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SEDIMENTATION OF CROSSBEDDED MEGARIPPLE TROUGH-FILL NEAR SEWANEE AND SIGNAL MOUNTAIN, TENNESSEE

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ABSTRACT

Two unusual exposures showing lee slope megaripple trough-filling in Pennsylvania sandstones were discovered near the town of Sewanee and on Signal Mountain, Tennessee. These trough-fillings are presumed to have formed parallel to Pennsylvanian paleocurrent flow. Foreset, toeset and bottomset bedforms were recognized and taken as supportive field evidence for laboratory studies of lee slope sedimentation by Alan V. Jopling.

Information gleaned from these two unusual exposures should enable one to determine the direction of sediment transport regardless of the given view of Pennsylvanian trough-filling.

INTRODUCTION

Two roadcut exposures of Pennsylvanian sandstone, belonging to the Sewanee Conglomerate and Warren Point Sandstone and exhibiting foreset, toeset and bottomset trough deposits formed on the lee side of a megaripple, have been located at the entrance to the University of the South, Sewanee, Tennessee (Fig. 1) and near the juncture of Shoal Creek Road and Taft Highway, Signal Mountain, Tennessee (Fig. 2).

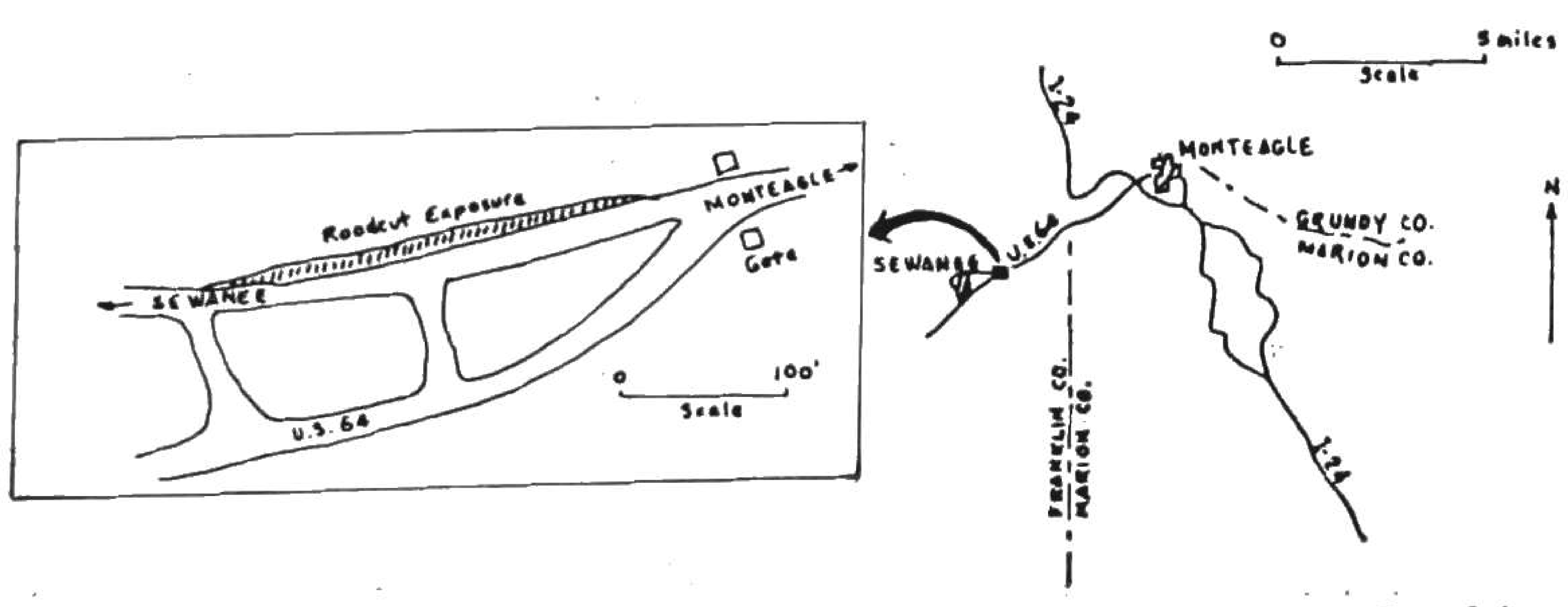


FIG. 1: *Location of roadcut exposure along U.S. 64, Sewanee, Tennessee.*

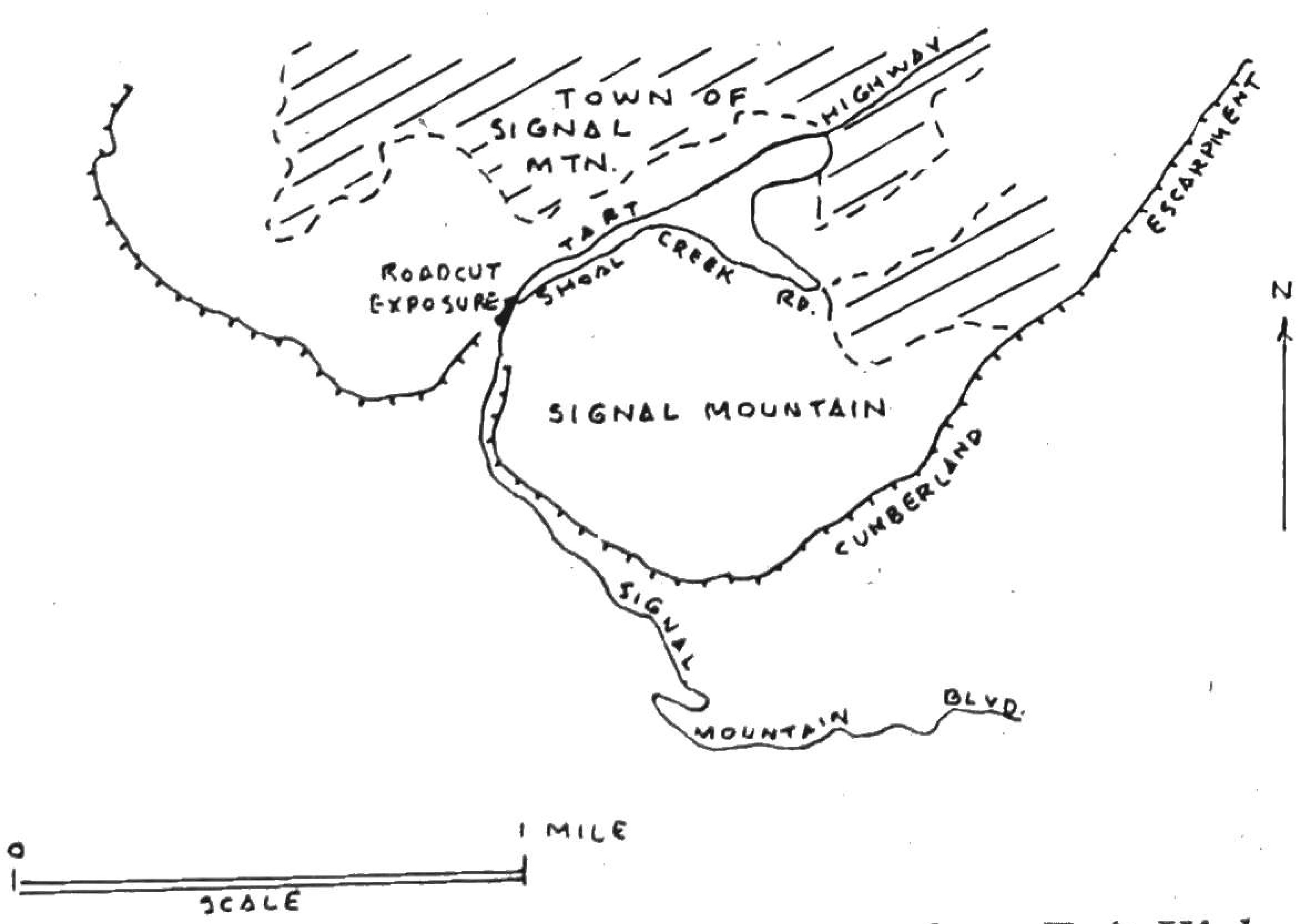


FIG. 2: *Location of roadcut exposure along Taft Highway, Signal Mtn., Tennessee.*

It is the purpose of this study to discuss the formation of these unusual examples of Pennsylvanian megaripple trough-filling in the light of a laboratory model of lee slope sedimentation developed by Alan V. Jopling.

Understanding at least part of the process of sedimentation in these unusual Pennsylvanian megaripples may lead to a better understanding of the sequence of most Pennsylvanian megaripple trough-filling.

STRATIGRAPHY

Figure 3 shows a generalized stratigraphic sequence for the Pennsylvanian System on the Cumberland Plateau in southeastern Tennessee.

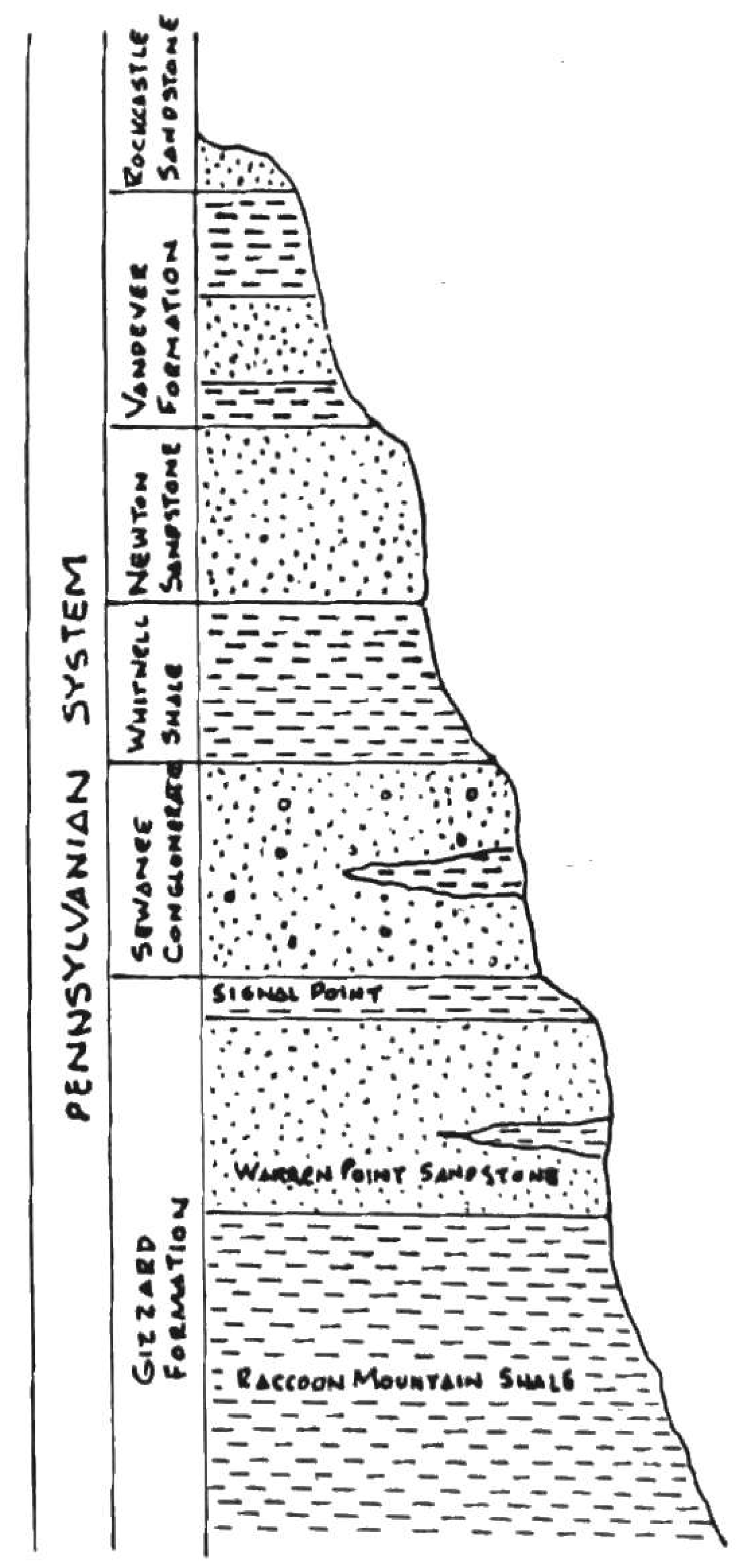


FIG. 3: *Generalized stratigraphic sequence in Southeastern Tennessee.*

DISCUSSION

Pennsylvanian Deltaic Complexes

John Ferm and Robert Ehrlich (1967) proposed that Pennsylvanian rocks in Alabama were deposited as part of a huge deltaic complex with offshore quartz sand barrier bars, or spits. This complex prograded generally northward during Pennsylvanian time.

Further, 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, which includes a large part of the states of Pennsylvania and West Virginia, plus part of eastern Ohio, western Virginia, eastern Kentucky and Tennessee, northeastern Alabama, and northwestern Georgia (Ferm, Milici, Eason, and others, 1972). Therefore, it is suggested that this eastern United States-Pennsylvanian deltaic complex gradually encroached to the northwest, west and southwest (Fig. 4).

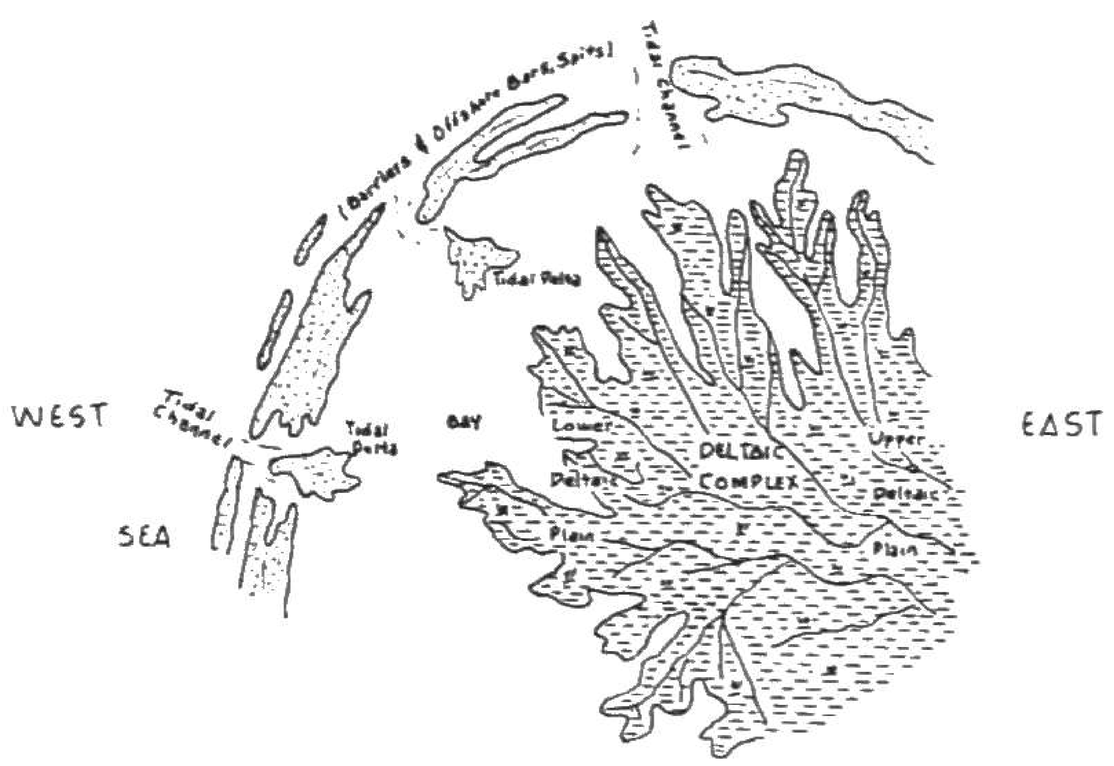


FIG. 4: *Generalized model of Marginal Marine-Deltaic system deposited in eastern United States during Pennsylvanian period.*

Thus, two masses of deltaic sediment were depositing at essentially the same time during the Pennsylvanian Period. Further, one was building generally northward and the other generally westward. Therefore, it follows that they should overlap in a given area, during a given time. According to John Ferm (personal communication), the area of overlap is in the vicinity of Cullman, Alabama.

Pennsylvanian Sandstone Bedforms

David Hobday (1969) refined and supported the marginal marine portion of the regional model suggested by Ferm and Ehrlich (1967), by distinguishing a number of bedforms in Pennsylvanian sandstone units. In order to communicate readily with other geologists, Hobday arbitrarily assigned letter designations to various bedforms.

Of particular interest are the megaripple trough-fillings which Hobday considered as festoon or "B" beds. B beds have curved bases that are concave upward and are filled with cross-bedded, laminated sandstone. These deposits may range from several to tens of feet in length and may show a wide range in degree of concavity of the base. Hobday considered B beds to have formed on shoals, atop tidal deltas, or by longshore currents moving essentially perpendicular to beachface deposits.

Jopling Model

A. V. Jopling (1965-A) used a laboratory study of fluid flow over a foreset slope to develop a sedimentational model (Figs. 5-A, 5-B).

Figure 5-A indicates the hydrodynamic flow model of Jopling where three different hydrodynamic zones have been recognized:

1. Zone of no diffusion
2. Zone of mixing
3. Zone of backflow

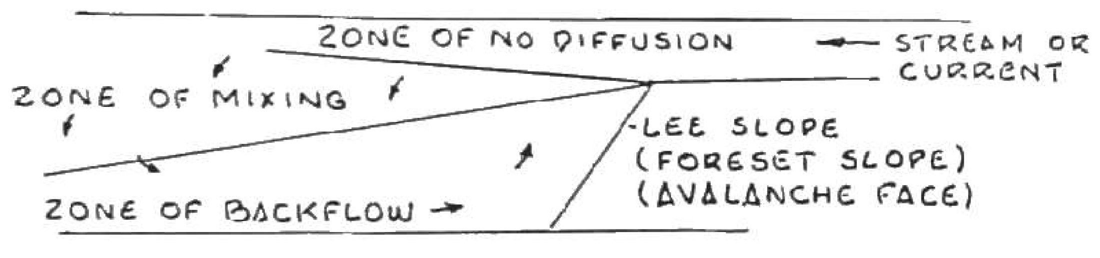
Zone of No Diffusion—Jopling considers this zone as a remnant stream flow (resembles expanding jet flow) that carries suspended sediment over and beyond the lee slope.

Zone of Mixing—The fluid in this zone contains vortices, or eddies, and displays rapidly changing longitudinal velocity.

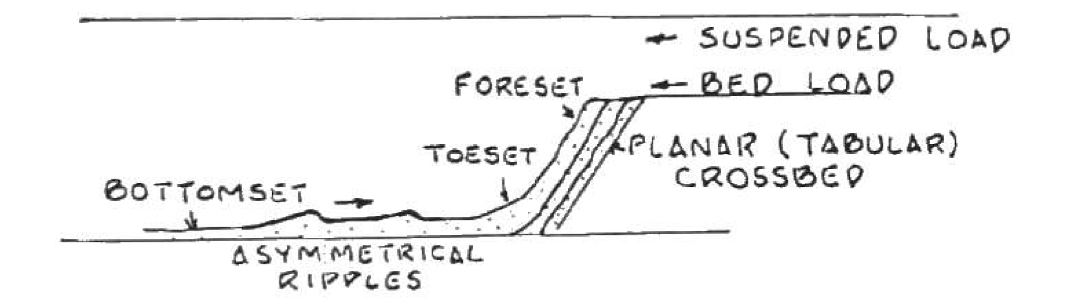
Zone of Backflow—This zone shows a return flow, usually referred to as reverse circulation, or backflow; i.e., a counter current forms and flows along a depositional interface and up a foreset slope.

Figure 5-B shows a bedform model in which three types of lee slope bedding have been observed:

1. Forest (tabular or planar) crossbeds.
2. Toeset beds.
3. Bottomset beds, with or without asymmetrical small ripples.



A, *Hydrodynamic flow model*



B, *Bedform model*

FIG. 5: *Sedimentation model of Jopling (1965-A).*

Foreset (Tabular, Planar) Crossbeds—In general, these are coarse-grained, laminated units formed by bed load material avalanching down the lee slope. When well developed, they intersect the depositional interface at steep angles (up to 35°).

Toeset Beds—These units join foreset and bottomset beds and consist of a mixture of particles that both avalanched down the lee slope and settled out of the zone of backflow.

Bottomset Beds—In general, bottomsets are finer-grained than toesets and foresets because they are largely suspension deposits that accumulated in the zone of backflow. Further, small, asymmetrical current ripples (backflow ripples) may form on the upper surface of bottomset beds. This is taken as supportive evidence of the presence of a backflow current.

Exposure Near Sewanee, Tennessee

Figure 6 shows the nature of a megaripple trough-fill in the western end of a roadcut in the Pennsylvanian Sewanee Conglomerate (Fig. 3) along U.S. 64 near Sewanee, Tennessee (Fig. 1). Here, foreset, toeset and bottomset beds are present as weathered, friable units which enabled grain size analysis by sieving.

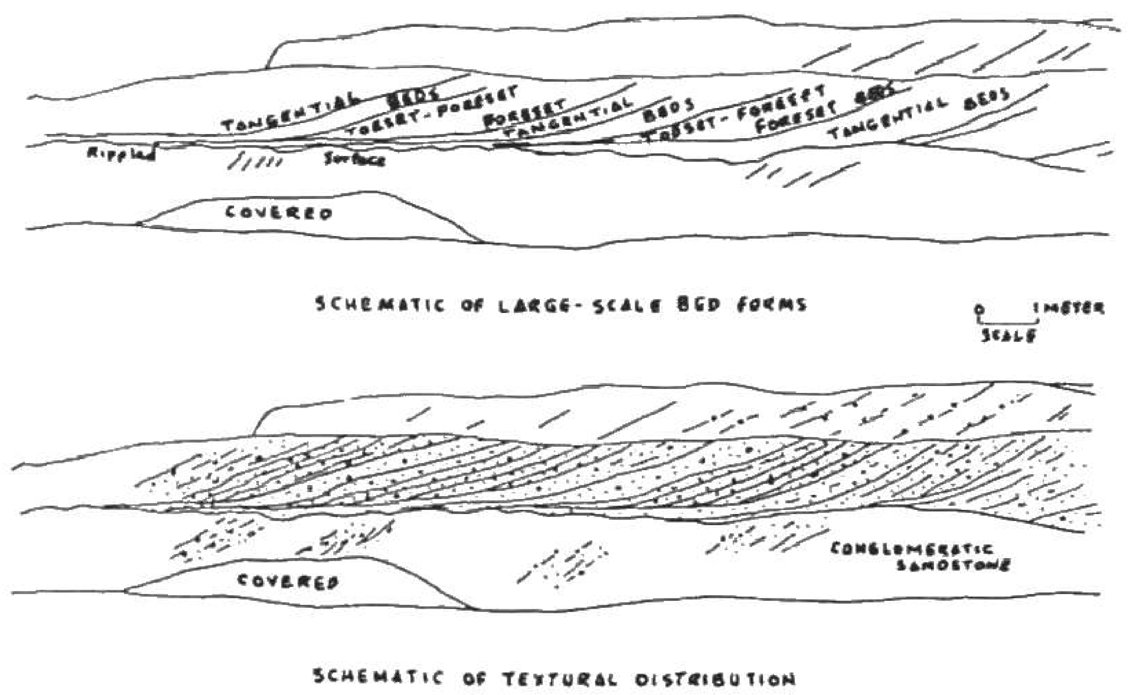


FIG. 6: *Western end of roadcut in Pennsylvanian Sewanee Conglomerate along U.S. 64, Sewanee, Tennessee.*

As previously stated, foreset beds tend to be coarse grained because they form by bed load particles avalanching down megaripple lee slopes, whereas bottomset beds tend to be fine grained because they form by suspension sedimentation in the zone of backflow.

Figure 7 shows the location of channel samples (4) of foreset and bottomset beds which were sieved in order to check the relationship of bedform and grainsize.

Data on Table 1 verify that these bottomset beds are finer grained than the foreset beds.

In addition, Figure 7 shows the location of dip direction readings on cross-beds in this exposure near Sewanee, Tennessee. Figure 8 summarizes these data and indicates that the general direction of sediment transport in this outcrop was between 50°-60° to the southwest.

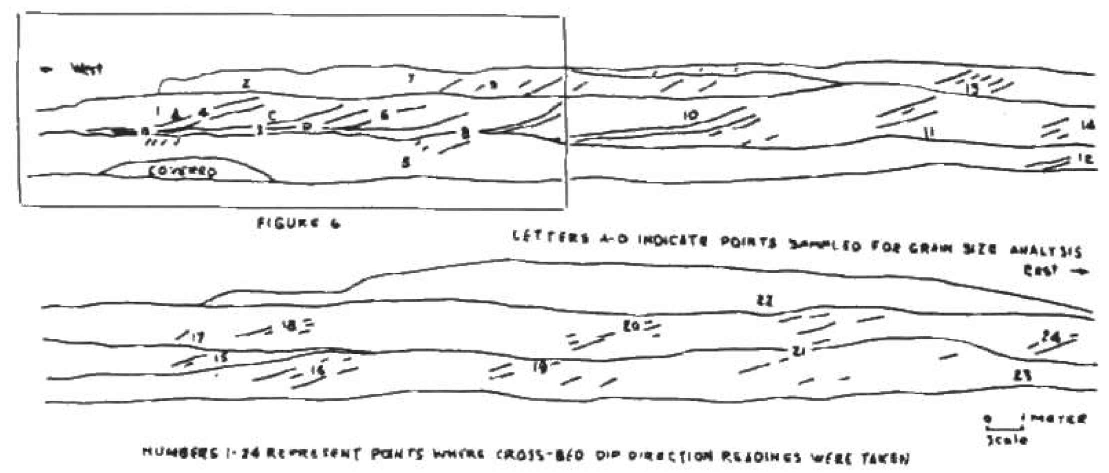


FIG. 7: *Generalized drawing of roadcut in Pennsylvanian Sewanee Conglomerate along U.S. 64, Sewanee, Tennessee.*

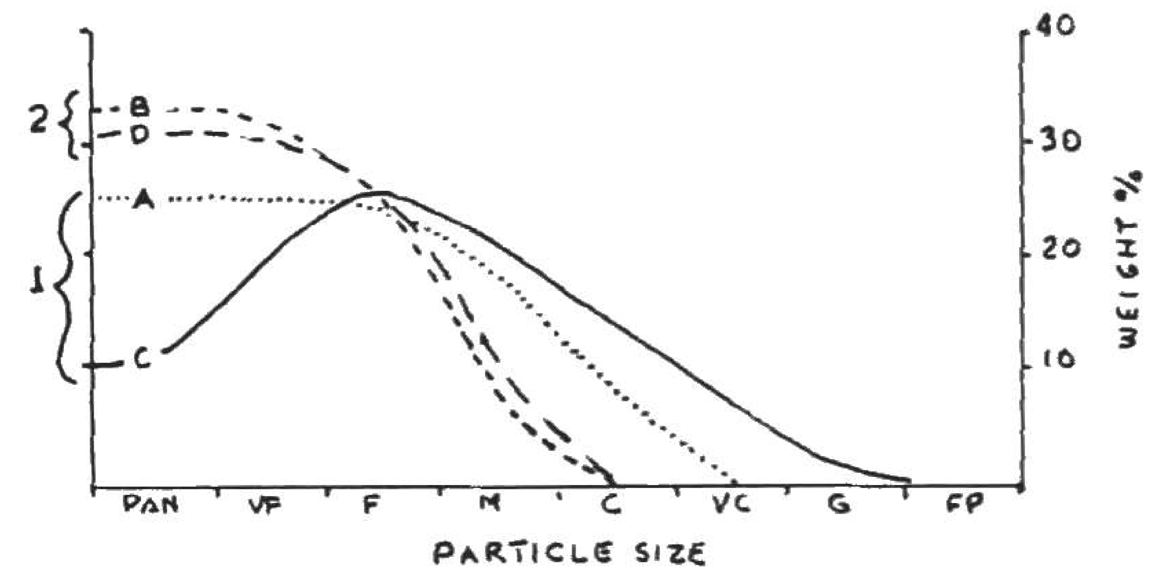
Also, these beds appear to be arranged in a cyclic, or repetitive, manner (Fig. 6). It may be considered that the cycle begins with relatively steeply dipping forest beds, followed by foreset-toeset beds, and ending with foreset-toeset-bottomset beds (well-developed tangential beds).

Jopling (1965-B) reports that relatively steeply dipping foreset beds indicate low current velocities; whereas, well-developed tangential beds indicate increased velocity.

TABLE 1: *Weight percent sieve analyses, Pennsylvanian quartzose sandstone near Sewanee, Tennessee*

PARTICLE SIZE		SAMPLES A[1]	B[2]	C[1]	D[2]
Fine Pebble		0.04	0.01	0.47	——
Granule		0.06	0.01	2.20	0.01
Sand:	Very Coarse	0.17	0.01	7.20	0.13
	Coarse	8.00	0.05	14.40	0.67
	Medium	18.68	8.31	20.50	10.31
	Fine	23.62	26.12	26.03	26.32
	Very Fine	24.05	31.58	19.07	30.68
Silt and Clay	Pan	24.85	33.10	10.05	31.44
		99.47	99.19	99.92	99.52

[1] Foreset bed channel samples
[2] Bottomset bed channel samples



Further, it is tempting to interpret this cyclic pattern of bedforms as evidence of tidal current control of sedimentation. This, in turn, could lead to the interpretation that rates of deposition are quite rapid with infilling of megaripple troughs accomplished in a matter of hours—during a single flood tide? However, the authors feel that these matters should await studies of both a more comprehensive and specific nature.

Finally, M. L. Jones (1972) made a statistical study of the dip direction and amount of dip of cross-bedded units in the Gizzard Group, Sewanee Conglomerate, Newton Sandstone, Vandever Formation, and Rockcastle Conglomerate on the Cumberland Plateau in Southeastern Tennessee (Fig. 8).

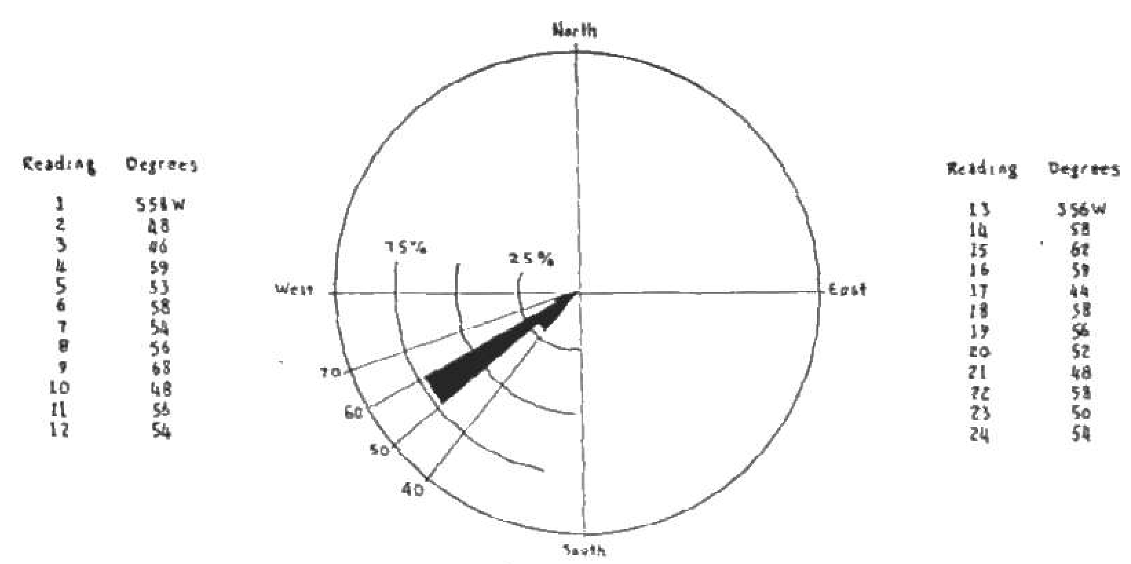


FIG. 8: *Rose diagram-summary of dip direction readings on cross-beds in roadcut of Pensylvanian Sewanee Conglomerate, Sewanee, Tennessee.*

Jones supported the marginal marine model of Ferm, Milici, Eason and others (1972) and indicated that the regional direction of sediment transport was to the south and southwest.

Exposure on Signal Mountain, Tennessee

Figure 9 (A-B) shows two views of a single megaripple trough-fill in the Warren Point Sandstone (Fig. 3) located near the juncture of Taft Highway and Shoal Creek Road, Signal Mountain, Tennessee (Fig. 2).

Figure 9A indicates the larger of the two views that is essentially parallel to Taft Highway and has a northwest azimuth. It shows part of the concave base of this very large megaripple. At first sight, it would appear that this view shows steeply dipping foreset cross-beds that formed parallel to a southeasterly paleocurrent flow; however, such is not the case.

The view on Figure 9B is essentially perpendicular to the view on Figure 9A and the azimuth of this rock face is toward the southwest. This view shows foreset, toeset and bottomset trough-filling dipping to the southwest which is arranged in a cyclic, or repetitive, sequence reminiscent of the exposure near Sewanee, Tennessee. However, here the cross-beds contain no granules or pebbles; the bottomset beds have asymmetric backflow ripples on their upper surface, and the trough height is not as great. In addition, visual inspection of these well lithified rocks reveals that the foreset beds are coarser grained than the bottomset beds.

Presumably this view shows lee slope cross-bedded deposits that formed essentially parallel to paleocurrent flow.

FIG. 9-A: *Rock face parallel to Taft Highway, Signal Mtn., Tennessee. Note large size of megaripple trough.*

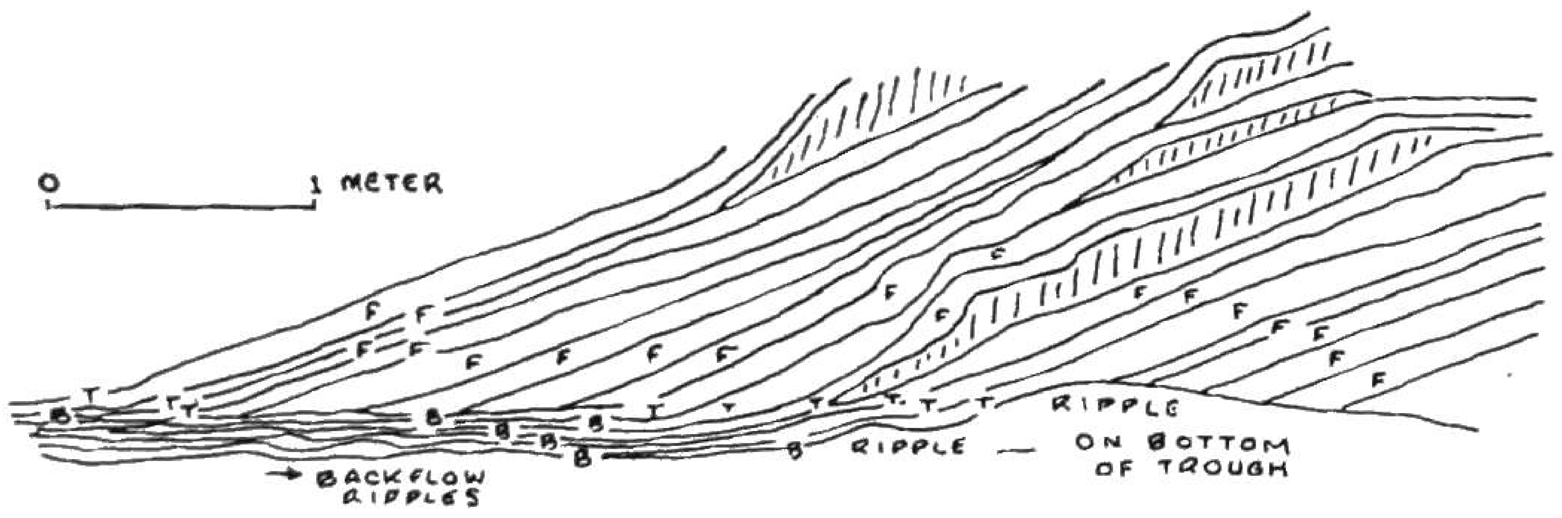


FIG. 9-B: *Megaripple trough fill, Signal Mtn., Tennessee—showing Forest, Toeset and Bottomset beds. (F) (T) (B)*

SUMMARY AND CONCLUSIONS

It is suggested that the two unusual roadcut exposures examined in this study support and verify laboratory studies of Alan V. Jopling on lee slope deposition.

Further, it is likely that these unusual exposures present a view of bedforms that were deposited essentially parallel to the direction of flow of Pennsylvanian paleocurrents.

Most outcrop views of Pennsylvanian megaripple trough-filling are likely at an oblique angle to paleocurrent flow, it should be possible to ascertain the sequence pattern of trough filling is difficult.

However, armed with information derived from trough-fillings that likely formed parallel to paleocurrent flow, it should be possible to ascertain the sequence of bedform filling, or formation, in most Pennsylvanian megaripple troughs no matter which view of the trough-fill is presented.

Finally, several statistical studies, such as the one by M. L. Jones (1972), of the dip direction of Pennsylvanian cross-bedded units have been made in order to determine regional or local direction of sediment transport. Presumably, these statistical studies include the dip direction of any view of megaripple trough-filling based on the idea that, with large numbers of readings, an *average* value may be used to interpret sediment transport direction.

However, the authors maintain that if one is able to examine any view of Pennsylvanian megaripple trough-filling and utilize the ideas presented in this paper, then one should be able to determine the sequence, or pattern, of trough filling. Therefore, these data should enable one to indicate the direction of ancient sediment transport with greater precision (Fig. 8) than the statistical approach based on averages.

Apparently, this problem in sedimentation is similar to a structural geology problem involving determination of true versus apparent dip.

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