Recent Sedimentation and Erosional History of Fivemile Creek Fremont County, Wyoming

GEOLOGICAL SURVEY PROFESSIONAL PAPER 352-A

Prepared as part of a program of the Department of the Interior for development of the Missouri River basin and part of the soil and moisture program

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By RICHARD F. HADLEY

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RECENT SEDIMENTATION AND EROSIONAL HISTORY OF FIVEMILE CREEK, FREMONT COUNTY, WYOMING

By Richard F. Hadley

ABSTRACT

A study of the terrace sequence was made along Fivemile Creek, Fremont County, Wyo. Three terraces and the modern flood plain border the present stream; the highest (terrace 3) is a gravel-capped, rock-cut surface and the lower two (terraces 1 and 2) are composed of alluvium. The three terraces and flood plain stand about 28, 18, 9, and 3 feet above the present stream.

The alluvium underlying the flood plain and terraces 1 and 2 and the gravels of terrace 3 were sampled for laboratory study. Textural analysis of terrace 1 alluvium showed a normal decrease in median diameter in a downstream direction, ranging from 0.185 to 0.123 mm near the mouth of the stream. Terrace 2 alluvium showed very little change of median gram size in the 55-mile length of the terrace; the median diameter ranging from 0.017 to 0.023 mm. Samples of flood-plain alluvium were highly variable in texture. Studies of roundness and sphericity of terrace 3 gravels in the 16–32 mm size range show that values of both indexes increase markedly from the head to the mouth of the valley. Roundness is also affected by mineral composition. The heavy-mineral suites from terraces 1 and 2 alluvium showed some marked differences in mineral content.

Terraces on Wind River which are correlative of terrace 3 have been traced to glacial moraines in the Wind River Mountains. Therefore, development of the terrace sequence on Fivemile Creek began in late Wisconsin time. No satisfactory evidence such as archeological sites or vertebrate remains were found by which terraces 1 and 2 could be dated. Historical evidence shows, however, that the latest trenching of the valley and formation of the modern flood plain has occurred since 1920. Measurements of aggradation on flood plains in historical time and other evidence indicate a probable rapid rate of accumulation of alluvial deposits.

INTRODUCTION

The erosional history of many stream valleys in the arid or semiarid regions of Western United States is recorded in alluvial terraces that were formed during periods of alternating erosion and deposition. Terrace sequences similar to the one in the valley of Fivemile Creek are common to many other stream valleys in the Rocky Mountain and Great Plains regions. The stratigraphy of alluvial fills has been studied in Colorado (Bryan and Ray, 1940); in Wyoming (Leopold and Miller, 1954); in the Hopi Country, Ariz. (Hack, 1942); near Gallup, N. Mex. (Leopold and Snyder, 1951); Texas (Albritton and Bryan, 1939); and in several other localities scattered through the Western States. All of these studies concern a sequence of alluvial fills that were deposited in late Pleistocene or Recent time. A chronology of events based on cultural evidence or fossil remains has been developed as a result of the many studies, although details of depositional morphology often vary from place to place. This report describes the postglacial history of Fivemile Creek, Fremont County, Wyo., and the sedimentary characteristics of the alluvial valley fills.

In the Wind River basin of central Wyoming the streams that drain the Wind River and Owl Creek Mountains are similar. Fivemile Creek was chosen for this study because its erosional and depositional features are common to the stream valleys of the region. The stream heads near the base of the Owl Creek Mountains and joins the Wind River near Shoshoni, Wyo., (fig. 1) draining an area of about 400 square miles. Fivemile Creek is an ephemeral stream, but it has been subjected to large floods several times in the last 35 years. On July 24, 1923, when heavy rains produced large floods in most tributaries of the Wind River the maximum discharge near the mouth of Fivemile Creek was estimated to be 3,500 cfs (Follansbee and Hodges, 1925, p. 111). The records for the Geological Survey gaging station Fivemile Creek near Shoshoni, Wyo., cover the period 1941–42 and 1948–54 and the maximum discharge observed is 3,200 cfs which is slightly less than the estimate for the 1923 flood (U.S. Geol. Survey, 1954, p. 152).

PHYSIOGRAPHIC FEATURES

The most prominent physiographic features of the Wind River basin are the gravel-capped, gently sloping surfaces standing at different levels above the major streams and their tributaries. Blackwelder (1915, p. 309) describes these surfaces as vestiges of Tertiary and Quaternary erosion cycles in central western Wyoming. These high erosion surfaces are not discussed in this report, but it is necessary to mention them briefly

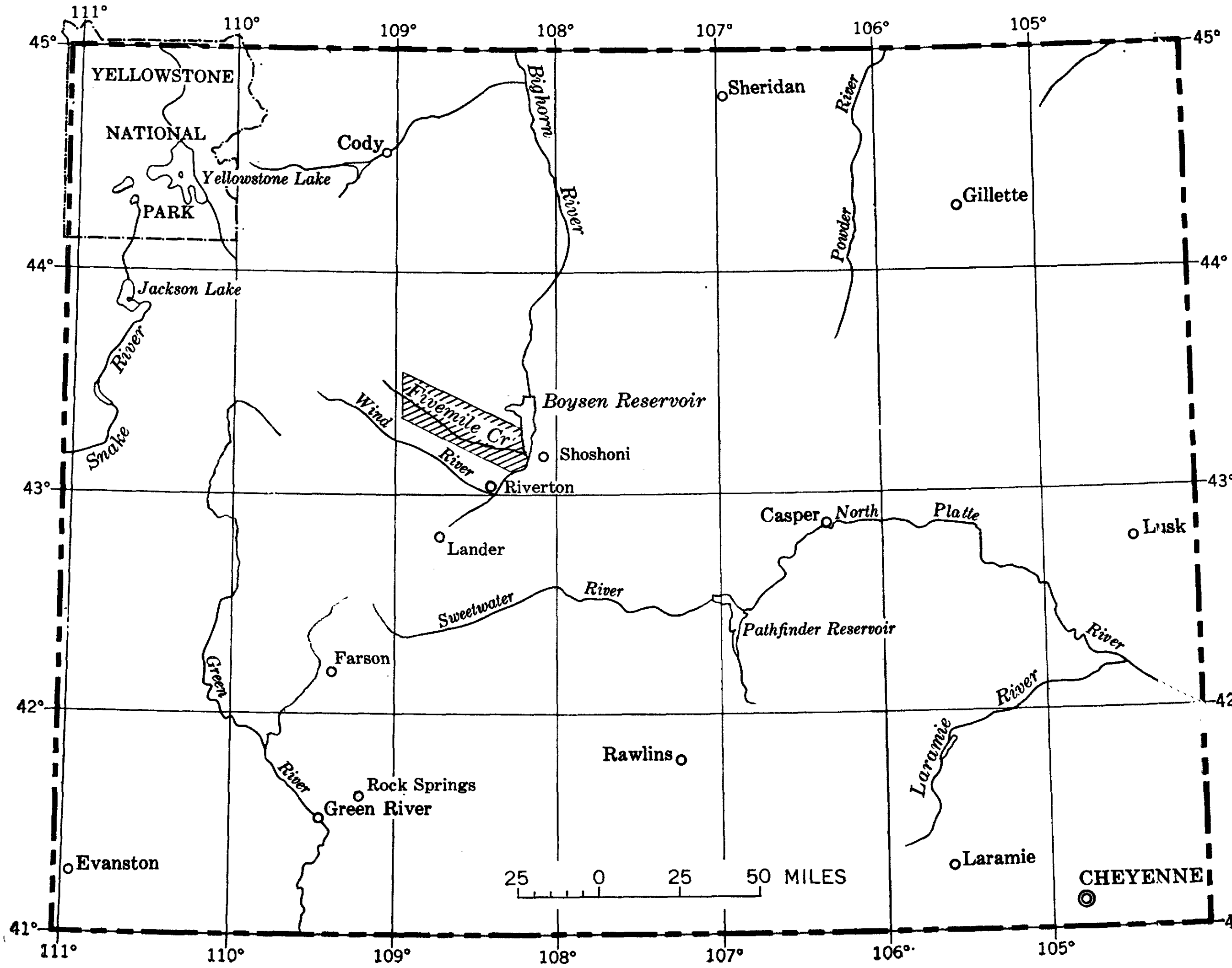


FIGURE 1.—Index map of Wyoming showing location of areas mentioned in this report. Shaded area studied in detail.

in relation to the terraces being considered in this investigation.

Blackwelder (1915, p. 310) describes four erosion surfaces which he believes to be younger than the elevated "Wind River peneplain," which is Pliocene in age. Blackwelder's youngest erosion surface (Lenore) is directly associated with the features described in this report. The Lenore cycle is represented by gravel-covered terraces, standing 10 to 30 feet above Wind River and Owl Creek, which have been traced to moraines of the Pinedale stage of glaciation (Blackwelder, 1915, p. 321). This terrace is the highest surface considered in this report. Throughout the length of Fivemile Creek it stands 25 to 30 feet above the present stream and joins a corresponding terrace along Wind River at the junction of the two streams.

The valley of Fivemile Creek may be divided into three reaches, each having distinct geologic and topographic characteristics. The longitudinal profile (fig. 2) indicates a fairly uniform gradient for the upper 20 miles where the channel traverses a shale valley alined between upturned Mesozoic sandstone units. Downstream from this reach the channel is confined in a canyon 1½ miles long cut into the Mesaverde formation. From below the point where the channel is cut into the Mesaverde formation, about mile 30 from the source, to the junction with Wind River, the stream traverses nearby horizontal sandstone and shale beds of the Eocene Wind River formation and maintains a generally uniform though lesser gradient.

Differential erosion of the alluvium and bedrock is reflected in the alternating wide and narrow sections of the channel throughout its sinuous course. Where bedrock crops out near the stream, the channel is confined and very narrow. Other places it has been widened until it reaches bedrock underlying the valley

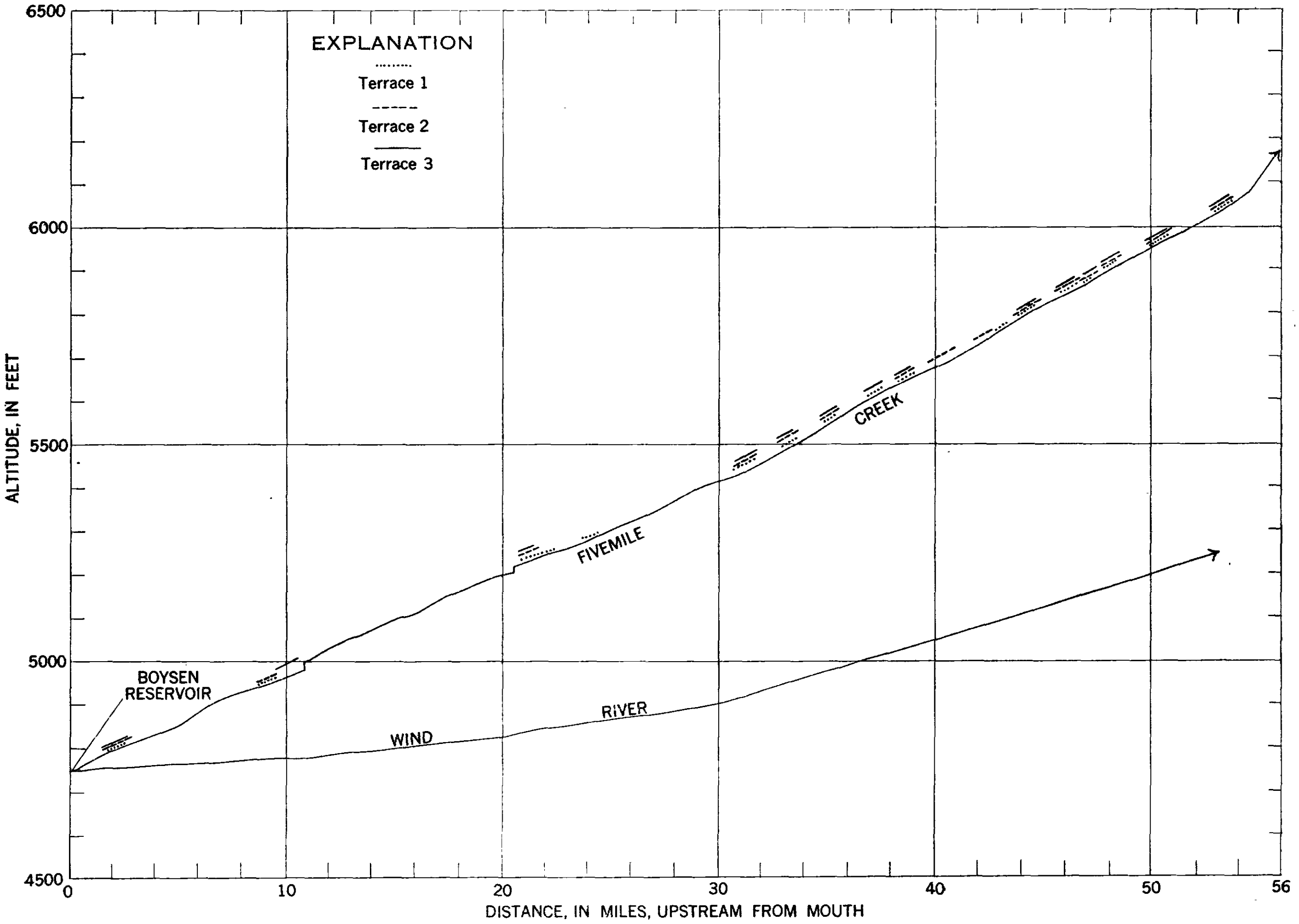


FIGURE 2.—Longitudinal profile of Fivemile Creek showing heights of terrace remnants at location of sampling sections.

side slopes. The valley floor is mantled with alluvium to a depth of about 20 feet, and these alluvial deposits underlie and form the terraces discussed in this report.

FIELDWORK

The fieldwork for this study was carried our during the summers of 1948 and 1949 as a part of the soil and moisture program of the Department of the Interior under the general supervision of R. W. Davenport. Field activities were supervised by H. V. Peterson. Laboratory studies and analysis of the samples were made at the University of Minnesota in partial fulfillment of a master of science degree.

The terraces and other prominent features of Recent erosion and deposition were mapped by planetable in 1948 along the part of the valley within the boundaries of the Wind River Indian Reservation from sec. 17, T. 5 N., R. 1 W. to sec. 25, T. 4 N., R. 1 E. (See pl. 1.) The height of the individual terraces above the present stream level was measured and the gradient of the stream bed was determined. Random elevations were taken on the terraces to determine their gradient. It was found that the gradients of the present stream and of the terraces are nearly the same.

Although the lower 35 miles of the valley was not mapped in detail, reconnaissance showed that the terraces in the upper part of the valley extend to the junction of Fivemile Creek and Wind River. The lower terraces, however, exist only as small remnants at many places in the lower part of the valley.

During the field season of 1949 the alluvial terraces were sampled throughout the length of the stream. This sampling was done primarily to determine if variations in the sediments could be used as a means of identifying the deposits. The location of the sampling sections appears in plate 2.

ACKNOWLEDGMENTS

The author is indebted to Profs. George A. Thiel and Herbert E. Wright of the Geology Department at the University of Minnesota, who made many helpful suggestions during the preparation of this report.

TERRACES AND ALLUVIAL DEPOSITS

River terraces have two essential components: (a) The top, or tread, which may or may not be the original surface of deposition; (b) the scarp, or riser, which is formed by subsequent downcutting by the stream. These two components may be formed by lateral stream corrasion on a rock surface or by cut and fill in deposits of stream alluvium.

Three terraces and the irregular modern flood plain are alined along the axis of the valley of Fivemile Creek (fig. 3). The modern flood plain rises 2 to 4

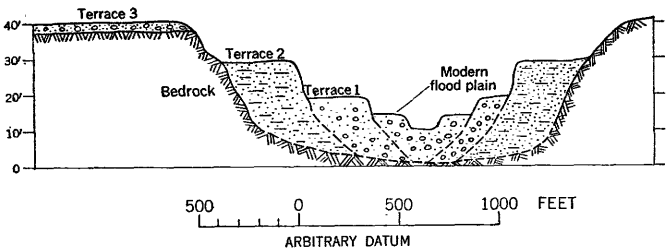


FIGURE 3.—Generalized valley cross section of Fivemile Creek showing relationship of terraces and alluvial fills.

feet above the present stream. Terrace 1 stands 8 to 10 feet above the channel and terrace 2 stands 18 to 20 feet above the channel. Terrace 3 stands 25 to 30 feet above the present stream and is a gravel-capped, rock-cut surface.

The three terraces and flood plain are conspicuous throughout the valley and can be traced with assurance. (See pl. 3*A*, *B*.) Although in some places the terraces are represented by disconnected remnants, their relative elevations are remarkably consistent along the valley (see table 1). The terraces can be identified by the alluvial materials of which they are composed. Heights of terraces 1, 2 and 3 above the present stream levels at different cross sections are given in table 1.

TABLE 1.—*Terrace heights, in feet, above present stream level, on Fivemile Creek, Fremont County, Wyo.*

Location (pl. 1)	Terrace 1	Terrace 2	Terrace 3
NW¼ sec. 16, T. 5 N., R. 1 W	5.4	18.5	29
SE¼ sec. 13, T. 5 N., R. 1 W	9.6	22	30
NE¼ sec. 22, T. 5 N., R. 1 W	12.2	20	30
NE¼ sec. 23, T. 5 N., R. 1 W	9.6	16.5	25
NE¼ sec. 24, T. 5 N., R. 1 W	7	20	28
NW¼ sec. 29, T. 5 N., R. 1 E	8	18.5	27
SW¼ sec. 29, T. 5 N., R. 1 E	10	---	---
NW¼ sec. 33, T. 5 N., R. 1 E	---	15.2	---
NW¼ sec. 4, T. 4 N., R. 1 E	---	18.8	---
SW¼ sec. 3, T. 4 N., R. 1 E	9.3	19	30
NE¼ sec. 10, T. 4 N., R. 1 E	9.2	24.4	27
SE¼ sec. 14, T. 4 N., R. 1 E	11.1	20	25
SE¼ sec. 24, T. 4 N., R. 1 E	9.5	24.3	30
SE¼ sec. 30, T. 4 N., R. 2 E	11.8	20	28
SE¼ sec. 8, T. 3 N., R. 3 E	9	---	---
SW¼ sec. 24, T. 3 N., R. 3 E	8.2	22.8	28
NW¼ sec. 35, T. 3 N., R. 4 E	7.0	20.4	29
SE¼ sec. 18, T. 3 N., R. 6 E	---	16.2	---
SW¼ sec. 19, T. 3 N., R. 6 E	10	20	26

TERRACE 1

A prominent surface standing 8 to 10 feet above the present stream is designated as terrace 1. This surface is almost continuous in the upper part of the stream valley but has been eroded extensively in the lower part so that only small, isolated remnants are found. In the reach immediately above the mouth of the stream where the channel has been widened to nearly 1,000 feet, terrace 1 is entirely absent.

The alluvial material underlying terrace 1 is coarser than that beneath the next higher surface. Terrace 1 alluvium has not undergone as much weathering and erosion as the older deposits, and there is no evidence of leaching or soil development.

Terrace 1 is distinguished nearly everywhere along the valley by a dense growth of rabbitbrush (*Chrysothamnus* sp.) which in places reaches a height of 3 to 4 feet. This dense cover of vegetation is in marked contrast to the barren aspect of terrace 2.

The longitudinal profile of terrace 1 is nearly parallel to the profile of the present streambed (fig. 2). The surface has slight local relief caused by rivulet washing and does not slope toward the channel perceptibly. It has the characteristics of a depositional surface, and the effects of subaerial erosion subsequent to deposition are slight. Throughout the valley, wind-blown sand is prominent on terrace 1.

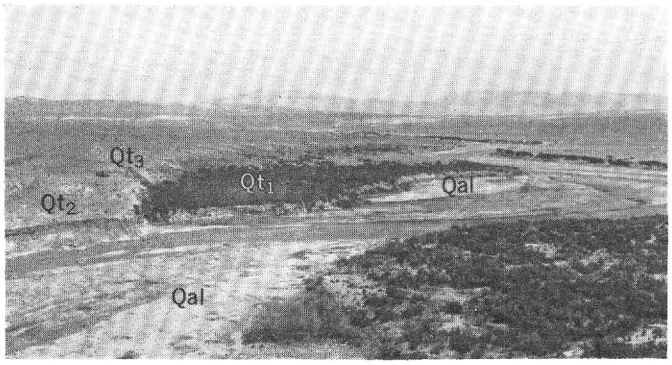
The underlying alluvial deposit is predominantly sand containing many gravel stringers. Many exposures show torrential crossbedding in gravelly material, indicating that most of the material was deposited by a stream capable of moving coarse gravel. (See pl. 3*C*.)

In most places terrace 1 rests unconformably against the older deposits of terrace 2 and in a few places it is in contact with the bedrock. In the places where the deposits underlying terraces 1 and 2 are in contact and the vertical exposure is free of slumped material, the abrupt textural change from one to the other is apparent.

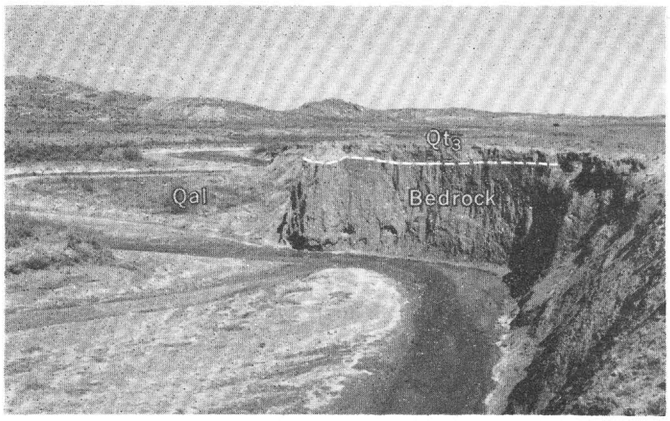
TERRACE 2

Throughout the valley a distinct surface stands 18 to 20 feet above the present stream level. This surface, designated terrace 2, is indicated on the geologic map and the accompanying cross sections (pl. 1).

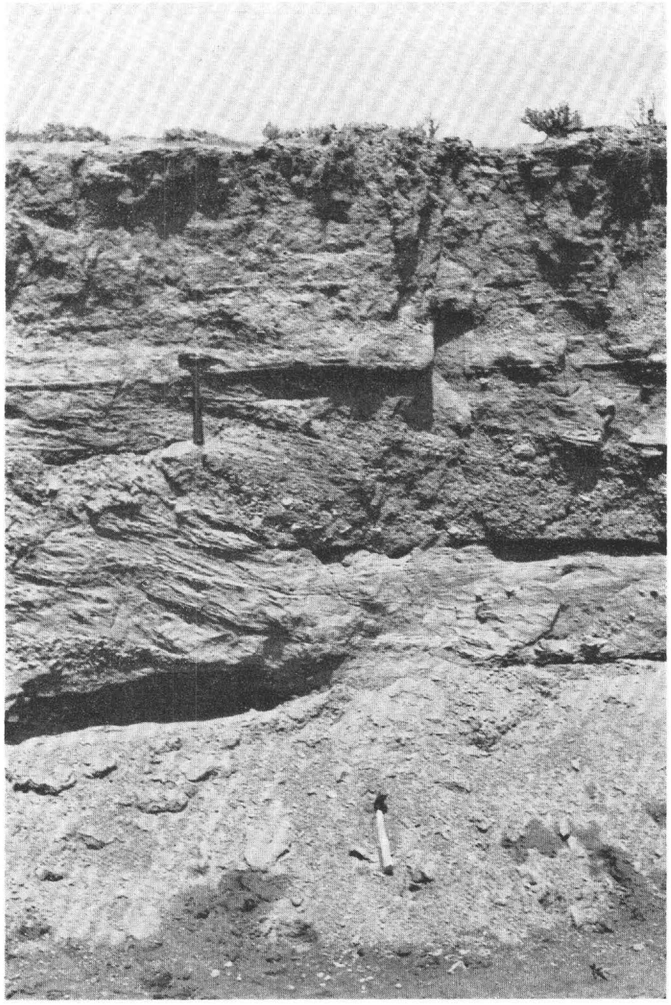
This terrace can be traced almost continuously throughout the valley. In places where it has been dissected by gullies disconnected remnants can be correlated readily. Terrace 2 is extensive and, unlike terrace 3, is found on both the north and south sides of the channel in most places. In the lower part of the valley it is a broad, flat area which has been con-



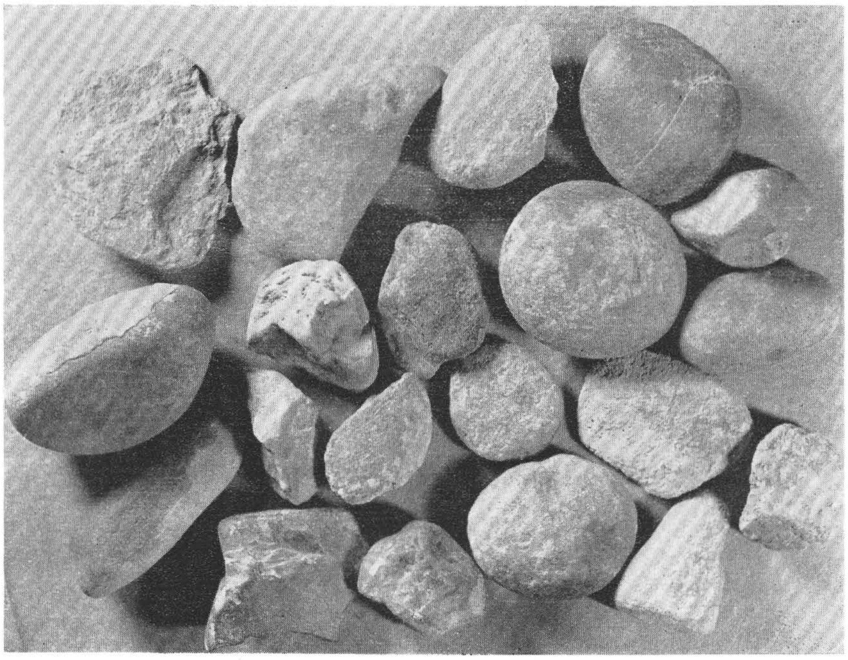
A. View of upper part of Fivemile Creek valley showing terraces



B. View of upper part of Fivemile Creek valley showing terraces and bedrock



C. Vertical exposure of alluvium underlying terrace 1 showing torrential crossbedding and coarse gravel lenses



Pebbles in the 16–32 mm class from terrace 3 gravels showing change in degree of roundness in 55-mile length of terrace verted to farmland on the Riverton Reclamation withdrawal area. The gradient of terrace 2 is generally the same as that of the present streambed and, like terrace 3, it does not slope perceptibly toward the stream channel.

The alluvial material which underlies terrace 2 is predominantly very fine sand and silt. The source of the material was probably the Mesozoic sedimentary formations cropping out at the head of the valley. Salt sage (*Atriplex* sp.), the typical vegetation on this surface, grows above the general level on small hummocks that are the result of rivulet washing.

The surface is covered with a thin mantle of windblown sand in scattered parts of the lower valley. This sand occurs locally in dunes, but it makes up only a small fraction of the total material underlying terrace 2 in the lower valley.

The deposits of alluvium underlying terrace 2 are in unconformable contact with the bedrock units in which the channel is confined. Sharp contacts, however, are not extensively exposed because of slumping subsequent to deposition of the alluvial material. In some reaches bedrock is exposed below the gravels of terrace 3, and the alluvium of terrace 2 abuts against the bedrock of the channel wall at a lower elevation. It is obvious that the deposits underlying terraces 3 and 2 are not of the same age. There is slight leaching of calcium carbonate to a depth of 4 to 6 inches in terrace 2 and some evidence of profile development.

Particle-size analyses of the deposits are given in another section of this report.

TERRACE 3

The surface, standing generally 25 to 30 feet above the present stream, was designated terrace 3 (pl. 3*A*, *B*). It is shown on the geologic map and the cross sections (pl. 1). This surface, which corresponds to the Lenore surface of Blackwelder (1915, p. 321), is consistently present on the south side from the head of Fivemile Creek near the base of the Owl Creek Mountains to its junction with the Wind River, about 55 miles. Throughout its length this surface overlies Cretaceous and Tertiary sedimentary rocks and is capped by gravel which ranges in thickness from 5 to 15 feet. Random samples taken of the gravel at intervals along the surface show a predominance of igneous rock pebbles and limestone and quartzite pebbles, indicating that the principal source of the material was upstream in the foothills of the Owl Creek and Absaroka Mountains where rocks of these types crop out. Some of the pebbles may have been contributed by slope wash from higher gravel-capped surfaces along the valley. Most pebbles have a thin coating of calcium carbonate and the deposit is deeply weathered.

Terrace 3 is absent on most of the north side of the present channel. Erosion probably removed this part of the terrace by undercutting after the stream had entrenched itself in the gravel deposits. South of the channel, however, terrace 3 is in places a quarter of a mile wide. The underlying formations, although consisting of beds of nonresistant shale and poorly cemented sandstone, constitute a barrier against erosion of the terrace riser which, in many places forms the channel wall. (See pl. 3*B*.)

Terrace 3 is a nearly plane surface with a maximum relief of 2 or 3 feet. The minor irregularities in relief have been caused by dissection after the deposition of the gravel. The gradient of the surface is nearly equal to that of the present streambed, averaging about 26 feet to the mile, and the surface does not slope perceptibly toward the axis of the valley.

MODERN FLOOD PLAIN

The flood plain of the stream is a poorly defined surface 2 to 4 feet above the present streambed (pl. 1).

Spring and summer floods overflow this surface resulting in aggradation in some reaches of the stream and degradation in others. Throughout the valley the surface is being constantly changed by the stream.

The alluvial material underlying the modern flood plain is composed mainly of sand, although gravel lenses and stringers occur along the slip-off slopes of meanders. Much of the material has probably been derived from sloughing banks and headward-cutting gullies in the older terraces, but undoubtedly some material has been transported from the mountain regions by waters from summer rainstorms and spring snowmelt.

The significance of these terraces in reconstructing the postglacial erosional history of the valley of Fivemile Creek is apparent. The terraces represent cycles of aggradation and degradation within the valley as the stream regimen varied with internal and external conditions.

PHYSICAL PROPERTIES OF ALLUVIAL DEPOSITS

Samples of the alluvium underlying terraces 1 and 2 and the modern flood plain and gravels on terrace 3 were collected at different sections throughout the valley of Fivemile Creek. Size-frequency analyses of the samples of alluvial terrace deposits and a study of the effect of transportation on the roundness and sphericity of pebbles of different lithology in terrace 3 gravels were made. The location of sampling sections was determined by the nature of the deposits and the exposures which showed best the contrasts between the alluvial fills. Samples were collected both from the surface (channel samples) and from pits.

The channel samples were taken in the vertical exposures of the terraces along the creek. The sampled sections were chosen so that a section near maximum thickness would be obtained. It was noted in the field that the alluvial fills underlying terraces 1 and 2 were uniform in texture throughout the length of the valley, and this observation was substantiated by mechanical analyses.

In the upper part of the valley, terrace 3 is exposed in scarp faces or in the terrace lip adjacent to the channel; but in the lower part of the valley where terrace 2 is extensive the scarps of terrace 3 stand at a distance from the channel and have been modified by slumping. In such locations it was necessary to dig a pit in order to obtain representative gravel samples.

SIZE-FREQUENCY ANALYSES

Mechanical analysis of the individual samples of terrace 1 alluvium showed a normal decrease in grain sizes in a downstream direction (fig. 4). The variability at a given sampling location was not large enough to mask this decrease. The 18 samples were, therefore, grouped into 4 composite samples (1–A, 1–B, 1–C, 1–D) so that the overall changes in texture of the deposit were obtained.

The alluvium of terrace 1 is much coarser than that of terrace 2. The median diameter for the 4 composite samples ranges from 0.185 mm at the head of the valley to 0.123 mm at the downstream end. The weight of particles with a diameter greater than 2 mm ranged from 1 percent in sample 1–D to 21 percent in sample 1–A. This distribution indicates that the competence of the stream which deposited the alluvium of terrace 1 was not extremely high even during floodflow. The absence of a concentration of fine material in terrace 1 deposits may be interpreted to mean that the velocity was too high for deposition of silt and clay when they were part of the suspended load.

The sorting coefficients for terrace 1 samples are markedly different from those calculated for samples of terrace 2. Coefficients range from 1.79 to 3.14 (see table 2) which means, according to the classification of Trask, that all of the samples are well sorted except 1–A, which has a coefficient of 3.14. This coefficient, however, is only slightly more than the normal sorting coefficient of 3.00.

The skewness coefficients calculated for samples of terrace 1 range from 1.06 to 2.66 (see table 2). These results indicate that the maximum sorting of samples 1–A and 1–C lies on the fine side of the median diameter, whereas the maximum sorting of 1–B is on the coarse side. It should be noted that the mechanical analyses of samples from terraces 1 and 2 disclose marked differences in texture and other physical properties.

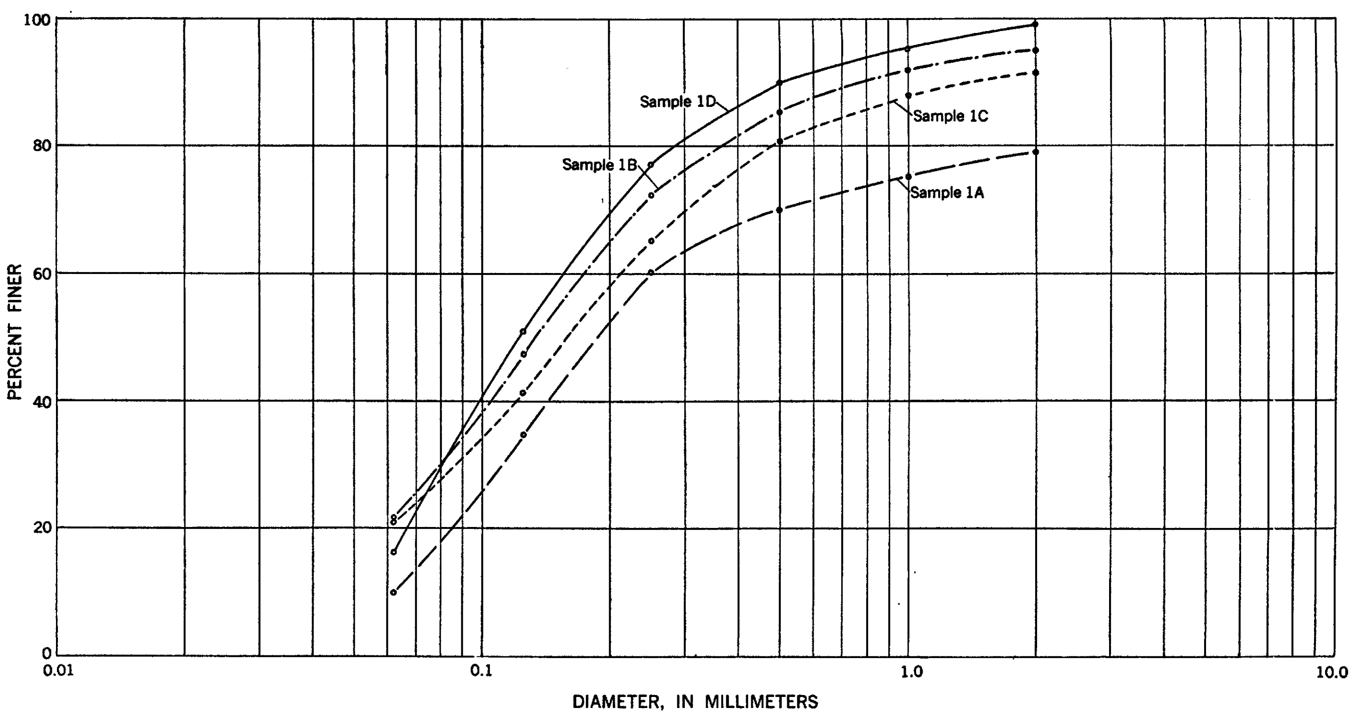


FIGURE 4.—Distribution of particle sizes in alluvial deposits underlying terrace 1.

Preliminary mechanical analysis of terrace 2 alluvium showed that the percentage of any grade size did not vary for samples from the head and mouth of the valley. After noting the slight variations in grain size, composite samples were made from the individual samples of terrace 2 alluvium. The 17 samples collected were consolidated into 4 composite samples for analysis (2–A, 2–B, 2–C, 2–D) representing sections of the terrace in downstream order. The size-distribution curves of particle size from the mechanical analysis data of terrace 2 composite samples are shown in figure 5.

Mechanical analysis of the four composite samples of terrace 2 alluvium showed little change in median grain size from the head of the valley to its mouth (table 2). The median diameter ranges from 0.017 to 0.023 mm in the 55-mile length of the terrace, with the upstream and downstream samples having nearly the same median diameter. Samples of this alluvium were examined by P. D. Trask (written communication, 1947). He noted that the samples show no consistent change in average diameter downstream. This lack of change is rare in an alluvial deposit which has been identified as a sedimentary unit. The velocity of the stream depositing terrace 2 alluvium must have been below the critical velocity for the transportation by suspension of particles of this size (Plumley, 1948, p. 544). The stream, therefore, probably had a low mean velocity with a marked absence of high flows. This conclusion is supported by the paucity of particles coarser than sand in the deposits.

The sorting coefficient was determined for the samples of terrace 2 according to Trask's classification (Twenhofel and Tyler, 1941, p. 111). The coefficients ranged from 4.33 to 5.18 (see table 2). According to Trask, if the coefficient is more than 4.50, the material is poorly sorted. Therefore, by Trask's standards, the samples of terrace 2 are poorly sorted.

The coefficient of geometrical quartile skewness indicates the degree of symmetry of the size distribution with respect to the median (Twenhofel and Tyler, 1941, p. 111). This coefficient of skewness was calculated for the terrace 2 samples (see table 2) and ranged from 0.73 to 1.33. When the skewness is unity, the mode coincides with the median diameter. When the skewness is greater than unity, the maximum sorting of the material lies on the fine side of the median diameter; if it is less than unity, on the coarse side (Twenhofel and Tyler, 1941, p. 112). Therefore, samples 2–A, 2–C, and 2–D with coefficients of 1.26, 1.09 and 1.33 have maximum sorting on the fine side of the median diameter. Sample 2–B has its maximum sorting on the coarse side of the median.

Samples of the flood-plain alluvium were analyzed individually because of their highly variable texture. Five samples were collected at scattered points along the valley. (See pl. 2.) They are lettered in the same sequence as the samples of terraces 1 and 2; sample

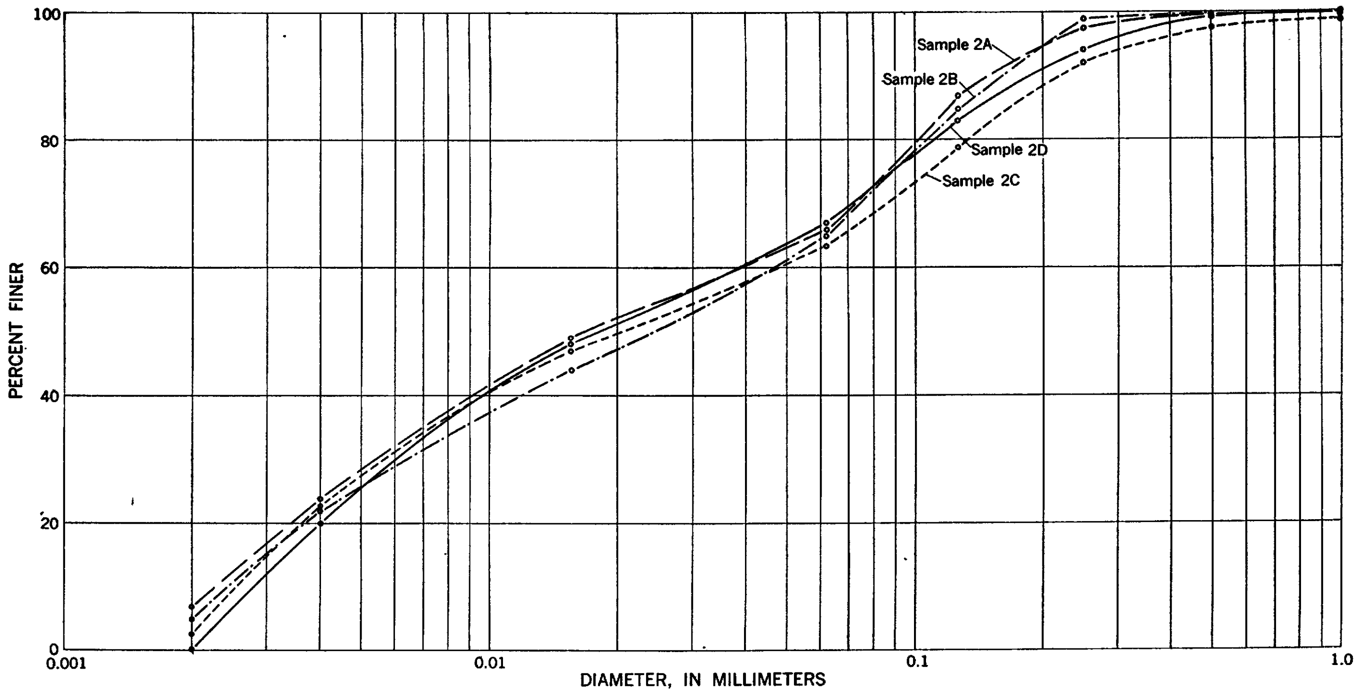


FIGURE 5.—Distribution of particle sizes in alluvial deposits underlying terrace 2.

4–A was taken from the upper end of the valley and sample 4–E from the downstream end.

The size-distribution curves show that the fraction with grains greater than 2 mm in diameter ranges from 16 to 32 percent (fig. 6). By comparing these percentages with the curves for terraces 1 and 2, it is evident that the present stream is depositing coarser material in either of the older terraces. Trask (written communication, 1947) states:

> It is not surprising that the sand in the present stream is coarser than the sand in the alluvium, because hand-lens inspections of the sand from the streambeds and from the alluvium in walls of the gullies from some 30 or more areas through Wyoming, Utah, Colorado, New Mexico, and Arizona indicated clearly that the sand in the present streams is coarse, on the average about twice as coarse, as the sections above.

Because the present stream gradient and the gradient of the alluvial terraces above it are nearly the same, conditions of deposition today must differ greatly from former ones. Evidently the velocity and thereby the competence of the modern stream is higher during floodflow.

The coefficients of sorting for the flood-plain samples range from 1.70 to 4.00 (see table 2). Samples 4–A and 4–E are well sorted, being below 2.5 in Trask's classification. Samples 4–B, 4–C, and 4–D fall between the limits of normal and poor sorting. This relationship shows clearly the erratic texture of flood-plain alluvium.

The skewness coefficients range from 1.08 to 2.79 (see table 2). Therefore, for all flood-plain samples the maximum sorting lies on the fine side of the median diameter.

TABLE 2.—*Summary of textural relationships*

Sample	Median diameter (mm)	Third quartile	First quartile	Coefficient of sorting	Coefficient of skewness
1–A	0.185	0.950	0.096	3.14	2.66
1–B	.135	.285	.068	2.05	1.06
1–C	.160	.385	.071	2.33	1.06
1–D	.123	.233	.073	1.79	1.12
2–A	.017	.087	.0042	4.55	1.26
2–B	.024	.089	.0047	4.36	.73
2–C	.021	.110	.0044	5.18	1.09
2–D	.018	.090	.0048	4.33	1.33
4–A	.550	1.20	.29	2.00	1.15
4–B	.730	2.50	.23	3.30	1.08
4–C	.500	3.20	.20	4.00	2.55
4–D	.320	2.20	.13	4.00	2.79
4–E	.560	1.10	.37	1.70	1.29

ROUNDNESS AND SPHERICITY OF TERRACE 3 GRAVELS

Six samples of terrace 3 gravels were collected at different points throughout its 55-mile length. The pebbles in the 16–32 mm range were used in a study of the changes in degree of roundness and sphericity with distance of transportation and the effect of the mineral composition of the pebbles on these two values.

The roundness of the pebbles in the 16–32 mm range collected from the terrace 3 gravels was determined by use of visual comparison charts. The sphericity of the same suites of pebbles was determined by the Wadell method which is expressed by the formula $d_n/D_s=\psi$ where d_n is the true nominal diameter of the pebble or the volume of a sphere of the same volume and D_s is

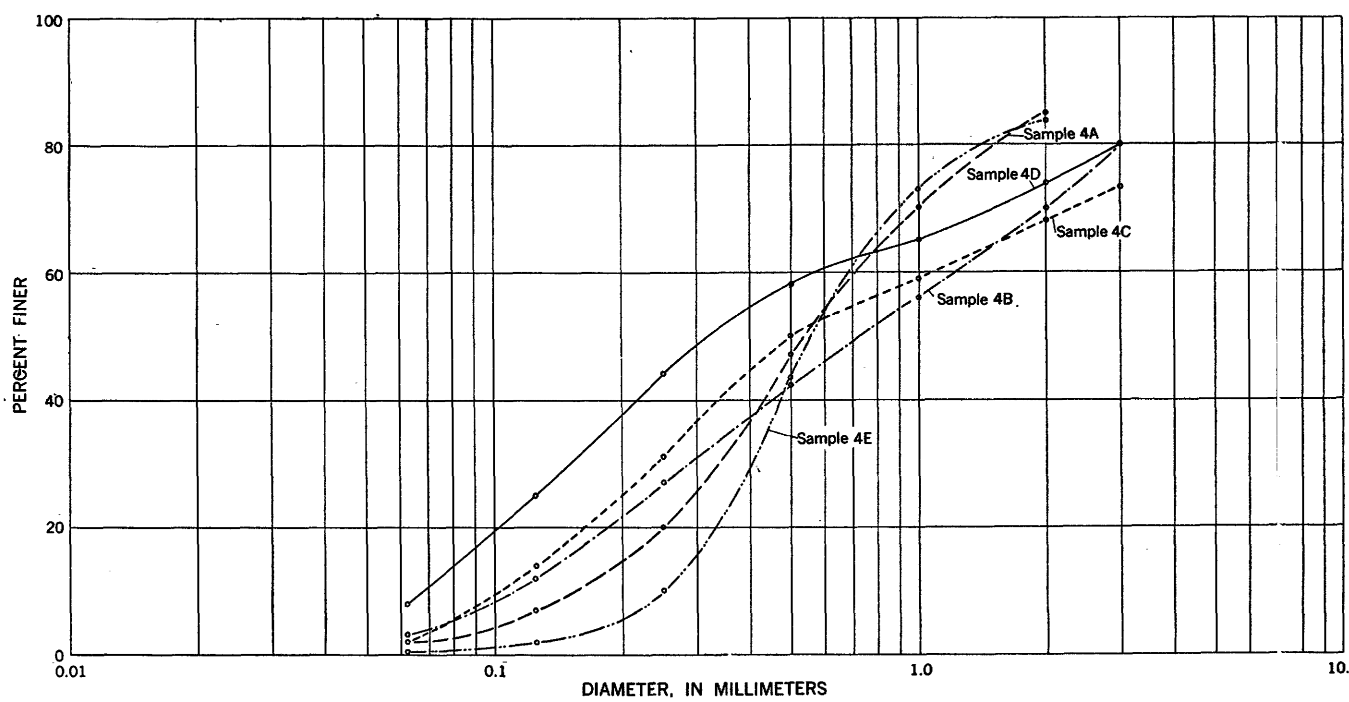


FIGURE 6.—Distribution of particle sizes in alluvial deposits underlying the modern flood plain.

the diameter of the circumscribing sphere (Krumbein and Pettijohn, 1938, p. 284).

Suites of 20 pebbles each were selected at random from the 16–32 mm fraction of terrace 3 gravels. Roundness and sphericity were determined for the individual pebbles and the averages were plotted for the single samples (fig. 7). The mineral composition of each pebble was determined and the effect of erosion during transportation noted.

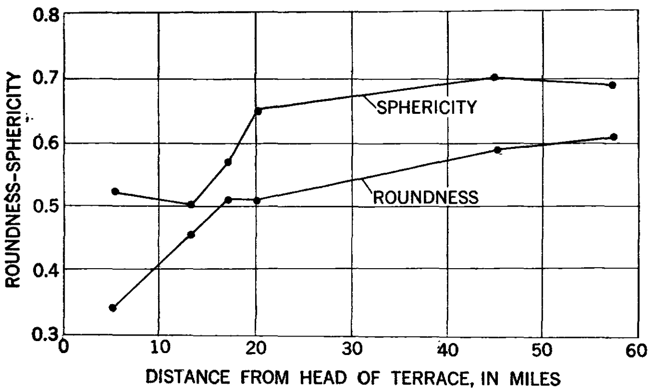


FIGURE 7.—Relation of roundness and sphericity to distance from head of terrace for pebbles in 16–32 mm size class from terrace 3.

Shape and roundness in gravels have been interpreted by geologists in many ways. Pettijohn (1949, p. 53) states that available data are insufficient to determine the geologic significance of these characteristics. He does say, however, that roundness is a good index to the maturity of a sediment. Pettijohn states further that both experimental and field studies show that gravel sizes are readily rounded through short transport, whereas prolonged abrasion is necessary for the rounding of sand. This may account for the similarity observed under the microscope in the roundness of the finer material of terraces 1 and 2 as compared with the coarse gravels of terrace 3.

The effects of distance of transportation on the roundness and sphericity of terrace 3 gravels are given in plate 4.

It will be noted that the roundness increases rapidly in the first stages of transportation and levels off after a certain roundness has been reached. (See table 3.) Perfect roundness, which is a value of 1.0, is never reached because of the nonhomogeneity of the material and the rigor of the abrasive processes (Pettijohn, 1949, p. 410). The sphericity of the pebbles is variable in the first few miles and then increases fairly constantly to the mouth of the stream except for sample 3–6, which shows a decrease in sphericity, perhaps because of breakage. In general, in the samples of terrace 3 gravels for which roundness and sphericity were determined there is a trend toward greater roundness with increasing sphericity. In studies of Black Hills terraces gravels, Plumley (1948, p. 558) found the same condition.

The pebbles are rounded to varying degrees because of their mineral composition (see table 4). The limestone pebbles in sample 3–1 have an initial roundness of 0.42; this value increased to 0.62 in the 55 mile-length of terrace. Plumley (1948, p. 558) suggests that limestone pebbles 16–32 mm in size reach a limit of rounding of about 0.73–0.74 when transported about 200 miles. Quartz pebbles in sample 3–1 have a roundness value of 0.30. This value increased to 0.70 at the mouth of the stream, which seems high and may be due to an influx of well-worn gravel from higher terraces that previously underwent more intensive abrasion. The absence of sandstone pebbles in sample 3–6 is to be expected because the sandstone cropping out in the area would probably disintegrate rapidly when subjected to stream abrasion.

TABLE 3.—*Average roundness for samples of terrace 3 gravels*

Sample	Approximate miles from head of stream	Average roundness	Average sphericity
3–1	5	0.34	0.52
3–2	13	.45	.50
3–3	16	[1] .51	.57
3–4	20	.51	.65
3–5	45	.59	.70
3–6	56	.61	.69

[1] Contribution of material from Teapot Draw may account for the sharp rise in short distance.

TABLE 4.—*Effect of composition on abrasion of terrace 3 gravels*

Composition	Sample 3-1		Sample 3-6	
	Number of pebbles	Average roundness	Number of pebbles	Average roundness
Limestone	5	0.42	4	0.62
Quartz	6	.30	7	.70
Chert	4	.17	4	.52
Granite	1	.30	1	.30
Siltstone	2	.45	3	.63
Sandstone	2	.50		
Quartzite			1	.50

HEAVY-MINERAL DATA

Heavy-mineral counts were made of samples from terraces 1 and 2 to determine whether the alluvial deposits could be identified on the basis of heavy-mineral suites. Samples 1–3 and 1–17 were chosen as representative of terrace 1 and samples 2–2 and 2–16 of terrace 2. Locations of sections from which samples were taken are shown on plate 2. Sample numbers increase downstream. The samples were sieved and a 10-gram part of the alluvium remaining on the 115-mesh screen (0.125-mm openings) was used for the bromoform separations. The results of the heavy-mineral counts appear in table 5.

No attempt was made to correlate the results of the heavy-mineral counts of the samples studied. There are, however, some significant differences: (a) The high percentage of zircon grains in samples 2–2 and 2–16 is in direct contrast to the rareness of zircon in samples 1–3 and 1–17. (b) Magnetite was not present in samples of terrace 2 and its occurrence was common in samples of terrace 1. (c) The contributions of tributaries between the upstream samples, 2–2 and 1–3, and the downstream samples, 2–16 and 1–17, probably are responsible for the high percentage of garnet grains in the downstream samples.

These data are not sufficient for correlation of these alluvial deposits on the basis of heavy-mineral content. A more detailed statistical analysis of the samples throughout the valley might show some definite trends that could be used for correlation.

TABLE 5.—*Heavy-mineral data for alluvial deposits of terraces 1 and 2*

Minerals	Percent of total grains present			
	Sample 1–3	Sample 1–17	Sample 2–2	Sample 2–16
Apatite	53.0	20.7	39.2	32.0
Biotite	3.0	8.4	2.3	5.0
Carbonate	1.7	3.3	3.9	2.3
Chlorite	(1)	(1)	.3	(1)
Epidote	(1)	12.2	(1)	4.7
Garnet	8.6	27.5	1.1	8.4
Hematite	(1)	(1)	.3	(1)
Hornblende	2.3	(1)	5.2	9.1
Muscovite	(1)	.3	.3	(1)
Staurolite	(1)	(1)	1.1	.3
Sphene	(1)	(1)	.3	(1)
Tourmaline	(1)	1.0	2.6	(1)
Zircon	2.7	1.3	40.5	27.5
Leucoxene	(1)	(1)	(1)	.7
Rutile	(1)	(1)	(1)	.3
Magnetite	16.9	4.9	(1)	(1)
Amphiboles	9.9	19.8	1.6	7.4
Unknown	1.7	.3	1.1	1.7

[1] Mineral not present in sample.

In summary, the alluvium underlying terraces 1 and 2 show marked differences in texture and other physical properties. Terrace 2 alluvial grains show no consistent change in median diameter, ranging from 0.017 to 0.023 mm, throughout the 55-mile length of the valley. Terrace 1 alluvium shows a normal increase in finer grade sizes in a downstream direction. The median diameter of alluvial grains decreases from 0.180 to 0.120 mm from the sampling section farthest upstream to the mouth of Fivemile Creek.

Frequency studies of flood-plain alluvium show that the present stream is depositing much coarser material than that found in older alluvium.

Studies of roundness and sphericity of terrace 3 gravels in the 16–32 mm range show that both indexes increase markedly from the head of the valley to the mouth. Roundness is also affected by mineral composition. Granite pebbles were the least abraded by transport, and quartz pebbles reached the highest index of roundness at the mouth of the stream.

The heavy-mineral suites in terraces 1 and 2 alluvium showed marked differences in some minerals. Zircon grains were common in terrace 2 alluvium whereas they were rare in the other. Magnetite was not found in terrace 2 samples but was abundant in terrace 1.

Differences in characteristics of the alluvium of the four fills suggest striking differences in runoff and erosional features during their deposition, and as a corollary, differences in climate during those periods.

CAUSES OF TERRACE DEVELOPMENT

It is generally agreed (Blackwelder, 1915, p. 307; Jahns, 1947, p. 42) that the formation of alluvial terraces in the erosional history of a stream that is progressively aggrading or degrading in an attempt to maintain equilibrium conditions can be attributed to one or several of the following causes:

1. Readjustment of stream grades by removal of channel obstructions or piracy in the lower reaches of the valley.
2. A series of general crustal uplifts.
3. Broad climatic variations, causing variation in the discharge of the stream, as well as in vegetational cover of the drainage basin.

We may now ask which of the above processes were responsible for conditions that now exist along Fivemile Creek. It should be remembered that the conditions observed in this valley apply in a broad sense to many other stream valleys in the Rocky Mountain and Great Plains regions.

Removal of obstructions in the channel could account for terraces within the drainage basin, but it can hardly explain the counterparts of these terraces in other stream valleys of the region, especially those of different master stream systems. Terrace 3, the highest terrace, exists along the Wind River and also along Muddy Creek a few miles to the north. The gradient of the surfaces and the texture of the alluvium would not be so uniform if they had resulted from the smoothing out of a rapids or from the elimination of a falls. A terrace system with marked similarities over a large area must be explained by some other means.

Before a detailed study was made on Fivemile Creek, the author felt that the terraces might have been preserved partly by buried bedrock spurs in the valley. If, however, the alluvial material had accumulated on the upstream side of such an obstacle and remained as a terrace facet, the gradient probably would not have been uniform. Also, the height of the terraces above the streambed would probably vary between these bedrock spurs. Such a spur cuts across the valley in SE¼ sec. 13, T. 5 N., R. 1 W. Some change in the texture of alluvium underlying terrace 1 occurs immediately upstream, but the bedrock was evidently eroded at a rate nearly equal to the downcutting of the streambed and has not caused a nick point on the profile of the stream. It seems evident, therefore, that the terrace system in this valley is the result of a more wide-spread phenomenon.

A series of crustal uplifts could cause trenching of the stream flood plains simultaneously throughout the region affected by the uplift. But, as Blackwelder (1915, p. 307) points out, the uplifts, if equal everywhere, would cause rejuvenation first in the lower courses of the streams. The terrace features developed during any given erosion cycle would be distinctly older in the lower part of the valley than farther upstream. The weathering of alluvium underlying terraces in this valley does not differ greatly from place to place, thus indicating that the terraces are the result of a process acting equally throughout the region at the same time and probably at a rapid rate. Although the terrace systems of valleys far from the mountains could be the result of uplift accompanying the mountain-building, the marked similarities from valley to valley suggest a more general cause.

In recent years the importance of climatic changes in terrace formation has been recognized increasingly. In the 19th century Gilbert stated (1877, p. 132) that, "river terraces as a rule are carved out, and not built up. They are always the vestiges of flood plains, and flood plains are usually produced by lateral corrasion." At the present time, however, many terrace systems are attributed to climatic fluctuations of glacial and postglacial time. Cotton believes (1948, p. 206) that a similarity in terrace patterns from one valley to another indicates that climatic change probably causes terracing.

The hypothesis of climatic terraces was developed by Huntington (1914, p. 23) and is often referred to as Huntington's principle. Huntington studied terrace systems in both Asia and America, and his studies in the Southwestern United States are closely related to this problem. Huntington (1914, p. 28) states that all terraces form in a similar manner as follows: The first cycle begins when the streams are deepening and widening their channels and are cutting into bedrock. Deposition is then brought about by a climatic change which encourages erosion. The process is reversed later and results in trenching of the alluvium. The vestiges of these alternating processes are terrace remnants.

The manner in which changes in climate affect stream regimen seems to be a moot question in the literature. Huntington (1914, p. 23) contends that degradation is caused by increased precipitation. Dutton (1882), Barrell (1908), and Gregory (1915, 1917) agree that downcutting is associated with a change to more humid climate. Bryan (1925, 1941) attributes valley trenching to periods of aridity. In a more recent study Leopold (1951) cites a change in rainfall intensities in New Mexico as a possible cause for arroyo cutting in the Southwest since 1880. All agree, however, that changes in climate have a marked effect on stream regimen. An increase in rainfall may increase the extent of a protective vegetative cover. This cover on the slopes reduces the ratio of runoff to infiltration. On the valley floor the vegetation may induce deposition. However, it may be that aggradation of channels proceeds more rapidly during droughts as a result of dissipation of flow in parched streambeds (Schumm and Hadley, 1957).

Some investigators have noted sand dunes as evidence for associating aridity with periods of erosion (Hack, 1942; Albritton and Bryan, 1939). There is some question whether dunes always indicate aridity. Cooper (1935) believes that dune building may be promoted by dry climate and absence of vegetation, but lowering of the water table by entrenchment can also be responsible. The dunes on terrace 1 may have been formed as Cooper suggests rather than by a change to a drier climate.

The general climatic fluctuations in Western United States in the past 9,000 years are fairly well documented by findings in the fields of botany, geology, and climatology. There is no need here to elaborate on the findings of several investigators of postglacial climatology but the following paragraph briefly summarizes the situation:

Beginning with the retreat of the last ice sheet, the climate became increasingly warmer from about 5000 B.C. to about 1000 B.C. (Willett, 1949, p. 47–50). This peak of warmth has been called the Climatic Optimum or Altithermal (Antevs, 1948). The period was characterized by widespread aridity, and most of the pluvial lakes in Western United States were lowered considerably or completely dried up (Flint, 1947, p. 494). In the next 2,350 years (2000 B.C. to A.D. 350) the climate changed to become generally wetter, and colder. This period is part of Matthes' (1939, p. 520) "Little Ice Age" which ended about A.D. 1850. Willett, however (1949, p. 49), cites historical evidence for a second warm period lasting from A.D. 400 to A.D. 1000 and he indicates that in the Western United States both lake levels and tree-ring records tend to confirm that this period was very dry. From about the year A.D. 1000 to the present, oscillations of the climate have been small but the climate has been generally colder and wetter than the milder postglacial periods (Willett, 1949, p. 49).

PROBLEMS OF TERRACE CORRELATION

Correlation of alluvial terrace sequences from valley to valley on a regional scale has been attempted by many writers (Bryan, 1940, 1941, 1954; Hack, 1942; Albritton and Bryan, 1939; Leopold and Snyder, 1951; Leopold and Miller, 1954; Judson, 1953). Correlation and dating of terraces by these investigators generally have been based on archeological finds, differences in terrace morphology, degree of weathering, or height of terrace remnants above present stream grade. Correlating remnants of Fivemile Creek terraces within the valley presents no problem because of the distinct lithologic and topographic characteristics of the individual alluvial fills. Terraces 1, 2 and 3 are probably remnants of three distinct valley fills throughout the length of the valley. However, it is difficult to date these terraces and correlate them with similar sequences in stream valleys throughout the Great Plains from Montana to New Mexico. No archeological sites were discovered in Fivemile Creek valley that could be used to date the alluvium. Two hearths associated with bones *Bison bison* were found in the terrace 2 fill, but no artifacts were present and the bones are not diagnostic. Therefore, dating of events which may have changed stream regimen and produced the terraces is hazardous.

Blackwelder (1915, p. 307–340) describes the sequence of glaciation in the Wind River Mountains and traces several terrace deposits to glacial moraines. This sequence has been studied further by Moss (1951) and Holmes and Moss (1955) and modified by Richmond (1948, 1957). This report is not concerned primarily with the late Pleistocene terraces of outwash gravels described by these investigators, but the youngest terrace in Blackwelder's sequence (Lenore) is terrace 3 along Fivemile Creek.

Blackwelder (1915, p. 324) traced the Lenore surface to moraines of the Pinedale glacial stage of Wisconsin age, and Richmond (1948, p. 1,400) traced the seven terraces related to the morainal sequence in the Wind River Mountains down the Wind River to Wind River Canyon which is about 10 miles below the mouth of Fivemile Creek. Richmond also tentatively correlates the Wind River sequence with the work of Bryan and Ray (1940) on the Cache la Poudre River in the Front Range of Colorado. In his correlation, the Lenore terrace of Blackwelder is comparable to terrace 3 of Bryan and Ray which is traceable to the Long Draw moraine. From the evidence it seems certain that terrace 3 on Fivemile Creek (Lenore of Blackwelder, 1915) was formed during the Pinedale glacial stage of Wisconsin time. The maximum age of the Fivemile Creek terrace sequence therefore is tentatively fixed. The possible correlation of the alluvial fills underlying terraces 1 and 2 with similar sequences throughout Western United States will now be considered.

Bryan (1941, p. 228–229) established an alluvial chronology for postglacial erosional events or periods of alternate deposition and erosion in Southwestern United States, and several writers since then have correlated alluvial sequences with Bryan's original chronology. In a recent reconnaissance study of postglacial terrace sequences in eastern Wyoming, Leopold and Miller (1954, p. 38) tentatively correlate Fivemile Creek terraces with Bryan's alluvial chronology and several other studies (Leopold and Miller, 1954, p. 58–59).

Alluvial deposits underlying terrace 1 have been correlated with Moorcroft period of deposition or stability (Leopold and Miller, 1954, p. 38) in eastern Wyoming. In that correlation the Moorcroft is contemporaneous with San Pedro cultural stage in Whitewater Draw, Ariz. (Sayles and Antevs, 1941), which has been given a radiocarbon age of about 2,500 years (550 B.C. ± 310 years) (Flint and Deevey, 1951, p. 280). Leopold and Miller (1954) also correlate Moorcroft deposition with the "main fill" at Chaco Canyon, N. Mex., which Bryan (1941, p. 230; 1954, p. 37) dates as beginning before A.D. 500–700 and continuing to A.D. 1250; and the upper part of the Nakaibito formation (Leopold and Snyder, 1951, p. 11) which is tentatively dated between A.D. 900 and 1100 on the basis of Pueblo II potsherds.

The author believes that alluvium underlying terrace 1 along Fivemile Creek is younger than the alluvial fills just described. Although no datable evidence such as artifacts or vertebrate remains were uncovered, a general argument for more recent deposition of terrace 1 alluvium will be presented based on physical characteristics of the deposits. At the 18 sampling sections located throughout the valley there is no evidence of soil profile development or leaching of calcium carbonate. At two sampling sections well-preserved sandburs with sharp spines were found buried about 3 feet below the surface. This would seem to indicate that terrace 1 alluvium was deposited in the past few hundred years and is probably not contemporaneous with fills that have been reliably dated as being deposited 1,500–2,000 years ago (San Pedro stage, Ariz.).

Terrace 2 is correlated with Kaycee deposition. The Kaycee deposition has been dated and correlated by Leopold and Miller with the Chiricahua cultural stage on Whitewater Draw, Ariz. (Sayles and Antevs, 1941) which has been given a radiocarbon age of about 4,000 years (2150 B.C., ±270 years) (Flint and Deevey, 1951, p. 280). Kaycee deposition is also correlated with the lower part of the Nakaibito formation near Gallup, N. Mex. (Leopold and Snyder, 1951), where potsherds of Pueblo I and II culture indicate the date of deposition to be approximately between A.D. 700 and 1100.

The alluvial deposits underlying terrace 2 may fit into a postglacial alluvial chronology as Leopold and Miller have suggested (1954, p. 38), but a lack of datable evidence restrains the author from making any correlation. The Kaycee formation as described by Leopold and Miller (1954, p. 10–11) and its correlatives in the Southwest generally have a well-developed soil profile to a depth of 1–2 feet. At the 17 sampling sections located on terrace 2 there was little evidence of soil profile development and surface leaching of calcium carbonate seldom exceeded 4–6 inches. Data available on rates of weathering and soil profile development (Jenny, 1941, p. 31–50) indicate that leaching of calcium carbonate from eluvial horizons and profile development undoubtedly would be present more prominently in terrace 2 alluvium if it were deposited 2,500–4,000 years ago, as suggested by the correlation chart of Leopold and Miller (1954, p. 58–59).

The modern flood plain of Fivemile Creek, in many reaches, has been formed since about 1920 according to residents of the area and personnel connected with irrigation works on the Riverton project. The present channel presumably was started by unusual floods of July and September 1923 (Follansbee and Hodges, 1925, p. 111) and the return of waste water from irrigation along the channel since 1920. Before these events the valley floor of Fivemile Creek reportedly was aggraded and without a well-defined channel and flood plain in many reaches. Although the alluvial deposit underlying the modern flood plain may be contemporaneous in part with Lightning deposition (Leopold and Miller, 1954, p. 38) the author prefers to associate it with comparable fills in eastern Wyoming that are known to be less than 100 years old (Schumm and Hadley, 1957, p. 170).

Using radiocarbon dates associated with early cultures, such as the Cochise in southern Arizona (Flint and Deevey, 1951) and dating fills with similar physical characteristics by other cultural evidence, a great disparity in age is apparent from valley to valley even within one physiographic province. For example, the San Pedro cultural stage discovered in Arizona on Whitewater Draw (Sayles and Antevs, 1941) has been assigned an age of about 2,500 years based on radiocarbon dating of charcoal found in the valley fill (Flint and Deevey, 1951). Correlation of San Pedro deposition with the upper part of the Nakaibito formation near Gallup, N. Mex., where potsherds of Pueblo I and II age (A.D. 700–1100) were found (Leopold and Snyder, 1951, p. 15) indicates a spread in dates covering about 1,700 years. When dealing with a postglacial chronology of perhaps 8,000–10,000 years in length, an age difference in deposits of 1,000–2,000 years based on datable evidence certainly precludes placing them in the same depositional phase of an alluvial sequence.

Alternating epicycles of erosion and deposition in the alluvial valleys of the semiarid West are undoubtedly related to postglacial climatic changes, but it does not seem necessary to expect the resulting alluvial fills and terraces to be contemporaneous from valley to valley. As Flint points out (1947, p. 483) it is difficult to draw climatic inferences from evidence in one stream or to infer that a climatic change will affect all streams in the same way.

In summary, even though Fivemile Creek terraces can be correlated in a general way with similar sequences in other parts of Wyoming, New Mexico, and Arizona, the author does not believe that the terraces can now be accurately dated. Definite physical similarities between Fivemile Creek terraces and other terrace sequences have been described in the literature and dated reliably on the basis of archeological evidence. However, certain incongruities in ages that have been assigned to various alluvial fills make correlation difficult.

The unweathered character of terrace 1 alluvium and the discovery of well-preserved sandburs in the fill at two localities substantiate the premise that this deposit is very recent.

The poorly developed soil profile and minor leaching of terrace 2 alluvium indicate to the author that correlation with deposits having well-developed soils and deeper leaching (Kaycee of Leopold and Miller 1954) is not warranted.

HISTORY OF TERRACE DEVELOPMENT

The question of what hydrologic conditions may have existed at the time Fivemile Creek terraces were being formed now will be considered. Factors of stream mechanics cannot always be determined for the ancient stream. Mackin (1948, p. 503) points out that, even after the type of deposit is distinguished, we cannot proceed to work directly from the grade sizes represented in the deposits to the characteristics of the depositing stream. We may, however, draw analogies from conditions observed in modern streams.

During the formation of terrace 3 the stream was probably deepening and widening its channel and had begun cutting into bedrock. This downcutting and widening could have been relatively rapid because the shale, sandstone, and siltstone formations cropping out in the valley are generally nonresistant to erosion. Although the valley of Fivemile Creek was never glaciated, terraces which are probably the correlatives of terrace 3 have been traced to glacial moraines at the heads of many valleys in this region (Blackwelder, 1915, p. 320; Moss, 1951; Holmes and Moss, 1955; Richmond, 1948). From his work on Pacific Creek, Sweetwater County, Wyo., Moss found evidence to support the hypothesis that streams, aided by severe periglacial climate, developed terraces at the same time as the glacial streams. Thus, it is inferred that glacial climate continued long enough to allow terrace 3 to be cut to a gradient of about 26 feet to the mile. The thin veneer of gravel found on terrace 3 is probably the residual of a thicker deposit laid down at the same time that the terrace tread was formed.

After the deposition of the upper terrace gravels, some climatic change took place which caused the stream to entrench a new channel in the gravel deposit. Bryan (1941, p. 235) attributes such downcutting to periods of aridity while Huntington (1914, p. 23) contends that increased precipitation is the cause of degradation. Regardless of the climatic conditions, the stream evidently cut vertically through the gravels of the upper terrace and entrenched itself deeply in the bedrock, widening the channel and removing the gravels at many places.

A reversal of conditions started aggradation of the widened trench, filling the inner channel to a level below the upper terrace. Dark bands visible in the vertical exposure of the deposit may represent interruptions in deposition. If that interpretation is correct, the deposition of this alluvium must have taken place in several stages. The textural analysis reveals a paucity of particles coarser than sand in the sampled sections, which implies a uniform streamflow to satisfactorily explain such a deposit. Consideration must be given to the effect of climate on the stream regimen as well as the vegetative cover, which may or may not have affected the character of the deposit. A hypothetical set of stream conditions may be assumed. After the stream had entrenched itself in the bedrock to a depth below the present streambed, the regimen shifted to aggradation. The terrace 2 deposit, about 20 feet of which is exposed in the vertical section, is consistently very fine sand and silt throughout the length of the valley. A deposit of this thickness could hardly be attributed entirely to overbank silting during flood periods. To deposit 20 feet of silt over a flood plain throughout a valley 55 miles long would require an extreme change in stream level as the deposit became thicker. Also, there is not enough evidence to support the hypothesis that the deposit is eolian in origin. The alternative which seems most applicable is a stream of lower velocity than the stream that flows in the present channel. The silt was deposited from suspension possibly aided by vegetation.

Could such streamflow conditions prevail long enough to allow the accumulation of such a volume of sediment? The study of modern valley sedimentation by Happ, Rittenhouse, and Dobson (1940, p. 20–22) lists some figures for known rates of silt accumulation in stream valleys of the Southern United States. They show that between 2 known dates 25 years apart 3 feet of sediment accumulated in a valley on a gradient of about 18 feet to the mile, and that deposits in the last 100 years in some valleys may reach 8–10 feet. These figures can only be used as an example of what streams can accomplish. The author is not prepared to say whether the conditions in Fivemile Creek at the time of deposition of terrace 2 were analogous to those described by Happ, Rittenhouse, and Dobson.

The extent of flood-plain aggradation in the last 30 years has been measured by the author in several valleys in the Cheyenne River basin of eastern Wyoming and western Nebraska. The many fence lines that cross flood plains, perpendicular to the direction of flow, provide excellent measuring sections when the age of the fences can be accurately determined. On the Joss Ranch, sec. 31, T. 36 N., R. 64 W., Niobrara County, Wyo., a cross section of the flood plain along a fence line showed aggradation of 3 feet at posts that had been in place 31 years. Partly buried trees and multiple node development on grass stems also indicate that aggradation in the valley is active at the present time. On Whitehead and Prairie Dog Creeks in Sioux County, Nebr., rapid aggradation in the past 20 to 30 years can be measured with considerable accuracy on fence lines and cottonwood trees. On Whitehead Creek the flood plain has been built up as much as 4 feet in 30 years. Therefore, the accumulation of a deposit about 20 feet thick such as terrace 2 on Fivemile Creek could have been accomplished in a short time.

After the alluvium of terrace 2 had reached a depth of about 18 to 20 feet the stream regimen shifted to degradation. As the stream entrenched itself in the alluvium, downcutting apparently proceeded without much lateral corrasion. This supposition is substantiated by the extensive remnants of terrace 2 standing on both sides of the stream throughout the greater part of the valley. The depth of trenching as determined by test borings in the valley show that the thickness of alluvium below the streambed is relatively thin.[1] After the stream had reached a position substantially the same as the present stream the stream regimen shifted to aggradation. The channel fill deposits that are represented by this period of aggradation reveal many sedimentary structures which give rise to speculation concerning the climatic conditions during deposition. In contrast to the older alluvium in the valley, this deposit is sandy with many stringers of coarse gravel. Torrential crossbedding is evident in many places and the over-all texture of the material indicates that it may have been deposited by a stream of seasonal high velocity and high competence. The climate during deposition might well have been semiarid with frequent storms of high intensity.

The deposit forming the lower terrace accumulated in the channel trench to a thickness of 8–10 feet. It unconformably overlies the older deposits in many places and abuts against scarps cut in the older alluvium in vertical contacts where slumping has not obscured the relationship.

After the deposit reached its present thickness, the stream regimen once again shifted to degradation. The downcutting progressed until the stream reached the position in the channel bottom very near to that of the present stream. The development of the present streambed followed the abandonment of the modern flood plain. The overbank silt deposits and channel gravels transported by stormflow which are being contributed to the flood plain at the present time make it a rather poorly defined surface in the process of formation.

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