The Parsonsburg Sand in the Central Delmarva Peninsula, Maryland and Delaware

GEOLOGICAL SURVEY PROFESSIONAL PAPER 1067-B

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By CHARLES S. DENNY, JAMES P. OWENS, LESLIE A. SIRKIN,
and MEYER RUBIN

SURFACE AND SHALLOW SUBSURFACE GEOLOGIC STUDIES IN THE EMERGED COASTAL PLAIN OF THE MIDDLE ATLANTIC STATES

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Sandy and peaty sediments suggest that the climate of the Delmarva Peninsula was cooler and drier during the late Wisconsin than it is at present

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THE PARSONSBURG SAND IN THE CENTRAL DELMARVA PENINSULA, MARYLAND AND DELAWARE

By CHARLES S. DENNY, JAMES P. OWENS, LESLIE A. SIRKIN,[1] and MEYER RUBIN

ABSTRACT

The Parsonsburg Sand, a surface sand largely of Wisconsin age, caps terraces east of some of the major streams and mantles broad areas on the uplands of the central Delmarva Peninsula, Maryland and Delaware. The main body of the formation east and south of Salisbury, Md., ranges from 1.25 to 6.00 m (4–20 ft) in thickness and is a medium-grained moderately feldspathic sand containing a relatively mature heavy-mineral suite. The sand is either stratified or massive, and in some areas contains peaty sand and silt-clay, typically at or near the base of the formation. The organic matter ranges in radiocarbon age from about 30,000 to about 13,000 years B.P. and contains microfloral assemblages suggesting that at the time the sand was deposited the climate was cooler and drier that it is at present. The region may have been a pine-birch barrens in which were small ponds, spruce bogs, and abundant shrubs. The distribution of the sand at or near the position of high stands of the Sangamon sea suggests that the Parsonsburg Sand was derived from sandy shore and nearshore deposits of Sangamon age. Deposition was in part eolian and in part fluvial and lacustrine, probably in small streams and ponds between sand dunes.

INTRODUCTION

The central Delmarva Peninsula in southern Delaware and adjacent Maryland (fig. 1) is covered by a surficial blanket of sand—the Parsonsburg Sand—that yields data about the environment of the central Atlantic Coastal Plain in middle and late Wisconsin time. The sand ranges in radiocarbon age from about 30,000 to about 13,000 years B.P. For two-thirds of this interval, including the maximum advance of the last ice sheet onto Long Island about 18,000–20,000 radiocarbon years ago, the record heretofore has been limited to a few isolated radiocarbon dates. A fairly complete record of the late Wisconsin is found on the central Delmarva Peninsula, about 250 km (160 mi) south of the terminal moraine of the Wisconsin ice sheet. Fluvial, eolian, and lacustrine sediments contain an extensive microflora that suggests a cooler and slightly drier climate at the time of deposition than at present. The region may have been a pine barrens that had abundant shrubs and small ponds between isolated sand dunes.

The name Parsonsburg Sand was applied by Rasmussen and Slaughter (1955, p. 118) to a "*** veneer of sand and associated deposits which compose the rims and, in places, the interior of the Maryland basins." The "basins" were defined by Rasmussen (1953, 1958; Rasmussen and Andreasen, 1959) as groups of more or less circular poorly drained basins bordered by low sandy ridges. The formation was named for the village of Parsonsburg about 9.6 km (6 mi) east of Salisbury, Md. The sand was believed to extend from below sea level to the crest of the divide near Parsonsburg and to be of Wisconsin age. Hansen (1966, p. 22) believes that some of the sand formed at the end of the Sangamon Interglaciation "as a submarine bar which later developed into an emergent sand spit capped by dune deposits."

In southern Delaware, the surficial sands have been studied in detail by Jordan (1964, 1967, 1974; Jordan and Talley, 1976), who believes that the sandy ridges are beaches or bars whose surface has been reworked by the wind.

As part of the Delmarva project, a study by the U.S. Geological Survey of the surface and shallow subsurface geology of the central Delmarva Peninsula, many auger borings were made not only in the Parsonsburg Sand as originally defined in Worcester, Wicomico, and Somerset Counties, Md., but also in areas to the north in both Maryland and Delaware. We have found that a surficial mantle of sand is present in many upland areas. The sand may form dunes or it may be a discontinuous sheet without any distinctive surface morphology. It rests on deposits of both Pleistocene and late Tertiary age and, in many areas, lacks any sediment rich in organic matter or other fossil materials. The sand has a complex origin and may include beds as old as the Pliocene and as young as the Holocene.

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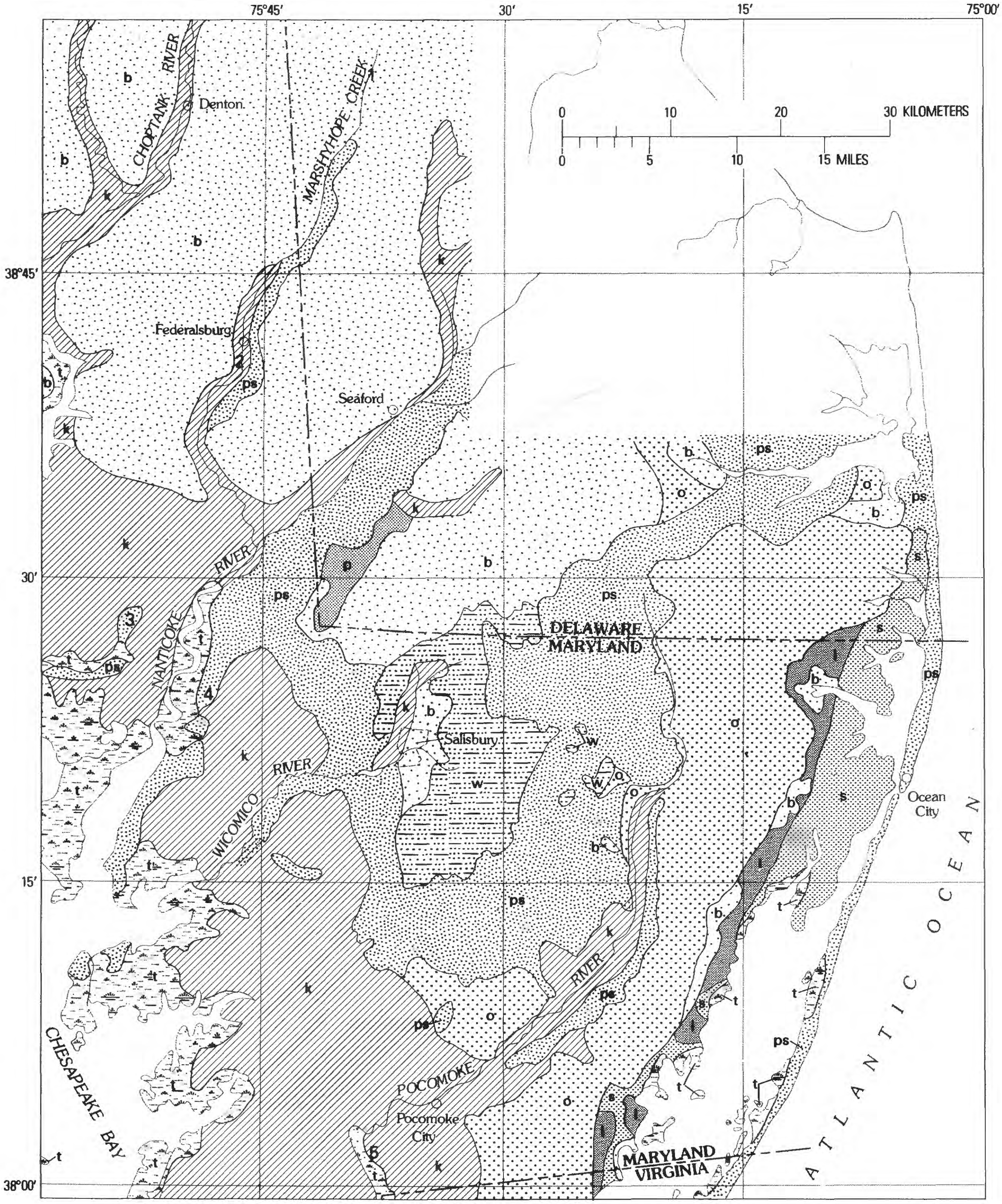

FIGURE 1.—Generalized geologic map of part of the central Delmarva Peninsula, Del., Md., and Va.

We use the name Parsonsburg Sand for this surficial mantle regardless of whether or not it contains diagnostic material (pollen or peaty sediment dateable by radiocarbon) because we are unable to separate sand known to be of late Wisconsin age from sand that could be older or younger.

Our study in southern Maryland and adjacent Delaware shows that the Parsonsburg Sand is found in two topographic situations: it forms parabolic dunes on the east side of the valleys of some of the rivers, such as the Nanticoke, Wicomico, and Pocomoke (fig. 1), and it blankets large areas on the uplands in the central part of the peninsula. In some upland areas, the surface of the sand is heaped up into dunes separated by shallow poorly drained depressions; in other upland areas, the surface is level to gently rolling. Sediment rich in organic matter is found in the Parsonsburg Sand in some upland areas such as that east and south of Salisbury, Md. (fig. 1). On the other hand, on the uplands northwest of Salisbury between the Wicomico and Nanticoke Rivers, an extensive blanket of Parsonsburg Sand is barren; it contains no peaty sediments or any other fossil materials. Along the rivers, the Parsonsburg Sand contains sediment rich in organic matter at only one or two localities. The deposition of the sand in the two upland areas mentioned above and along the rivers may or may not have been contemporaneous.

In this paper, we describe the Parsonsburg Sand in the valleys of the Nanticoke, Wicomico, and Pocomoke Rivers and in the uplands east and south of Salisbury, Md. The uplands include the type area of Rasmussen and Slaughter (1955) on the divide near Parsonsburg between Salisbury and Ocean City, Md. On the uplands, the Parsonsburg Sand commonly consists of an upper

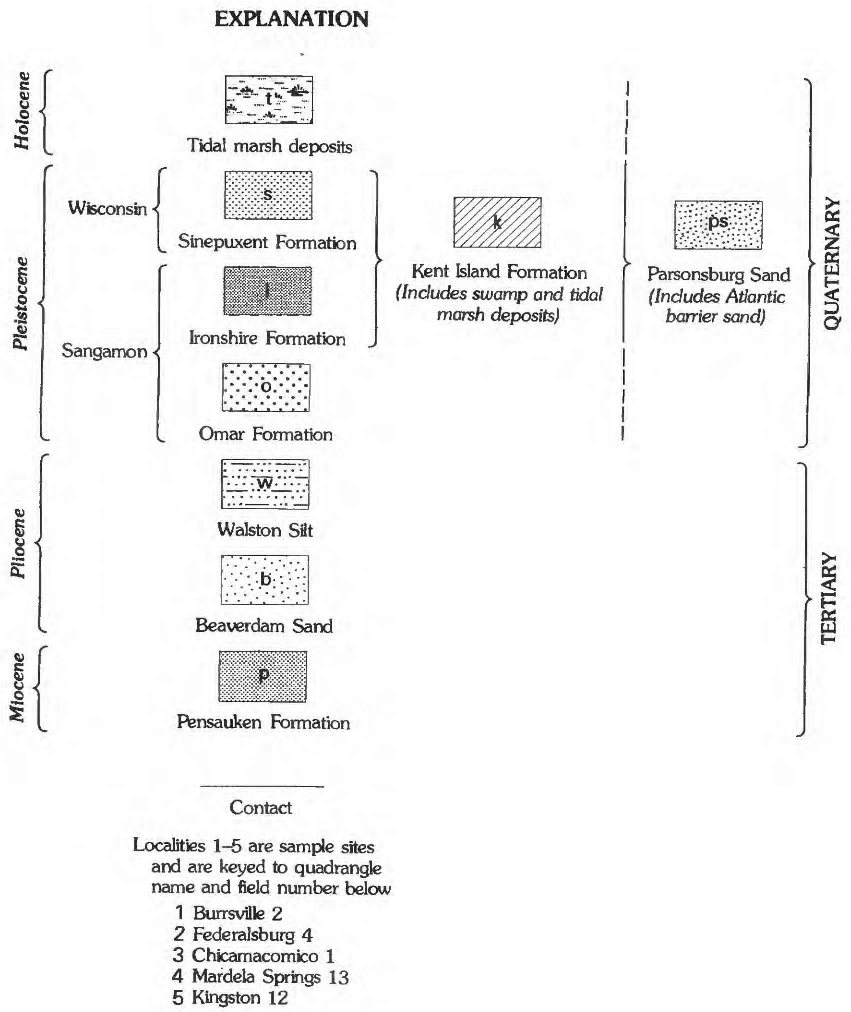

FIGURE 1.—Continued.

light-colored sand (pale yellow to brown) and a lower dark-colored sand or clay silt (light brown to dark gray) rich in organic matter.

The paper is based on observations in a few borrow pits and of samples from about 60 auger holes. Here we discuss the nature and origin of the Parsonsburg Sand. Sirkin and others (1977) have described the microfloral assemblages, and Denny and Owens (1978) have discussed the surface morphology. (See also Hess, 1977.)

GEOGRAPHIC AND GEOLOGIC SETTING

The Delmarva Peninsula is a broad upland, generally not more than 24 m (80 ft) above sea level except at its extreme northern end. The peninsula is bordered by wetlands that separate it from Chesapeake Bay to the west and the Delaware Bay and Atlantic Ocean to the east. An extensive barrier-backbarrier system forms the Atlantic shore. The sediments that directly underlie the central and northern parts of the peninsula form a sheet of interbedded and interfingered sand and gravel. These alluvial and marginal marine sediments were deposited in a broad valley in Miocene and Pliocene time. Presumably the valley was bordered by uplands of low relief that have since been eroded away to form Delaware and Chesapeake Bays. The formations adjacent to the Parsonsburg Sand, which are, therefore, possible source rocks for the Parsonsburg Sand are described below. (See also Owens and Denny, 1978.)

The Pensauken Formation, late Miocene in age, is a fluvial deposit consisting of orange to reddish-brown sand and gravelly sand. The unit is a feldspathic quartz sand (fig. 2.), the heavy-mineral assemblages being immature, notably hornblende rich (fig. 3). The Beaverdam Sand, Pliocene in age, is principally light-colored gravelly sand and interbedded clay-silt beds. The sands are highly feldspathic and contain a moderately mature suite of heavy minerals. The Beaverdam was deposited in a marginal marine environment.

The Walston Silt, of probably late Pliocene age, underlies the highest part of the central Delmarva Peninsula. The unit is a deeply weathered sequence of interbedded clay, silt, and sand. The clay-silt fraction contains a disordered kaolinite that is probably detrital rather than secondary. Halloysite and gibbsite are present in the upper weathered strata. In the weathered zone there is a mature suite of heavy minerals; below the weathered zone, the heavy-mineral suite is less mature but more so than in the underlying Beaverdam Sand. The Walston Silt is the oldest unit in the Delmarva Peninsula that probably is part of a barrier-backbarrier sequence. The formation suggests a marine high-stand about 21 m (70 ft) above present sea level. The Omar Formation of Sangamon age, extending southward into the Accomac trough in Virginia, is interbedded dark-colored clay-silt and light-colored sand, primarily part of a barrier-backbarrier system. The clay-sized clasts are kaolinite, montmorillonite, illite, and chlorite. The heavy-mineral assemblages are immature (abundant hornblende, epidote, and garnet). The clay-silt facies reaches altitudes of nearly 10.6 m (35 ft) above sea level. The sand facies resembles the Parsonsburg Sand, making it difficult to establish the maximum elevation of the Sangamon sea that may have stood as much as 17.0 m (55 ft) above present sea level.

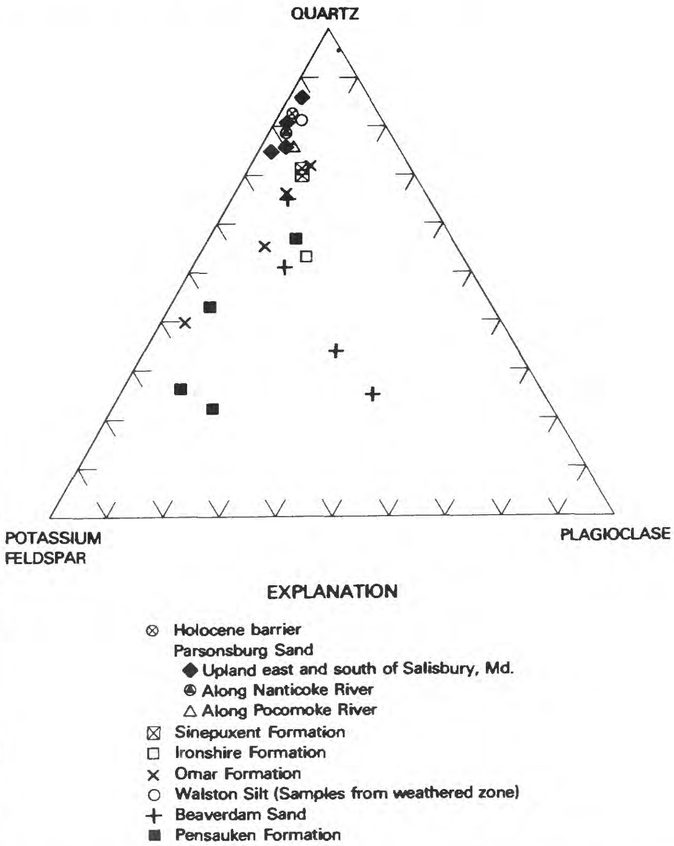

FIGURE 2.—Ternary diagram showing light-mineral distribution (<2.80 sp gr; 0.149–0.074 mm diam) in the Parsonsburg Sand and adjacent formations in the central part of the Delmarva Peninsula (fig. 1).

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On behalf of the Delmarva project, it is a pleasure to acknowledge the assistance of the Maryland Geological Survey, K. N. Weaver, Director, and the Delaware Geological Survey, R. R. Jordan, Director, and the staffs of both Surveys. Several members of the U.S. Department of Agriculture aided the study in various ways, especially Klaus Flack, R. L. Hall, Ray Daniels, and Paul Siegrist. Grace Brush, C. B. Hunt, and L. C. Peltier visited the area and offered helpful suggestions.

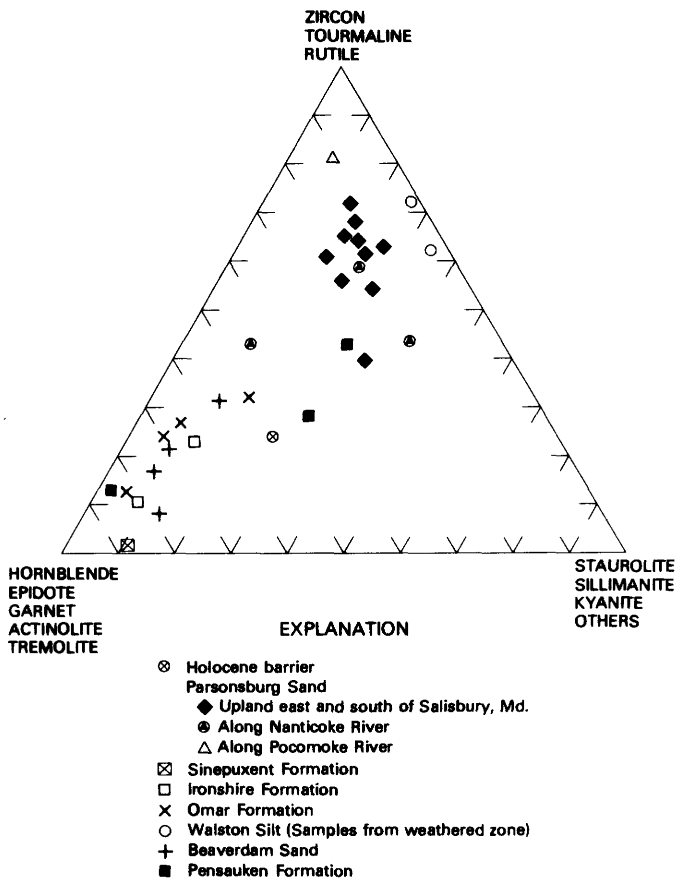

FIGURE 3.—Ternary diagram showing heavy-mineral distribution (>2.80 sp gr; 0.149–0.074 mm diam) in the Parsonsburg Sand and adjacent formations in the central part of the Delmarva Peninsula (fig. 1). Note general tendency of the Parsonsburg Sand to have a higher zircon-tourmaline-rutile concentration than do all the underlying formations except the Walston.

Finally, our thanks to our colleagues in the U.S. Geological Survey—to M. J. Grolier, J. T. Hack, W. S. Kirk, R. B. Mixon, William Raspet, R. S. Sigafoos, and the late Karl Stefansson for discussions and for assistance in the field, and to J. A. Wolfe for some preliminary palynological investigations.

DISTRIBUTION AND LITHOLOGY

The distribution and type of material found in the main body of the Parsonsburg Sand on the uplands east and south of Salisbury, Md., are presented in figure 4. The individual columnar sections illustrate the relationship of the upper sand to the underlying peaty sediments and to the older formations that underlie the Parsonsburg.

In general, most of the sand fraction in the Parsonsburg is medium grained and light colored (pale yellow to brown). The sand grains are in general subrounded to well rounded. Sand in the Parsonsburg appears to have a lower feldspar content than sand in most of the other formations in the region (fig. 2). The heavy-mineral assemblages in the Parsonsburg are also more mature than those in the adjacent formations except for the Walston (fig. 3).

The clay-silt fraction in the upper sand ranges from about 0.2 to 3.0 percent and was X-rayed to determine its mineralogy. The major minerals are dioctahedral vermiculite and kaolinite. Smaller amounts of gibbsite, halloysite, illite, and montmorillonite are also present; the last two minerals are increasingly abundant near the upper surface of the formation. Basically, the mineralogy of the clay-silt fraction is dominated by minerals that are stable in well-drained (leached) deposits.

The clay mineralogy of the basal peaty sediments of the Parsonsburg, however, is much less mature than it is in the upper sand. Kaolinite is the major mineral present, but montmorillonite and chlorite (+ chloritized vermiculite) are much more abundant. Small amounts of gibbsite and halloysite are also present in the basal peaty sediments.

The mineralogy of the sand both in the upper part of the formation and in the basal peaty sediments indicates derivation of sediment from an already leached source such as weathered sand in the Beaverdam Sand or Walston Silt, which are beneath or adjacent to the Parsonsburg Sand. The high concentration of montmorillonite in the peaty sediments could be interpreted as a product of diagenesis, much as postulated by Jackson (1965). He suggested that aluminated clays could be transformed to montmorillonite in the swampy environment indicated by the peaty sediments.

The only extensive exposure of the Parsonsburg Sand was a large borrow pit on the divide north of Parsonsburg, Md. (Pittsville 17[2], fig. 4) described in detail below. It was also the only exposure of the peaty sediment. In the pit, about 1.5 m (5 ft) of peaty sand and clay-silt is overlain by about 3 m (10 ft) of bedded sand. In places, the bedded sand is overlain by 1–2 m (3–6 ft) of loose sand forming a low ridge, probably part of an ancient sand dune (fig. 5; table 1). Beds of coarse to fine sand are present interbedded with a few lenses of coarse sand and granules. In places, lenses of very fine gravel range in thickness from about 0.1 to 10.0 cm (0.04–4.0 in.); some are about one grain thick.

The internal structure of the material exposed in the borrow pit suggests deposition by currents in standing water (figs. 6 and 7). The stratification is horizontal to slightly inclined (fig. 6*A*). Many of the horizontal beds are slightly undulating. Ripple marks are absent. One sequence of beds may be disconformable on the adjacent sequence (fig. 6B). In the borrow pit, in the lower part

[2] The borrow pit and drill holes are located in figure 4 by quadrangle name and number.

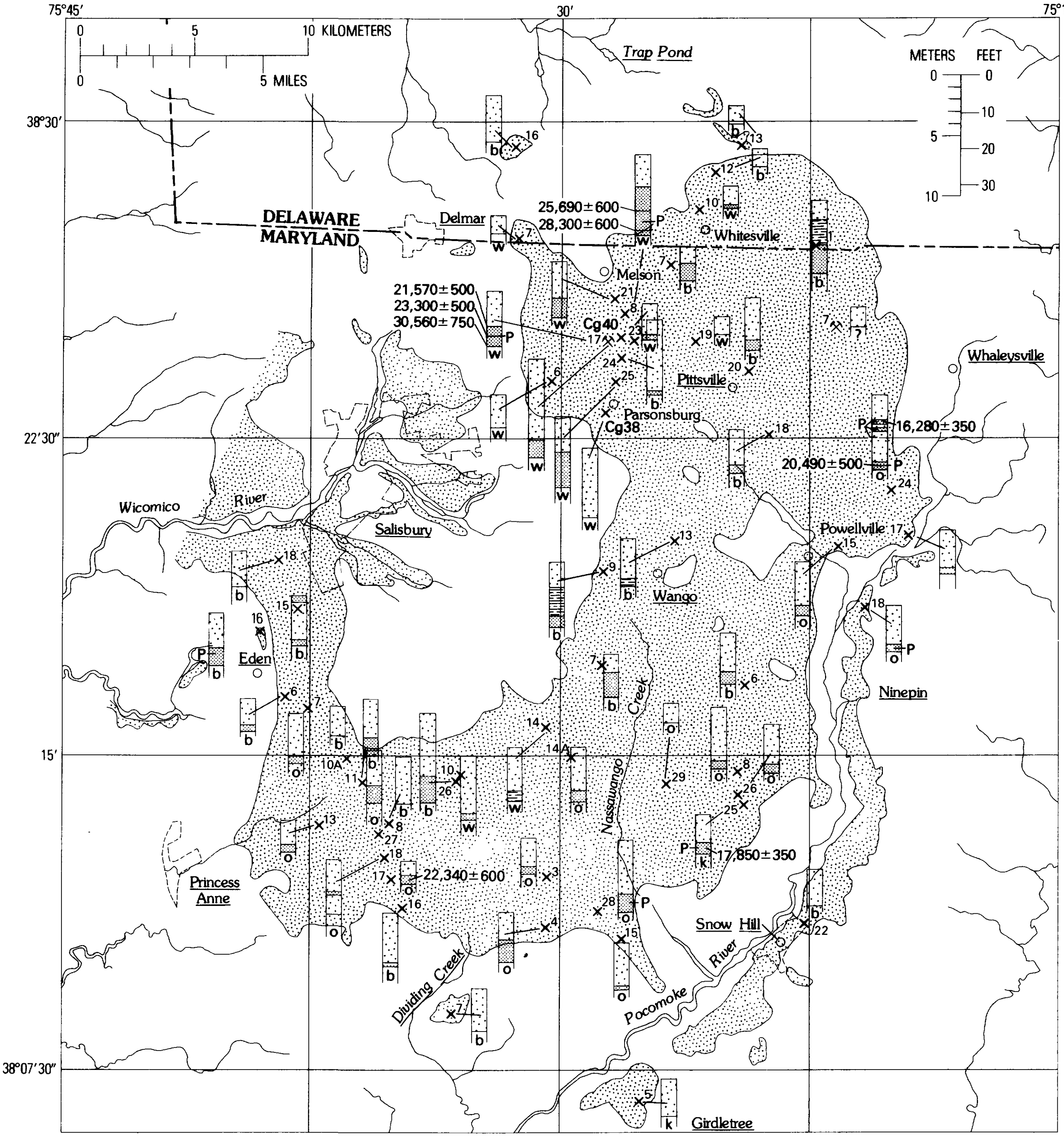

FIGURE 4.—Map of Parsonsburg Sand in area east and south of Salisbury, Md. Columnar sections show materials found in drill holes.

of unit 2 (fig. 5), small-scale crossbedding (fig. 7*A*) includes lenses containing abundant dark-mineral grains.

On the north wall of the borrow pit (Pittsville 17) the sand directly overlying the basal peaty sediment is deformed (fig. 7B). Beds of fine sand containing thin clay laminae near the base overlie peaty fine sand and clay-silt. The beds are symmetrically folded, the axes being more or less vertical. Some of the clay laminae are broken. The deformed beds are cut off above by an essentially horizontal surface on which rests medium sand a

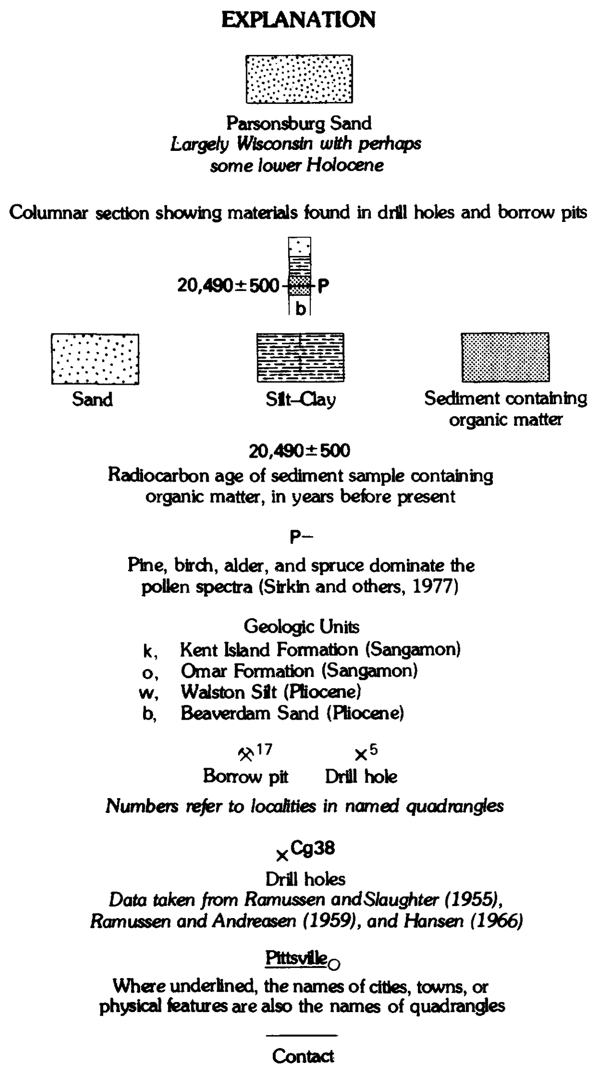

FIGURE 4.—Continued.

few inches thick overlain conformably by sand containing thin wavy laminae of organic matter. Horizontally bedded sand overlies the peaty sand layer. The section suggests deformation, erosion, and deposition, perhaps related to changes in the level of the surface of the pond in which the sediments were deposited.

MICROFLORA

The microflora in layers of peaty sediment, at or near the base of the formation (fig. 4) has been described by Sirkin and others (1977) on the basis of examination of samples from auger holes and from the large borrow pit north of Parsonsburg (Pittsville 17). Pine, spruce, birch, alder, grass, sedge, and the composites are present in at least 20 of the 24 samples of the Parsonsburg Sand that have been analyzed; heaths (Ericaceae) are present in 14 of the samples, and willow, oak, and Rosaceae, in 11 of

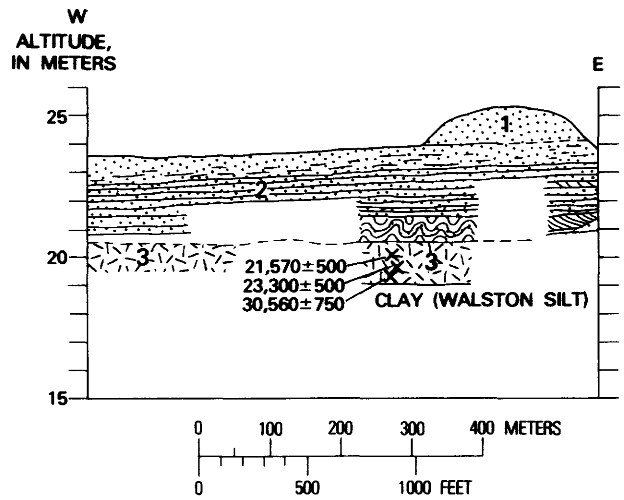

FIGURE 5.—The Parsonsburg Sand on divide north of Parsonsburg, Md. Generalized cross section of the material exposed in borrow pit about 2.8 km (1.7 mi) north of Parsonsburg (Pittsville 17, fig. 4). Units 1, 2, and 3 are described in table 1. Ages of samples dated by radiocarbon are given in years B.P. Vertical exaggeration × 40.

the samples (table 2). For a detailed account of the microflora, the reader should consult Sirkin and others (1977). The microfloral assemblages dated by radiocarbon suggest that from about 30,000 years B.P. to about 13,000 years B.P., the climate of the central Delmarva Peninsula was cooler and drier that it is at present. The area may have been a pine-birch barrens similar in part to the New Jersey pine barrens or to the Pocono Plateau in northeastern Pennsylvania. Shrubs were abundant, and there were small ponds and bogs containing spruce.

THICKNESS AND STRATIGRAPHIC RELATIONS

The Parsonsburg Sand on the uplands east and south of Salisbury, Md., ranges in thickness from about 1.25 to 6.00 m (4–20 ft); the mean value is about 4 m (13 ft). The formation is thicker in the type area north of Parsonsburg and in a belt running northeast through Pittsville than it is in much of the remainder of the uplands (fig. 8*A*). The base of the formation is at about 18 m (60 ft) above sea level in the type area north of Parsonsburg (fig. 8*B*) and slopes southeastward to about 9 m (30 ft) near the eastern and southern limits of the formation on the uplands.

The Parsonsburg Sand overlies the Pensauken Formation, the Beaverdam Sand, the Walston Silt, the Omar Formation, and the Kent Island Formation (fig. 1).

East of Salisbury, the northeast-trending belt of thick Parsonsburg Sand that passes through Pittsville (fig.

TABLE 1.—*Section of the Parsonsburg Sand exposed in borrow pit on divide north of Parsonsburg, Md. (Pittsville 17, fig. 4)*

[Altitude of ground surface about 25 m (83 ft)]

Unit		Range in thickness in meters (feet)	Average depth in meters (feet)
1	Sand, pale-yellowish-brown, medium-grained, loose, apparently structureless, forms a low ridge (dune). Where present, the underlying sand of unit 2 is reddish brown and slightly cemented	0.0-2.5 (0-8)	0.0-1.2 (0-4)
2	Sand, yellowish-brown above to pale-gray below, medium-grained; some coarse-grained and fine-grained sand and granules; thin lenses of small pebbles; beds 1.3-15 cm (0.5-6 in.) thick, bedding essentially horizontal to gently inclined; abundant "finger" burrows in upper part; locally small-scale undulations and possible load casts; small-scale crossbedding and channeling and heavy-mineral laminae, especially in lower part. Thin beds of fine sand, silt, and clay near base of unit. Near center of north wall, bedded sand contains thin layer of peaty sediment, depth about 1.5 m (5 ft), underlain by about 1.25 m (4 ft) of fine sand containing thin clay lenses. The fine sand and clay are symmetrically folded; folds are about 0.6 m (2 ft) high, and axial planes are essentially vertical. In places, the clay beds are broken. The folds die out abruptly above and below	3.0-3.7 (10-12)	1.2-4.6 (4-15)
3	Peaty fine sand and silt, dark-gray to black (moist); contains abundant organic matter, fragments of wood; becomes brown and more clayey near base	1.5 (5)	4.6-6.1 (15-20)

8*A*) is close to the position of the 12-m contour on the base of the formation (fig. 8*B*). South of Salisbury, the 12-m restored contour is close to the northern limit of the formation. We suspect that the 12-m contour is close to the position of the highest stand of the Sangamon Sea or the northwest limit of the Omar Formation. Perhaps the belt where the sand is thick is related to sandy deposits near the shore of the Sangamon Sea. We will discuss the source of the Parsonsburg Sand in more detail later.

On the upland north of Parsonsburg, at altitudes of about 18–25 m (60–80 ft), the Parsonsburg Sand was exposed in the borrow pit at Pittsville 17 and was penetrated in six adjacent drill holes (fig. 9). Here the formation includes about 5 to 8 m (17–26 ft) of sand and peaty sediment underlain by clay-silt beds of the Walston Silt.

The section is drawn on the assumption that the sediment rich in organic matter was deposited in several small ponds, which in the line of section were about 0.5–2.0 km (0.3–1.2 mi) in diameter. For example, the peaty sediment at the base of test hole Cg40 would, on this assumption, be older than that in adjacent holes. Other relationships are possible. Perhaps there was a larger pond with an uneven bottom; sand mixed with organic matter might have been deposited on part of the pond bottom, while only sand was being deposited elsewhere. On the other hand, if we are dealing here with several small ponds between sand dunes, the ponds might have been contemporaneous but not necessarily at the same elevation. If sand were being blown by the wind during the life of this pond or ponds, the relationship of the units shown in the cross section could be explained in part as the result of the advance of a sand dune into a pond. In holes P24 and P25, for example, organic matter mixed with sand was deposited in a pond. At a later time, a sand dune advanced into the pond from the north. As a result, only sand was deposited in the north half of the pond (P24), while sand mixed with organic matter continued to accumulate in the south half of the pond (P25).

Stratigraphic relations near the eastern side of the area of Parsonsburg Sand on the uplands east and south of Salisbury suggest that the sand moved eastward across the western limit of the clay-silt facies of the Omar Formation. As shown in figure 10*A*, about 3–6 m (10–20 ft) of Parsonsburg Sand overlies the Beaverdam Sand, Omar Formation, and Kent Island Formation. In auger hole SH25, the dated horizon of peaty sediment contains pine,

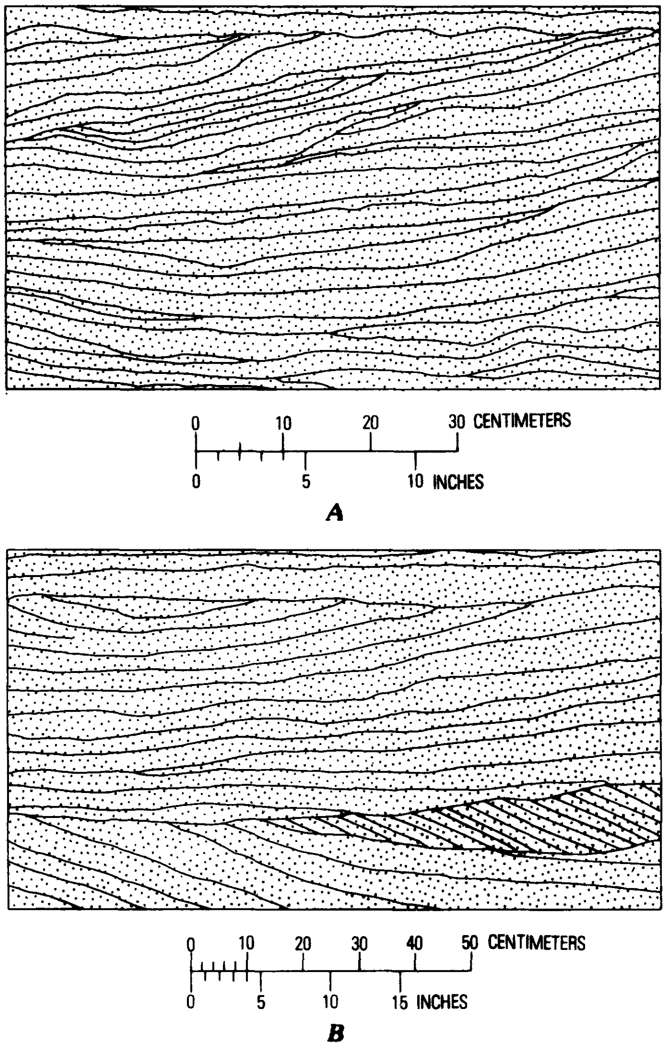

FIGURE 6.—Bedding in Parsonsburg Sand exposed in borrow pit north of Parsonsburg, Md. (Pittsville, 17, fig. 4), sketched from photographs. *A*, Bedding horizontal or gently inclined. Disconformity at top of section. *B*, Inclined bedding in lower part of unit 2, figure 5.

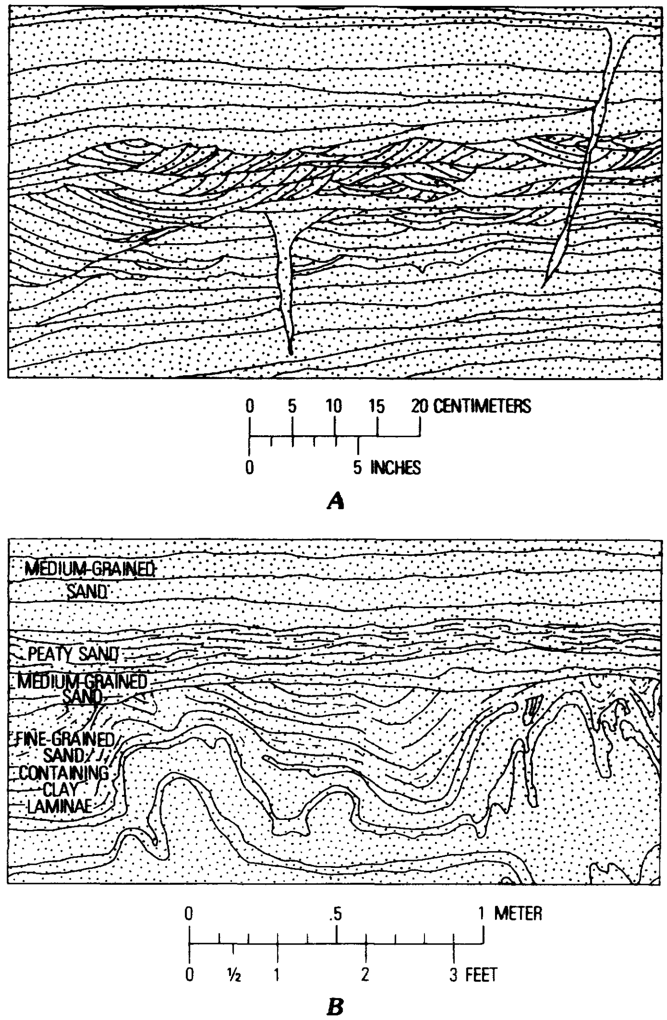

FIGURE 7.—Crossbedding and deformation in Parsonsburg Sand exposed in borrow pit north of Parsonsburg, Md. (Pittsville, 17, fig. 4), sketched from photographs. *A*, Small-scale crossbedding in horizontally bedded sand. Crossbeds contain considerable amounts of dark minerals. Origin of vertical structures is unknown. *B*, Deformed beds of fine sand containing clay laminae between beds rich in organic matter. The basal peaty sand and silt (unit 3, fig. 5) is beneath the section shown in the figure.

birch, and spruce pollen. The peaty sediment in the two other holes has not been analyzed. The data suggest that the sand spread southward across a pond or swamp.

On the east edge of the sand sheet northeast of Powellville, Md. (fig. 10*B*), the Parsonsburg Sand contains four horizons of peaty sediment and rests on the Omar Formation (Ninepin 24). The organic sediments contain cool-climate indicators (pine, spruce, birch, and alder) and range in radiocarbon age from 20,490 ± 500 years B.P. near the base to 16,280 ± 350 years B.P. in a layer about 2 m (7 ft) below the ground surface. Deposition of Parsonsburg Sand began here (Ninepin 24) nearly 10,000 years after the start of deposition on the upland north of Parsonsburg (Pittsville 17). Sand was transported eastward and deposited on the clay-silt of Sangamon age. Sand movement took place over a period of more than 4,000 years. Sand deposition alternated or was contemporaneous with the deposition of organic material in small ponds or swamps. The sand now forms a low bluff on the west side of the Pocomoke River (east of Ninepin 24). We postulate that sand of Omar age west of Powellville was picked up by the wind, carried eastward, and deposited as a blanket about 4 m (14 ft) thick. The surface of this blanket of sand was molded into parabolic dunes. The low bluff along the river is the stabilized front of the sand sheet.

The Pocomoke River came into being when sea level fell in late Omar (early Sangamon) time; it occupied its

TABLE 2.—*Presence or absence of arboreal and nonarboreal pollen in 24 samples of the Parsonsburg Sand*

	Number of samples in which present	Percent of total number of samples
Arboreal pollen		
Spruce	23	96
Pine	24	100
Hemlock	4	17
Cedar group[1]	11	46
Willow	11	46
Hickory	2	8
Birch	22	92
Alder	21	88
Oak	11	46
Black gum	4	17
Ericaceae	14	58
Rosaceae	11	46
Others	15	63
Nonarboreal pollen		
Pondweed	8	33
Cattail	7	29
Grass	23	96
Sedge	24	100
Polygonaceae	8	33
Compositae	20	83
Others	23	96

[1]Cypress present in one sample.

present channel during the deposition of the Parsonsburg Sand. The sand on the Omar Formation southeast of the river (fig. 4) may have come from the flood plain. Deposition may or may not have been contemporaneous with that of the Parsonsburg Sand northwest of the river; certainly the sand southeast of the river antedates the formation of the swamp that now borders the river's channel.

AGE

The Parsonsburg Sand in the area of this report is largely of late Wisconsin age; its upper part is perhaps early Holocene. The evidence is both stratigraphic and radiometric. In the eastern and southern part of the central Delmarva uplands, largely in Maryland (fig. 1), the Parsonsburg Sand overlies the Omar Formation of Sangamon age. Peaty sediments in the formation have been dated by the radiocarbon method and range in age from about 30,000 to about 13,000 years B.P. (table 3). An environment favorable for Parsonsburg deposition may have lasted several thousand years longer because the cool climate of the late Wisconsin may have persisted in the early Holocene. Spruce is present in the pollen record until about 9,000 years B.P. (Sirkin and others, 1977).

In areas where peaty sediment is absent, sand mapped as Parsonsburg may be sandy beds of the Omar Formation of Sangamon age or of the Walston Silt of Pliocene age. Such an area is the belt of Parsonsburg Sand northwest of Salisbury (fig. 1). The belt marks the approximate position of a shoreline of the ancestral Chesapeake Bay during Sangamon time. In the absence of radiocarbon ages or of pollen data, some of the sand in this belt may be nearshore deposits of Sangamon age perhaps overlain or mixed with eolian sand of Wisconsin age derived from the adjacent Sangamon deposits.

SURFACE EXPRESSION

The surface of the Parsonsburg Sand consists of long, narrow, sinuous ridges separating broad poorly drained swales. Many of the ridges are stabilized U-shaped dunes built by northwest winds. The sand ridges are low with gentle side slopes, and their spacing is irregular. The dunes probably formed in late Wisconsin time or in the early Holocene. They are best developed on the east side of the Nanticoke, Wicomico, and Pocomoke Rivers, but U-shaped dunes also are found in some areas on the uplands between the rivers. The dunes are described in more detail by Denny and Owens (1978).

ORIGIN

IN THE VALLEYS

The Parsonsburg Sand caps terraces along the east side of the Nanticoke, Wicomico, and Pocomoke Rivers. Here the sand forms parabolic dunes whose axes trend northwest, indicating that the sand came from riverbank or flood plain and was picked up, transported, and deposited by winds from the northwest. At present the rivers are bordered by tidal marsh or fresh-water swamp. Only one or two of the auger holes on the terraces along the three rivers found peaty sediment beneath sand. Along the Nanticoke River, about 19 km (12 mi) above its mouth (loc. 4, fig. 1), peaty sediment beneath 5.2 m (17 ft) of sand has a radiocarbon age of about 28,000 years B.P.; its pollen spectra is dominated by pine, spruce,

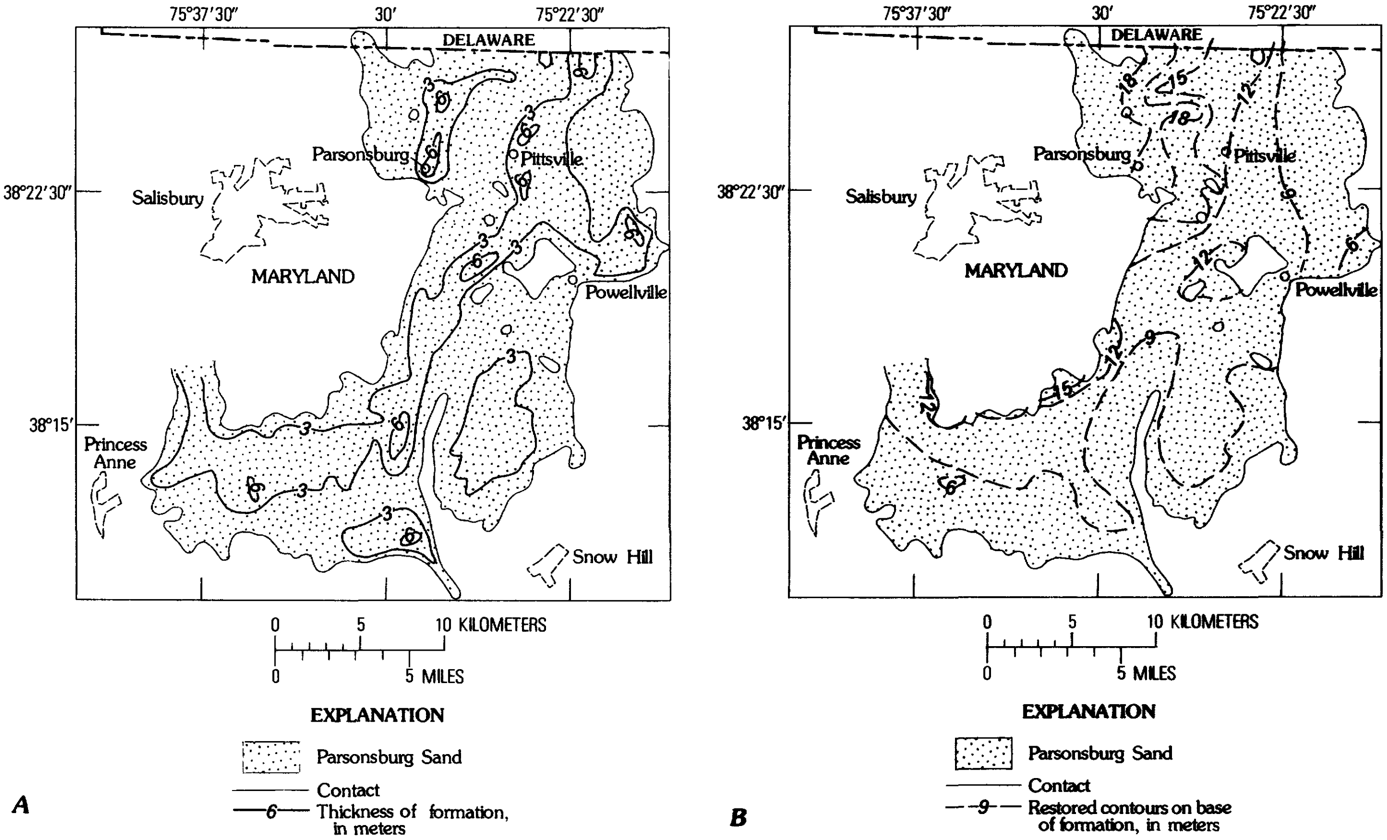

FIGURE 8.—Maps showing Parsonsburg Sand on uplands east and south of Salisbury, Md. *A*, Contour map showing thickness of formation. *B*, Map showing restored contours on base of formation.

birch, and alder. The data suggest that the Parsonsburg Sand in this vicinity was deposited at the same time as that on the uplands east and south of Salisbury, Md. (fig. 4). However, most of the Parsonsburg Sand in the Nanticoke and other valleys might be as young as early Holocene.

The Parsonsburg Sand has not been found in the valley of the Choptank River (fig. 1) nor in the upper reaches of the Pocomoke Valley. Laminated silt and micaceous sand of the Choptank and Calvert Formations (Owens and Denny, 1978) are exposed in the banks of the Choptank River, and the upper Pocomoke River is bordered by dark-colored clay-silt of the Omar Formation. Perhaps these beds were not an adequate sand source because they are too fine grained. Southeast of the Choptank Valley, the rivers are bordered either by sandy beds of the Beaverdam Sand or Pensauken Formation or by one or more terraces underlain by sandy fluviatile or estuarine deposits (Kent Island Formation, fig. 1).

Along the Pocomoke River, the body of Parsonsburg Sand on the east side of the river more or less coincides with the extent of the underlying Kent Island Formation (fig. 1). Neither formation is present upriver from the vicinity of Powellville (fig. 4).

ON THE UPLANDS

The Parsonsburg Sand mantles about a third of the upland areas east of the Nanticoke River (fig. 1) where the older rocks are the Beaverdam Sand, the Walston Silt, and the Omar Formation. These units contain abundant sand, yet none of them appear to have been the principal sand source for the Parsonsburg. The Parsonsburg generally contains less feldspathic material and a more stable heavy-mineral assemblage than do the adjacent formations (figs. 2 and 3). We postulate that the sands of the Parsonsburg came from sandy beds in the Omar Formation or Walston Silt. In order to explain the mineralogy of the Parsonsburg Sand, we further postulate that the Sangamon and upper Tertiary sands were reworked, probably on a beach or associated dune field, prior to deposition as Parsonsburg Sand. The reworking may have taken place during a Sangamon high stand of the sea about 12 m (40 ft) to perhaps as much as 17 m (55 ft) above present sea level.

Chlorite is abundant in the clay-silt fraction of the Parsonsburg Sand and the Omar Formation and in the Holocene fill of Chesapeake Bay (Owens and others, 1974), but it is absent in beds of late Tertiary age (Walston, Beaverdam, and Pensauken). The distribution of chlorite

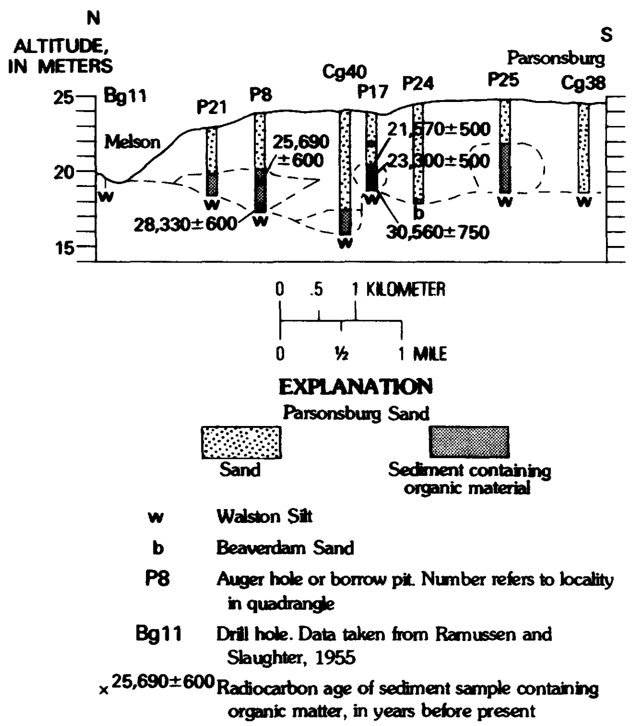

FIGURE 9.—Cross section of the Parsonsburg Sand overlying the Walston Silt on the upland north of Parsonsburg, Md. Section is on the Wicomico River-Pocomoke River divide from Melson south to Parsonsburg. Section includes the large borrow pit at Pittsville 17. For location of auger holes and borrow pit, see figure 4. Vertical exaggeration × 200.

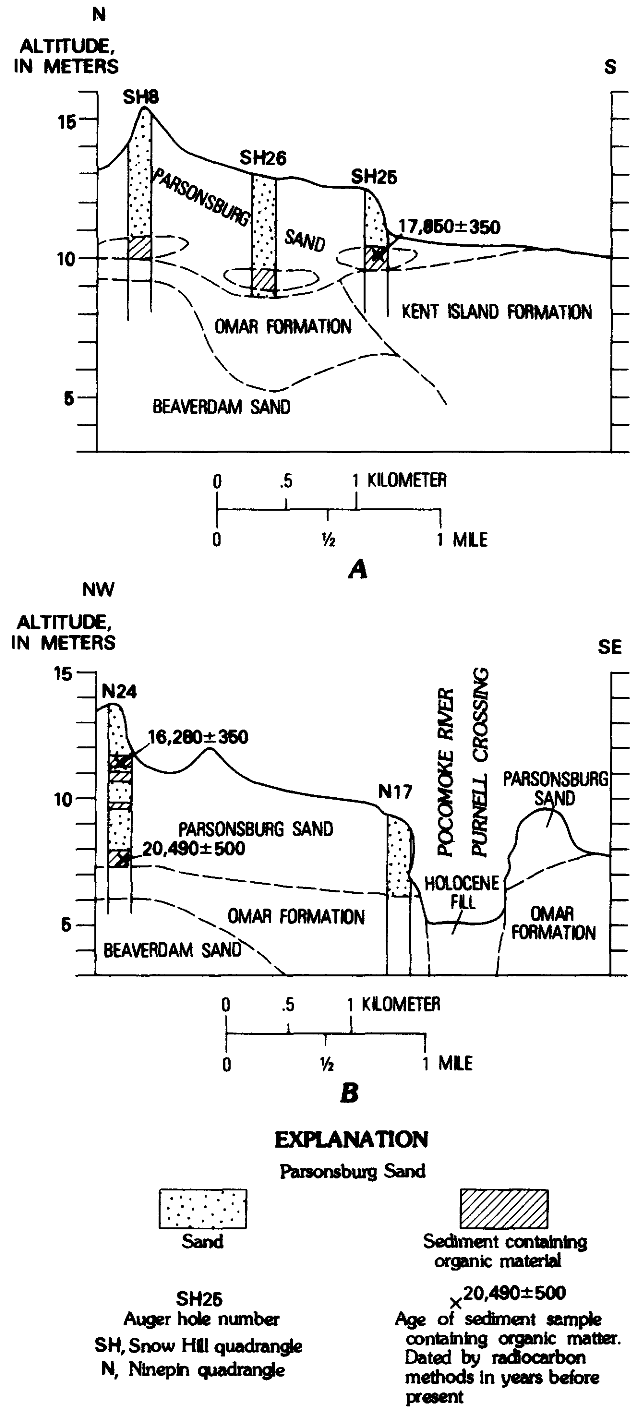

FIGURE 10.—Cross sections showing Parsonsburg Sand overlying Beaverdam Sand, Omar Formation, and Kent Island Formation. *A*, North-south section north of Snow Hill, Md. *B*, Northwest-southeast section northeast of Powellville, Md. For location of auger holes, see figure 4. Vertical exaggeration × 200.

in the rocks of the peninsula appears to support our belief that the Parsonsburg was derived from the Omar. However, the chlorite in the Parsonsburg could have come from bay fill of Wisconsin age. The soils over much of the area have loamy surface horizons (R. D. Hall, oral commun., 1975), suggesting a thin mantle of eolian silt. If we postulate strong northwest winds during late Wisconsin (Parsonsburg) time when the level of the bay was 50 m (165 ft) or more below present sea level, fine-grained chlorite-rich sediment may have been picked up by the wind from the exposed bay floor, blown across the Delmarva Peninsula, and deposited as a thin loess cover over the entire area.

The distribution of the Parsonsburg Sand on the central Delmarva uplands (fig. 1) does not conform with the distribution of any of the older sandy deposits that might be the source of the sand. As previously mentioned, the mineralogy of the Parsonsburg Sand suggests that the sand was not derived directly from an older formation. The explanation for the distribution of the Parsonsburg Sand on the uplands that seems reasonable ties the distribution of the sand to possible high stands of the Sangamon Sea.

On the uplands of the central Delmarva Peninsula (fig. 1), a belt of Parsonsburg Sand roughly 2–8 km (1.2–5 mi) wide extends from the Nanticoke Valley southeast through the southern part of Salisbury to a point about 12 km (8 mi) north of Pocomoke City. The southern half of the belt south of the Wicomico River is also shown in

TABLE 3.—*Radiocarbon age determinations on samples from the Parsonsburg Sand and adjacent formations*

[Locations in figs. 1 and 4]

Laboratory no.	Quadrangle and field no.	Sample site and location	Description of sample	Age (years B.P.)
W-2842	Snow Hill 25-----	Auger hole on low ridge, altitude about 12 m (40 ft), Forest Lane Road about 2 km (1.2-mi) north of State Route 354.	Peaty silt, 1 m (3.3 ft) thick, beneath 2 m (6.6 ft) of sand.	17,850±350
W-2843	Dividing Creek 17	Auger hole on plain, altitude about 9 m (30 ft), north-south road about 2 km (1.2 mi) south of West P.O.	Peaty sand and silt, 0.6 m (2 ft) thick, beneath 1.5 m (5 ft) of sand.	22,340±600
W-2995	Kingston 12------	Davis-type piston core in cypress swamp at sea level east of Pocomoke River, about 2.4 km (1.5 mi) east-southeast of Rehobeth and about 0.4 km (0.25 mi) east of Hickory Run Road.	Sandy, muddy peat 0.25 m (0.8 ft) thick beneath 9 m (30 ft) of peat.	8,940±250
W-3002	Ninepin 24-------	Auger hole on low ridge, altitude about 14 m (46 ft), at Mt. Pleasant, about 4.7 km (2.9 mi) northeast of Powellville.	Peat and silty sand, 0.3 m (1 ft) thick, beneath 2 m (6.6 ft) of sand.	16,280±350
W-3003	Pittsville 8-----	Auger hole on low ridge, altitude about 24 m (80 ft) on Parsonsburg divide about 2 km (1.2 mi) south of Melson.	Peat 2.8 m (9 ft) thick, beneath about 3.6 m (12 ft) of sand. Sample from depth of about 4.6 m (15 ft).	25,690±600
W-3016	Ninepin 24-------	Same as W-3002-------------	Peat and silty sand, 0.6 m (2 ft) thick, beneath about 5.9 m (19 ft) of interbedded sand, thin clay lenses, and peat beds 0.3-0.6 m (1-2 ft) thick.	20,490±500

TABLE 3.—*Radiocarbon age determinations on samples from the Parsonsburg Sand and adjacent formations*—Continued

[Locations in figs. 1 and 4]

Laboratory no.	Quadrangle and field no.	Sample site and location	Description of sample	Age (years B.P.)
W-3019	Pittsville 8-----	Same as W-3003-------------	Same as W-3003, Sample from depth of about 6.5 m (21 ft).	28,330±600
W-3096	Pittsville 17----	Borrow pit, altitude about 20 m (66 ft), on Parsonsburg divide about 2.8 km (1.7 mi) north of Parsonsburg.	Sandy peat about 1.5 m (5 ft) thick, beneath about 3.0-4.6 m (10-15 ft) of sand containing thin lenses of clay and peaty sand. Sample from depth of about 3.6 m (12 ft).	21,570±500
W-3097	-------do--------	-------------do------------	Same as W-3096. Sample from depth of about 4 m (13 ft).	23,300±500
W-3098	-------do--------	-------------do------------	Same as W-3096. Sample from depth of about 4.3 m (14 ft).	30,560±750
W-3105	Federalsburg 4---	Gully on west bank of Marshyhope Creek, about 1.5 km (0.9 mi) south of Federalsburg, altitude about 8 m (26 ft).	Wood from humus-stained sand, 1.5 m (5.0 ft) thick, beneath about 1.5 m (5.0 ft) of dune sand. Wood from depth of about 2.8 m (9 ft).	13,420±300
W-3106	Burrsville 2-----	West bank of Marshyhope Creek at Gut Bridge, altitude about 15.5 m (51 ft), about 8 km (5 mi) east-northeast of Burrsville.	Peat about 1.2 m (4 ft) thick overlies clay. Sample from depth of about 0.9 m (3 ft).	9,020±300
W-3271	Mardela Springs 13.	Auger hole on low ridge altitude about 7 m (23 ft), on plain east of Nanticoke River, about 1.1 km (0.7 mi) north-northwest of Camphels Wharf.	Peaty sand, 1 m (3.3 ft) thick, beneath 5.2 m (17 ft) of sand.	27,900±700

figure 4. Altitudes in this belt range commonly from about 10 to 14 m (35–45 ft). The belt appears to mark a shoreline of Omar (Sangamon) time. We believe that the sand in this belt consists largely of shore and nearshore deposits of Sangamon age that were partially reworked in Parsonsburg time. Scattered data on the microflora in a few auger samples from the belt south of the Wicomico River support our thesis that the belt is composed of materials of both Sangamon and Wisconsin age.

The distribution of the Parsonsburg Sand on the uplands east of Salisbury may also be related to a Sangamon high stand of the sea. East of Salisbury, the outcrop belt of the Parsonsburg Sand is wider than it is in the area to the west (10–15 km (6–10 mi)), but the range in altitude is about the same. The exception is the divide area near Parsonsburg (fig. 8), where the altitude is as much as 24 m (80 ft).

On the drainage divide north and south of Parsonsburg in an area roughly 8 by 10 km (5 by 6 mi), altitudes range from about 18 to 24 m (60–80 ft). The Parsonsburg Sand is heaped into parabolic dunes formed by northwest winds, suggesting an eolian origin for the formation. However, the internal structure of the unit as exposed in the large borrow pit on the divide (Pittsville 17, fig. 4) suggests that the dunes are underlain by water-laid sand deposited in small ponds between older dunes. The area on the divide is only about 80 sq km (30 sq mi). The base of the Parsonsburg Sand is at about 18–20 m (60–65 ft) above sea level in the subsurface beneath the divide (fig. 8B) that in Sangamon time was a low-lying island near the southern end of the ancestral Delmarva Peninsula. We postulate that in Sangamon (Omar) time, this island was capped by sand dunes 9–12 m (30–40 ft) high, their tops being about 30 m (100 ft) above present sea level. In Parsonsburg time, sand of Sangamon age was moved by the wind. Small ponds and swamps between dunes were filled first by peaty sediment and later by sand. We suggest that sand dunes of Sangamon age were reworked more or less in place by water and by wind to form the Parsonsburg Sand that now mantles the divide.

The structural and topographic relations of the Parsonsburg Sand on the divide support our belief that the formation was in part laid down in small interdune ponds. At Melson (figs. 4, 9), the upland stands about 20 m (65 ft) above sea level, and to the north and northwest, it ranges from about 15 to 18 m (50–60 ft). If the sand exposed in the borrow pit (Pittsville 17, figs. 4, 9) was laid down in a small pond, then there must have been a barrier of some sort between the pit and Melson. Perhaps the sand found in the auger hole at Pittsville 8 or 21 is part of a dune ridge that dammed the pond at Pittsville 17. Small ponds or bogs at Pittsville 8 and 17, perhaps separated by sand ridges, came into existence about 28,000–30,000 years B.P. The northern pond (Pittsville 8) was filled, at an average rate of about 0.072 cm/year, with sediment containing abundant organic matter, and about 25,000 years B.P., the sediment was buried by sand. The pond at the site of the borrow pit to the south (Pittsville 17) filled with sediment containing much organic matter at a slower rate (0.004–0.017 cm/year), and about 21,500 years B.P., sand containing only a little organic matter was laid down. Deposition continued until about 4.5 m of sand had accumulated. Perhaps the sand came from a dune that was advancing into the pond.

On the upland north of Whitesville (fig. 4) are a few isolated parabolic dunes whose sand probably is derived from the adjacent Beaverdam Sand. In the auger hole at Pittsville 13, for example, the dune sand rests directly on the Tertiary rocks without any intervening layer containing organic matter. The isolated dunes appear to have been formed by northwest winds, and their sand presumably came from sand reworked or weathered from the underlying Beaverdam Sand.

The age of the Parsonsburg Sand, on the basis of the available carbon-14 dates (table 3), ranges from about 30,000 years to about 16,000 years B.P., perhaps to as late as about 13,000 years B.P. The dated samples are largely from the base or the lower part of the formation, and most of them are more than 20,000 years old. The dated samples may indicate that most of the formation is older than about 20,000 years B.P. On the contrary, deposition of sediment containing abundant organic matter may have been widespread during early Parsonsburg time and may have been much more limited in late Parsonsburg time when sand was the principal material to be deposited. Perhaps deposition of the upper part of the Parsonsburg Sand is related to the cold climate of the last glacial maximum about 18,000 years B.P.

We picture the central Delmarva upland during Parsonsburg time as a pine-birch barrens where isolated sand dunes were separated by small ponds or bogs. The present landscape on the Parsonsburg Sand consists of low sandy ridges separated by broad poorly drained swales (Denny and Owens, 1978) and perhaps resembles the landscape as it was during Parsonsburg time. The dune sand came from bare sandy areas on the shores of the ponds or in small areas of parkland. Perhaps eolian activity was dominant when the water table was low, and lacustrine deposition was dominant when the ponds were full. Ponds were present between sand hills because evapotranspiration was low as a result of cool temperatures and sparse vegetation. Dunes advanced into ponds, where the sand was redistributed by circulating currents in the water. Runoff in the spring when the ground was still frozen may have promoted transport and deposition of sand in the interdune depressions.

The dunes are irregularly spaced and are commonly associated with poorly drained swales, as if the sand came from the swale—perhaps the shore of a small pond—and was heaped up on the edge of the swale. This association suggests that the dunes did not move any great distance across the uplands. Only on the east side of the uplands along the west side of the Pocomoke River where Parsonsburg Sand overlies clay-silt of the Omar Formation is there clear evidence that sand was carried southeast for several kilometers across the underlying clay-silt. In most of the central Delmarva Peninsula, the Parsonsburg Sand appears to be close to its source, regardless of whether it was transported by water or by wind.

Freezing or thawing of the ground does not appear to have been a factor during deposition of the Parsonsburg Sand. The deformed beds seen in the borrow pit near Parsonsburg (Pittsville 17) and elsewhere are best explained as the result of slumping caused by either loading of sand on saturated fine sand or clay-silt, or by changes in water level, or by both processes.

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