Collecting fossil fish in the excavation for the Firestone Library, Princeton University, *Princeton, N. J.*

NEW JERSEY STATE MUSEUM

PORTRAYING NEW JERSEY'S STORY

STATE DEPARTMENT OF EDUCATION, TRENTON, N. J.

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THE NEW JERSEY STATE MUSEUM

State House Annex, Trenton, New Jersey
Hours: Daily 9 to 5. Sundays and holidays 2 to 5.
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"A NATURAL LIBRARY"

GLENN L. JEPSEN

Early in 1946 while excavations were in progress for the new Firestone Library Building of Princeton University, some remarkably well preserved fossils were recovered, and, at the request of Mrs. Kathryn B. Greywacz, Director of the New Jersey State Museum, this account of their discovery and significance has been prepared for the Bulletin. Examples of the fossils are on display in the State Museum and in the Princeton Geological Museum.

UNDERGROUND RICHES

Beneath New Jersey's fertile soil lie many treasures of nature's ancient history, preserved in rocks that were part of the surface of the earth millions of years ago. Occasionally a few bits of this scientific wealth are brought to light, studied by specialists, and placed in museums so that the knowledge of the old natural records may be shared by everyone.

To a geologist, most of New Jersey is unexplored. Nor is it probable that anyone will ever see very far in the direction of the State's third and greatest dimension which extends about four thousand miles to a point at the center of the earth. Thus, the State is not merely 7,836 square miles of surface, but is shaped like a great fluted and irregular wedge.

Professional geologists and paleontologists cannot see into or through a rock any better than can anyone else, but by practice they learn what to look for on the surfaces of stones and how to recognize what they see. Everyone can develop this skill as a rock sleuth and thus learn some of the most interesting of the so-called "secrets" of nature, some of the clues to information about the billions of years and of events which we have inherited. As Carlyle remarked "The Present is the living sum-total of the whole Past." Reading the general history of the remote past, directly from the records of the earth's crust, is not so difficult nor so uncertain as reading an ancient and defunct language.

By a method which will be described presently anyone who has access to the proper machines can see the inside of some rocks.

New Jersey no longer ranks high among states where the greatest numbers of fossils are found. Three-quarters of a century ago, however, the State stood near the top of the list. Our decline from this exalted scientific position was of course not caused by an actual decrease in the number of fossils in the rocks; nor have all the fossils been found and collected. Lagging public interest in this State and a great increase in concern about relics of the past in other states, particularly in those where fossils are more abundant and the rocks containing them are well exposed, make it impossible for us to hold our former place of eminence in this field.

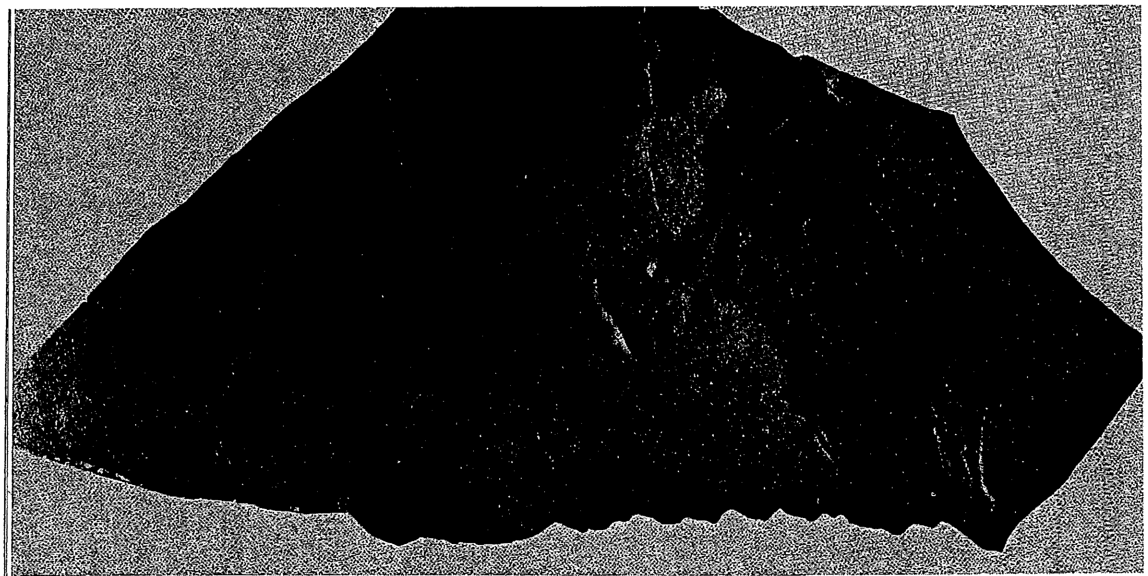
The climate which gives New Jersey its outstanding position as an agricultural state is so favorable for plant growth that we have no great areas of bare rock similar to those in the deserts of Wyoming, the Dakotas, New Mexico, and other western regions. As a consequence most of the fossils which are found in New Jersey come from excavations for buildings or reservoirs or roads or dams or from digging operations in tunnels and in sand, gravel, and marl pits.

Moreover, some other states and countries stand far ahead of us in the number of amateur scientists and students who carefully search every excavation for fossil animals and plants and, by continued vigilance, help advance geological work. These trained, but non-professional paleontologists and anthropologists, have found many of the most important scientific evidences about man's own past, such as the remains of the famous dawn man, ***Eoanthropus,*** in England. Important discoveries should of course be placed in museums, where the records and labels will properly and publicly credit the scientific services of the finders, and where the specimens will be safely preserved for visitors to examine and study.

NEW JERSEY'S GREAT RED STONE FACE

By taking liberties with the outline of New Jersey, some maps of the northern half of the State resemble the head of a westward-gazing Indian. A strip of land which constitutes the side of the face of the aborigine and extends diagonally northeastward is shown on geological maps to be composed mostly of shales (actually and appropriately red), sandstones, siltstones and igneous intrusions. These rocks, named the Newark series, were formed during Mesozoic time (the Age of Reptiles), in the Triassic Period about 175 million years ago. Such a time figure can be visualized by analogy. Let the thickness of a single sheet of this paper represent one year. A stack of 175 million sheets would be 10.87 miles high or, tipped over, would extend in a straight line from the Princeton library excavation to the Delaware River at the point closest to the State Museum. Similarly represented, the two billion or so years since the beginning of the earth would pile up almost 11½ times as high or about 124.27 miles. This is approximately the ground distance from Princeton to Cape May.

In New Jersey the three sedimentary formations of the Newark rocks, the Stockton sandstone, the Lockatong argillite, and the Brunswick shale are estimated to total about three miles in actual thickness. These strata, origi-



A thin piece of shale enclosing scattered bones and a skeleton of *Osteopleurus*. One-half natural size.

nally sands, silts, and muds which had washed from the disintegrating rocks of neighboring uplands, were deposited in brackish water bays and lagoons or in fresh water lakes and stream valleys.

In some places molten or igneous rocks were intruded between layers of the sedimentary rocks and in other areas lava flowed out on the surface. The Hudson Palisades and the Watchung Mountains and Rocky Hill and Sourland Mountain are remnants of these igneous masses.

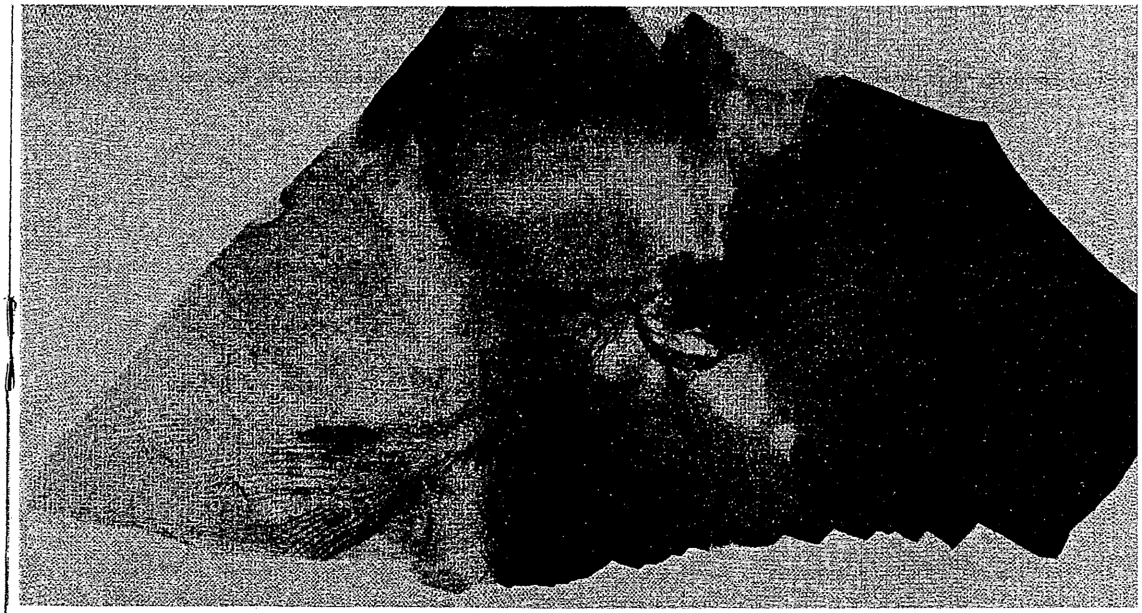
At the time of deposition the rocks of the Newark series were almost horizontal, but subsequent earth movement has tilted them to an inclined position; the beds now dip, in general, toward the northwest.

Footprints of dinosaurs and other reptiles, rain drop impressions and mud cracks prove that the Triassic mud flats were sometimes above the water surface. Fish remains and ripple or wave marks and trails of horse-shoe crabs show that shallow water periodically covered the area. Actual remains of animals are very rarely found in the Newark series in New Jersey. About eighty years ago, however, fossil fish were discovered near Boonton in such abundance as to lead to the belief that their death was caused by some kind of violent natural cataclysm, such as earthquakes or volcanic disturbances.

More recently a few skeletal remains of primitive reptiles have been found in a quarry in the Clifton-Passaic area and in West Somerset. Taken as a whole the known Triassic history of vertebrates in New Jersey is poor indeed. The record of plants is even less satisfactory and consists of a few remnants of ferns, cycads, conifers, and horse-tail rushes.

NATURE'S OLD VOLUMES

In view of this poor record of fossils from the Newark formations, no one could be very optimistic about the possibility of



Radiograph of the same piece of shale showing the skeleton. Note the absence of vertebrae, which were made of cartilage and hence were not preserved. One-half natural size.

finding good specimens in the excavation for the library. The strata there form part of the Lockatong formation and consist of hard gray sandstones and thin beds of black shale and yellow clay. We hoped to find a few dinosaur tracks in some of the sandstone layers, but had no luck. However, this disappointment was soon forgotten in the excitement of discovering a layer which contained billions of shells, each about one-eighth of an inch in diameter, of ***Estheria***, a crustacean which is related to barnacles, but has a shrimp-like body enclosed in two clam-like shells. Tests of another and even smaller crustacean, ***Candona***, an ostracod, were even more abundant in this layer. It also contained a few plant fragments which were identified by Dr. Erling Dorf as ordinary Triassic cycads and conifers.

Persistence paid in the search for more interesting and significant fossils. Early in March, 1946, Professor A. F. Buddington, Chairman of the Department of Geology, and the writer picked up some small muddy slabs of shale, cleaned them, and saw the first of thousands of fossil fish which were removed from the excavation. Dr. Julian Boyd, Librarian, immediately reported the discovery to the architect, Mr. R. B. O'Connor, who, with the contractor made it possible to proceed with the scientific work. Mr. H. A. Schroedel, superintendent for the Turner Construction Co., arranged to have workmen remove the rock above the fossiliferous layer and to keep heavy machinery out of the southeast corner of the excavation until the fossils had been collected. Truck drivers and other members of the excavating crew became interested, after their original expression of scepticism about fishing with shovel, hammer, chisel and brush, and found some of the best specimens.

Dr. Meredith Johnson, New Jersey State Geologist, examined the rocks in the excavations, and Dr. Bobb Schaeffer, of the American Museum of Natural History in New York, made a preliminary study of the specimens and pronounced them the best fossils of their kind in the Western Hemisphere.

Many students in the University and other local schools enthusiastically joined in the search. Classes in paleontology were held at the site where methods and purposes of collecting fossils were illustrated as they were described. Dozens of faculty members and other Princeton residents became temporary geologists and visited the dig which soon was dubbed "the old aquarium."

Only one six-inch zone of rock, consisting of very thin layers of black shale and yellow clay, contained the well-preserved fossil fish. These sheets could be split readily along the original bedding planes. The procedure therefore was to clear away the overburden, pry up large slabs of the "pay dirt," place them on end and separate them into thin flat sheets. As Dr. Boyd remarked "This is like opening the pages of ancient books."

Near the original surface of the ground the dipping fossiliferous rocks were weathered to loose soil and shale chips, whereas deep in the excavation the strata were too hard and dense to be separated into layers. The zone that contained the fish was in the right state of disintegration. We were thus just in time. A few million years more and we would have been too late.

Mr. Robert Witter, preparator of vertebrate fossils, devised methods of lifting large slabs of the soft rock and removing them to laboratories and storage rooms, where Mr. Frank Goto now patiently picks and grinds away the rock to expose the fish.

This deposit of natural treasure was almost discovered three-quarters of a century ago. Some of the piling for the old School of Science which was built in 1873 (and destroyed by fire in 1928) came within two inches of the fossiliferous stratum, a fact which was revealed during the recent excavations. It would have been especially gratifying if the thousands of students who used the old science building could have known that it was literally built upon the materials of science.

ANCESTORS OF LIVING FOSSILS

At least three and perhaps six or more genera and species of fish are represented in the collections from an area about fifty by fifteen feet in the floor of the library excavation. Exact details of numbers of individuals and of kinds will not be known until all the specimens have been studied. Only a few fragments of some sorts of fish were found, but there are thousands of specimens of ***Osteopleurus.*** This generic name means "bone rib" in reference to the numerous ribs which these fish possessed, in contrast to their lack of bony vertebrae.

Osteopleurus was a member of the great group Coelacanthini which in turn is classified as part of a still larger division, the Crossopterygii. Crossopts and dipnoans (true lungfish) are the two orders of the subclass Choanichthyes, bony fish with lungs and internal nostrils and two dorsal or back fins. Earliest members of this subclass are known from Devonian rocks about 325 million years old.

The Dipnoi are represented by living lungfishes in Australia, Africa, and South America.

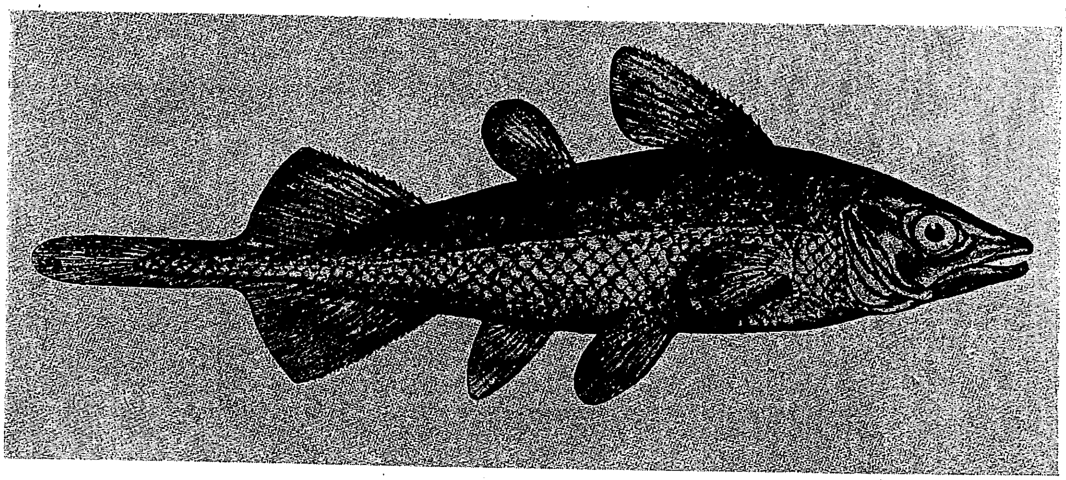
Fishes with internal nostrils are thus classified in part as follows:

Subclass Choanichthyes
- Order Crossopterygii ("fringe fins")
  - Suborder Coelacanthini
    - Genus ***Osteopleurus***
    - Genus ***Diplurus***
- Order Dipnoi ("true lungfishes")

For many decades, paleontologists believed that all crossopts had become extinct in Cretaceous times, about 90 million years ago, but recently a specimen of a living crossopt (5 feet long and weighing 127 pounds) was taken in a net off the coast of South Africa. It demonstrated the perfection of the restorations of crossopts which had been made by paleontologists and thus somewhat eased the shocks and surprise of finding a kind of living fossil which has survived for so long with no other known record of its continued existence. ***Latimeria*** is the name given to this amazing relict and paleontologists and biologists are eagerly awaiting the discovery of other specimens. Unfortunately the scientific importance of the capture was not realized for some days, by which time the fish had become so "unpleasant" that only the skin and parts of the skeleton were saved.

Crossopts hold an especially important place in biological classification because from them evolved the earliest amphibians, which in turn gave rise to the reptiles, the group that developed into birds and mammals. Hence, the ancestry of all land living vertebrates, including man, may be traced back to the early crossopt fishes. Crossopts originated in fresh water and went to sea in Triassic time.

Fossil coelacanths are widely distributed, having been found previously in a few places in North America, Brazil, Greenland, Spitzbergen, the British Isles, Germany, France, Spain, Belgium, Russia, Syria, South Africa, and



The Triassic fish *Osteopleurus,* restored from cleaned specimens and radiographs. About three-quarters life size.

Australia. Individuals of different species vary from a few inches to a yard in length. A few specimens of Triassic age have been collected from the Connecticut Valley region, from Virginia, from a site near North Wales, Pennsylvania, and from a quarry near North Bergen, New Jersey. None of the other American sites, however, has yielded as many or such splendidly preserved coelacanths as the petrified "school" of them from the Princeton locality. These new specimens reveal many new anatomical details.

Osteopleurus is a small coelacanth, specimens ranging from about an inch to eight inches in length. They had large heads and, as shown in the restoration, a curious long third or middle lobe of the tail. Behind the head the body was covered with oval-shaped scales which had numerous needle-like spines projecting from them. The lungs or swim bladders became calcified in life and are preserved in a few of the fossils. ***Osteopleurus*** was a wide or "flat" fish and probably used its paired pectoral and pelvic fins, which had fleshy bases near the body, to rest or crawl on the floor of the water. This may account for the fact that an exceptionally large number of the fossils were buried in a "standing" position rather than on their sides which is the normal position for dead fish.

Only a few fragments of another and much larger kind of crossopt, ***Diplurus,*** turned up in the excavation. ***Diplurus*** was about three feet long. Even in paleontology the largest fish gets away.

Some of the fish from the library pit are in thin layers of very soft clay. When this matrix is gently stroked with a camel's hair brush many details, even the sharp microscopic teeth in the small jaws, are revealed. After the specimens are thus exposed it is necessary to treat the clay with many applications of thin collodion cements which penetrate and harden it.

Other skeletons are in thin hard layers of shale. These require slow and painstaking microscopic work with small needles and drills if they are to be exposed for study. However, Mr. W. Landon Dennison, of the Princeton Infirmary, has developed a technique of taking excellent X-ray photographs of the specimens while they are in the rock. These radiographs will supply the necessary information for some studies and thus make it unnecessary to clean the hard rock from the specimens. Looking at the contents of rocks in the X-ray laboratory is a fascinating kind of geological exploration.

By combining the information supplied by these different techniques of examination it is hoped that new knowledge may be gained of the living conditions in New Jersey one and three-quarters millions of centuries ago.