GEOLOGY AND PALEONTOLOGY
OF THE LOWER MIOCENE

POLLACK FARM FOSSIL SITE

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RICHARD N. BENSON, Editor

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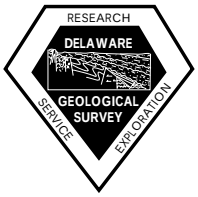

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CONTENTS

The Cover

Aerial view of the Pollack Farm Site viewed toward the east in 1992. The Leipsic River is in the upper left. Right-of-way for Delaware State Route 1 runs from left to right in foreground. Photograph by Tim O'Brian.

INTRODUCTION

Richard N. Benson[1]

The Pollack Farm Site, Kent County, Delaware, is named for a borrow pit on the former Pollack property that was excavated during 1991 and 1992 for road material used in the construction of Delaware State Route 1 (see cover photograph). The site lay east of U.S. Route 13 on the divide between the Leipsic River on the north and Alston Branch on the south (Fig 1). The Delaware Geological Survey (DGS) identifier for the site is Id11-a (39°14' 08" N, 75°34' 36" W). By 1993, the pit was back-filled, graded, and developed into a wetlands mitigation site.

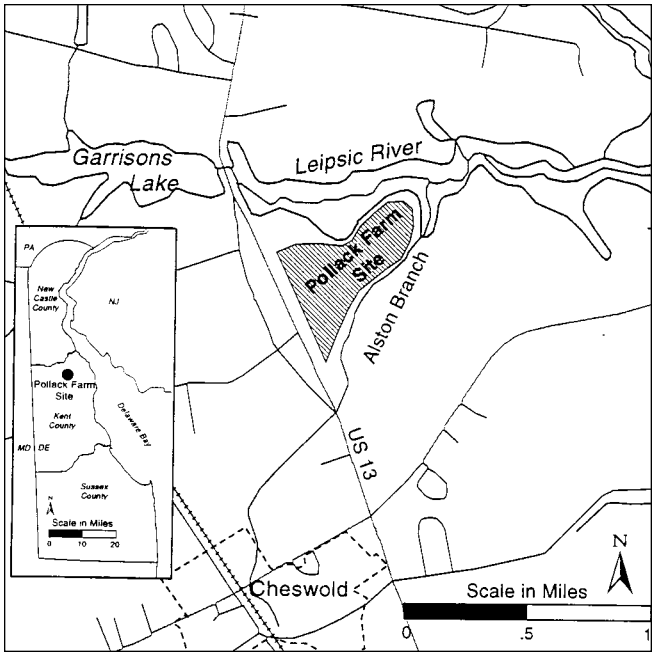

Figure 1. Map showing the location of the Pollack Farm Fossil Site, Delaware

In the summer of 1991 during their routine check of excavations of earth materials as highway construction proceeded, DGS staff members recognized an exposure of a mud bed of the Calvert Formation beneath Quaternary sediments at the Pollack Farm Site. As the pit was deepened to extract sands of the Cheswold aquifer below the mud bed, the first (upper) shell bed was revealed with its abundant molluscan fossils. As the quality of the sand was excellent for highway construction, the pit was deepened below the water table but kept dry by continuous pumping. Thus began a series of visits to the site as excavation continued through 1992, not only by DGS geologists but by scientists from other institutions when the lower shell bed with its fragmentary vertebrate remains was exposed.

Kelvin W. Ramsey of the DGS proposed that the results of the studies of the geology and paleontology of the site be gathered together in one volume. Thomas E. Pickett agreed to coordinate the project and was instrumental in obtaining commitments and, indeed, several of the 13 manuscripts from the 19 contributors to this volume. With Pickett's retirement from the DGS in 1996, the project was on hold until I took over the task of editing the volume in 1997.

The geology of the Pollack Farm Site is reported in the first five papers. Richard N. Benson describes a radiolarian assemblage indicating a strong degree of neritic versus oceanic conditions and with taxa that identify the late early Miocene *Stichocorys wolffii* Zone with an age estimated between 17.3 and 19.2 Ma, thus establishing correlation of the beds containing both marine and terrestrial fossils at the site to a formal marine global biostratigraphic zone. He also correlates the Miocene fossil vertebrate assemblages of the middle Atlantic Coastal Plain (Maryland to New Jersey) to global foraminiferal, calcareous nannofossil, and radiolarian biozones, to regional diatom and dinoflagellate biozones, and to the geomagnetic polarity time scale by means of published strontium-isotope studies.

From analyses of strontium isotope ratios of marine mollusks from the lower shell bed at the site, Douglas S. Jones, Lauck W. Ward, Paul A. Mueller, and David A. Hodell determined the mean age of the shells as 17.9±0.5 Ma, which is consistent with the age determined by the radiolarians and with the early Hemingfordian age assigned to the land mammal fossils.

Kelvin W. Ramsey interprets the depositional environments of the sediments exposed at the Pollack Farm Site: marine inner shelf at the base of the pit; succeeded in order by a tidal channel represented by the lower shell bed and lower sand; a subtidal channel margin; a cross-bedded sand (same stratigraphic level as the upper shell bed) representing a subtidal sand flat shoaling upward to a subtidal to intertidal flat; and an intertidal to supratidal flat represented by the upper mud, the part of the Calvert first exposed by excavation.

Molly F. Miller, H. Allen Curran, and Ronald L. Martino interpret the cross-bedded sand underlying the upper mud as deposited in a broad tidal or estuarine channel, and they identify channel-axis and channel-margin facies on the basis of relative densities of *Ophiomorpha nodosa* burrows.

A. Scott Andres and C. Scott Howard describe several types of soft-sediment- and brittle-deformation features in the Calvert and overlying Quaternary formations and ascribe some to cold-climate freeze-thaw processes and others possibly to movements along faults, to erosional unloading, or to weathering and mineralization processes.

With the exception of the palynomorphs from the Pollack Farm Site, most if not all of the invertebrate and vertebrate fossils were collected from the lower shell bed by construction workers at the site, during the many visits by David J. Bohaska, Robert J. Emry, Ralph E. Eshelman, and Robert W. Purdy and others from the Smithsonian Institution and Lauck W. Ward of the Virginia Museum of Natural History, and by others invited to the site. Most but not all fossil groups recovered from the site are described in the eight paleontology papers.

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Johan J. Groot reports that palynomorphs from the Pollack Farm Site indicate an early Miocene climate similar to one that now prevails in the coastal region of Georgia or northern Florida. The diversity and abundance of the palynoflora representing trees and shrubs and the near absence of herbaceous pollen indicate a dense forest growing right up to the coast. Marine palynomorphs decrease stratigraphically upward indicating a slight regression or a change from an open marine to an estuarine environment.

Lauck W. Ward describes a prolific, well-preserved invertebrate fossil assemblage, principally of mollusks, that is the equivalent of that collected from the Kirkwood Formation near Shiloh, New Jersey. The molluscan assemblage is analyzed, and 104 species are discussed and/or figured. The mollusks appear to have originated in a deltaic setting where fresh-water, brackish-water, and marine mollusks have been mixed and rapidly deposited in a channel. The assemblage consists of a number of new species, first occurrences, last occurrences, subtropical and tropical species, and taxa not previously reported from North America.

From the lower shell bed Robert W. Purdy identifies 30 fossil fish taxa comprising 24 cartilaginous and 6 bony fishes. Except for the relative abundances of the taxa, the assemblage is identical to those of equivalent age from the Calvert and Pungo River formations of Maryland and North Carolina, respectively, and indicates a subtropical, shallow-water, nearshore paleoenvironment with a water temperature warmer than that found in the Carolina Bight today.

J. Alan Holman reports a unique reptile fauna from the Pollack Farm Fossil Site that, among other species, has yielded the first North American remains of small Miocene lizards and snakes east of the Great Plains and north of Florida, including *Pollackophis depressus*, a distinctive new genus and species of small colubrid snake, and *Pterygoboa delawarensis*, a new species of a distinctive small boid genus. Also identified are aquatic turtles, a very large tortoise, and a very large crocodile. Large reptiles such as giant tortoises and crocodilians indicate that the climate in Delaware during deposition of the Pollack Farm sediments was probably subtropical. The terrestrial reptile assemblage suggests a group of forms that probably occupied a rather open grassy or brushy habitat with loose or sandy soil. This habitat was probably near a large sluggish lake or oxbow as crocodiles normally need large, permanent bodies of water in which to live.

Only 11 specimens of fossil birds, all fragmentary and unassociated, have been recovered from the Pollack Farm Fossil Site. The five avian taxa Pamela C. Rasmussen identified are mostly or exclusively marine in distribution—modern loons and sulids, the two most common taxa at the site, and pseudodontorns which were strictly marine. The fossils apparently all belong to species already known from the younger part of the Calvert Formation of the western shore of Chesapeake Bay in Maryland. The composition of the avifauna supports the depositional hypothesis of a nearshore area of a large embayment.

The land mammals from the Pollack Farm Site are represented predominantly by single teeth and parts of postcranial elements. Robert J. Emry and Ralph E. Eshelman write that the collection of fossils grew to become the most diverse Tertiary land mammal fauna known in eastern North America north of Florida. The age established by the land mammals is early Hemingfordian (early Miocene). The assemblage, termed the Pollack Farm Local Fauna, includes at least 26 species representing at least 17 families in 7 orders. Families represented include shrew, hedgehog, bat, beaver, mice and other rodents, ancestral bear(?), racoon, dog, horse, chalicothere, rhinoceros, peccary, hippopotamus-like artiodactyl(?), oreodont, and deer-like ruminant. The land mammal assemblage suggests a nearby forested habitat, probably with some open grassy areas, and fresh water. Possible settings are a coastal barrier island or a delta with flowing fresh-water rivers and streams, oxbow lakes and ponds, with marshes and swamps developed in the lowlands and forest and open park-like grasslands on the higher elevations. Beaver, peccaries, browsing and grazing horses, chalicotheres and rhinos could all find suitable habitats in such places.

Alan H. Cutler's observations of the surface features of terrestrial mammal bones suggest that the bones were exposed subaerially for a period of time before burial and that they were buried and permineralized prior to transport and abrasion. Carcasses washed to sea by flooded rivers is therefore unlikely, and reworking is the favored model of assemblage formation.

David J. Bohaska reports that the marine mammal collection from the Pollack Farm Site is more fragmentary and less diverse than the marine mammal fauna from the Calvert Formation of Maryland and Virginia, lacking the more nearly complete skulls and skeletons found there. At least six cetaceans are present—five porpoises and a sperm whale. Also present is a dugong, and one of the earliest records of a true seal. The long-beaked porpoise *Zarhachis flagellator* suggests a non-open ocean habitat as it has a body plan resembling modern river porpoises. A dead river-dwelling porpoise could easily float downstream into the marine environment and be preserved. Sirenians (dugong) tend to occur in fresh and near-shore marine waters and are generally tropical to subtropical in distribution.

The authors of the studies of the sediments and fossils from the Pollack Farm Site presented in this volume are remarkably consistent in their age determinations and paleoenvironmental interpretations. The age is well-established as early Miocene, about 18 Ma, as corroborated by the radiolarian, molluscan, and strontium isotope studies, and early Hemingfordian as determined by the land mammal assemblage.

The bulk of the invertebrate and vertebrate macrofossils, ranging from terrestrial to fully marine taxa, are from a channel deposit, therefore, transported from where they lived. The terrestrial mammal assemblage consists of disassociated elements. Articulated bones were probably buried and permineralized before they were transported and abraded. The abraded condition of the marine mammal bones resembles that of the terrestrial mammals.

The likely depositional setting for the sands at the site was a tide-dominated delta with shallow open marine waters nearby as indicated by the radiolarian bed at the site. Depositional environments at the site include marine inner shelf, subtidal to tidal channels with *Ophiomorpha* burrows, and tidal flats. Both the land climate and marine environment were subtropical. Densely forested uplands with open areas of grasslands grew right up to the coast. Lowland environments consisted of fresh-water rivers and streams with swamps, marshes, and large lakes on the floodplain.

Acknowledgments

Gordon Simonson, supervisor at the Pollack Farm Site for Pierson Engineering, is acknowledged by all authors who collected fossils at the site. He personally found many of the specimens, encouraged his fellow workers at the site to donate or loan fossils they collected for study by contributors to this volume, and even operated a backhoe to dig out fresh material for collecting. Simonson, David Duke of the Delaware Department of Transportation (DelDOT), and Edward S. Adams of Century Engineering were cooperative in granting access to the site. Kevin W. Cunningham, DelDOT Archaeologist, was enthusiastic about the plans for this volume and was instrumental in arranging financial support by DelDOT for its publication. Finally, I express my sincere appreciation to the authors contributing to this volume and the reviewers of their manuscripts. All were cooperative in responding to my schedule for producing this volume after I became its editor.