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An Early Tertiary Stream Channel between Fish and Pipestone Creeks, Ten Miles West of Whitehall, Montana

Henry D. Olson

AN EARLY TERTIARY STREAM CHANNEL BETWEEN FISH AND PIPESTONE CREEKS, TEN MILES WEST OF WHITEHALL, MONTANA

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A Report for Geology 113
Submitted to Dr. E. S. Perry
Department of Geology

MONTANA SCHOOL OF MINES
Butte, Montana

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CONTENTS

LIST OF ILLUSTRATIONS

<u>AN EARLY TERTIARY STREAM CHANNEL</u>

<u>BETWEEN</u>

<u>FISH AND PIPESTONE CREEKS</u>

<u>TEN MILES WEST OF WHITEHALL, MONTANA</u>

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INTRODUCTION

Driving between Butte, and Whitehall, Montana, on highway U.S. 10S, one observes an interesting phenomenon in the lower end of Little Pipestone Creek canyon. One side and the bottom of the canyon is cut in the hard igneous rocks of the Boulder batholith, and the other side of the canyon is made of unconsolidated sand, gravel, and cobbles. These unconsolidated sediments appear to be the channel material of a mountain stream which was older than, larger than, and apparently unrelated to, the present Little Pipestone Creek.

Finding out more about this ancient stream channel was chosen by the writer as a project for Geology 113, Advanced Studies of Sedimentary Rocks, at Montana School of Mines. The presence of several gold placers associated with the old stream deposits suggested the project might have an economic as well as a geologic significance.

The center of the area studied is about 10 miles west of Whitehall, Montana. Most of the remenants of the ancient channel are found between Grace, a siding on the Chicago, Milwaukee, St. Paul, and Pacific Railway, and the junction of highways U.S. 10S and Montana 41. This junction is locally known as Cactus Junction.

Thanks are due Dr. E. S. Perry, and Mr. O. D. Blake of the Montana School of Mines Geology Department for their help and suggestions which facilitated this investigation.

PROCEDURE

Original plans to map the area directly on aerial photos had to be altered because of the early advent of winter. Before ordering the photographs two and one-half days in October, 1951, were spent in reconnaissance of the area. Winter weather arrived before the photos did, so it was decided to do the problem by photogeology. Two books and several articles on the geologic interpretation of aerial photographs were read and studied, and a map was made. Two days were then spent in the field during February, 1952, checking critical portions of the map and obtaining necessary field data. A thorough library search was also made for references to the area being studied. Only two of the numerous paleontological references are listed in the Bibliography (9,15).

The aerial photographs used for this problem were obtained from the U. S. Forest Service office at Missoula, Montana. Each photo measures 9x9 in., and the scale is: 1 in. equals approximately 2100 ft. The photos used were:

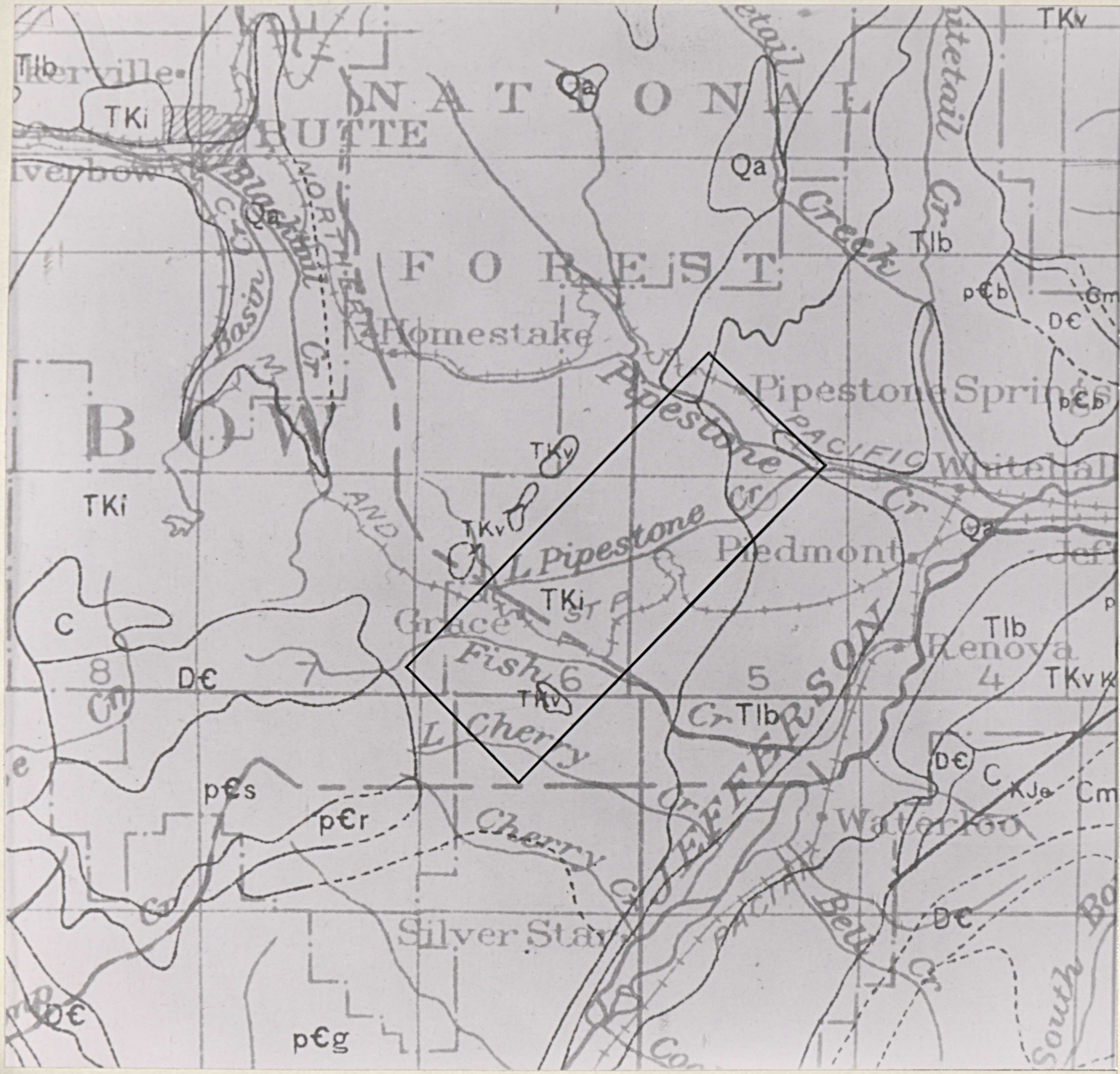
Taken 7-30-47:

DFH-1-20	DFH-1-46
DFH-1-21	DFH-1-47
DFH-1-22	
DFH-1-43	DFH-1-108
DFH-1-44	DFH-1-109
DFH-1-45	DFH-1-110

Taken 8-6-47:

DFH-3-14	DFH-3-45
DFH-3-15	DFH-3-46
DFH-3-16	DFH-3-47
DFH-3-17	DFH-3-48
DFH-3-18	DFH-3-49
DFH-3-19	DFH-3-50

The photos were studied in stereo-pairs and the geologic contacts drawn in. Two stereoscopes were available for use, a Fairchild F-71 mirror type stereoscope, and an Abrams CF-8 lens type stereoscope (See Pl. II.). Both instruments were inadequate. The Abrams stereoscope which has a magnification of 1.25 x, very helpful, is so small that only about one-fifth of each photo can be studied stereoscopically, and that is at the edges of the photo where distortion is greatest. The Fairchild stereoscope is big enough so that the centers of the photos could be studied. However, the instrument is incomplete, as it lacks the 4 x binoculars it is designed for. Photos viewed through the Fairchild stereoscope without the binoculars appear 0.75 x their actual size. This resulted in a loss of some of the important details needed for solution of the problem by photogeology.



GEOLOGIC INDEX MAP

PLATE I

E X P L A N A T I O N

SEDIMENTARY ROCKS

Qa	Alluvium	- QUATERNARY
Tlb	Lake beds	- TERTIARY
KJe	Kootenai and Ellis fms.	- CRETACEOUS - JURASSIC
C	Carboniferous rocks undivided	- CARBONIFEROUS
Cm	Madison group	- MISSISSIPPIAN
DC	DEVONIAN through CAMBRIAN rocks	
p€b p€s p€r	Belt series Siyeh group Ravalli group	- PRE-CAMBRIAN

METAMORPHIC AND IGNEOUS ROCKS

TKi	Intrusive rocks undifferentiated	- TERTIARY
TKv	Volcanic rocks undifferentiated	- TERTIARY
p€g	Metamorphic rocks	- PRE-CAMBRIAN

SCALE

0 ——— 5 Miles

(Adapted from 1.)

PLATE II

Fairchild F-71 mirror stereoscope (Top), and Abrams magnifying stereoscope (Bottom) used by author for this report.

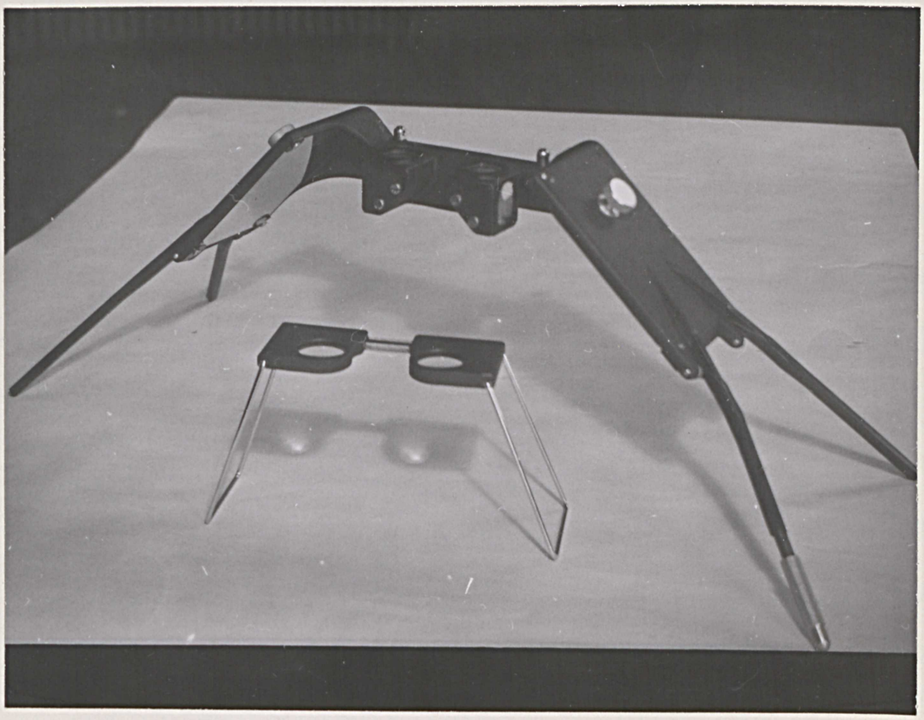


PLATE II

To make the map, the photos were accurately aligned and matched by plotting on each photo its center point as well as the center points and reference points of adjoining photos. A grid of the center points was then laid out on a sheet of tracing paper, each photo in turn placed under the tracing paper and correctly oriented, and the desired features traced from the central portion of the photo. Only the central portions were used as they have the least distortion.

Nine samples were collected and six pebble counts were made at strategic locations (See Pl. IX.). Only sand to clay-sized material was selected for the samples which were later studied with the aid of both a binocular microscope and a petrographic microscope. The pebble counts were made using pebbles ranging from 2 to 4 in. size. The pebbles were from either tailings piles in the placers or loose material on the surface of the ground. One hundred pebbles were used at each count (50 at E) and classified as quartzite, argillite and tactite, or igneous. Statistically significant results were obtained.

No sufficiently detailed topographic map of the area studied exists. Plans to obtain elevations with a barometer were canceled because of winter weather. Therefore, the few elevations used were obtained from the references.

GENERAL GEOLOGY OF SOUTHWESTERN MONTANA

Most geologists will agree on the geologic history of southwestern Montana through Mesozoic time. Dominantly marine Paleozoic and Mesozoic sediments were laid down in the Cordilleran Geosyncline on Proterozoic argillites and quartzites, or on Archeozoic metasediments. These Paleozoic and Mesozoic sediments, mostly limestones and shales, are remarkably conformable, even though there are stratigraphic breaks of non-deposition or erosion up to a geologic period in length. Thus, the sedimentary record shows that southwestern Montana was not a region of orogeny until the close of Cretaceous time and the advent of the Laramide revolution.

Intrusion of the Boulder batholith and intense deformation of the earth's crust during the Laramide revolution (late Cretaceous-early Tertiary), is also an agreeable concept to most geologists. However, geologic history from early Tertiary to the present seems to have as many interpretations as there are geologists who have studied the problem. Although both physiographic and sedimentary evidences of Tertiary-to-Recent geologic history are available for study, controversies arise because southwestern Montana is now in a zone of complex geology. Faults, folds, local and regional uplifts, erosion, and glaciation during Tertiary times have influenced and complicated the sedimentary and physiographic record.

The mountainous portion of western Montana, roughly west of a line between Glacier, and Yellowstone National Park, is in the physiographic province called "Northern Rocky Mountains", by Fennemen (16:366). Characteristic of this region are intermontane basins, or valleys, surrounded by the mountain ranges. These basins, varying from about 2 to 20 miles wide and 10 to 50 miles long, have a general north to northwest trend that parallels the trend of the main mountain ranges (16:Pl.1). Present day rivers that flow through these basins are in most instances considered too small to have carved the valleys. Neither do modern rivers always flow through the basins the same direction that early and middle Tertiary rivers did (11:2) (17:7). Some rivers now flow essentially crosswise to the ancient stream trends, and flow through deep gorges when passing from one basin to the next. Pardee (16) believes these intermontane basins and their bordering mountains are the result of block faulting of the Basin and Range type.

PHYSIOGRAPHIC HISTORY OF SOUTHWESTERN MONTANA

Throughout the Northern Rocky Mountains, a geologic observer is impressed by the existance of three generalized topographic "levels". First is the concordance of the tops of the mountain ranges forming a "summit level". Second is the occurrence of terraces, benches, and pediments along the edges of the mountain ranges forming an "intermediate level". Pediments at this level are commonly found cut into mountain spurs. Third is the "present level", the level of the present river bottoms and their associated Recent terraces in the intermontane valleys.

There is obviously no controversy concerning the age of the present erosion surface or "level"; it exists now. However, there is a variety of opinions on the age of the summit and intermediate levels. Atwood (2:706) believes the summit level is of Eocene-Oligocene age, and divides the intermediate level into three cycles of erosion, one in middle-to-late Oligocene, one in Miocene, and one in Pliocene. Black~~stone~~welder (5:543-545) believes the summit level to be post-Miocene, probably Pliocene. Perry (17:2-7), and Brox (6:2-14) are in accord with Atwood except they believe Atwood's 2nd, 3rd, and 4th levels are but different phases of an intermediate middle Tertiary level. Kavanagh (11:10,11) discusses the Eocene vs. Pliocene age summit-level controversy, but does not take sides. He does indicate however, that Fennemen favors the Pliocene hypothesis for southern Idaho (equivalent to southern Montana). Pardee (16) believes a peneplain existed at the end of Eocene time, but that only a few patches of coarse Eocene gravels remain. The summit level is a "Late Tertiary Peneplain" of late Miocene age, and the intermediate level is due to an erosion cycle, "Old Valley Cycle", that occurred during a halt in Pliocene uplift when the present mountains were forming.

Pardee's Cenozoic history of western Montana (16) seems to be the best physiographic history available because it is the result of field observations over a period of about 30 years as well as a result of an extensive review of the available literature. His study necessitated integrating numerous local physiographic and geologic features into a single, correlated, regional sequence of events. Therefore, an attempt will be made to correlate the findings of this paper with Pardee's sequence of events. The abstract of his paper, "Late Cenozoic Block Faulting in Western Montana", (16) is here presented in its entirety:

> "Many of the mountain ranges in western Montana, and the adjoining intermontane basins, are interpreted as chiefly the effects of block faulting like that in the Great Basin. The region was elevated above the sea in late Cretaceous or early Tertiary time; then followed a long period of crustal stability in which a great thickness of rocks was eroded. By Oligocene time the region had been generally reduced to a surface of moderate to slight relief. During the Oligocene and Miocene the drainage became sluggish or ponded, chiefly because of slow crustal movements that outlined the present basins and ranges. Areas corresponding approximately to the present basins became depressed, and in these accumulated the Tertiary "lake beds." Areas of uplift corresponding to the present mountains were eroded and thus contributed land waste and volcanic ash to the "lake beds." In the late Miocene or early Pliocene the surface comprised areas of older rocks that, except for scattered residual peaks and ridges, had been eroded to slight or moderate relief; and areas of the "lake beds" that formed gently sloping or level plains.

Excluding the residuals, this surface is called here the Late Tertiary peneplain.

"Further leveling of the older rock areas and deposition of the "lake beds" was interrupted by a general re-elevation of the region accompanied by greatly accelerated local crustal movements that relatively elevated the present mountains. These movements continued intermittently and with decreasing intensity through the Pliocene and, except for small displacements on some of the faults as late as the Recent epoch, ceased in early or middle Pleistocene. They are thought to constitute a distinct late stage of the Cenozoic mountain building.

"During the halt in the uplift of the mountains, wide stream valleys as much as 1500 feet deep were eroded in the elevated and deformed peneplain. In the basins during this pause, called the Old Valley cycle, the "lake beds" were reduced to gently sloping plains collectively referred to as No. 1 Bench. With renewed uplift the more vigorous streams deepened their channels across the mountain blocks as fast as the surface rose and thus excavated narrow inner valleys or gorges. In this, the Present cycle of erosion, No. 1 Bench of the "lake bed" area was, in most of the basins, dissected to a series of terraces. The faulting appears to be indirectly related to an axis of compression trending northwestward from Yellowstone National Park. Horizontal compressive forces moved opposite parts of a deeply buried layer of the earth's crust toward this axis. Relief from the compression raised the overlying layer thus causing tensional strains that were relieved by normal faulting and movements away from the plane of the axis."

¶ Evidence of alpine glaciation, cirques, moraines, etc., of Wisconsin age is found in many of the mountains of southwestern Montana. If any glacial material of Wisconsin age was present in the area described by this report, it has now been removed by erosion (18:12). However, glacial material of pre-Wisconsin, early Pliestocene, age is present in the described area according to Atwood (2:714,718) (3:242-244).

GENERAL DESCRIPTION OF MAPPED AREA

The mapped area, on a northeast flank of the Highland mountains, lies mostly in the southeastern corner of the Boulder batholith (Pl. I). Profiles across the area show a general decrease in elevation from west to east (Pl. VIII), with most of the area lying between 5000 and 6000 ft elevation (16:386) (20:14). Referring to the map (Pl.IX), one sees that representative parts of the three main physiographic features common to the mountain and basin topography of western Montana are present. Included in the map are: (1) high, rugged mountains having a rather definite front (left edge of map), (2) a pediment or bench cut in the hard rocks of the mountain core and having a peneplain surface that slopes downward from the mountain front to (3) the terraces and fill of relatively unconsolidated sediments that typically form the floor of an intermontane valley or basin. (See Pls. IV, V, VI.)

The mountain front and pediment surface are cut in the igneous rocks, mostly quartz monzonite, of the Boulder batholith. Present drainage is dissecting the pediment with deep narrow gorges, Fish Creek canyon being the most spectacular (Pl.V).

The intermontane basin or "lake bed" deposits include the well known Pipestone Creek fossil beds in which vertebrate fossils have been found. The fossil beds are classified biostratigraphically as the Titanotherium* zone; equivalent

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*Carl O. Dunbar in Historical Geology, New York, John Wiley

PLATE III

TOP: Stream channel deposit in railroad cut where sample 1 was taken.

BOTTOM: Stream channel deposit in railroad cut where sample 2 was taken.

PLATE III

PLATE IV

TOP: View of stream channel deposit looking west from where sample 2 was taken.

BOTTOM: View across pediment toward mountain front. Looking northwest from where sample 2 was taken.

PLATE IV

PLATE V

TOP: Fish Creek canyon near east edge of pediment, looking east.

BOTTOM: View southwest across Fish Creek canyon showing pediment surface and mountain front in background.

PLATE V

to the Chadron formation. The Chadron formation is the lowermost member of the White River Group which is lowermost Oligocene in age (15:103) (9) (21:1670). These lake-bed deposits are known both as "Pipestone Creek Beds", and "Bozeman 'lake beds'" Neither term is now used in U. S. Geological Survey reports according to their Bulletin 896, Lexicon of Geologic Names of the United States (21), nor is the term "lake beds" accurate. The last entry in the Lexicon under "Bozeman 'lake beds'", (21:246) is:

> "W. P. Haynes, 1916 (Jour. Geol., vol.24, pp. 270-290). The whole series of Tert. Valley sediments (in region about Three Forks) has been grouped under heading Bozeman fm. for convenience in mapping. Dr. Peale's name 'Bozeman lake beds' seems no longer applicable, since they have been shown to be due to subaerial and fluviatile deposition rather than to lakes.. Bozeman fm. here is chiefly Mio., but in some parts of region strata of Olig. (White River) age have been identified."

However, the term "Tertiary lake beds" is now widely used and accepted by geologists as meaning the fill of the intermontane basins, whether of lacustrine origin or not.

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and Sons, Inc., 1949, pp 471, describes the titanotheres thus:

> "Another magnificent tribe of mammals, remotely related to the rhinoceroses and the horses, was the titanotheres. These were ponderous beasts of rhinocerous-like appearance, many of them with great nasal horns made of bony outgrowths from the skull. Early Eocene titanotheres were scarcely larger than a big hog and were hornless, but the tribe developed rapidly to great size before its extinction about the middle of the Oligocene epoch. One of the latest was Brontotherium, which stood about 8 feet high at the shoulder and far outbulked the largest living rhinoceros. During Oligocene time this was the largest land animal in America ....They left no descendants, either collateral or direct."

The lake-bed material consists mostly of light-brown to light-grey clays containing volcanic ash fragments, with inter bedded thin layers of pure ash. Some of the ash layers are altered to bentonite. Along with the clays are thick beds of dirty sand and some gravel. These materials in most cases are not too well rounded and consist of material similar to the rock of the adjoining mountain ranges; thus indicating that they are probably alluvial material from the surrounding mountains. Douglass (9) describes the lithology of the fossil beds thus:

> "The strata containing the bones are a sandy clay that swells and cracks on weathering and crackles under the feet when dry, and a light-grey fine-grained homogeneous material. Under the microscope the latter shows many angular glassy fragments which are undoubtedly volcanic dust."

Pardee's (16:364) summarized description of lake beds in general is as follows:

> "The 'lake beds' are mostly fine-grained water-laid tuff or volcanic ash mixed or interbedded in varying proportions with generally fine-textured land waste chiefly sand and clay, but including in places a bed of gravel. An almost universal feature is the occurrence of relatively thin beds of pure or unmixed ash."

Within the mapped area are accumulations of material that has been locally placered for gold and is coarser than the typical lake-bed deposits. These coarser sediments, apparently following old channels, occur both on the pediment surface and in the lake-bed deposits. The principal thesis of this report is that part of the coarse material is a stream channel deposit of Eocene age. The criteria and arguments in favor of this hypothesis follows.

AN ANCIENT STREAM CHANNEL

INFORMATION FROM AVAILABLE LITERATURE

As additional background for the consideration of an ancient stream channel, the following information from the available literature is presented. This information is pertinent because it deals specifically with some of the same geologic features that were studied by the author for this report.

The oldest reference found was in Atwood's study in 1915 of the physiography of the Butte, Montana, area (2:714,718).

> "The long period of deposition during which the Bozeman Beds were accumulating in the great intermontane troughs was closed by a renewal of mountain growth throughout this portion of the Rocky Mountains..... At Grace, on the Chicago and Milwaukee Road southeast of Butte, there are Bozeman Beds 1,400 feet above the valley floor to the east. At this locality the Bozeman sediments rest at an angle of about 15 degrees, and are partially covered by glacial outwash gravels."....

> "Along the route of the Chicago, Milwaukee and St. Paul Railroad, southeast from Butte and near the little station known as Grace, there is a coarse alluvial deposit in which there are striated stones. This wash material is high above the main valley of Fish Creek, and beyond the point reached by the ice of the later glacial stage. This material and its topographic position have led to the interpretation that ice of a pre-Wisconsin stage in Fish Creek Canyon advanced northeastward from Red Mountain, and spread over the country now bordering that canyon. The waters issuing from that earlier ice distributed the material now exposed in the railroad cut and traceable northeastward for nearly a mile into the valley of Little Pipestone Creek. The location of this material suggests that the present inner gorge of Fish Creek Canyon did not exist at the time of the earlier glacial stage."

Atwood again mentioned the Grace-Little Pipestone Creek area in 1938 (3:242-244).

"In the vicinity of Butte, Montana, there are remenants of a very old glacial drift which was interpreted by the senior author in 1915 to be possibly of Cerro age. A re-examination of these deposits during the past season by the present authors has removed all doubt as to the accuracy of the earlier age determination. ...

"One and a half miles north of the little railroad station at Grace, Montana, which is southeast from Butte, there are exposed along the newly built highway several sections in an ancient till that is far removed from and unrelated to the modern canyons or modern cirques. At this locality all the physical characteristics of glacial drift are displayed and striated stones are abundant.

"... At the two best localities, the one south of Silver Bow and the one near Grace, the old glacial deposits rest upon eroded surfaces in the Bozeman beds which have been judged to be of Oligocene or Miocene age. This evidence makes it clear that the Butte deposits do not correspond in age to the Eocene till found near Ridgway, Colorado.

"The exact geologic age of the Cerro-Buffalo glacial deposits cannot be definitely determined, but it seems reasonable from studies made at various localities in the Rocky Mountain region to believe that they mark the opening of the Pleistocene."

Pardee, referring to Tertiary "lake beds" says (16:364):

"Outside the basins, however, they have not been identified except in one or possibly two places. A small patch, apparently elevated by the fault at Little Pipestone Creek, occurs well up on the range (Continental Divide) west of Jefferson Valley (Atwood, 1916, Pl. XXXVII A)."

Pardee also described the fault in sec. 13, T. 1 N., R. 6 W.

6 W. (16: 386) (See Pl. VII, Top.).

"A road cut, excavated in 1939 on U. S. highway 10 along Little Pipestone Creek about 10 miles west of Whitehall, exposes a normal fault near the upper (west) edge of a gravel-capped terrace at 5300 feet altitude on the western side of the Jefferson valley. The fault trends northward, dips 70°E., and displaces Tertiary (?) stream-washed gravel that is locally gold bearing. Back of the fault line the surface rises steeply 500 feet or more to flats (5800-6000 feet altitude) preserved on spurs north and south of the creek. One flat occupies an area of 2 or 3 square miles east of Grace Station on the Chicago, Milwaukee, St. Paul and Pacific Railroad. It cuts across granitic rocks and a small overlying patch of tilted Tertiary (Miocene ?) "lake beds" (Atwood, 1916, Pl XXXVII A). The flats and the terrace plain east of the fault are interpreted as dislocated parts of the Old Valley or Bench No. 1 surface."

FIELD OBSERVATIONS

Field observations were made primarily in the area where the channel deposits are found. Some of the features the writer desired to recheck were covered by snow when the area was revisited in February. However, a combination of field observations and information from the literature makes it possible to derive the conclusions and relations presented in this paper.

About 10 miles southwest of the mapped area Fish Creek rises in the heart of the Highland Mountains. Most of the headwaters of Fish Creek drain areas underlain by the pre-Cambrian Belt sediments which are dominantly argillites. These argillites are usually greenish grey in color and weather to a reddish brown. Brown and pink quartzites of Belt and Cambrian Flathead age, greenish to grey Paleozoic argillites and tactites which were metamorphosed by the Boulder batholith, as well as a variety of igneous rocks, quartz monzonite, diorite, aplite, and pegmatite, are also found in the channel of the present Fish Creek. These observations are corroborated by Sahinen (18).

Fish Creek travels nearly a straight line, a little north of east, out of the mountains until it makes about a 45 degree turn in sec. 28, T. 1 N., R. 6 W., and then continues in a direction somewhat south of east. This abrupt change in trend is very noticeable from the westernmost end of the channel deposits (Pl. IX) which terminate at the edge of the present Fish Creek canyon and are aligned with the upstream portion of the canyon. (The bald knob on the left skyline in the top photo of Plate IV is this western end of the deposit on the rim of the canyon. The skyline is estimated to be 200 ft above the railroad.)

Near Grace, in the railroad cuts where samples 1, 2, and 3 were taken, the channel deposits are well exposed (Pl. III). The unconsolidated channel material, apparently of Highland Mountains origin, is unsorted and ranges in size from microscopic fragments to blocks 6 ft in diameter, Blocks of quartzite, argillite, and quartz monzonite up to 6 ft in size are also found in the 25 to 50 ft thickness of channel material at its western termination. From this westernmost point thru where sample 1 was taken to a little past "A", the sediments lay esker-like on the quartz monzonite. At the railroad cut where sample 3 was obtained, the unsorted, hetrogeneous material lays above layers of coarse sand, gravel, and ash that show some sorting and irregular bedding. Here the sediments lie in a channel in the quartz monzonite. Correlation of the preceeding observations with Atwood's observations, previously quoted, leads to the following conclusion. The western end of the stream channel deposits consists mostly of early Pliestocene glacial material overlying older channel deposits.

Additional glacial deposits, of early Pliestocene age according to Atwood, are found along the north side of Little Pipestone Creek in sec. 13, T. 1 N., R. 6 W., and secs. 7 and 18, T. 1 N., R. 5 W. A normal fault in these deposits, drag criteria indicates the east side moved down, is exposed in a road cut in sec. 13 (Pl. VII,Top). This fault, described by Pardee (16:386), has no surface indications of its presence. These glacial deposits are not the same as the previously described deposits to the southwest. The material appears to have come down a canyon from the northwest. Samples 6 and 7 are different from the other samples by containing mostly freshly weathered quartz monzonite, having a relatively small amount of fines, and containing green tactite and purplish argillite; the other samples contain well weathered quartz monzonite, contain lots of fine dust and clay, and contain no green tactite (all samples contain volcanic dust). Finally,the quartzites are present in very small amounts, 5% or less, and are white instead of pink and brown as are the quartzites from the Highland Mountains, and the argillites have a definite purplish color as opposed to the green and grey argillites of the Highlands.

The pebble counts indicate that the sediments found at each location are from a common source, namely the Highland Mountains. The counts, mostly made with placer gravels, show the gravels consist of about 80% metasediments and 20% igneous rocks. The placers near Pipestone Hot Springs, secs. 33 and 34, T. 2 N., R. 5 W., have gravels composed of about 25% metasediments and 75% igneous rocks, and therefore do not seem too closely related to the channel deposits.

The channel deposits that have been placered consist mainly of clays, ash, and sand with interbedded lenses of somewhat rounded gravels and cobbles; isolated pieces of gravel in the sand and clay matrix also occur (Pl. VII, Bottom). The placer gold is probably largely from the Highlands also, an area of lode and placer districts, because no evidence of placering could be found in the gravels that presumably came from the northwest. The gold in the placer near Pipestone Hot Springs may have come from the direction of the Homestake district.

Nearly everywhere that the channel deposits are found, they lay directly on quartz monzonite in channels, saddles, or wind gaps cut into the pediment surface. The relationship could not be determined at the placer in sec. 16, T. 1 N., R. 5 W., however. Plate VI, taken from a point about 1000' south of the fault in sec. 13, T. 1 N., R. 6 W., shows a saddle, slightly right of center, and a wind gap at "W" (where pebble

PLATE VI

View eastward showing: stream channel deposits in foreground; quartz monzonite pediment surface in center and right background; Little Pipestone Creek, U.S. 10S, and "lake beds" in left background; Cactus Junction placer (P); and wind-gap (W) where stream used to flow.

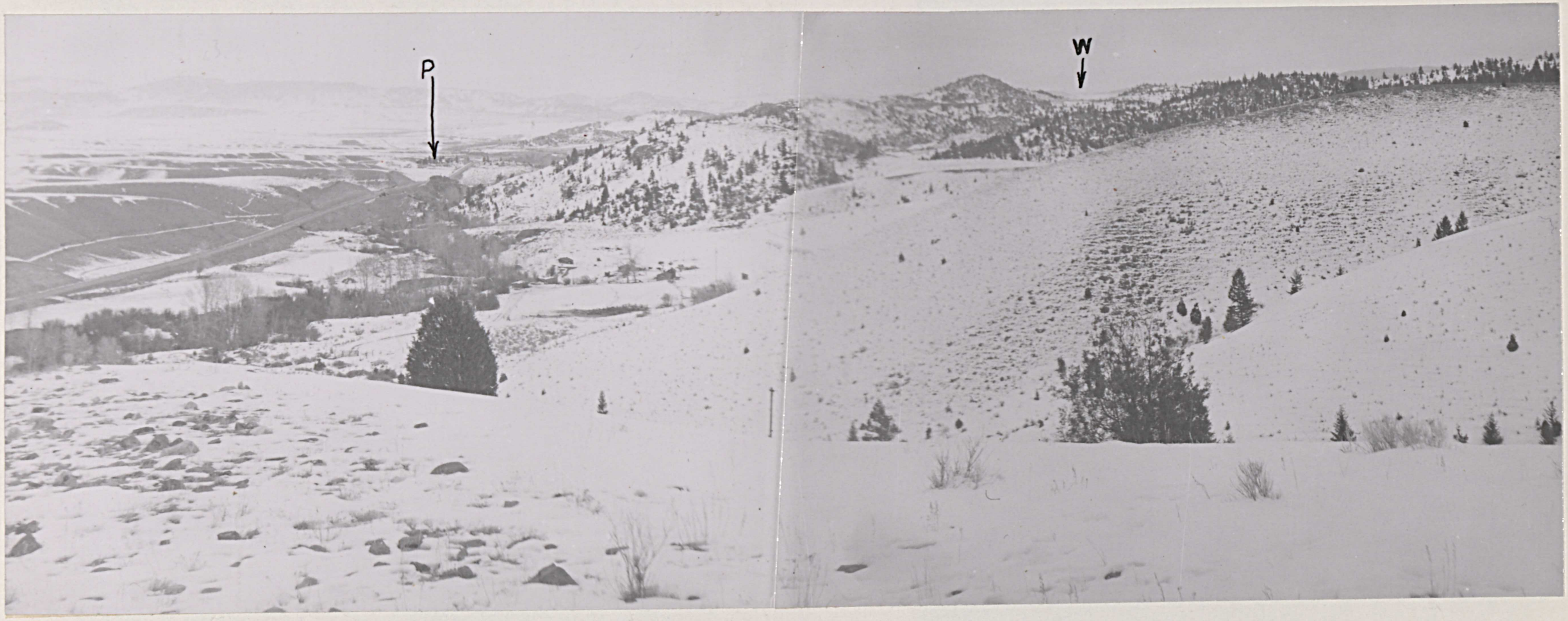


PLATE VI

PLATE VII

TOP: Fault in road cut on U.S. 10S in sec. 13, T.1N., R.6W.

BOTTOM: Portion of the placer near Cactus Junction, looking east.

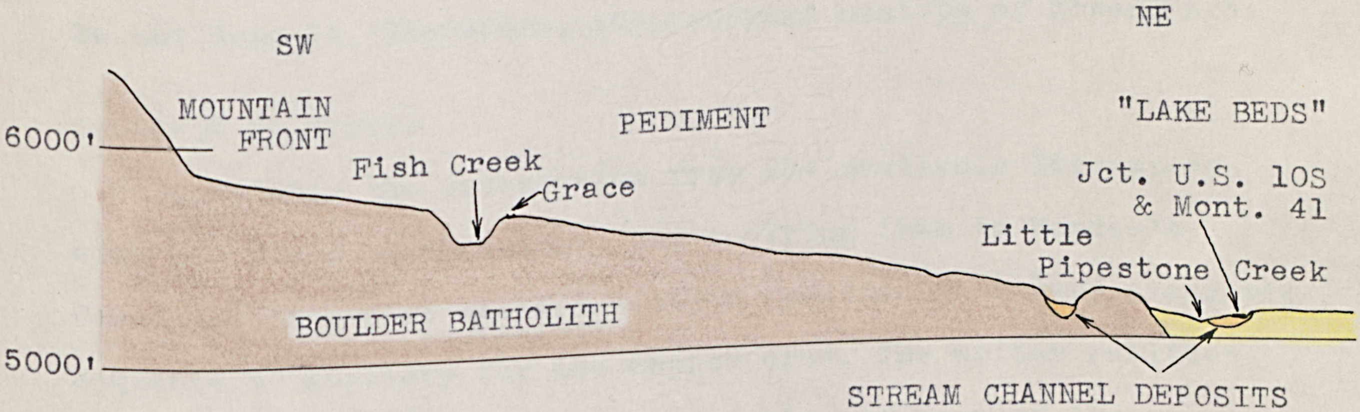
PLATE VII

p peneplain o old valley gr granite gn gneiss
PM Paleozoic-Mesozoic Tlb Tertiary "lake beds"

CROSS SECTION: CONTINENTAL DIVIDE - JEFFERSON RANGE

(16:Pl.5,K)

-A-



Hor. Scale: 1"=Approx. 700'

GENERALIZED CROSS SECTION ON A SW-NE LINE
PASSING THROUGH GRACE AND THE JUNCTION OF HIGHWAYS U.S. 10S & MONT. 41

-B-

PLATE VIII

count E was made). Both are cut into quartz monzonite and are evidence of an ancient channel across the pediment. The placer near Cactus Junction at "P" (Pl. VI) and those downstream along Little Pipestone Creek show that the ancient river followed more than one channel during its existance. The discrepancy between the present elevations of "P" and "W" (Pl. VI) is probably due to later faulting. Following along the edge of the pediments on either highway U. S. 10S or Montana 41, one can observe that the typical "White River" type of sediments, clay, ash, and sand, are stratigraphically higher than the channel deposits. This would date the channel deposits as lowermost Oligocene or uppermost Eocene in age. Since these deposits lay in channels cut in the pediment, the channels must have been cut before the deposits were laid down. The pediment surface into which the channels are cut would have to have been formed and then uplifted before channels could be cut into it. Therefore, the pediment must be of Eocene age.

SEQUENCE OF EVENTS

Combining the information from the available literature with the field observations, and applying them to Pardee's Cenozoic history of western Montana resulted in a very plausable sequence of Tertiary events for the mapped area. The writer realizes however, that a different interpretation of some of the same observations could result in other sequences.

1. A late Eocene peneplain.

2. Near the end of Eocene time an eastward dipping fault block starts to form; the east and west edge respectively about where the present Jefferson River and Continental Divide are. Streams cut channels into the peneplain, and the ancestral Highland Mountain block begins to rise differentially.

3. At the Eocene-Oligocene time boundary, material carried by an ancestral Fish Creek from the rapidly rising Highlands begins to be deposited in the channels in the Eocene peneplain.

4. The fault block continues to tilt as early Oligocene sediments mostly derived from the uplands to the west are laid down with the ash and tuff from the volcanos in the region.

5. Entire area buried under Oligocene, and possibly Miocene sediments composed chiefly of volcanic ash and material eroded from the uplifted area to the west. "Late Tertiary Peneplain" formed by end of Miocene resulting in "summit level".

6. Renewed uplift during early Pliocene.

7. Halt in uplift, "Old Valley Cycle" cuts "No. 1 Bench" exposing and cutting into part of Eocene peneplain and forming "intermediate level" pediment. (Pl. VIII, A) (16: Pl. 5, N).

8. Renewed uplift with erosion of lake beds.

9. Deposition of glacial material in early Pliestocene.

10. Continued uplift and erosion with minor faulting. Fish Creek changes trend.

11. Continued erosion to form present surface as Fish Creek cuts canyon into pediment.

SUMMARY AND CONCLUSION

Remanents of an ancient stream channel that crossed present drainage trends are found in an area about 10 miles west of Whitehall, Montana. Field observations and a map made from aerial photographs, combined with published references to the area, show that an ancestral Fish Creek flowed through this channel about the end of Eocene time. Gold carried by this stream was concentrated to form placer deposits.

The use of a modern, dry-land type of gold dredge on the old stream channel might be profitable. However, past production of gold was insignificant; also, part of the area has been tested for dredging and subsequently left alone (13:51). It is the writer's opinion that the deposits' greatest potentiality is in providing an existance wage for a few individuals engaged in small scale placering operations during some future depression.

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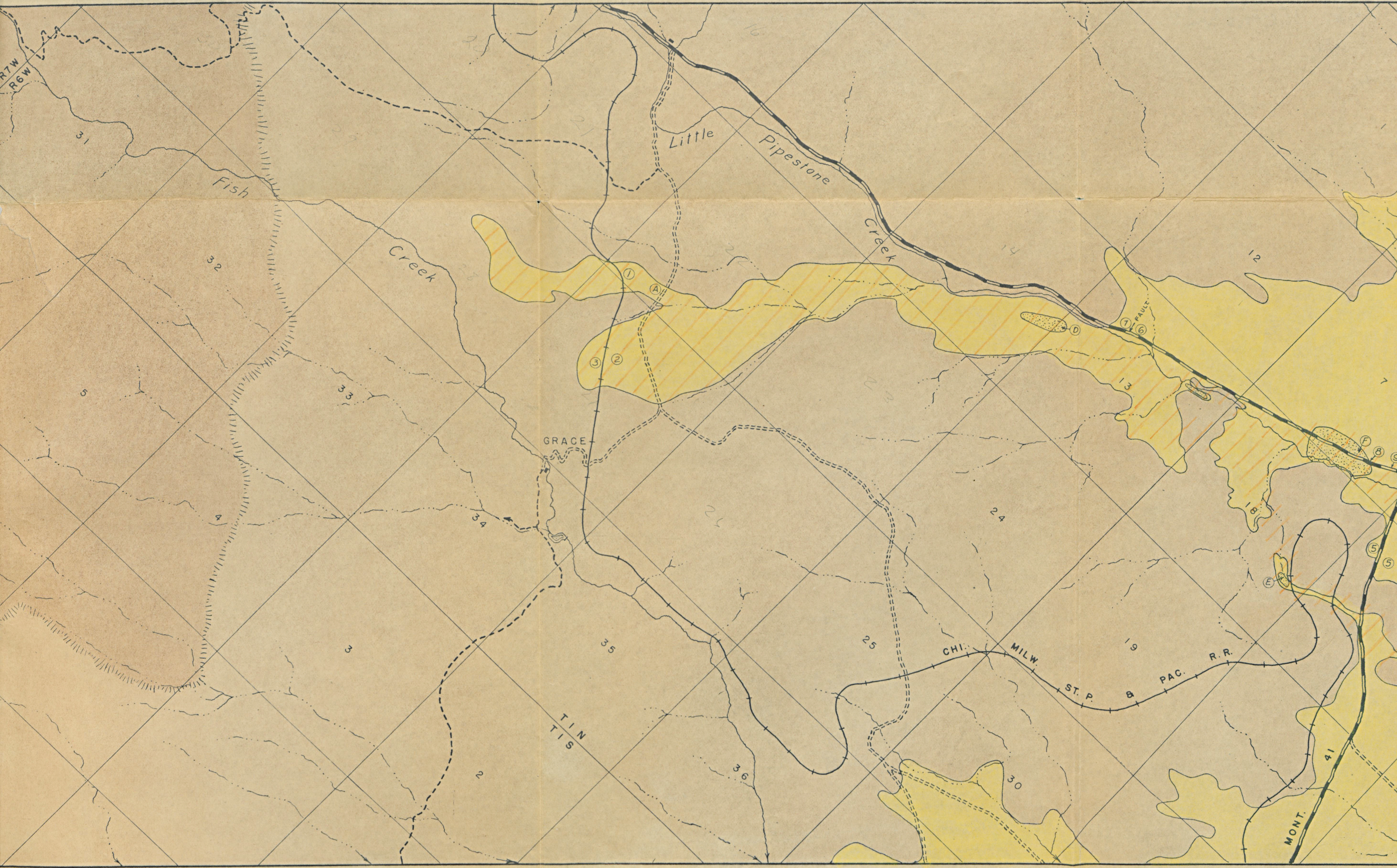
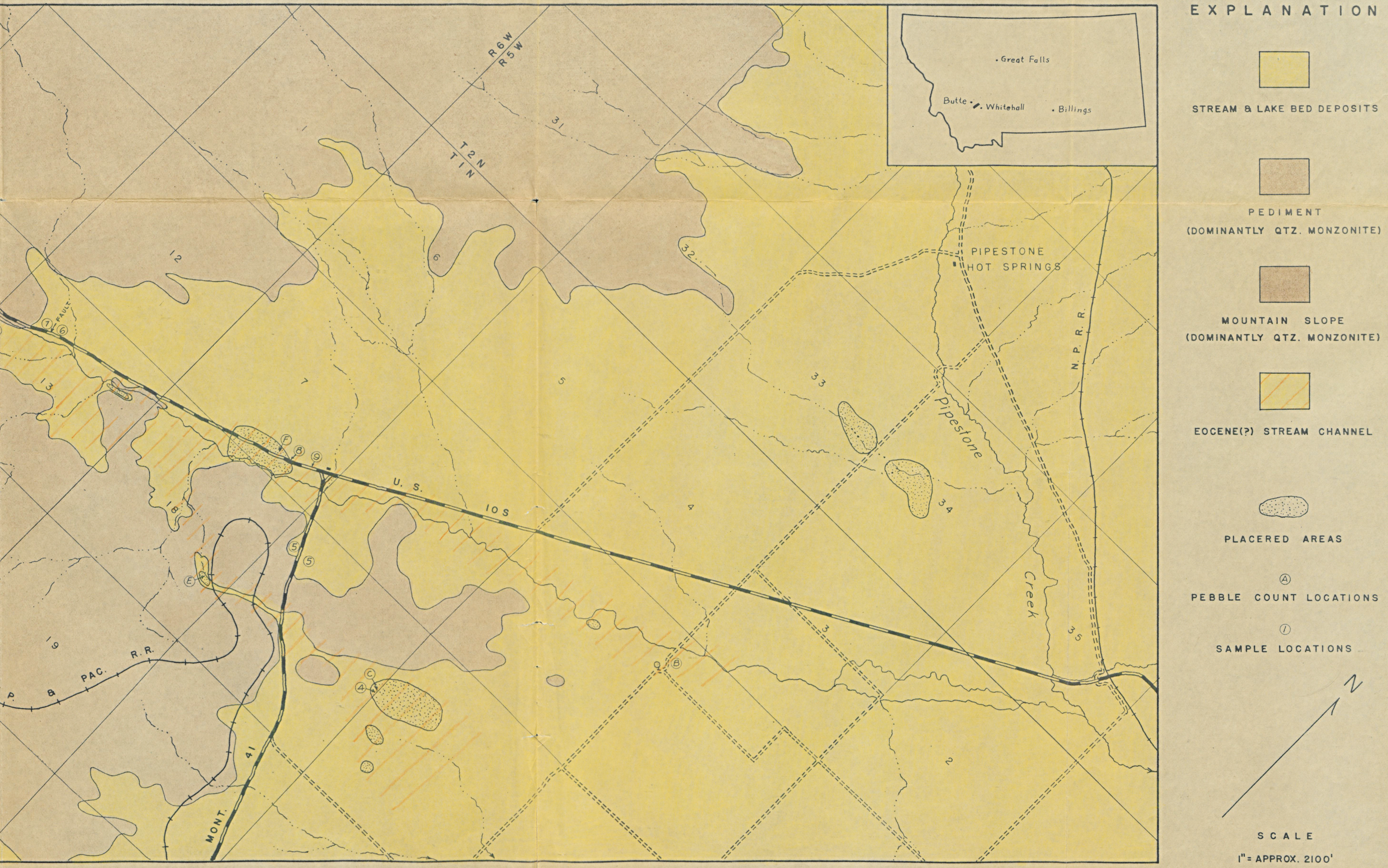


MAP SHOWING A PROBABLE EARLY TERTIARY STREAM CHANNEL IN

MONTANA SCHOOL OF MINES

HENRY D. OLSON — 1952



STREAM CHANNEL IN UPPER PIPESTONE CREEK AREA

SCHOOL OF MINES

D. OLSON — 1952

PLATE IX