Reports

Middle Pennsylvanian Plant Fossils: Problematic Occurrence in the Bronx

Abstract. *A possible glacial boulder of undeformed and unmetamorphosed siltstone containing Middle Pennsylvanian plant fossils was recovered from the Bronx. The rock cannot be explained by known geologic relations and suggests the possibility of undetected outliers of Pennsylvanian rocks in the Hudson valley.*

In November 1967 we noticed in the museum of the Suffolk County Historical Society in Riverhead, Long Island, a collection of plant fossils from the Pelham Bay region, New York; it was of Pennsylvanian age (*1*). The specimens had been collected (*2*) during construction of an overpass for the Bruckner Expressway in 1958; the finder kindly supplied us with 23 more chips of material from his personal collection, and described from memory the mode of occurrence of the rock.

The rock chips are as big as 7.5 cm in largest dimension. All consist of a medium-dark-gray [N3 to N4 of the Rock-Color Chart (*3*)], uniformly fine-grained, noncalcareous claystone (Fig. 1). Poor fissility is visible in a few specimens, and the rock shows no evidence of metamorphism or deformation. Coalified compressions of plant fragments, some of which are preserved in excellent detail, are abundant; they occur on rudely planar surfaces—undoubtedly the original bedding planes. The specimens resemble in appearance those on exhibit at the Riverhead museum.

The rock was found near the bottom of a pit, estimated at 6 to 8 m in depth, excavated during construction of the overpass at Country Club Road and Jarvis Avenue, the Bronx. The chips were broken from a large rock protruding from and surrounded by soft earth. The site is now covered with concrete, so that the finder's observations cannot be checked for the geologic nature of the exposure.

We identified the following plant fossils: *Annularia*? sp., *Asterophyllites* sp., *Calamites* sp., *Cordaites*? sp., *Lepidophyllum*? sp., *Neuropteris rarinervis* Bunbury, *Neuropteris cf. N. tenuifolia* Schlotheim, and *Sphenophyllum* sp. Also present are several unidentifiable roots and other plant fragments. Judged by the concentration of plant material in the small sample available, this is a representation of an originally rich, well-preserved lowland flora.

The fossil assemblage permits no doubt that the rock is of Pennsylvanian age. Its position within the Pennsylvanian is determined primarily by *N. rarinervis,* the dominant plant in the collection. This species, easily recognized by its widely spaced veins, is represented by more than two dozen pinnules; interpreted in terms of the upper Paleozoic floral zonation of the United States (*4*), this abundance signifies a stratigraphic position within the Middle Pennsylvanian Zone 9 (zone of *N. rarinervis*), which embraces the lower part of the Allegheny Formation or equivalent stratigraphic intervals.

As we have indicated, the geologic setting of the rock that yielded these fossils is not altogether clear from the available descriptions. Several reasonable possibilities come to mind: the rock may derive from ship's ballast dumped at the site or from earth fill, it may be a glacial boulder, or it may be part of the bedrock—either a miniature Carboniferous basin (possibly fault-bounded), or a boulder from a Triassic bed.

The U.S. Geological Survey topographic sheets of the Harlem 15-minute quadrangle, 1901 (*5*), and of the Flushing 7.5-minute quadrangle, 1955, show the crossing by Bruckner Boulevard (the new expressway precisely follows the boulevard here) of Country Club Road; the location is beside a gentle ⩾16-m knoll and above the 20-foot (6.0-m) contour line. Folio 83 (*5*) shows the area covered by thin till rather than by artificial fill; artificial fill of the magnitude needed to explain the depth of burial of the rock seems unlikely for this location before 1902 and probably would have been recorded.

Any later artificial fill to the required depth would be reflected in difference between the contour lines of

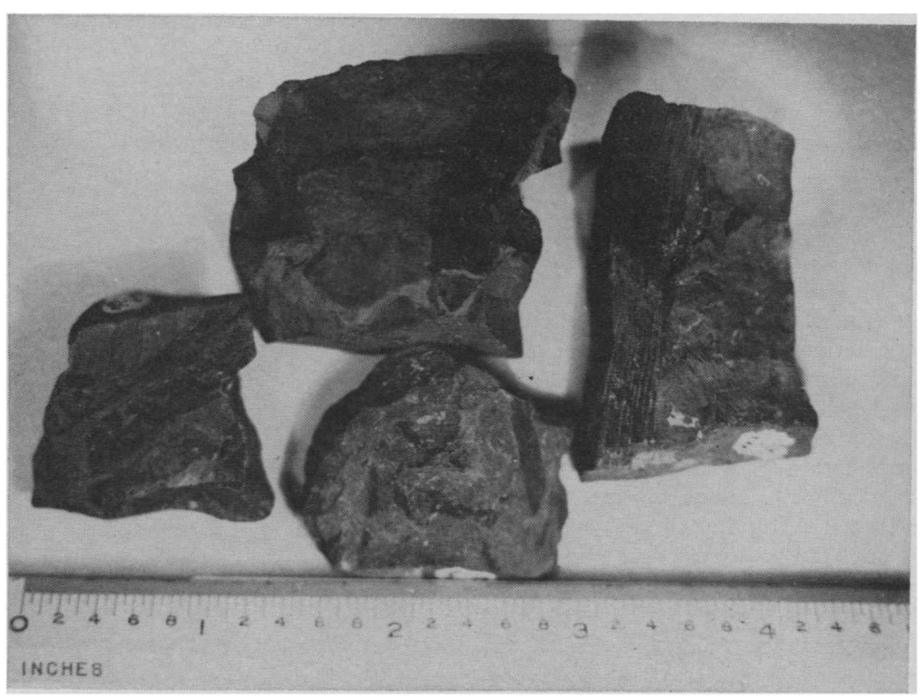

Fig. 1. Pennsylvanian siltstone showing general lithology and fossil plants; 1 inch, 2.5 cm.

the two editions of the topographic sheets. The contour lines on the 1901 and 1955 topographic sheets agree closely, except for the effect of building construction since 1901. Because both Bruckner Boulevard and Country Club Road existed in 1901, their elevations tightly control any possible removals of earth between these dates that are not explicitly shown. There is no evidence of such removals. Thus the first two of the four possibilities probably can be safely dismissed.

Six holes were drilled at the road intersection in 1958 during preparation for construction of the overpass. These holes, numbered J-5 through J-10, went through sand, silt, and rarer "gravel" (4 to 6 m in thickness, depending on the hole) underlain by a zone of disintegrated gneiss; the holes bottomed in Precambrian and Lower Paleozoic crystalline rocks which are the prevailing country rocks in this area (*5, 6*). Nothing that may be interpreted as Triassic or Upper Paleozoic bedrock was recorded. It appears that the fossil-bearing rock was indeed a large glacial boulder.

A glacial-boulder interpretation, however, leads to problems. The boulder seems much too fresh to be derived from an earlier glacial advance. Derivation of the boulder from basal Cretaceous strata in the lower Hudson valley or southwestern Connecticut, now totally removed by erosion, cannot be ruled out, but large boulders have not been found in basal Cretaceous beds in the Long Island–Staten Island area and seem unlikely. Another hypothesis, that the boulder came by ice-rafting from the extensive Carboniferous basins of the Maritime Provinces in eastern Canada, cannot be ruled out, but it too seems a remote likelihood because of the great distance in an odd direction.

The dominant direction of movement of continental ice sheets of Wisconsin age during Pleistocene glaciation in the area of New York City is considered to be north–south (*5*), but the only reasonable source of undeformed, unmetamorphosed Pennsylvanian rocks is the anthracite region of eastern Pennsylvania, almost 130 km due west of the Bronx. If the boulder did come from eastern Pennsylvania, a rather thick sheet of ice (to overcome the major north–south ridges such as Kittatinny Mountain) would have been needed, and our ideas on the direction of movement of ice would have to be drastically revised. Rather, the boulder suggests to us the existence along the Hudson valley of hitherto overlooked outliers of Pennsylvanian rocks.

Carboniferous basins of deposition extend from western Newfoundland, central and southern New Brunswick, Nova Scotia, Rhode Island, and eastern Massachusetts, to Pennsylvania. Rocks in the Narragansett basin of Rhode Island are severely deformed and metamorphosed (*7*), and those in the Maritime Provinces are only locally deformed and metamorphosed (*8*), whereas those of Pennsylvania are mildly deformed but unmetamorphosed. A possible location of a basin of deposition in the Hudson valley would be on trend with the major basins; the fact that these specimens are free of deformation and metamorphism would then place significant restrictions on the extent of late Paleozoic diastrophism in the northern Appalachian region.

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9. We thank Marian Terry of the Suffolk County Historical Society for information on the fossil specimens; B. M. Williams of the New York Thruway Authority and J. C. Griek of the Department of Transportation, State of New York, for subsurface data; Henry Andrew, C. S. Denny, J. B. Epstein R. B. Neuman, and C. B. Read for reviewing the manuscript; and J. P. Owens for discussion of Cretaceous geology. Especially we thank Gary Zippelius and his mother, Mrs. Hans Zippelius, for supplying specimens and information on their collection, and for enthusiastic cooperation; they have permitted us to keep the fossils upon which the determination of Pennsylvanian age is based. Publication authorized by the director, U.S. Geological Survey.

17 May 1968

Precambrian Marine Environment and the Development of Life

Abstract. *The tropical thermocline must have existed since the ocean's depth exceeded 300 meters. The density gradient in this layer concentrated organic aggregates formed abiologically near the surface of the sea, and the low rates of diffusion across this layer permitted the accumulation of oxygen once the layer was populated by blue-green algae; thus the evolution of eukaryotes became possible within the layer. Because of rapid mixing over the shelves, the eukaryotes were restricted initially to the thermocline over deep water. The shelves could not be permanently inhabited by organisms requiring respiration until the oxygen level of the atmosphere was adequate. At this stage, the swimming Metazoa of the thermocline could adapt to a benthic environment on the shelves by developing exoskeletons.*

In order to investigate the origin and early evolution of life on Earth one must consider the Precambrian environment. Our knowledge of Precambrian paleooceanography is extremely limited, and so the Precambrian ocean has usually been characterized by a single value for its parameters as if it had been a well-mixed system. A more realistic reconstruction of the Precambrian ocean may lead to new insights into the early development of life on Earth.

The distribution of noble gases on Earth and in stars indicates that Earth initially lost its fluid envelope, and that the present ocean and atmosphere must have accumulated from outgassing of Earth's interior (*1*). Thus the volume of the oceans has increased with time during the last 4×10^9 years. If the ratio of outgassing of chlorine and water remained relatively constant, the salinity of sea water did not vary greatly; thus its density has probably always been a function of salinity as well as temperature.

The volume of the oceans increased significantly during Precambrian times and approached its present value at the beginning of the Cambrian. This increase in volume does not necessarily imply an increase in the fractional area of Earth covered by the oceans. If, as is probable, the evolution of