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FAULTING IN WESTERN IDAHO, AND ITS RELATION TO THE HIGH PLACER DEPOSITS

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Prepared in cooperation with
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ABSTRACT

West-central Idaho was subjected to elevation and to extensive block faulting, probably in Pliocene times. The faults have a prevailing north or northwest trend, show displacements of a few hundred to 3,500 feet, are normal faults, and, with few exceptions, have scarps facing eastward and back slopes dropping westward. Fourteen of these faults are described in some detail. Outside of glaciated areas the scarps are steep, readily recognizable, and the back slopes are only moderately altered by erosion. There is no evidence that a mature erosion surface has been developed since the faulting took place. Such major streams as the South Fork of the Clearwater River and Salmon River are antecedent streams where they cross the faulted area, but many of their tributaries were diverted to the troughs between the faulted blocks, thus accounting for the unusual drainage pattern.

Many of the high placer areas of the region lie in the north trending faulted valleys, and are thus of late Miocene or later age. Three stages of Pleistocene glaciation have been recognized, and ice erosion and deposition has had an important influence upon the distribution of certain placer deposits. Nine distinct types of gold placer deposits have been distinguished, and each of the six placer districts discussed contains from three to seven types of deposits.

INTRODUCTION

For several years past, a study of the mineral resources of west-central Idaho has been in progress as a cooperative project between the Idaho Bureau of Mines and Geology and the U. S. Geological Survey. During those years, a number of mining districts were studied by P. J. Shenon and J. C. Reed, whose attentions were directed mainly to the lode mines and to areal geologic mapping.

This part of Idaho, however, has won its reputation as one of the country's great mining districts largely through its output of placer gold from such notable camps as Pierce, Florence, the Boise Basin, Warren, Newsome, Elk City, and Dixie. Some of these camps were very rich and yielded enormous returns during the Civil War and ensuing years, but most of them were then difficult of access, mining methods were primitive, according to the standards of today, and only the richest ground could be profitably exploited. With the exhaustion of the bonanza ground activity waned and production fell off rapidly. In recent years, however, conditions have changed and placer mining has had a sharp revival. The improvement of such mining machinery as the dredge, the dragline scraper, and the bulldozer have greatly reduced mining costs and have lengthened the mining season by doing away with the need for large quantities of water under head for hydraulic mining and sluicing. In this region the summer rainfall is scant and irregularly distributed. By recirculating the sluice water with pumps the dragline scraper and the dredge can operate in areas where no large water supply is to be had, for they require only a small water supply during the dry summer months when most hydraulic mining is restricted or shut down entirely. Along with lower costs per unit of ground handled by machine mining, the revaluation of gold in terms of the dollar has also greatly increased the area of minable placer ground. These changes too have come at a time when a campaign of road-building in the national forests has made many areas easily accessible that could formerly be reached only over poor trails, so that now heavy machinery and supplies can be hauled into places that earlier were almost inaccessible.

PAST PRODUCTION

Accurate figures of the gold placer production from this region for the period between 1860 and 1900 are not available, and most estimates of gold production for that period fail to separate the placer output from that from lodes. Furthermore, as much of the greater part of the gold was produced in the early period of bonanza mining before accurate records were kept, there will always be a considerable discrepancy between estimates of production made by different persons. The accompanying table, therefore, compiled from a number of sources, makes no claim to greater accuracy than to indicate the order of magnitude of the placer output from this region.

Estimated gold placer production of west-central Idaho

Florence		$ 22,500,000
Elk City		18,500,000
Pierce City		11,000,000
Newsome		2,000,000
Dixie		1,000,000
Warren		18,000,000
Boise Basin		50,000,000+
	Total	$123,000,000+

The changed conditions that have affected placer mining during recent years have already resulted in increased activity in Idaho, and many areas not yet exploited are being prospected, especially those in which there is a large volume of material of relatively low grade that it is hoped can be profitably mined by low cost methods and with skillful management. It, therefore, seemed an opportune time to carry out a broad study of the alluvial deposits of central Idaho, with the hope that an understanding of the geologic and physiographic conditions under which they were formed would help in the discovery and development of other deposits not yet exploited. The physiographic history of this area is highly complex. The logical approach to its solution seemed to be to make detailed studies of certain camps that have been productive in the past, to determine the sequence of events in them, and from the facts so learned to endeavor to reach conclusions as to the history of the region as a whole. Gold placers are the result of the working of physiographic processes upon areas in which gold lodes occur. Without gold lodes no gold placers will result, but the operation of the agencies of weathering, transportation of the detritus so produced, and removal of much of the lighter waste matter and concentration of the heavy minerals are necessary to produce workable placers. Shenon and Reed had already made such detailed studies of the Elk City, Florence, and Warren districts. The writer similarly studied the Dixie district in 1937, and the Secesh Basin in 1938. The following list of publications, while not exhaustive, gives the principal reports that deal with the geology and mining developments in this general area.

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PRESENT INVESTIGATION

During the summers of 1937 and 1938, while engaged in studies in the Dixie district and in the Secesh River Basin, the writer was strongly impressed with the role that faulting and warping have played in determining the stream pattern in west-central Idaho. As will be shown, many stream valleys have a pronounced north-south or northwest-southeast alignment, directions that are not radial from the highlands to the lower surrounding country as one might expect, but that are along the strike of such bedded rocks as are present, and parallel to the mountain front. If it could be shown that this drainage is subsequent to folding and warping, and if the age of that orogeny could be determined, an important step forward would be taken in interpreting the physiographic history of this part of Idaho, and in understanding the origin and age of the high placer deposits. A reconnaissance of the region indicated that the problem could be best approached by a study of the western front of the Rocky Mountains between Grangeville and Boise for there the Columbia River lavas, whose middle or upper Miocene age has been determined from the plant remains of interbedded Latah sediments, lap up against the mountain mass. These lavas serve to indicate the amount of deformation in the region since they were extruded, for in the main their original bedding was approximately horizontal, and their present attitude gives evidence of any deformation they have suffered is post-Latah in age. Farther east the lavas are missing, in part having been removed by erosion. It is unlikely, however, that they ever extended much farther eastward than the line marked by the existing easternmost outlier.

With these facts in mind, it was decided to spend the summer of 1939 in a careful study of a section of the west front of the Clearwater and Salmon mountains in west-central Idaho. The newly completed, though not yet published, Riggins topographic sheet was available in photographic form, and the older Meadows, Squaw Creek, and Garden Valley quadrangle, all on a scale of 1:125,000, also lie in this belt. Considerable areal geologic mapping was done in the Riggins and Meadows quadrangle, not as an end in itself but in order to work out the structural relations and the fault pattern of the region. It is hoped that within the next few years the areal and structural geologic mapping of the Riggins quadrangle can be completed, as this, along with the studies now in progress in the adjacent Seven Devils region, will no doubt reveal many details of structure that have escaped notice in the more general study here described.

GENERAL GEOLOGY

The geology of parts of west-central Idaho has been described in considerable detail by various writers in the publications listed in the bibliography given above, and there follows a brief summary of the principal geologic events that have affected the physiographic history of the region, and, therefore, have a bearing on the distribution and origin of the placer deposits. This summary will serve as a setting for the discussion that follows. The oldest rocks in the region are certain quartzites, argillites, and limestones partly of pre-Cambrian age and partly Paleozoic, but all now so altered that their ages are difficult to determine. In the western part of the region, extending from Grangeville southward through the Seven Devils Mountains, there is also a group of volcanic and sedimentary rocks that have been described as the Seven Devils formation. This group includes tuffs, agglomerates, limestones, and other sedimentary rocks that are, in part at least, of Permian age. These pre-Cambrian and Paleozoic materials were intruded at depth, probably in Cretaceous time, by a tremendous volume of granitic rocks, mainly granodiorite and quartz monzonite, that compose what is now known as the Idaho batholith. These granitic rocks are now the prevailing surface rocks over many thousand square miles of central Idaho. By their intrusion they profoundly altered the sedimentary rocks into which they were injected. Some of the sedimentary rocks were so changed and recrystallized that their sedimentary origin is now almost unrecognizable. Others are less altered and now appear as quartzites, schists, and gneisses. To be sure, some of these changes may be due to metamorphism that took place before the granitic rocks were intruded, for there is evidence that the old sedimentary rocks had been much folded and faulted before the batholith was emplaced, but there is also abundant evidence of metamorphism as the result of its intrusion. After the granitic rocks had solidified, pegmatite dikes were formed in many places, and solutions bearing gold and silica came in from below to form the lodes of the region. Later, dikes of several kinds of igneous rocks cut the altered sedimentary rocks, the rocks of the batholith, and the quartz veins.

After the intrusion of the Idaho batholith, the region was exposed to a long period of erosion that extended through early Tertiary time, during which several thousand feet of material must have been removed from much of the surface of Idaho. This erosion stripped the cover from the batholith over many thousand square miles, and exposed the coarsely crystalline granitic rocks that must have cooled slowly beneath a thick cover.

In early Miocene times there occurred the effusion of large volumes of lavas and of associated fragmental rocks, now known as the Challis volcanics which covered extensive areas in south-central Idaho in Blaine, Lemhi, and Custer counties and extended northward as far as the Thunder Mountain district in Valley County. These Challis volcanics were later deformed and along with the older associated rocks were subjected to erosion which reduced the country to a mature surface of rolling ridges and open valleys, with here and there higher mountain masses that stood well above the prevailing altitude of surrounding ridge tops. This surface was not a peneplain for there always was a relief ranging from a few hundred to a thousand feet or more between valleys and adjacent ridges. At that time the central Idaho mountains probably stood somewhat lower than they do at present.

In Middle or Upper Miocene time the tremendous outpouring of basaltic lavas known as the Columbia River lavas occurred. These lavas have been described at various localities as ranging in age from Eocene to Pliocene, but in the area here concerned they contain interbedded sedimentary rocks that contain the Latah flora, ascribed to the Middle or Upper Miocene. They reached a thickness of several thousand feet in the Snake River basin to the westward, but in the region under consideration the basin in which they accumulated was bordered on the east by the Clearwater and Salmon mountains, and successively younger flows lapped higher and higher against those mountains, apparently up to an altitude of between 5,000 and 6,000 feet. The extreme east margin of the flows in this region reached about to the 116th meridian, or about the longitude of Grangeville and McCall.

As has been stated, sedimentary beds associated with the youngest of the basaltic lavas in this part of Idaho contain Latah fossils, and are, therefore, of Middle or Upper Miocene age. Farther south, however, in the Snake River basin from Boise eastward the extrusion of basaltic lavas continued to a much later date, and the youngest of them, such as those in the Craters of the Moon National Monument, are of recent age and perhaps not more than 1,000 years old.

After the effusion of basaltic lavas in west-central Idaho had ceased, there occurred, probably in Pliocene time, a period of elevation of the Clearwater and Salmon mountains, mainly as a broad domal uplift modified by vigorous block faulting, especially along its western edge. The faults bounding the blocks have a general northerly or northwesterly trend. This faulting dislocated much of the tributary drainage of the Salmon, Snake, and South Fork of the Clearwater rivers, diverting it along the troughs between the tilted blocks, although the major streams were powerful enough to maintain their antecedant courses at least in part. The general elevation of the mountainous region rejuvenated drainage and started the development of the great canyons that are so characteristic along the trunk streams in this part of Idaho. Canyon-deepening continued as the Columbia and Snake rivers cut their trenches into the lava flows of the Columbia Basin and so lowered the base-level of all their tributaries. This process is still active and far from completion.

Except for minor changes the present drainage pattern of the region is believed to have been established by early Pleistocene time. The events of the Pleistocene in this area included several recurring periods of glaciation in the high mountains, although those glaciers were of Alpine type, and nowhere descended to altitudes of much below 5,000 feet. Considerable areas above that altitude remained unglaciated. Moraines of at least three such stages of glaciation have been recognized, the oldest probably of early Pleistocene age, yet even by that stage most of the tributary streams followed valleys that had much the same alignment as they have today. Postglacial erosion has continually deepened the canyons of the main streams, and only small areas now remain unaffected by the present vigorous rejuvenation.

BLOCK FAULTING

In his attempt to work out the physiographic history of this region, the writer has come to the conclusion that block faulting has had a dominant influence in determining the stream pattern. In the following pages he believes that proof of this faulting is given, and that the age of the period of faulting is determined within fairly accurate limits. If these conclusions are accepted, it is possible to date other events, some as antedating the faulting, and others as following it. On the accompanying map (Pl. 1), the known faults in the region are shown, and a discussion of the evidence for each is given in the text.

In a paper published in 1934, A. L. Anderson [1] mapped and described a number of faults in this region that he recognized mainly from physiographic evidence, and properly determined their age as post-Miocene and at least mainly pre-Pleistocene. He also recognized the dominant north-south direction of the faulting, and the fact that in western Idaho all or nearly all of the faults bound tilted blocks whose scarps face east, and whose back slopes are tilted down to the westward. He believed the faulted area of western Idaho to be a northward continuation of the Basin Range faults of the Great Basin. With all of these conclusions the writer is in agreement. There follows a brief description of faults that have been recognized in this area. The number of the fault given in the text is the same as that shown in Plate 1.

1/ Anderson, A. L., A preliminary report on recent block faulting in Idaho: Northwest Science, vol. VIII, pp. 17-28, 1934.

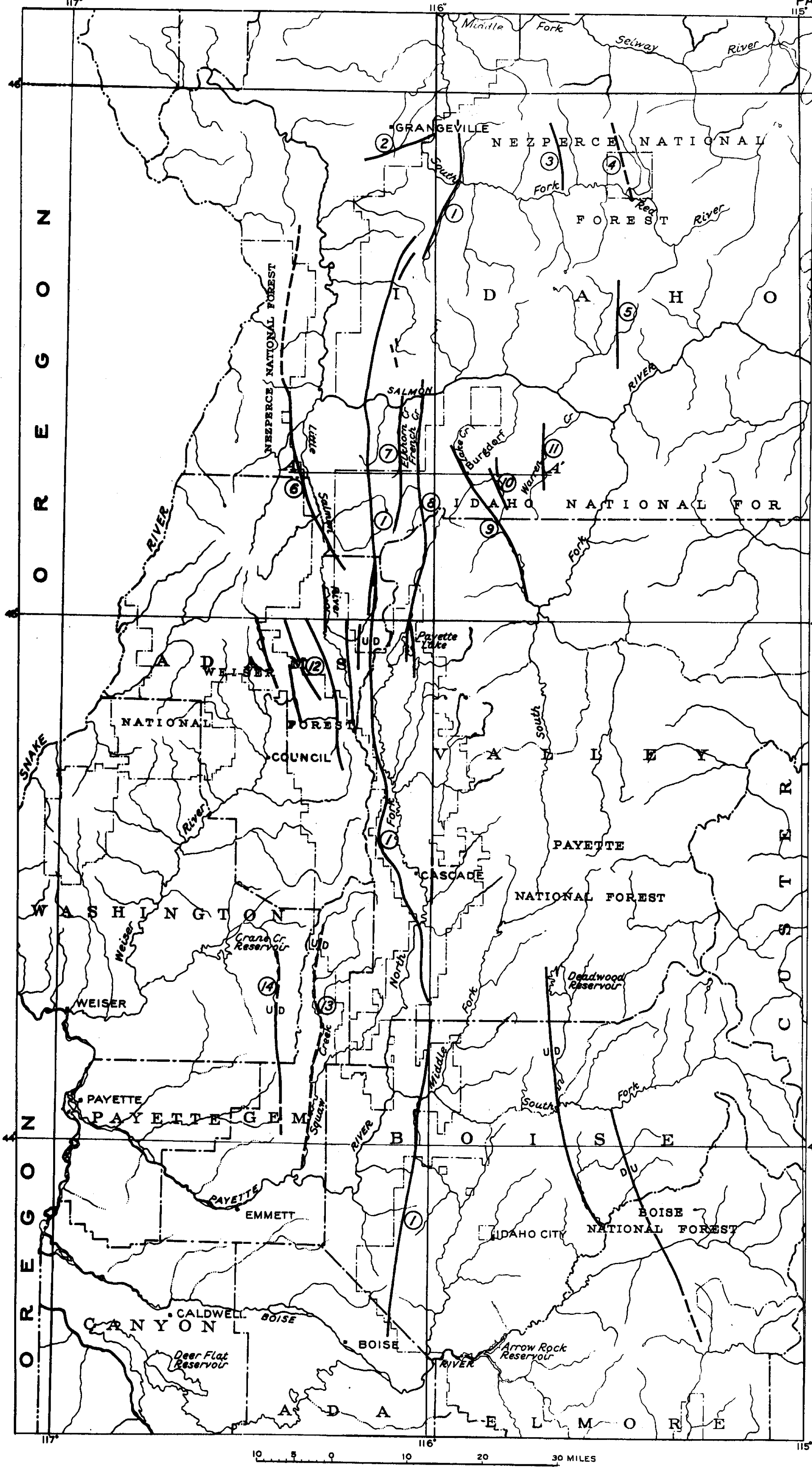
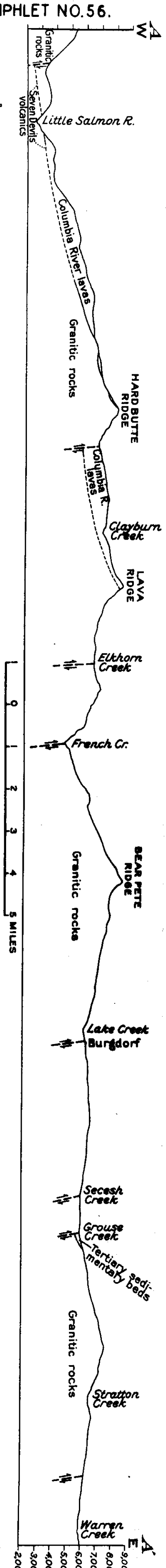


Plate I. Sketch map of west-central Idaho, showing position of the major faults that have been recognized there.



I(a). Diagrammatic cross section of part of Salmon Mountains, west-central Idaho.

Long Valley Fault

The most continuous line of faulting is that extending from a point a few miles east of Grangeville in a southerly direction almost to Boise, a distance of 158 miles, with possibly one or two short interruptions. This fault, for purposes of description, is called the Long Valley fault. Its northernmost part lies along the valleys of Meadows and Mills creeks, where the eastward facing scarp is lava-capped, and where, near the head of Mills Creek, areas of the same lava flows are found east of the fault and several hundred feet lower in altitude. Near the head of Mills Creek there appears to be a break in the continuity of the rift, which, however, again appears about two miles farther west. It continues thence southward across Slate Creek and along the east face of the Slate Point-Nut Basin Ridge, follows Allison Creek to its mouth and crosses Salmon River at Riggins Hot Springs, which no doubt emerge from the fault zone. South of Salmon River the fault follows Warm Springs Creek, passes east of Patrick and Hard buttes where the lava beds are also displaced and dip westward against the granitic rocks of the bordering scarp. From Hard Butte the rift lies along Vance, Goose, and Thorn Creek valleys, and crosses the highway at the mouth of Thorn Creek. From Patrick Butte southward to the lower valley of Goose Creek the region traversed by the fault has been heavily glaciated, and the fault scarp so modified by glacial erosion that it is no longer conspicuous, although the displacement of lava beds and the alignment of the stream valleys attest to its position. At Thorn Creek the displacement of the fault is probably only a few hundred feet, although pre-lava Tertiary sedimentary beds, as well as the lavas, dip westward and terminate abruptly against the fault. In the latitude of McCall also the displacement along the fault is only a few hundred feet, and is insufficient to expose the underlying granitic rocks in the fault scarp, the bed rock on both the upthrow and downthrow sides being basaltic lavas.

From the mouth of Thorn Creek southward, the rift continues as the conspicuous Long Valley fault, which forms the steep escarpment along the west side of Payette Valley and which is probably continuous to the south with the fault that borders Round Valley on the west. In this stretch, the scarp has been little affected by glaciation and is still steep and only slightly modified by streams. The maximum displacement is at least 3,000 feet, the scarp face is composed mainly of granitic rocks, but the scarp is capped by westward dipping lava beds and remnants of the displaced lavas occur in the valley at the foot of the scarp. For a distance of more than 30 miles in Long Valley the drainage divide between Payette River on the east and the Weiser River on the west follows the crest of the scarp at an average distance of less than two miles from the floor of Long Valley. This fault in Long Valley is one of the most conspicuous and easily recognized faults of west-central Idaho. Both the topographic and structural evidences are unmistakable and represent a typical basin-range structure.

This great rift appears to continue southward from Round Valley as the Boise Ridge fault, described by Anderson [1] as displacing an old erosion surface as much as 3,500 feet, and forming typical block mountains with eastward facing scarps and westward dipping back slopes. The connection between the Boise Ridge and the Round Valley faults has not been definitely established, but their alignment, the amount of displacement, and the direction of movement are such as to suggest strongly that they are parts of the same major dislocation.

This great line of faulting is believed to give a clue to the general structure of this part of Idaho. Much of it lies outside of areas of strong Pleistocene glaciation so that the scarps have distinct topographic expression. It is also favorably situated, near the eastern edge of the Columbia River basalts, to

1/ Anderson, A. L., op. cit., p. 23.

show actual displacement of the lavas, with westward dipping lavas east of the fault displaced against much older granitic rocks and with the westward dipping lava flows west of the fault indicating the amount of tilting that the blocks have undergone. In one place also near the mouth of Thorn Creek pre-lava Tertiary sedimentary beds can be seen faulted down against granitic rocks.

Mount Idaho Fault

Reed 1/ has mapped a fault some two miles south of Grangeville that passes through the village of Mount Idaho and forms a scarp on the north face of the Mount Idaho ridge. This fault displaces the Columbia River basalt of Camas Prairie, the corresponding flows appearing at the top of the scarp on Mount Idaho where they overlie rocks of the Seven Devils formation. This fault is unusual in that it has an east-northeast trend whereas most of the faults in this region have northerly or northwest trends.

Newsome Creek Fault

Although no detailed geological work has been done on Newsome Creek, a southward flowing tributary of the South Fork of the Clearwater River in Idaho County, nevertheless a study of the topographic map (Buffalo Hump quadrangle) plainly indicates that a southward trending fault there cuts spurs on the east slope of the Pilot Knob-Reed Mountain ridge with a displacement of as much as 800 feet, and has dropped a series of gravel-covered ridges against an eastward facing scarp.

Elk Basin Fault

Although no fault has actually been traced in the Elk Basin, Shenon and Reed 2/ express the belief that the basin was formed by faulting or warping, and tilted beds of probable Tertiary age, observed by the writer in the Cal-Idaho mine, confirm that conclusion. However, neither the actual position of the fault nor the amount of displacement along it is accurately known.

Dixie Fault

Recent studies in the Dixie placer district 3/, Idaho County, indicate that the upper basin of Crooked Creek lies in a closed structural depression that has resulted from faulting or folding. This depression has a north-south trend, and, although erosion has so modified the slopes that no well defined scarp is now recognizable, nevertheless the closed character of the bedrock basin demands structural deformation and probably faulting.

Little Salmon River Fault

A prominent fault, the course of which has not yet been accurately mapped, lies roughly parallel to the course of the Little Salmon River, and from one to three miles west of it from a point one mile south of the mouth of Hazard Creek to and beyond the latitude of Riggins. East of this fault the Columbia River

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1/Reed, J. C., Unpublished map.

2/Shenon, P. J., and Reed, J. C., Geology and ore deposits of the Elk City, Orogrande, Buffalo Hump, and Tenmile districts, Idaho County, Idaho: U. S. Geol. Survey Circular 9, pp. 22-23, 1934.

3/Capps, S.R., The Dixie placer district, Idaho, with notes on the lode mines by R. J. Roberts: Idaho Bureau of Mines and Geology Pamphlet 48, 1939.

basalts dip rather uniformly westward at angles of 5° to 20°. West of the fault the rocks are in part granitic and in part volcanic rocks of the Seven Devils formation. This fault continues north of Riggins for an unknown distance, but the depression formed by the fault is responsible for the north-south alignment of the Little Salmon River from New Meadows to Riggins, and of the Salmon River from Riggins to Whitebird.

Elkhorn Creek Fault

The Elkhorn Creek fault extends southward from the Salmon River up the valleys of Elkhorn Creek and a tributary of French Creek. This fault is parallel to and five miles east of the Long Valley fault. Its eastward facing scarp is composed of granitic rocks, capped at Hershey Point and on Lava Ridge by westward dipping Columbia River basalts. The dip of these lavas on the back slope of this tilted block is from 12° to 15° west, the same as the average slope of the block itself. This slope continues westward to the Long Valley fault, which again displaces the lava flows. (Pl. 1-A)

French Creek-Payette River Fault

The straight, northward trending valley of French Creek lies along a fault that is roughly parallel to the Elkhorn Creek fault, and two to three miles east of it. This fault follows French Creek southward to Jackson Creek, crosses the divide at the head of Jackson Creek through a conspicuous col, and thence follows the Payette Valley southward to Payette Lake where it disappears beneath the moraines and glacial outwash of Long Valley. From Salmon River to Payette Lake, only granitic rocks are displaced by the fault, but at Payette Lake a remnant of Columbia River basalt lies on the downthrow side of the fault and forms the peninsula that projects into the lake. Apparently this fault splits near its south end, one branch lying along the east shore of Payette Lake and extending southward along the west shore of Little Payette Lake. Like the other faults of this region, the French Creek fault is a normal fault, with the block to the west elevated and tilted westward and the scarp facing eastward, but throughout most of its length this fault trough was occupied by vigorous Pleistocene glaciers and the surface forms have been much modified by glacial scour.

Lake Creek-Secesh Creek Fault

There is considerable evidence that the depression occupied by Lake Creek, and extending southeastward through portions of the valleys of Ruby and Willow Basket creeks and thence down Secesh Creek, is the result of faulting. Parts of this depression have been modified by glacial erosion, but a succession of hot springs on Lake Creek and on Secesh River strengthens the conclusion that it lies along a fault and that the hot springs emerge from a fault rift. This fault has a pronounced northwest trend, and so departs somewhat from the prevalent northerly trend of the other major faults of the region.

Secesh Meadows Faults

The southwest edge of Secesh Meadows, from Grouse Creek to the foot of the meadows, is bordered by a fault, and a branch of this fault is present along lower Grouse Creek. Placer mining operations have disclosed Tertiary sandstones, shales, and lignites to a maximum thickness of more than 600 feet that dip about 25° southwest or west, and that in one place, at least, are cut off abruptly by a fault that places their edges against the scarp of granitic rocks. The main fault has a northwest trend, parallel to the Lake Creek-Secesh River fault, and, like it, the block to the west of the fault is elevated and the scarp, now modified by glacial erosion, faces east.

Warren Creek fault

In his report on the Warren mining district, Reed [1] infers from physiographic evidence that the Warren basin is a structural basin bounded by a northward-trending normal fault on which the east side is the downthrow side. In 1937, the writer was fortunate in visiting the district at a time when stripping operations in advance of dredging had uncovered Tertiary sedimentary beds below bench gravels. These Tertiary beds dip westward and confirm Reed's conclusions both as to the presence of a fault and as to its direction of movement. The exposures referred to have now been covered with tailings from the dredge.

Meadows Faults

In the vicinity of Meadows, in Adams County, seven faults have been traced for distances ranging from 6 to 20 miles each, partly from structural and partly from physiographic evidence. These faults all cut the Columbia River basalts, have displacements ranging from 100 to probably as much as 1,000 feet, and have northward or northwestward trends. All are normal faults and have eastward-facing scarps, and the back slopes of the tilted blocks in a general way conform in declivity to the dip of the lava beds. The depressions between these fault blocks have had a controlling effect upon the stream pattern, and have determined the prevalent northwest or northern trend of many of the streams. These faults occur in a region where the basalt flows have considerable thickness, so that the underlying rocks are not brought to the surface along the scarps of the tilted blocks, and consequently no accurate measure of the amount of displacement along the faults has been obtained. The abundance and the close spacing of faults mapped in the vicinity of Meadows, as compared with other areas along the western front of the mountains between Grangeville and Boise, are quite possibly due to the fact that the Meadows area was more closely studied than other parts of the region. The writer has little doubt that there are many other faults in the region that have so far escaped observation.

Squaw Creek Fault

The north-south alignment of the valley of Squaw Creek, on the Squaw Creek topographic sheet, strongly suggests that the course of this stream has been controlled by faulting. Kirkham [2] considers such a fault probable, although not positively proved, and suggests that it is a normal fault with the block west of Squaw Creek tilted westward and the scarp facing eastward. This direction of strike, and the relations between the blocks to east and west of the fault are of the same habit as that of most of the faults of the region. On the downthrow side of the fault the rocks of the batholith appear in places, but the upthrow side is mainly of basalt. The fault appears to be over 30 miles long, and to have a displacement in places of at least 2,300 feet. The north-south alignment of several headward tributaries of Squaw Creek suggests that there are other similar though less conspicuous faults of the same general type between Squaw Creek and the Long Valley fault to the east.

Big Flat Fault

From 5 to 6 miles west of the Squaw Creek fault, and parallel to it, is another long, north-south depression occupied by Big Willow and Crane creeks. Anderson has called attention to this depression as probably lying along a fault. The topography certainly suggests that the basin is bordered on the west by a fault, with the ridge on the west forming a tilted fault block with an eastward

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1/Reed, J. C., Geology and ore deposits of the Warren mining district, Idaho County, Idaho: Idaho Bureau of Mines and Geology Pamphlet 45, 1937.

2/Kirkham, V. R. D., Igneous geology of southwestern Idaho: Jour. Geol. vol. 39, pp. 573-574, 1931.

facing scarp and a gentle back slope to the west. Kirkham maps this valley as lying entirely within the Columbia River basalt, so apparently the displacement which was probably as much as 1,500 feet in places was not great enough to bring the underlying rocks to the surface in the fault scarp.

Other known faults

Anderson [1] has described two other faults to the southeast of the region here considered as the Deer Park fault and the Deadwood fault, both recognized only by their displacement of an old summit erosion surface. These faults both have a north-northwest trend and the upthrow side of the western or Deadwood fault is on the west, but Anderson says that the block east of the Deer Park fault moved upward in relation to the block west of it.

SIGNIFICANCE OF BELT OF FAULTING HERE OUTLINED

It has been shown from the above description of recognized faults, and in Plate 1A, that the west face of the Salmon and Clearwater mountains of Idaho, from Boise northward to Grangeville, is characterized by a belt of block faulting, the faults having a pronounced northerly trend, and almost all of the blocks having east-facing scarps, and back slopes dipping at moderate angles to the west. The general relationships are shown diagramatically in Plate 1A. In age, the faults are younger than the Columbia River basalts, or,more specifically, are younger than the Latah sediments interbedded with the basalts; therefore, are post-Middle or Upper Miocene. They are also older than the oldest Pleistocene moraines of the region, and these are considered to be of early Pleistocene age. The faulting, therefore, must have occurred in late Miocene or Pliocene times. The faults have been recognized either through their topographic expression, through the recognizable displacement of older erosion surfaces, or through the actual displacement and tilting of beds that were approximately horizontal before they were faulted. These key beds are either the basalt flows of the Columbia River lavas or Tertiary sedimentary formations that are in part older than the lava flows and in part interbedded with them. It will be noted in Plate 1 that most of the faults mapped lie west of the 116th meridian, which passes a few miles east of Grangeville and Boise. It so happens that the meridian also marks roughly the eastern border of the Columbia River lavas. This coincidence of the eastern border of the lavas and of the region of numerous recognized faults is not fortuitous, but is a measure of the importance of the lava beds as a key to the recognition of the presence of faults. The few faults that have been positively identified east of the 116th meridian occur in places where fortunate excavation show the presence of tilted Tertiary beds, where lines of hot springs indicate faults, or where enclosed rock basins or displaced erosion surfaces give convincing evidence that faulting has occurred. It so happens also that much of the region west of the 116th meridian lies outside the area of severe Pleistocene glaciation. Where recurrent Pleistocene glaciers have occupied the high valleys, they have modified the topography of asymmetrical valleys produced by faulting, and imposed upon them a typical glacial topography. In the unglaciated areas, many of the scarps are steep and little modified by erosion, and the back slopes of the tilted blocks in many places still retain the same general slope as that of the lava beds with which they are capped.

It is perhaps to be expected that during a period of mountain growth the borders of a great range like the Rocky Mountains with their resistant core of batholithic materials would yield to stresses more readily than the massif itself, and that faulting would, therefore, be more prevalent along its flanks than in the heart of the range. Yet there is considerable reason to believe that faulting is more common within the heart of the batholith than has heretofore been suspected.

1/ Anderson, A. L., op cit., pp. 22-23.

It is only as the result of detailed studies at Warren, Secesh Basin, and Dixie that definite evidence of faulting has been found at these places. At Newsome Creek a fault has been mapped from evidence that an old erosion surface has been displaced, and Anderson's mapping of the Deer Park and Deadwood faults is on the same sort of evidence. In those areas where no bedded deposits are present to serve as horizon markers, it is difficult to prove the presence of faults, and this is particularly true in the higher parts of the range where glacial erosion has modified the surface forms. In those areas, however, the stream pattern gives clues to the structure that are highly suggestive in conjunction with what is definitely known of the fault habit along the west flank of the mountains; for example, the straight alignment of the South Fork of the Salmon River above the mouth of Secesh River may well be due to a southward continuation of the Secesh fault, and this course is in line with the Deadwood fault. A similar fault may determine the course of the Middle Fork of the Payette River. Johnson Creek, a tributary of the East Fork of the South Fork of the Salmon River also has an alignment that suggests a north-trending fault, and this break may be continued southward along the upper valley of Deadwood Creek. The valleys of headward tributaries of Gold Fork and of Lake Fork Creek, both eastern tributaries of the Payette River, show a north-south orientation that suggests faulting and many more similar examples could be cited. In all of these examples the valleys lie parallel to the axis of the range, and not radially out from it, as might be expected in a mountain mass in which the rocks are of nearly uniformly hardness and resistance to erosion, and in which there is no apparent lithologic control capable of yielding the present unusual stream pattern. The writer is therefore of the opinion that future detailed studies will demonstrate that block faulting of the basin-range type will be found to be prevalent throughout much of the mountain province of central Idaho.

BEARING OF FAULTS UPON THE DISTRIBUTION OF HIGH PLACER DEPOSITS

The distribution and orientation of faults in central Idaho is considered of great importance in an understanding of the distribution of high placer deposits because these faults are believed to have exercised a control over the present position of many placer-bearing valleys. Undoubtedly gold placer deposits have been in process of formation in this region ever since erosion first stripped the cover off of the Idaho batholith and exposed the gold-bearing lodes in it and in the associated host rocks. Those earliest concentrations of placer gold were, however, doubtless attacked by erosion and shifted in position with each lowering of the base-level of erosion, or with each period of folding or faulting that resulted in shifts or changes in the stream pattern. It is quite likely that some of the placer gold that is being mined today was first released from the lodes in early Tertiary times, and has since been shifted in position a number of times before it lodged in the places where it is now found. This process is still in operation, and, as the canyons of the present cycle of erosion work back still farther into the uplands, the gold placers there will be again attacked by streams and the gold redeposited in new and different types of placers.

Little is known about the positions occupied by the stream valleys during early Tertiary times. This region has been a land mass throughout much of Mesozoic and all of Tertiary and Quaternary times, and throughout all of the tens of millions of years that have elapsed since the Idaho batholith was intruded streams have been continuously engaged in carving their valleys and in removing immense amounts of detrital material from the region. Thus, we know that during the first half of the Tertiary, before the effusion of the Challis (Lower Miocene) volcanic rocks, a mature topography was developed in central Idaho, which, however, had locally a relief of at least 1,000 feet. On that surface there must have been a well integrated stream pattern, and in those parts of it where erosion had uncovered croppings of gold-bearing lodes there weredoubtless gold placer deposits in the stream valleys. After the Challis lavas and tuffs had buried large areas of that old erosion surface there followed, in pre-Columbia River basalt (Middle or Upper Miocene) time, a period of folding in the region, and this folding, together with the great fill of volcanic material, must have brought about profound changes in the stream pattern. In places, pre-Challis placers were probably buried, and may be still present beneath the volcanic materials. Elsewhere, beyond the areas in which the Challis materials occurred, this folding doubtless disturbed and shifted many stream courses, and in places the pre-Challis placers may have been reworked and shifted to the newer valleys. The erosion surface developed in post-Challis and pre-Columbia River basalt time is probably the one of which the existing roughly accordant summit ridges of the Clearwater and Salmon mountains are remnants. That surface also apparently was never reduced to peneplanation, and probably always had a maximum relief of 1000 feet or more, although when formed it certainly stood nearer the base-level of erosion of the region than it does now.

There is some evidence that after the post-Challis surface was developed base-level was lowered, probably by an uplift of the region, at least once and possibly twice, and that lower erosion surfaces were developed in places upon it before the effusion of the Columbia River lavas. These lavas originated in the great basin of Oregon and Washington, west of the Rocky Mountains, and as they filled that basin they lapped up higher and higher onto the face of the mountains that bordered the basin toward the east. In the region here under discussion the highest flows spread eastward along the mountain front to about the 116th meridian, but east of that meridian the mountains stood too high to be flooded by the lavas. Whatever placer concentrations there may have been in the region, invaded by the lavas, were buried beneath the basalt flows, and, although no extensive placers so buried have been discovered so far, certain high-bench placers on the South Fork of the Clearwater River may eventually be shown to extend beneath the lava flows. If so, they would thus be proved to be of Miocene age.

As has been shown, the drainage pattern of the region was greatly changed in late Miocene or in Pliocene time by a general elevation of the mountains accompanied by the extensive block faulting to which this part of Idaho was subjected. In this general uplift the east and southeast parts of the region were raised higher than the west and northwest parts, giving a northwest tilt to the old surface so that all the drainage of this part of Idaho flowed westward to the Columbia River. This change of drainage was so complete that little is known about the courses followed by the streams before that uplift and faulting took place. Inasmuch as the Salmon River, in its westward course across the state, traverses directly across the axis of the mountain range and in so doing flows at right angles across some of the faulted blocks, it is presumed that in that stretch the river follows about the same course it had before the faulting and uplift of the mountains took place. It is, therefore, an antecedent stream whose erosive power was sufficient to enable it to cut across the rising mountain mass and the faulted blocks as they arose. The feebler tributary streams, however, were unable to maintain their original courses, and were diverted to the north-trending troughs formed between the tilted fault blocks. It is in such faulted troughs that the placer camps of Dixie, Newsome, Florence, Warren, and Secesh Basin occur, and these placer deposits are therefore no older than late Miocene or Pliocene. In them the placer-forming processes of erosion, removal of rock waste, and concentration of gold have continued to the present time.

CHARACTERISTIC FEATURES OF THE VARIOUS PLACER DEPOSITS

Owing to their mode of origin, the high gold placer districts of west-central Idaho that have been studied in some detail, among which are the Florence, Elk City-Newsome, Dixie, Warren, and Secesh Basin districts, have certain features in common, and there is some evidence that the placers of the Boise Basin also have these features. This discussion is confined to the high placer basins of this general region, and purposely excludes the many bench, terrace, and bar placers that occur in the canyons of the main streams. All these are related to the vicissitudes of canyon-cutting during the present cycle of vigorous rejuvenation of the region, and their study involves many incidents of recent erosional history that are beyond the scope of this paper. Among these common characteristic features of the high placers here considered, the most important is that they occur in the valleys of streams that follow troughs formed by the tilting of fault blocks, and that these troughs formed in late Miocene or Pliocene times have northerly or northwesterly trends. The placer deposits have, therefore, been formed since late Miocene time. In detail, however, each of the various placer districts has individual features peculiar to itself. There follows a brief summary of the conditions encountered in each of a number of these camps.

FLORENCE DISTRICT

As described in some detail by Reed 1/, the Florence placer area lies on a portion of an erosion surface that was developed from 500 to 1,500 feet below the summit level surface, in pre-Columbia River basalt time, and that surface is, therefore, of pre-middle Miocene age. Reed suggests that the Salmon River may at one time have turned northward at about the present location of Florence and joined the South Fork of the Clearwater near Castle Creek Ranger Station, and so developed the Florence surface. The highest flows of the Columbia River lavas covered the Florence surface in places and later the uplift and block faulting of the mountains along the great Long Valley fault tilted the Florence surface to the westward, displacing the lava flows as much as 1,000 feet so that some remnants are now found in the Florence trough, although the corresponding beds cap the fault scarp that bounds the Florence surface on the west. Apparently the crustal movements were completed before Pleistocene times, for early Pleistocene moraines on the Florence surface are undisturbed, and their distribution indicates that the glaciers that deposited them flowed northward across what is now the canyon of upper Slate Creek before that canyon had been excavated. The youngest Wisconsin glaciers pushed down into canyons carved hundreds of feet below the Florence surface.

The placer deposits of Florence are of three types; (1) deposits in weathered bedrock, (2) deposits in older gravel, (3) deposits in younger sediments. These three types may be briefly characterized as follows:

Deposits in weathered bedrock

Long continued weathering of the Florence surface, with only slight dissection by streams brought about deep decomposition and disintegration of the granitic bedrock, and hillside creep and rill wash on the gentle slopes caused the removal of much rock waste, leaving behind a part of the gold that was released from veins within the bedrock. The placers thus formed were essentially residual placers, and the process may have started in Miocene time, and have continued to the present. Locally the bedrock is so intimately cut by gold-bearing quartz veinlets that the residual weathered material was sufficiently rich to mine without further concentration. In places the weathered bedrock was mined to depths of 10 feet or more.

1/ Reed, J. C., Geology and ore deposits of the Florence mining district, Idaho Co., Idaho: Idaho Bur. Min. and Geol. Pamphlet 46, pp. 17, 22-24.

Deposits in older gravel

Within the Florence area there are certain deposits of older gravel that were brought in by streams from outside the district and deposited on the Florence surface. In most places these old gravels, where undisturbed, are too lean to be mined profitably, although one or two small pits have been mined in them. At other places, however, the older gravels have been moved down hill from their original position, and during this transportation some concentration of gold has taken place. In places too pits mined in the older gravels have penetrated into the underlying decomposed bedrock, and this also has yielded some gold. The older gravels have, however, been much less productive than either the weathered bedrock or the younger sediments.

Deposits in younger sediments

During the dissection of the Florence surface by the present streams, gold from weathered bedrock and from the older gravels, as well as a great quantity of waste rock material, has been carried into the newly formed stream channels. Much of this rock waste has been removed entirely from this district, and some of the finer gold has been carried down Meadow and Slate creeks as far as the Salmon River. The greater part of the gold, however, found lodgement in the younger gravels and sands of the present streams, and it is these younger stream gravels that are said to have produced the bulk of the gold from this district. In places exceptionally rich placers in the younger sediments can be traced directly to zones of quartz stringers from which the gold was originally derived.

ELK CREEK AND NEWSOME DISTRICTS

The gold placers of the Elk Creek and Newsome districts have been studied by Shenon and Reed,[1] and the following statement concerning the types of placer deposits there is digested from their report. They consider that both of these basins were formed by the warping or faulting of an old erosion surface, although, in the absence of the Miocene Columbia River lavas in these districts, they did not state the age of that deformation, which resulted in the formation of oval depressions about 8 miles long and 3 miles wide. These depressions were later filled with detritus, probably during the deformation, for only small amounts of lake beds have been observed. The filling is comprised of a variety of materials, including angular gravel, well-sorted gravel, clay, sand, and coal-forming material.

As the basin-filling was derived from a terrane in which there were many gold-bearing quartz veins, much of it also contains gold, although generally in too small amounts to be profitably mined. Locally, however, there was sufficient concentration of gold to encourage placer mining, as at the Montana, Buffalo Hill, Cal-Idaho, and other placers, and these deposits have been referred to as the high-level type of placer.

Another type of placer, called by Shenon and Reed the "reconcentrated type", occurs in places where erosion has removed large quantities of the high-level gravels, leaving behind their contained gold either on the underlying bedrock, or in the stream beds, and so forming the rich "skim diggings" and gulch deposits such as those of French Gulch, Newsome Creek, the lower workings on Pioneer Hill, and Nugget Creek. Placers of this type have yielded by far the largest part of the placer gold from these camps.

1/ Shenon, P. J., and Reed, J. C., Geology and ore deposits of the Elk City, Orogrande, Buffalo Hump, and Tenmile districts, Idaho County, Idaho: U. S. Geol. Survey Circular 9, pp. 22-24, 31-32, 1934.

A third type of placer includes small gravel deposits along streams whose basins contain little or none of the old gravel, but in which auriferous veins in the immediate drainage basins have weathered to yield enough gold to form workable placers. Placers of this kind are referred to as the "recent-stream" type, and include the Simmons placer on Red Horse Creek, and the upper Segal Creek placers.

DIXIE DISTRICT

The Dixie district 1/, like the other districts here described, lies in a basin that has been depressed by faulting or folding below the general level of the much older erosion surface of which it was formerly a part. The depression was filled with locally derived detritus by streams and by hillside creep, and later was partly dissected and much of the fill removed as the canyon of the rejuvenated Crooked Creek worked headward and tapped the basin. In places in the head of the basin, and above the points to which rejuvenation has affected the streams, there are areas of residual placer in which the granitic bedrock is thoroughly decomposed and the only rock fragments are irregular and angular pieces of quartz that have weathered from veins in the bedrock. The removal of the fine weathered granitic material has left a surface concentration of gold from the quartz veins, and formed residual placers, or "skim diggings", some of which are said to have been quite rich. Examples of this type of placer are found in the headward basins of Olive and Fourth of July creeks.

A second type of placer deposit is found in the valleys of the rejuvenated streams which in cutting their canyons have concentrated gold from the residual material on the old erosion surface, as well as some from veins that were intersected by the canyons. These present stream deposits have yielded most of the gold the district has produced, and include the stream gravels of Crooked Creek, and its tributaries, Olive Creek, Hundred Dollar Gulch, Fourth of July Creek, and Dixie and Nugget gulches.

WARREN DISTRICT

The Warren district has been studied in detail by Reed 2/, and the following statement is a summary of his description of the placer deposits. He believes that the Warren basin constitutes a portion of the old erosion surface of the region that was dropped down by a normal fault whose eastward facing scarp forms the western boundary of the basin. This faulting formed a closed rock basin that was first filled with detrital material, and this material was later largely removed by erosion as the rejuvenated canyon of Warren Creek worked headward and tapped the basin. He classifies the unconsolidated deposits as consisting of older gravels composed of landslide material from the fault scarp and of pre-Wisconsin glacial moraine, and of younger gravel that includes bench or terrace gravel, high-meadow gravel, Wisconsin glacial moraines and alluvium of the present streams. All of these deposits contain some gold, and all of them have been mined in places, but the alluvium of the present streams and the bench or terrace gravels have yielded by far the greater part of the gold produced.

An examination of deep cuts on Houston Creek that have been made since Reed's study convinced the writer that large amounts of the "older gravel" are in fact moraines of an early Pleistocene stage of glaciation that was considerably more extensive than the Wisconsin stage. This moraine is now so thoroughly decomposed

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1/Capps, S. R., and Roberts, R. J., The Dixie placer district, Idaho, with notes on the lode mines: Idaho Bur. Mines and Geology Pamphlet 48, pp. 12-25, 1939.
2/Reed, J. C., Geology and ore deposits of the Warren district, Idaho County, Idaho: Idaho Bur. Mines and Geology Pamphlet 45, pp. 10-19, 26-30, 1937.

that most of the granitic boulders disintegrate completely upon mining. This older morainal material contains some gold, especially near its surface, where post-glacial erosion has removed much of the weathered material and affected some concentration of the gold.

The bench or terrace gravels include at least three sets of terraces, the highest of which are as much as 150 feet above their adjacent streams. They represent various episodes in the removal of the alluvial fill from the Warren basin as the young canyon of lower Warren Creek worked headward to tap that basin. The largest deposit of terrace gravels lies along the western side of Warren meadows. It has been extensively mined by hydraulic methods, and in 1939 was being mined by dredge. This terrace has a face that stands about 20 feet above the adjacent stream flat, and slopes up gently to the mountain foot to the west. In the progress of mining the gravels were found locally to lie unconformably upon westward dipping Tertiary sands and clays. These gravels, where dredged, are obviously much older than the present stream gravels, for many of the granitic boulders go to pieces completely as they pass through the dredge trommel, and the tailings piles are, therefore, in sharp contrast to those in the stream flat where the granitic boulders are still firm and fresh.

The high-meadow gravels occur in two meadows at elevations of between 7,000 and 7,500 feet. They are swampy, are covered with peat and appear to be composed of sand with a few fragments of vein quartz and quartz monzonite. They contain some gold, but no attempt has been made to mine them. Their age is uncertain.

Reed describes moraines of Wisconsin age on Steamboat Creek, and states that, although they probably contain some gold, he does not consider them a probable source of any considerable production. The writer visited one small operation on Schissler Creek in which mining was being carried on in a fresh terminal moraine of Wisconsin age, and considerable gold was recovered, although the abundant boulders made mining difficult and expensive.

The occurrence of gold in minable amounts in both the early Pleistocene morainal material and in Wisconsin moraines raises interesting speculations as to the reasons for its presence there. Most gold placers have resulted from the concentration of gold from large quantities of waste material by gravitative selection by streams, the lighter materials being carried away and the heavy gold left behind. No such concentration takes place through ice erosion. It, therefore, seems likely that the concentration took place in the stream valleys in pre-glacial or interglacial times, and that the advancing ice plowed up those concentrations and incorporated them in the moraines, and that, although this resulted in a dispersion of the gold, the resulting moraines were still rich enough to mine.

The alluvial deposits, or gravels of the present stream flats, such as those on Warren, Thomas, Steamboat, and Stratton creeks, all contained placer gold and have been extensively mined. A large proportion of the gold recovered from this district has come from these deposits, and dredging is still actively in progress in the Warren meadows. The present stream gravels range in thickness from 5 to 20 feet or more. Those portions that were not too deep, and in which there was sufficient grade were mined by hydraulic methods, but there remained large areas not adapted to hydraulic mining. Gold dredges were introduced in 1931 to mine the deeper ground, and they also reworked much ground that had already been mined in whole or in part by hydraulic methods. The dredged ground is said to have yielded from 20 to more than 50 cents per cubic yard.

The gold in these stream flats was derived from various sources. All of it had its original bedrock source in veins within this basin, but from these veins it was transported to the glacial moraines, the older gravels, and the terrace deposits, and all of these sources, together with gold directly eroded from the veins, have contributed to the concentration in the present stream flats. The gold now being recovered by the dredges, therefore, represents the produce of several generations of placer concentration, and, unless the natural processes had been interfered with by mining, these placers were on the verge of still another state of reconcentration, as the head of the rejuvenated canyon of Warren Creek is now working headward into the foot of the meadows.

SECESH BASIN

The placer deposits in the basin of Secesh Creek were studied by the writer 1/ in 1938. There the physiographic history of the placers has many similarities to that at Warren, although the district has been much less productive and the proportion of the gold recovered from the various types of deposits is quite different. In the Secesh Basin, the types of placer deposits include early Pleistocene moraines and outwash deposits, interglacial terraces, Wisconsin moraines, Wisconsin outwash, and the alluvium of the present streams. Some single mines have deposits that include placers of two or even three of these types. Although the gold in all of these placers had its original source in veins that were present in this basin, nevertheless the present placers all occur at some distance down valley from the known mineralized areas of bedrock, and a large part of this transportation is believed to have been due to glacial erosion.

The oldest type of placers in the district includes gold contained in glacial moraines of early Pleistocene age, and of reconcentrations on the surface of those moraines by weathering and erosion of the moraines since they were deposited. These placers are characterized by the fact that the boulders encountered in mining are composed almost exclusively of resistant quartzite, the granitic boulders having completely disintegrated. The original morainal character of the deposits can be recognized only when deep, fresh excavations show the ghosts of the granitic boulders, now disintegrated to arkosic sand. In most places only the surface layers of these old moraines, where creep, rill wash, and wind action have affected some concentration of the gold, have been found to be rich enough to be mined profitably. Mining has been done on such deposits at the Lake Creek placer on Lake Creek, at Ruby Meadows, at the Golden Rule placer on Grouse Creek, and on the Gayhart Burns ground on Secesh Creek.

A second type of placer deposit in the Secesh district includes terrace deposits that are associated with early Pleistocene moraines and may be of about the same age. Gravels of this type have been mined at the Three Mile placer on Lake Creek, 2.4 miles north of Burgdorf, where a broad, well defined terrace stands some 30 feet above the level of Lake Creek. The placer excavations show the material to consist of an aggregate of coarse gravel and boulders up to 3 feet in diameter, including mainly granitic, gneissic, schistose, and quartzite boulders. The granitic boulders, and most of those of gneiss and schist, are so decomposed that they disintegrate on mining, and the dumps consist almost exclusively of quartzite. The cuts average about 12 feet deep, and no bedrock is exposed. The deep oxidation and disintegration of the material indicate an early Pleistocene age for the deposit, which may be in part an old moraine, and in part moraine modified by streams and intermingled with glacial outwash gravels.

A third type of placer includes terrace deposits that are of pre-Wisconsin age but are distinctly younger than the earliest Pleistocene deposits described above. These include terraces on Secesh Creek that have been mined at the Thorp property, and on Grouse Creek where a part of the Golden Rule pit is excavated in

1/ Capps, S. R., Gold placers of the Secesh Basin, Idaho County, Idaho: Idaho Bur. Mines and Geology Pamphlet 52, 1940.

them. In these deposits the gravels are oxidized for several feet below the surface, and many of the granitic boulders are sufficiently decomposed so that they disintegrate on exposure in the tailings piles. Nevertheless, many other granitic boulders are still firm, and the depth and degree of weathering are much less than in the early Pleistocene moraines. These terraces are intermediate in age between the earliest recognized moraines and those of Wisconsin age. Attempts have been made to mine these terraces in several places, but the amount of gold recovered from them has not been large.

At one locality, at the Davis Mining Company ground, between Secesh and Ruby creeks, mining has been successfully carried on in morainal material of Wisconsin age. On this ground there are also extensive deposits of early Pleistocene morainal material, and some pre-Wisconsin gravels, as well as present stream deposits, so that the placer ground there comprises gold concentrations of several ages. Recent mining has been confined to a deposit of fresh Wisconsin moraine, beneath which there are in places remnants of pre-Wisconsin gravels. Abundant hard, granitic boulders make mining difficult and expensive, yet the gold content of the moraine, together with gold derived from patches of older, underlying gravel, have encouraged the exploitation of this deposit.

Present stream gravels are present in large volume in places along the valley floor of Lake Creek, in the lower basin of Grouse Creek, in the Secesh Meadows, and in the upper basin of Ruby Creek. In all these places, extensive prospecting has shown the gravels to carry some gold, but the low average gold content of the ground and the flat gradient of the streams have so far prevented any large-scale mining operations. Some of the ground is physically suitable for dredging. The only successful attempts to mine the present stream gravels have been in the lower one and one-half miles of Ruby Creek, but there the gravels lie in a narrow canyon, and were largely worked out many years ago.

The foregoing summary describes the types of placer deposits found in those gold placer camps of west-central Idaho that have been studied in detail. The facts are shown in tabular form herewith.

Table showing types of gold placer deposits in certain districts of west-central Idaho

District	In structural valleys, mainly along normal faults	Residual deposits	Old gravels (age uncertain)	Early Pleistocene Moraines	Early Pleistocene Outwash	Interglacial outwash, or Pleistocene terraces of intermediate age	Late Pleistocene (Wisconsin) Moraines	High Meadow gravels (age uncertain)	Recent stream gravels
Florence	X	X	X						X
Elk City-Newsome	X	X	X						X
Dixie	X	X							X
Warren	X		X	X		X	X	X	X
Secesh Basin	X			X	X	X	X		X

From the foregoing table, it may be seen that only two of the features listed, namely, the occurrence of the placer deposits in structural valleys and the presence of placers in the recent stream gravels, are common to all the districts listed. Conditions are simplest in the Dixie district, which, in addition to present stream placers, has only residual placers. In the Florence and the Elk City-Newsome districts, residual placers, old high gravels, and present stream gravels have all been mined. The most complex set of conditions is found in the Secesh Basin, where five types of placer deposits have been distinguished, and in the Warren district where six types are present. Hasty visits to the placer mining areas of the Boise Basin and at Pierce suggest that these also are structural basins, but more detailed studies will be necessary to classify the placer deposits there.

One purpose of these studies of the placer deposits of west-central Idaho has been to determine the geologic and physiographic conditions that have resulted in the formation of commercially important gold placers there, and on the basis of that information to suggest possibilities for the discovery of other deposits not yet exploited. It is believed that block faulting in the mountains of central Idaho is much more prevalent than has been generally realized, and that there are many important faults that have not yet been mapped. Inasmuch as all of the districts studied lie in depressions formed by block faulting or by warping, it seems likely that other placer deposits may be found in similar depressions. Obviously, however, the presence of faulted basins alone is no assurance that placers exist in all of them. To contain gold placers, such basins must contain mineralized areas in which lodes containing native gold crop out, and those lodes must have been eroded to free the gold and make it available for concentration in placers. Further, the physiographic history of each basin must have been such that the placer gold concentrations have survived to the present time. In many areas of high, rugged mountains there has been a succession of glacial advances throughout Pleistocene times, and the tendency of glaciers is to scatter gold placers rather than to concentrate them. In exceptional circumstances, pre-glacial or interglacial stream concentrations of placer gold may have been so rich that the moraines of glaciers that destroyed the stream placers themselves became rich enough to mine. Only careful prospecting can determine whether any particular moraine is promising. Residual placers may occur at any place when long continued weathering has released the gold from outcropping veins provided that vigorous stream erosion or glacial scour have not removed the liberated gold. Bench and terrace gravels and the gravels of the present streams all offer conditions for the concentration of placer gold if the areas that supplied the detritus to the streams was gold-bearing. After all, there is no substitute for the prospector's pan in the search for placer gold, and even when some gold is found to be present the long-tried methods of test-pitting or of drilling must be relied upon to prove the average gold tenor, character, and quantity of gold-bearing material present before plans can be wisely made to install mining equipment and inaugurate a new enterprise. In recent years, the improvements in mining machinery, the increased price of gold, and the opening of roads to many hitherto inaccessible districts have all tended to reduce the costs of mining per unit of ground, and so have made it possible to mine profitably in ground that a decade ago was considered worthless. There are probably many such deposits of placer ground still left in central Idaho.