JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE

VOLUME 53, NUMBER 3, JULY, 1978

SUBSURFACE BACK-BARRIER DEPOSITS IN THE WHITWELL SHALE, NORTHWESTERN HERBERT DOMAIN QUADRANGLE, CUMBERLAND COUNTY, TENNESSEE

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ABSTRACT

Core samples of Pennsylvanian Whitwell shale located in northwestern Cumberland County, Tennessee, enabled recognition and interpretation of five facies:

Facies	Interpretation
1. Dark-gray shale with coal beds	Upper tidal flat
2. Flaser-bedded, medium-gray shale	Mid-tidal flat
3. Standstone-siltstone-shale complex	Lower tidal flat
4. Sandstone-siltstone burrowed complex	
5. Dark-gray shale with siderite	Pools and lagoons of stagnant water

INTRODUCTION

A number of coreholes located on the Herbert Domain quadrangle in northwestern Cumbreland County, Tennessee (Fig. 1) penetrated the Pennsylvanian Whitwell Shale. These cores were examined for bedforms which would enable interpretation as to likely environments of accumulation.

John C. Ferm, of the University of South Carolina, is one of the pioneers who studied bedforms in Pennsylvanian sediments with the view of determining sediment environmental origin.

Ferm and Ehrlich (1967) discussed the sedimentary rocks and stratigraphy of Alabama coal fields and proposed that Pennsylvanian rocks in Alabama were deposited as part of an huge, ancient deltaic complex separated from offshore quartz sand barriers, or spits, by back-barrier bays or lagoons (Fig. 2). Presumably, barriers and bays, or lagoons, were scoured by tidal channels; tidal deltas possibly were associated with tidal channels. Further, the Ferm and Ehrlich model

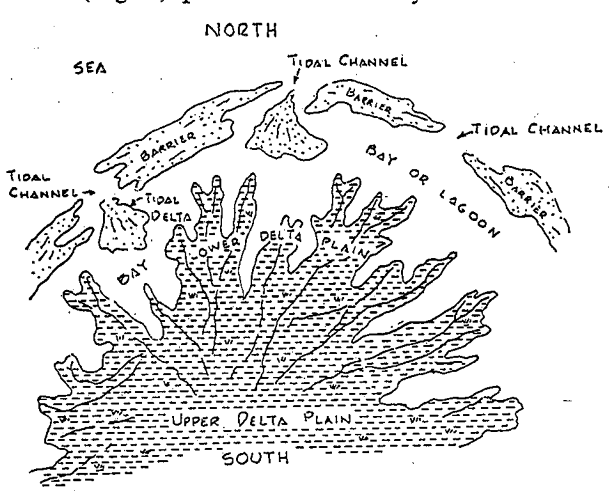

FIG. 1: *Model of Pennsylvanian Deposition in Alabama deltaic complex with offshore quartz sand barrier bars—modified after Ferm and Ehrlich (1967).*

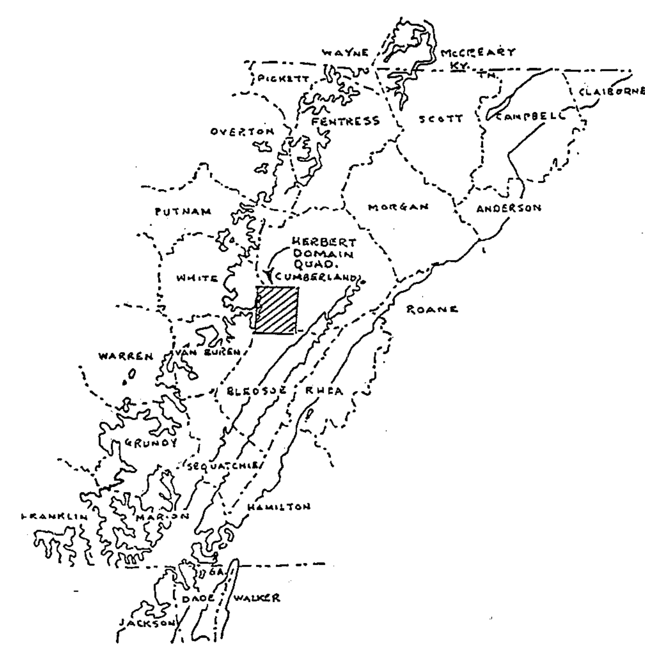

FIG. 2: *County names and boundaries over the Cumberland Plateau in Alabama, Georgia, Kentucky, and Tennessee.*

suggested that this deltaic complex deposit encroached northward during the Pennsylvanian in Alabama.

However, it appears that this deltaic complex in Alabama was dwarfed by a much larger deltaic mass that encompassed the modern geographic area of eastern United States, including a large part of Pennsylvania, West Virginia, eastern Kentucky and Tennessee, northeastern Alabama and northwestern Georgia (Hobday, 1969). It is suggested that this Pennsylvanian complex gradually build westward, northwestward and southwestward.

Presumably, westward progradation was not constant, because it is likely that there were countless large- and small-scale advances and retreats of the Pennsylvanian strand line.

It is important to note that the entire Pennsylvanian System in the Cumberland Plateau of Tennessee, northeast Alabama and northwest Georgia is considered to be situated in the southwestern portion of the gigantic eastern United States deltaic complex and that the general direction of sediment transport in this area is to the southwest (Ferm, Milici, Eason & others, 1972).

Thus, two masses of deltaic sediment existed at essentially the same time during the Pennsylvanian. One was building generally northward and the other generally westward. Therefore, they should overlap in a given area during a given time, and according to Ferm (personal communication) the area of overlap is in the vicinity of Cullman, Alabama.

PALEOENVIRONMENTS

Four major paleoenvironments are indicated in the Ferm model (Fig. 2):

1. *Sand barriers or spits* with distinctive bedforms that were locally transected by tidal channels and later filled with quartz sand.
2. *Shale deposits of back-barrier bays or lagoons,* locally scoured by tidal chanels, which may contain tidal delta deposits of quartz sand that display distinctive bedforms. In this back-barrier environment, coals formed in tidal marshes. Such coals are typically of limited areal extent, irregular thickness and a wide range in quality. Quality variation may be due to:
   a. A wide range of intrinsic sulfur content in plants from various communities.
   b. Localized differences in geochemical conditions (such as proximity to saline water) that allowed formation of inorganic sulfur (pyrite).
   c. Large differences in the amount of sediment (clay, silt and sand) deposited locally with the coal, which would result in a wide range in ash content.
3. *Lower delta plain,* marked by locally thick, laterally discontinuous quartz sand deposits with distinctive bedforms interpreted as river channel sediments.

Shales are thick and widespread and are considered to be interdistributary bay-fill deposits. Coals, formed largely in tidal marshes, are more through-going than those formed in tidal marshes associated with lagoonal environments, but may exhibit localized variations in sulfur and ash content.

4. *Upper delta plain* environments are generally marked by widespread swamp deposits (shales) and localized river channel deposits (quartz sands). Generally, coals are through-going with less variation in sulfur and ash.

STRATIGRAPHY, CUMBERLAND COUNTY

The general stratigraphic sequence on the Herbert Domain quadrangle in Cumberland County, Tennessee is indicated in Fig. 3.

The lowermost Pennsylvanian stratigraphic unit is the Gizzard Group, which ranges from 125-175 feet (37.5-52.5 meters) in thickness, and is composed of sandstone and shale units with thin Wilder and Bon Air coal zones.

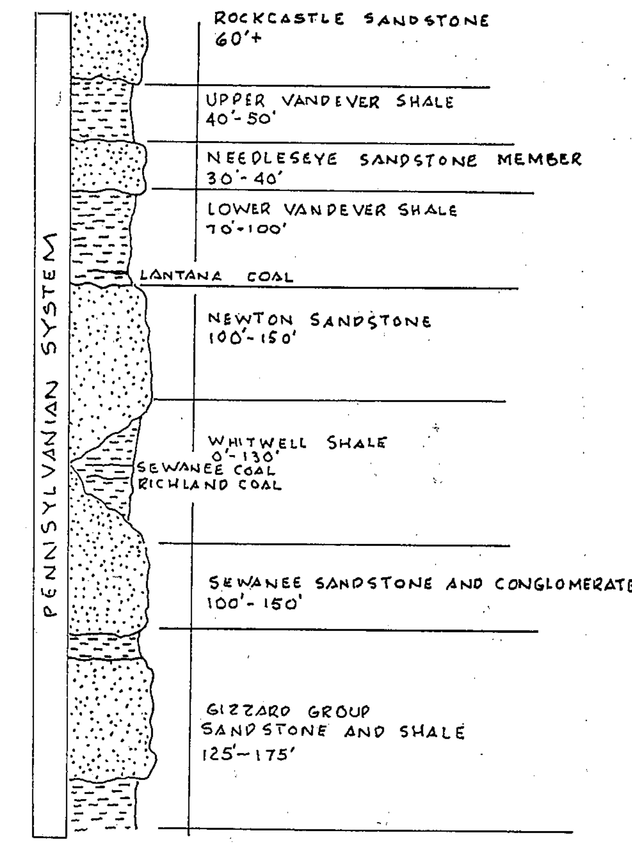

FIG. 3: *General stratigraphic sequence on Herbert Domain Quadrangle.*

Overlying the Gizzard Group is the Sewanee Sandstone and Conglomerate, which ranges from 100-150 feet (30.6-46.0 meters) in thickness. The Whitwell Shale ranges up to 130 feet (40 meters) thick and contains the Sewanee and Richland coals. Generally it separates the underlying Sewanee Conglomerate and the overlying Newton Sandstone, but it is locally absent. The Newton Sandstone ranges from 100-150 feet (30.6-46.0 meters) in thickness.

The Vandever Formation overlies the Newton Sandstone. The Lower Vandever Shale contains thin, discontinuous Lantana coal and ranges from 70-100 feet (21.4-30.6 meters) in thickness. The Needleseye Sandstone ranges from 30-40 feet (9.2-12.2 meters) in thickness and is overlain by the Upper Vandever Shale, which ranges from 40-50 feet (12.2-15.2 meters) in thickness.

The highest stratigraphic unit in this area is the Rockcastle Sandstone, which has an erosional upper surface.

CORE DATA

Cores in northwestern Cumberland County, Tennessee, show the Whitwell Shale to have the form of a lens in east-west cross-section. The overall geometry of the Whitwell Shale in this area is that of a sinuous, branching depression filling.

The stratigraphic distribution of bedforms in three cores of Whitwell Shale is shown in Fig. 4. Sandstone, siltstone, shale and coal are the major rock types observed.

In this area, coals are generally associated with seat earths, or underclays. Shales are medium-gray to dark-gray; some contain bands of siderite or flaser beds. Flaser beds formed where quartz sand accumulated in ripple troughs. If troughs were shallow, flaser beds appear as thin sand streaks. If troughs were relatively deep, sand may form small-scale crossbeds.

Sandstone forms sedimentary complexes with siltstone and shale. Many of these complexes show flaser bedding and vertical and horizontal burrows. Less commonly, burrowing has been so extensive as to obliterate bedding, and the deposit is described as churned.

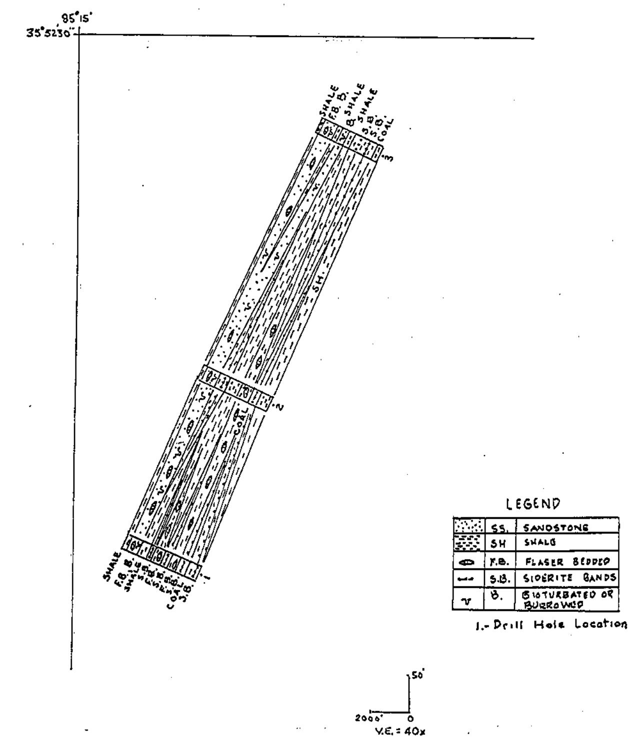

FIG. 4: *Generalized stratigraphic distribution of bedforms in selected cores of the Pennsylvanian Whitwell Shale, Cumberland County, Tennessee.*

BEDFORM DESCRIPTIONS

Cores of Whitwell Shale taken in the area of the Herbert Domain quadrangle have enabled discernment of five facies:

1. *Dark-gray shale with coal beds* (Fig. 5): Tidal marshes formed when shallow water areas within a lagoon were completely filled with sediment. This situation enabled vegetation to take root and ultimately led to the formation of a coal seam.

Groups of sedimentary layers may be bounded by coal seams. The thickness of these coal-bounded sedimentary sequences provides a clue to the depths of ancient lagoons during the time of sedimentation because the interval of underwater deposits between coals indicates the maximum possible depth of the original depression.

2. *Flaser-bedded, medium-gray shale* (Fig. 5): Tidally affected lagoon muds or tidal flats probably accumulated landward of quartz sand barriers.

In some situations, mud flats may have been ripple-marked by tidal currents. Subsequently, fine grains of sand may have accumulated in ripple troughs which were then covered by mud. This process likely resulted in the formation of small sand lenses or flaser beds.

3. Sandstone-siltsone-shale complex (Fig. 5): Thin-bedded, interlayered light-gray sandstone and medium-gray to dark-gray siltstone and shale show ripple-markings, flaser-bedding and are burrowed. Burrows in these rocks are largely horizontal or parallel to bedding.

These burrows generally have a cylindrical shape, range from 1/8" to 3/4" in diameter, and are filled with fine-grained, light-gray sandstone.

Walker and Laporte (1970) have pointed out that horizontal burrows may indicate that worms, or some other burrowing

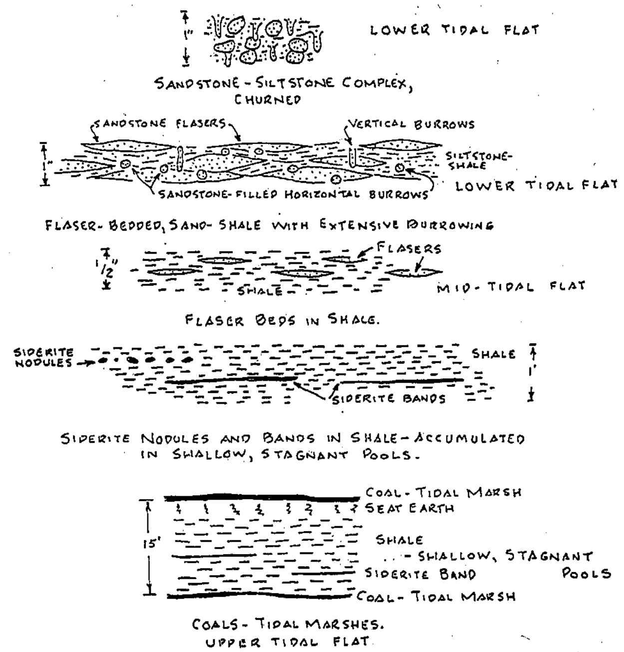

FIG.5: *Generalized vertical distribution of bedforms in Pennsylvanian Whitwell Shale, Cumberland County, Tennessee.*

organisms, lived entirely under water (i.e., in a subtidal environment). Vertical burrows likely indicate a habitat on an intertidal flat.

4. *Sandstone-siltstone burrowed complex* (Fig. 5): This is a medium-gray sandstone and siltstone complex that has been so extensively burrowed that it may be described as churned, with no trace of original bedding remaining.

Both horizontal and vertical burrows are present with horizontal burrows dominant, which suggests both intertidal and subtidal environments.

5. *Dark gray shale with siderite bands or nodules* (Fig. 5): Lagoonal muds may have accumulated in shallow, possibly stagnant bodies of water. Jelly-like masses of iron carbonate (siderite) likely were chemically precipitated in these stagnant water bodies. Upon hardening, siderite probably formed maroon-purple, or reddish-purple, lumps or nodules and flattened, pancake-like masses which—if viewed edge-on—would appear as a band.

BACK-BARRIER MODEL

Detailed study of bedforms in the Whitwell Shale in Cumberland County, Tennessee, suggests that they are largely tidal flat deposits with associated sideritic shales that may have formed in shallow, stagnant pools or lagoons.

Tidal flats are broad, low-lying areas of sedimentation that are alternately flooded by and drained of shallow sea water. Further, geologists have recognized three main tidal flat environments:

1. Lower tidal flat.
2. Mid-tidal flat.
3. Upper tidal flat.

Fig. 5 indicates the generalized vertical distribution of bedforms in cores of the Whitwell shale (Fig. 4).

Fig. 6 (based on Figs. 4 and 5) is a back-barrier model suggesting the paleogeographic distribution of tidal flat environments, and associated lagoons.

These ancient lower tidal flat environments were likely marked by a sandstone-siltstone complex in which all bedding had been destroyed by the churning action of burrowing organisms. Landward, in transitional relationship, was a sandstone-siltstone-shale complex that shows rippling, flaser-bedding and burrowing, or bioturbation, by organisms that generally formed horizontal burrows.

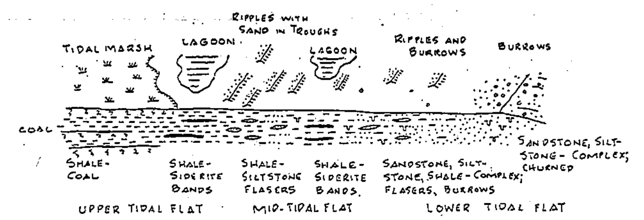

FIG. 6: *Model of back barrier tidal flat showing arrangement of ancient environments as indicated by bedforms in Pennsylvanian Whitewell Shale.*

Flaser-bedded and rippled dark shales probably mark a mid-tidal flat environment. These sediments may have graded laterally into lower tidal flat environments, as suggested by an increase in flaser-bedding, rippling, burrowing and sand content, or they may have graded into upper tidal flat environments which may be marked by a decrease in burrowing and flaser-bedding and an increase in dark shale and coal. Coal deposits probably formed from tidal marsh vegetation because there is no evidence of fossilized trees.

Dark shales with siderite nodules and bands may be associated with any of these tidal flat deposits, but in this area they seem to be found with mid- and upper-tidal-flat sediments. It is likely that siderite was chemically precipitated in stagnant bodies of water (pools or lagoons) adjacent to tidal flat areas.

Therefore, it is likely that early deposition in the depression containing the Whitwell Shale began with upper tidal flat deposits plus shallow, laterally restricted pools or lagoons and, with minor fluctuations, proceeded through mid-tidal flat to lower tidal flat deposits in the latter stages of channel filling.

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JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE

VOLUME 53, NUMBER 3, JULY, 1978

IDENTIFICATION OF SOME SYMPATHOMIMETIC AMINES BY THIN LAYER CHROMATOGRAPHY (TLC)

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ABSTRACT

The sympathomimetic amines were dissolved in water and ethanol, and treated with bromocresol green on a thin layer of alumina, silica gel and cellulose plates. Systems with two, three and four solvents were tested. The more polar spots were separated satisfactorily.

INTRODUCTION

Thin Layer Chromatography (TLC) is presently considered one of the most suitable techniques for drug analysis. It is fast, requires minimal equipment, and provides highly reliable results (Stahl, 1973). In addition, TLC is especially powerful because of its high sensitivity and resolution. Adequate separations of sub-microgram quantities of material may be accomplished in under half an hour (Clarke, 1969).

In a previous report from this laboratory (Shah & Shah, 1976), sympathomimetic amines were separated satisfactorily using a two-solvent system. Rasin et al. (1969) showed that N-2,4 dinitro-phenylsulfenyl derivatives of some sympathomimetic amines are useful in the separation of the amines. The techniques used were ascending and multiple thin layer chromatography techniques on silica gel G or Al_2O_3 G. The best separation is obtained by multiple chromatography in 1:1 benzene-petroleum ether on silica gel G thin layers. The choices of solvent systems for the development of sympathomimetic amines are rather limited. Only systems containing either n-butanol or phenol are in practical use. These solvent systems are acidified either by acetic acid or by hydrochloric acid (Fabini & Konig, 1958a; Wachsmuth & Van Koeckhonen, 1962; Perry & Schroeder, 1963; Weidner & Weiss, 1958). Those most frequently used for paper chromatography (PC) are n-butanol, water, and acetic acid.

In TLC, the most commonly used sorbents are silica gel and cellulose; solvent systems are analogous to those for PC (Choulis, 1967a; DePotter et al., 1965). Sandri-Cavichi et al. (1966) used these systems for the separation of epinephrine and levarternol and for the separation of other adrenergic drugs as well. Halmekoski (1963) in some cases adds molybdate, tungstate or borate ions to the silica gel layer, an action which results in the marked decrease of mobility of compounds with two hydroxyl groups in the ortho position.

The purpose of this study was to develop systems and specific techniques suited for the identification of