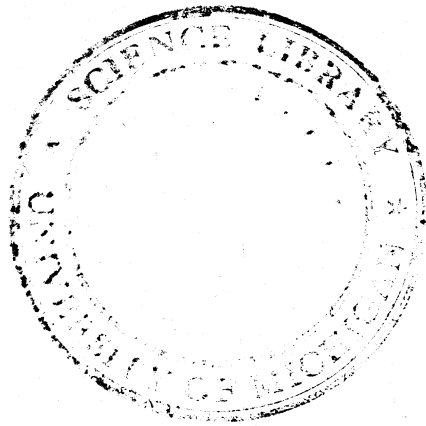


MASTERS' THESIS

Gray, A
Terraces of the Hoback Basin,
Western Wyoming. 1946.



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ABSTRACT

The previously unstudied Pleistocene terraces in Hoback Basin are of three separate ages. The two highest terrace levels are of outwash of the first and second advances of Bull Lake ice respectively. The lowest terrace is related to the Pinedale or latest glacial stage. Thick deposits of loess on one terrace in the basin were valuable criteria for working out terrace sequence and tying the terraces of Hoback Basin with those of neighboring basins. The terraces in the canyon below the basin proved the connecting link between Hoback Basin and Jackson Hole.

Examples of piracy following Second Bull Lake time and in post-Pinedale time were noted. These and three abandoned stream channels were of interest and aided in unravelling the history of the area.

INTRODUCTION

Location and geography of the region: The area described includes the Hoback Basin, the middle section of the Hoback River, and Hoback Canyon which is the link between the Hoback Basin and Bryan Flat on which Camp Davis is located. The Hoback Basin is in north-western Wyoming about one hundred miles south of the southern boundary of Yellowstone Park and forty miles east of the Idaho state line. The area lies within the parallels $43^{\circ}00'$ and $43^{\circ}20'$ north latitude and meridians $110^{\circ}16'$ and $110^{\circ}40'$ west longitude, and is entirely in Sublette County. The basin is bounded on the north and north-east by the Gros Ventre Mts. and on the west by the Hoback Range. It is closed in to the south and southeast by what is known as the Rim which separates the Hoback Basin from the larger Green River Basin.

The Hoback River has its origin in the southern end of the Wyoming Range, which is parallel with and just west of the Hoback Range. It flows north a short distance before turning abruptly east to cut through the southern part of the Hoback Range. About two and one half miles south of Hoback Peak the river crosses the mountains in what is called the Upper Hoback Canyon. The investigations for this paper begin at the place where the river issues from the mountains and flows out into the basin. For about twelve miles the Hoback ^{follows} ~~flows~~ a northeasterly course in small meanders with much braiding and aggrading. At the mouth of Fish Creek, which enters the Hoback from the east, the river makes a sharp left bend and continues its flow in a northwesterly direction across Hoback Basin. After eighteen or twenty miles of meandering and accumulating volume from the numerous tributaries

which join it, the river leaves the open basin and is in general closed in by high walls of slightly dipping Tertiary rocks. Four miles farther, in the vicinity of Shoal Creek, the river flows swiftly through the deep and narrow Hoback Canyon, and recrosses the Hoback Range. In the canyon proper, the river has cut through the highly distorted Mesozoic and Paleozoic rocks for a distance of some six or seven miles, with the mountains rising over three thousand feet above the level of the river. There are some sections where the walls of the canyon recede, leaving room for both cut and built terraces, some of which can be correlated with those found in the basin. About three miles above the place where the Hoback enters Bryan Flat, the river leaves Sublette County and flows into Teton County.

Throughout the Hoback Basin, the Eocene beds are almost flat lying. These consist of 15,000 feet of lower Eocene, the Hoback formation, and 1000 to 5000 of Middle Eocene, the Pass Peak formation. In some places the dip is as high as 15° but in general it does not exceed 5°. The Pass Peak formation consists of layers of interbedded shales and sandstones with a few lenses of poorly cemented conglomerates. It is usually most difficult to differentiate between a true terrace and a flat lying surface scattered with the Pass Peak cobbles which have been left after the finer material was removed. This is especially true in Fish Creek for the terrace materials are almost entirely of Pass Peak cobbles with only a few granites and limestones and sandstones present. The Pass Peak conglomerates are composed of quartzite cobbles, mainly light colored, which exhibit compression fractures. They range in size up to about three inches in diameter.

Erosional history of the region: In his Post-Cretaceous History of Western Wyoming, Blackwelder (1) describes five cycles

(1) Blackwelder, Eliot, Post-Cretaceous history of the mountains of central western Wyoming: Jour. Geology, vol. 23, no. 2, pp. 97-340, 1915.

of erosion in the Wind River Range and Basin and in Jackson Hole. The Hoback Basin does not enter into his discussion, but Blackwelder (2) points out that in his studies he found that the

(2) Idem., p. 308.

topographic features in different parts of a district and even in entirely different drainage basins, are so alike in every way as to suggest that each has passed through a similar history owing to some widespread influence. Therefore it is possible that the erosion levels of the area under consideration may correlate very well with all or some of Blackwelder's five cycles.

The oldest and highest level in western Wyoming is called the Fremont surface by Blackwelder, and it is found at an elevation of over 12,000 feet in the Wind River Range. This may correlate with a surface in the Gros Ventre Mts. at about 10,300 to 10,800 feet in elevation. In the Tetons the cobble strewn summit of Mt. Moran at 12,600 feet elevation is supposed to be an example of the Fremont surface. This surface is believed to have been developed during the Pliocene epoch (3).

(3) Blackwelder, Eliot, Post-Cretaceous history of the mountains of central western Wyoming: Jour. Geology, vol. 23, no. 2, pp. 206-207, 1915.

The next level is at an elevation of about 9,500 feet in the Wind River region at Union Pass and takes its name from that locality. The northwestern part of the Teton Range and the west end of the Gros Ventre Mts. are thought to exhibit surfaces of

this age which are found about 2000 feet above present drainage. The Union Pass cycle was completed by Late Pliocene time.

Just before or in early Pleistocene (before glaciation in Jackson Hole) the Black Rock surface was being formed and remnants of it are found today at an elevation of about 7500 feet, from 800 to 1200 feet above present drainage. Flat gravelly spurs and tabular areas in the Snake River valley below Jackson Hole about 400 to 650 feet above the river (4) correspond to

(4) Fryxell, F.M., Glacial Features of Jackson Hole, Wyoming: Augustana Library Publications, No. 13, 1930, pp. 19-20.

this surface. The Black Rock surface was the one on which Buffalo drift was deposited. The formation of the surface must have terminated by the time of the first prominent glaciation in this region which is Illinoian or Kansan.

It is between the Black Rock and the following Circle surface that locally, at least, another level exists here, which will be called the Porcupine. Blackwelder (5) suggests this

(5) Blackwelder, op. cit., pp. 315-316.

level when he wrote: "Between the Black Rock cycle and the next one clearly discriminated (Circle) there may well have been one or more cycles now represented by terraces visible here and there in the Wind River and Green River bad lands. These are however, but little known and appear not to have left notable marks in any but the softest strata. For the present, therefore, they must be neglected." Later, Fryxell (6) studied the area in

(6) Fryxell, op. cit., p. 72.

northern Jackson Hole a little more thoroughly and conceived the idea that while there is not sufficient evidence to justify recognition of two distinct glacial stages between the Buffalo and the third or youngest glaciation, the Pinedale, it should be borne in mind that there may have occurred two glaciations--possibly two advances of the same stage--during the time. This then, locally, makes possible the development of the Porcupine surface between the Black Rock and the Circle levels. The Porcupine surface is best observed in South Park in the vicinity of the Porcupine and Squaw Creeks along the Snake River several miles north of the Hoback Snake junction. This area was studied by Elizabeth Pretzer (7) and by Helen Walberg (8) and the latter

(7) Pretzer, Elizabeth, The Squaw Creek Glacial Deposits: Unpublished manuscript, 1942.

(8) Walberg, Helen, The Pleistocene History of South Park, Jackson Hole, Wyoming: Unpublished manuscript, 1943.

found the surface to be at a level that ranges from 200 to 500 feet above present drainage and dipping to the north. Not enough work has been done in connection with the Porcupine surface to know its actual extent and at present it is known only around the region of the confluence of the Snake and Hoback rivers. On this erosion level there is glacial debris of Bull Lake age, covered with loess. This level, where present, will be referred to as First Bull Lake terrace.

The Circle terrace in the type locality, Wind River Basin south of Dubois, is from 100 to 200 feet above the present drainage. In the type locality, Blackwelder (9) states: "...the Bull Lake

(9) Blackwelder, op. cit. , p. 319.

moraines rest upon the Circle terraces and blend into them in such a way as to indicate that the terraces were parts of the floodplains in the earlier glacial stage." In the southern end of Jackson Hole, the Circle terrace is about sixty feet above the Snake. The highway runs along the top of this terrace for some distance as it continues south from about three miles below the town of Jackson to the southern end of the basin. This terrace consists first of bevelled Tertiary strata capped by a quartzite gravel, probable Bull Lake outwash, and topped by compound piedmont alluvial fans. In this work those terraces which may correspond to the Circle will be called Second Bull Lake terraces or outwash.

The latest erosion cycle of Blackwelder is the Lenore which in the Wind River Basin is found one hundred to one hundred and fifty feet below the level of the Circle terrace. This is also found in the southern part of Jackson Hole and is mentioned by Blackwelder (10) as "...observable along Fall or 'Hoback' River,

(10) Blackwelder, op. cit., p. 320.

down the Grand Canyon of Snake River, etc..." This level, along the Wind River, has been entrenched ten to thirty feet to the present river level. In the southern part of Jackson Hole, Fryxell (11) mentions that near Wilson the Pinedale outwash is

(11) Fryxell, op. cit., p. 109.

only about ten feet above the river and that it is subject to overflow during high stages of the Snake and Fish Creeks. At Moose, about twelve miles north, this terrace is as much as forty feet above drainage.

Therefore, the work of others in areas not too distant suggests relations to be expected in the Hoback Basin. However, since the Jackson Hole region is separated from the Hoback Basin by seven miles of canyon through the Hoback Range (See Fig. 1), parallel history may not have occurred, and a close correlation may not be found. Also the names used by Blackwelder and others in describing levels to be found in distant basins are herein used in a provisional way. Those names given to levels that are known to be widespread and far-reaching are used here without hesitation but the more recent levels, which may have been formed under variable local conditions in the different basins, possibly should be designated by provincial names.

Purpose of study: The purpose of this study is to work out a logical sequence in the terrace levels of the Hoback Basin and, if possible, to correlate these terraces with those in Jackson Hole.

The index or key terrace: Along the Hoback River, on Upper Hoback Road south of Fish Creek, about three miles south of Highway 187 and in the vicinity of the Noble's Ranch there is a good exposure in a road cut of the materials in a terrace. (See Fig. 2). This terrace rises 40 feet above present drainage and it consists of about 70% quartzite cobbles and 30% cobbles derived from sedimentary rocks. The upper six feet of the terrace is of loess and the contact between cobbles and loess is sharp in the cut. One mile farther upstream, where the same terrace rises only eighteen feet above the river, the upper five to six feet are of loess also.

Through work done in Jackson Hole and in the Wind River Basin it has been substantiated that following the main Bull Lake glaciation there was a period in which widespread deposits of loess

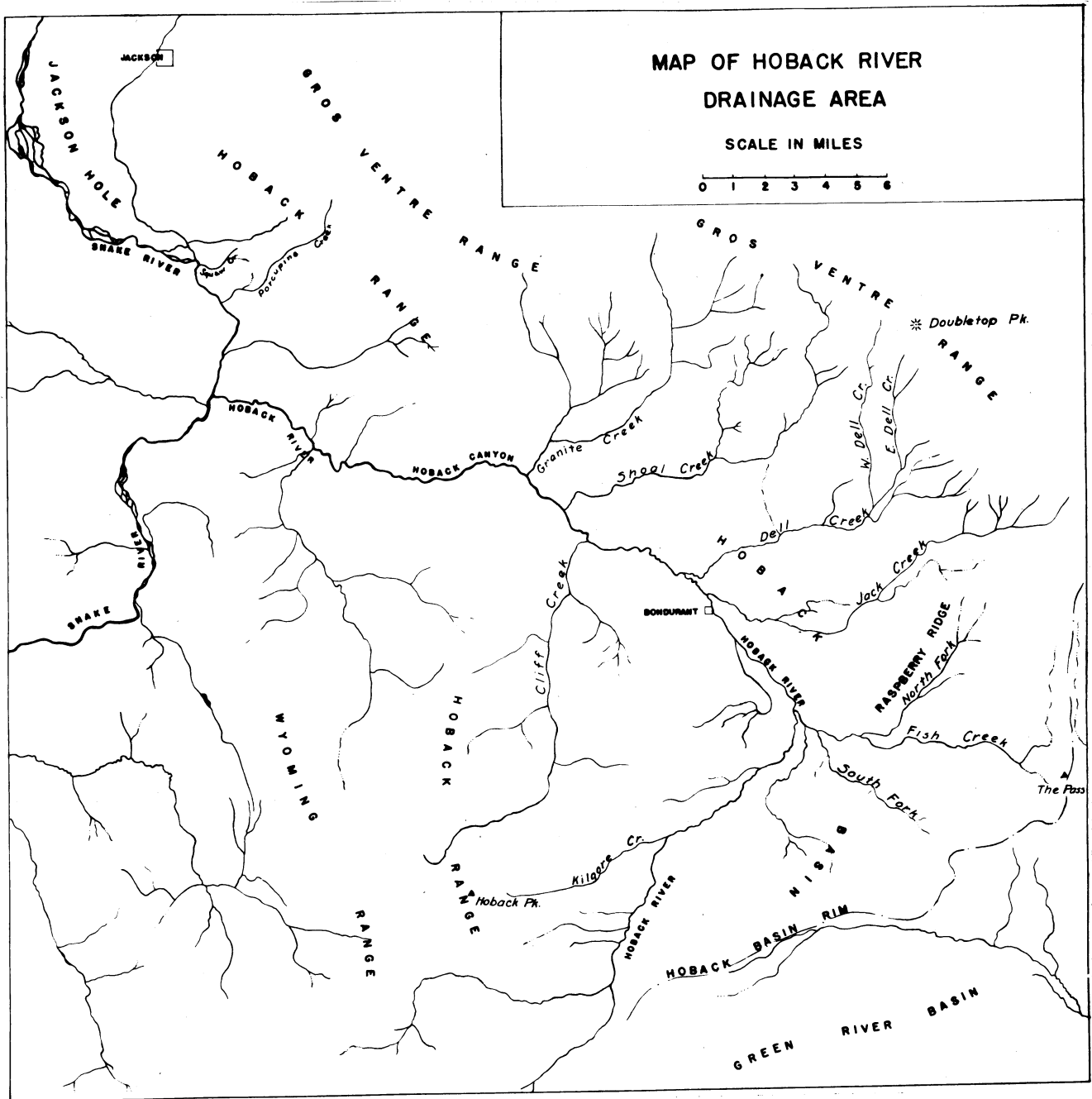


FIGURE 1.

were laid down. Therefore, the Circle^{or}Second Bull Lake terrace in the two basins has come to be recognized as that level which carries a heavy covering of loess. This then leads to the assumption that the eighteen to forty foot terrace remnants of Hoback River may also be Circle or equivalent.

Tracing this Second Bull Lake level down the Hoback River it is continuous with the main Dell Creek terrace which stands 60 feet above present drainage (See Fig. 3). In Dell Creek about two miles upstream from its mouth there is an alluvial fan issuing from a small valley in the hills to the north (See Fig. 2). This alluvial fan spreads out over and blends in with the main Dell Creek terrace. When traced upstream, the outwash blends into moraine believed to be Bull Lake in age. This fact and the apparent age indicated by extent of weathering of the boulders likewise gives further testimony leading to the recognition of the Second Bull Lake terrace.

Using this loess covered terrace and its continuations as a key for the erosional and depositional surfaces in the area, the other surfaces could be dated as older or younger. Some terraces could be traced back to moraines and thereby dated. Pebble counts proved diagnostic. By means of these methods of study a terrace sequence was found similar to that of Jackson Hole. This key terrace was valuable in working out the sequence but herein the present drainage level will be the datum plane.



FIGURE #3

SECOND BULL LAKE TERRACE AT MOUTH OF DELL CREEK

GROS VENTRE MOUNTAINS IN LEFT DISTANCE

EVIDENCES OF BLACK ROCK SURFACE

If a person climbs above the floor of the basin and looks about, the most conspicuous feature to be seen, other than the Gros Ventre Mountains to the northeast and the Hoback Range to the west, is the Hoback Basin Rim (See Fig. 2). To the eye the Rim is a level divide at an elevation of from 7500 to 8000 feet. It connects the southern end of the Hoback Range with the southeastern end of the Gros Ventre Mountains and causes the Hoback Basin to resemble a segment of a circle, with the Rim the arc and the two ranges the radii.

The Rim separates the Hoback Basin from the much more extensive Green River Basin which lies to the south and east. The streams flowing off the Rim into the Hoback drainage system have a more pronounced gradient than those that flow south and east through the Green River system. It may be expected that the more energetic streams of the Hoback system will someday work headward enough to cause the capture of the headwaters of some of the tributaries of the Green River. There is an example of imminent piracy in the region of the Pfiester Cabin, where the highest reaches of Muddy Creek have a chance of intersecting Middle Beaver Creek six miles below its source (See Fig. 2).

In the region north of the Pass, piracy may have already taken place for there a small stream on the Hoback side has the general characteristics of the Green River streams and parallels one of them for a distance of over three miles as it flows straight south before it turns sharply west into Fish Creek.

The Rim, which is level and which occurs at the same elevation as the Black Rock surface in other regions close by, has been considered to be the Black Rock surface by members of the staff of

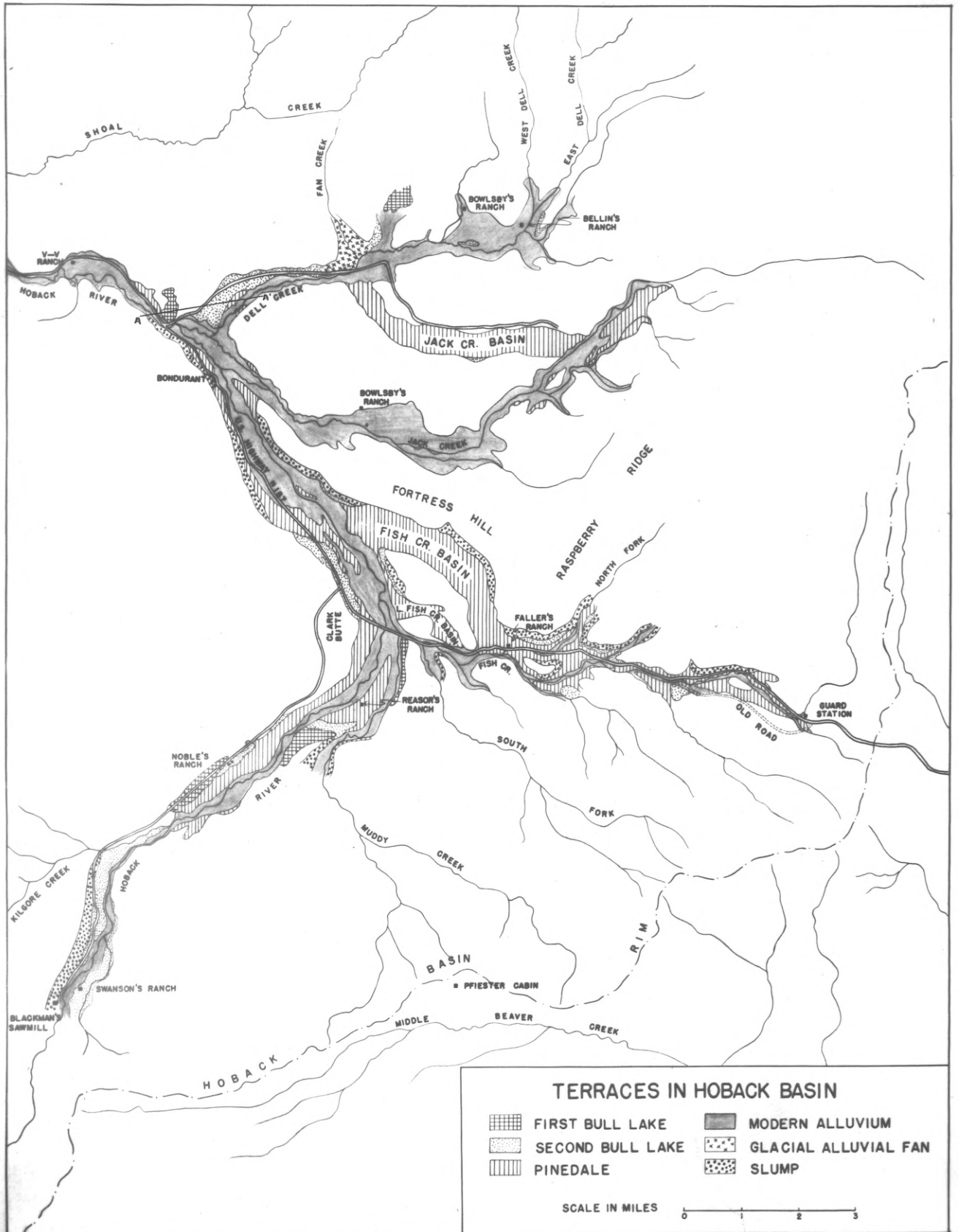


FIGURE #2

Camp Davis. Scattered through the upper part of the basin-- between the upper part of the Hoback and Fish Creek and on the north side of Fish Creek, there are numerous remnants of flat topped hills at 7500 feet elevation. The level summits are very apparent on the topographic map and to the eye when driving through the basin. Several of these hills along the north side of Fish Creek were investigated and it was found that although they appeared flat from the distance, they were actually only level along the river edges for a width of fifty or seventy-five feet and the remainder of the 'buttes' followed the general dip of the underlying Pass Peak formation of the Eocene. There must have been some widespread erosion surface at one time in order that so many remnants at the same level exist. Subsequent down-cutting was probably accompanied by stripping of the tops of the erosional remnants down a little to conform to the gentle 3°W dip of the underlying strata.

According to Dr. Eardley, the ridge crests on either side of Granite Creek and the divides between Shoal Creek and Dell Creek are remnants of Black Rock surface. Deer Ridge, which is a prominent highland between the upper parts of Shoal Creek and Granite Creek, and Game Hill, which rises above the mouth of Shoal Creek are both 7500 foot levels which Dr. Eardley considers remnants of Black Rock surface. Also in the Paleozoics at the mouth of Hoback Canyon there are prominent shoulders that accord with the Mesa surface. The Mesa surface opposite Camp Davis along the lower Hoback is supposed to represent the Black Rock surface.

THE FIRST BULL LAKE TERRACE

In the Hoback Basin there are five distinct remnants of a high level (See Fig. 2) which may possibly be the same as the Porcupine level in South Park of southern Jackson Hole. The most prominent one is about two miles up the Hoback from the mouth of Fish Creek (See Fig. 6). It is a well defined terrace and quickly catches the eye when one looks south from the bridge which carries highway #187 across the Hoback. This terrace is at an elevation of 7000 feet, about 150 feet above the river and is approximately a mile long and one third of a mile wide in its widest part. There is a steep descent to the modern floodplain on its west side where the river has been undercutting the terrace. The slope is almost as steep on the eastern side where it has been cut by Muddy Creek. To the south it is bordered by hills of bedrock and on the north side it makes a comparatively gentle descent to the lower terraces that stretch out several miles to form the upland area between the river and Muddy Creek. On the Hoback side of the terrace, where undercutting has caused recent slumping, the character of the terrace is well shown. There is sixty to sixty-five feet of alluvium made up of fine to medium-sized gravels which have been deposited on top of beveled Eocene strata. These gravels are derived entirely from sedimentary rocks. On top of the terrace there are small to medium-sized boulders, whereas scattered over the surface of the slopes and in the exposed parts larger boulders will be found. No striae were seen on the flat sided and well worn cobbles. These sixty feet of cobbles are possibly First Bull Lake outwash deposited on a surface which may be equivalent to the Porcupine surface.



FIGURE #6

TERRACES ALONG HOBACK RIVER SOUTH OF DISH CREEK MOUTH

SKYLINE IS HOBACK BASIN RIM

F--First Bull Lake
S--Second Bull Lake
P--Pinedale

Another remnant rises to the same elevation about a mile southwest of this terrace. Investigation proved it to be somewhat more than 150 feet above the river and its composition comparable to that of its counterpart downstream. This remnant is located just above Noble's Ranch (See Fig. 2) and runs for a little over a mile along the river. It is close to a thousand feet in width. The Upper Hoback River Road skirts this terrace, about a hundred feet below the top. Here again the cobbles are small to medium in size and apparently derived from sedimentary beds largely Cretaceous in age. This terrace is bordered on the river side by the Pinedale terrace, the Second Bull Lake terrace having been almost entirely washed away.

Near the mouth of Fish Creek is a nose that separates the South Fork of Fish Creek from the Hoback River. This nose is in bedrock and in the main rises higher than the general level of the terrace described farther up the valley. Along the Hoback side of this highland there is a crease or ledge that is very noticable and which is 150 feet above the modern floodplain, and aligned N-S, paralleling the river. This ledge at first appears to be a cut terrace but investigation proves it to be a resistant ledge of bedrock, exposed along the strike and dipping 7-10°E. For a distance of a thousand or so feet along the length of this ridge at the N end is a cap of gravel about twenty-five feet thick (~~See Fig. 5~~). These gravels rest on the sandstones of the Hoback formation and are mainly quartzites of a type similar to those in the Pass Peak formation. It seems that this would indicate a different source of materials in the two terraces along the Hoback River in the vicinity of Noble's Ranch from the source of materials in the terrace at the confluence of Fish Creek and the Hoback. However, both the Hoback River and Fish Creek

have tributaries that transverse outcrops of Pass Peak formation. Fish Creek tributaries cross only Pass Peak formation; Hoback River above junction of Fish and Hoback crosses both Pass Peak and older formations. Why it is that there are no Pass Peak cobbles and boulders on the two Porcupine terraces in the vicinity of Noble's Ranch is unsolved.

There are two more remnants of the first Bull Lake terrace which under certain conditions may correlate with the Upper Hoback terraces just described. These are located six or seven miles downstream from the junction of the Hoback and Fish Creek. The most obvious one is just below the mouth of Dell Creek (See Fig.2). The greater part of this terrace is found to be 250 feet above the present drainage but about two hundred yards back from the river edge there is a gentle rise of fifty feet in about a hundred yards to a higher level. This higher level, at 6800 feet elevation (300 feet above the river) is the main level and it may be assumed that the lower of the two is merely a lowering of the higher main terrace.

Most of the cobbles are around six inches in diameter, with some up to a foot in diameter which would be classed as boulders. Ninety percent of these are quartzites, Pass Peak type, complete with the percussion marks, and the remaining ten percent consists of both granites and sedimentary rocks.

On the southwest edge of the lower portion of this terrace a small gully has cut through the terrace and exposed a good cross-section. It appears that the underlying Hoback formation which in the main consists of sandstones and shales with some conglomerates in the base, here has a dip of 17°SE and it is beveled off with twenty feet of gravels lying unconformably on top of it. This again may correlate with the Porcupine surface of Jackson Hole--

here/with a cap of twenty feet of First Bull Lake outwash debris.

Toward the headwaters of Dell Creek, about four miles up on the same side of the creek, is found a high level at an elevation of 7000 feet and which is 345-350 feet above present drainage. This terrace is in the form of a U, for a small stream bisects it. It is ninety-nine percent granite with boulders up to five feet across and the remaining one percent is of sedimentary rocks which are very small and not well rounded. The granites are well weathered in place and the entire terrace has the appearance of having been a moraine or till deposit that was leveled off at a later date.

The gradient of the ancient Hoback River as measured by the three remnants above the mouth of Fish Creek in first Bull Lake time, was about sixty feet per mile. Dell Creek, however, at this time had a gradient of over eighty-seven feet per mile (See ^{Fig. 7a} Fig. 7b). Using the high level at the mouth of Dell Creek and that at the mouth of Fish Creek and spanning the six or seven miles between them, the gradient of the main part of the basin turns out to be less than thirty feet in a mile. That the gradient of Dell Creek was so much greater than that of the Upper Hoback may be due to the fact that it was closer to the mountains or because the higher Gros Ventre Mts. which fed Dell Creek, was an area of more intense precipitation and glaciation and consequently greater quantities of debris were carried off.

These five terrace remnants then may be First Bull Lake deposits and the surfaces on which they rest may possibly correlate with the Porcupine as described by Helen Walberg (1943) in South Park of Jackson Hole. However, since no connecting links have been found so far through the length of the canyon, it may be that the erosional histories of the two regions are distinct from one another.

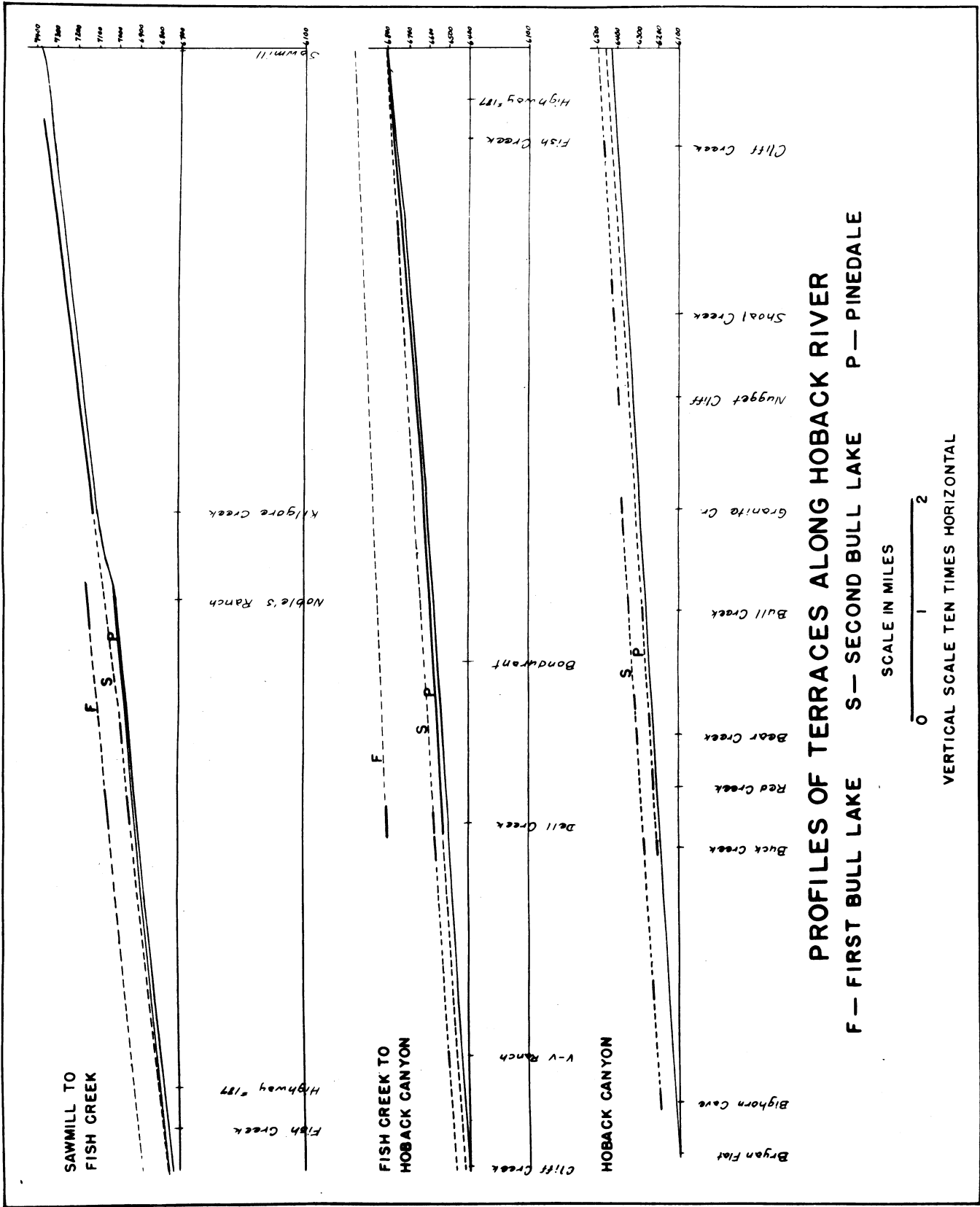


Figure # 7a

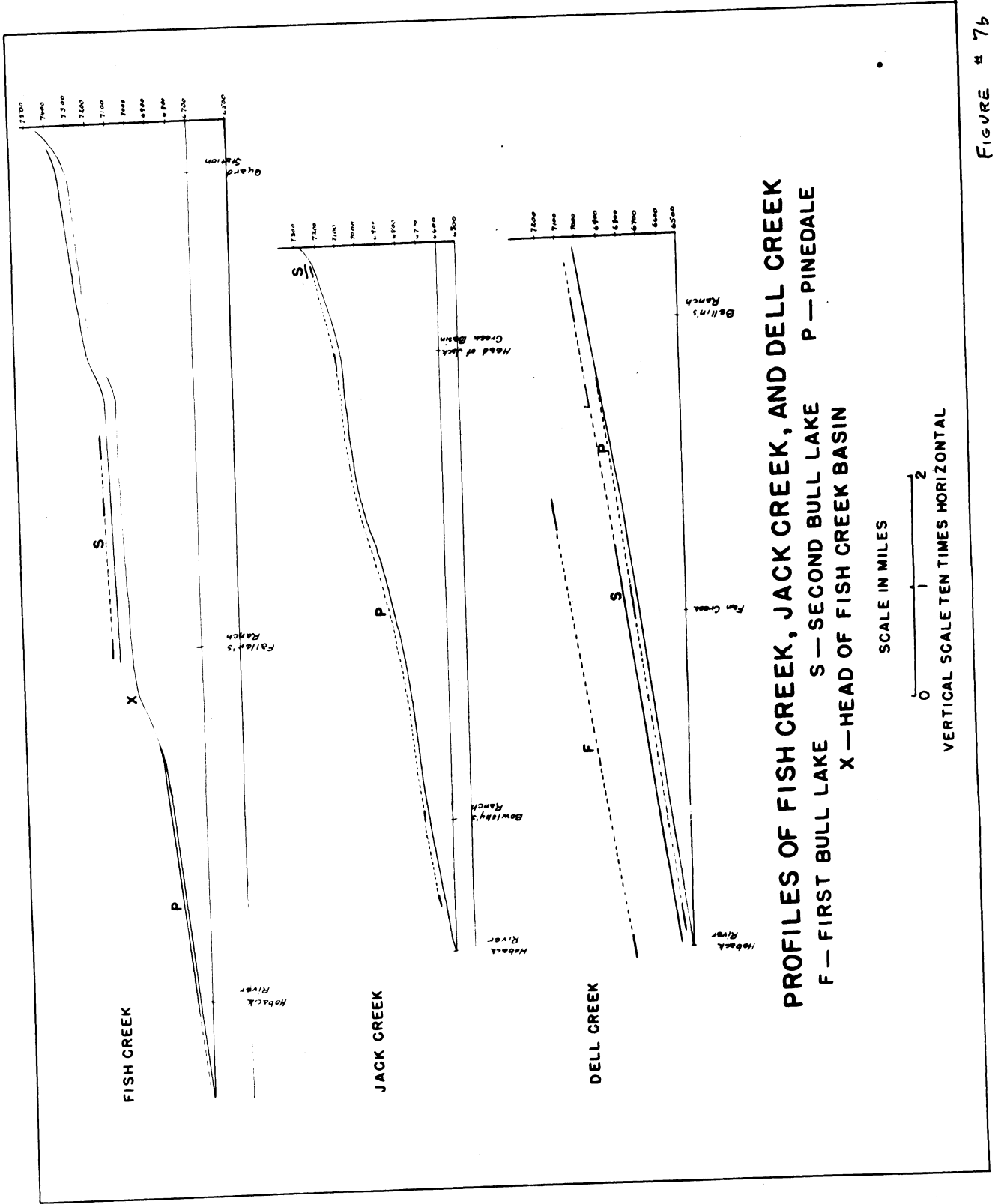


FIGURE # 7b

SECOND BULL LAKE TERRACE

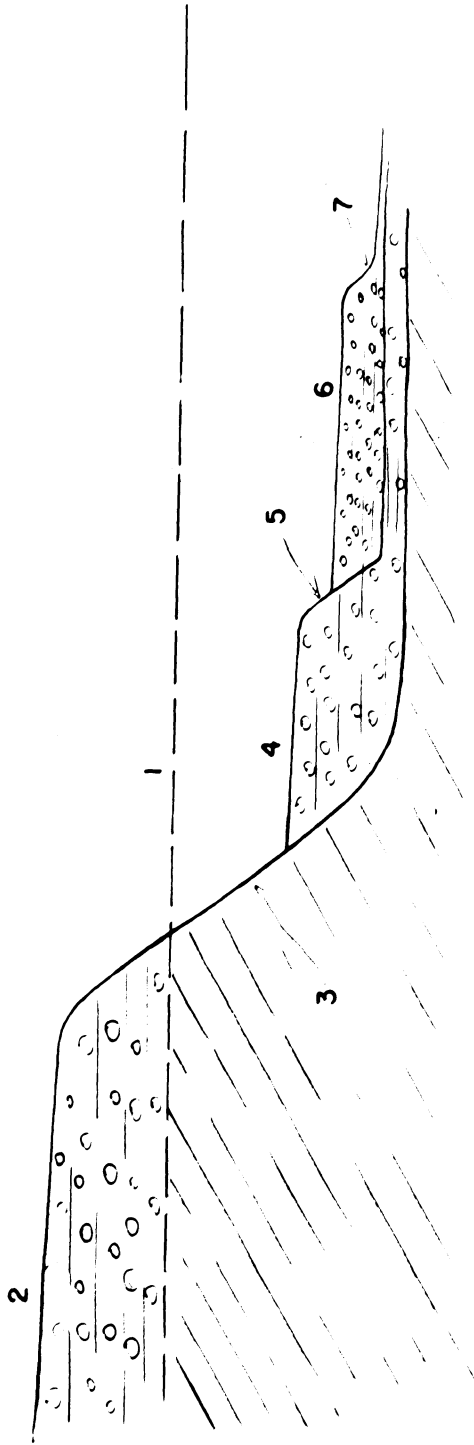
General description: Following the First Bull Lake advance and the subsequent deposition of outwash, there was a period of erosion which removed a great quantity of the material, leaving only the First Bull Lake remnants as evidence of the once extensive valley fill. (See step #3 of Fig. 8).

The Circle terraces of Blackwelder in the Wind River and Jackson Hole basins seem also to have their counterparts in the Hoback Basin. As on the terraces and outwash in the type localities, here too are found deposits of loess which is generally considered to have been deposited in post Bull Lake time (Peorian in the Middle West?). Also some of these "Circle" terraces can be traced back to a moraine which is considered to be Bull Lake. It is this level that was taken as the key terrace of the area. The traces of this terrace are more numerous than those of the earlier stage and remnants are to be found in all of the main tributaries to the Hoback and also in the canyon. The height of this terrace above present drainage varies from eighteen feet in the Upper Hoback to around ninety feet in the canyon, but the slope is an even one and the difference in height is due to a more recent change in grade of the drainage. Figure 8, step 4 shows the relation of the Second Bull Lake terraces to the previous erosion cycle and the deposition of the earlier outwash.

This change in grade is quite important in the Hoback River above the mouth of Fish Creek. The profiles (See Fig. 7a) show this very well.

Upper Hoback River terraces: Evidence of the First Bull Lake level is found near the beginning of the Upper Hoback River road, across the river from Blackman's sawmill and just below what is

GENERALIZED TERRACE SEQUENCE IN HOBACK BASIN



- 1 PORCUPINE SURFACE
- 2 FIRST BULL LAKE OUTWASH
- 3 DISSECTION OF FIRST BULL LAKE OUTWASH
- 4 SECOND BULL LAKE OUTWASH
- 5 DISSECTION OF SECOND BULL LAKE OUTWASH
- 6 PINEDALE OUTWASH
- 7 DISSECTION OF PINEDALE OUTWASH

FIGURE # 8

labeled on the Hoback Basin map as 'Swanson Ranch' (See Fig. 2). Here the terrace is found to be thirty-three to thirty-five feet above the river and less than a half mile north of the Swanson Ranch is duplicated on the opposite side of the stream. The remnants vary in width, along the stream. The cobbles which are up to a foot in diameter and not very well worn, seem to be primarily from the Cretaceous rocks, although some older quartzites are also found. The terrace gradually decreases in height above the river in a downstream direction. In the vicinity of Kilgore Creek it is twenty-one feet high, including the upper five feet which is of loess. Here the terrace is found only on the west side of the river for the stream hugs the high hills on the east side and no evidence of the terrace remains.

One mile south of Noble's Ranch, the Second Bull Lake terrace rises but eighteen feet above present drainage including a five foot cap of loess. The boulders measure in diameter from one to six feet and are well-rounded quartzites and sedimentaries in the proportion of seventy to thirty percent. From here on down the river, the remnants of the Second Bull Lake terrace are relatively few and the first evidences of the Pinedale terrace are seen. At Noble's Ranch the road runs along the Circle terrace just beneath the First Bull Lake terrace. At the road cut just above the first small creek below Noble's, there is a good exposure of six feet of loess and the contact with the gravels beneath is clear. The top of the terrace itself is thirty-five to forty feet above the modern floodplain and contains mainly quartzites of the Pass Peak formation with some sedimentaries. About a mile upstream from Reasor's Ranch the First Bull Lake terrace which is on the southeast side of the river is bordered on the north side by about three hundred yards of the Second Bull Lake and this is duplicated on the opposite side

of the river in a very narrow area between the road and the river.

The gradient of the Second Bull Lake terrace along the Hoback River above the mouth of Fish Creek is just over sixty-six feet per mile. The present river gradient on the average is about seventy-three feet in a mile--varying from fifty feet per mile in some parts to over a hundred per mile in others (See Fig. 7a).

The Upper Hoback River Road entrance is on the Second Bull Lake outwash and it extends for about three quarters of a mile to a mile on either side of the entrance, along Highway #187. In this vicinity the terrace is about a quarter of a mile wide, twenty-four feet above the river and is duplicated on the opposite side by a very narrow strip of terrace bordering the western side of the highland which separates Fish Creek Basin from the Little Fish Creek Basin (See Fig. 2).

Fish Creek terraces: Another remnant of the Second Bull Lake level is about two miles west of the Guard Station along the old road which runs along the south side of Fish Creek. At this spot both the Second Bull Lake and Pinedale terraces are well shown in relation to one another (See Fig. 9). The Second Bull Lake rises forty-four feet above the Pinedale terrace and is about ninety-five feet above the creek. It contains quartzites exclusively, which have the characteristic Pass Peak pressure marks and which are small to medium in size. About a mile farther down the creek on the opposite side is found another part of the second level. Here looking downstream it forms a semi-circular border to a prominent knob on the right of the highway and rises to the level of a remnant farther downstream which is just above the mouth of North Fork. These two terraces are each not more than a quarter of a mile in length and only a hundred yards in width. They appear to be built terraces with the side toward the hills covered with



FIGURE #9

ALONG FISH CREEK THREE MILES WEST OF THE GUARD STATION

S--Second Bull Lake
P--Pinedale

slump. Also a small patch is to be found up North Fork a half mile north of the highway. Between Raspberry Ridge and the creek there is a terrace that runs for about a mile and is over a hundred yards wide. A half mile east of Faller's Ranch, there is a level over ninety feet above present drainage. Here the cobbles are mainly of quartzite with a scattering of sedimentaries. The quartzites show the usual Pass Peak fracture marks. The terrace in this locality appears to be cut rather than built with only a thin layer of cobbles and boulders on top. The slump blocks from Raspberry Ridge tend to cover up the terrace. Using the handlevel and looking due south from this last mentioned terrace, another small remnant about a mile to the south comes to the same level, but because it is small and rather difficultly accessible, it was not investigated.

From the entrance of Fish Creek Basin on down to the Hoback River, there is no evidence of the Second Bull Lake terrace. In fact, several features seem to indicate that Fish Creek flowed northwest through Fish Creek Basin during this stage and joined the Hoback several miles north of the present junction. This will be discussed later when the Pinedale terrace is taken up.

Judging by the Second Bull Lake remnants which are found then only along the three mile stretch described above, the gradient of the ancient Fish Creek was about thirty feet per mile while the present stream runs along this stretch at a gradient of forty feet per mile (See Fig. 7b).

Continuing down the Hoback, there is a long narrow strip of Second Bull Lake outwash not more than fifty yards wide having its start just below the mouth of Fish Creek Basin on the northeast side of the river extending for nearly a mile along Fortress Hill. Then there is no further evidence of Lower Bull Lake terrace until

Dell Creek is reached.

Jack Creek terraces: Jack Creek, about seven miles above the spot where it enters the Hoback, exhibits one small remnant of Second Bull Lake terrace which is found across the creek from the east end of Jack Creek Basin. It is almost forty feet above the stream and twenty-four or twenty-five feet above the lower terrace. It is a very small remnant, close to the hills, about seventy-five yards wide and not over a third of a mile long. Along the hills bordering the south side of Jack Creek Basin there is a lens of a higher level which may be Second Bull Lake. No terraces of this age being found down the present Jack Creek except across from the entrance to Jack Basin may indicate the possibility that piracy came about in the period of erosion between the Second Bull Lake advance and Pinedale time.

Dell Creek terraces: Dell Creek's headwaters drain regions in the Gros Ventre mountains that contain exclusively sedimentaries (southeast of Doubletop Peak) and regions that are made up of both sedimentaries and pre-Cambrian metamorphics and granites. (see Fig.1).

Six miles above the mouth of Dell Creek the creek, on entering the basin, makes an abrupt turn to the right and continues almost due west until it joins the Hoback. It is about a mile above this turn that the entire valley is filled with morainal material and from here to the source of the numerous tributaries, nothing but morainal material is found. Beavers have dammed the streams and backed up the waters to make a wide willow filled marsh in many places but there are no terraces. The moraine up main Dell Creek (or West Dell, as it is called) consists of a hodge-podge assortment of sedimentaries and igneous and metamorphics up to a size of thirty feet in diameter. This morainal material is believed to be Bull Lake in age for the Pinedale in this region is found only

close to the mountains and because the boulders are well weathered in place and have the general aspect of the Bull Lake moraines in other localities. East Dell Creek, however, has its headwaters in the highlands southeast of Doubletop Peak and in these valleys, morainal debris is found to contain only sedimentary rocks. There is a tongue of land, possible First Bull Lake moraine terminating near Bellin's Ranch on the east side of Dell Creek just downstream from the junction of the east and west segments of the creek. (See Fig. 2). It is composed of sedimentaries and quartzites up to about four feet across and is topped by three to four feet of gray-buff loess. The hill rises to an elevation of 7300 feet from the valley floor which is somewhat less than 7000 feet above sea level. Around the western and southern sides of the highland is a narrow rim of level land about fifty feet above the present drainage which possibly is Second Bull Lake glacial fill, now forming a terrace plastered up against the moraine of the earlier stage. The terrace consists of sedimentaries only.

Continuing down Dell Creek, the low hills bordering the valley on the north are of bedrock (Pass Peak) with a mantle of glacial outwash. A fresh exposure above Bowsby's Ranch as well as other slides on the higher hills clearly show this. From the bend in the river to Bowsby's Ranch, the debris consists mainly of sedimentaries with only a scattering of granites. At Bowsby's Ranch there is a small stream that enters the valley from the high land to the north in the bed of which the cobbles are almost exclusively granites and from there on down Dell Creek, granites make up an important part of the stream gravels and glacial debris.

An "island" rises abruptly from the floor of the valley and is some sixty feet above the creek which runs along its south side.

This "island" is on the opposite side of the valley from Bowlsby's Ranch. It is relatively flattopped, about a hundred feet wide and about four or five hundred feet long sloping downstream. Throughout are strewn cobbles and boulders of limestone, sandstone, and quartzite up to ten inches in diameter. Taking normal stream gradient into consideration, this island appears at the same level with the Second Bull Lake terrace farther downstream but it appears to be much lower than the terrace above Bellin's Ranch. For a mile upstream and for more than a mile downstream, there are no other remnants of this level. Therefore, it is questionable whether or not it can be called the Second Bull Lake terrace. All along the south side of Dell Creek, there are no terraces or glacial debris. The bed rock of the region forms the hills and these rise abruptly from the basin with a small amount of slump and landslide materials bordering them.

Heretofore in Dell Creek the Second Bull Lake remnants have been widely separated but over a mile downstream from the "island" the first of the continuous Second Bull Lake terraces has its beginning. It is here, where the Dell Creek road turns south toward Jack Creek that the high First Bull Lake terrace is also found on the north side of the valley described above (See Fig. 2). The Second Bull Lake terrace mostly of sedimentary cobbles and boulders is very close to the hills and starts as a narrow fringe which becomes wider as it progresses downstream. A feature that dates the Second Bull Lake terrace in this place is the alluvial fan, composed of ninety-five percent granite and **five percent** sedimentary rocks, which comes out of the hills to the north just across Dell Creek from the mouth of Jack Creek Basin. This fan can be traced up the stream valley to its source which is a

Bull Lake moraine. It is believed that the histories of Dell Creek and Shoal Creek which parallels it to the north are linked by this stream and fan. Investigation showed that the valley of Shoal Creek below the vicinity of the fan stream is rather narrow, whereas above, it is relatively broad and open. The fan stream, which will be called Fan Creek for simple identification, occupies a valley that is wide and U-shaped and filled with morainal debris. The boulders range up to six feet in diameter toward the head of the valley. The drainage pattern of the region of upper Shoal Creek and Fan Creek leads to the belief that Shoal Creek, in pre-Bull Lake time joined Dell Creek by way of what is now Fan Creek across a low divide that separated the two. A lobe of ice then, in late Bull Lake time followed the original Shoal Creek, depositing till, and causing the fan to be built in and on the Second Bull Lake terrace that was being formed throughout Dell Creek. That Dell Creek was never glaciated below the right angle bend of Bellin's Ranch substantiates this belief. The outlet of Shoal Creek into Dell Creek via Fan Creek eventually became so clogged with morainal material, and the divide built so high, that Shoal Creek was forced to find a new outlet to the Hoback, and began flowing along its present course, due west for about seven miles before joining the Hoback.

It may be that a stream which emptied into the Hoback, had a tributary that worked actively headward and finally tapped the upper reaches of the original Shoal Creek. This piracy then would have made it easy for Shoal Creek to change its course when morainal debris blocked its route. In view of the evidence presented, this seems then to be the logical cause of the formation of the fan terrace. That the fan was formed at the same time that the Second Bull Lake terrace was being formed is richly demonstrated.

From the fan downstream, granites are present in great quantities-- up to forty percent-- intermingled with the quartzites and sedimentaries, whereas upstream from the fan, the terrace is made up of sedimentaries and quartzites almost exclusively. Also, if the fan were post-terrace, the granites would not be found throughout but rather only on the surface of the terrace.

Continuing downstream from the fan, there appear to be no evidences of the Second Bull Lake terrace on the south side of the creek at all but the entire floor north of the Creek is Second Bull Lake terrace excepting the modern floodplain which is relatively narrow and the very small remnants of the Pinedale terrace which will be described later. Throughout its length the main Dell Creek terrace then stands about sixty feet above the present drainage. There are some lower levels as much as thirteen feet below but they are due to recent cutting of the true terrace. Pebble counts indicate the constituents in general to be quartzites--fifty percent, igneous materials--almost fifty percent and a scattering of sedimentaries. It is this terrace that is so striking when passing the mouth of Dell Creek on Highway #187.

The Second Bull Lake level in Dell Creek has a gradient of over seventy feet to the mile which is very close to the gradient of the present drainage (See Fig. 7b).

Down the Hoback, the next remnant of the Second Bull Lake terrace occurs on the west side of the road and river just downstream from the level highland that is topped by the First Bull Lake gravels. Here the terrace is about sixty-five feet above drainage and the upper seven feet is of loess. The boulders are not more than a foot across, mainly six inches or so and appear

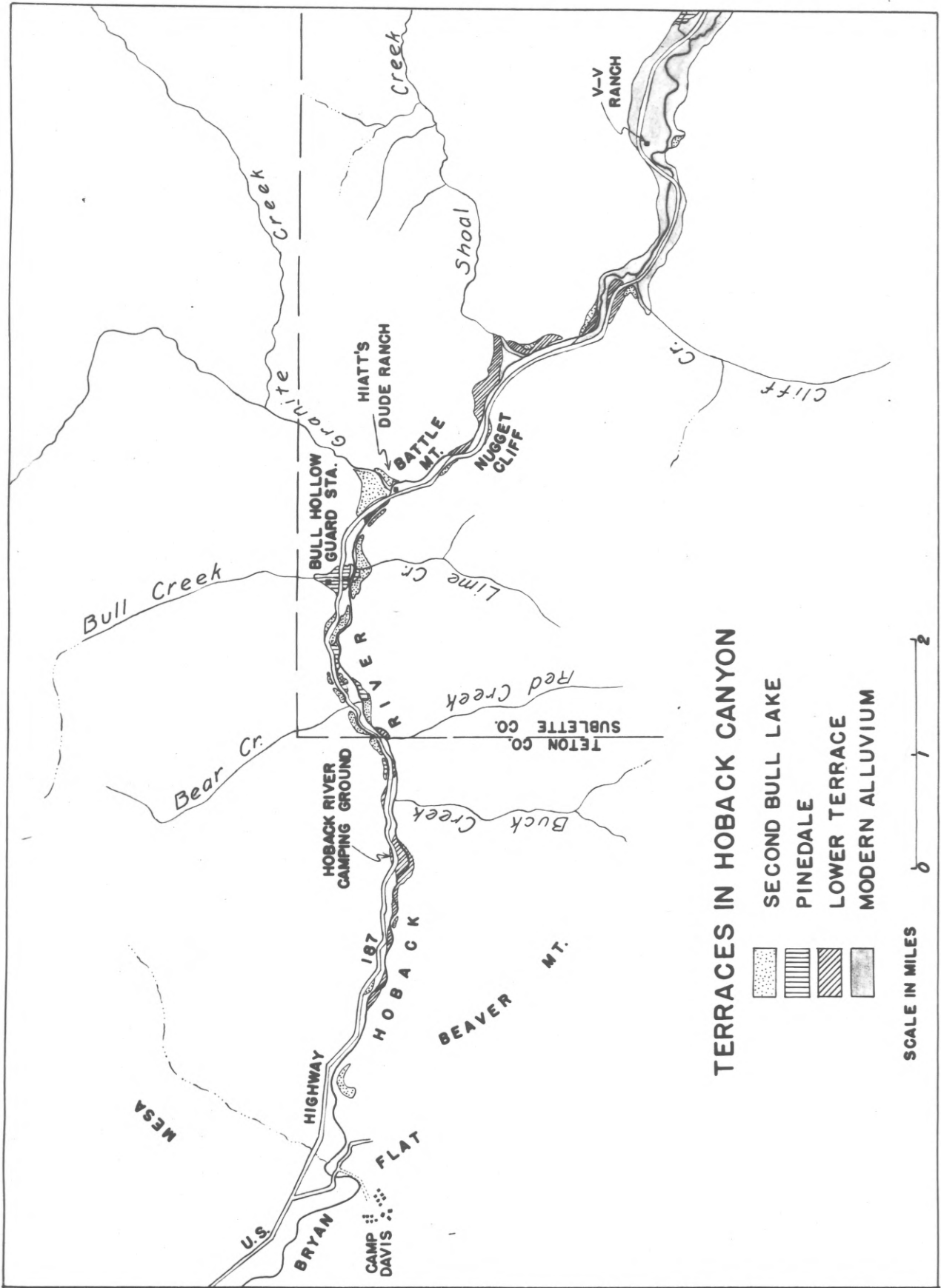
to be about fifty percent granite and fifty percent sedimentaries and quartzites, the latter with the Pass Peak markings.

One more remnant is found before the canyon is entered. This was only sighted on, not investigated, but is obviously a terrace at the mouth of a small stream which enters the Hoback from the south across the river from the V-V Ranch, and levels up with the other ^{Second Bull Lake} ~~stone~~ remnants in the area. It is a very small remnant, a hundred or so feet across and barely half that in width.





Hoback Canyon terraces: At the V-V Ranch the Hoback leaves the basin and enters the canyon (See Fig. 4). Although the canyon of the Hoback in some places is very steep walled and narrow, there are stretches here and there which widen out enough to permit the preservation of some of the earlier fill. The evidences of higher terraces are rather spotty and the remnants are in some places quite small but nevertheless a continued picture of the different terraces may be had when all of these are plotted up on a profile and viewed as a whole (See Fig. 7a).

On the northwest side of Cliff Creek at its mouth there is a slight suggestion of flatness about seventy-five feet above the river. Slump from above covers the 'terrace' to such an extent that only a small part is visible. Inasmuch as this terrace is composed entirely of sedimentaries with a minor amount of quartzite boulders and none of granite, the level here was most likely formed by Cliff Creek alone and the remnant represents a part of the valley fill just upstream from the mouth of Cliff Creek at the time the Second Bull Lake terrace was being formed.

Going down the Hoback for a mile, on the north side of the river about a half mile above the mouth of Shoal Creek, will be



TERRACES IN HOBACK CANYON

-  SECOND BULL LAKE
-  PINEDALE
-  LOWER TERRACE
-  MODERN ALLUVIUM

SCALE IN MILES 0 1 2

FIGURE 24

found a narrow piece of the Second Bull Lake terrace, the top of which is about seventy to seventy-five feet above the Hoback.

The lower fifty feet are sandstones of the Hoback formation and this is topped by ten feet of quartzitic, granitic and sedimentary cobbles. Just a narrow remnant of the same terrace is found southeast of Shoal Creek. It has the same composition and rises above the Pinedale terrace which is present there.

About a half mile below the mouth of Shoal Creek in the Nugget Cliff which towers over the highway there is again evidence of the Second Bull Lake terrace. The gravels are so intermingled with talus even in a fresh cut that the exact height cannot be determined, nor can the exposure be reached in order to tell its exact composition. Just beyond the Nugget Cliff on the same side of the highway--and across the river from Battle Mountain--there is further evidence of a terrace about seventy feet above the river. Here, too, the gravels are so covered with talus of Nugget and Twin Creek that they are impossible to map. The cobbles and boulders are mainly sedimentaries although some granites and quartzites are present.

The best examples of the Second Bull Lake terrace occur at the mouth of Granite Creek (See Fig. 4). This creek, which extends its headwaters high into the Gros Ventres, was very instrumental in the formation of the extensive terraces at its mouth as well as those farther down the river. The Second Bull Lake terrace is most conspicuous on the downstream side of the mouth of Granite where it stands above the Hoback some ninety or ninety-five feet and extends over a quarter of a mile along the highway. The top of the terrace is gently undulating and continues up Granite where it is easily traceable. Granites and sedimentaries alike make up

the terrace. Boulders ranging up to six feet in diameter are plentiful with the granites, especially, badly weathered. Looking southeast from this terrace, another remnant, smaller in extent, may be seen behind Hiatt's Battle Mt. Ranch at the foot of Battle Mt. When viewed from across the Hoback, the terrace has a stratified appearance, easily seen in the cut made for the highway. Also on the old road, which runs from Granite Creek to Bryan Flat along the opposite side of the canyon from the highway, there is a narrow strip of Second Bull Lake level which ties in with the main Granite Creek terrace and is found several hundred yards downstream from the mouth of Granite Creek.

Above Lime Creek, which enters the Hoback on the south side, there is a very indistinct but bonafide terrace remnant which is at the same level as the Granite Creek terrace. It too contains boulders up to three feet in diameter mainly of granite but with minor amounts of limestones, sandstones, and quartzite. Downstream from Lime Creek, just opposite Bull Hollow, the high terrace appears in a cut. The top of the terrace, seventy to eighty feet above the river, is very uneven, having been badly dissected by a small stream. Its composition and height however ties it in with the other Second Bull Lake levels in the same locality.

One half mile below Bull Hollow on the highway side of the Hoback, is a combination cut and built terrace which levels off about eighty-five feet above present drainage. The highway in this spot is in a cut that gives a good picture of the structure of the terrace. The lower forty feet is beveled sedimentary rocks; fifteen feet above the road, the stream deposits begin and the upper forty-five feet are built terrace. Its width is not

over a hundred yards ~~long~~ and the remnant is only about one thousand feet long.

Between Bull Hollow and Bear Creek, which is the next small stream to the west, there are two more inconspicuous remnants of the Second Bull Lake level and in the cliffs below Bear Creek there is another good exposure of cut and built terrace. Here the highway is fifteen to twenty feet above the river and above the road rise twenty-five feet of sedimentary rocks in a vertical attitude. Resting on the beveled edges of these beds are thirty-five feet of gravel and boulders. In this place in the canyon, there is no place for any width of terrace so the gravels are in turn topped by talus and slump from the mountains which tower above.

Across from Buck Creek which enters the Hoback from the south are gravels and boulders of the Second Bull Lake level but they are ~~so~~ intermingled with talus and are unmappable. They are at the proper height, however, to be the Second Bull Lake terrace. Once again there is a stretch of about two miles of canyon where only slight evidence may be had of this level. One mile above Bryan Flat at the end of the canyon another road cut shows talus mixed with gravels and boulders and this exposure farther on down gives a distinct division between the bedrock and gravels just as in the several other cuts farther upstream. It is the Second Bull Lake terrace again, the top of which would be approximately eighty-five feet above the river were the talus removed.

The opening of the canyon out into Bryan Flat presented a problem at first. It was hoped that southern Jackson Hole and Hoback Basin could be linked by means of the terraces through the canyon. It was disappointing therefore to find no levels in Bryaa

Flat that appeared to correlate with those in the canyon. The last remnant of Second Bull Lake, one mile above Bryan Flat, was about seventy-five to eighty feet above the stream. Bryan Flat exhibits a prominent terrace, forty-four feet above stream, which seemed too low to be Second Bull Lake and much too high for Pine-dale. However, the five foot cover of loess on the forty-five foot terrace was diagnostic and the terrace can be called Second Bull Lake without hesitation. The reason for the difference in height of the two remnants of the same age terrace only a mile apart may be that there was a tendency for the alluvial fill to be thicker in the constricted valley of the canyon and thinner when the valley widened out at Bryan Flat. Although the main part of the terrace is only forty-five feet above the Hoback, there is a lens or crescent just twenty feet higher back a short distance from the river edge. And very close to the west side of Beaver Mountain, where it would be protected from the currents of the Hoback by the promontory or nose of Beaver Mountain, there is a third level. This third level is also a crescent close to the west side of Beaver Mountain and rises twenty feet above the first crescent. The highest crescent shaped terrace then is eighty-five feet above the river. The three levels appear to have the same composition--medium sized boulders of granites and sedimentary rocks--and the levels appear to be of nearly the same age for they are all well weathered in place. It is possible that the two lower levels suffered post Bull Lake downcutting while those regions closer to Beaver Mountain were protected. It is noteworthy on the second level that the surface is covered with pebbles about a half inch in diameter and only a few larger rocks are to be seen. Cuts in the level however prove the composition throughout to be a mixture of the larger boulders, ranging up to two feet

in diameter and in general present the same characteristics as the other Bull Lake terraces upstream. It is possible that when the level was reworked and downcut, a decrease in velocity of the river for a relatively long period of time before the lowering of the stream caused this excellent sorting.

The forty-five foot terrace plus the two crescents adding to a total of eighty feet of terrace in Bryan Flat therefore does correlate with the Second Bull Lake terrace remnants in Hoback Canyon. A more thorough study of the terraces in Bryan Flat and tracing the sequence to the Snake River will someday make the picture more complete.

The gradient of the Second Bull Lake stream based on the terrace remnants was pretty even throughout the length of the canyon and was a little over thirty feet per mile. Present gradient for the Hoback in the eight miles of canyon is closer to thirty-five feet per mile (See Fig. 7a).

PINEDALE AND LOWER TERRACES

General description: The Bull Lake glacial advances were accompanied by the period of deposition by meltwater and then followed by a period of erosion (See step 5, Fig. 8). The effects of erosion can be found throughout the basin. It may have been due to a relatively sudden break-through in resistant beds in the canyon of the Hoback, possibly a more widespread rejuvenation due to a lowering of the Snake, or to a decreased load. The advance of Pinedale ice was rather local and of much smaller extent in comparison with those of Bull Lake and Buffalo but nevertheless, the evidences of deposits of the outwash, forming the Pinedale terraces in the Hoback Basin are quite widespread, mainly because deposition was made a relatively short time ago and also there were no later advances of ice to bring about the flow of rapid meltwaters which would tend to erase the evidence.

Upper Hoback River terraces: Starting at the higher reaches of the Hoback River again, the Pinedale terrace is not to be found until about a mile south of Kilgore Creek (See Fig. 2). Here it makes its appearance as a very low surface barely rising above the present floodplain and is found on both sides of the river. Starting at this point, it rises gradually and steadily all the way down the river, represented continuously west of the river and intermittently on the east side until in the vicinity of the highway bridge it is found to be seven to ten feet above the Hoback. The reason that the Pinedale disappears as it is followed upstream may be that its formation is comparable to the growth of a pediment slope. A pediment slope works headward wearing down the rocks

in such a way that the initial slope of the highland remains. The profile shows this to good advantage (See Fig. 7a). In this instance, and the same holds for the present floodplain, it is due to the fact that in the region of the first evidence of the Pinedale terrace in Hoback River, where Kilgore Creek joins the river, there is a relatively sudden change in gradient of the stream. At this place, junction of Kilgore Creek and Hoback River the bedrock on either side of the Hoback River closes in, causing a slight constriction in the valley. This is evident on the maps and may be caused by the presence of resistant bedrock. In the Hoback River above the mouth of Kilgore Creek, there is no evidence of the Pinedale terrace and it may be there were no terraces formed there in that time. The Second Bull Lake level is very much in evidence above the constriction near the mouth of Kilgore Creek and except for the present floodplain, which is quite narrow here, it fills the valley continuously to the region just north of the sawmill where the gradient increases rapidly as the mountains are approached. Profiles (Fig. 7a) show that in Second Bull Lake time, the stream had an even gradient of over sixty-five feet per mile from the sawmill to the bridge while the present stream has a gradient of about sixty-six feet per mile for the first three miles from the sawmill to the beginning of the constriction and the next mile shows a gradient of a hundred feet per mile. Then the stream levels out somewhat with a gradient of close to fifty feet per mile from there to the bridge some three miles below. In Pinedale times, then, conditions were similar to those of the present as far as the stream gradient is concerned and it is only below this constriction or sudden change of gradient that the Pinedale levels are found--and the same will be the case with the floodplain or alluvium being deposited today should the

same sequence of events occur as in Pinedale time.

Fish Creek terrace: Turning once again up Fish Creek, it is found that the Pinedale level is represented pretty continuously throughout the length of the stream and in its smaller tributaries. The first Pinedale level is seen at the National Guard Station, for this is where the stream leaves the higher land near the Rim and flattens out and the valley widens out enough to make room for the terraces. It is twenty feet above the present drainage and is composed of Pass Peak quartzite cobbles that range up to two inches in diameter, with only a scattering of igneous and sedimentary rocks. In a road cut it can be seen that it is a cut terrace with not much over a foot of cobbles lying unconformably on the underlying Pass Peak sandstone. Following the old road, about a quarter of a mile below the Guard Station it is apparent that the terrace has risen with respect to the stream at an even rate to nearly thirty-eight feet above Fish Creek and continues to "rise" gradually as it is followed downstream. Two miles west of the Guard Station along Highway #187, the terrace is fifty feet above the river and a mile farther down, it is more than fifty-two feet above drainage. The composition remains the same as it was near the Guard Station.

In the vicinity of North Fork, the divide between this tributary and Fish Creek was at grade in Pinedale time for the terrace completely encircles the "island" that is an extension of Raspberry Ridge to the north of it (See Fig. 10). Also it was noted that the slope of the island grades more to the lower level (floodplain of today) than to the terrace, which seems to have been plastered against the side of the island. Not enough time has passed since the formation of the terrace to have reduced the hill to a gentle profile where it meets the terrace. Figure 11 is a sketch of the



FIGURE #10

LOOKING DUE WEST ALONG FISH CREEK TOWARD "ISLAND"
SURROUNDED BY PINEDALE TERRACE

HOBACK RANGE IN THE DISTANCE

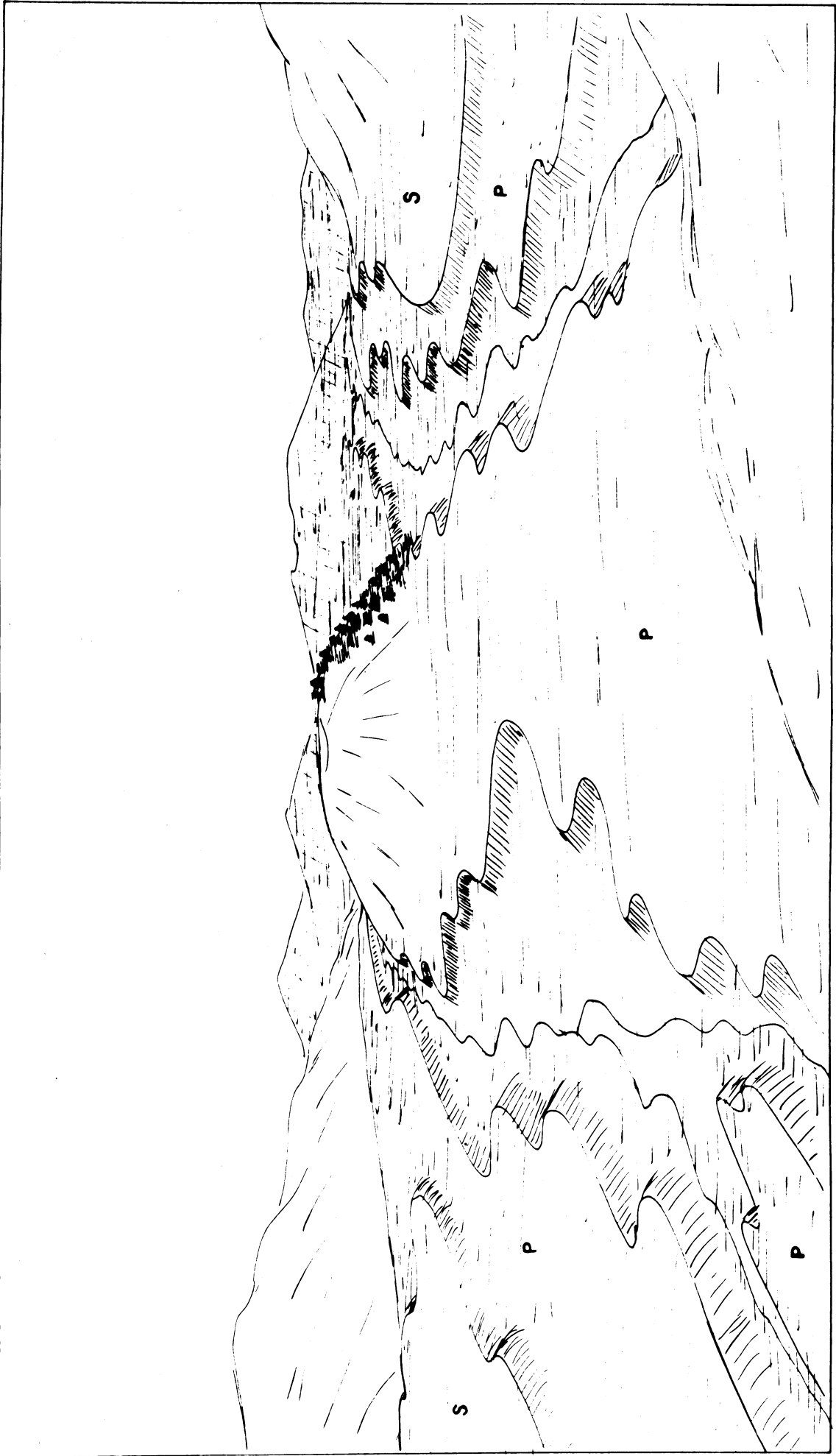


FIGURE #11

area showing the Pinedale terrace (P) surrounding the island. Second Bull Lake terraces are also represented (S).

Where the North Fork joins Fish Creek near Faller's Ranch the terrace is about sixty feet high and it is here where the Pinedale Fish Creek made an abrupt turn to the right or north and followed the now streamless Fish Creek Basin to join the Hoback about three miles north of its present outlet to the Hoback (See Fig. 2). The basin is filled with alluvium which is the same composition as the Pinedale terrace farther upstream, to the height of the Pinedale level. The channel was abandoned soon after the Pinedale deposits were made for there has been no further dissection. The origin of this abandoned basin will be discussed more fully later on. At the mouth of this basin, the Pinedale level is only ten feet above the Hoback.

Returning to the present Fish Creek, just below the entrance to Fish Creek Basin, all trace of the heretofore very prominent Pinedale terrace is lost and no trace of any outwash can be found. The present floodplain occupies the entire valley, which here is rather narrow when compared with Fish Creek Valley above the entrance to Fish Creek Basin. It is apparent that this was an entirely different drainage system before capture came about. About a half mile below the entrance to Fish Creek Basin the valley widens out and there is a basin comparable to Fish Creek Basin which here will be called Little Fish Creek Basin. It is smaller than Fish Creek Basin by half. At its entrance the basin is ~~is~~^{from} ten to twelve feet above present drainage and about a mile and a half beyond, where it opens out onto the Hoback, it is about five feet above the river. Its composition is comparable to that of the Pinedale terraces farther up Fish Creek and since at its mouth it matches the

Pinedale levels of the Hoback, it is believed to be a terrace of the same age, even though at its beginning it cannot be tied in with any other Pinedale terrace. Except for this remnant in the Little Fish Creek Basin, there are no terrace levels to be found along Fish Creek from the entrance of Fish Creek Basin to the Hoback--either of Pinedale or earlier levels.

Continuing down the Hoback, the Pinedale outwash is well represented by an almost continuous terrace. There is a break in its continuity at the entrance to the Upper Hoback River road. Here the river at one time was following the west side of the valley and cut into the terraces at its border and succeeded in carrying away all of the Pinedale at that spot, leaving the Second Bull Lake terrace directly above the modern floodplain. From the break, it can be followed continuously on the west side to the mouth of Dell Creek. It varies greatly in width and is from a half mile wide where the highway traverses its length two miles below Clark Butte to not much more than a few hundred feet wide in the vicinity of Bondurant. There are only four remnants of the Pinedale terrace to be found on the east side of the river from the mouth of Fish Creek to the mouth of Dell Creek. These are at the mouths of Little Fish Creek Basin, and Fish Creek Basin, and there is a long tongue upstream (Hoback) from the mouth of Jack Creek, just across from Bondurant. This tongue is attached to the long narrow highland that separates Jack Creek from the Hoback as they run almost parallel to each other for a distance of close to two miles. This tongue of terrace is duplicated by a very narrow remnant hugging the highland on the north side of the mouth of Jack Creek. It is not over two hundred yards long.

The Pinedale terrace in the basin consists of about eighty-five

percent quartzites of the Pass Peak variety and the remaining fifteen percent are sedimentaries--mainly sandstones of the Hoback formation and Cretaceous sediments. The cobbles range up to six inches in diameter. The gradient of the present stream is over thirty-five feet to the mile and the Pinedale outwash has a gradient of thirty-three feet per mile (See Fig. 7a). Therefore, as expected, Pinedale levels that are seven to ten feet above the Hoback at the mouth of Fish Basin are found to increase steadily in height above the present drainage until at Dell Creek, the terrace is almost twenty-five feet high.

Jack Creek terraces: Jack Creek is almost barren of any terraces, the stream in recent times being most efficient in removing nearly every trace. Were it not for the two well preserved remnants at its mouth and the three exceedingly small remnants found in the seven miles of its length, it would seem altogether possible that the present channel of Jack Creek from the entrance to Jack Creek Basin to the Hoback was via Dell Creek, following Jack Creek Basin, the floor of which is Pinedale outwash entirely. However, the small bits of evidence lead to the belief that during Pinedale time when the level was being formed, Jack Creek possibly occupied both channels, first one then the other, in such a fashion that deposits were being made in both at approximately the same time. Then, at the time the stream was flowing to the Hoback via the present channel, rejuvenation occurred and Jack Creek Basin was left high and dry--its floor of Pinedale fill high above any stream. Also, if it weren't for the presence of Pinedale remnants in the regions of Jack Creek just below the entrance to Jack Creek Basin, the possibility of capture in early post-Pinedale time would

be good, but the Lenore remnants can't be ignored. If it were captured, Pinedale terraces could be present in the former headwaters of the pirate stream but it seems the terraces would have to be at a higher level than the Pinedale terrace of Jack Creek Basin because the profile in the headwaters is relatively steep. As it is, through the length of Jack Creek the Pinedale terrace is found to be over fifteen feet above present drainage. The remnants are quite scattered. The first is almost three miles from the mouth of Jack Creek in the center of the floodplain just south of Bowsby's Ranch. It is a small circular island two hundred feet across. Three miles further upstream on the south side of the creek a narrow lens of Pinedale outwash borders the hills for nearly three-quarters of a mile. A quarter of a mile above this on the south side of the creek, there is another remnant of circumdetritation "island" but this one rises two hundred feet above the floodplain and the terrace is just a narrow bench on its north side and is approximately three hundred yards long. Then, across, the creek, from the entrance to Jack Creek Basin to a spot some two miles further upstream, where the gradient of the creek increases rapidly and no more terraces are to be found, the Pinedale outwash occupies almost the entire valley. Its width is about a half a mile wide in its widest part. Jack Creek Basin, which obviously was formed by the waters of Jack Creek, has a floor of alluvium at the Pinedale level and is almost seventeen feet above the waters of Jack Creek. At its mouth which opens out into the valley occupied by Dell Creek, the floor of the abandoned basin is twenty-five feet above present drainage.

The Pinedale terrace in this area is composed of boulders up to one foot in diameter which are mainly quartzites of the Pass Peak type. There are no granite boulders.

Dell Creek terraces: In Dell Creek no Pinedale levels were noted other than one which is a quarter of a mile upstream from its mouth. This one remnant, several hundred feet wide, hugs the main Dell Creek terrace (Second Bull Lake) and continues for a distance of about a half mile. Figure 12 is a cross-section showing relationship of First Bull Lake, Second Bull Lake and Pinedale terraces to present stream. This Pinedale terrace is twenty-five feet above the creek and is composed of about fifty percent sedimentary rocks and twenty-five percent each of granite and quartzite cobbles and boulders. Why is it that there is only one small remnant of the Pinedale level found in Dell Creek when they are so extensive in every other creek? Perhaps the steepening of gradient above a certain point prevented terraces from being formed. This situation may be comparable to that in the Upper Hoback River where the Pinedale terrace starts just downstream from a constriction in the river but is absent above the narrow part. The profiles (Fig. 7b) indicate that this could have been possible. It has been suggested that during Pinedale times the part of Dell Creek that is above the mouth of Jack Creek Basin was not occupied by any stream due to blocking by moraine somewhere in the vicinity of Bellin's Ranch and that the waters of upper Dell Creek made a detour via Jack Basin and thus into Dell. This seems rather improbable however inasmuch as the divide is at least two hundred feet above the Pinedale level.

Hoback Canyon terraces: From Dell Creek to the canyon there are no remnants of Pinedale outwash and the same is true on down the canyon for some distance, although terraces that range from five to ten feet are plentiful (See Fig. 4). The first true Pinedale is probably the one occurring in the vicinity of Lime Creek

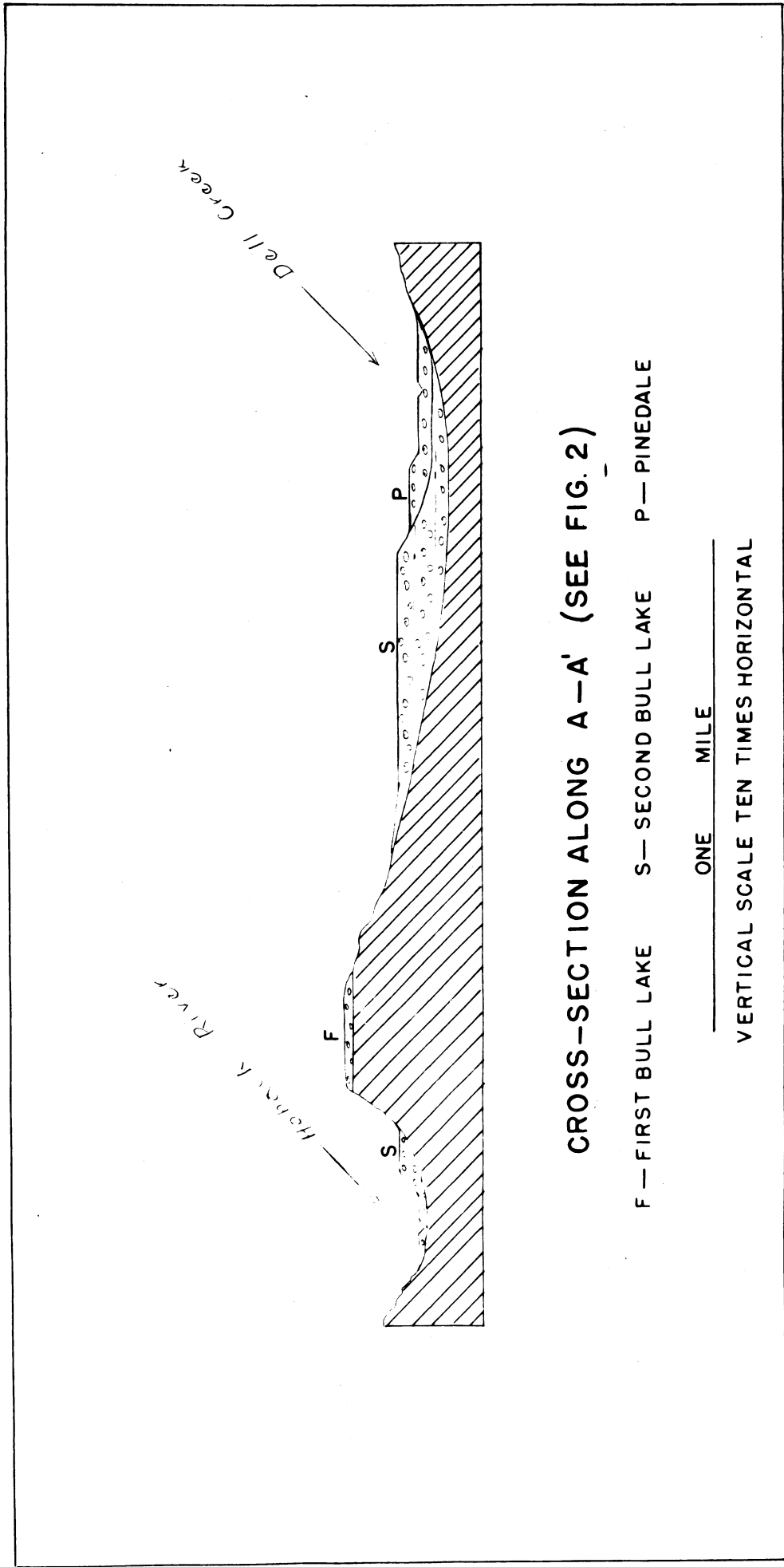


FIGURE # 12

a half mile or so below Granite Creek. Here on the south side of the river, the terrace is twenty-one feet above the river and it contains boulders, mainly sedimentaries, up to two feet in diameter. At Bull Hollow, this terrace rises to over twenty-five feet and is represented by a comparatively wide opening in the canyon which the road traverses. Again the boulders range up to two feet in diameter and are predominately sedimentary rocks. One mile below Bull Hollow on the same side of the river, the Pinedale level rises twenty feet above present drainage, the largest boulders are not much more than a foot in diameter and sedimentary rocks predominate.

At Red Creek, just beneath the Pennsylvanian rocks that have been folded into an asymmetrical anticline, the Pinedale terrace rises fifteen feet above the Hoback. The last remnant of Pinedale terrace in the canyon is located on the north side of the river, opposite Buck Creek and a half mile downstream from the anticline.

A lower level extends throughout the length of the canyon (See Fig. 4). It is lower than the one here called Pinedale. This level is first noticed in the relatively wide opening in the canyon about a half mile upstream from Shoal Creek. It is found to be five to six feet above the river and it carries the highway on its surface for a distance of about a half mile before the hills begin to close in on the canyon near Shoal Creek. The very noticeable level on both sides of the mouth of Shoal Creek is believed to be a continuation of this terrace which here is six to eight feet high. This level isn't found again until Granite Creek is reached, where it makes up the low terrace between the road and the river on the northwest side of the Hoback bridge. Here it is seven feet above the river and since boulders found there range up to five feet in diameter, it may be that this is just the result of reworking and lowering of an older higher level and those boulders too

large to be carried away were left strewn over the surface. Again, at Bull Hollow this appears to be the case and the ten foot level is a crescent bordering the twenty foot terrace of much greater extent in the inside of the bend of the river. The same holds true across from Red Creek. Here there is a narrow lens of level only seven feet above the river backed up by the Pinedale which is fifteen feet high. At the Hoback River Camping Ground, where the canyon widens considerably, the seven foot level is well represented, making up the entire floor of the opening. It may be that this lowest level is just the result of a reworking and lowering of the Pinedale terrace. Since it only found in the canyon and not represented at all in the Hoback Basin or any of its main tributaries, this lower level will not be considered further.

Through the canyon the Pinedale outwash has a gradient of thirty-five feet per mile while the present river flows at a gradient of thirty-three feet per mile.

ABANDONED STREAM CHANNELS AND THEIR RELATION TO GLACIAL STAGES

In connection with the Pinedale outwash several abandoned basins have been mentioned. There are three such features and all three of these may indicate stream capture in one form or another.

The layout of Jack Creek and Jack Creek Basin very strongly suggests a clear cut case of simple capture in post-Pinedale time. A small detail however that causes a confusion in the sequence of events is found. Pinedale terrace makes up the floor of Jack Creek Basin but remnants of the Pinedale level are also in Jack Creek proper between the abandoned channel and the Hoback. This indicates that capture came about in one or the other of two different ways. It is possible that the present Jack Creek, which became the pirate stream, had as its headwaters the stream which enters Jack Creek from the east opposite but just a short distance below the entrance to Jack Creek Basin and was separated by a narrow highland from the stream which occupied Jack Creek Basin and the valley of the present Jack Creek from the abandoned basin to the mountains. These two streams then went about the work of depositing Pinedale gravels independently of one another and, at the close of Pinedale time, capture came about before enough time had passed to entrench the outwash in Jack Creek Basin.

The other possibility is that capture came about in the time just before the Pinedale glaciation or even during its accumulation. When more swiftly flowing and heavily laden streams began issuing from the ice in the higher reaches of the valley, the true piracy was not maintained and water flowed to the Hoback through the old abandoned channel as well as by way of the pirate stream distributing its gravels in both channels at the same time or possibly alternating, flowing first down one then the other.

Then when rejuvenation of the streams in the area came about it happened that the present outlet was being utilized and the stream continued in the channel it now occupies. This rejuvenation must have taken place then soon after the formation of the Lenore level for the gravels in Jack Creek Basin at that level were not cut through by any post-Pinedale stream.

A fact that indicates the improbability of the first sequence of events is that the first Pinedale remnant below the entrance to Jack Creek Basin (less than a quarter of a mile) is the same distance above the stream as the terrace at the entrance to Jack Creek Basin. It seems that the level of this terrace should be somewhat higher than that at the entrance to the basin and the corresponding levels on the other side of the river because of its position higher up on the profile of the stream. The second sequence of events therefore appears to be the most logical.

Abandoned stream channels are also found in the vicinity of the mouth of Fish Creek. These are Fish Creek Basin and Little Fish Creek Basin and their floors are at the level of the Pinedale terrace. In these two instances, it is rather clear that capture occurred soon after the deposition of the Pinedale outwash. During Pinedale time then, Fish Creek found its way to the Hoback via Fish Creek Basin and the smaller stream, whose headwaters still lie about half way between and parallel to Fish Creek and South Fork, followed Little Fish Creek Basin to the Hoback. At this time, a tributary to Little Fish Creek was working headward in the same direction toward Fish Creek and at approximately the same time these headward working tributaries cut through and made their captures.

It may have been that during late Pinedale time, when the rivers were swift flowing but carrying little load, the sharp bend

that Fish Creek was making to enter what is now Fish Creek Basin would have been an area of excessive and rapid erosion, and eventually broke through into the lower and much steeper drainage system of Little Fish Creek. Fish Creek then, for a very short time followed Little Fish Creek to the Hoback. It may have followed this channel for a short time before the above process was repeated and a break-through was made on the outside bend at the entrance of Little Fish Creek Basin causing Fish Creek and the upper part of Little Fish Creek to flow into the drainage system of South Fork and thus into the Hoback as it does today. The periods of time during which Fish Creek flowed through Fish Creek Basin and Little Fish Creek Basin must have been very short for no stream channels were made in the floors of the basins in the Pinedale fill.

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