted a dead-end evolutionary line that became extinct at the close of Devonian time, some crossopterygians (similar to *Holoptychius*, in fact) were the direct ancestors of



Bothryolepis.



Holoptychius.

amphibians and other land-living vertebrates. Another group of crossopterygians, the coelocanths, were long thought to have died out at the end of the Cretaceous Period about 65 million years ago. In 1939, however, fishermen off the coast of Madagascar caught a living coelocanth (genus *Latimeria*)! Since that time several more of these "living fossils" have been caught in the same area, proving that extinction in the fossil record may not always be as final as it appears.

GEOLOGY. The rocks exposed on the Myers farm are part of the Catskill Formation of Late Devonian age. They were deposited about 380 million years ago by meandering streams that were building a delta similar to that of the present Mississippi River. The flat-lying sandstone ledges on the hillside are the channel portions of several cycles of stream deposition. The gentle slopes between the ledges are developed on red claystone and siltstone that formed from the fine-grained muds deposited during Late Devonian floods. The layer in which the fish scales actually occur is a peculiar mixture of calcium carbonate fragments, claystone chips, and carbonized plant stems, which probably accumulated at the base of a shallow stream channel. Small patches of malachite, a green copper carbonate mineral, are conspicuous in the fossil-bearing rock; some fish scales are beautifully speckled with this mineral.

The area was excavated at the height of the uranium prospecting boom of the 1950's. Rocks at the site are slightly radioactive and contain trace amounts of uranium associated with the malachite and carbonized plant debris. Many other localities in this portion of Sullivan County contain uranium minerals, but none have economic potential at the present time.

REFERENCE

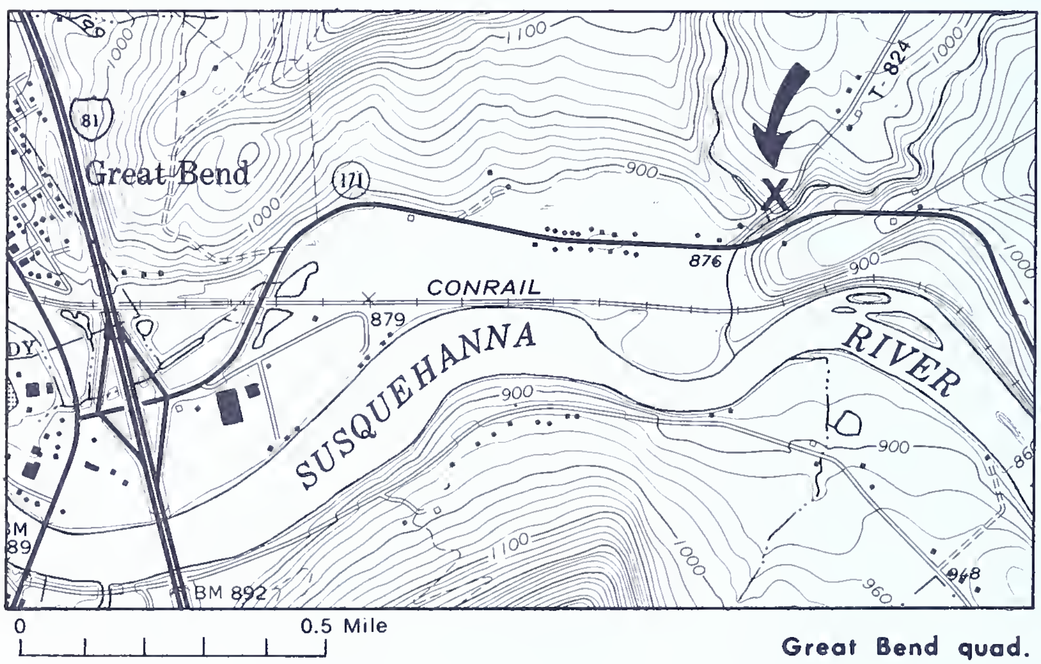
Smith, R. C., II, and Hoff, D. T. (in press), *Geology and mineralogy of copper-uranium occurrences in the Picture Rocks and Sonestown quadrangles, Lycoming and Sullivan Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Mineral Resource Report 80.

SUSQUEHANNA COUNTY

SITE 49—NEARSHORE-MARINE FOSSILS AT GREAT BEND

LOCATION. Marine fossils are not abundant in northeasternmost Pennsylvania, but a few localities near Great Bend contain thin layers of marine fossils interbedded with thick zones of unfossiliferous rock. The recommended locality is along a dirt road 1.2 miles east of Great Bend, measured from the exit on Interstate Route 81. Follow Pa. Route 171 east from Great Bend to the first road leading left (Great Bend Twp. Route 824). The exposure that has fossils is about 700 feet along the road in a low cut bank on the left. The rocks exposed along the township road are also exposed along the small stream leading northwest from the road, past a small, picturesque falls.

Similar rock is exposed along Route 171, just east of the road turnoff, as it ascends the hill. Collecting at this exposure is much more dangerous because the road is narrow and traffic cannot be easily seen.



Great Bend quad.

FOSSILS. The fossils found at these two localities are listed below and illustrated on Plates 6, 8, 9, and 21.

BRACHIOPODS	PELECYPODS	CRINOIDS	TRACE FOSSIL
Ptychomaletoechia	*Nuculoidea*	Columnals	*Planolites*
Cyrtospirifer	*Palaeoneilo*		

GEOLOGY. The marine rocks exposed along the Susquehanna River at Great Bend are in the uppermost part of the Lock Haven Formation of Late Devonian age. Within a few tens of feet stratigraphically and vertically above these rocks occur red-colored rocks marking the base of the dominantly nonmarine Catskill Formation.

This part of the Lock Haven Formation was deposited under conditions generally unsuitable for marine fossils, due to the presumed low salinity of the water and the rapid influx of muds and silts from the rivers and distributaries of the nearby Catskill delta. The few thin zones of fossils accumulated when currents swept shells from areas of more normal salinity into channels and nearshore zones, where they were deposited as a "hash" of partially broken shells and other material.

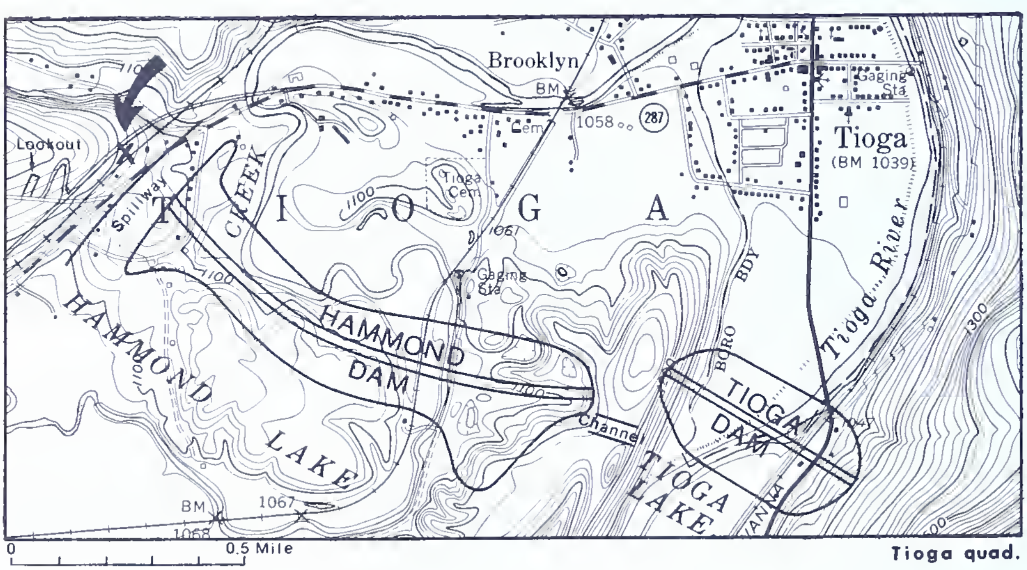
TIOGA COUNTY

SITE 50—"CLAMS" AT HAMMOND DAM

LOCATION. Probably the most imposing engineering works in north-central Pennsylvania are the newly constructed Tioga and Hammond Dams, built by the Army Corps of Engineers on the Tioga River and Crooked Creek about 1.5 miles south of the borough of Tioga. The construction of these two great earth-fill dams necessitated relocation of several nearby highways and railroads from their original positions. Reconstruction of these transportation routes produced some large cuts that expose long sections of Late Devonian age rocks containing marine fossils. Well-preserved fossils can be collected in one of these new cuts on Pa. Route 287 near the west end of Hammond Dam.

To get an overview of the area, travel west from Tioga about 1.5 miles on Pa. Route 287 to the turnoff on the right. This leads to a scenic overlook from which Hammond Dam and the lake it creates can be viewed. A detailed description of the area and rocks at this site was published as part of the field trip conducted in 1981 by the Field Conference of Pennsylvania Geologists. To investigate all of the rocks, it is best to park at the overlook and walk back to the highway, and then walk along the south side of the highway, where the cut bank is lower and the rocks are more easily accessible. DO NOT WALK ALONG THE NORTH SIDE OF THE HIGHWAY; rocks falling from the very high cut there may cause a severe accident.

The best collecting to be found is at the east end of the Route 287 cut on the south side of the highway. Many blocks, containing abundant large "clams" (pelecypods), have fallen from the cut.



Tioga quad.

FOSSILS. The fossils listed below are illustrated on Plates 6, 7, 8, 10, and 21.

BRACHIOPODS
Protoleptostrophia
Spinulicosta
Ptychomaletoechia
Composita
Tylothyris
Cyrtospirifer

PELECYPOD
Edmondia

CRINOIDS
Columnals

TRACE FOSSIL
Arenicolites

GEOLOGY. The rocks exposed at the Hammond Dam cuts are in the upper part of the marine Lock Haven Formation of Late Devonian age. Many sedimentary structures and different rock types may be seen along the traverse from the scenic overlook to the site of the "clam bed." Many beds in the outcrop are filled with brachiopods that have shell material preserved. The rocks and the fossils record repeated cycles of deposition on a shallow marine shelf, interrupted by influxes of material from tidal channels.

The fact that many of the layers contain well-preserved trace fossils, such as *Arenocolites*, shows that a well-developed fauna lived in the sediment.

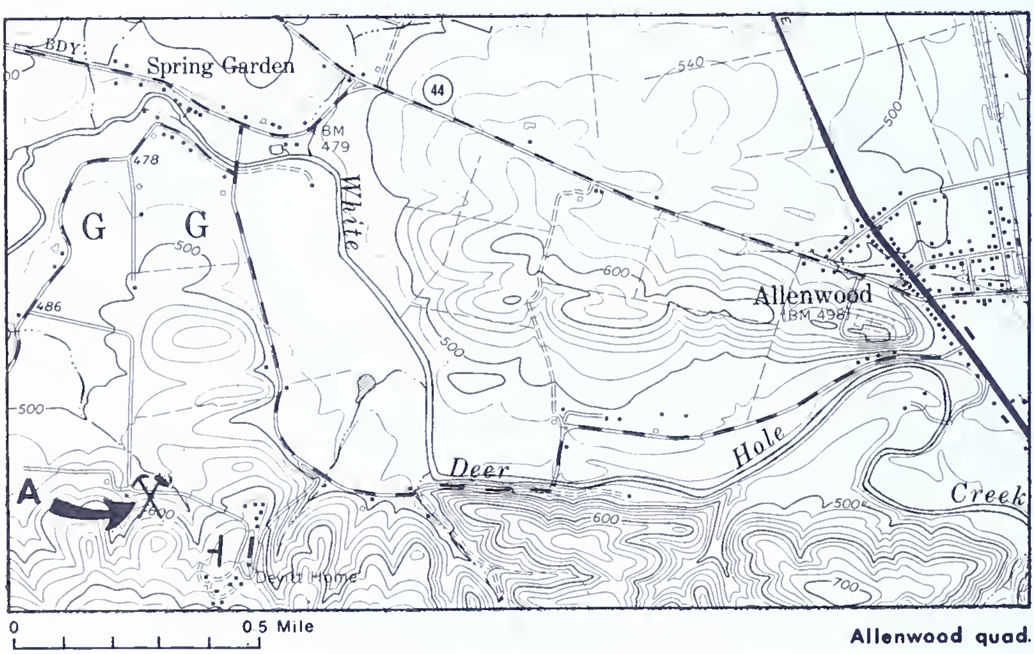
REFERENCE

Berg, T. M., Crowl, G. H., Edmunds, W. E., and others (1981), *Geology of Tioga and Bradford Counties, Pennsylvania*, Annual Field Conference of Pennsylvania Geologists, 46th, Wellsboro, Pa., 1981, p. 153–159.

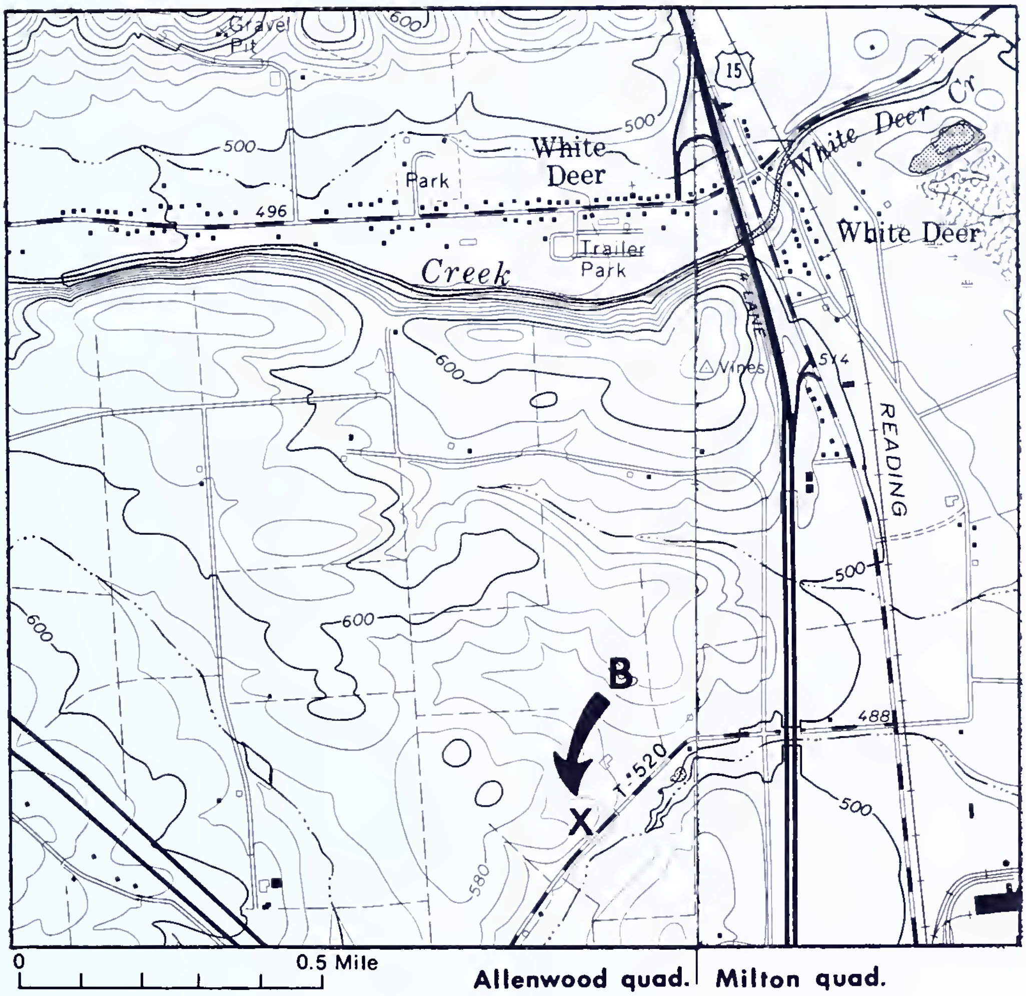
UNION COUNTY

SITE 51—BRACHIOPODS AND OSTRACODES FROM THE MIFFLINTOWN FORMATION

LOCATION. The outcropping rock strata of eastern Union County consist of folded Silurian and Devonian formations, several of which are highly fossiliferous. Some of the best fossil-collecting localities are in the Mifflintown Formation of Early to Late Silurian age, a 200-foot-thick sequence of limestones and limy shales that is exposed on the flanks and noses of the numerous mountain ridges that decrease in height and disappear eastward across the county. Two easily accessible Mifflintown localities within 4 miles of each other are (A) an inactive borrow pit on Pine Knoll Farms, 1.6 miles west-southwest of Allenwood; and (B) a rubble-covered slope on the northwest side of Deitrick Road (White Deer Twp. Route 520), 1.0 mile south of White Deer. Permission to collect at the Pine Knoll Farms borrow pit must be obtained in advance from either Mr. Harry W. Sunanday, R.D. 1, Allenwood, PA 17810 (phone 717-538-1746), or Mr. Bradley J. Sunanday, R.D. 1, Box 25A, Allenwood, PA 17810 (phone 717-538-5977). After you have received permission to enter the property, you may drive directly to the pit, which is located 300 feet east of the farmhouse. At the Deitrick Road locality, enough space to park several cars exists at the top of the hill on the shoulder opposite the outcrop. Although this road is lightly traveled, watch out for vehicles coming over the crest of the knoll.



Allenwood quad.



FOSSILS. A variety of typical Silurian fossils, especially brachiopods, can be collected at the Pine Knoll Farms locality (A). The easiest fossil specimens to collect are those that are concentrated in thin (0.5- to 2-inch) limestone beds. These beds commonly break out of the outcrop in slabs that are often crowded with white calcareous brachiopod shells and crinoid columnals. Some of the limestone layers are deeply leached, and the fossils occur as rusty-brown, friable internal and external molds. More difficult to find are the small, coarsely ribbed brachiopods (*Stegerhynchus* and *Cupulorostrum*) that weather completely free of the gray, olive-weathering shale on the floor of the pit.

The only fossils known to occur in the cut on Deitrick Road (B) are myriads of ostracodes. Thousands of these tiny crustaceans can be found in the limestone blocks that litter the slope between the crest of the hill and the northeast end of the cut. Probably the best method of collecting at the locality is to split the limestone slabs along the layering (bedding) with a chisel or the chisel end of a rock hammer. The ostracodes are beautifully preserved and stand out as white speckles, 1 to 2 mm in diameter, against the gray background of the unweathered limestone. A 10-POWER HAND LENS IS A NECESSITY AT THIS LOCALITY.

Illustrations of the fossils listed below can be found on Plates 3 and 4.

Pine Knoll Farms borrow pit (A):	Deitrick Road cut (B):
BRACHIOPODS	OSTRACODES
Isorthis	*Velibeyrichia*
Brachyprion	*Kloedenia*
Stegerhynchus	
Cupulorostrum	
TRILOBITE	
Dalmanites	
OSTRACODE	
Velibeyrichia	
CRINOIDS	
Columnals	

GEOLOGY. The rock strata exposed at these two localities occur in the lower (A) and upper (B) parts of the Mifflintown Formation and date from the middle of the Silurian Period approximately 415 million years ago. The highly fossiliferous, lower Mifflintown limy shales accumulated under fairly deep water, open-marine conditions. Most of the thin shelly layers probably represent skeletal debris transported from nearby shoals during storms. The interbedded limestones and shales of the upper Mifflintown, on the other hand, were deposited, at least in part, in shallow brackish-water lagoons. Because of wide fluctuations in salinity and oxygen levels, only a few organisms found these lagoons hospitable. Those that did, however, such as the ostracode genera *Velibeyrichia* and *Kloedenia*, proliferated by the millions.

Note that the shale and limestone layers (beds) in the Pine Knoll Farms borrow pit have a pronounced northward inclination. This "dip" reflects the fact that the rock strata lie on the north limb of one of the great anticlines, or upfolds, that characterize the Appalachian Mountains of central Pennsylvania. The high, smooth arch of South White Deer Ridge just to the south of the borrow pit is the topographic expression of a similar roll in the resistant, Early Silurian age quartzitic sandstone beds that underlie the mountain crest and slopes. Younger rock strata (including the Mifflintown Formation) that once extended over the top of the fold were eroded away millions of years ago and are now preserved only on the fold limbs.

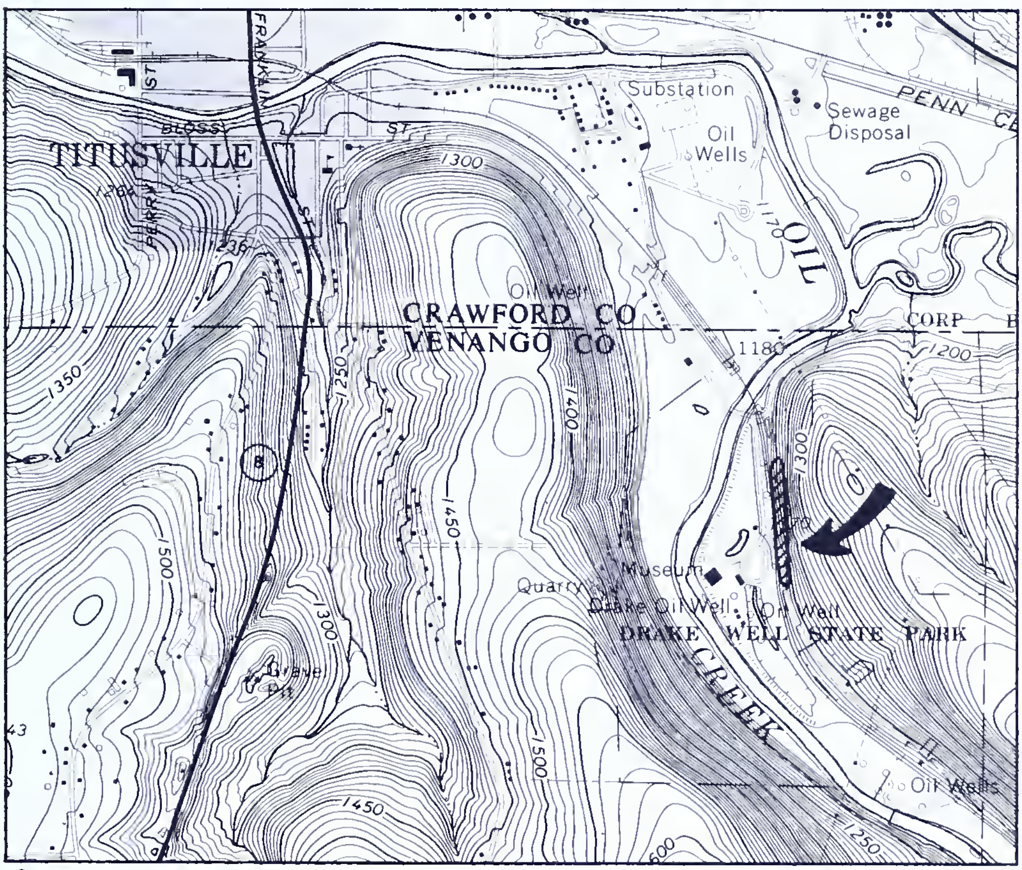
REFERENCE

Inners, J. D. (in preparation), *Geology and mineral resources of the Allenwood and Milton quadrangles, Union and Northumberland Counties, Pennsylvania*, Pennsylvania Geological Survey, 4th ser., Atlas 144cd.

VENANGO COUNTY

SITE 52—MISSISSIPPIAN SPONGES AT DRAKE WELL STATE PARK

LOCATION. Both body fossils and trace fossils can be found in the Corry Sandstone of Early Mississippian age at Drake Well State Park in northern Venango County. The park is just south of Titusville, across the Venango-Crawford County boundary. The site can be reached by traveling into Titusville on Pa. Route 8 and turning east onto Bloss Street just south of the bridge over Oil Creek. Proceed about 1.5 miles, following signs to the state park. Parking is available and convenient at the park entrance. The fossiliferous sandstone crops out along the railroad tracks just above the parking lot. The outcrop extends for several miles along the tracks south of the park entrance, but fossil collectors will find abundant fossils within 100 yards of the parking lot. The most fossiliferous beds crop out just above track level. Many excellent specimens can be picked up from the ground, where fragments of the rock have fallen over the years.



0 0.5 Mile

Titusville South quad.

Visitors to the park are urged to visit the Drake Well Museum to learn about the history of the oil industry in Pennsylvania. The museum has a reconstruction of the Drake oil rig, as well as many examples of nineteenth-century oil-drilling, -producing, and -transporting equipment.

FOSSILS. Fossils are abundant and diverse at this locality and consist of two general varieties: (1) body fossils, which are found either as molds and casts or as preserved shells and skeletal fragments; and (2) trace fossils, which are especially common in some of the sandstone beds and consist of tracks, trails, and horizontal and vertical burrows. One of the more interesting fossils found at this locality is *Titusvillia*, a curious branching sponge composed of cuplike nodes. See Plates 12 and 13 for illustrations of the fossils listed below.

SPONGE
  Titusvillia
BRACHIOPODS
  Lingula
  Rugosochonetes
  Shumardella
  Spirifer
GASTROPOD
  Euomphalus
PELECYPODS
  Parallelodon
  Leiopteria
CRINOIDS
  Columnals

GEOLOGY. The Corry Sandstone covers a large area in northwestern Pennsylvania and typically consists of three members. The upper, massive sandstone member is separated from the lower, platy and fossiliferous sandstone member by a middle member of shale and siltstone. The Corry probably represents sand, silt, and clay deposition on a lobate delta or deltaic system which spread southeastward from New York into northern Pennsylvania. Because the Corry is an easily recognized formation in drill holes, it is an important unit to the oil and gas industry in determining the approximate depth to producing horizons. (Drillers have used the unlikely names "Blue Monday" and "Mountain" for the Corry Sandstone in the vicinity of Titusville and Oil City.) The thin-bedded nature of the fine-grained sandstones, especially those in the lower member of the formation, make it an excellent source for flagstone and other types of construction material where it is exposed at the surface.

REFERENCES

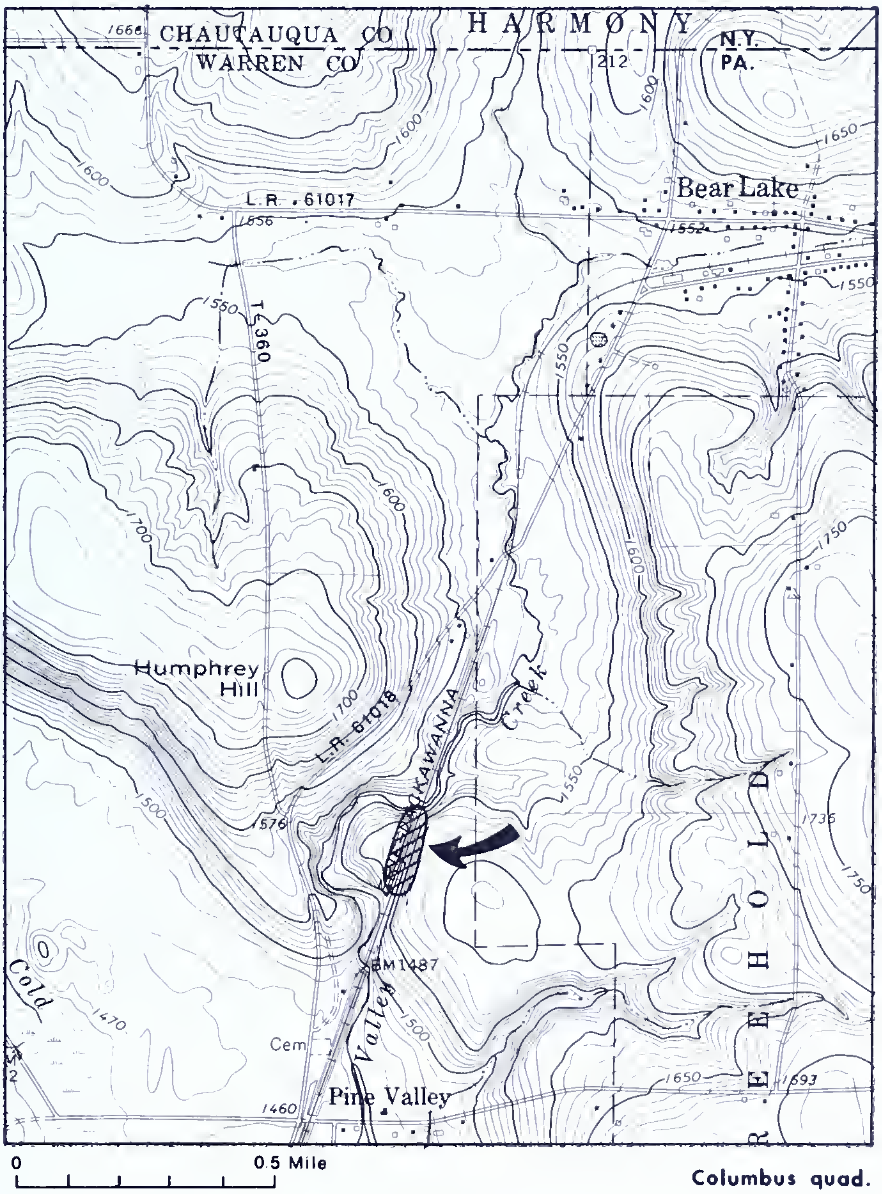
Caster, K. E. (1934), *The stratigraphy and paleontology of northwestern Pennsylvania*, Bulletins of American Paleontology, v. 21, no. 71, 185 p.

__________ (1939), *Siliceous sponges from the Mississippian and Devonian strata of the Penn-York embayment*, Journal of Paleontology, v. 13, p. 1–20.

WARREN COUNTY

SITE 53—AN ICHNOFOSSIL (TRACE-FOSSIL) PARADISE

LOCATION. Tracks, trails, and burrows, those marks in the rocks that indicate the presence or passage of an animal that did not have, or did not leave behind, a shell or skeleton, are common in many of the rocks of Pennsylvania. But it is a rare locality where one can collect good specimens of these trace fossils. Most traces are too indistinct, have been re-



Columbus quad.

worked by later activities, or are just not sufficiently developed to be "collectible." An additional difficulty in collecting trace fossils is that one usually has to collect large chunks of rock to show the trace fossil. At a locality near Bear Lake in Warren County (not far from the New York-Pennsylvania border), however, many good display trace-fossil specimens can be collected.

Reaching this "paradise" of ichnofossils involves a walk of about 0.4 mile. The easiest access is to park near the small cemetery 0.15 mile north of Pine Valley, walk to the railroad embankment, and then walk along the Erie and Lackawanna Railroad tracks north 0.4 mile to the outcrop that extends for about 200 yards on both sides of the railroad. This railroad is little used and provides a reasonably safe locality for collecting.

Because many of the specimens you will collect here may be quite large, it is wise to bring along a backpack or rucksack to carry samples from the site.

FOSSILS. Both body fossils and trace fossils are abundant at the railroad cut. Large spiriferid brachiopods are common, as are rhynchonellids. Rarer types include clams, trilobites, and fragments of fish spines or other armor.

The trace fossils are of three basic types. One type is sand-filled burrows preserved on the bottom sides of rock layers. These are referred to as *Planolites* and are simple, smooth tubes that meander without distinct pattern and occasionally cross over other tubes. A second type is clay-filled burrows in sandstone that now may appear as holes and open tubes in the rock. These two types probably were made by different animals because, in the case of *Planolites*, the animal that created the burrow was ingesting the sand as it moved through, whereas in the second type, the filling of the tube came later after the animal left. The latter were probably dwelling tubes and are called *Chondrites*. A third type, which may be up to 2 feet in length and 4 inches wide, is *Rhizocorallium*. This fossil occurs along the surfaces of rock layers and appears as two long, tubular burrows that have parallel curved structures (spreite) between them.

The fossils listed below are illustrated on Plates 8, 9, and 21.

BRACHIOPODS
- *Spinulicosta*
- *Ptychomaletoechia*
- *Cyrtospirifer*

PELECYPODS
- *Palaeoneilo*
- *Pseudaviculopecten*

FISH
- Unidentified plates and spines

TRACE FOSSILS
- *Chondrites*
- *Planolites*
- *Rhizocorallium*

GEOLOGY. The shales and sandstones exposed along the Erie and Lackawanna Railroad north of Pine Valley are part of the Venango Formation. The Venango Formation is geologically important in this area because many of its sandstones are the reservoir rock that has produced much of Pennsylvania's Penngrade crude oil.

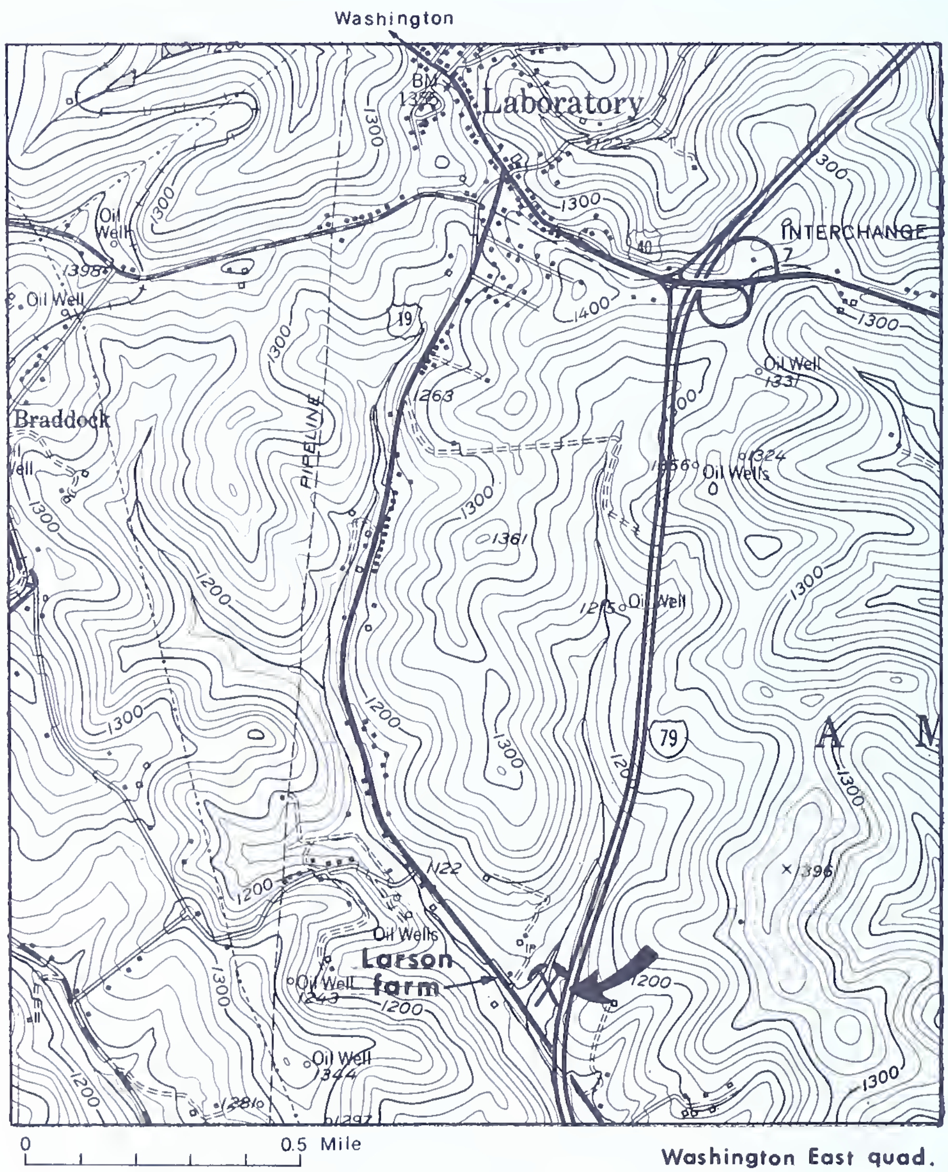
These rocks were formed in the relatively nearshore environment of a shallow marine sea that supported a large population of animals living on and in the muddy/sandy sea bottom. Many of these animals had no hard parts for fossilization, but we can see that they were present at the time the sediments were deposited due to the extensive amount of preserved burrows in the rocks. These burrows could have been formed by such animals as worms, shrimp, crabs, and pelecypods.

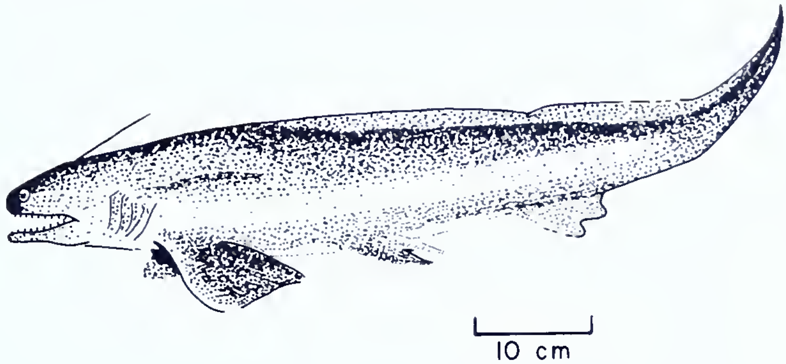
The animals that had hard skeletal parts and lived on the surface or swam above it (the pelecypods, brachiopods, and fish) existed in the same environment as did the soft-bodied animals that made the trace fossils. The trace fossils, because they were not disturbed after they were formed, show the nature of the sediment at the time of deposition, altered only in that it is now hard rock.

WASHINGTON COUNTY

SITE 54—PERMIAN FISH-TEETH LOCALITY

LOCATION. Both invertebrate and vertebrate fossils are common in some of the Late Paleozoic freshwater limestones of extreme southwestern Pennsylvania. One of the best collecting localities is a small abandoned limestone quarry on the Ed Larson farm on the east side of U.S. Route 19 just west of the Interstate Route 79 overpass. The quarry is about 1.5 miles south of the intersection of U.S. Routes 19 and 40 in Laboratory.

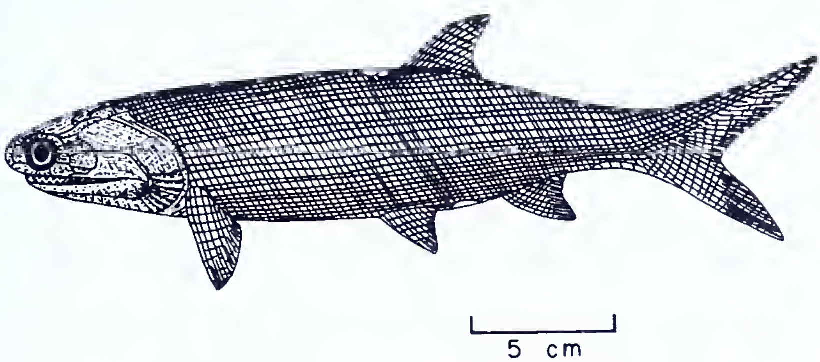




Xenacanthus.

Because the quarry is now in a pasture and is accessible only by crossing over a fence, it is necessary to secure the permission of Mr. Larson before entering. Please park at the farmhouse and get his okay before walking south along the road to the quarry.

FOSSILS. Because all of the fossils that occur at this locality are very small, a magnifying lens of about 10 power is a necessary tool for collecting. Three types of fossils can be found here: (1) worm shells—small coiled shells, much like a snail, which housed polychaete worms (*Spirorbis*); (2) ostracodes—small pea-shaped valves of the genus *Cytherella*; and (3) fish teeth of two types—single teeth and bony plate fragments of the genus *Palaeoniscus* (class Osteichthyes), and two-pronged teeth (assigned to the form genus *Diplodus*) from a type of medium-sized freshwater pleurocanth shark (class Chondrichthyes), possibly the genus *Xenacanthus*. See Plate 18 for illustrations of these fossils.



Palaeoniscus.

GEOLOGY. The fossils occur in the upper limestone member of the Washington Formation, a series of flat-lying Permian age sandstones, shales, and limestones that formed in freshwater lakes, swamps, and streams about 285 million years ago. The limestones of the Larson quarry are typical shallow-lake deposits. In the quarry, ostracodes are common in the limestone beds and shaly interlayers, and fish teeth and worm shells are found mostly in the shaly interlayers. The best place to look for fish teeth is on some of the large blocks on the quarry floor and at the top of the uppermost limestone layer in the quarry wall.

The upper limestone member of the Washington Formation, Ed Larson quarry.

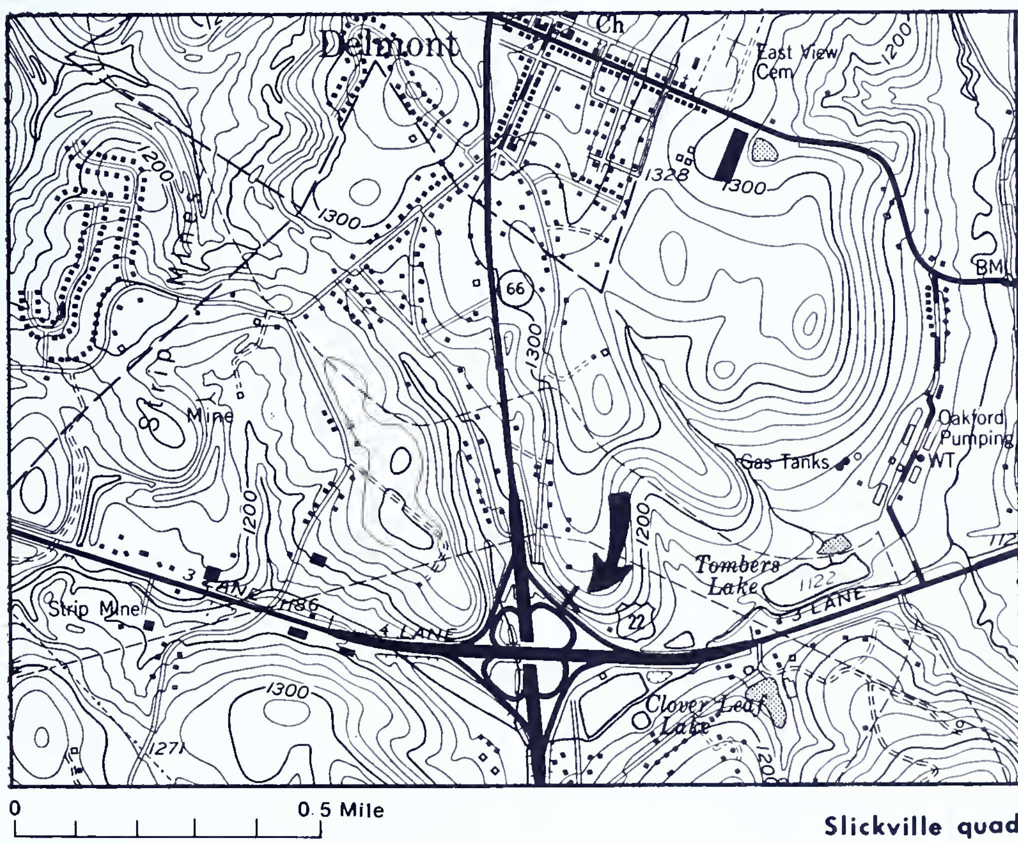
REFERENCE

Kent, B. H., Roen, J. B., Schweinfurth, S. P., and Carswell, L. D. (1965), *Stratigraphy of the Pennsylvanian and Permian rocks of Washington, Mercer, and Lawrence Counties, Pa.,* Annual Field Conference of Pennsylvania Geologists, 30th, Pittsburgh, Pa., 1965, Guidebook, 95 p.

WESTMORELAND COUNTY

SITE 55—AMES FOSSILS NEAR DELMONT

LOCATION. Westmoreland County, like most of the western counties of Pennsylvania, is underlain predominantly by nonmarine rocks formed when the great coal swamps occupied the area. During this period of geologic history (aptly known as the Pennsylvanian), several thin, fossiliferous limestone layers were deposited in marine seas, which occasionally covered all of western Pennsylvania. One of these limestones, the Ames, crops out 7.5 miles north of Greensburg at the junction of U.S. Route 22 and Pa. Route 66. The exposure is on the northeast side of the cloverleaf interchange 1 mile south of Delmont. To get to the site follow U.S. Route 22 west. Turn right (north) at the east end of the cloverleaf as if to drive north to Pa. Route 66. The limestone is a blocky, buff-colored rock that sticks out from the surrounding shales on the bank adjacent to the road. Vehicles can park without much difficulty on the road shoulder. TRAFFIC IS MODERATELY HEAVY AROUND THIS INTERCHANGE, SO BE CAREFUL.



0 0.5 Mile

Slickville quad.

FOSSILS. The Ames—here consisting of about 18 inches of gray muddy limestone—has traditionally been recognized as one of the more fossiliferous rock units in western Pennsylvania. Most common of the many types of fossils in the limestone at this site are the small brachiopods *Crurithyris* and *Neochonetes*, both of which occur as pockets of fossil hash. Numerous choice specimens can be collected if care is taken to hunt through the entire unit. The underlying and overlying shales, though thin, can be more easily broken up and yield a different suite of fossils. The gray shales below the limestone, especially within 6 inches of the base, are particularly fossiliferous, the flat-shelled brachiopod *Derbyia* being the most common form. The typical occurrence of *Derbyia* in thin layers at this and other fossil localities in southwestern Pennsylvania, Ohio, and West Virginia suggests that in life myriads of these brachiopods formed a "pavement" on the sea floor, upon which other marine organisms developed (rather like a large patio filled with small, flat cobbles). The *Derbyia* shells acted as attachment surfaces for other brachiopods, as well as for oysterlike pelecypods, and may have formed a hard substrate on which sea grasses and algae flourished. The plants were food for some of the foraging animals, such as the herbaceous gastropods, which in turn provided food for carnivorous cephalopods and fish. The fossils listed below are illustrated on Plates 13 to 16 and 21.

CORAL
- *Stereostylus*

BRACHIOPODS
- *Rhipidomella*
- *Derbyia*
- *Neochonetes*
- *Juresania*
- *Linoproductus*
- *Wellerella*

BRACHIOPODS (cont.)
- *Composita*
- *Crurithyris*
- *Neospirifer*

GASTROPODS
- *Euphemites*
- *Anania*s
- *Strobeus*

PELECYPODS
- *Phestia*
- *Astartella*

CEPHALOPODS
- *Brachycycloceras*
- *Pseudorthoceras*
- *Tainoceras*

CRINOIDS
- Columnals and plates

TRACE FOSSIL
- *Conostichus*

GEOLOGY. The Ames Limestone was deposited approximately 300 million years ago during the last of the Pennsylvanian age marine invasions of southwestern Pennsylvania. The Ames is muddier and thinner here than at outcrops farther to the west in the vicinity of Pittsburgh, indicating that this area lay closer to the shoreline or at least received a great influx of land-derived sediment. Although its thickness and nature vary, the Ames is an important "marker" horizon that is easily recognized both at the surface and in drill holes throughout western Pennsylvania. This makes it especially important to the coal, oil, and natural gas industries. Because the Ames is typically overlain and underlain by soft red clays, claystones, and shales (the "Pittsburgh red beds") that are largely responsible for the landslide problems common to western Pennsylvania, it is also valuable as a "marker" of potential problems for the housing and highway construction industries.

DISPLAYS OF FOSSILS IN PENNSYLVANIA COLLEGES AND MUSEUMS

Many Pennsylvania colleges and museums maintain collections of fossils for public use as well as for study by students and professional paleontologists. To help familiarize yourself with fossils you should visit these exhibits. They will help you learn about the many kinds of fossils that exist as well as help you identify the fossils you may collect. The curators who take care of the collections will, in most cases, be able to help you with your problems of identification.

Some of the colleges and smaller museums do not have their exhibits open to the public. To examine these collections, which are generally small collections used in teaching, it is necessary to make an appointment with those in charge.

For help with fossil identification you may wish to contact the science departments of the many Pennsylvania colleges, even if they do not have any displays or collections. Many of the science departments of these colleges have geologists on their staff who will often be able to help you identify fossils.

ALLEGHENY COUNTY

CARNEGIE INSTITUTE, 4400 Forbes Avenue, Pittsburgh 15213

A visit to the excellent Museum of Natural History at the Carnegie Institute is a must for all serious fossil collectors. The Museum has numerous displays depicting reconstructions of invertebrate and vertebrate fossils in their natural habitats. Many individual fossil specimens are also on exhibit. Specific halls to visit are

(1) Paleozoic Hall (invertebrate fossils);
(2) Mesozoic Hall (vertebrate fossils, especially dinosaurs); and
(3) Cenozoic Hall (vertebrate fossils, including large Ice Age mammals, such as the mammoth and mastodon).

The Museum also includes the Hilman Hall of Minerals, housing one of the finest displays of minerals in the country, and a new Hall of Geology.

The hours are as follows: Tuesdays to Saturdays, 10:00 A.M. to 5:00 P.M.; closed Mondays. Sunday hours are 12:00 noon to 5:00 P.M. Telephone (412) 622-3263 for information on invertebrate fossils.

BERKS COUNTY

READING PUBLIC MUSEUM AND ART GALLERY, 500 Museum Road, Reading 19611

In addition to displays devoted to birds, mammals, reptiles, fish, insects, and minerals, the Reading Museum has several fossil exhibits illustrating life in most of the Paleozoic and Cenozoic Eras.

Collections include the Unger Collection of plant fossils from the Pennsylvanian Period as well as a general suite of fossils. To see the collections it is necessary to make arrangements in advance. Telephone (215) 371-5850.

Museum hours are as follows: weekdays, 9:00 A.M. to 5:00 P.M. (9:00 A.M. to 4:00 P.M. between Memorial Day and Labor Day); Saturdays, 9:00 A.M. to 12:00 noon (closed Saturdays between Memorial Day and Labor Day); and Sundays, 2:00 to 5:00 P.M. year-round.

BRADFORD COUNTY

BRADFORD COUNTY HISTORICAL SOCIETY, 21 Main Street, Towanda 18848

Together with a large number of local Indian relicts, the Bradford County Historical Society has two cases partially devoted to fossils that were collected from the local area.

From March through December, the Historical Society museum is open Monday and Friday evenings, 7:00 to 9:00 P.M., and Thursday and Saturday afternoons, 2:00 to 4:00 P.M. The museum is closed in January and February. Appointments can be made for times other than the normal hours (including January and February). Telephone (717) 265-2240.

TIOGA POINT MUSEUM, 724 South Main Street, Athens 18810

In addition to fine paleontologic material from outside Pennsylvania (including a large slab of dinosaur footprints from the Connecticut Valley), this museum has fossils from the local area. Of most interest are the large numbers of Carboniferous plant fossils from the Pennsylvania coal fields. Most of the major groups of fossils are included in the collection, which is housed in open display cases.

The Museum is open Mondays, 7:00 to 9:00 P.M., and Wednesdays and Saturdays, 2:00 to 5:00 P.M.; in June and July, it is also open Mondays 2:00 to 5:00 P.M. Group tours should make appointments by calling during Museum hours. Telephone (717) 888-7225.

CENTRE COUNTY

THE PENNSYLVANIA STATE UNIVERSITY, Department of Geosciences, University Park 16802

The Earth and Mineral Sciences Museum of Penn State University is located in the Steidle Building on Pollock Road in State College. Some of the important features of the Museum are as follows:

(1) Pennsylvania-related fossils (including Pennsylvanian Period) are housed in the Pennsylvania Room.

(2) Fossils are arranged in cabinets in the first floor west corridor between entrances to Rooms 104 and 107.

(3) The Museum is most noted for its rather extensive mineral collections and push-button-activated demonstration exhibits.

Hours are Tuesday through Friday, 9:00 A.M. to 5:00 P.M.; Saturday and Sunday, 1:00 P.M. to 5:00 P.M.; closed Monday and main legal holidays and during the University-observed Christmas–New Years Day recess. Admission is free. Telephone (814) 865-6427.

CRAWFORD COUNTY

ALLEGHENY COLLEGE, Department of Geology, Meadville 16335

The Department of Geology has a few displays of fossils in the corridors of Alden Hall, including some representative fossils from the Meadville area (plants and invertebrates) and several mastodon bones and teeth. These displays may be examined whenever the college is in session. Telephone (814) 724-2350.

CUMBERLAND COUNTY

DICKINSON COLLEGE, Department of Geology, Carlisle 17013

On display in Althouse Science Building is the "George S. Rennie III Collection of Vertebrate Fossils," which includes original and reproduced specimens of many vertebrate fossils. Also on display is a collection showing the evolution of plants from the Cambrian to the present. In addition, the Department of Geology maintains a research collection of invertebrate and vertebrate fossils. The collections are open to the public during school hours and evenings by appointment. Telephone (717) 245-1355.

DAUPHIN COUNTY

PENNSYLVANIA GEOLOGICAL SURVEY, Department of Environmental Resources, P.O. Box 2357, Harrisburg 17120

The Geological Survey has an extensive Paleontologic Reference Collection consisting of hundreds of Paleozoic fossils from Pennsylvania and nearby states. Many of the specimens are from localities described in this report. New material is continually being added to the collections as a result of in-progress mapping projects. The best specimens are periodically used in semipermanent hall displays, but most of the material is housed in the paleontology laboratory. Appointments to examine the collections should be made in advance. Telephone (717) 787-6029.

WILLIAM PENN MEMORIAL MUSEUM, Third and North Streets, Harrisburg 17105

The Hall of Geology features invertebrate-, vertebrate-, and plant-fossil exhibits arranged chronologically by geologic periods. Special emphasis has been given to lifelike plant and animal reconstructions, of which the most notable are as follows:

(1) Carboniferous Period—a walk through a Pennsylvanian age tropical forest, showing insects, fish, amphibians, and a reptile. This habitat group depicts an area of Pennsylvania during the deposition of peat, which gave birth to our commercial coal deposits.
(2) Triassic Period—excellent reconstructions of vertebrate animals.
(3) Cenozoic Period—a diorama showing mastodons during the Pleistocene Epoch. The plaque-mounted skeleton of the Marshalls Creek Mastodon is displayed adjacent to the diorama.

Study collections are restricted to fossils from Pennsylvania localities. Noteworthy are Leo Lesquereux's Pennsylvania plants and Edward W. Claypole's Devonian invertebrates, representing the efforts of the Second Pennsylvania Geological Survey (1874–89); and the recently donated William F. Klose, II, collection of Pennsylvanian plants and insects. Vertebrates include Late Triassic age specimens. Appointments can be made to examine the study collections. Telephone (717) 783-9897.

The Museum is open 9:00 A.M to 5:00 P.M, Tuesday through Saturday, and 12:00 noon to 5:00 P.M. on Sunday.

DELAWARE COUNTY

DELAWARE COUNTY INSTITUTE OF SCIENCE, 11 South Avenue, Media 19063

The Institute has a general collection of fossils from Pennsylvania and elsewhere. About 125 specimens are on display. Contact the Institute for the hours they are open. (Preferably, call Mondays between 9:00 A.M. and 1:00 P.M., except holidays.) Telephone (215) 566-5126.

GREENE COUNTY

WAYNESBURG COLLEGE, Department of Geology, Waynesburg 15370

The Department of Geology has on display and in study collections a large number of specimens of representative fossils from the southwestern counties of Pennsylvania and extensive material from the famous insect and plant locality of Florrisant, Colorado.

Contact the geology department for information on viewing the displays and collections. Telephone (412) 627-8191 (ext. 250).

LACKAWANNA COUNTY

EVERHART MUSEUM OF NATURAL HISTORY, SCIENCE, AND ART, Nay Aug Park, Scranton 18510

The Everhart Museum has a large collection of plant fossils, of which about 24 are displayed in one case. The Brooks Model Coal Mine is adjacent to the Museum. Contact the Museum for visiting hours. Telephone (717) 346-7186.

LACKAWANNA HISTORICAL SOCIETY, 232 Monroe Avenue, Scranton 18510

The Edward S. Jones Collection of Carboniferous plants from the anthracite fields is maintained by the Society. The entire Jones collection consists of over 100 specimens, approximately a dozen of the finest of which are on exhibit. Specimens not displayed are identified and catalogued and are available for examination on request. The Museum also has an extensive library on coal.

The museum is open Monday through Friday, 10:00 A.M. to 5:00 P.M. Telephone (717) 344-3841.

LANCASTER COUNTY

NORTH MUSEUM, Franklin and Marshall College, College and Buchanan Avenues, Lancaster 17604

This is a general natural history museum that has exhibits and collections ranging from archeology to zoology (including a planetarium). Fossil displays consist of small dioramas depicting "Life through the Ages," as well as larger permanent displays of trilobites and Carboniferous plants. The museum collections include many Early Paleozoic age fossils that were found locally.

The museum is open September through June, Wednesday to Saturday, 9:00 A.M. to 5:00 P.M.; Sunday 1:30 to 5:00 P.M.; July and August, Saturday and Sunday, 1:30 to 5:00 P.M.; closed New Years, Easter, and Christmas. Telephone (717) 291-3941.

LUZERNE COUNTY

WYOMING HISTORICAL AND GEOLOGICAL SOCIETY, 49 South Franklin Street, Wilkes-Barre 18701

The Society has in its possession a portion of the LaCoe Collection of Paleozoic Fossils. To examine the collection, contact the Society. Telephone (717) 823-6244.

MONTGOMERY COUNTY

BRYN MAWR COLLEGE, Department of Geology, Bryn Mawr 19010

The paleontology museum of the Bryn Mawr geology department has 14 small display units. These displays include typical fossils from the various eras, models of dinosaurs and ancient man, and exhibits on several of the major fossil groups.

The study and research collections total 25,500 specimens, with emphasis on modern mollusks, Cenozoic fossils from Maryland, and an extensive set of fossils arranged by phyla.

The display material is open to the public during regular college hours. The research material is available for examination by pre-arrangement with the department. Telephone (215) 645-5000.

NORTHAMPTON COUNTY

LAFAYETTE COLLEGE, Department of Geology, Easton 18042

On display in the newly remodeled geological museum in Van Wickle Hall are two paleobotanical exhibits. One deals with the coal-forming plants of the Pennsylvanian Period. The other shows remarkably well preserved leaves and insects from the Tertiary Florissant lake beds of Colorado. Other displays have included "Color Adaptations of Marine Bivalves" and "Dinosaur Remains of New Jersey."

The Van Wickle Hall Museum is open from 8:00 A.M to 4:00 P.M., Monday through Friday. Arrangements for group tours should be made by calling the department. Telephone (215) 250-5193.

LEHIGH UNIVERSITY, Department of Geological Sciences, Bethlehem 18015

The geology department of Lehigh University maintains several public exhibits of fossils at the east end of the third floor of Williams Hall. These include a wall display of Triassic-Jurassic dinosaur tracks from the Connecticut River valley, a beautiful polished slab of Ordovician limestone from northern Vermont on which internal, longitudinal sections of more than a half-dozen large, straight nautiloid cephalopods can be seen, and a glass case containing many specimens of Pennsylvania trilobites.

Interested individuals may visit the displays whenever the university is in session. Groups should make advance arrangements with the department. Telephone (215) 861-3000.

PHILADELPHIA COUNTY

THE ACADEMY OF NATURAL SCIENCES, 19th Street and Benjamin Franklin Parkway, Philadelphia 19103

A major permanent exhibition called "Discovering Dinosaurs" will open at the Academy in late 1985. The exhibition will feature original fossil material as well as casts of rare specimens and will be enhanced through the addition of computer programs and a variety of audiovisual and lighting techniques. It will focus on the recent revolution in thought about dinosaurs as living animals and on the fascinating process by which paleontologists use the fossil evidence to unravel some of the mysteries surrounding them.

Fossil dinosaur specimens displayed (all from the Cretaceous Era) will include *Hadrosaurus foulkii*, the first largely complete dinosaur skeleton discovered in the world (uncovered in Haddonfield, New Jersey, 1858); another duckbill, *Corythosaurus*; a small, as yet unidentified ceratopsian; and at least one fiberglass cast of *Deinonychus* (a small and possibly warm-blooded, carnivorous dinosaur). Also on display will be two marine reptiles—a mosasaur and a plesiosaur. The latter is the type specimen of *Elasmosaurus platyurus*, a 42-foot-long marine reptile said to have sparked a 30-year rivalry between two leading nineteenth-century paleontologists. Other specimens are still under consideration as this book goes to press.

Regional material will be highlighted. There will be sections included on dinosaur sizes, footprints as evidence, as well as dinosaur biology (endothermy versus ectothermy) and behavior (parental care, herd behavior). A geologic-time tunnel will feature many fossil invertebrate specimens and casts of specimens and serve as a transition to a future exhibition on plate tectonics and the fossil evidence for it.

Starting early in 1984 and continuing until the exhibition opening, "*Discovering Dinosaurs*-in-the-Making" will be on view to the visiting public. This working preparation lab and exhibit testing area will be housed in the Museum's Changing Exhibit Gallery. Tours and education programs will be available.

Research collections specialize in Mesozoic and Cenozoic fossils, but Paleozoic fossils from Pennsylvania are included. Arrangements can be made to study the collections; however, scholars who do not have formal academic affiliations will be charged a fee. Undergraduate and graduate students must make arrangements through their advisors to obtain access to the collections.

The Education Division of the Museum offers 45-minute lessons on fossils (for junior high) and dinosaurs (grades 1–12, adapted for grade level) to visiting school groups *by reservation only*.

Classes for adults on fossil-related topics are regularly included in the Academy's twice-yearly adult courses program, and fossil-collecting field trips are frequently offered for individuals aged 14 and up.

The Museum is open from 10:00 A.M. to 4:00 P.M., Monday to Friday, and 10:00 A.M. to 5:00 P.M. on Saturdays, Sundays, and holidays. There is an admission charge. Telephone (215) 299-1061 (submitted by Hollister Knowlton).

THE PHILADELPHIA COLLEGE OF PHARMACY AND SCIENCE, 43rd Street and Kingsessing Mall, Philadelphia 19104

The College maintains several displays of fossil specimens, emphasizing plants and the invertebrate phyla. These displays are available for examination by the public. Entrance to the display area must be secured by visiting the office in the main college building. Telephone (215) 596-8800.

WAGNER FREE INSTITUTE OF SCIENCE, 17th Street and Montgomery Avenue, Philadelphia 19121

On display at the Institute are 16 large cases exhibiting invertebrate and vertebrate fossils. The cases are organized by geologic periods. Two other cases emphasize plant and invertebrate fossils from Pennsylvania.

The Institute is open to the public Tuesday to Thursday, 10:00 A.M. to 4:00 P.M., and Sunday, 12:00 noon to 3:00 P.M. The Institute also periodically sponsors free, noncredit courses on geology and paleontology; contact the director of the Institute for further information. Telephone (215) 763-6529.

UNION COUNTY

BUCKNELL UNIVERSITY, Department of Geology and Geography, Lewisburg 17837

The geology department has an extensive study collection of invertebrate fossils. The collection is available for examination on prior request. Telephone (717) 524-1147.

ADDITIONAL READING

BOOKS ON PALEONTOLOGY

BOOKS GENERALLY SUITABLE FOR AMATEURS. ARRANGED IN GENERAL ORDER OF INCREASING COMPLEXITY.

First Book of Prehistoric Animals, by Alice Dickinson. Franklin Watts, New York (1954). For grade schools (grades 4–6).

Geology. Boy Scouts of America, Dallas/Fort Worth Airport, Texas (1953). Contains one short chapter outlining fossils (grades 6–12).

Fossils—A Guide to Prehistoric Life, by Frank H. T. Rhodes, Herbert S. Zim, and Paul R. Shaffer. Golden Press, New York, 160 p. (1962). Handy, well-illustrated "field guide" which includes not only pictures but also verbal descriptions of many index fossils. An introductory section describes the life of the various geologic periods.

The Fossil Book—A Record of Prehistoric Life, by Carroll L. Fenton and Mildred A. Fenton. Doubleday, Garden City, New York, 482 p. (1958). An excellent, easily read reference book for the interested amateur of high-school to adult age.

A Fossil-Hunter's Notebook: My Life with Dinosaurs and Other Friends, by Edwin H. Colbert. Dutton, New York, 288 p. (1980).

Fossils for Amateurs, by Russell P. MacFall and Jay C. Wollin. Van Nostrand Reinhold Company, New York, 341 p. (1972, to be revised 1983). An up-to-date book containing all of the information that the serious collector needs. Contains many literature references.

Handbook of Paleontology for Beginners and Amateurs—Part 1, The Fossils, by Winifred Goldring. Paleontological Research Institution, Ithaca, New York, 394 p. (1969). Reprint of Handbook 9 of the New York State Museum and Science Service, originally published in 1929 and revised in 1950. Although somewhat dated, this is still an excellent introduction to the study of fossils. Many line drawings of typical invertebrate and vertebrate fossils from the classic New York Paleozoic rock section are included.

Fossils—An Introduction to Prehistoric Life, by William H. Matthews, III. Barnes and Noble, New York, 337 p. (1962). A paperback book which quite thoroughly covers all of the information needed by the fossil hunter. The book is well illustrated and contains numerous references for additional reading and sources of information.

Search for the Past—An Introduction to Paleontology, 2nd ed., by James R. Beerbower. Prentice-Hall, Englewood Cliffs, New Jersey, 512 p. (1968). An excellent, up-to-date, college-level text that may be of interest to the adult amateur.

Index Fossils of North America, by Hervey W. Shimer and Robert R. Shrock. The Technology Press, Massachusetts Institute of Technology, 837 p. (1944). A detailed survey of fossils devoted mainly to illustrations of North American fossils.

FOSSIL COLLECTING IN NEARBY STATES

An Illustrated Guide to Fossil Collecting, 3rd ed., revised, by Richard Casanova and Ronald P. Ratkevich. Naturegraph Publishers, Happy Camp, California, 240 p. (1981). A short, nontechnical booklet containing lists of collecting localities for most states.

DELAWARE

Guide to Common Cretaceous Fossils of Delaware, by Thomas E. Pickett. Delaware Geological Survey, Newark, Delaware, Report of Investigations 21, 28 p. (1972).

MARYLAND

Miocene Fossils of Maryland, by Harold E. Vokes. Maryland Geological Survey, Baltimore, Maryland, Bulletin 20, 85 p. (1957).

Collecting Fossils in Maryland, by John D. Glaser. Maryland Geological Survey, Baltimore, Maryland, Educational Series 4, 76 p. (1979).

NEW JERSEY

Fossils of New Jersey, by James S. Yolton. Geological Society of New Jersey, Trenton, New Jersey, Report 2, 46 p. (1965).

NEW YORK

Mammoths and Mastodons — Ice Age Elephants of New York, by Judith Drumm. New York State Museum and Science Service, Albany, New York, Educational Leaflet 13, 31 p. (1963).

OHIO

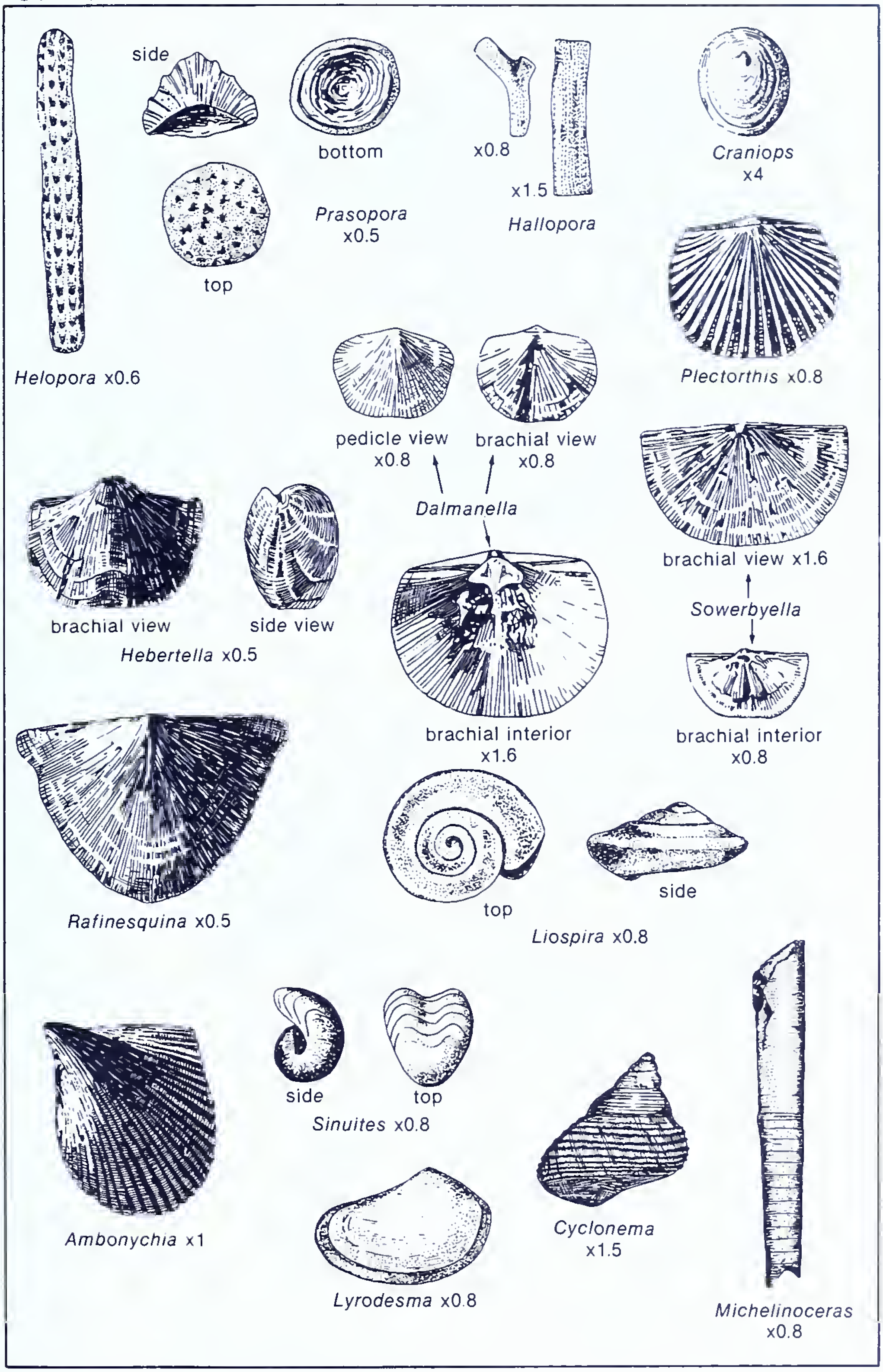
Ohio Fossils, By Aurèle LaRocque and Mildred F. Marple. Ohio Geological Survey, Columbus, Ohio, Bulletin 54, 152 p. (1955). An introduction to the paleontology of Ohio. Identification keys and collecting localities are given.

WEST VIRGINIA

Plant Fossils of West Virginia, by William H. Gillespie, John A. Clendening, and Hermann W. Pfefferkorn. West Virginia Geological and Economic Survey, Morgantown, West Virginia, Educational Series ED-3A, 172 p. (1978).

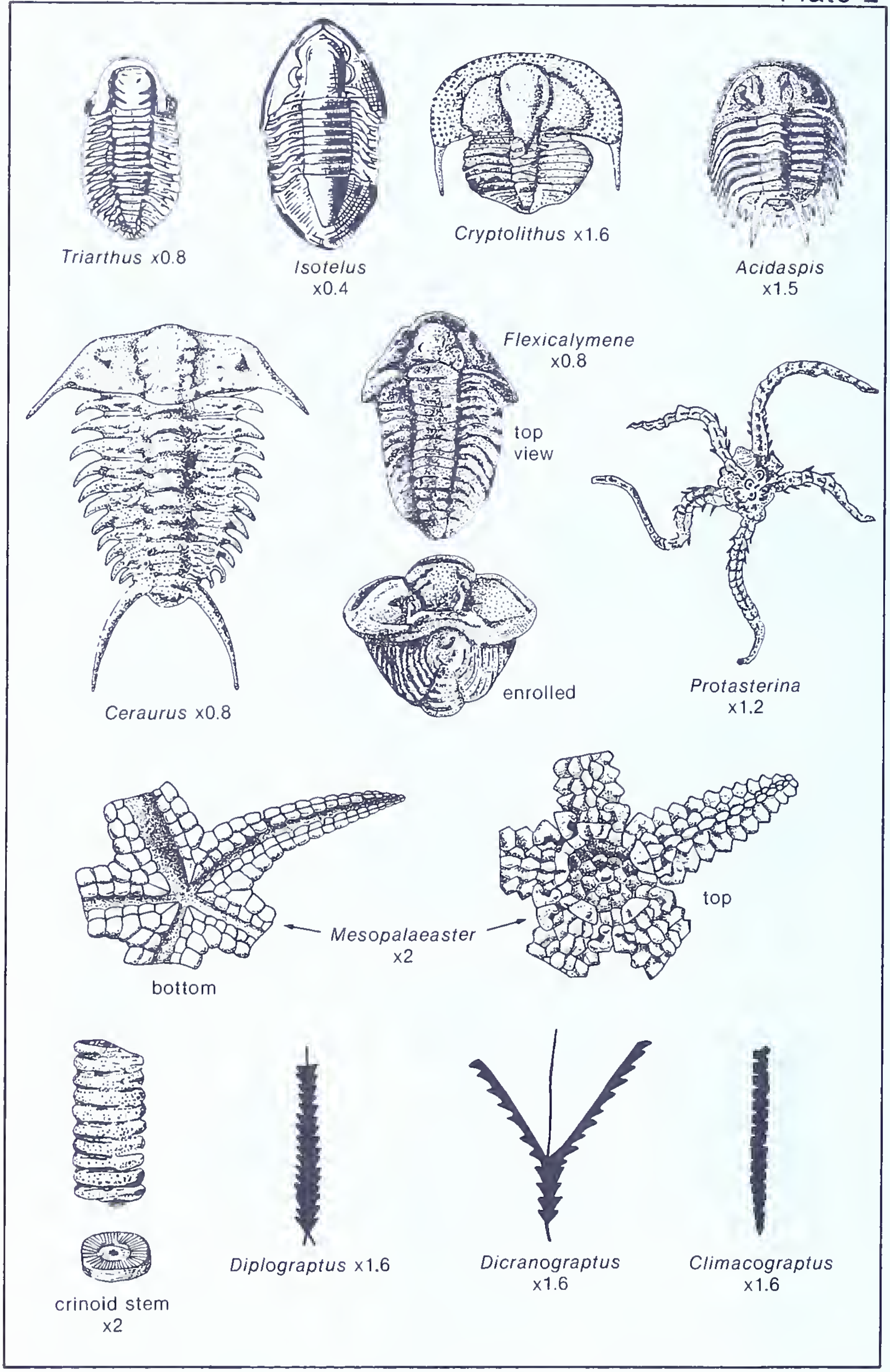
Many other states have published booklets on fossils containing information on collecting localities. To obtain these, should you wish to visit a particular state, write to the geological survey of that state and request their help.

ORDOVICIAN FOSSILS Plate 1

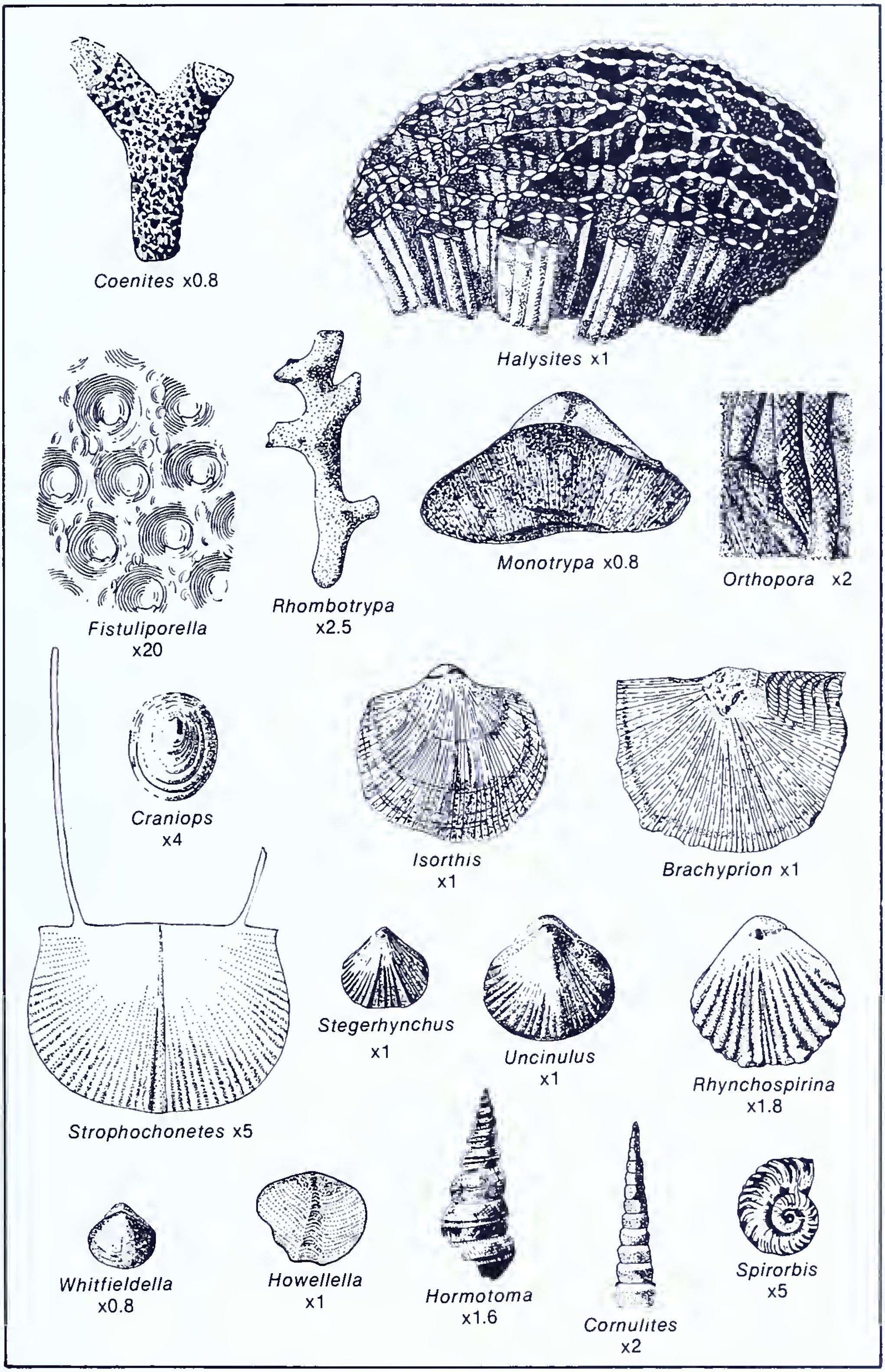


ORDOVICIAN FOSSILS

Plate 2

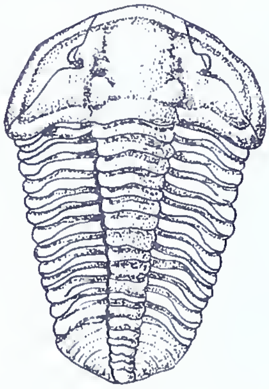


SILURIAN FOSSILS Plate 3



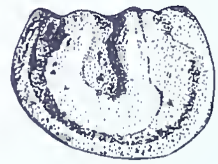
SILURIAN FOSSILS

Plate 4



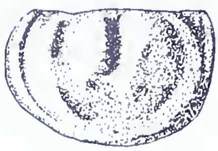
Calymene x1

Dalmanites x0.5



Bonnemaia x6

Velibeyrichia x13



Kloedenia x8

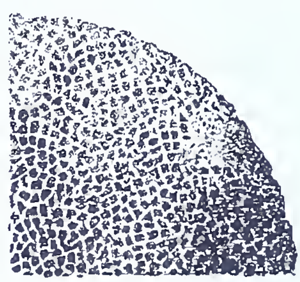
Kloedenella x13

Leperditia x3

SILURIAN AND DEVONIAN FOSSILS

Plate 5

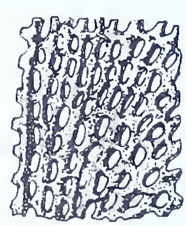
Stromatoporoid x0.4



Favosites x0.4

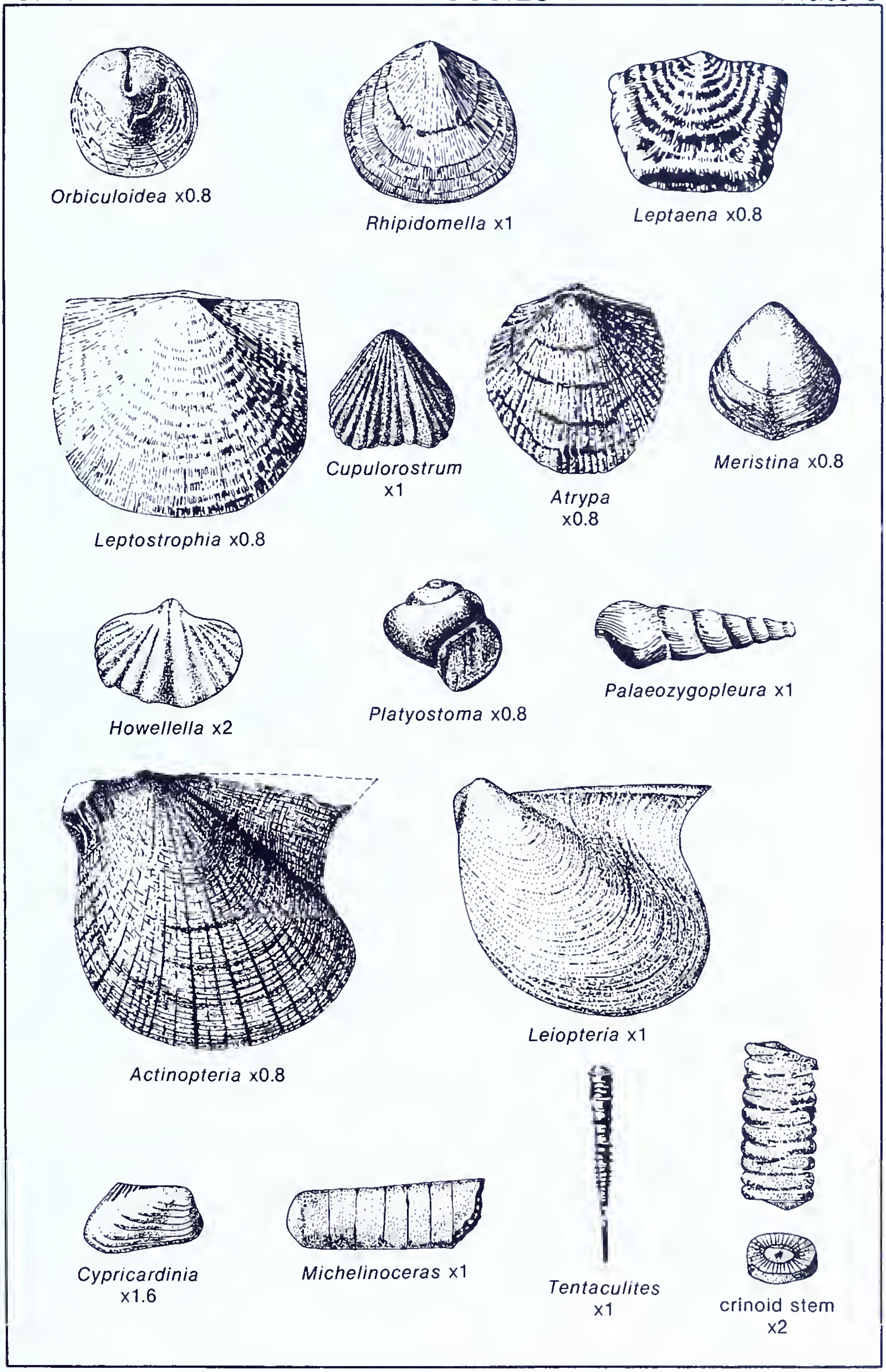
Aulopora x1.6

"*Batostomella*" x2



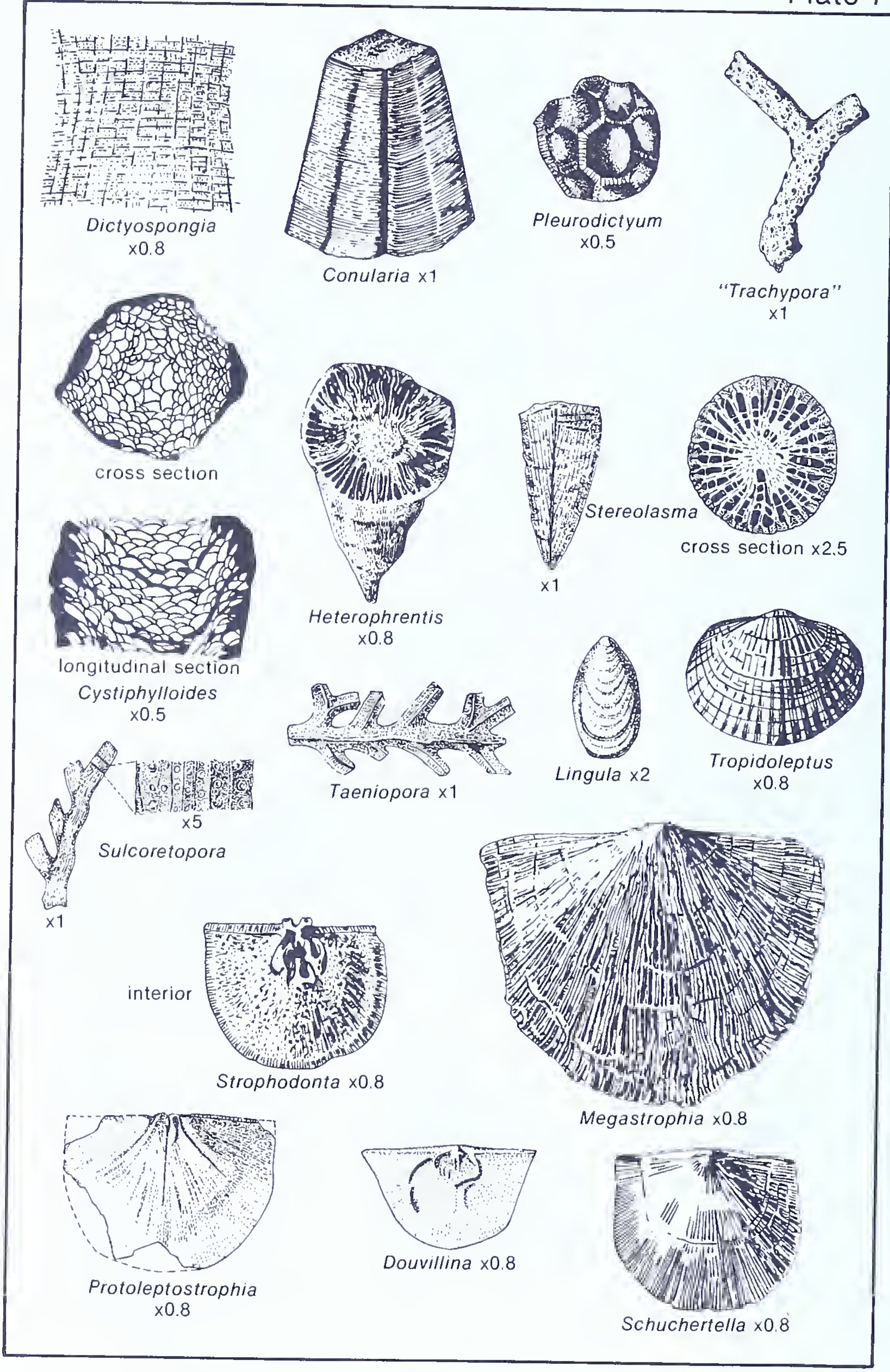
Fenestella x1

SILURIAN AND DEVONIAN FOSSILS Plate 6

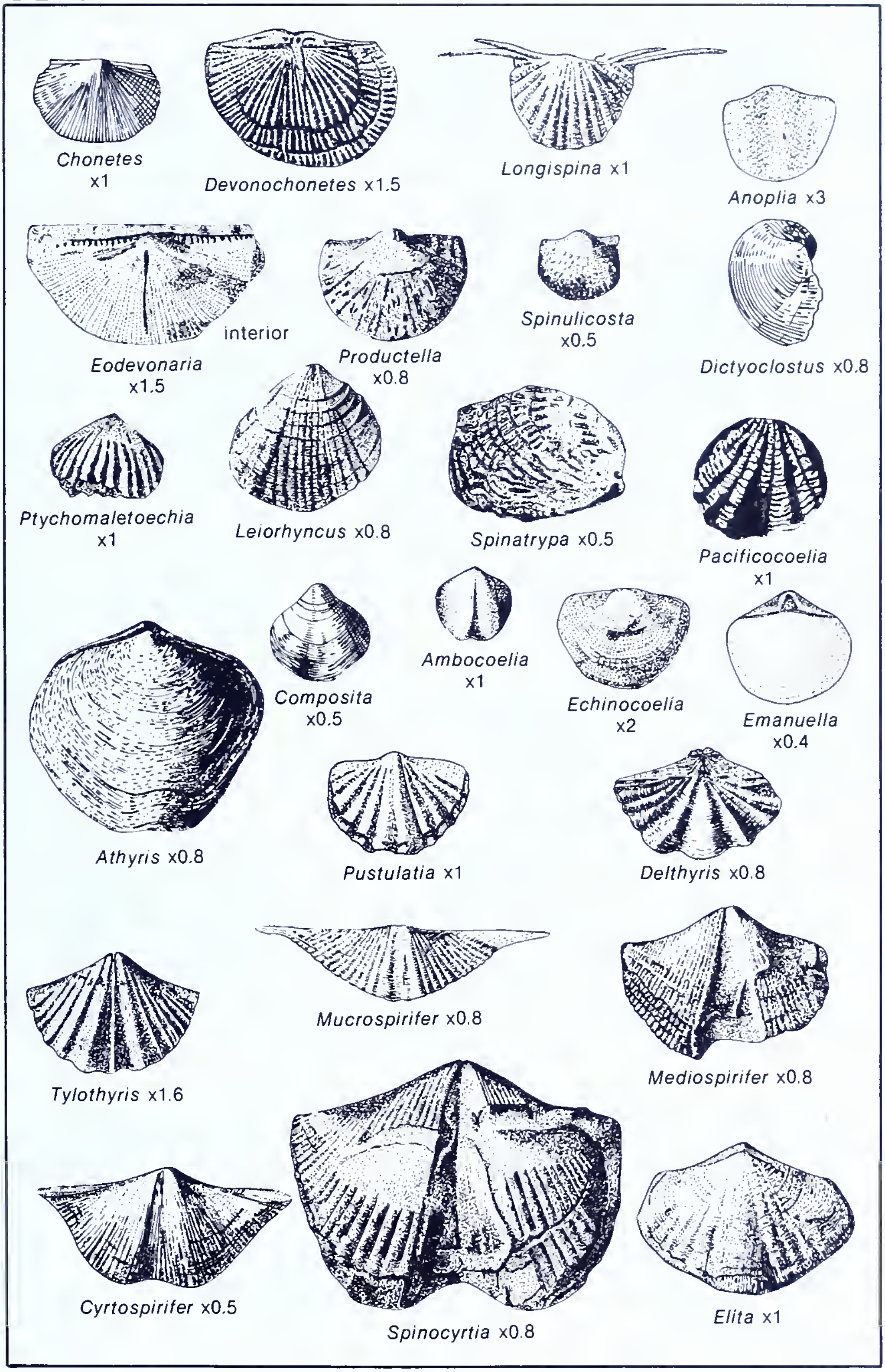


DEVONIAN FOSSILS

Plate 7

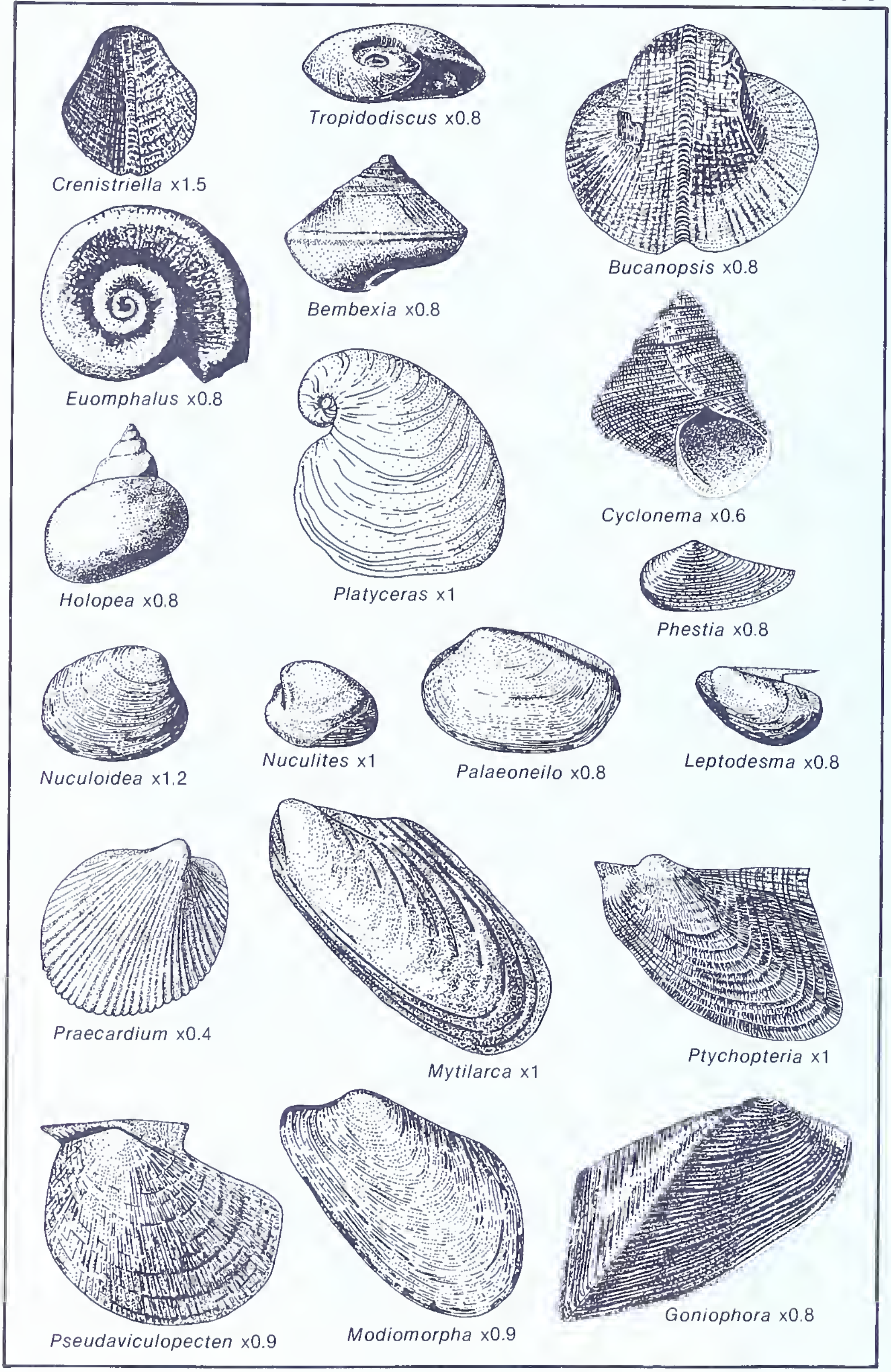


DEVONIAN FOSSILS Plate 8



DEVONIAN FOSSILS

Plate 9



Crenistriella x1.5

Tropidodiscus x0.8

Bucanopsis x0.8

Euomphalus x0.8

Bembexia x0.8

Cyclonema x0.6

Holopea x0.8

Platyceras x1

Phestia x0.8

Nuculoidea x1.2

Nuculites x1

Palaeoneilo x0.8

Leptodesma x0.8

Praecardium x0.4

Mytilarca x1

Ptychopteria x1

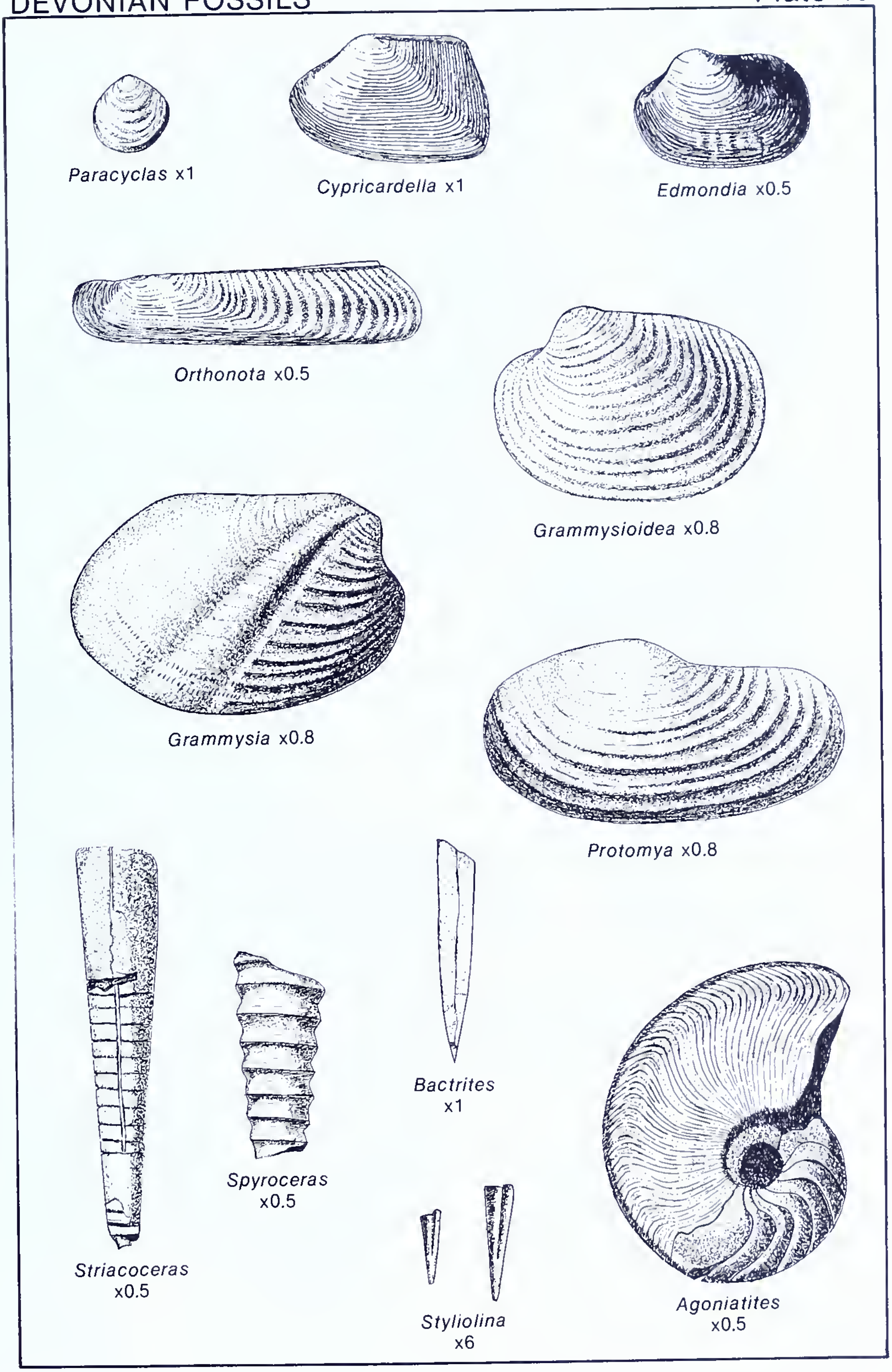
Pseudaviculopecten x0.9

Modiomorpha x0.9

Goniophora x0.8

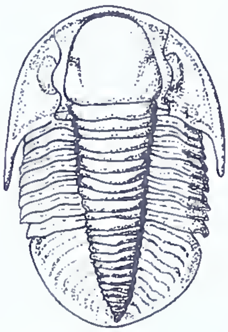
DEVONIAN FOSSILS

Plate 10

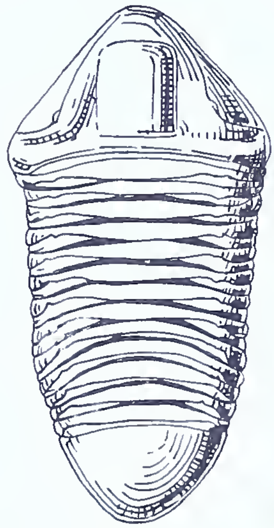


DEVONIAN FOSSILS

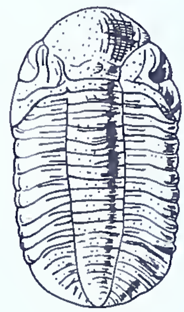
Plate 11



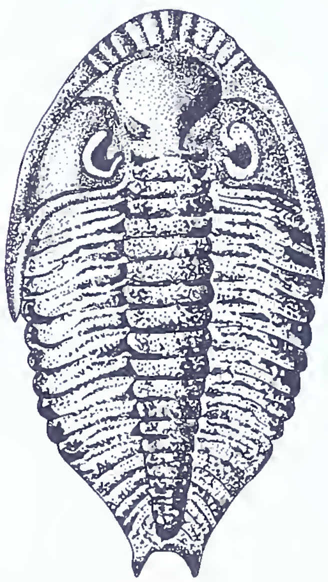
Dechenella x1



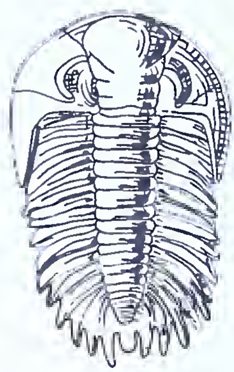
Trimerus x0.5



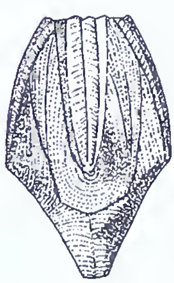
Phacops x1



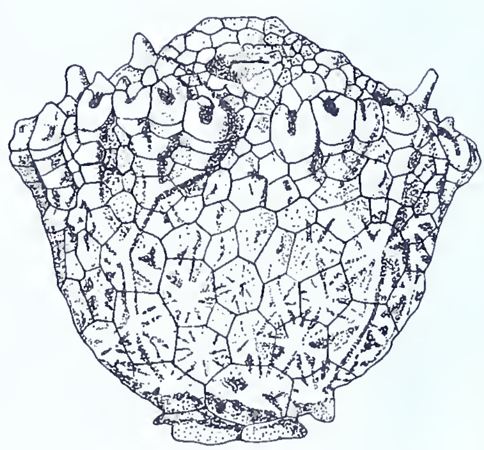
Odontocephalus x1



Greenops x1

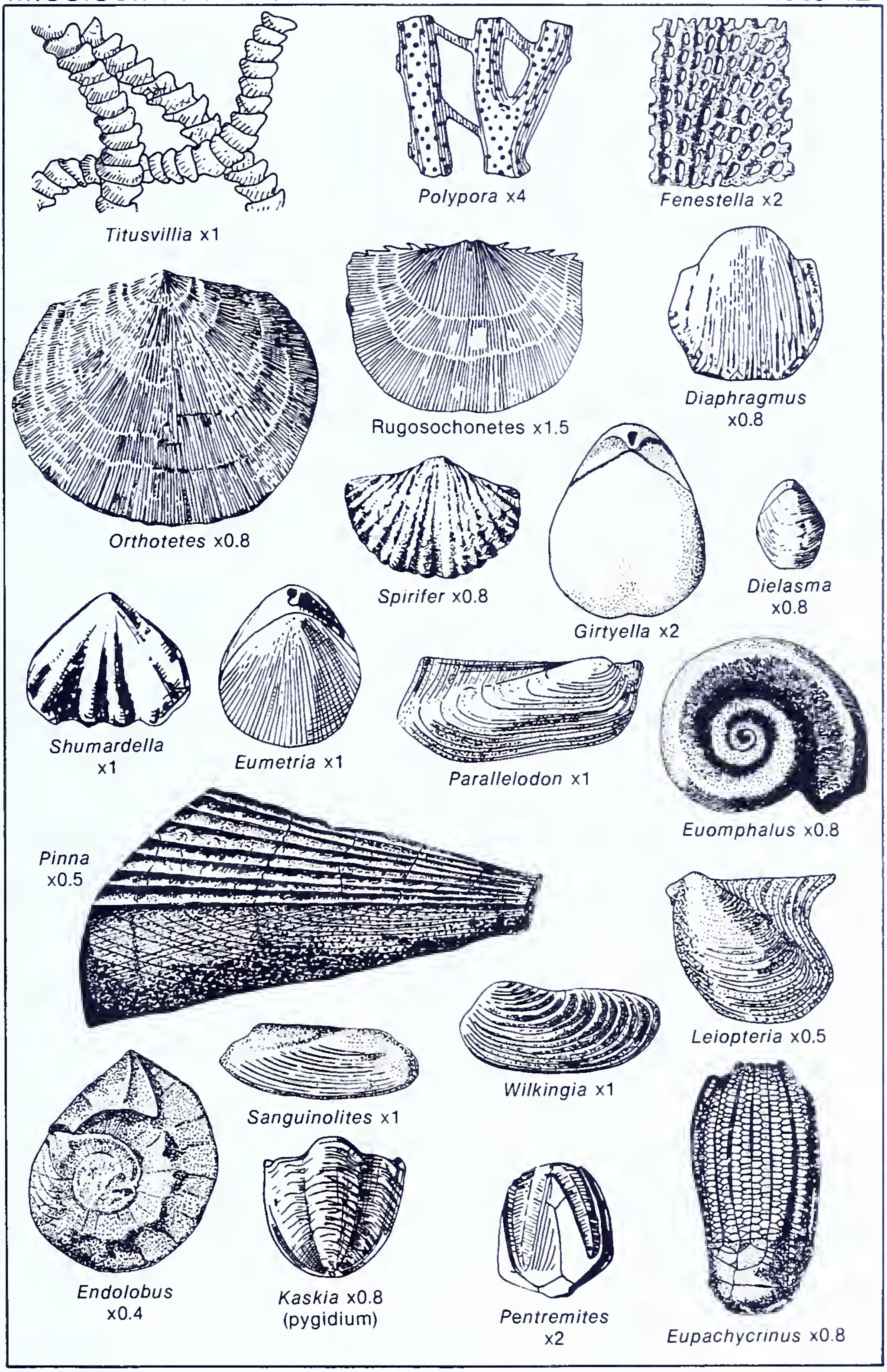


Pentremitidea x1.5



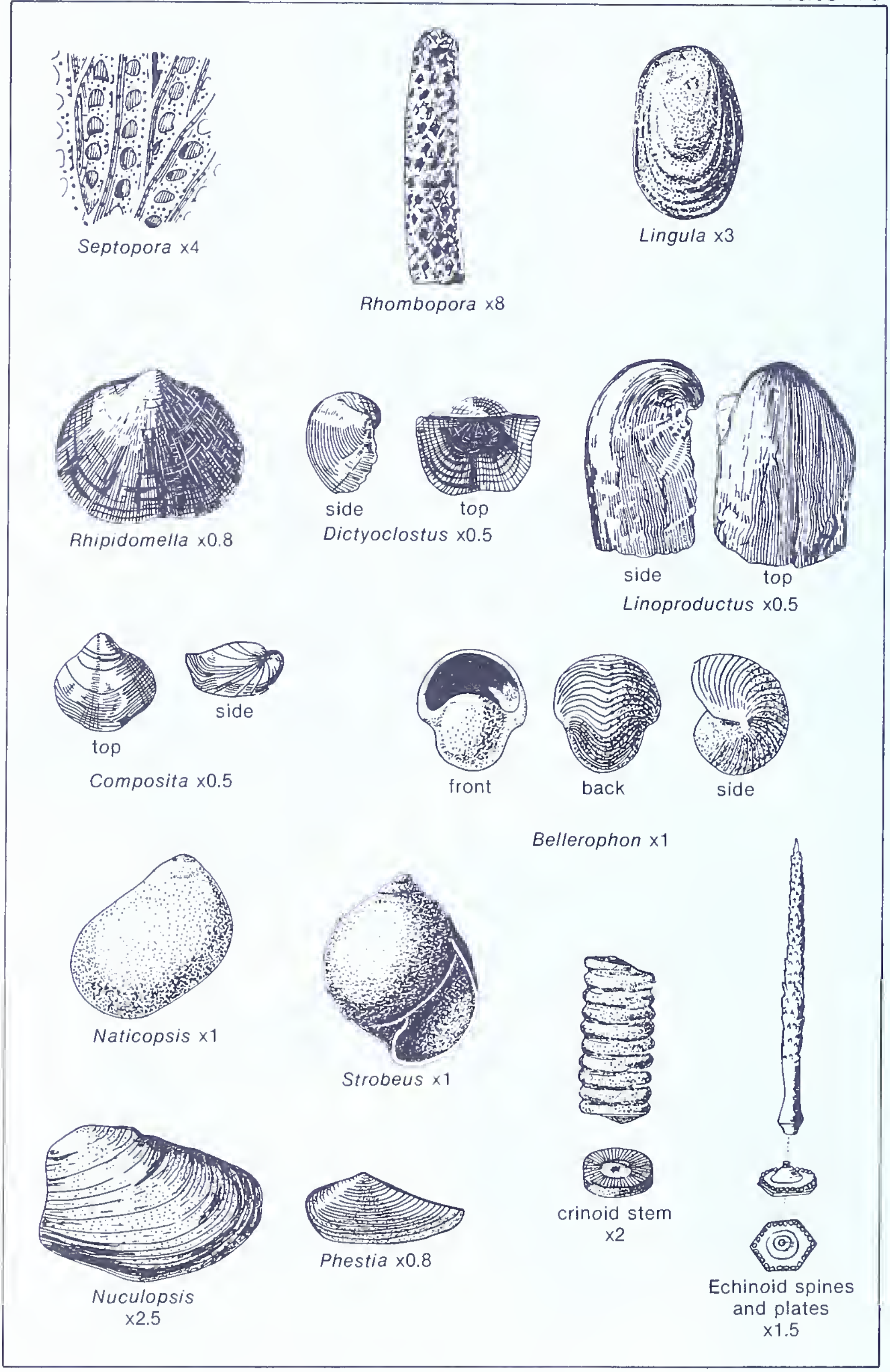
Gennaeocrinus x2

MISSISSIPPIAN FOSSILS Plate 12

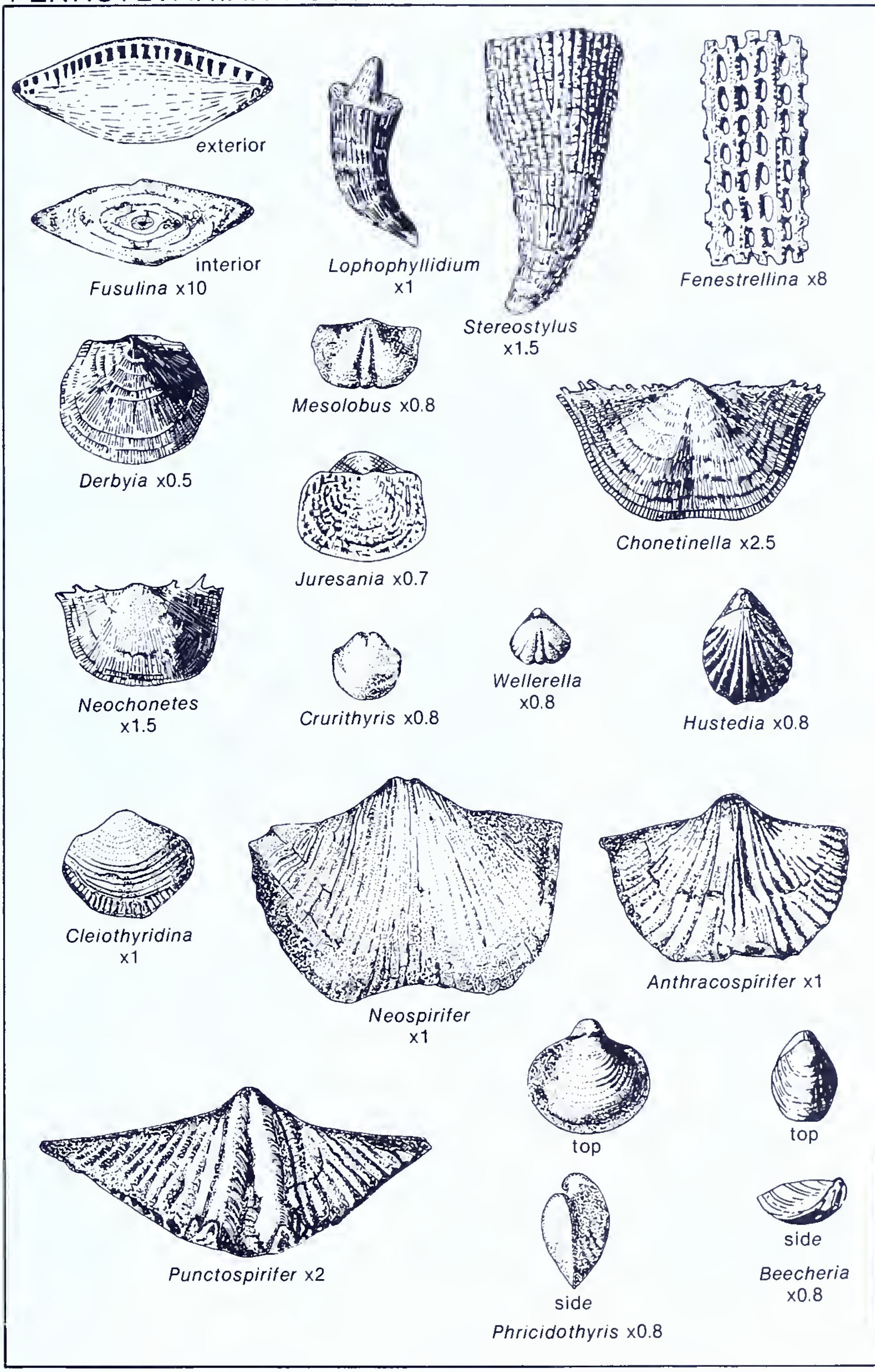


Titusvillia x1
Polypora x4
Fenestella x2
Orthotetes x0.8
Rugosochonetes x1.5
Diaphragmus x0.8
Spirifer x0.8
Girtyella x2
Dielasma x0.8
Shumardella x1
Eumetria x1
Parallelodon x1
Euomphalus x0.8
Pinna x0.5
Leiopteria x0.5
Wilkingia x1
Sanguinolites x1
Endolobus x0.4
Kaskia x0.8 (pygidium)
Pentremites x2
Eupachycrinus x0.8

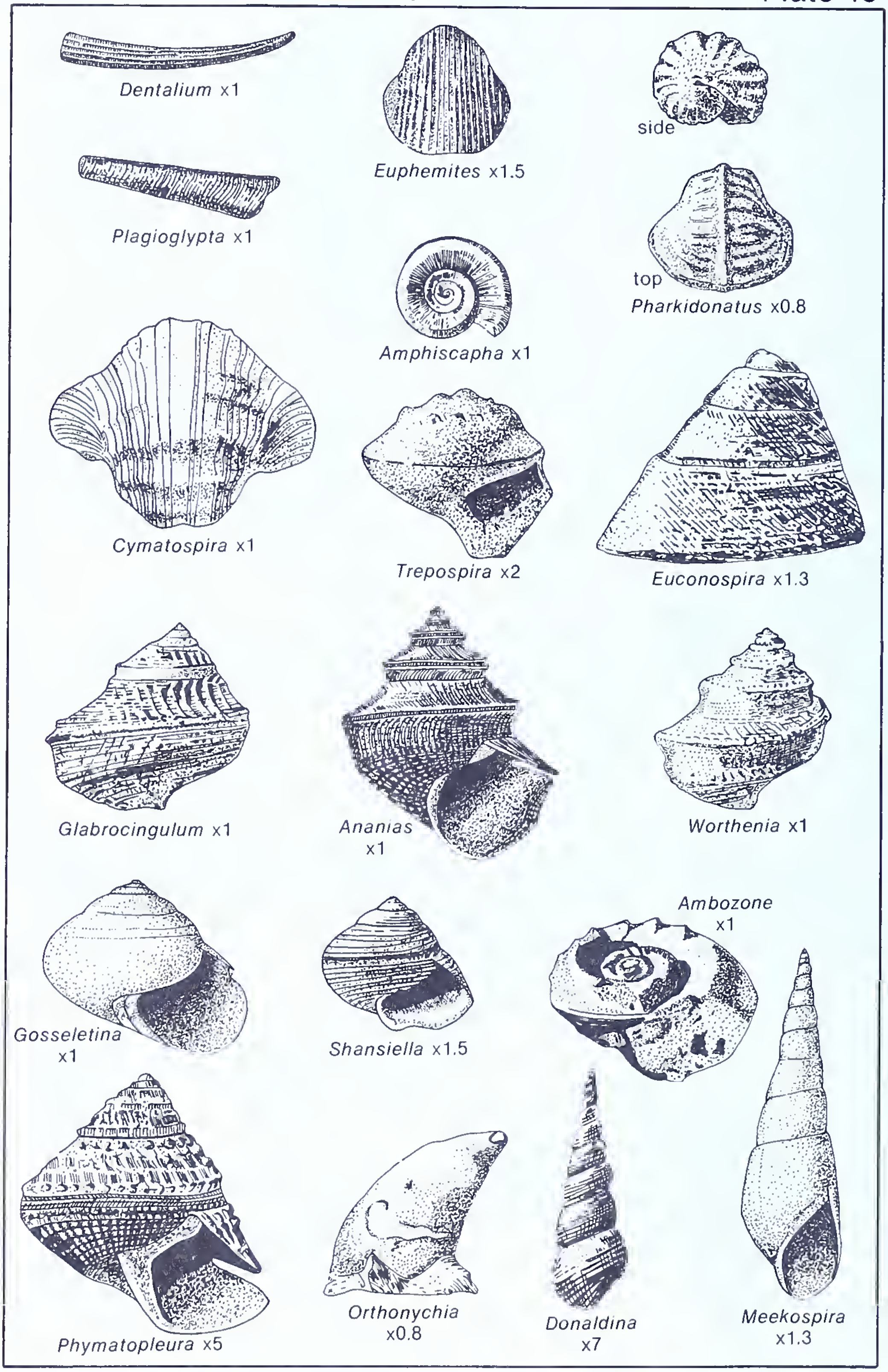
MISSISSIPPIAN AND PENNSYLVANIAN FOSSILS Plate 13



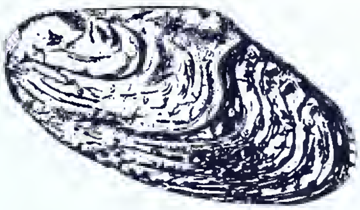
PENNSYLVANIAN FOSSILS Plate 14



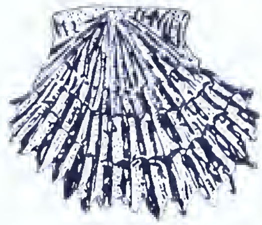
PENNSYLVANIAN FOSSILS Plate 15



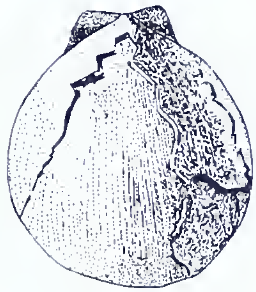
PENNSYLVANIAN FOSSILS Plate 16


Anthraconauta x2


Aviculopecten x0.8


Acanthopecten x1

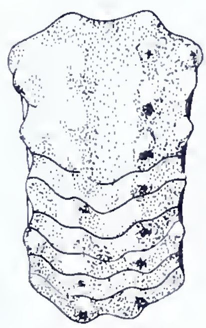

Dunbarella x2


Pernopecten x1


Astartella x0.8

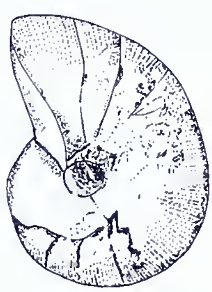

Brachycycloceras x1


Pseudorthoceras x0.7


Tainoceras x0.5

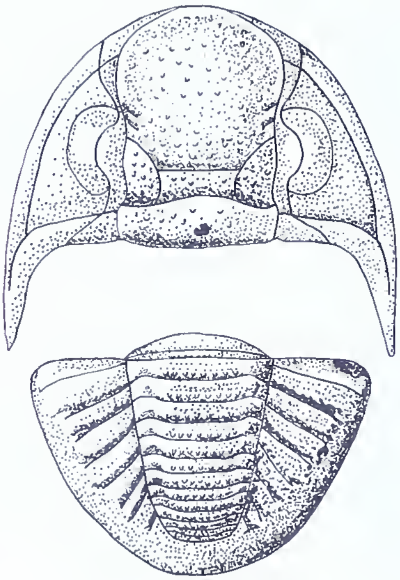

Metacoceras x0.5


Domatoceras x0.3

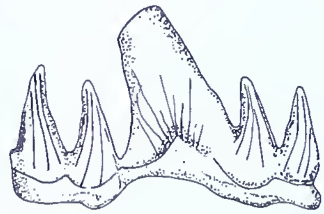

Liroceras x1


Eoasianites x1

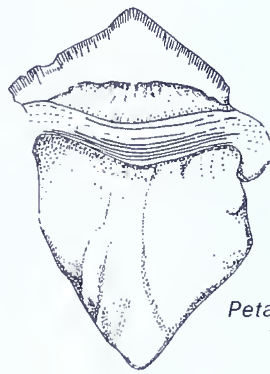
PENNSYLVANIAN FOSSILS Plate 17



Ditomopyge x4



Cladodus x1.3



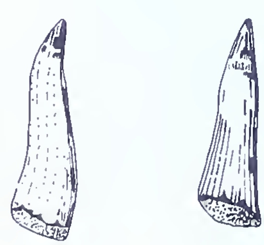
Petalodus x2

PENNSYLVANIAN AND PERMIAN FOSSILS Plate 18

Spirorbis x10

Cytherella x50

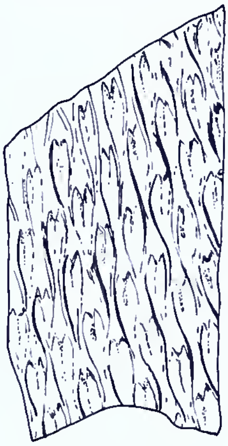
Diplodus x14



Paleoniscus x7

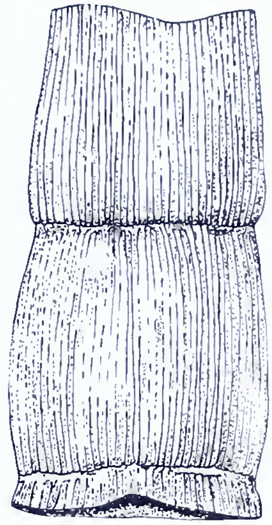
PENNSYLVANIAN AND PERMIAN PLANT FOSSILS

Plate 19

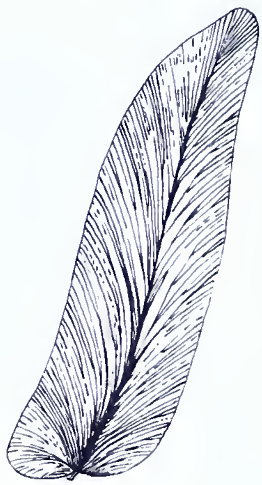


Lepidodendron x0.5

Sigillaria x0.5

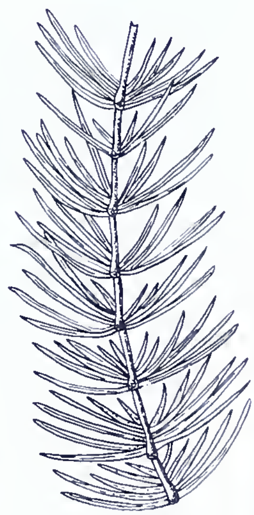


Calamites x0.5

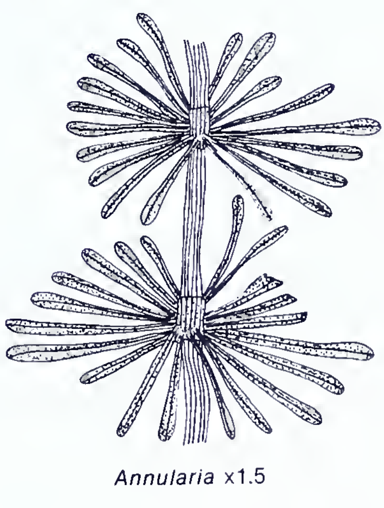


Neuropteris x0.8

Pecopteris x0.6



Asterophyllites x1

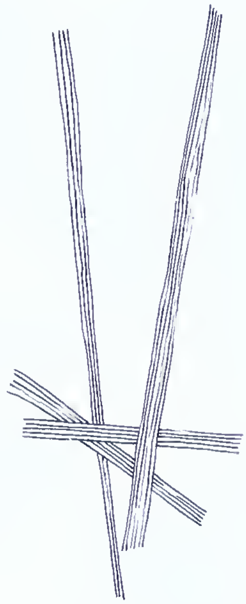


Annularia x1.5

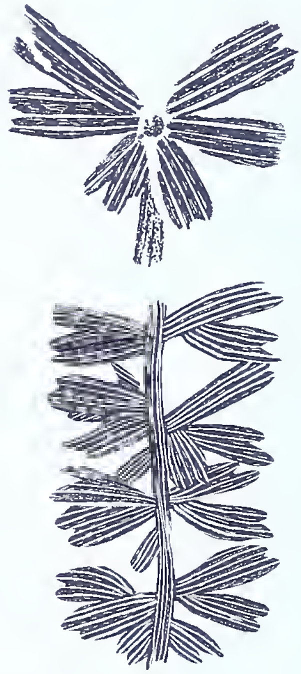
PENNSYLVANIAN AND PERMIAN PLANT FOSSILS

Plate 20

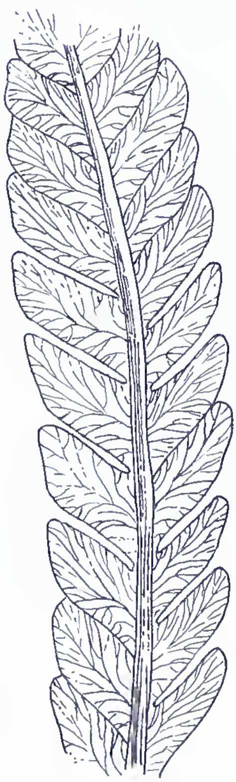
Neuropteris
x0.4



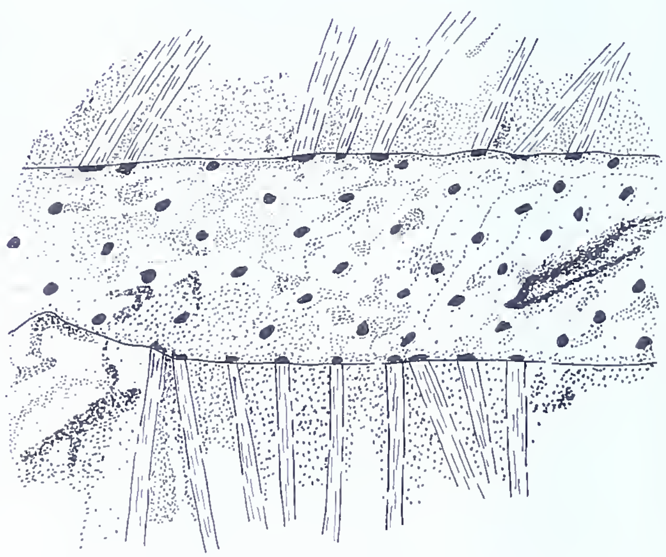
Lepidophylloides
x1.5



Sphenophyllum
x2



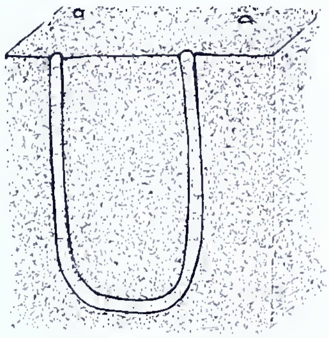
Odontopteris
x1



Stigmaria x0.5

TRACE FOSSILS

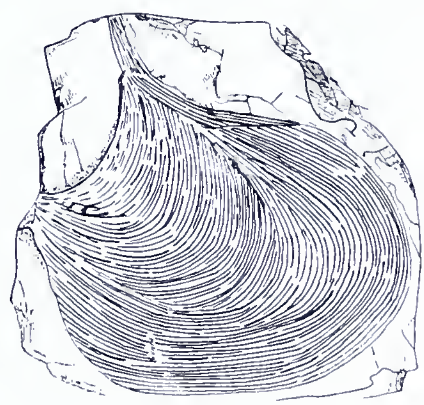
Plate 21



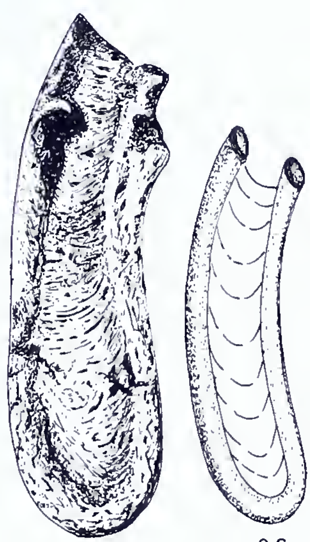
Arenicolites x1

Chondrites x1

Planolites x1



Zoophycos x0.5



x0.8 x0.6

Rhizocorallium

Conostichus
x0.3

ISBN: 0-8182-0019-7