AN INVESTIGATION OF THE RELATIONSHIP BETWEEN ROCK STRUCTURE AND DRAINAGE IN THE SOUTHERN HALF OF THE JUNCTION CITY, KANSAS, QUADRANGLE

by

WILLIAM MOECKER BAEHR

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INTRODUCTION

Purpose and Location

The purpose of this investigation is an attempt to find a relationship between rock structure and drainage in a given area. The area investigated is the southern half of the Junction City quadrangle, Kansas. This area embraces major portions of Riley and Geary counties and small portions of Clay, Dickinson, Pottawatomie, and Wabaunsee counties. A total of 460 square miles is involved.

Preliminary Note

Various students of geology have noticed in many instances, that streams appear to be influenced in their courses by the structure over which they flow. If one looks at a drainage pattern of a given locality, it is sometimes quite apparent that some of the streams appear to show structural control.

Chamberlin and Salisbury (1904), p. 120, mentioned monoclinal shifting; a stream flowing parallel to the strike is observed to develop its valley not vertically, but in the direction of dip. Campbell (1896), p. 661, stated that in a region of tilt the minor drainage lines will arrange themselves at right angles to the axis of uplift and the major streams will flow parallel to the rising fold.

Cole (1930), p. 433, noted that joint structure may produce meanders as well as a rectangular drainage pattern. Streams which are cutting a set of master joints at right angles will meander, while those flowing parallel to the master joints and normal to another set of joints almost as strong as the master set, will flow in a rectangular pattern. Zernitz (1932), p. 521, remarked that the importance of drainage patterns exceeds the attention devoted to them, though inferences regarding the geology made from drainage patterns should be regarded merely as tentative until further corroborated.

Upon observing the drainage pattern of the southern half of the Junction City quadrangle, the writer was of the opinion that a definite relationship could be found between rock structure and drainage. This opinion was based upon the observation of several common drainage pattern types, along with areas exhibiting a decided asymmetrical drainage pattern.

Topography

The relief of the southern half of the Junction City quadrangle is approximately 500 feet. The highest point, in the southeast corner of the quadrangle, is almost 1,500 feet above sea level. The lowest point is the surface of the Kansas river, east of Manhattan, and is about 1,000 feet above sea level.

The topography of the quadrangle's southern half consists of three types; the high uplands, the major stream valleys, and the broken hilly country which lies between the boundaries of the uplands and the valley floors. The last type of topography includes the Flint Hills.

The high uplands or prairies are generally above the Fort Riley limestone member. They are described as the dip slopes of the limestone strata, though usually they are covered by a shale layer. Streams have carved through the thick shale, turning the upland surface into a rolling plateau.

The main stream valleys are those through which flow the Kansas Republican, Smoky Hill, and Blue rivers. These streams, on a physiographic basis, may be described as being of mature age. They have a typical meandering course, along which lie oxbow lakes and swamps. The valleys are from 1 to 4 miles wide. The smaller streams have valleys from .25 to .5 miles in width. Most of their deposits are colluvium, which result from downwash from the valley walls.

Bluffs from 50 to 200 feet high form the valley walls. Near Ogden and Manhattan however, Pleistocene terraces are present. They are thought to be of glacio-fluvial or lacustrine origin. Loess deposits also modify the valley walls here, producing an appearance similar to the rolling uplands (Jewett, 1941).

The Fort Riley limestone member contains a massive resistant layer. Since its regional dip in the quadrangle is to the west, the major limestone outcrops lie to the east of the high uplands. Where the more resistant Fort Riley has been destroyed by weathering, the underlying strata weather to steeply terraced slopes, forming the Flint Hills, which make up the third type of topography in the area.

Regional Structure

In the Midcontinent region, west of the Ozark dome, outcropping Pennsylvanian and Permian rocks dip westward at a low angle, forming a structure called the Prairie Plains homocline. The two rock systems form long parallel outcrop belts which stretch in an uninterrupted manner from southeastern Nebraska, through Kansas, and into south-central Oklahoma.

The Nemaha anticline, which may be considered as being part of the Prairie Plains homocline, is a buried structure of basement granite. It extends southward as a narrow belt from southeastern Nebraska across Kansas into central Oklahoma. In places on the Nemaha anticline basement rocks lie within

500 feet of the surface; or at altitudes surpassing 600 feet above sea level, though in the Midcontinent region they generally lie 3,000 feet below sea level and are covered by 4,000 feet or less of sediments.

The Midcontinent region is divided by the Nemaha anticline into two basins, the Forest City on the east and the Salina on the west. In the Forest City basin rocks of Pennsylvanian age and older descend in a long regional slope across northwestern Missouri and most of Iowa to a low point near the common corner of Nebraska, Kansas, and Missouri. In the Salina basin the rocks descend across Nebraska to a low point in north-central Kansas (King, 1951, p. 470). The basement rock in the Salina basin stands 2,000 feet or more below its position on the anticline.

The Salina basin is a pre-Pennsylvanian syncline, bounded on the southwest by the central Kansas uplift, on the east by the Nemaha ridge, and on the south by a saddle between the Chautauqua arch and the Central Kansas uplift. The basin extends northward into Nebraska (Barwick, 1928). The Junction City quadrangle lies on the east flank of this basin.

A rather pronounced fold west of, and practically parallel to the Nemaha anticline, is known as the Abilene anticline. It passes through the northwest corner of the southern half of the Junction City quadrangle, extending southward into Dickinson county. The beds dip steeply on its southeastern side, but gently on the northwest. The northern extension of the anticline is called the Barneston anticline and extends through Marshall county up into Nebraska (Jewett, 1951).

A synclinal fold east of the Abilene anticline and west of the Nemaha anticline is known as the Irving syncline. It extends from the Riley-Marshall county line northward a short distance into Nebraska.

In the Junction City quadrangle's southern half, the regional dip of the rock strata is almost due west, trending slightly to the northwest. At the western edge of the area the dip experiences a slight reversal, due to the zone of flexures and faulting called the Abilene anticline. The average or regional dip of the area is about 17 feet per mile. As the Nemaha anticline is approached the regional dip increases (Archer, 1951).

Stratigraphy

The stratigraphy of the region under investigation is made up largely of Permian strata. These strata alternate between thick layers of easily eroded shale and thinner layers of more resistant limestone. Upon erorsion of the shale, prominent limestone benches or terraces are left.

The list that follows is the stratigraphic nomenclature for the area of the southern half of the Junction City quadrangle.

- Quaternary system
  - Recent and Pleistocene series
    - Loess, fluvial or lacustrine terraces

- Permian system
  - Wolfcamp series
    - Chase group
      - Nolans limestone
        - Herington limestone member
        - Paddock shale member
        - Krider limestone member
      - Odell shale
      - Winfield limestone
        - Cresswell limestone member
        - Grant shale member
        - Stovall limestone member
      - Doyle shale
        - Gage shale member
        - Towanda limestone member
        - Holmesville shale member
      - Barneston limestone
        - Fort Riley limestone member
        - Oketo shale member
        - Florence limestone member

Matfield shale
Blue Springs shale member
Kinney limestone member
Wymore shale member
Wreford limestone
Schroyer limestone member
Havensville shale member
Threemile limestone member
Council Grove group
Speiser shale
Funston limestone
Blue Rapids shale
Crouse limestone
Easly Creek shale
Bader limestone
Middleburg limestone member
Hooser shale member
Eiss limestone member
Stearns shale
Beattie limestone
Morrill limestone member
Florena shale member
Cottonwood limestone member
Eskridge shale
Grenola limestone
Neva limestone member
Salem Point shale member
Burr limestone member
Legion shale member
Sallyards limestone member
Roca shale
Red Eagle limestone
Howe limestone member
Bennett shale member
Glenrock limestone member
Johnson shale
Foraker limestone
Long Creek limestone member
Hughes Creek shale member
Americus limestone member
Admire group
Hamlin shale
Oaks shale member
Houchen Creek limestone member
Stine shale member
Five Point limestone
West Branch shale
Falls City limestone

The total thickness of the Permian system which outcrops in this area is near 690 feet (Jewett, 1941).

MATERIAL AND METHODS

Topographic Maps

Eight accurate topographic maps covering the southern half of the Junction City quadrangle were used as the basis for all map work done in the area. These maps were prepared by the Army Map Service, Washington, D. C., and edited and published by the United States Geological Survey.

Each of the maps covers an area 7 minutes and 30 seconds by 7 minutes and 30 seconds. The topography was taken from aerial photographs by multiplex methods. The photographs were taken in 1947 and field checked in 1949. The scale of each map is 1:24,000, the contour interval is 20 feet. Editions of 1950 and 1951 were utilized by the author. Since the scale of these maps is sufficiently large, an excellent representation of the drainage systems is indicated. Besides topography and drainage, these maps also show the towns located in the area, roads, section lines, buildings, and political boundaries.

Drainage Map

In order to make a study of the drainage systems and patterns of the area, a drainage map was constructed. The drainage was traced directly from the topographic sheets unto tracing paper. Both intermittent and perennial streams were included on the tracing. All reservoirs and man-made channels were also included.

The traced copy of the drainage system of the locality was reduced photographically to a scale of 1:48,000. A tracing was then made of the photographic reduction, additional data were added, and finally, an ozalid copy produced. This last copy includes various data collected in the field.

Structural Map

Structural contour lines superimposed on the drainage map were obtained from a structural contour map of the region drawn in 1951 (Archer, 1951). The contour interval shown by these lines is ten feet. The contours were drawn by using the Fort Riley limestone member as the key bed. Other structural data placed on the drainage map consists of joint, dip, and strike data observed in the field by the author.

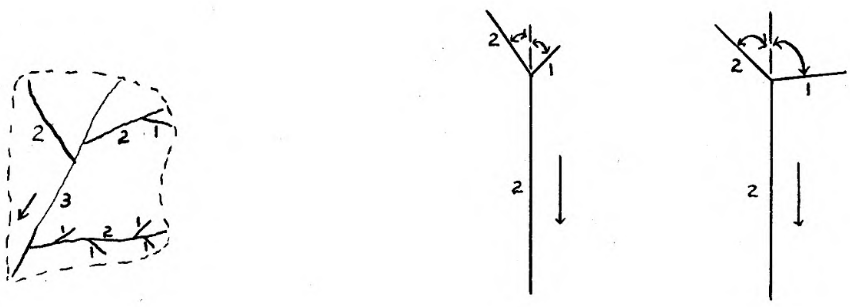
Tables and Graphs

It was decided that one helpful way of analyzing drainage behavior would be by the study of certain tables and graphs. Consequently, several tables and a variety of graphs and cross sections were constructed, using information gleaned from the eight topographic sheets.

Drainage Basins; Horton's Method of Analysis

To aid in the analyzing of local drainage basins, a method suggested by Horton (1945) was employed. This method consists of recording various measurements of the streams within the basin and then studying these measurements by algebraic or graphical means. According to Horton, the method has shown promise in relating drainage and structure (Horton, 1945, p. 303).

In studying a given drainage basin by Horton's method, each stream or branch in the basin, both perennial and intermittent is taken into account. The streams in each basin are first classified as to their order. In assigning an order to a stream the smallest tributaries, those having no branches, are classified as first order. Second order streams would then have one branch or group of tributaries; third order streams would have tributaries of second order streams, etc. The following figure will aid in making this clear:



(a) (b-1) (b-2)

Fig. 1

The figure represents a drainage basin whose main stream is of the third order. As shown in (a), streams marked "1" are of first order, since they receive no tributaries and flow into second order streams. Those streams numbered "2" are of second order, since they flow into a third order stream.

In determining parent and tributary stream one extends the parent stream upstream, as shown in (b-2). The stream joining the parent at the greatest angle is the tributary of lower order. If both streams are at the same angle to the parent, as in (b-1), the shorter is taken as the lower order.

After the order of each stream has been obtained, the numbers of streams of different orders are counted and recorded. Thus in Fig. 1 (a) there is one stream of third order, three of second order, and five of first order. When the number of streams of each order has been ascertained, the bifurcation ratio may be computed. This is a ratio of the average number of branchings or bifurcations of streams of a given order to that of streams of the next lower order. Thus $r_b = n_3/n_2$ where n_3 equals the average number of branchings of streams of the third order and n_2 equals the average number of branchings of streams of the second order. Referring again to Fig. 1 (a), one notes that the average number of branchings of third order streams is 3, of second order streams is 5/3, where 5/3 = (0 ≠ 1 ≠ 4 branchings) /3 streams. Hence, $r_b = \frac{3}{5/3}$.

In Horton's analysis the following law was used: the numbers of streams of different orders in a given drainage basin tend closely to approximate an inverse geometric series, in which the first term is unity and the ratio is the bifurcation ratio (law of stream numbers, Horton, 1945, p. 291). This may be stated in a simplified form as follows: $N_0 = r_b\ (s-0)$, where:

N_0 = the number of streams of a given order.

r_b = the bifurcation ratio.

s = the order of the main stream in the basin (highest order).

o = given stream order.

To study the drainage basin further use is made of the law of stream lengths (Horton, 1945, p. 291): the average lengths of streams of each of the different orders in a drainage basin tend closely to approximate a direct geometric series in which the first term is the average length of streams of the first order. The simplified algebraic equivalent is: $l_a = l_1 r_1 (0-1)$, where:

l_a = the average length of streams of a given order.

l_1 = the average length of streams of first order.

r_1 = the stream length ratio. This is a ratio of the average length of streams of a given order to that of streams of the next lower order.

0 = given stream order (as in stream number formula).

In measuring the average lengths of the different streams within the basin, all tributaries of a given order are measured. These lengths are added together and the sum divided by the total number of streams of that particular order. The final answer then is the average stream length for the given order.

To clarify the analysis of the drainage basins, the number of streams in a basin is plotted versus the orders on a sheet of semilogarithmic graph paper. This same procedure is continued by plotting the average stream lengths versus the stream orders.

Joint Data

In collecting joint data, the trend of the major and minor sets of joints was noted at different spots in the three drainage basins. Since so few readings were taken and since the trend of the major joint set appeared reasonably constant, no rigorous statistical analysis was made of these data. An average reading was merely taken for each spot under examination.

Structural Cross Section

Geologic sections are vertical cross sections of the underground structure as it is thought to exist from data obtained from outcrops, artificial excavations, and bore-hold data. Geologic structure is shown by means of certain conventional lines, patterns, or colors.

The line of intersection of the land surface with the plane of the geologic section as shown on a map, is called the line of section (Lahee, 1941, p. 610). It is along this line that the geologic section is constructed.

In constructing a geologic section a base section is made upon which the structural features may be drawn. A profile base section consists of a lower horizontal line, two vertical end lines, and an upper profile line which represents the intersection of the geologic section with the land surface.

Within the geologic section all lines representing structure are drawn. Between these lines the rocks or formations are either labeled or filled in by using conventional colors or patterns.

Dip and Strike Determination. In determining the dip and strike of the rock strata the three point method was employed. When using this method, it is assumed that three points determine a plane, rather than merely lying on a curved surface. Upon determination of the attitude of the plane, its strike and dip can then be easily found.

The process undertaken in the three point method is carried out through the following steps: first, a certain stratigraphic horizon, such as the top of a formation, is picked out; secondly, three points lying on this horizon are located and their relative elevations established; thirdly, the dip and strike are found by the application of the tangent vector method.

To carry out the first two steps an aerial photograph was obtained covering each local drainage basin investigated. Upon arriving in the field a point of rock outcrop was found and located on the photo. From this point two other points were sighted on the same stratigraphic horizon and their locations established on the photo. In locating these points on the photo a Brunton compass was at certain times of valuable assistance.

The establishment of the relative elevations of the three points was carried out by means of a hand level and measuring rod. Upon arriving at the first outcrop point its rod elevation was established from a level shot by means of the hand level. Next the rod elevations of the other two outcrop points, with respect to the elevation of the first, were also obtained from a level shot making use of the hand level. The following diagram may be of assistance in regard to this operation:

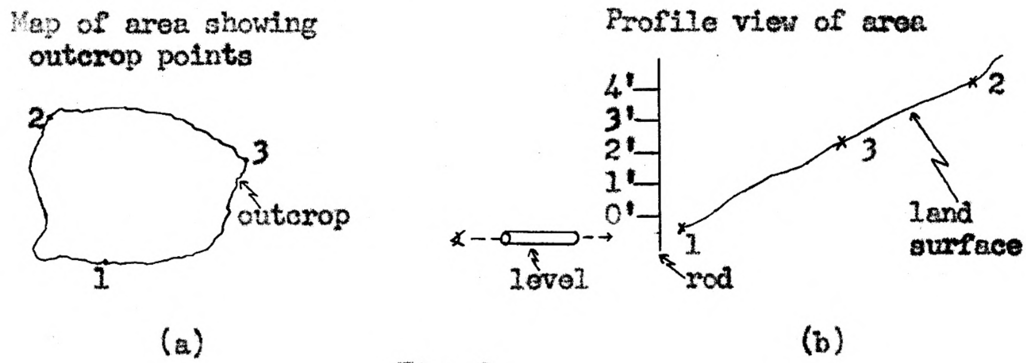


Fig. 2

The observer stands in the vicinity of point 1, takes a level shot with the hand level of point 1, and finds its height on the rod which is placed nearby. Still remaining in the near vicinity level shots of points 2 and 3 are taken and their heights ascertained on the rod. In Fig. 2 (b) then, a relative elevation of 0 feet for point 1, 4 feet for point 2, and 2 feet for point 3 is found.

When using the hand level in the above procedure a five foot stake was always used by way of supporting and steadying it. This was done to help the level bubble come to rest quickly, especially when the wind was blowing.

The third step of actually obtaining the dip and strike is carried out by a practical application of the principles of trigonometry. One proceeds as follows:

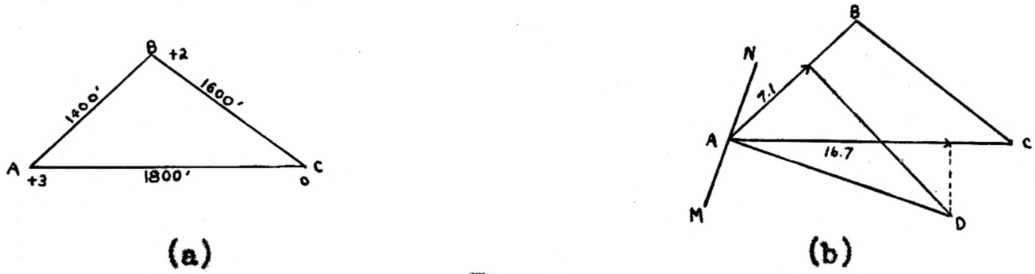


Fig. 3

In Fig. 3 (a), the horizontal distance between the three points is measured by using the scale of the photo. The apparent dips for two sides of the triangle are next calculated and expressed as tangent functions. Thus for leg AB, 1 ft./1,400 ft. or .00071 and for AC, 3/1,800 or .00167 is obtained. The next step is shown in Fig. 3 (b), where AB has a vector of 7.1 units laid off on it and AC a vector of 16.7 units. Perpendiculars are drawn to AB and AC and their intersection located. The true dip is now shown as being in the direction AD and the amount of dip is equal to the number of units on AD. The strike is a perpendicular line to AD shown in the figure as MN.

(The transferring of the dip and strike data from a map to a geologic structural cross section is a rather involved procedure. Therefore, the author omits an exposition of this subject. The reader is referred to Lahee (1941, pp. 613-626) for an outline of this procedure.)

Stratigraphic Interval. In each of the three drainage basins investigated rock outcrops were found in the field and the stratigraphic interval was measured between the various horizons, such as members or formations. It was intended that the measurement begin with the bottom of the highest member and proceed to the top of the lowest member outcropping in the area of the drainage basin.

Intervals were taken using a hand level and measuring rod. It was assumed in measuring the intervals that the beds within each area remained at a constant thickness and were essentially horizontal.

Use of Topographic Data. To draw the upper profile line in a geologic section, perpendiculars are dropped from the line of section located on the map onto a vertical scale. The perpendiculars are dropped wherever a topographic contour line crosses the line of section. The vertical scale which also makes up the vertical scale of the geologic section determines how far the perpendiculars are dropped. Figure 4 shows how this is carried out.

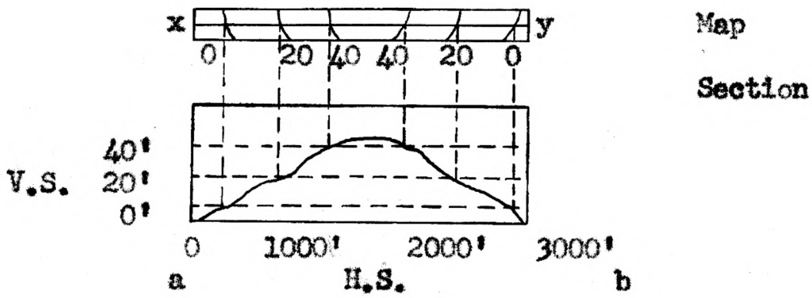


Fig. 4

<u>Assembly</u>. In assembling a geologic section the data listed under the preceding three subheadings are grouped together.

By using the topographic data, a profile line can be drawn which is the upper boundary of the geologic section. Contact lines which depict the structure and represent the various rock units are next drawn in, their attitude and position depending on the dips and stratigraphic intervals of the various rock strata. Finally, the proper rock labels or symbols are filled in completing the section. Figure 5 gives an illustration of an idealized geologic section.

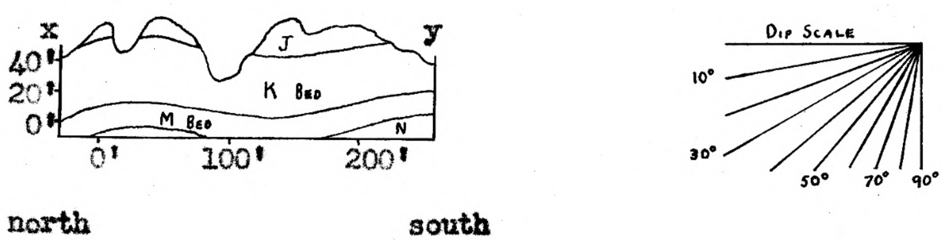


Fig. 5

EXPERIMENTAL WORK

Stream Measurements

In carrying out the investigation of a relationship between structure and drainage, several means which might aid in this respect were utilized.

It was first decided to make various measurements of the main streams in the area being investigated, in the hope that some pattern of behavior might thereby be observed which would show the evidence of structural control. With this in mind, nine of the largest streams in the quadrangle were selected on which to run a series of measurements.

The nine streams chosen, consisted of the Kansas River, the Smoky Hill river, the Republican river, the Big Blue river, Clark creek, McDowell creek, East McDowell creek, Humboldt creek, and Wildcat creek. As shown by the map (Plate V) it can readily be seen that all of the above mentioned streams are part of the Kansas river drainage basin. The Republican and Smoky Hill rivers flow into the Kansas river directly northeast of Junction City while the Big Blue river enters the Kansas straight east of Manhattan. McDowell creek flows into the Kansas about three miles south of Manhattan. Clark creek enters it about two miles south of Ogden on the Riley-Geary county line. Wildcat creek, another tributary, enters the Kansas river immediately south of Manhattan.

East McDowell creek is as its name implies, a tributary of McDowell creek. East McDowell is located in the southern portion of the Swede Creek (7½ minute series) quadrangle. Humboldt creek flowed into Clark creek in the southwest part of the Ogden (7½ minute series) quadrangle.

The measurements taken of the streams included the following: 1. length of channel, 2. length of floodplain, 3. gradient of stream, 4. gradient of floodplain, 5. average width of meander belt, 6. average width of floodplain, and 7. average width of stream (only taken of four largest streams).

The first measurement, the channel length, is the total length of the stream's channel as shown in the Junction City quadrangle's southern half. Thus, the Smoky Hill was measured from its mouth to the point where it left the south edge of the quadrangle.

The floodplain length is the length traversed by the meander belt and is consequently shorter than the channel length. The stream gradient is the ratio of the change in elevation the stream undergoes in its travels divided by its channel length. The floodplain gradient is similar to the stream gradient, except that the floodplain length is used in place of the channel length.

The meander belt width is an average for several readings taken at various places in the stream's course. The floodplain width and stream width are likewise such averages.

A résumé of the above measurements is listed below in Table 1.

Table 1. General stream measurements.

	Channel length	Floodplain length	Stream gradient	Floodplain gradient
Kansas	31.3 mi.	21.0 mi.	1.9 ft./mi.	2.9 ft./mi.
Smoky Hill	9.6	4.2	2.1	4.8
Republican	24.7	21.7	2.4	2.8
Big Blue	9.0	5.1	2.2	3.9
Clark	15.5	6.4	3.2	9.4
McDowell	27.0	11.8	7.4	16.9
East McDowell	5.0	3.3	16.0	24.2
Humboldt	7.7	4.5	13.0	22.2
Wildcat	25.5	14.0	7.8	14.3

	Meander belt width (av.)	Floodplain width (av.)	Stream width (av.)
Kansas	7125 ft.	9697 ft.	375 ft.
Smoky Hill	6000	7250	150
Republican	5000	7514	250
Big Blue	6625	8958	233
Clark	2586	4000	
McDowell	1738	2667	
East McDowell	400	1750	
Humboldt	2033	2438	
Wildcat	1000	2659	

A perusal of Table 1 brings to light some interesting facts. The Kansas river had less channel length per length of floodplain than such small streams as Clark, McDowell, and Wildcat creeks. Accordingly, a look at the drainage map (Plate V) reveals a large number of meanders on these small streams. Though the Kansas river is supposedly an older stream, it does not have as many meanders as its smaller tributaries. Its meander belt is wider however, compared to its floodplain width than in the case of these small streams.

The stream or channel widths of the Smoky Hill and Big Blue rivers were about 1/40th of their Meander belt widths. The Kansas and Republican rivers had stream widths about 1/20th of their meander belt widths. The floodplain gradients of the Smoky Hill and Big Blue rivers were also greater than those of the Kansas and Republican rivers.

A group of graphs were plotted on ordinary coordinate paper using the various measurements of the streams as abscissas and ordinates. Some of these plots suggested possible relationships between these measurements.

Plate I shows a plot of the stream gradient versus the meander belt width. The curve drawn resembles a natural, i.e., a logarithmic curve. This would signify the two quantities are interrelated.

Again, on Plate I, the stream gradient is plotted against the floodplain gradient. Here again, a natural type curve is produced. The same type of curve is also shown in the plot of stream gradient versus floodplain width.

A curve drawn through the plot of meander belt width versus floodplain width in Plate I implies a direct relationship between these two quantities.

Stream Valley Cross Sections

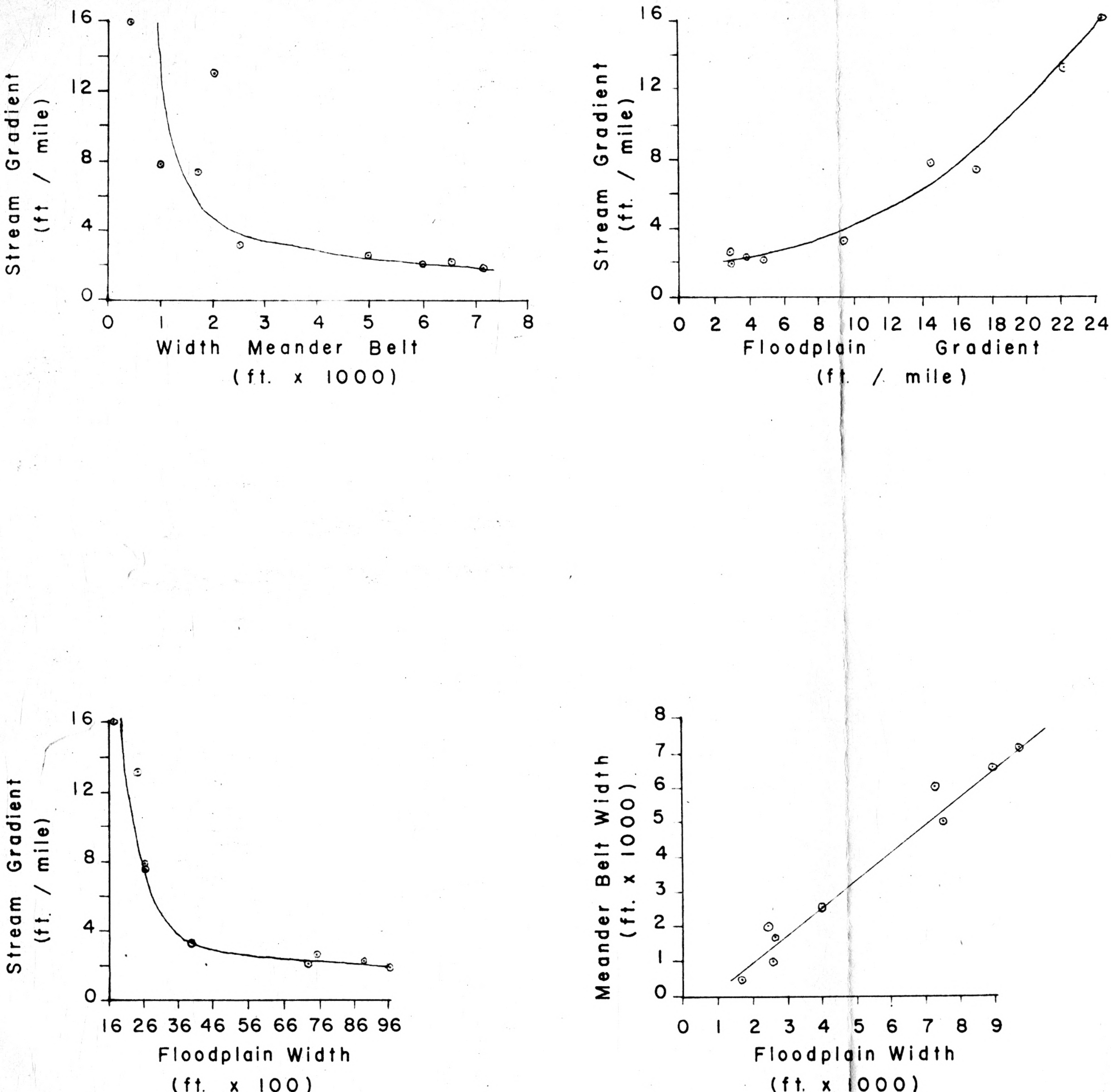
An undertaking carried out to further assist in the analysis of streams was the construction of stream valley cross sections. The cross sections were taken at different places along the stream's courses and are shown in Plate II. These cross sections were of assistance in measuring the widths of the floodplains.

Upon observing the cross sections in Plate II, it can be seen that the larger streams have in general a transverse floodplain profile of a broad flat nature, while the smaller streams have floodplain profiles showing a greater slope. Both the large and small streams do, in a general way, show the same transverse slope for their valley walls.

EXPLANATION OF PLATE I

Plots of various stream measurements listed in Table 1.

PLATE I


Stream Gradient
(ft. / mile)
0
4
8
12
16
0
1
2
3
4
5
6
7
8
Width Meander Belt
(ft. x 1000)
Stream Gradient
(ft. / mile)
0
4
8
12
16
0
2
4
6
8
10
12
14
16
18
20
22
24
Floodplain Gradient
(ft. / mile)
Stream Gradient
(ft. / mile)
0
4
8
12
16
16
26
36
46
56
66
76
86
96
Floodplain Width
(ft. x 100)
Meander Belt Width
(ft. x 1000)
0
1
2
3
4
5
6
7
8
0
1
2
3
4
5
6
7
8
9
Floodplain Width
(ft. x 1000)

EXPLANATION OF PLATE II

Transverse cross sections showing the topography at various places along the different stream valleys. Vertical and horizontal scales are in feet.

t = tributary

s = stream

PLATE II (a)

HUMBOLDT CREEK

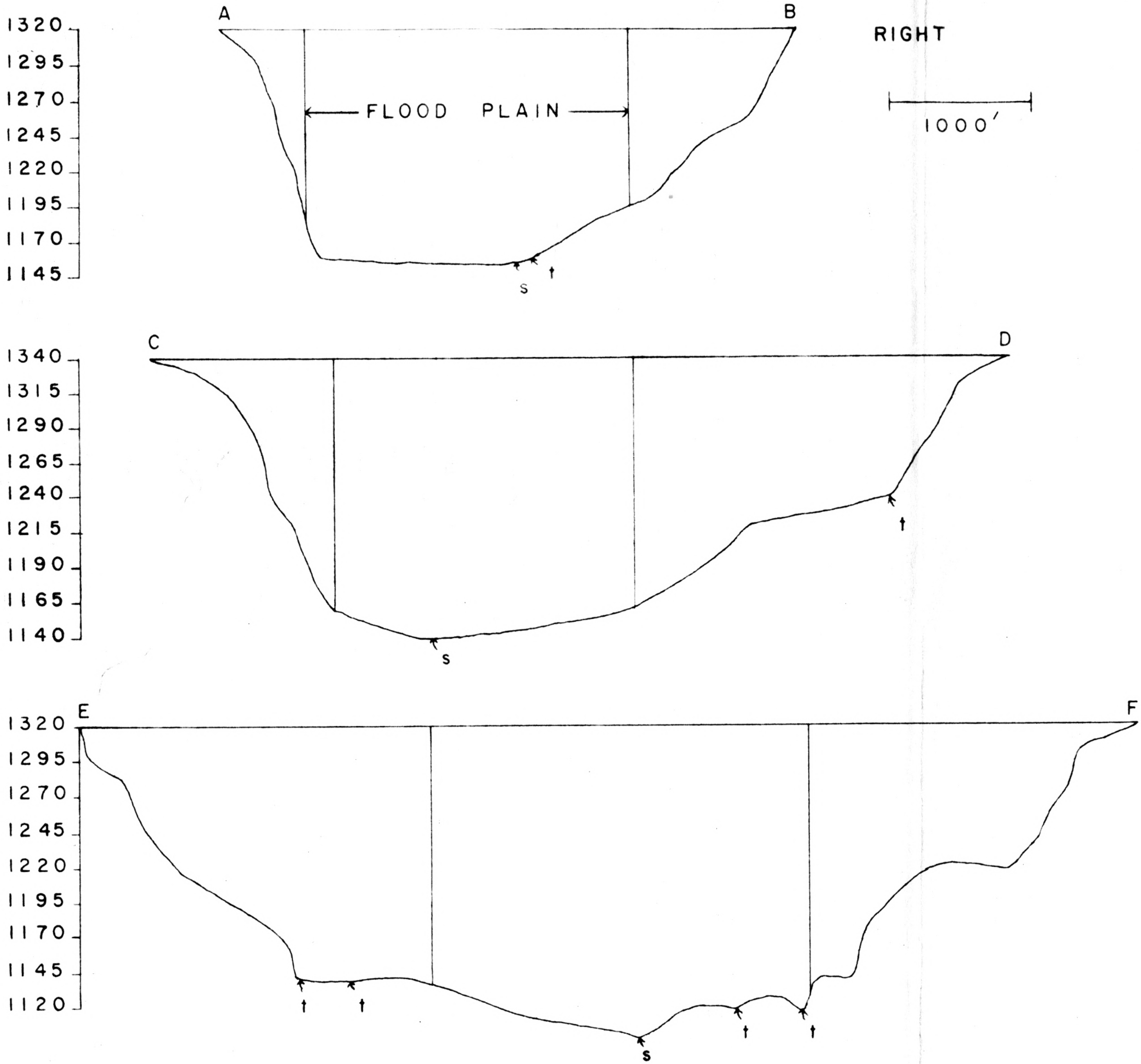
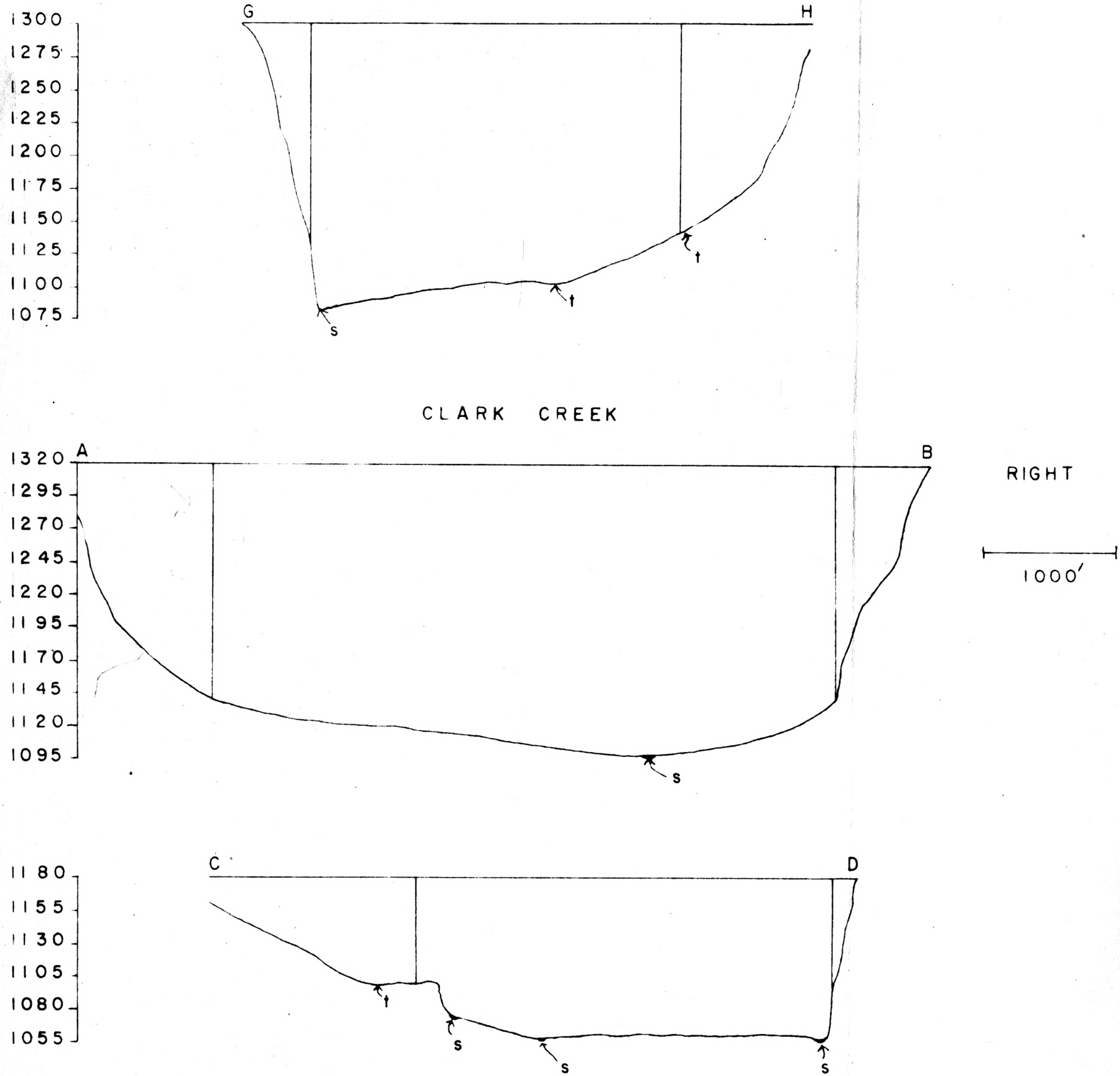
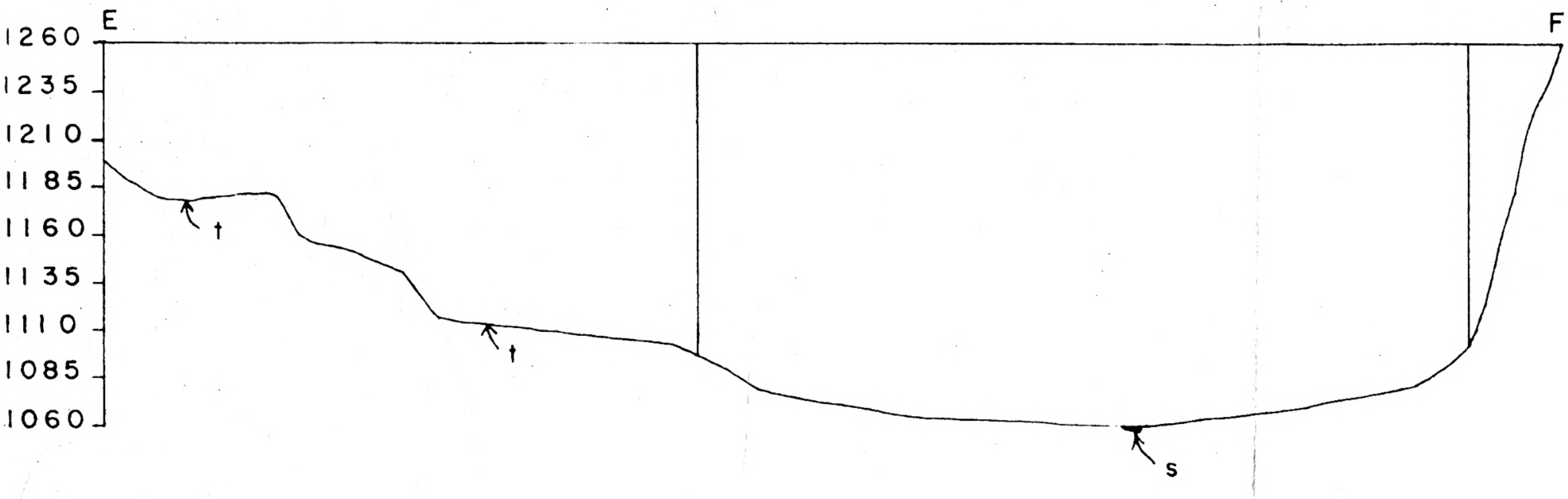
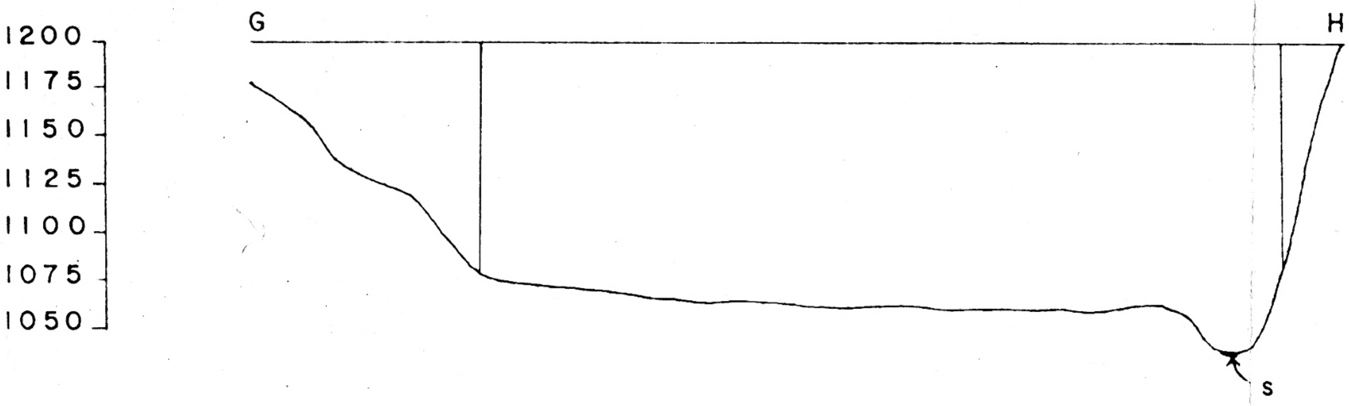


PLATE II (b)


G
H
1300
1275
1250
1225
1200
1175
1150
1125
1100
1075
t
t
s
CLARK CREEK
A
B
RIGHT
1000′
1320
1295
1270
1245
1220
1195
1170
1145
1120
1095
s
C
D
1180
1155
1130
1105
1080
1055
t
s
s
s





MCDOWELL CREEK

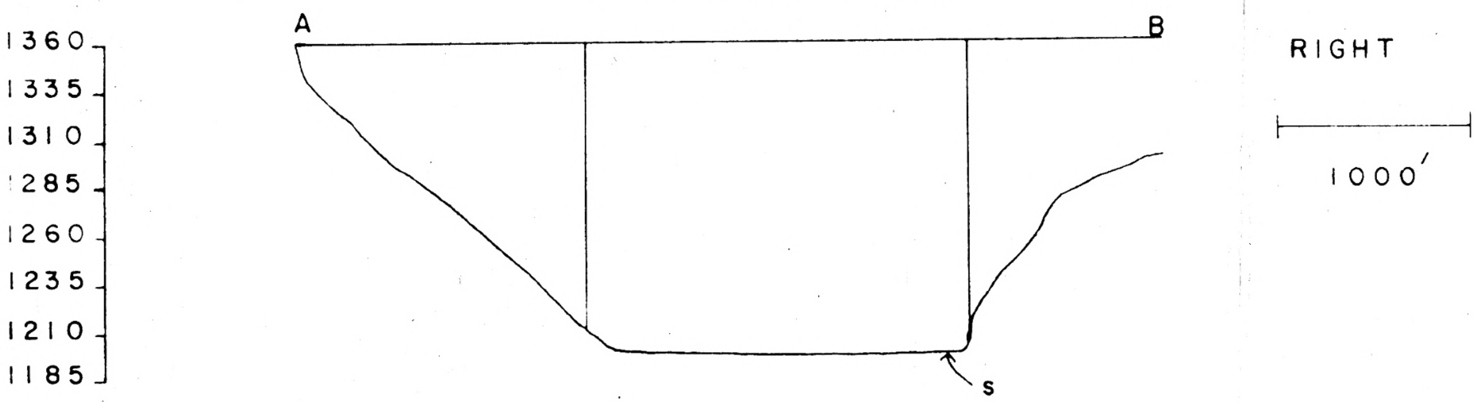
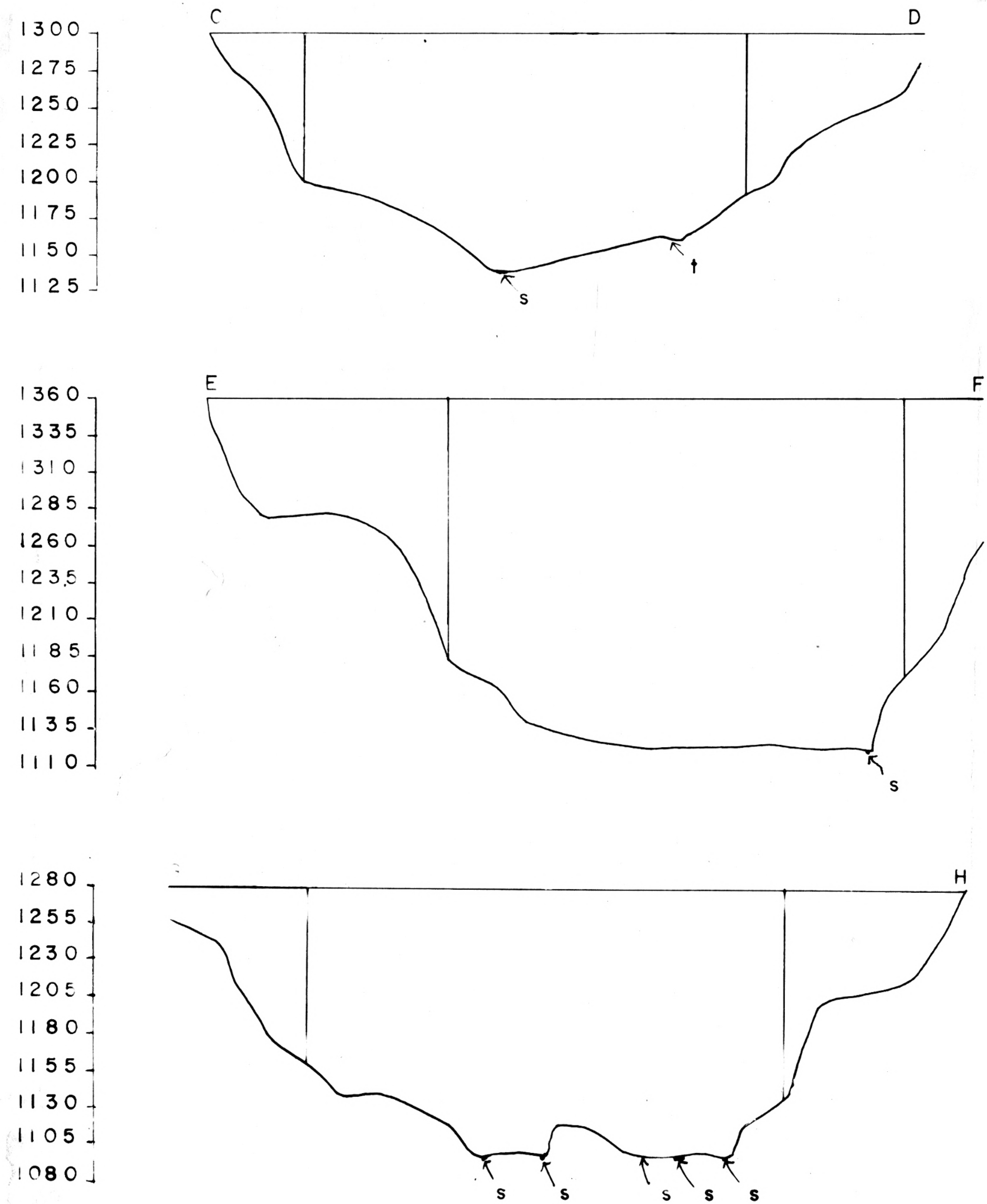
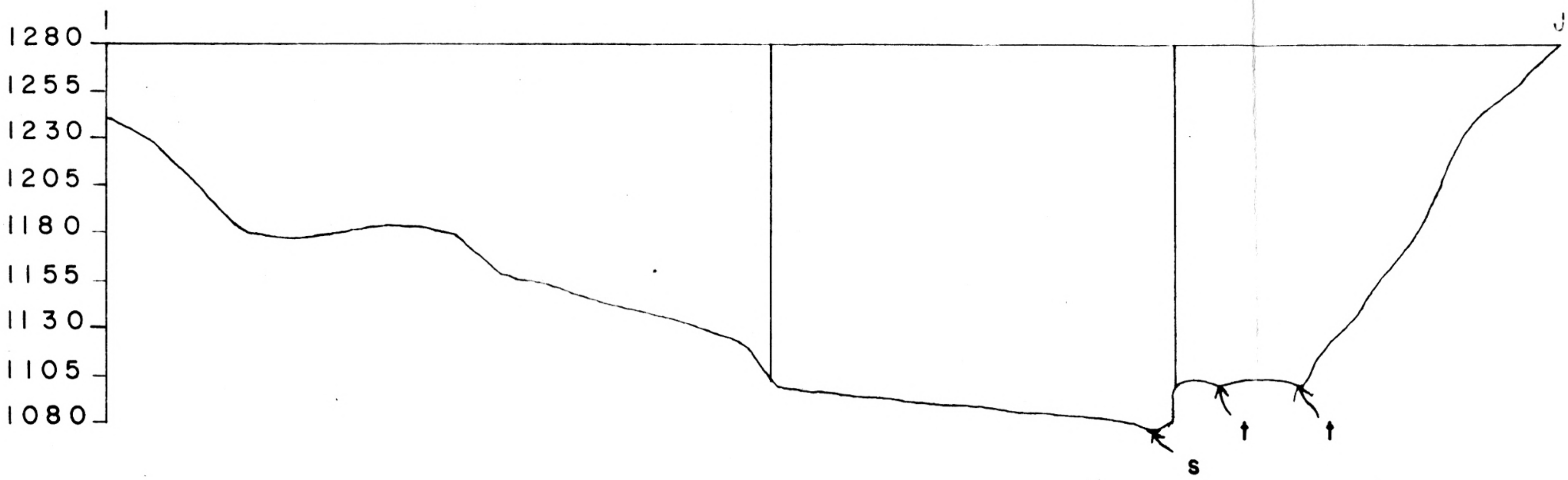
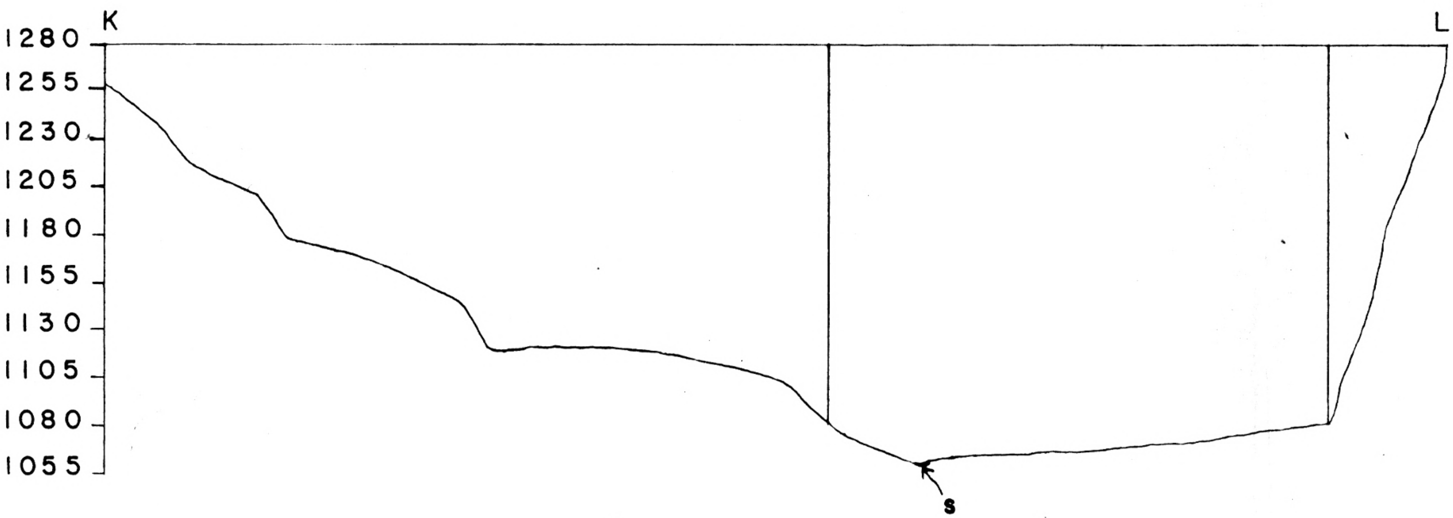


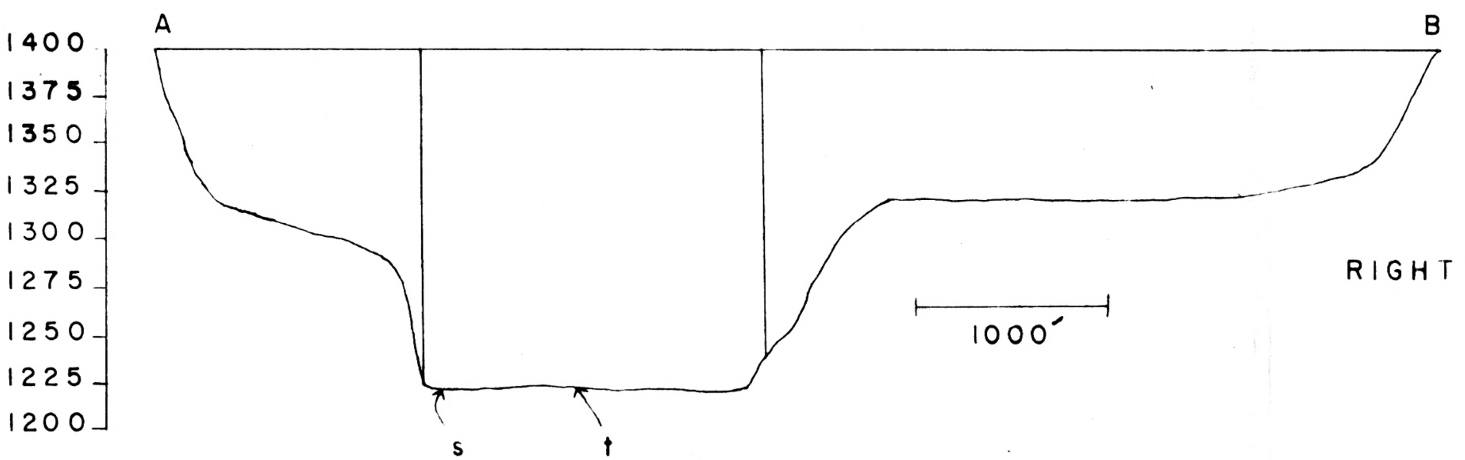
PLATE II (d)


C
D
1300
1275
1250
1225
1200
1175
1150
1125
s
t
E
F
1360
1335
1310
1285
1260
1235
1210
1185
1160
1135
1110
s
H
1280
1255
1230
1205
1180
1155
1130
1105
1080
s
s
s
s
s





EAST MCDOWELL CREEK



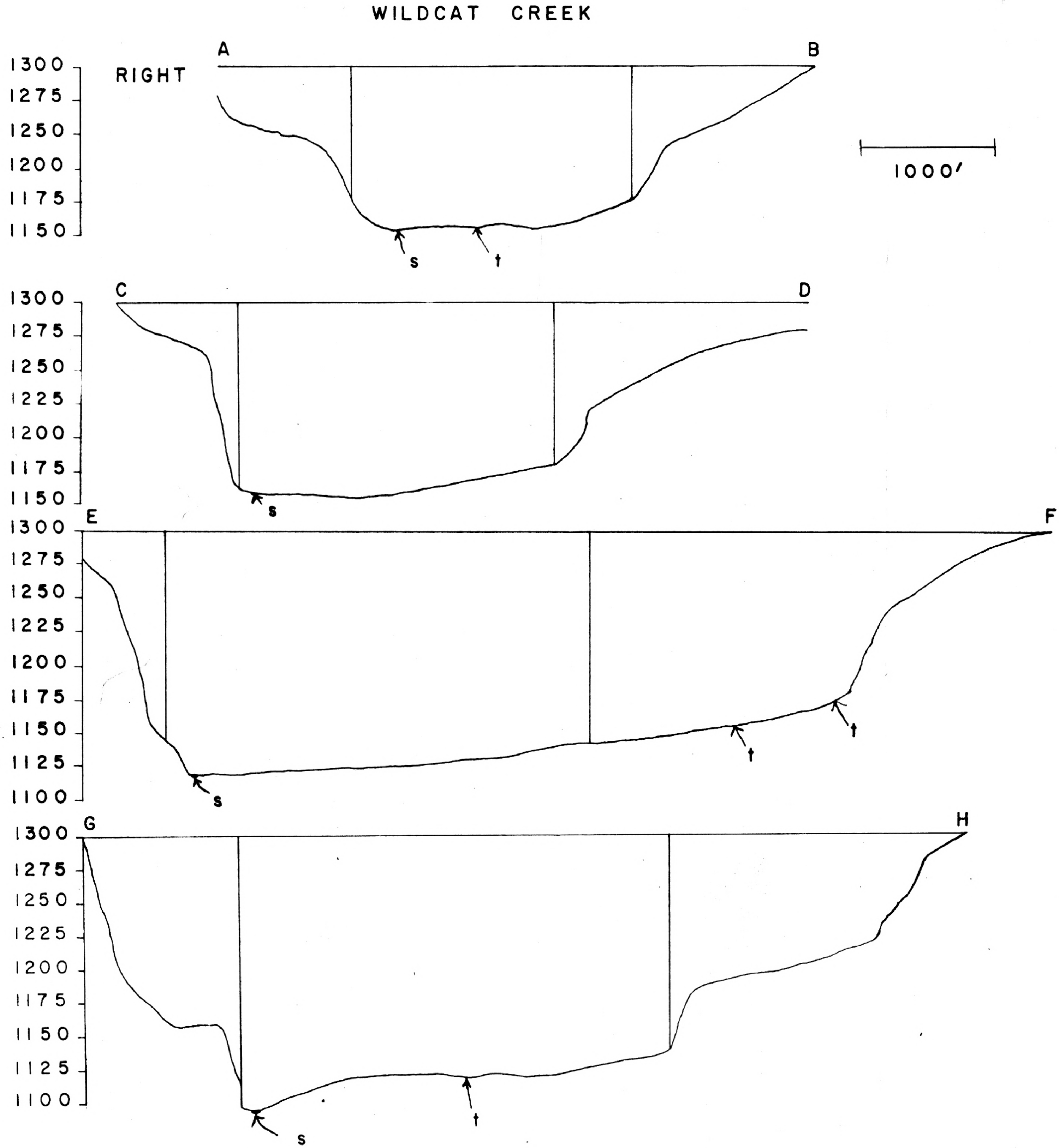
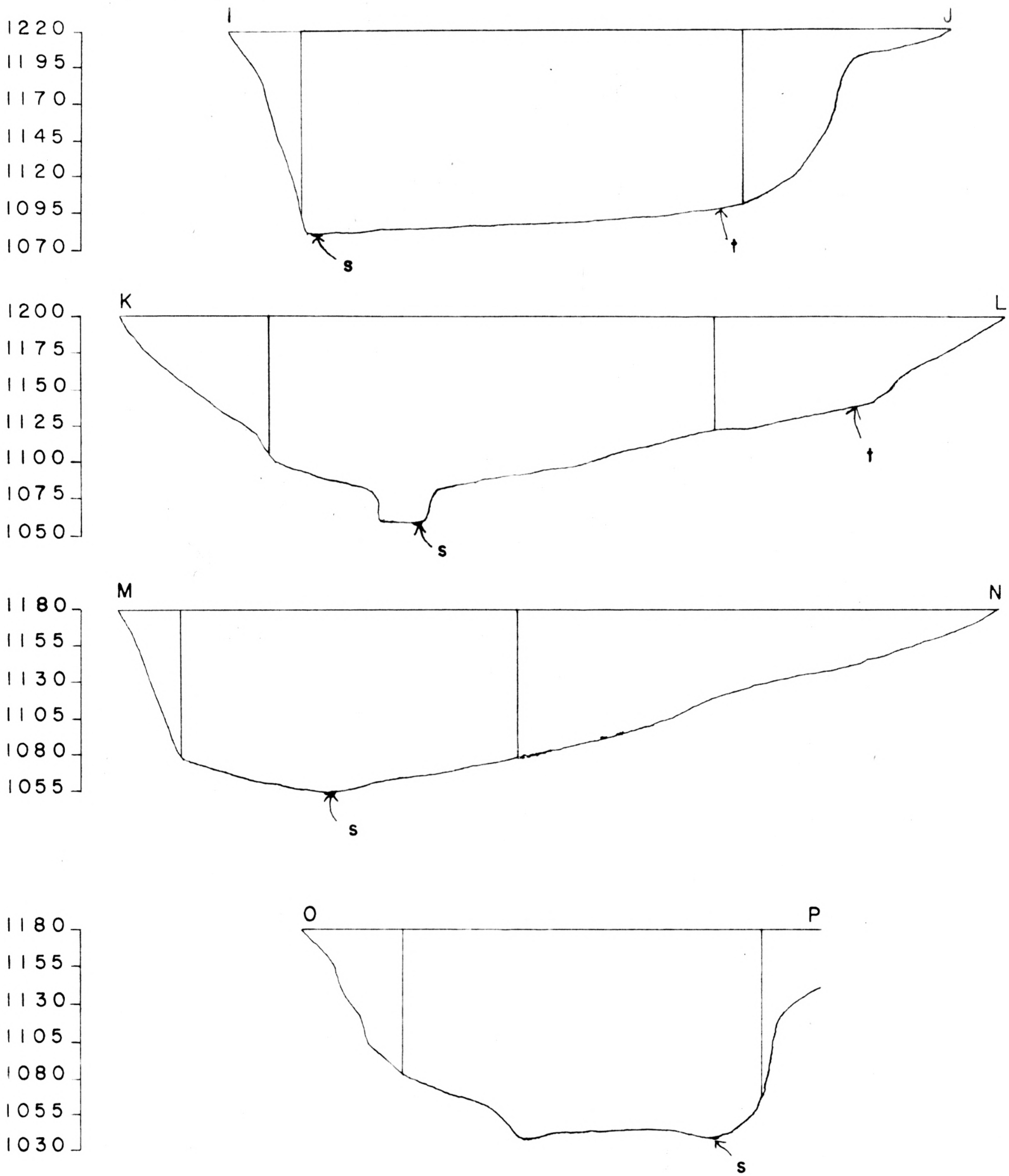

WILDCAT CREEK
A
B
RIGHT
1300
1275
1250
1200
1175
1150
s
t
1000′
C
D
1300
1275
1250
1225
1200
1175
1150
s
E
F
1300
1275
1250
1225
1200
1175
1150
1125
1100
s
t
t
G
H
1300
1275
1250
1225
1200
1175
1150
1125
1100
s
t

PLATE II (g)


1220
1195
1170
1145
1120
1095
1070
I
J
s
t
1200
1175
1150
1125
1100
1075
1050
K
L
s
t
1180
1155
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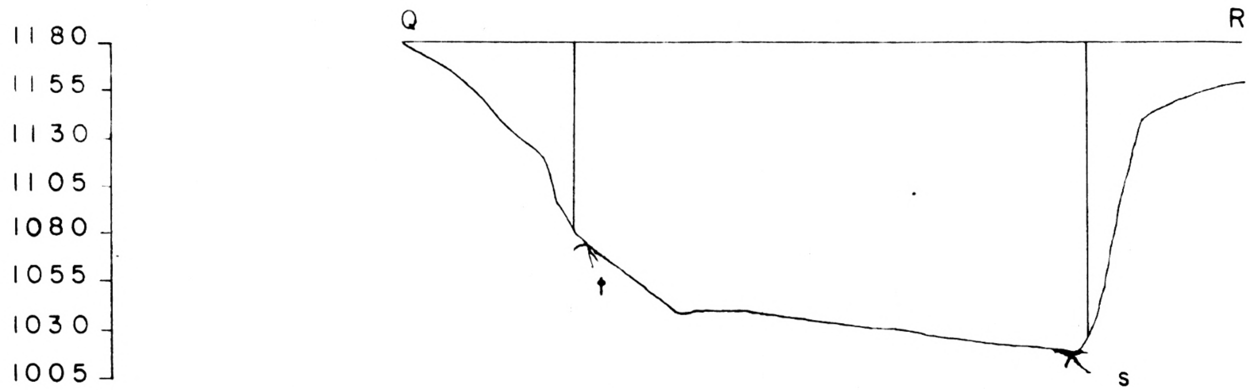
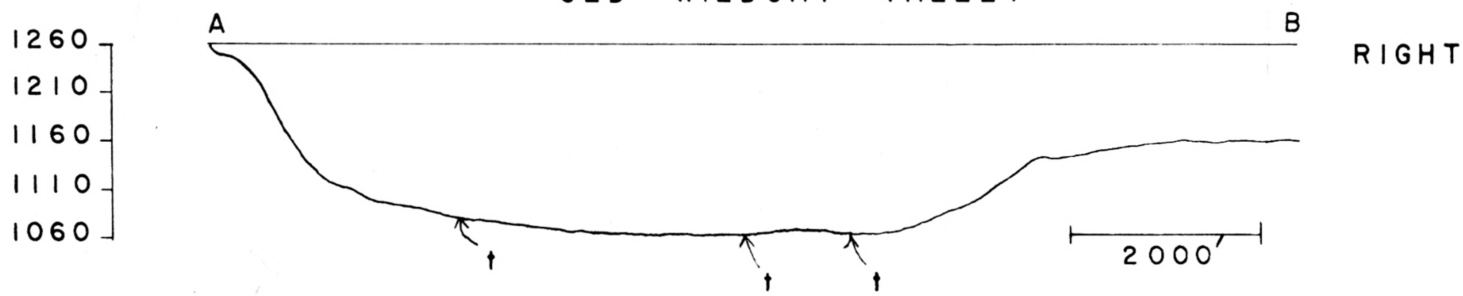
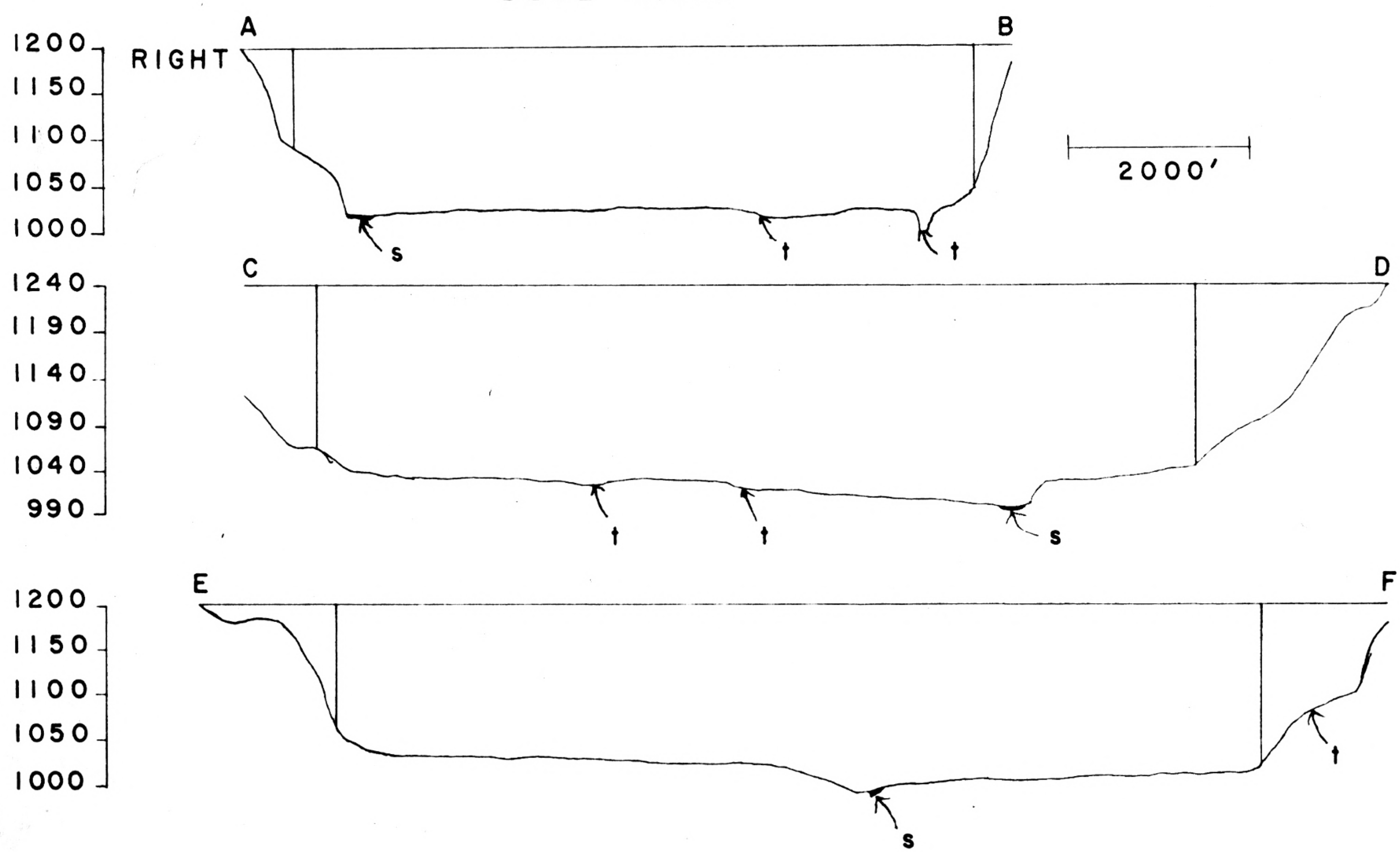
1055
1030
O
P
s



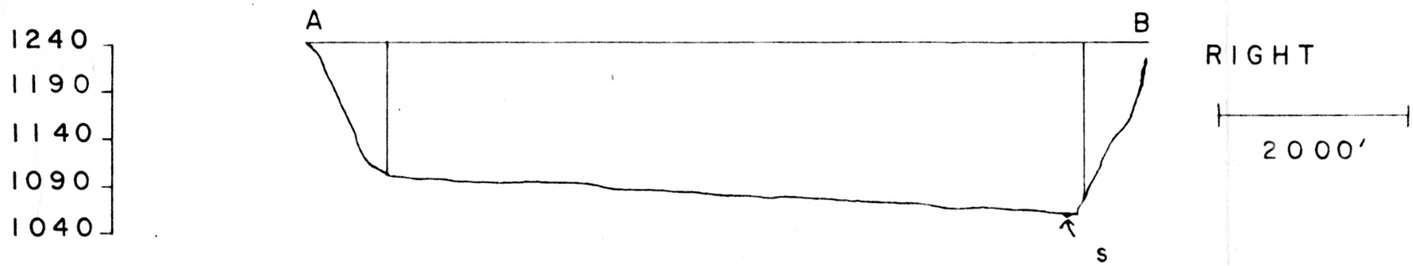
OLD WILDCAT VALLEY



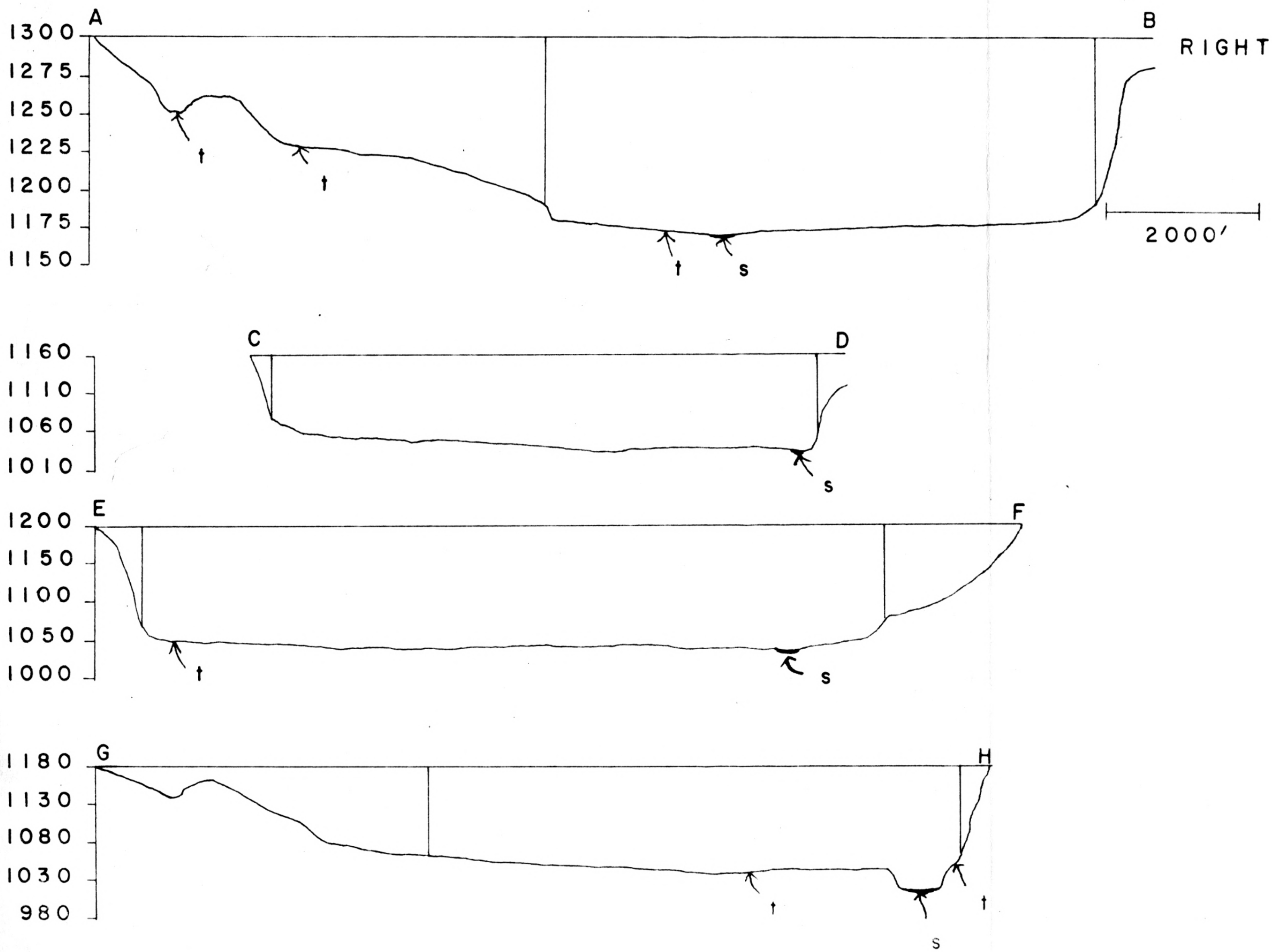
BLUE RIVER

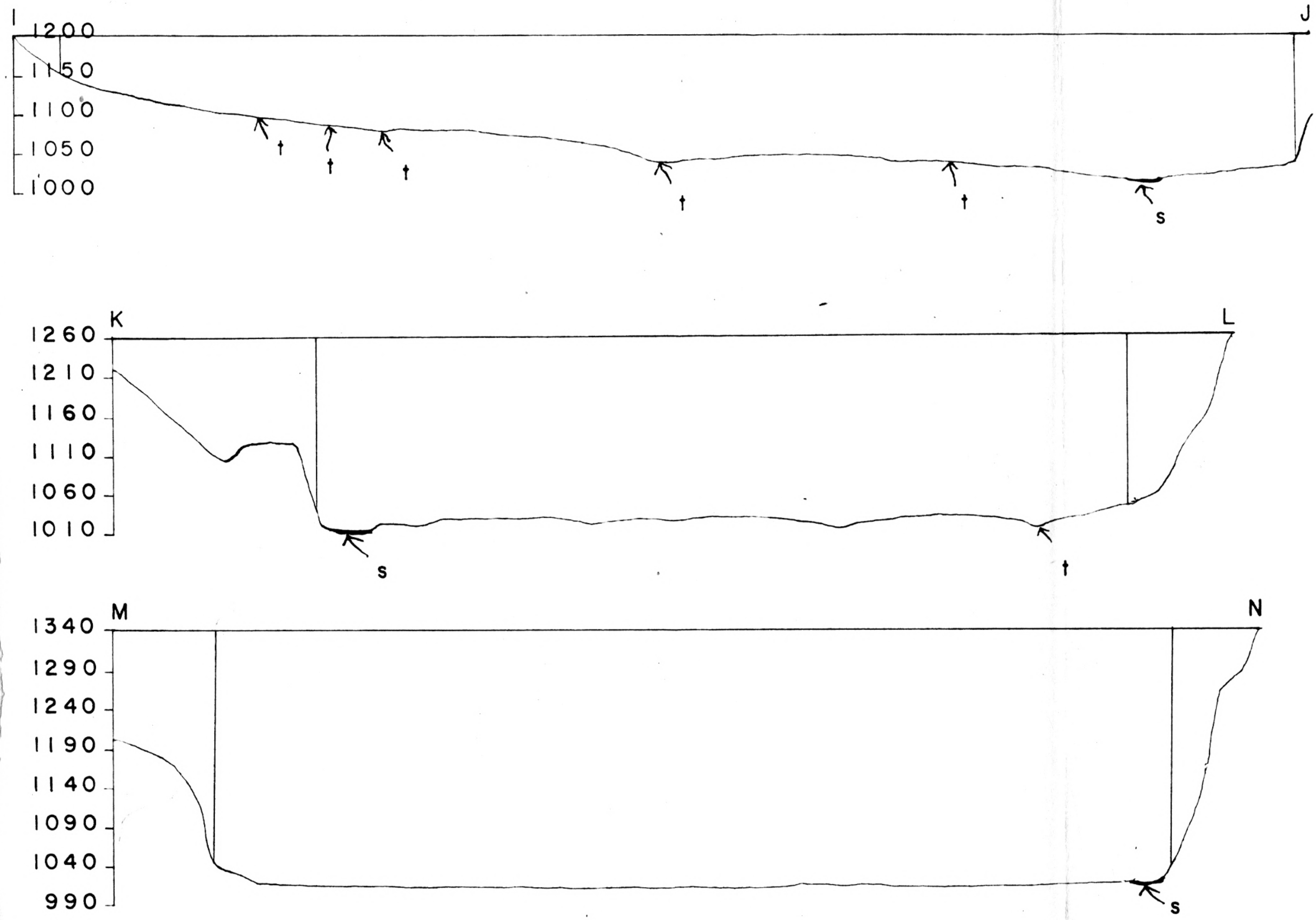


SMOKY HILL RIVER

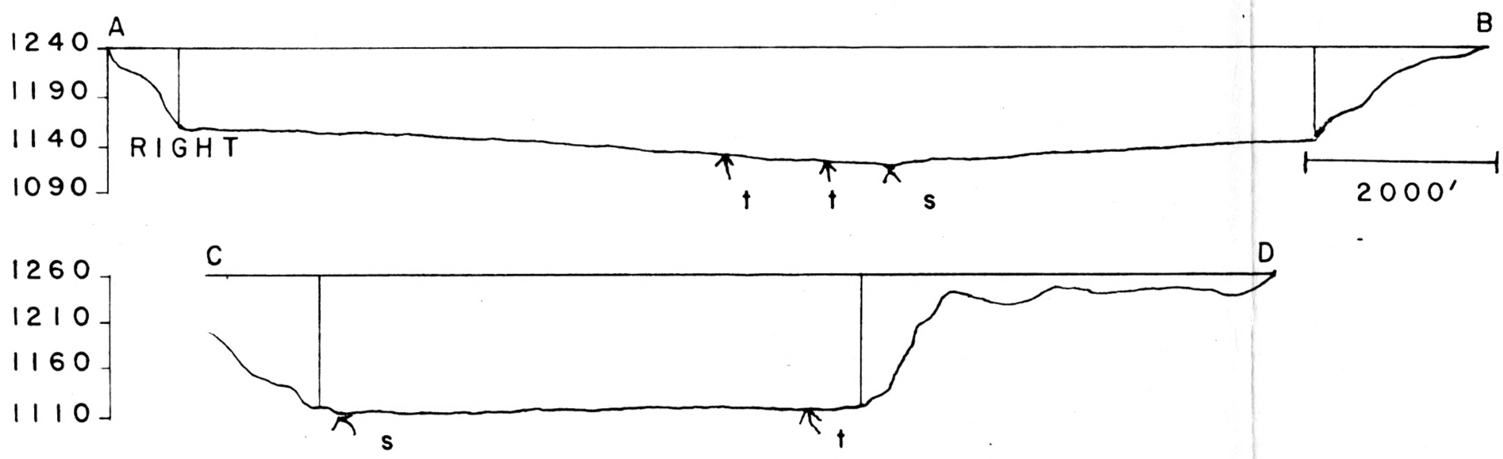


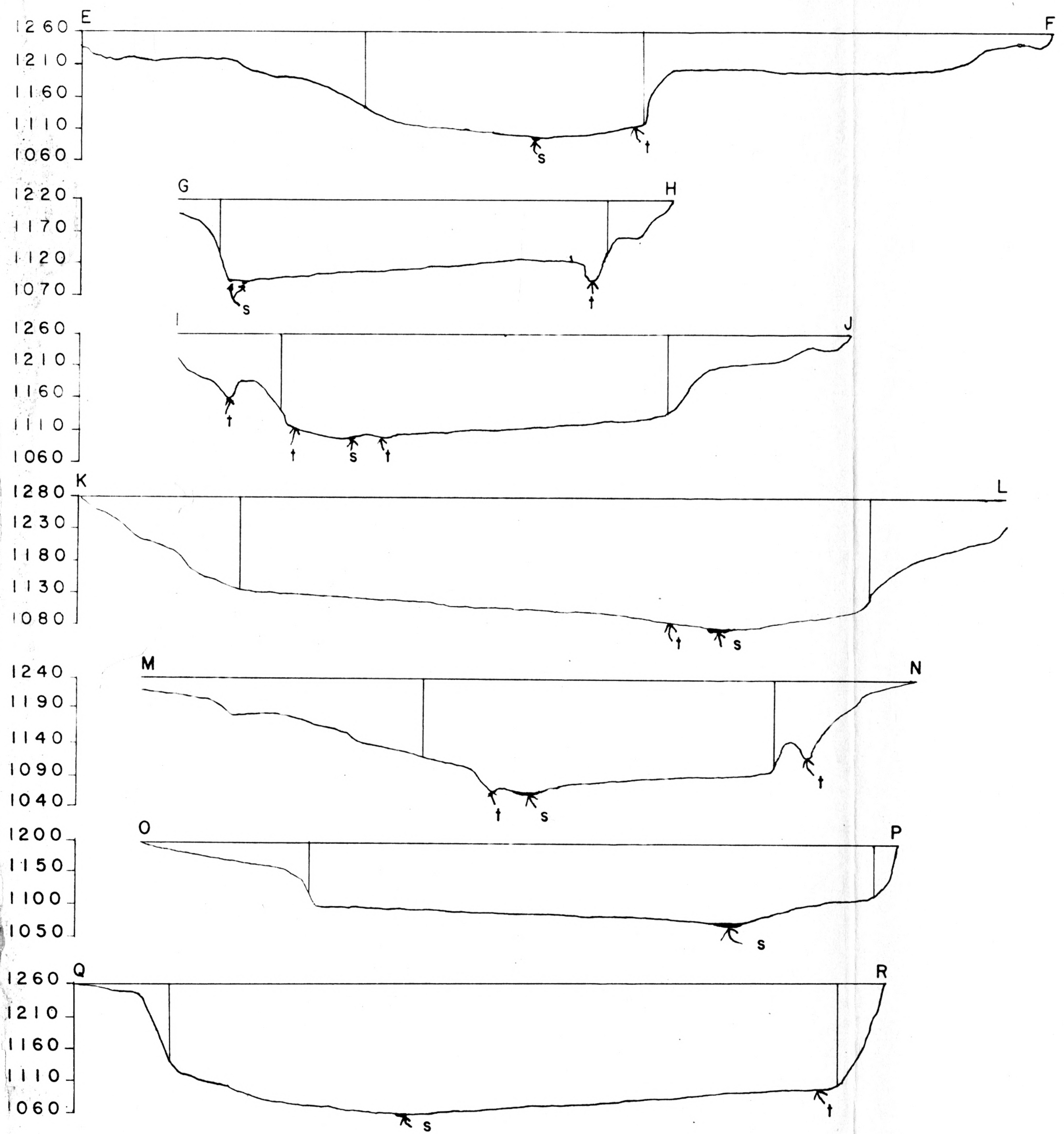
KANSAS RIVER





REPUBLICAN RIVER




E
F
1260
1210
1160
1110
1060
s
t
G
H
1220
1170
1120
1070
s
t
I
J
1260
1210
1160
1110
1060
t
t
s
t
K
L
1280
1230
1180
1130
1080
t
s
M
N
1240
1190
1140
1090
1040
t
s
t
O
P
1200
1150
1100
1050
s
Q
R
1260
1210
1160
1110
1060
s
t

Longitudinal Stream Profiles

A longitudinal profile was prepared for each of the nine major streams. It was thought that such a profile would offer a better picture of the streams' behavior, thus perhaps furnishing a clue which would aid in relating structure and drainage. Plate III depicts the longitudinal profiles for the various streams.

Upon glancing at the longitudinal profiles of the nine streams it is noted that the gradients of the streams are not constant, but vary along their length. This variation shows no general pattern however. For instance, the Republican river flows into the Kansas river and the gradient decreases. Yet, further along its length, towards its mouth, the Kansas river has a gradient which begins to increase.

The Smoky Hill-Kansas river profile revealed an increase in gradient as the Smoky Hill flowed into the Kansas. Where Clark creek flowed into the Kansas the gradient decreased. The gradient of Humboldt Creek starts as a gentle slope, gradually increases, and then decreases again as the creek flows into Clark creek. The gradient of Wildcat creek as indicated by the profile, becomes less and less until near the creek's mouth, where it rather abruptly steepens.

The fact that the gradient of the Smoky Hill river increases, as shown by the profile, when the river approaches the Kansas may be of note. Noteworthy also, is Wildcat creek's gradient. It first decreases as the creek approaches the Kansas. Then a short distance from the creek's mouth it suddenly begins to increase. When East McDowell creek enters McDowell the gradient of McDowell steepens.

EXPLANATION OF PLATE III

Showing the longitudinal profile curves for the various streams in Table 1. A plot of the stream altitude in feet against its channel length in thousands of feet.

PLATE III (a)

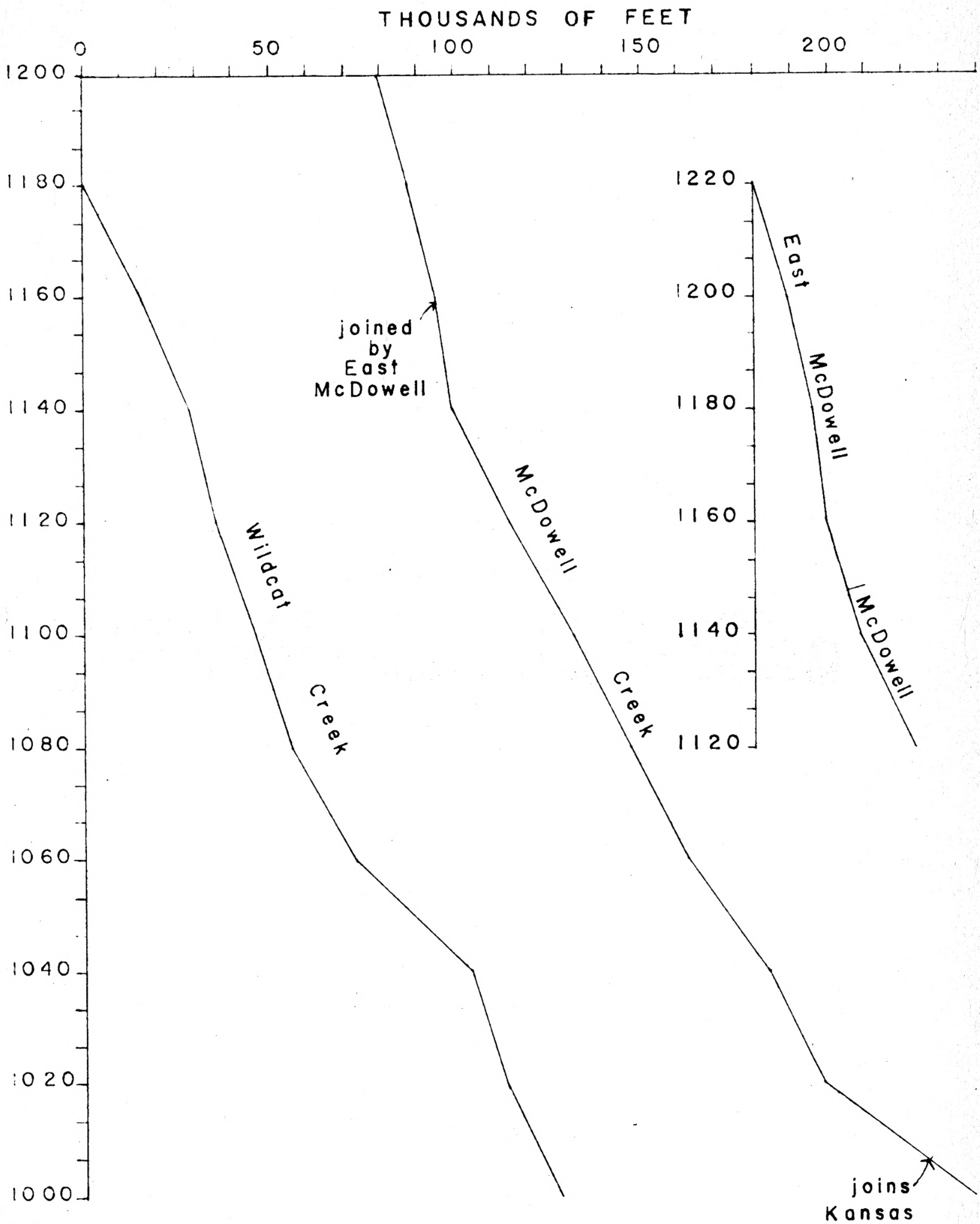
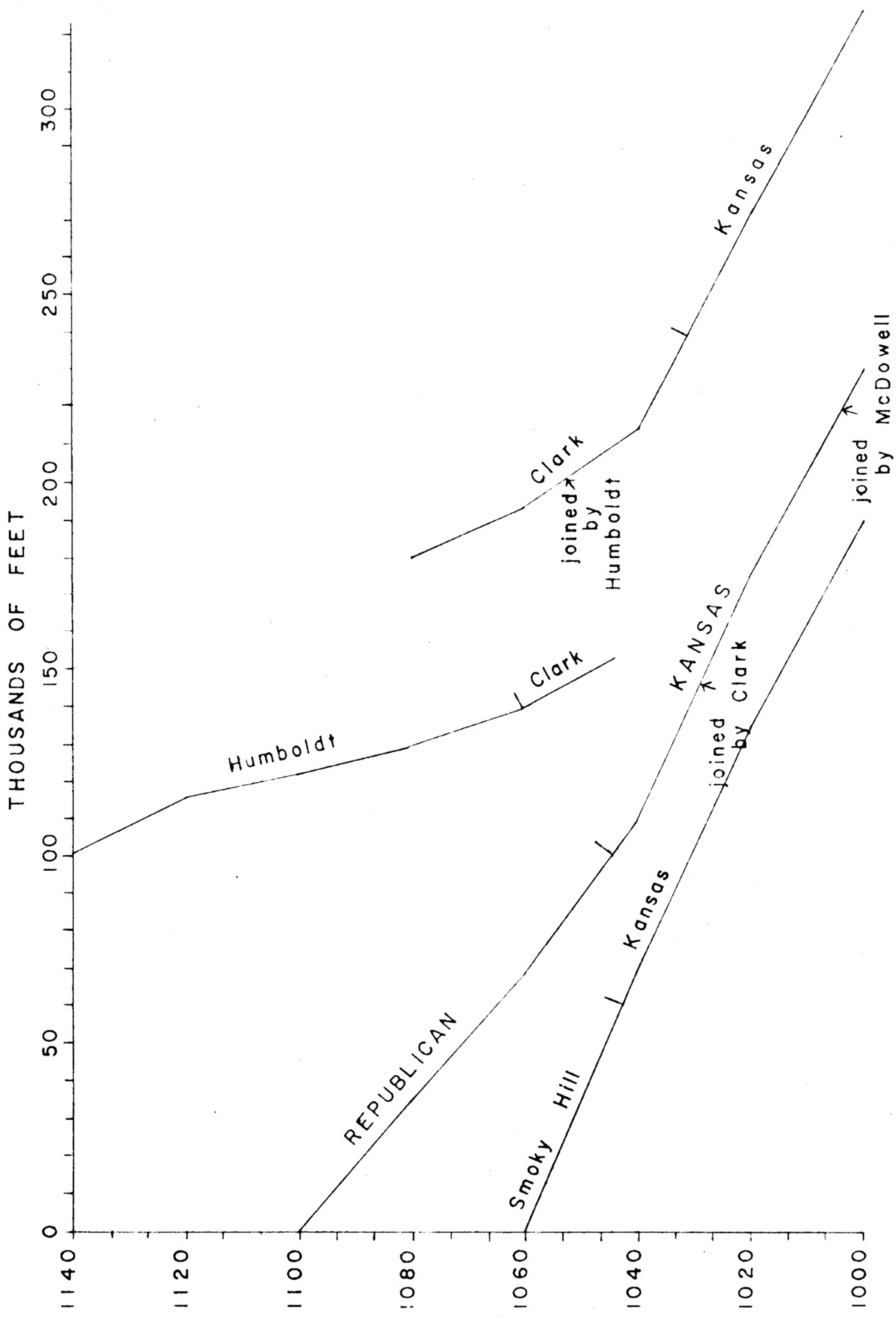

THOUSANDS OF FEET
0
50
100
150
200
1200
1180
1160
1140
1120
1100
1080
1060
1040
1020
1000
Wildcat
Creek
joined
by
East
McDowell
McDowell
Creek
joins
Kansas
1220
1200
1180
1160
1140
1120
East
McDowell
McDowell

PLATE III (b)


THOUSANDS OF FEET
0
50
100
150
200
250
300
1140
1120
1100
1080
1060
1040
1020
1000
Humboldt
Clark
Clark
Kansas
joined by Humboldt
REPUBLICAN
KANSAS
joined by Clark
joined by McDowell
Smoky Hill
Kansas

Local Basin Studies

In an attempt to discover a relationship between structure and drainage three drainage basins within the area under investigation were analyzed, using Horton's (1945) method. A field study of the structure in each of these three areas was also undertaken. In this instance the structure was located by employing a hand level and rod.

Stream Numbers and Lengths. The first area studied by an analysis of stream numbers and lengths was the Humboldt creek drainage basin. Table 2 shows the results of this analysis.

Table 2. Humboldt creek drainage basin analysis.

Part A

Stream order	Average length (ft.)	r_1	Calculated average length (ft.)	Total meas. length (mi.)
4	40,250	2.5	33,188	57
3	12,300	"	13,275	
2	6,471	"	5,310	
1	2,124	"	2,124	

Part B

Stream oder	N_0	r_b	Calculated	N_0	Total no. streams
4	1	3.8	1		76
3	4	"	4		
2	14	"	14		
1	57	"	55		

Part A of Table 2 uses the formula: $l_a = l_1 r_1 (0-1)$ where l_a is the average length of streams of any given order, l_1 is the average length of streams of the first order, r_1 is the stream length ratio, and 0 is the order of l_a. In the table the stream order and average lengths were found by actual measurement off the drainage map (first two columns).

The stream length ratio was found by an averaging process. Using semilogarithmic graph paper the average stream lengths as measured from the map, were plotted against the stream orders. After the points on the graph were established, a straight line curve was fitted along them; (appendix, Plate VI). The various stream orders were then followed in a vertical direction to the point of intersection with the curve. These points of intersection then established the stream lengths used to compute r_l.

Once r_l had been computed, l_a was calculated by substitution in the formula. These results are shown in the column: calculated average lengths.

A comparison between the calculated and true lengths reveal no substantial discrepancy for the third, second, and first orders. The fourth or main order stream however, did show quite a discrepancy amounting to about 7,000 feet.

Part B of Table 2 utilizes the formula: $N_0 = r_b(s-0)$, where $N_0 =$ the number of streams of a given order, $r_b =$ the bifurcation ratio, $s =$ the largest order, and $0 =$ the order of N_0. The first two columns list the stream orders and numbers as actually found from the drainage map.

Like r_l the stream length ratio, r_b was also found by an averaging process. Using semilogarithmic graph paper, the stream numbers were plotted against the stream orders. A straight line curve was then fitted to these points. Next the second highest stream order was followed up the vertical direction to its intersection with the curve. A horizontal line was then extended from the intersection over to the stream number axis, thus giving the averaged value of the stream number. Upon consulting the stream number formula, one becomes aware that this value is also the value of the bifurcation ratio.

The calculated stream numbers in Part B of Table 2 agree very closely with the values taken directly from the drainage map.

The Farnum Creek drainage basin was also studied by the analysis of stream numbers and lengths. Table 3 shows that for the top three orders the calculated average and the true average stream lengths do not agree very closely. In Part B of the table, the stream numbers for the first and second orders are substantially out of agreement.

Table 3. Farnum creek drainage basin analysis.

Part A

Stream order	Average length (ft.)	r_l	Calculated average length (ft.)	Total meas. length (mi.)
5	59,150	2.3	64,660	43.8
4	25,550	"	28,118	
3	8,525	"	12,225	
2	6,638	"	5,315	
1	2,311	"	2,311	

Part B

Stream order	N_0	r_b	Calculated N_0	Total number streams
5	1	1.48	1	45
4	1	"	1	
3	2	"	2	
2	8	"	3	
1	33	"	5	

The drainage basin of a tributary of McDowell creek was the third basin to be examined. This tributary is found in the northwest corner of the Swede Creek quadrangle (7½ minute series).

After the stream orders were ascertained on the drainage map, the stream numbers and average lengths were both measured and computed. r_l and r_b, the stream length ratio and the bifurcation ration respectively, were obtained graphically as in Table 2 and 3. Table 4 lists the data for the McDowell creek tributary basin.

Table 4. Drainage basin #3 analysis.

Part A

Stream order	Average length (ft.)	r_l	Calculated average length (ft.)	Total meas. length (mi.)
5	31,475	2.0	38,468	35.8
4	13,800	"	18,318	
3	6,266	"	8,723	
2	4,000	"	4,154	
1	1,978	"	1,978	

Part B

Stream order	N_0	r_b	Calculated N_0	Total number streams
5	1	1.48	1	58
4	1	"	1	
3	3	"	2	
2	10	"	3	
1	43	"	5	

Table 4 shows poor agreement between the average measured lengths and the average calculated lengths as they pertain to the 4th and 5th orders. The measured stream numbers and the calculated numbers differ considerably for the first and second orders.

In making an analysis of a drainage basin as was done in the preceding paragraphs, correct results cannot be obtained from the two equations, stream length and stream number, unless the drainage basin is reasonably homogeneous. Therefore, the three drainage basins under investigation should be looked at with this in mind.

In the Humboldt creek basin the Fort Riley "rim rock" caps the upper portions of the area. The slopes cut by stream erosion pass from the Fort

Riley into the Florence limestone and on down to the Crouse limestone which lies a little above floodplain level, (see appendix for stratigraphic section). The upper reaches of the basin above the floodplain are thus typical Flint Hills topography.

The same type of Flint Hills topography was present in the basin studied in the Swede Creek quadrangle. The stratigraphic column of the area however, contained the Florence limestone member at its top. The Neva limestone was near the bottom of the column slightly above the floodplain.

The Farnum creek basin is located mainly in a rolling type of topography. The Cresswell limestone member is present at the top of the stratigraphic column. Approximately 45 feet of Gage shale along with the well-fractured Cresswell aid in producing this kind of topography.

According to Horton (1945, p. 290) the bifurcation ratio varies from about 2 for flat or rolling drainage basins up to 3 or 4 for mountainous or highly dissected drainage basins. The bifurcation ratio is higher for hilly, well-dissected basins than for rolling basins.

The values of the stream length ratios would vary from 2 to 3 in the above mentioned cases, 2 being the value for flat or rolling territory and 3 for mountainous or highly dissected land.

In a given drainage basin the law of stream numbers is generally more closely obeyed than that of stream lengths. Stream lengths may be definitely limited by geologic controls.

The Humboldt creek drainage basin, a hilly, well-dissected basin, has, as expected, a high bifurcation ratio, being 3.8. The stream length ratio of 2.5 was the highest for the three basins investigated.

The Farnum creek drainage basin has a low bifurcation ratio of 1.48

which is correct for a rolling type of topography. The stream length ratio 2.3, is however not significantly different from that of the Humboldt system.

From the above information one would probably decide Basin #3 in the Swede Creek quadrangle, to also have a large bifurcation ratio and possibly a large stream length ratio, since it is physiographically similar to the Humboldt basin. A look at Table 4 shows this decision to be incorrect. Table 4 shows a small bifurcation ratio of 1.48 and the smallest stream length ratio, 2.0 of the three basins.

In two physiographically similar basins of different area, the order s, of the main stream will in general be larger for the larger drainage basins. Humboldt creek basin should therefore be of larger order than Basin #3. As shown in Tables 2 and 4 however, it is actually of smaller order.

Field Data. The dip and strike symbols shown on the drainage map in the Humboldt creek drainage basin represent the data found by the three-point method in which a hand level and rod were used. The intersection of the dip line with the strike line is essentially the center of the triangle formed by the three points.

In the Humboldt creek basin, outlined on the drainage map, strike and dip were determined from shots taken either on the massive, resistant, lower bed of the Fort Riley limestone member, which outcrops over most of the higher levels of the basin, or on a bed of the Florence limestone member. This particular bed in the Florence was considerably less flinty than most of the member and made a fairly good outcrop in several places. Shots were taken on the Florence however, only where the Fort Riley had been removed by erosion.

The dip and strike designations for the Humboldt creek area tend to align themselves in the direction of regional dip, towards the west.

The tributaries of Humboldt creek were so oriented that they suggested some degree of structural control. A look at the drainage map showed a basin which is of an asymmetric character. The tributaries on the northern side of the main stream were long and well branched, while the tributaries on the southern side were short and less branched.

The dip symbols in the southeast corner of the Humboldt system were lined up fairly well with the direction of flow of the tributaries in that part of the basin. The other dip symbols in the basin on the north side of Humboldt creek tended to be aligned either parallel to Humboldt itself, or parallel to its main tributaries. The same thing applies for dips shown on the south side of the creek. The last mentioned dips however, while being parallel to the main tributaries, point in the opposite direction of stream flow.

In the drainage basin the two joint readings, A and C, have one set of joints parallel to Humboldt creek and the other set parallel to its main tributaries on the north. The set of joint readings B, D, and E are also parallel to these main tributaries.

The Farnum creek drainage basin lies in an area whose uppermost limits are underlain by the Cresswell limestone member and covered with mantle of variable thickness. Below the Cresswell lies the Grant shale member and the Stovall limestone member. Under the Stovall limestone member lies the Doyle shale, consisting of the Gage shale member at the top, followed by the Towanda limestone member and the Holmesville shale member. The Towanda limestone has many miniature wrinkles and folds in its beds which are made up mainly of thin shales and limestones.

The Gage shale is a thick gray shale which is in part responsible for the rolling topography found in this area. The Stovall limestone is a thin, blocky bed with chert nodules throughout. The Grant shale is calcareous, gray, and about 10 feet thick. The Cresswell seen in this region is well fractured, even to the extent of some faults being present.

As shown on the drainage map, the dip in this area varies widely, both in direction and in amount. No relationship is clearly present between the dips shown and the orientation of Farnum creek and its tributaries. The joint readings also fail to attach any structural connection to the drainage pattern which would be easily noticed.

The drainage pattern had an asymmetric appearance; an elongate drainage basin with short tributaries on one side, long on the other. This suggested that perhaps the drainage was controlled by an underlying regional structural pattern rather than the surface structure of the Cresswell and Towanda limestones.

The rock layers used in dip, strike, and joint determinations in Basin #3, were the Schroyer, Threemile, and Cottonwood members. These three members made bold outcrops from which good hand level shots could be made. As implied above, these layers of rock were of a massive, erosion resistant nature.

The drainage pattern of Basin #3 appeared at first glance to be of the insequent variety. However, upon further observation one readily discerns an asymmetric pattern has developed. Here the short, less branched tributaries were on the north side of the main stream. On the other hand, the two major tributaries on the south had a dendritic appearance, i.e., an insequent drainage pattern.

The dips shown on the drainage map have an average trend slightly south of west in Basin #3. The dips shown on the north side of the main stream can be said to point in the direction of flow of the northern tributaries. The two regions of no dip in the drainage basin are located in the dendritic tributaries thus giving rise to the supposition of no structural control in this particular spot.

One set of joints (at points A, B, and D in the basin) trends in a north of east, south of west direction. Another set (points B, C, and D) trends parallel to the direction of slope of the drainage basin taken as a whole. The dip symbols in the southwest corner of the basin tend to point downstream. In general then, some structural control of the drainage can be ascertained in Basin #3.

Structural Cross Sections. The structural cross sections which were drawn up for each of the three drainage basins aid in giving one a better conception of the general kinds of structure present there.

The cross section passing through the Humboldt creek basin suggests a homoclinal dip as the predominant type of structure present. Therefore, since the trend of the dips in the basin is towards the west, the structure would be classified as a homocline dipping towards the west.

The author attempted to construct a structural cross section for the Farnum creek drainage basin. This attempt depicted a generalized series of anticlines and synclines in the area. However, there was such a paucity of data accumulated for this basin because of a lack of outcrops that it was decided a cross section would not be truly significant in giving a picture of the structure in the area. Hence, this cross section is not included in this paper. Field evidence seemed to indicate a series of sharply plunging anticlines and synclines superposed on the regional structure.

The cross section for Basin #3 depicts a structural area consisting of small folds running parallel to each other. These folds have no more than about 10 feet of closure as shown by the section.

SUMMARY OF DATA

Stream Measurements

In summarizing the data obtained from Table 1, a few statements should first be made concerning stream behavior.

The meandering of a stream is controlled by the amount of load it carries in relation to its capacitance, its gradient (floodplain), and the resistance of the rock through which it flows.

A graded stream has a gradient just sufficient to permit transportation of its load. Hence, this kind of stream gradually reduces its slope as the load brought by its headwaters decreases.

Young streams have gradients steep enough that they are everywhere able to erode their channels. These streams may acquire a swinging flow due to changes in the direction of the initial consequent courses or from the irregularities of structure which they meet as their valleys become deeper. These swings become more pronounced and enlarged before a graded condition is reached. After a graded condition has been reached, the streams begin cutting laterally more rapidly. Meanders are enlarged, thus lengthening the stream. This disturbs the equilibrium by reducing the gradient. Material is then deposited to bring the gradient back up to normal. This deposition is the beginning of a floodplain.

In Table 1, comparing the floodplain gradients with the stream gradients

EXPLANATION OF PLATE IV

Showing structural geologic cross sections taken across Humboldt creek drainage basin and across drainage basin #3.

PLATE IV (a)

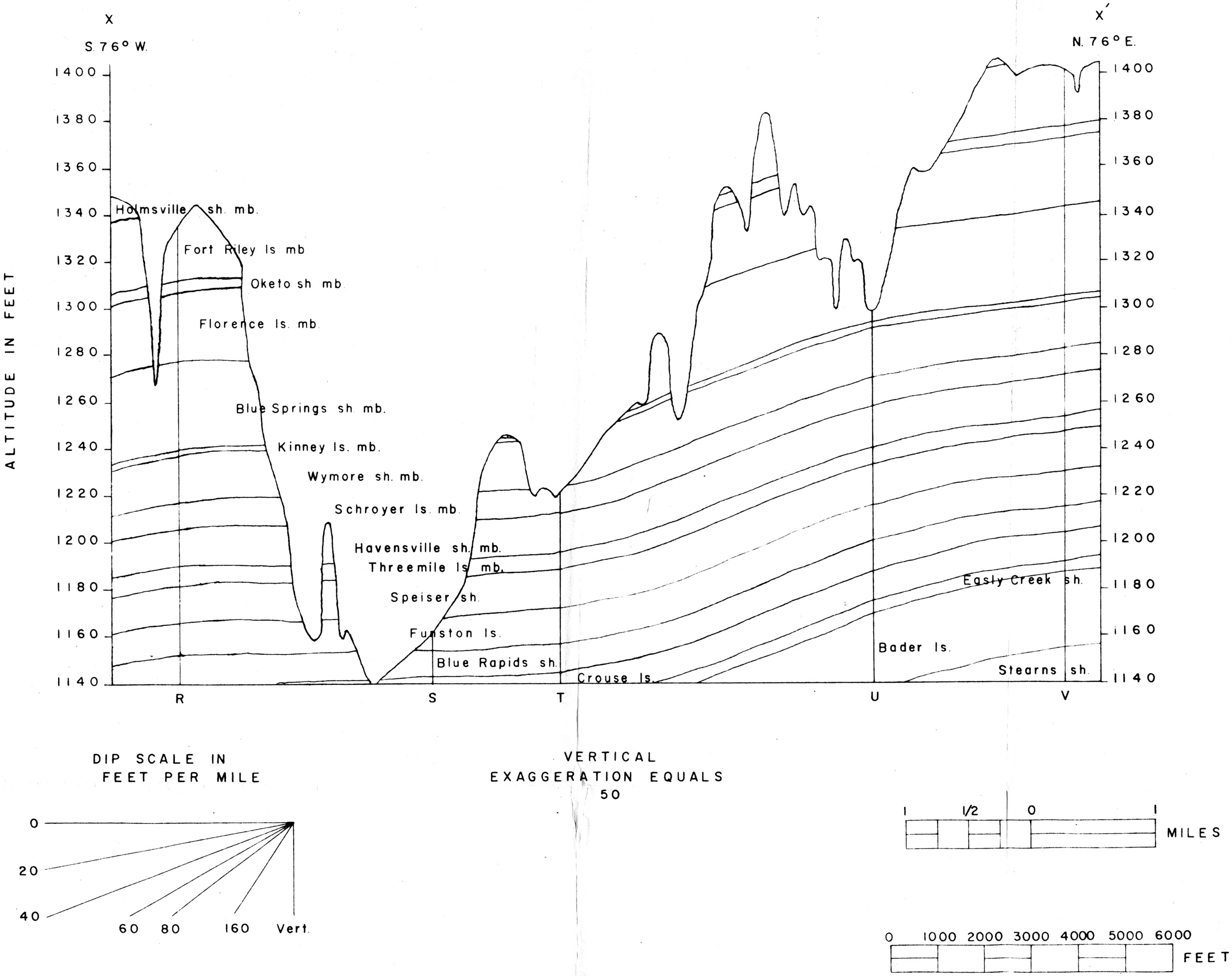
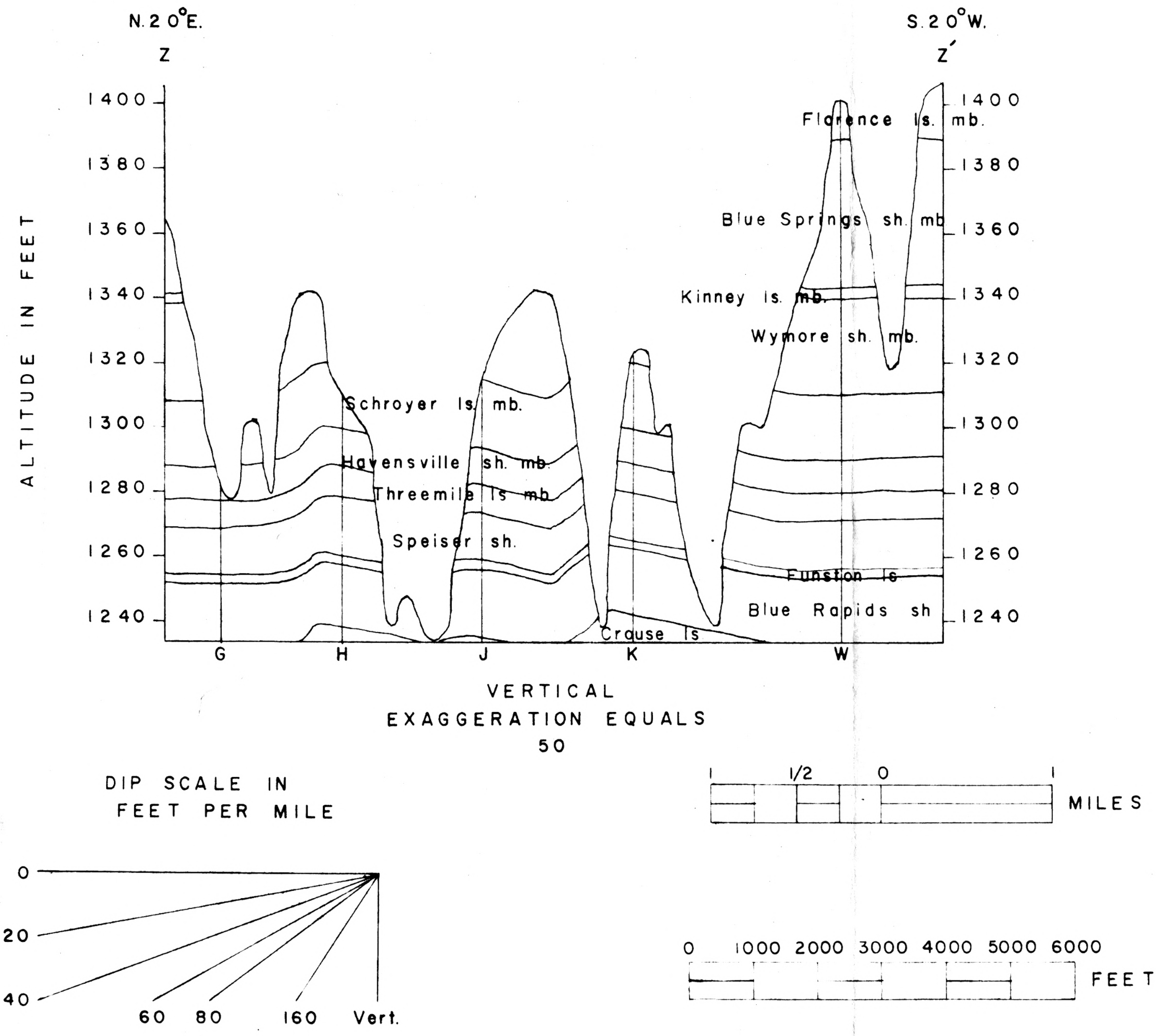

X
X'
S. 76° W.
N. 76° E.
ALTITUDE IN FEET
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
1180
1160
1140
Holmsville sh. mb.
Fort Riley ls. mb.
Oketo sh. mb.
Florence ls. mb.
Blue Springs sh. mb.
Kinney ls. mb.
Wymore sh. mb.
Schroyer ls. mb.
Havensville sh. mb.
Threemile ls. mb.
Speiser sh.
Funston ls.
Blue Rapids sh.
Crouse ls.
Easly Creek sh.
Bader ls.
Stearns sh.
R
S
T
U
V
DIP SCALE IN FEET PER MILE
0
20
40
60
80
160
Vert.
VERTICAL EXAGGERATION EQUALS 50
1
1/2
0
1
MILES
0
1000
2000
3000
4000
5000
6000
FEET

PLATE IV (b)


N.20°E.
Z
S.20°W.
Z′
ALTITUDE IN FEET
1400
1380
1360
1340
1320
1300
1280
1260
1240
Florence ls. mb.
Blue Springs sh. mb
Kinney ls. mb.
Wymore sh. mb.
Schroyer ls. mb.
Havensville sh. mb.
Threemile ls mb.
Speiser sh.
Funston ls
Blue Rapids sh
Crouse ls
G
H
J
K
W
VERTICAL
EXAGGERATION EQUALS
50
DIP SCALE IN
FEET PER MILE
0
20
40
60
80
160
Vert.
1
1/2
0
1
MILES
0
1000
2000
3000
4000
5000
6000
FEET

shows a smaller ratio between these two factors as they apply to the large streams (except the Smoky Hill whose length on the map is too short to so compare) than as they do to the small streams. This fact is due to the large amounts of meandering of these smaller streams. It is thought that the streams early in their career had their courses controlled by the regional joint pattern, thus causing the tendency to meander which as the streams got older, resulted in the present large number of meanders.

The ratio of the width of the floodplain to the width of the meander belt is greater for the smaller streams as one can observe by consulting Table 1. In this connection it is true that it is rather difficult to define a meander belt in the case of the smaller streams. However, a plot of the width of the so called meander belt vs. the width of the floodplain for all the streams in Table 1 shows a direct relationship between these two quantities. Also, the above two quantities when plotted separately against the stream gradient give the same type of curve, i. e., a natural or logarithmic type, which signifies they are related to the stream gradient.

Longitudinal Stream Profiles

In discussing the longitudinal profile curves, the following statement should first be made: the longitudinal profile gradually decreases in slope due to greater volume of the stream (because of tributaries). Therefore, the stream erodes deeper in its lower length. The profile is not a smooth curve since it passes over areas of varying resistance to erosion (Hinds, 1943, pp. 452-453.

Utilizing Archer's (1951) structural map and the drainage map, it can be seen that where East McDowell creek enters McDowell creek the larger stream begins to flow down dip rather than parallel to the strike. This may explain the increase in slope of the profile of McDowell creek after East McDowell has entered it.

The profile of Wildcat creek decreases as it nears the old channel which carried it toward the Big Blue river. As soon as this spot is passed the gradient again increases.

The structural contour lines across Humboldt creek indicate that Humboldt flows parallel to the strike for part of its length and then parallel to the dip. This point of change was near 1120 feet according to the topographic map from which the drainage map was taken. Hence, this change would be a possible answer for the increase in Humboldt's slope at that point, as shown on the profile.

The Smoky Hill river has a lower gradient than that of the Kansas river. Since the change is very small it is probably caused by varying resistance to erosion of the area passed over (Hinds, 1943).

In discussing stream behavior it should be mentioned that glacial action may have played a large part in determining the course and action of the streams in the area of the Junction City quadrangle. Since the Kansas ice sheet is thought to have reached at least to the junction of the Kansas and Big Blue rivers, one should readily realize that important changes could have been made in the behavior and pattern of the streams in this area.

Stream Cross Sections

The stream valley profiles that show most signifigance are those of Humboldt creek, Clark creek, Kansas river, and Wildcat creek. The Humboldt creek cross sections show the creek as flow-closest to its left bank, indicating monoclinal shifting. In this connection alluvial fans are shown by the topographic sheet of this area to be present on the north side of the creek thus further favoring the idea of monoclinal shifting. The dip symbols on the drainage map also tend to bear this out and it is further suggested by the structural cross section across Humboldt.

Clark creek's valley profile supports evidence of Ferrel's law. Ferrel's law states that streams flowing in the northern hemisphere tend to be deflected to their right due to the earth's rotation. 4 our of 4 of the profiles show the steep side of the valley on the streams right side. The dip as shown by the dip symbols is towards the west, however. Thus, here is an indication of Ferrel's law rather than monoclinal shifting.

The Kansas river has 5 our of 7 cross sections showing the steep bank on the streams right. Perhaps the evidence of Ferrel's law is thus shown. The author is of the opinion, however, that a more suitable explanation is monoclinal shifting. Also, glacial action during Pleistocene times may have forced the stream towards the right.

Wildcat creek has 6 out of 9 profiles with the steep bank towards the right. The same opinion is held for this case as that of the Kansas river, monoclinal shifting produced by a southwestern component of the western trending regional dip.

Stream Number and Length Analysis

In the Humboldt creek drainage area the analysis of stream numbers and lengths showed one anomaly which suggested structural control. Humboldt creek basin and Basin #3 are both Flint Hill basins. The Humboldt basin is larger than Basin #3 in area. Yet Basin #3 has a main stream of the 5th order while Humboldt has only a 4th order stream.

The Farnum creek Basin analysis indicated very strongly, evidence of structural control. The calculated average lengths did not agree with the measured average lengths and the calculated stream numbers show no agreement for the 4th and 5th orders.

In Basin #3 the analysis shows poor agreement between the measured average length and the calculated average length of the 4th and 5th orders and no agreement in stream numbers for the 1st and 2nd orders. Also, r_b is of to low a value. Therefore, structural control of drainage is again indicated.

Field Data

The field data collected in the three drainage basins indicates definite structural control in the Humboldt creek basin and Basin #3. In each of these basins an alignment of the streams with the dips or with the strikes can be discerned.

In the Farnum creek basin the structural contour lines suggest a series of synclines and anticlines. If the axes of these folds are drawn with a strike of N65°E-S65°W, the structural control of the drainage becomes more apparent; the small tributaries flowing perpendicular to the axes of the anticlines and synclines and the main streams tending to flow parallel to them.

GENERAL DISCUSSION

The appearance of the various drainage patterns in the southern one half of the Junction City quadrangle seems to indicate drainage which is controlled in its development by the structure of the underlying rock formations.

The Milford quadrangle (7½ minute series) has a stream pattern in its northeast corner which is of a pinnate appearance. Farnum creek's drainage system has an asymmetric appearance.

In the southern half of the Alida quadrangle, streams were shown flowing almost directly north or south, away from an axis trending east-west.

The Wind creek quadrangle has a drainage pattern with a trellis appearance in its east central section. In the Keats quadrangle Wildcat creek has short tributaries on the south, long on the north.

Clark creek and McDowell creek in the Ogden quadrangle describe a semi-circle as they flow towards the Kansas river. Stream basins in the Swede Creek quadrangle slope away from a central point in the upper central part of the quadrangle.

All of the above stream designs pictured on the drainage map allude to some degree of structural regulation or influence. A structural contour map (Archer, 1951) of the southern one half of the Junction City quadrangle was referred to in the early phases of this investigation in order to compare it with these and other designs on the drainage map, in an attempt to find possible relationships between structure and drainage. Parts of this contour map are reproduced on the drainage map (Milford, Wind Creek, Ogden, and Swede Creek quadrangles).

Archer's contour map is suitable for a study of the regional structure of the area but is inadequate for detailed studies. Hence, the three drainage basins were chosen for a more detailed study of the structure, hoping that by the results obtained a more definite conclusion could be drawn.

The general stream measurements given in Table 1, the longitudinal profile curves, and the stream valley cross sections were used as supplementary material to further aid in finding evidence of structural control of the drainage.

In studying the three drainage basins the two methods: basin analysis by use of stream numbers and lengths, and determination of local structure from field data; it was hoped these two means would serve as a double check in showing structural control of the drainage.

The supplementary methods of analysis were useful in several cases in making structural control appear more evident.

From Table 1 the comparison of ratios of floodplain gradients and stream gradients of the large and small streams resulted in showing the small streams had more meanders per length of floodplain. This suggested original joint control of these streams (Cole). The stream valley cross sections gave support to the opinion of monoclinal shifting in the case of humboldt Creek and Wildcat Creek (Chamberlin and Salisbury, 1904).

The longitudinal stream profiles along with the structural contour lines helped to point to structural control of the drainage in the cases of McDowell and Humboldt creeks.

CONCLUSION

The locating and measuring of rock structure in the field was the most important method used to determine dips. Hence, it is felt that perhaps some mention should be made as to the quality of the data obtained by its use.

The method was sufficiently accurate that the author is quite confident he has obtained reliable data to show the direction of the strikes and dips in the three drainage basins. Several back sights were made when using the hand level and rod. It was found that about 2 to 3 feet of error (maximum) might occur over a sight line of 1800 foot length. A plane table and alidade were used to determine this error factor. Since the maximum error factor represents a change much less than the actual dip, it was decided to be insignifigant.

The strike and dip symbols, along with the joint symbols show the best correlation with the drainage in the Humboldt creek drainage basin. Here the structural cross section aids in making the relationship clearer by giving one an idea of the type of structure present, the dip symbols then serving as a means of orienting this structure.

Basin #3 probably had the poorest apparent correlation between structure and drainage of the three basins examined. This lack of structural control is suggested by the insequent type of drainage pattern shown there.

The Farnum creek drainage basin does not show much of a relationship to the unaided eye. However, structural contour lines drawn across the basin suggest a series of parallel folds. If the axes of these folds are drawn along a NE-SW strike, agreement between the drainage and structure becomes more evident. Here the main stream flows parallel to the axes of the folds and the tributaries flow perpendicularly to them (Campbell, 1896).

The measurement of stream numbers and lengths served as a good check on the field data in the Farnum creek basin and Basin #3. In the Humboldt creek basin however, the only factor of significance was the small order of the main stream as compared to those of the other two basins.

It is the opinion of the author that the stream patterns of the southern one half of the Junction City quadrangle serve as good guides to the structure that lies beneath them. In this connection, perhaps the recognition of certain stream patterns in a region would serve some purpose in the exploration for structure favorable for the accumulation of petroleum.

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APPENDIX

Stratigraphic Section for the Humboldt Creek Drainage Basin

	Feet
Permian system	
Wolfcamp series	
Chase group	
Barneston limestone	
Fort Riley limestone member	7 to ?
Oketo shale member	5
Florence limestone member	30
Matfield shale	
Blue Springs shale member	37
Kinney limestone member	2.5
Wymore shale member	20
Wreford limestone	
Schroyer limestone member	11.5
Havensville shale member	16.5
Threemile limestone member	8.2
Council Grove group	
Speiser shale	15.6
Funston limestone	15.4
Blue Rapids shale	11
Crouse limestone	?

(See also Jewett, 1941, pp. 150-152)

Stratigraphic Section for the Farnum Creek Drainage Basin

Permian system	
Wolfcamp series	
Chase group	
Winfield limestone	
Cresswell limestone member (bottom)	6
Grant shale member	9
Stovall limestone member	1.5
Doyle shale	
Gage shale member	45
Towanda limestone member	17

Stratigraphic Section for Drainage Basin #3 (Swede Creek quad.)

System / Series / Group	Formation	Member	Feet
Permian system			
Wolfcamp series			
Chase group			
	Barneston limestone		
		Florence limestone member	?
	Matfield shale		
		Blue Springs shale member	45
		Kinney limestone member	3
		Wymore shale member	30
	Wreford limestone		38.8
		Schroyer limestone member (upper)	2
		Lower Schroyer, Havensville shale member, and upper Threemile member	30
		Threemile limestone member	6.8
Council Grove group			
	Speiser shale		14.4
	Funston limestone		3.3
	Blue Rapids shale		20
	Crouse limestone		10
	Easly Creek shale		22
	Bader limestone		
		Middleburg limestone member	5.4
		Hooser shale member	5.6
		Eiss limestone member	6.8
	Stearns shale		20
	Beattie limestone		
		Morrill limestone member	2
		Florena shale member	10
		Cottonwood limestone member	5.5
	Eskridge shale		?

EXPLANATION OF PLATE V

A drainage map of the southern half of the Junction City quadrangle; taken from topographic maps published by U.S.G.S.

Perennial stream

Intermittent stream

Drainage basin boundary

Structural contour line 1400

Dip and strike giving amount of dip in ft./mi. 10

Joint trend

Thrust fault with throw in feet 7.5

Horizontal strata

Line of structural cross section X —— X'

Line of stream cross section A —— B

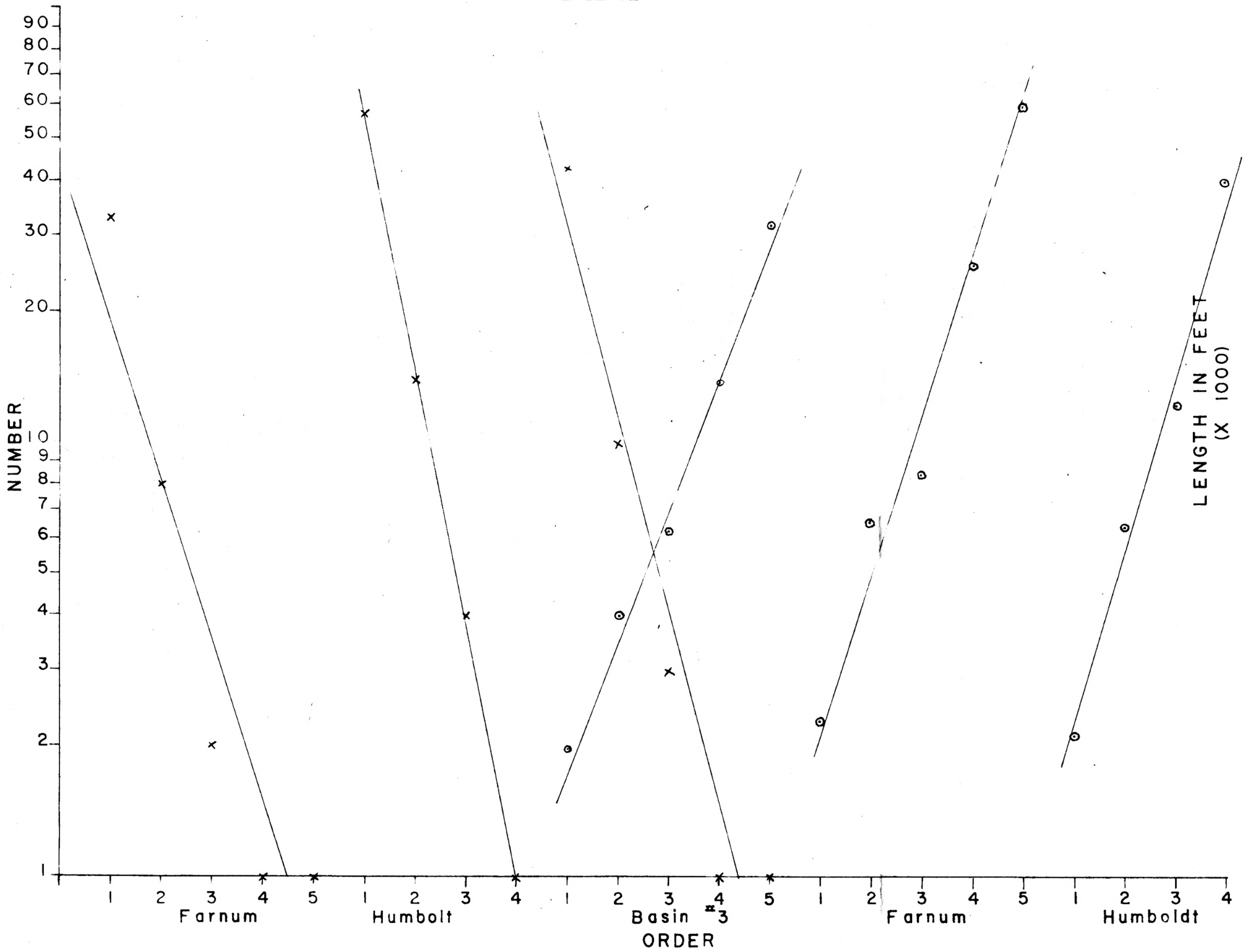
PLATE V

A DRAINAGE MAP OF THE SOUTHERN ONE HALF OF THE JUNCTION CITY QUADRANGLE

EXPLANATION OF PLATE VI

Plot of stream number versus stream order and plot of stream length versus stream order. Used in finding average value of r_b and r_l.

PLATE VI



NUMBER
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
LENGTH IN FEET
(X 1000)
1 2 3 4 5
Farnum
1 2 3 4
Humbolt
1 2 3 4 5
Basin #3
1 2 3 4 5
Farnum
1 2 3 4
Humboldt
ORDER

AN INVESTIGATION OF THE RELATIONSHIP BETWEEN ROCK STRUCTURE AND DRAINAGE IN THE SOUTHERN HALF OF THE JUNCTION CITY, KANSAS, QUADRANGLE

by

WILLIAM MOECKER BAEHR

B. S., Kansas State College
of Agriculture and Applied Science, 1951

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PURPOSE

The purpose of undertaking this investigation was an attempt to find a relationship between rock structure and drainage in the southern half of the Junction City, Kansas, quadrangle.

Procedure

In order to carry out the investigation, several methods of approach were utilized. A drainage map of the quadrangle was prepared showing the various drainage patterns formed by the major streams and their tributaries.

Measurements were taken of certain characteristics of the major streams in the area. These measurements consisted of such quantities as stream gradients, meander belt widths, and flood plain widths. The measurements were then analyzed by tabular and graphic means. Both transverse topographic cross sections of the major stream valleys and longitudinal stream profiles were also constructed and studied.

In order to make a more detailed study of the relationship between rock structure and drainage, three separate drainage basins found in the area were examined. An analysis of their stream numbers and lengths was undertaken. This was supplemented by a determination of the surface rock structure in the basins and compared with the drainage patterns of the basins.

The surface rock structure in the three localized basins was determined in the field by use of a hand level and Brunton compass. The field data were augmented by structural data obtained from the literature.

SUMMARY OF FINDINGS

The various methods of approach used in the investigation all support the conclusion that the drainage patterns in the Junction City quadrangle are controlled to a large extent by the rock structure found there.

The measurements taken of major stream characteristics suggested structural control of some of the larger creeks in the area. Topographic cross sections and longitudinal stream profiles in several instances, gave good evidence of structural control of the drainage.

The analysis of stream numbers and lengths pointed toward the structural control of drainage in the three separate drainage basins. Structural data collected in the field showed very well in most cases, that the drainage is largely dependent on the rock structure.