One hog was injected three times for a total of 11 trials. Six trials (55 percent) resulted in immobilization at dosages of 1.14 to 3.23 mg/lb. Two hogs (18 percent of the trials) were killed at dosages of 1.95 and 3.33 mg/lb and, in three trials (27 percent) at dosages of 0.81 to 1.09 mg/lb, the hogs were not completely immobilized. One hog was not immobilized at dosages of 0.9 and 0.97 mg/lb but was immobilized at a dosage of 1.95 mg/lb. Immobilization occurred in 3 to 6 minutes and averaged 4.1 ± 0.6 minutes for five trials.

The Seronat ED 50 and LD 90, with corresponding 95 percent confidence limits for pen-anesthetized hogs were 1.9 (3.2-1.1) and 4.3 (6.1-3.1) mg/lb, respectively. The ED 50 with 95 percent confidence limits, for wild trapped hogs was 1.1 (1.6-0.7) mg/lb; however, because of the small sample size, the LD 90 could not be computed. The expected effects, i.e., the ED or LD at the 1, 16, 50 and 99 percent levels are found in Table 3. The only complication observed, other than mortality, was abortion, which occurred in one sow. A period characterized by thrashing of the feet usually precedes calmness. A sideways movement of the jaw is also a characteristic effect. The eyes are shut when the hog is immobilized, but eye reflexes are good. Defecation, urination or respiration did not occur except in those animals near death.

The hogs that died were necropsied and hemmorhaging was apparent. The fat in five of six hogs was pink in color and hemorrhagic and the renal pelvis was hemorrhagic in one hog. Perichondius of various parts of the heart was characteristic and blood was found in the pericardial cavity of one hog. The spleen was enlarged in all hogs examined and was ruptured in one animal.

### Table 3. Expected effect, ED or LD, at 1, 16, 50 and 99 percent level.

<table>
<thead>
<tr>
<th></th>
<th>Expected effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>ED 50</td>
<td>0.08 mg/lb</td>
</tr>
<tr>
<td>ED 90</td>
<td>2.4 mg/lb</td>
</tr>
</tbody>
</table>

### Literature Cited


### Introduction

Recent studies of cross-bedding have polarized into two main effects—those type studies, such as Brevett's (1965) use scattered observations over a large area and another type such as that of Brevett et al. (1967) is based on numerous measurements made in a very small area. Both these systems may be used to infer stream flow characteristics and to aid in the explanation of depositional history. Foster and Pettijohn (1963) offer a summary of such studies.

Probably the best approach is to combine the two methods of cross-bedding analysis, and it is likely that the results of these studies depend upon (1) the mapping system used, and (2) the three-dimensional orientation of the exposed strata. Thus, study of various exposures in detail over a representative large area minimizes abnormal measurements collected in confined observational networks.

### Previous Work and Description of Study Area

In order to test the usefulness of cross bedding in a point bar deposit to determine ancient stream flow direction, a group from the University of Cincinnati traveled to

![Figure 1](image1.png)

*Figure 1. Location of point bar deposit near Philadelphia, Pennsylvania.*

![Figure 2](image2.png)

*Figure 2. Three-dimensional representation of the Pennsylvania Kittanning formation exposed near Philadelphia, Pennsylvania.*
The arrangement of sedimentary units within the sandstone complex ranges widely, depending upon whether one is inspecting Face A or Face B. On Face B, several of the sedimentary units possess a sigmoidal morphology that is, they resemble a scalloped, backward "S" (Figure 4). As observed from east to west, these units dip westward at no more than 15 degrees until they approach the sandstone-shale discontinuity. Near the discontinuity they curve once again and are almost parallel to the underlying units. Here the sigmoidal units thin and pinch out westward at the sandstone-shale contact. This pattern is repetitive throughout the sandstone complex with stratigraphically higher sedimentary units preceding farther westward than their immediately underlying units. Allen (1961) describes sigmoidal sedimentary units in the Old Red Sandstone of North Wales.

Further, the transverse sections of the sigmoidal units of Face B appear on Face A as a sequence of beds containing well-defined cross beds. Interstratified enough, a view of Face A alone does not yield any indication of the sigmoidal bedding found on Face B. Consequently, without an appreciation of the relationships existing between the two faces, meaningful interpretation of the three-dimensional cross-bedding structures cannot be obtained.

In April of 1969, Dr. B. G. Williams of the Pennsylvania State University furnished valuable insights regarding the work of Bachtel, et al. (1967), much of which was done under his supervision. However, in order to learn more about the genesis of the sandstone complex, the orientation of the cross-bedded units shown on Face A was determined (Figure 5). According to Dr. Williams, Bachtel, et al. utilized a statistical approach in selecting the points at which cross-bedding orientations were measured. In essence, their crossbedding measurements were taken at points determined by the intersection of lines in a grid coordinate system superimposed on the sandstone exposures without regard to sedimentary units. The readings thus obtained presumably constitute a representative, random sample of the various orientations of the internal cross-bedding. After collecting the readings, Bachtel, et al. evaluated their work and determined that the dip direction of the cross-bedding ranged from essentially north-south to N 24° W and averaged N 15° W.

On the basis of their observations, Bachtel, et al., presented the following arguments regarding the origin of the sandstone complex:

1. The sandstone body was formed almost completely by lateral accretion of bed-load sediment on the inside of a meander bend in a north-flowing stream, the sandstone-sandstone discontinuity (scalloped contact) resulting from channel scouring by the stream as it migrated westward across the area.
2. The presence of discrete sedimentary units exposed as overlapping sigmoidal units on Face B and as tubular cross-beded units on Face A indicates that the sand was deposited by downstream-transporting bed forms and bars.
3. The factor which controls the bedding geometry appears to be the orientation of the downstream face of the bar with respect to the current direction in the channel. If the downdrift (sedimentational) edge of a transverse bar is perpendicular to flow direction, the entire edge would acquire a transverse channel section at a given time. An individual bed deposited during this time might then theoretically extend the full width of the unit in a transverse section (Figure 6A). On Figure 2, bedding as exposed on Face B is approximately parallel to unit boundaries and on Face A, forms tubular cross-beds essentially horizontal unit boundaries.

If the shoreward portion of the bar reached a given section before the channelward portion, deposition would occur first near the shore, and successive beds in transverse section would overstep toward the channel (Figure 6B). No complete units of channelward overlapping beds are present on Face B, but part of several units have this configuration, indicating that channelward legs of the downstream bar face may have been a transverse phenomenon.

Similarly, if the shoreward portion of the bar lagged behind the channelward portion, deposition in a given transverse section would occur well within the channel at first, and successive beds would overlap upward and shoreward (Figure 6C). The bar form might then tend toward a finger-like projection pointing downstream. Several units and numerous small parts of units with shoreward and upward overlapping beds are present on Face B, indicating that the bar morphology shown in Figure 6C occurred frequently but subordinately.

THEORETICAL DISCUSSION ON CROSS-BEDDING

Harrns and Fashstock (1965) point out that stratification in stream environments is essentially the result of migrating bed forms, and Leopold (1964) asserts that bed forms commonly referred to as "cross-
bedding" are formed by dune migration under the influence of prevailing currents. Subaqueous dunes move downstream in much the same manner that terrestrial dunes are known to migrate in deserts. Localized scour occurs on the gently sloping, upperface of the dune while the grains disrupted by the scouring are re-deposited along the convex or concave slope, or at points where the upward movement of the dune occurs. Continued supply of sediment to the area is necessary for the forward progression of the inclined forward face of the dune.

Discontinuous supply of sediment, post-depositional erosion of partially consolidated sediment, deposition of lithologically dissimilar detritus, along with numerous other variables may produce apparent boundaries along the inclineted foreslope of the migrating dunes.

Potter and Pettijohn (1963) suggest that such features as cross-bedsding may be considered as vector properties of the sedimentary deposit in which they occur.

The point bar may be defined as a sedimentary structure generated by the deposition of sediment along the convex portion of a meandering stream channel following previous erosion of the sediment from the concave portion of an "upstream" meander. The mechanics involved is not totally unlike those responsible for the formation of stratified rock layers.

The point bar may be considered as a natural, self-sustaining system; the only difference being the introduction of more variables. As water moves through a meander bend, there is an increase in the flow velocity away from the convex section of the meander and toward the concave section of the meander. Therefore, within the concave section of the bend, the consequent is evident. Sediment along the concave bank is no longer competent to withstand the increased velocity; therefore, the bank will begin to erode more rapidly and the stream itself will approach being saturated with the additional load of sediment. The process governing the return to equilibrium will begin to function at this point. In other words, the coursed stream will re-deposit the course of its channel in the form of a dunes at the earliest convenience of the stream. The site where the sediment will be re-deposited will reflect the pressure exerted by the lower velocity regime away from the site where the sediment was eroded. As meanders are repetitive along the course of a river, the sediment will be dropped as the current velocity falls between meanders. Any point approaching and including the convex curve of the next lower meander in the channel may be considered as a potential locus for deposition.

Summary and Conclusions

The random samples of dip orientation measurements confirm the expected occurrence of widely varying values within a point bar complex. Further, the point bar complex in a meandering stream seems to provide the utility of "averaging" readings in order to predict regional stream flow directions, particularly in a point bar. Granted, the individual directional values observed may be collected and "manipulated" to yield an "average" but this average "average" is obscure. In an environment as an area of countercurrent flow, these directional values, taken collectively, lose their significance.

The question arises as to the external geometry of the entire point bar. Only a small part of the point bar is exposed in the coal strip mine pits, and the size and morphology of the bar in its entirety are unknown. Britten, et al., suggest a westwardly migrating channel and submit the westwardly migrating channel observed sigmoidal units on Face B as evidence of such a migration. In addition, they present models (Figure 6A, 6B, 6C) suggesting possible orientations of the entire point bar within the ancient river channel. Study of their models leads to the idea that migrating point bars may assume any orientation within the channel. Their models depict point bars exhibiting various degrees of curvature in their external morphology. It is important to realize that this curvature is common place in the growth of a point bar; that the bar is sinusous throughout its length; and that the sinuosity of the point bar is an expression of the range of orientations of its component dunes.

The exposures studied least represent random cuts through a lithified point bar. There is no way of knowing the entire dimension or morphology of the point bar from the present exposures. Nor is the orientation of the present exposures known with respect to overform or morphology of the ancient point bar. Therefore, it is hazardous to predict regional stream flow trends from the present exposures, or even to indicate in partial exposures, particularly on a point bar.

The proposal of Britten, et al., that the point bar migrated westward may or may not be correct. One possible alternative is that the exposed sandstone complex may represent a portion of an ancient point bar that is oriented approximately parallel to, rather than perpendicular to, the bounding river banks. In such a case, the apparent migration could be misleading.

Acknowledgments

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Literature Cited