CROSSBEDDING OF THE POTOMAC FORMATION IN FAIRFAX COUNTY, VIRGINIA

By

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FIGURES

TABLES

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Abstract

Crossbedding in sandstone units is the most conspicuous sedimentary structure of the Potomac Formation in Fairfax County, Virginia. Most sets of crossbeds are a few feet thick and several feet wide and tens of feet long. Trough sets are dominant, but planar sets are also common. Dip directions of crossbeds show great variation, though westerly dips are sparse. The averages (resultant vectors) of crossbedding dip-directions measured at 33 localities do not show significant differences according to their geographic or stratigraphic distribution. The average dip-direction of the 292 crossbeds measured is N. 85° E. The data suggest that the depositional slope was easterly in Fairfax County throughout the time of deposition of the Potomac Formation. Major sand bodies, potential aquifers of the formation, are probably elongated along easterly trends.

Introduction

The Potomac Formation (Cretaceous) is a wedge-shaped deposit underlying the eastern part of Fairfax County, Va. (Force, 1975). It rests on saprolitic crystalline rock of pre-Cretaceous age and is overlain by upland gravels of Cenozoic age. The formation consists of mudstone, sandstone, and minor amounts of conglomerate and ranges in thickness from an irregular feather edge to more than 600 feet. Exposures are sparse and generally limited to stream bottoms, sea cliffs and recent artificial cuts.

Mudstone of the Potomac is mostly greenish gray to reddish brown and ranges from claystone to clayey sandy siltstone. It occurs in layers ranging from distinct seams only a few inches thick to ill-defined bodies probably many tens of feet thick. The mudstone rarely crops out naturally and in artificial exposures it is commonly obscured by weathering.

Sandstone and conglomerate of the Potomac is light gray, variably stained yellowish to brown by iron oxides. It ranges from very fine to coarse grained but consists mostly of subangular to subrounded, fine to medium grains of clear quartz and lesser amounts of white feldspar weathered in part to clay. Conglomerate is irregularly interstratified in sandstone as thin lenses consisting mainly of rounded pebbles of quartz in a matrix of medium- to coarse-grained sand. Intraformational pebbles, cobbles, and boulders of greenish-gray mudstone are found locally in sandstone and quartz-pebble conglomerate. The sandstone and conglomerate occur in irregular layers ranging from small lenses, a few feet thick and a few tens of feet long, to bodies of undetermined size, probably tens of feet thick and thousands of feet long.

This report summarizes a six-week survey of depositional structures of the Potomac Formation of Fairfax County made in November-December, 1975. I was introduced to the problem by A. J. Froelich and was aided in the search for outcrops by the geologic maps of Force (1975) and Huffman and others (1975).

Primary sedimentary structures noted in the sediments of the Potomac Formation include crossbedding, horizontal bedding, cut-and-fill structures, contorted bedding and ripple marks. Crossbedding and to a lesser extent horizontal bedding are depositional structures found in most exposures of sandstone and conglomerate. Cut-and-fill structures are locally conspicuous. Contorted bedding and ripple marks are rare. Obscure horizontal lamination is characteristic of the mudstone of the Potomac. In places the mudstone forms part of the fill of cut-and-fill structures. Because crossbedding is the most common and conspicuous depositional structure of the exposures of the Potomac Formation in Fairfax County, the nature and import of the crossbedding form the subject of this report.

Description of crossbedding

Trough sets of crossbeds are dominant but planar sets are also common. In small exposures or where transverse views are lacking these two types of crossbedding may not be separable. Fully exposed sets are commonly a few feet thick, several feet wide, and a few tens of feet long. They range, however, from sets measureable in inches, ripple marks in section, to sets made of large [redacted] bedforms more than 10 feet thick, tens of feet wide, and more than 100 feet long. Figure 1 B shows the frequency of

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Figure 1 near here.

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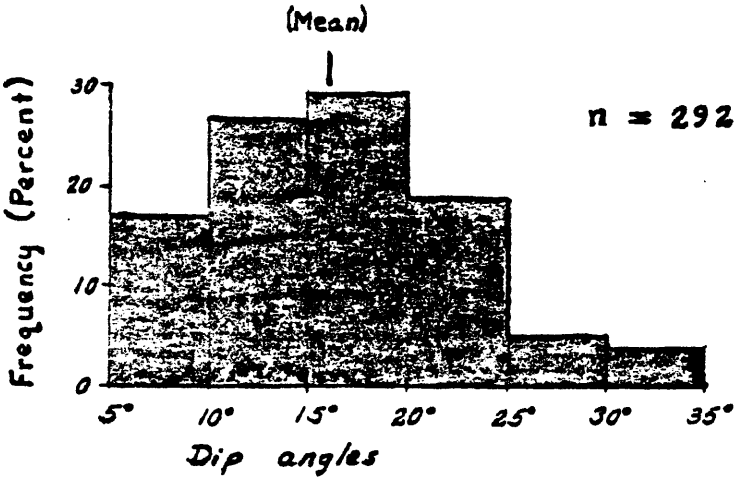
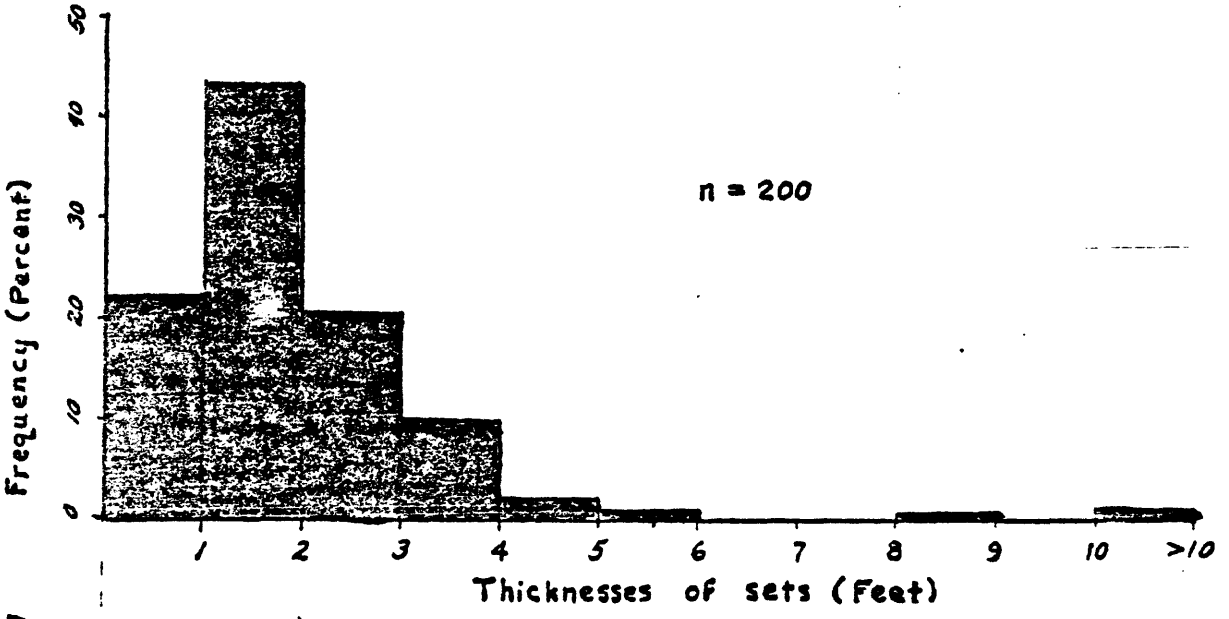
thicknesses of sets based on field estimates and measurements and indicates the average thickness of the sets studied was about 2 feet. This distribution omits many small and large sets. Sets thinner than 0.5 feet were rarely measured, and because of small exposures, thicknesses of sets more than about 3 feet thick could seldom be determined.

Crossbeds within the sets range from a fraction of an inch to a few inches in thickness. They commonly are steepest near the top of the set and flatten slightly near the base. Figure 1 A shows the frequency distribution of the dip angles of crossbeds measured if practicable where most steeply inclined. The mean inclination of about 16 degrees is lower than the 20 degree average determined by Glaser (1969, p. 21) for the whole Potomac outcrop of the Atlantic Coastal Plain, probably because I could not reach the most steeply dipping parts of beds in many exposures. In most sets the crossbeds meet the base of the set at a fairly sharp angle of more than 10 degrees. In some sets, especially in fine-grained sandstone, the beds are asymptotic or nearly parallel to the base of the set, and may show a reverse dip as the base of many sets climbs near its distal end.



A.—Frequency of dip angles of measured crossbeds



B.— Approximate thicknesses of crossbedding sets

ure 1.— Histograms showing frequency of dip angles and thicknesses of crossbedding sets, Potomac Formation, Fairfax County, Virginia. 4A

Figures 2 and 3 are sketches based on photographs and field measurements.

Figures 2 and 3 near here.

They show the shape of the major sets and the inclination of the contained crossbeds.

Although differing considerably in size, the crossbedding in the sandstone (and minor conglomerate) of the exposures on Seventh Street and along the road in Fort Belvoir appear much the same (fig. 2 A, B). At each of these localities the average dip direction of the crossbeds is about parallel with the face of the outcrops shown and thus these views are roughly transverse sections. The erosional surfaces bounding the sets are for the most part nearly straight at the head but curve near the base and rise gently towards the toe. The upper part of the contained crossbeds parallels the head of the set but as shown meets the base at a sharp to gentle angle. The boundary at the head of the set commonly nearly parallels crossbeds in an older truncated set so that frequently the division between sets is obscure in longitudinal views. Wedge-shaped planar sets are intercalated with the trough sets; they seem to be generally smaller than the trough sets and to have more gently dipping crossbeds. Some sets as that below the wavy clay seam near the northeast end of the outcrop shown in Figure 2 B are composite, made up of many small trough sets only a few inches thick.

The exposure at the Fort Belvoir landfill cut (fig. 3) shows a transverse view of stratification in the Potomac Formation. Here the average dip-direction was inferred to be nearly perpendicular to the face of the cut. The curving boundaries of the trough sets are more conspicuous

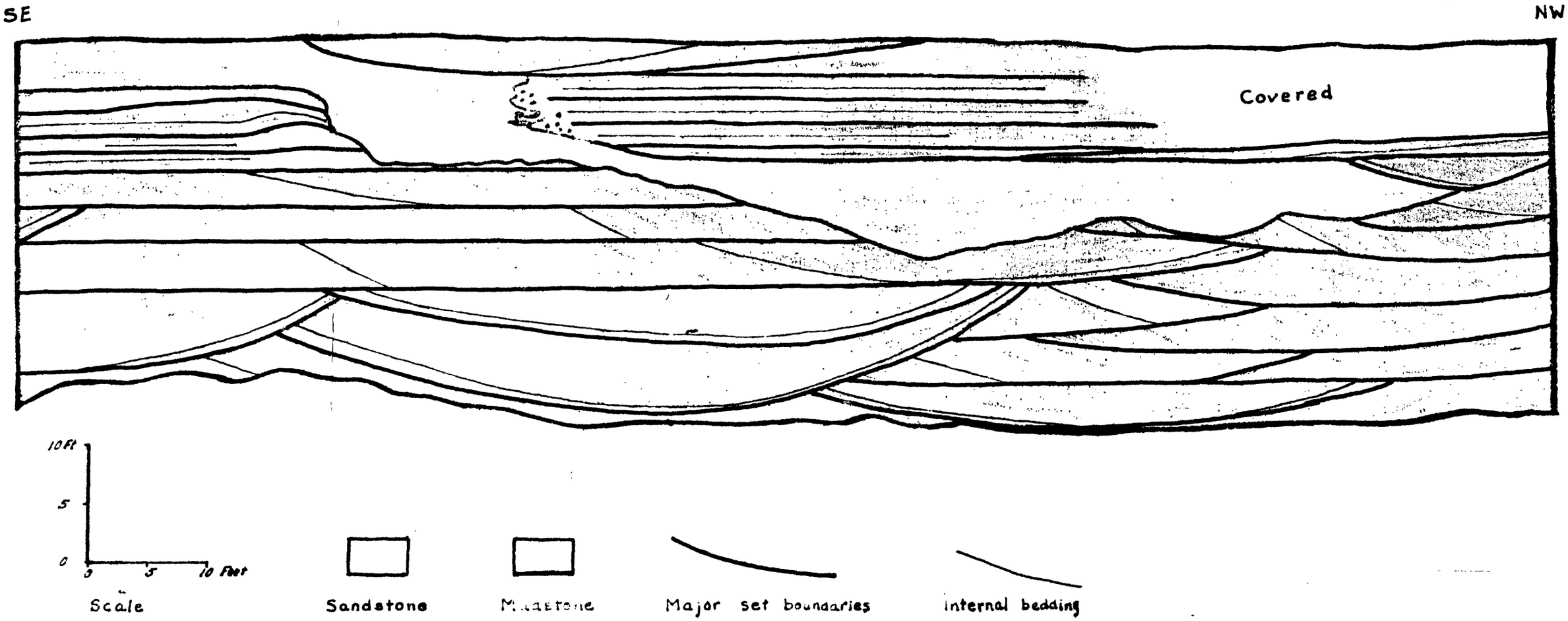
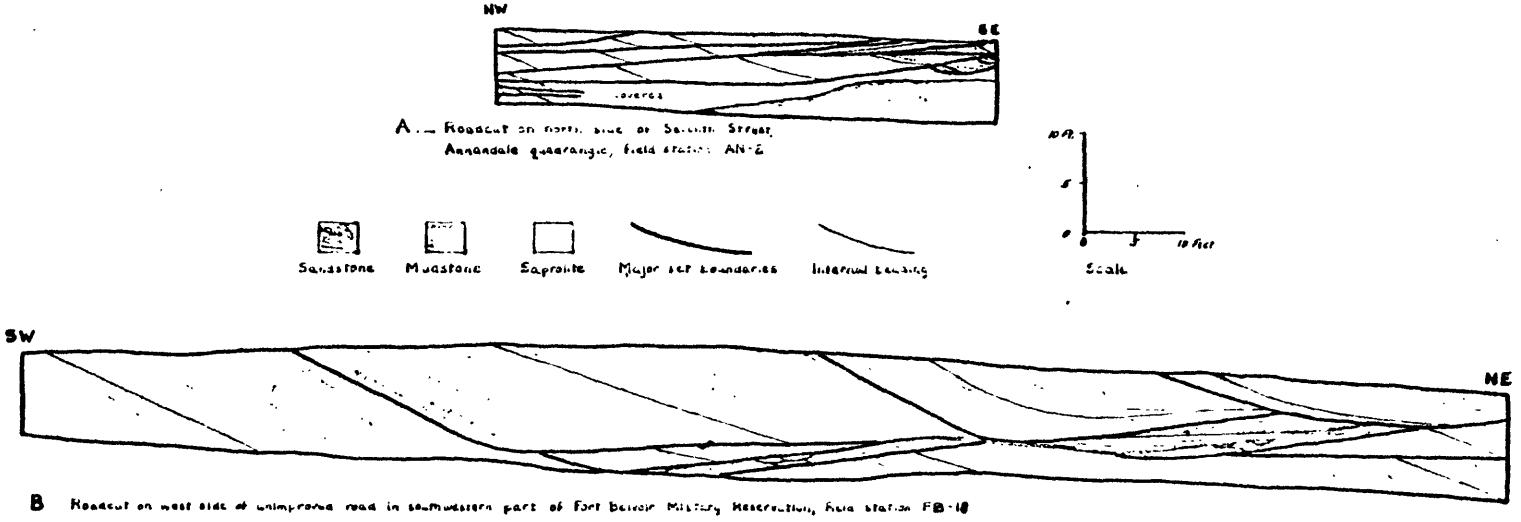


Figure 3 — Transverse view of stratification in Potomac Formation in landfill cut, southwestern part of Fort Belvoir Military Reservation, Fairfax County, Virginia.



A.— Roadcut on north side of Seventh Street, Annandale quadrangle, field station AN-2

B Roadcut on west side of unimproved road in southwestern part of Fort Belvoir Military Reservation, field station FB-18

Figure 2.— Longitudinal views of stratification in sandstone of the Potomac Formation, Fairfax County, Virginia

than in longitudinal views. Some sets are filled more or less symmetrically but many seem to be asymmetrically filled from the east. At this locality the stratification seems to grade upward from trough sets to planar sets. The sand deposition was interrupted by scouring leading to the formation of a cut-and-fill structure. Mudstone fills much of the scour. On the southeast flank of the scour the mudstone is partly a mudstone-boulder conglomerate that grades laterally into horizontally thinly planar-bedded sandstone. The sandstone overlying the mudstone of the hill also contains thin planar and trough sets of low-angle crossbeds.

Orientation of crossbeds

The dip directions of crossbeds were measured at 33 localities shown on figure 4 and described in table 4. In a few places measurements

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Figure 4 in Appendix

Table 4 in Appendix

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could be made directly on outcropping bedding planes but generally only careful cleaving of the weakly cemented sediments exposed the surface of the crossbeds. Orientation of the beds weee measured with a Brunton compass and a dip-direction indicator (Pryor, 1958). In some localities where the sediments were too poorly consolidated to cleave along bedding the orientation of the beds was determined by carving a v-cut in the exposed face, placing the dip-direction indicator on three points of a bed lamination and rotating the indicator bubble to level. Except in rare unequivocal exposures of both flanks of a trough set, only one crossbed was measured in each set.

From 1 to 22 crossbeds were measured at each field station. The measurements were grouped in 10 degree classes and were averaged using trigonometric methods suggested by Curray (1956). The average dip direction is the trigonometric sum, the resultant vector azimuth, denoted by the symbol $\underline{\theta}$. A measure of the dispersion of measurements around the average is given by the length of the resultant vector expressed in percent and denoted by the symbol $\underline{L}$. Where the value of $\underline{L}$ is high dispersion is low; where $\underline{L}$ is low dispersion is high. The number of measurements ($\underline{n}$) and $\underline{\theta}$ and $\underline{L}$ are tabulated for each locality in Table 1.

Table 1 near here.

Table 1

CROSSBEDDING DATA BY FIELD LOCALITIES, SANDSTONE UNITS OF THE POTOMAC FORMATION, FAIRFAX COUNTY, VIRGINIA

Reference No.	Number of Measurements (n)	Resultant Vector Azimuth (θ)	Resultant Vector length in Percent (L)
AL-1	6	S. 71° E.	66
AL-2	10	S. 85° E.	70
AN-1	15	S. 28° E.	51
AN-2	7	S. 52° E.	92
AN-3	10	N. 43° E.	87
AN-4	7	S. 87° E.	85
AN-5	13	S. 66° E.	88
AN-6	8	N. 90° E.	37
AN-7	9	N. 65° E.	32
AN-8	4	S. 43° E.	67
FB-1	16	N. 40° E.	74
FB-2	5	N. 30° W.	70
FB-3	17	N. 68° E.	23
FB-4	7	N. 48° E.	63
FB-5	9	N. 70° E.	53
FB-6	14	N. 74° E.	75
FB-7	22	S. 34°E.	72
FB-8	7	N. 86° E.	85
FB-9	7	N. 63° E.	46
FB-10	4	N. 64° E.	78

Table 1 (Cont'd)

CROSSBEDDING DATA BY FIELD LOCALITIES, SANDSTONE UNITS

OF THE POTOMAC FORMATION, FAIRFAX COUNTY, VIRGINIA

ference No.	Number of Measurements (n)	Resultant Vector Azimuth (θ)	Resultant Vector length in Percent (L)
FB-11	3	N. 33° E.	94
FB-12	16	N. 77° E.	39
FB-13	1	S. 04° E.	100
FB-14	14	N. 82° E.	48
FB-15	5	N. 66° E.	94
FB-16	8	N. 46° E.	72
FB-17	6	S. 19° E.	64
FB-18	11	N. 84° E.	70
FB-19	10	N. 90° E.	87
FB-20	16	N. 68° E.	66
FB-21	2	S. 75° E.	90
OC-1	3	N. 43° E.	89

The sum of all the measurements of dip directions of crossbeds in the Potomac Formation of Fairfax County is shown in the circular graph of Figure 5. The average dip direction is N, 85° E. The dispersion of the

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Figure 5 near here.

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measurements, as indicated by the 52 percent resultant-vector length, is moderately large. A related indicator of the dispersion is the mean angular deviation ($\overset{s}{\delta}$), akin to standard deviation of non-vectorial measurements, that includes about two-thirds of the vectors (Till, 1974, p. 38-43); s of the measured dip-directions of this study is ± 56°.

A resultant vector for each locality is plotted on Figure 4, the map of Coastal Plain sediments (Force, 1975). These vectors are not weighted for the number of measurements or the amount of dispersion which vary greatly among the localities. 1/ The map suggests, however, that the

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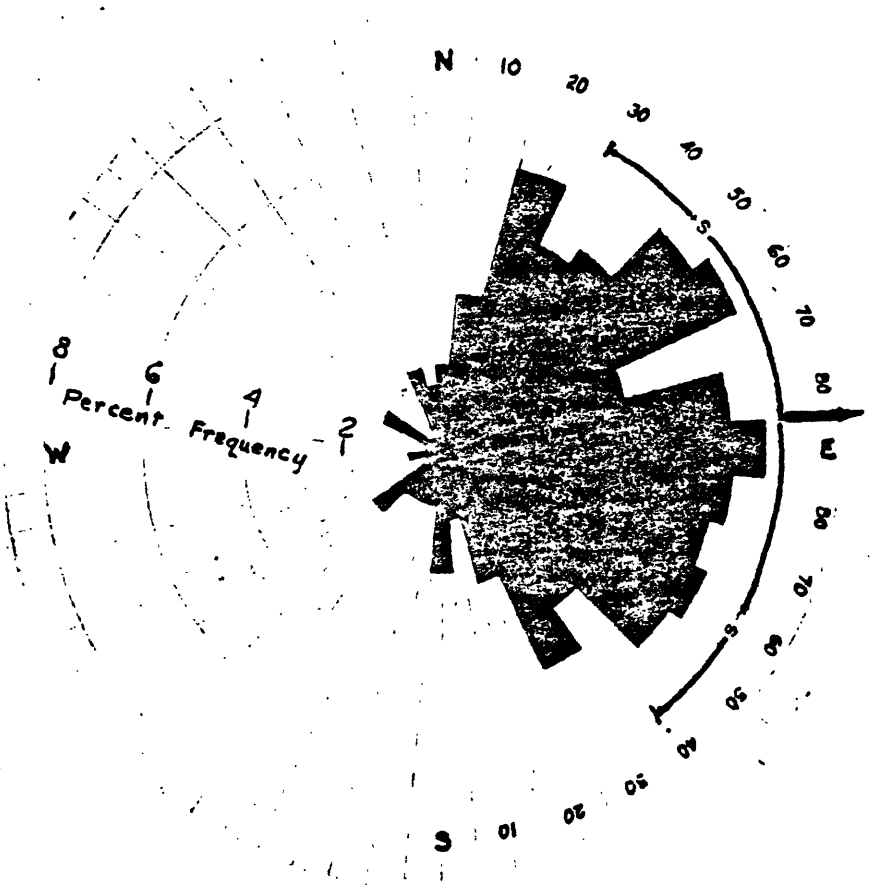
1/ Because of the small number of measurements at any one locality, it was not possible to determine differences in the average dip-direction resulting from sampling different sets and inherent difficulties in precise measurements of the orientation of the beds. Comparison of data from studies by Glaser (1969, p. 97) who used class intervals of 30° and my own studies at or near the same locality, the railroad cuts about 1 mile northeast of Accotink, indicate the magnitude of such sampling differences and difficulties is about 30°. The comparitive data are tabulated below:

		$\overset{n}{}$	$\overset{\theta}{}$	$\overset{L}{}$
Weir	Ref. No. FB-7	22	S. 34° E.	72
Glaser	Loc. No. 61	15	S. 02° E.	80



POTOMAC FORMATION, FAIRFAX COUNTY, VIRGINIA

Number of measurements (n)	292
Resultant vector azimuth (θ)	N. 85° E.
Resultant vector length in percent (L)	52
Mean angular deviation (s)	56°

Figure 5 Dip azimuths of crossbeds in sandstone units of the Potomac Formation, Fairfax County, Virginia.

average dip directions do not vary systematically according to geographic position. Table 2, which summarizes the crossbedding data by quadrangles also indicates that the average dip directions of the crossbeds do not differ significantly by geographic area, especially considering the fairly large angular dispersions about the mean directions.

The crossbedding data were also summarized in terms of elevation intervals above the base of the Potomac Formation. The data are listed in classes of 50-foot intervals in Table 3 and shown graphically in classes of 100-foot intervals in Figure 6. The resultant vectors vary

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Table 2 near here
Table 3 near here.
Figure 6 near here.

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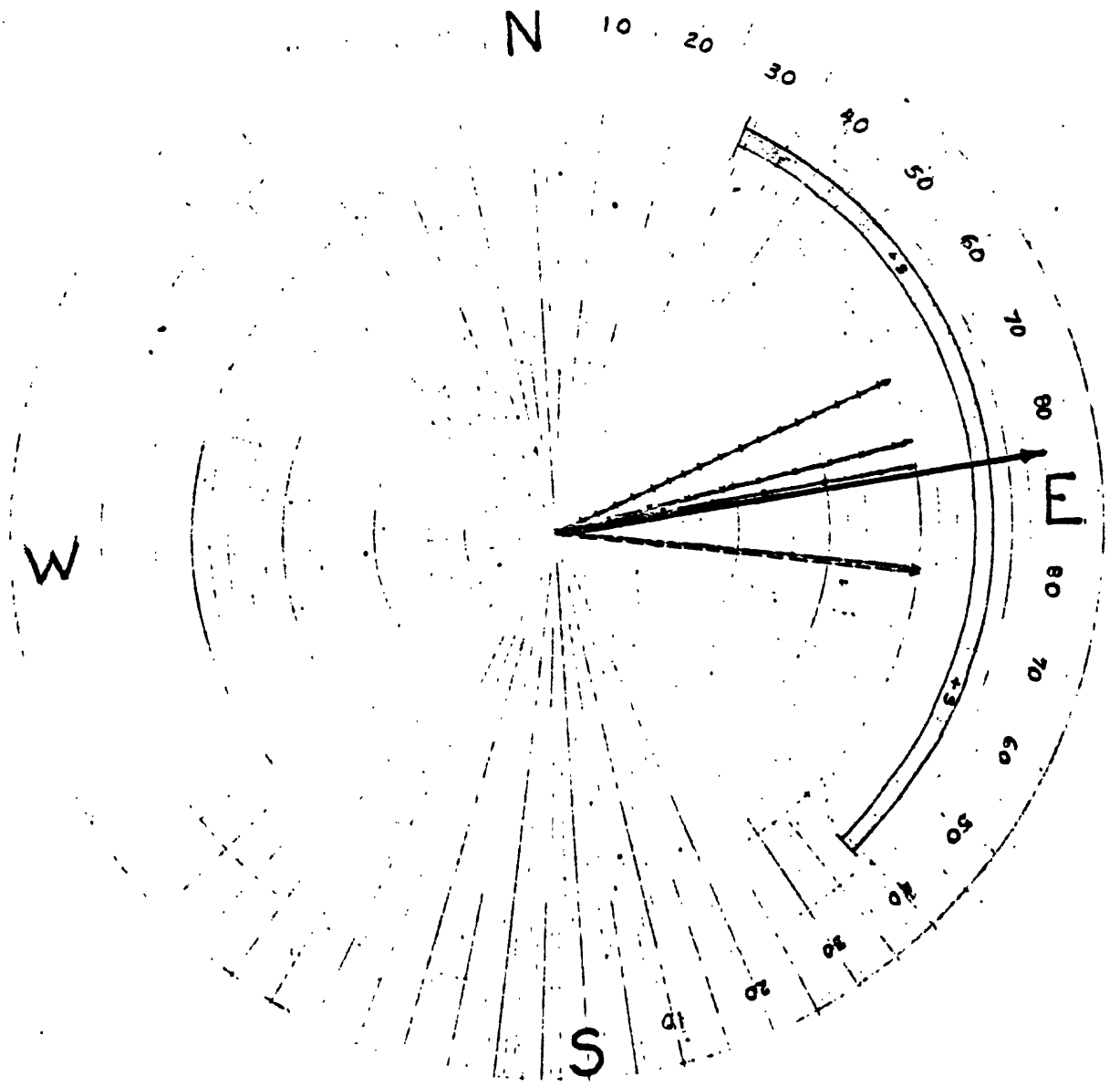
unsystematically. The dispersions about the average dip directions, as indicated by L, are fairly large. The average dip directions of each elevation interval lies well within the 56° angular dispersion of the sum of all the measurements. The data indicate that the dip directions of crossbeds of the Potomac do not vary significantly according to elevation above the base of the formation.

In sum, the average dip direction of crossbedding appears to be fairly constant in an easterly direction but ranging from northeasterly to southeasterly throughout the Potomac Formation of Fairfax County.



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Key	Elevation above base (feet)	n	θ	L
———	0 - 100	121	N. 70° E.	49
———	100+ - 200	74	S. 80° E.	55
———	200+ - 300	46	S. 80° E.	58
———	300+ - 400	11	N. 84° E.	70
———	400+ - 500	40	N. 80° E.	60
———	All	292	N. 85° E.	52

Mean angular deviation of all measurements = 56°

Figure 6 Resultant vector azimuths of crossbeds in the Potomac Formation grouped by elevation above base of formation, Fairfax County, Virginia.

Table 2

SUMMARY OF CROSSBEDDING DATA BY AREAS, SANDSTONE UNITS OF THE POTOMAC FORMATION, FAIRFAX COUNTY, VIRGINIA

Study Area	n	θ	L
Fairfax County	292	N. 85° E.	52
Alexandria quadrangle	16	S. 80° E.	68
Annandale quadrangle	73	S. 79° E.	54
Fort Belvoir quadrangle	200	N. 78° E.	52

Table 3

SUMMARY OF CROSSBEDDING DATA BY ELEVATION ABOVE BASE OF FORMATION, SANDSTONE UNITS OF THE POTOMAC FORMATION, FAIRFAX COUNTY, VIRGINIA

Elevation above base in feet	n	θ	L
0 - 50	88	N. 73° E.	50
50+ - 100	33	N. 60° E.	47
100+ - 150	22	N. 74° E.	57
150+ - 200	52	S. 69° E.	58
200+ - 250	30	S. 73° E.	58
250+ - 300	16	N. 90° E.	60
300+ - 350	11	N. 84° E.	70
350+ - 400	None	-	--
400+ - 450	26	N. 79° E.	66
450+ - 500	14	N. 82° E.	48
All	292	N. 85° E.	52

SIGNIFICANCE OF CROSSBEDDING

The Potomac Formation was deposited in a fluvial environment as indicated by the presence of plant fossils, cut-and-fill structures, mudstone-clast conglomerates, lensing and intergrading of rock units and the absence of marine fossils (Glaser, 1969, p. 71-73; Force, 1975, p. 9). The crossbedding of the Potomac is consonant with this interpretation of environment. The sets of crossbeds probably represent parts of point bars, transverse bars, and longitudinal bars of meandering and braided streams. Some planar sets of low-angle crossbeds in fine-grained sandstone probably formed in levees and overbank sand splays.

The dip direction of crossbeds indicates the local direction of sedimentary transport. The range in variations among the average dip directions of localities plotted on Figure 4 is in large part due to the fact that this map is a palimpsest of many directional structures, a "multiple exposure" of the deposits of several subenvironments through a considerable period of time.

Of more importance is the range and average direction of all the crossbeds measured (Fig. 5). The mean dip direction of N. 85° E. indicates the paleoslope on which flowed the streams depositing the Potomac sediments. The dispersion about the mean suggests that the stream flow ranged from northeasterly to southeasterly.

Studies of sedimentary structures and shape of sand bodies show that the dip direction of crossbeds indicate the direction of accumulation and elongation of sand bodies (Potter and Mast, 1963; Mast and Potter, 1963). The shape and size of the sand bodies in the Potomac Formation is not presently known in detail. Studies of the modern fluvial

environment (Allen, 1964), and ancient analogs (Shawe and others, 1968, fig. 36, 37, pls. 8, 10, 11; Greenman and others, 1961, pls. 9, 10, 14) suggest that sand bodies formed in stream deposition range from discrete ribbon-like lenses to irregular patchy sheets with and without vertical connections with overlying and underlying sand bodies. The major sand bodies of the Potomac, potential acquifers of the formations, may be expected to be elongated along the depositional trend shown by the average dip direction of the crossbeds.

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Appendix

Table 4

Location of crossbedding studies. (All in Fairfax County, Virginia except as noted)

ALEXANDRIA QUADRANGLE

AL-1 Outcrops along west bank of Pike Creek near Burgundy Village Subdivision about 1,000 ft. from mouth of creek

AL-2 Outcrops along unnamed stream about 200 ft. south of U. S. No. 1, about 0.4 mi. northeast of Penn Daw.

ANNANDALE QUADRANGLE

AN-1 Outcrops on cuts and along access roads of borrow pits 200-800 ft. northeast of Hayfield Road between Telegraph Road and Old Telegraph Road.

AN-2 Cut on northeast side of 7th St. between Cherokee Avenue and Virginia Street, Weyanoke Subdivision,

AN-3 Outcrops in gully along service road in quarry about 0.4 mi. northwest of junction of Hayfield Road and Old Telegraph Road.

AN-4 Outcrops along service road and power line about 700 to 1,000 ft. about 1.3 mi. northeast of junction of Hayfield Road and Old Telegraph Road.

AN-5 Cuts on west side of Richmond, Fredericksburg, and Potomac Railroad east of Loisdale Estates Subdivision, about 1.3 mi. southeast of I-95 interchange at Springfield.

AN-6 Cuts on east side of R.,F.,& P. RR. about 1,000 ft. south of I-495 west of Mt. Hebron Park Subdivision.

AN-7 Outcrops in gully south of Chamblis Street bicycle path (Alexandria City)

AN-8 Cuts on south side of Cherokee Road about 900 ft. southwest of Cherokee Run.

FORT BELVOIR QUADRANGLE

FB-1 Cuts on access road to R.,F.,& P. RR. on east side of overpass of Pohick Road, Va. #638.

FB-2 Cuts along R.,F. & P. RR. 0.5 mi. north of underpass at Newington.

FB-3 Outcrops on west side of Silver Brook Road near junction with Lorton Road.

FB-4 Cut along R. F. & P. RR. 0.3 mi. south of Lorton Road.

FB-5 Cut along R. F. & P. RR. 0.6 mi. south of Lorton Road.

FB-6 Cuts on east side of U. S. No. 1, 0.2 mi. southwest of junction with Pohick Road, Va. #638.

FB-7 Cuts on northeast side of U. S. Govt. R. R. (Ft. Belvoir Mil. Res.), about 1 mi. NE. of U. S. No. 1 at Accotink.

FB-8 Ditch exposures along dirt road to Massey Cr. from Belmont Blvd., west side of Mason Neck.

FB-9 Bluff behind newly constructed (11/75) warehouses, west side of Telegraph Road, 0.3 mi. north of U. S. No. 1.

FB-10 Outcrops along service road on east side of dump on east side of Furnace Road about 1.4 mi. south of Lorton.

FB-11 Unmapped borrowed pit about 800 feet east of Furnace Road, 0.7 mile southeast of Lorton.

FB-12 Cuts on northeastern part of gravel pit southwest of Backlick Road, Va. 617, 0.3 mile northwest of Telegraph Road, Va. #611.

FB-13 Cut behind house, on east side of U. S. No. 1 about 0.5 mile southwest of junction with Gunston Road, Va. #242.

FB-14 Cuts along abandoned road to Gunston Cove, southeastern part of Ft.

FB-16 Outcrops in banks and ditch of dirt road to west in southwestern part of Ft. Belvoir Military Reservation, about 1 mile west-southwest of Accotink.

FB-17 Outcrops near junction of dirt roads in southwestern part of Ft. Belvoir Military Reservation, about 1.8 mile west-southwest of Accotink.

FB-18 (A) Cuts along dirt road to south southwest in southwestern part of Ft. Belvoir Military Reservation about 0.8 mile southwest of Accotink.

~~(B)~~ ~~Landfill~~ cut about 1,000 ft. north of A.

FB-19 Outcrops near road and bleachers in southwestern part of Ft. Belvoir Military Reservation, about 1.9 mile southwest of Accotink.

FB-20 Gravel pit in southeastern part of Ft. Belvoir Military Reservation about 1.2 mile south southeast of Accotink.

FB-21 Ditch exposures along dirt road in northeastern part of Ft. Belvoir Military Reservation about 1.8 mile north northeast of Accotink.

OCCOQUAN QUADRANGLE

OC-1 Cuts on northwest side of Lorton Road about 800 ft. east northeast of junction with Ox Road.