Atlantic Geology

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Volume 8, numéro 1, april 1972

URI : https://id.erudit.org/iderudit/ageo08_1rep05

Aller au sommaire du numéro

Éditeur(s)

Maritime Sediments Editorial Board

ISSN

0843-5561 (imprimé)
1718-7885 (numérique)

Découvrir la revue

Citer cet article

Schubel, J. R. & Zabawa, C. F. (1972). Report on Investigations to Delineate the Ancestral River Valley Systems of the Chesapeake Bay. *Atlantic Geology*, *8*(1), 32–35.

Maritime Sediments, Vol. 8, No. 1, April 1972, pp. 32-35.

Report on Investigations to Delineate the Ancestral River Valley Systems of the Chesapeake Bay*

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Introduction

The Chesapeake Bay estuary was formed during the most recent rise in sea level when the rising sea penetrated into the Bay basin. The general features of the origin and development of the present Chesapeake Bay estuary during the Holocene are intuitively obvious, but the origin and development of the Chesapeake Bay basin throughout the Pleistocene are obscure. The basin now filled by the Chesapeake Bay is an ancestral Susquehanna River valley system, probably cut during the most recent lowstand, the Wisconsin (Hack, 1957; Harrison et al., 1965). But, there is some evidence that during the Wisconsin the Susquehanna may either have followed a course different from the valley of the modern estuary in the vicinity of the Bay mouth, or that the entire region of the Bay mouth was uplifted by approximately 52 m (Harrison, et al., 1965). Any of the routes taken by the Susquehanna and the other major rivers prior to the Wisconsin were undiscovered until recently. The positions and configurations of the estuaries of these rivers prior to the Holocene are unknown, and the development of the Delmarva Peninsula (the Eastern Shore) during the Pleistocene is obscure.

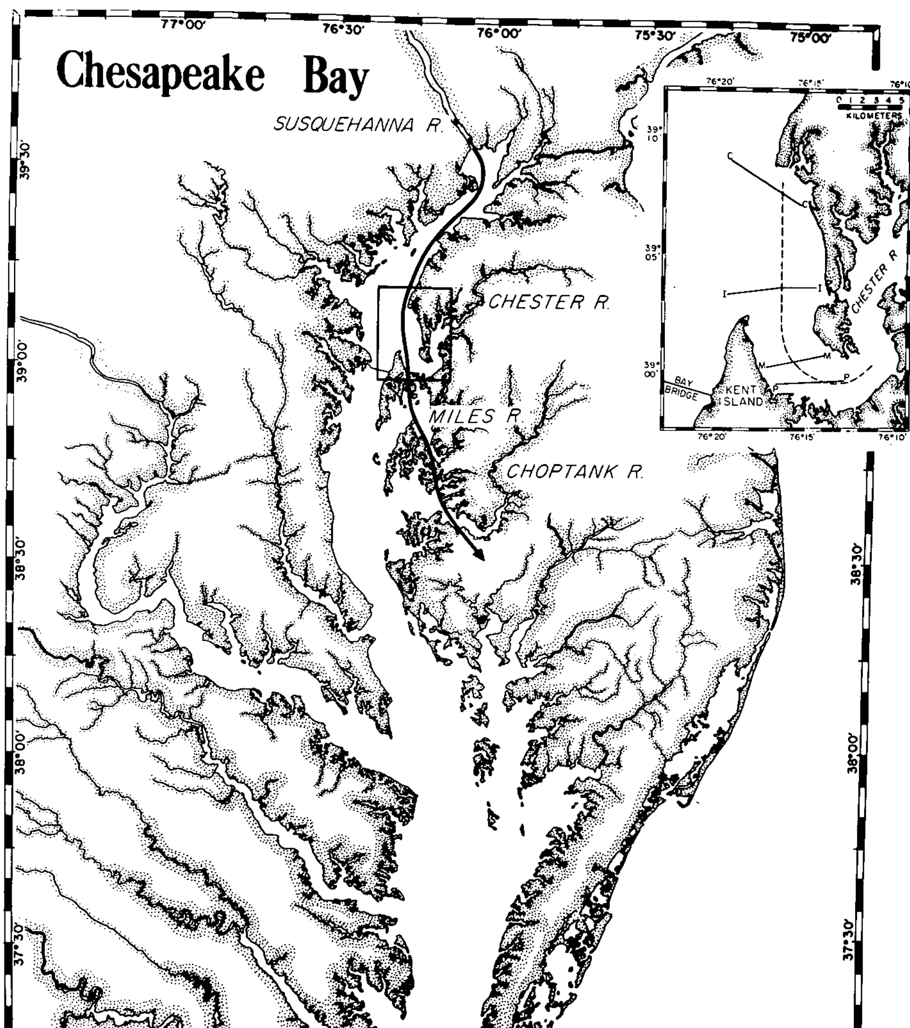

Figure 1 – Map of the Chesapeake Bay with an enlarged view of the Lower Chester River estuary showing the locations of the cross-sections depicted in Fig. 2. The geometric axis of the lower Chester estuary is indicated by a dashed line. The course of the Susquehanna paleochannel is snown as a heavy arrow.

* Manuscript received September 22, 1972.

Hansen (1968) and Schubel (1971) suggested that during the Illinoian glaciation the Susquehanna River may have cut southeasterly through the present Delmarva Peninsula, and Schubel suggested that it may have debouched into the sea through the Washington Canyon. Hansen's suggestion was apparently prompted by the discovery of a buried paleochannel filled with sand and gravel near Salisbury, Maryland, on the Delmarva Peninsula (Weaver, et al., 1966). Schubel's hypothesis was based on a preliminary examination of sub-bottom profiling records from the Chesapeake Bay and its tributaries. Schubel (1971) also suggested that the Potomac probably cut directly through the Delmarva Peninsula during the Illinoian. Both Hansen's (1968) and Schubel's (1971) suggestions were based on very scant data. There are now many more subsurface data available and it is worthwhile to examine those data that have been analyzed.

In 1971 the Chesapeake Bay Institute initiated a continuous-seismic-reflection-profiling study of the Chesapeake Bay estuarine system. One of the objectives of this study was to determine the courses and depths of the ancestral river valley systems. Profiles were run over the length of the Bay, and some profiling was done in selected Eastern Shore tributaries.

This paper is a description and interpretation of some of the sub-bottom records obtained from the Chester River estuary, from Eastern Bay, and from the segment of the Bay adjacent to these two tributaries (Fig. 1).

In their upper and middle reaches the Chester, Choptank and Miles Rivers flow roughly southwest, approximately paralleling the regional strike, and apparently following subsequent stream valleys. Each of the tributaries makes a peculiar sharp bend to the northwest in its lower reaches and opens into a broad estuary. The peculiar and similar character of the drainage patterns of these tributaries suggest that a valley may at one time have connected their lower reaches, and prompted us to hypothesize that the lower reaches of the Chester, Miles, and Choptank estuaries were cut by the Susquehanna River during a period of lowered sea level. To test this hypothesis, extensive continuous seismic reflection profiles were run in these tributaries.

Methods

The sound source used was a modified E.G.&G. boomer--a displacement type sound source. The sound source utilizes stored electrical energy to displace a submerged plate and the surrounding water, thus generating a pressure pulse. The unit was towed on a specially designed catamaran (Schiemer and Schubel, 1971). The peak energy of the system, approximately 250 joules, is concentrated at a frequency of about 5000 Hz. The reflected signals were received with a ten-element hydrophone array, filtered through a band-pass filter, and recorded with a Gifft model 4000 precision depth recorder--a 19" wet paper recorder. A pulse rate of 0.5 seconds, and a sweep time of either 0.250 or 0.125 seconds were used. The system is capable of resolving layers less than 0.5 m in thickness. Positioning was done with sextant angles from shore objects.

Results

The results of selected runs from the Chester River estuary are presented as line drawings of the original records. The vertical exaggeration of the drawings is 20X. Both one-way travel times and depths are given. The conversion from travel time to depth in metres is based on a sound speed of 1500 m sec^{-1}, approximately the average speed of sound in sea water. No sound speed data are available for the sediments.

Line drawings of the records from the transects shown in Figure 1 are presented in Figure 2. The records clearly reveal an ancient river channel buried 40 to 50 metres beneath the modern estuary floor. The paleochannel, oriented in a north northwest-south southeast direction has been traced over a distance of more than 75 km. The northern sections made in the Bay proper show that the paleochannel hugs the eastern shore; farther south it continues into the lower Chester. Although the paleochannel follows the general trend of the modern Chester River estuary nearly to the place where the estuary makes a sharp bend, the thalweg of the paleochannel is located west of the modern thalweg. At the bend in the estuary the course of the paleochannel departs markedly from that of the modern estuary. Sections M and P (Figs. 1 and 2) show clearly that the paleochannel does not follow the bend of the modern estuary, but continues along its same approximately southwest course. Sections M and P contain only the eastern bank of the paleochannel and a portion of its bottom indicating that the ancient river continued south and flowed under what is now a part of Kent Island. Sub-bottom profiles made south of Kent Island in Eastern Bay have demonstrated the continuity of the buried river valley, and profiles run in the lower reaches of the Choptank estuary show that the valley is present as far south as about 38°39'N. The course of the paleochannel farther south is uncertain. It may cut through the Delmarva Peninsula or it may continue into Tangier Sound. The evidence does not permit an unequivocal determination.

The paleochannel ranges in width from about 2.5 to 4 km, and its maximum depth varies from 40 to 60 m below present sea level, and increases to the south. The cross-sectional shape of the

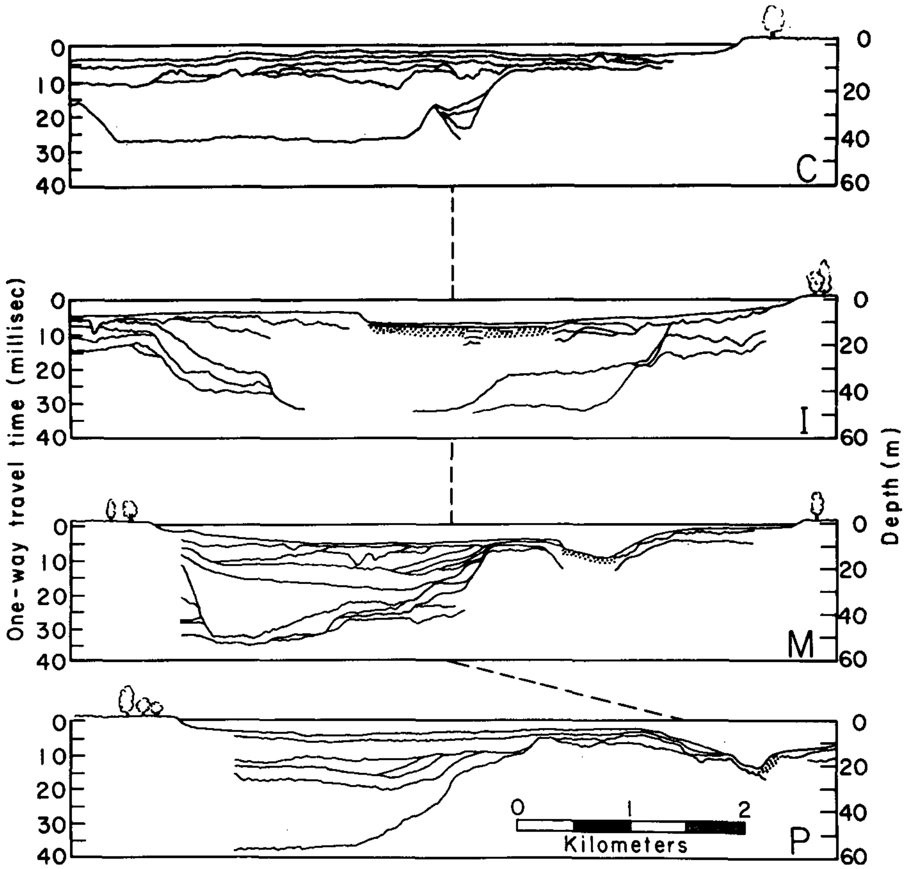

Figure 2 – Line drawings of the continuous-reflection profiles from the lower Chester River estuary, Fig. 1. Vertical exaggeration 20:1. The dashed line indicated the position of the geometric axis of the lower Chester estuary.

paleochannel varies quite markedly. In the Bay proper, Section C, and in the mouth of the Chester, Section I, the channel is relatively symmetrical. Farther south, near the bend of the estuary, the cross-section of the paleochannel becomes much more asymmetrical. The slope of the west bank steepens appreciably, suggesting that the west bank is the outer bank of a meander in the paleochannel, Section M. The sub-bottom profiles made in Eastern Bay confirm this, showing the channel to the east of its position on Section P. In Eastern Bay the channel widens and becomes more symmetrical.

Cores were taken in the Chester River, but the limited lengths of the cores, less than 6 m, do not permit identification of the important reflecting horizons. The sequence of valley fill however, would be similar to that observed at the Bay Bridge crossing a few miles away and described by Ryan (1953) and Hack (1957). That valley, cut into Cretaceous sediment, is lined with a thin bed of sand and gravel which was interpreted as river-bed deposits laid down in the river channel during a period of lowered sea level (Hack, 1957). These coarse sediments are overlain by silt, clayey silt, and sandy silt, that in places contain shells, plant material, and a few scattered lenses of gravel. Hack (1957) suggested that this material was deposited during a period of rising sea level and represents "a stage intermediate between a fluviatile stage and an estuarine stage". It represents the transition from riverine to estuarine conditions. These deposits are overlain by soft clay and clayey silt except in the littoral zone where wave action winnows out the fine sediment. This soft mud is the material that has been accumulating since the change from riverine to estuarine conditions. Borings should be made to identify the reflectors, to establish the sequence of deposition, and, if possible, to date the events.

The shapes of the reflecting surfaces in many of the profiles, for example M and P, appear to conform to the idealized textbook sequence of alluvial fill: a flat lying basal gravel, overlain by cross-bedded channel deposits, which are in turn overlain by flat-lying flood-plain deposits.

The Chester paleochannel is Pleistocene in age, and it is obviously older than the paleochannel discovered beneath the floor of the main body of Chesapeake Bay near Annapolis, Maryland, (Ryan, 1953; Hack, 1957) since the latter valley cuts through the Chester paleochannel farther north in the upper Chesapeake Bay. The available data however, do not allow dates to be assigned to the various sub-bottom reflectors. The paleochannel that connects the valleys of the lower reaches of the Chester, Miles and Choptank Rivers must have been cut by the Susquehanna, and it was probably cut during the Illinoian glacial period. The paleochannel discovered at the bridge-crossing in the Bay near Annapolis has been interpreted as the Wisconsin channel of the Susquehanna since gravel was found at the bottom and along the walls of the valley, but was absent in the overlying fill (Hack, 1957). Hack (1957) assumed that this channel continued beneath the thalweg of the modern Chesapeake Bay and he estimated, from its gradient in the upper Bay, that it would have a maximum depth in the mouth of the Bay of about 110 m below present sea level. When later studies around the mouth of the Bay showed that the deepest valley, "almost certainly the valley of the Pleistocene Susquehanna" (Harrison, et al., 1965), had a maximum depth of only about 50 m below present sea level, Harrison, et al., (1965) suggested that the entire region of the Bay mouth had been uplifted by more than 50 m during the past 18,000 years. Harrison, et al., (1965) cited some additional evidence from radiocarbon dates in support of their argument for uplift, but the suggestion was based largely on the shallow depth of the paleochannel. They gave some consideration to the possibility that the Susquehanna could have flowed through what is now the Delmarva Peninsula, but dismissed the idea on the basis of the examination of only 9 drilling logs made in the vicinity of Cape Charles City.

Our study shows that references to "the" Pleistocene Susquehanna valley and perhaps even to "the" Wisconsin channel or "the" Illinoian Susquehanna channel are naive. The new data clearly show that there were a number of Pleistocene Susquehanna valleys some of which followed courses very different from the buried valley underlying the thalweg of the modern Chesapeake Bay.

The data described in this report show that the Susquehanna River followed a course to the east of the present Bay along a path connecting the lower reaches of the Chester, Miles, and Choptank Rivers. The course of this paleochannel farther south is obscure. It may cut through the Delmarva Peninsula or it may continue into Tangier Sound. Preliminary seismic profiles run in both of these areas have revealed several deep buried valleys (Schubel and Zabawa, in preparation).

Acknowledgements

This work was supported in part by the Oceanography Section, National Science Foundation, NSF Grant GA-24786; in part through a project jointly-funded by the Fish and Wildlife Administration, State of Maryland, and the National Marine Fisheries Service, Department of Commerce through 89-304 funds, Project AFC 5-1; and in part through a second project jointly-funded by The Fish and Wildlife Administration, State of Maryland, and by the Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Department of the Interior through Dingell-Johnson Funds, Project F-21-1. We thank Captain W.J. Gilbert, E.W. Schiemer, W.B. Cronin, R. Snyder, G.M. Schmidt, T.W. Kana, Captain C.V. Wessels, and E. Evans for their assistance in the field.

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