UNITED STATES DEPARTMENT OF THE INTERIOR

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RECONNAISSANCE GEOLOGY OF PLACER DEPOSITS CONTAINING RADIOACTIVE MINERALS IN THE BEAR VALLEY DISTRICT, VALLEY COUNTY, IDAHO*

By

J. Hoover Mackin and Dwight L. Schmidt

January 1953

*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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RECONNAISSANCE GEOLOGY OF PLACER DEPOSITS CONTAINING RADIOACTIVE MINERALS IN THE BEAR VALLEY DISTRICT, VALLEY COUNTY, IDAHO

By J. Hoover Mackin and Dwight L. Schmidt

ABSTRACT

A reconnaissance of the Bear Valley district was undertaken to provide a geologic interpretation of placer deposits drilled by the U. S. Bureau of Mines. The placer minerals are monazite and a group of uranium bearing rare earth columbates and tantalates here referred to loosely as radioactive blacks. The monazite is an accessory mineral in the granitic country rock; the radioactive blacks occur in pegmatite dikes. The supply of these minerals to the placers was controlled (1) by the geography of their occurrence in the parent rock, and (2) by the distribution of alpine glaciers during two late Pleistocene glacial stages. By reason of a favorable combination of these factors, the richest placer deposits of the district are in Big Meadow, a valley fill formed as a result of the blocking of Bear Creek by a glacier from a tributary valley during the Illinoian (?) stage. The Big Meadow fill consists of intertonguing depositional units formed by Bear Creek and its tributaries, including both normal alluvium and glacial outwash, and ranging from rich to barren. The richest phase that has been blocked out by drilling was derived from the drainage basin of Casner Creek, an east tributary of Bear Creek. The geologic relations suggest that a neighboring stream, Howard Creek, should have supplied equally rich material, but the part of the valley fill formed by Howard Creek has not been tested. The Howard Creek deposits and shallow alluvium in the upper valleys of Casner and Howard Creeks may considerably increase the reserves of the district.

INTRODUCTION

The Bear Valley district is situated in southwestern Idaho, in the drainage of the Middle Fork of the Salmon River (see fig. 1). The placer deposits were drilled by the U. S. Bureau of Mines in 1951 and 1952 to determine their content of monazite and "radioactive black minerals" (here referred to loosely as "radioactive blacks"). The purpose of the study outlined here was to provide a geologic background for an understanding of the origin and distribution of the placer minerals. Field work was carried on by Mackin and Schmidt working together for about 3 weeks, and Schmidt working alone for about 3 weeks, during August and September 1952.

Because the placer deposits underlie the present valley floors and are exposed only to a depth of a few feet, the geologic field work was chiefly limited (1) to study of the bed rock sources of the placer minerals in inter-stream areas and their occurrence in the channel gravels of tributaries entering the main valleys, and (2) to the mapping of glacial deposits that are closely associated with the placers. About 400 pan concentrates were collected and the amounts of the various placer minerals in each were estimated in the field. These field estimates provide a good general picture of the feed of placer minerals into the main valleys, but the pan concentrates must be studied in the laboratory before the results can be expressed quantitatively. In this preliminary report, the placer mineral content of bed rock and residual soil, morainal materials, and the channel deposits of the present streams, can be discussed only in qualitative terms.

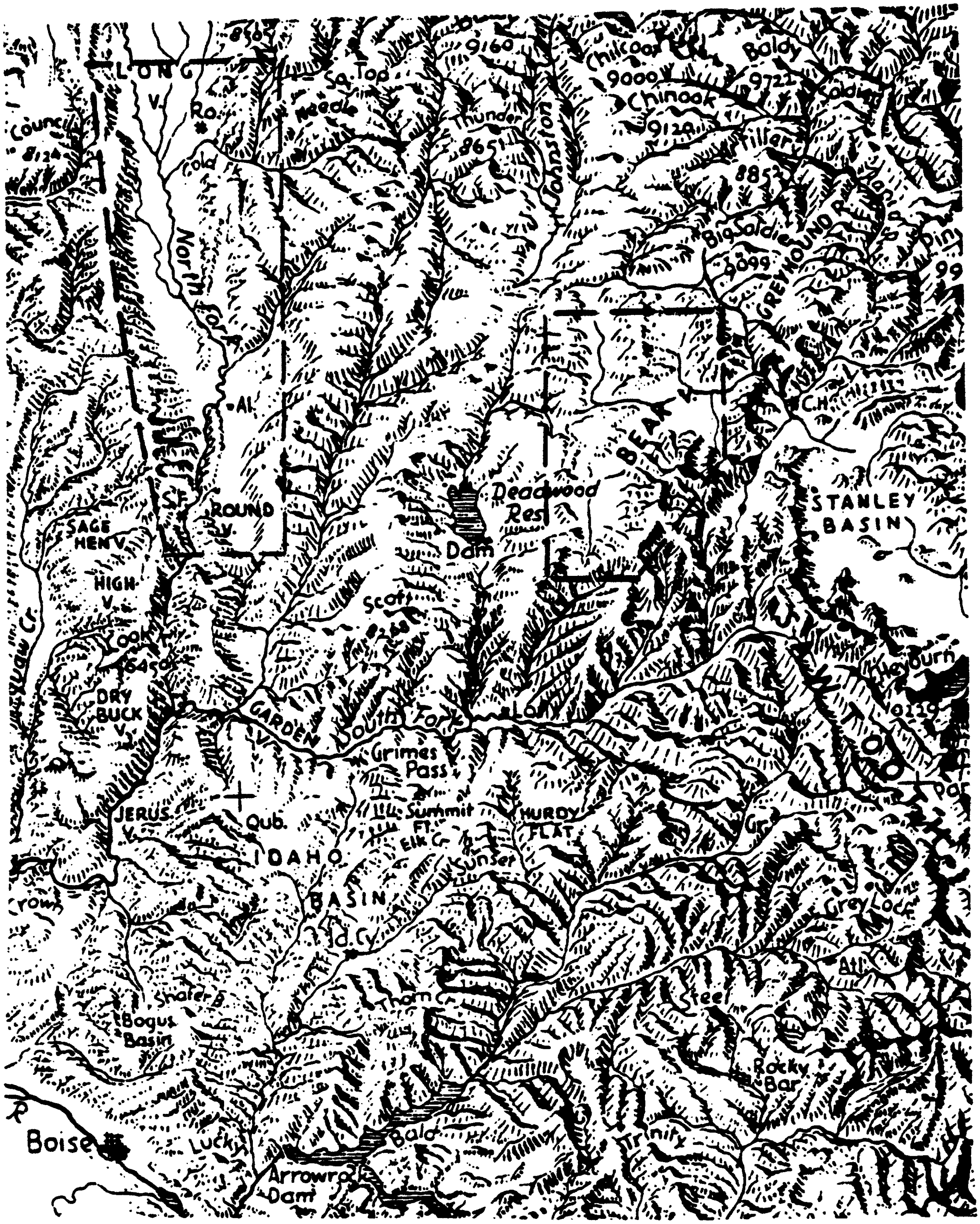

Figure 1. Map showing the general physiographic setting of the Bear Valley District (Raisz, Landforms of the Northwestern States). The east-west dimension is about 65 miles. The Bear Valley and Long Valley districts are bordered by dashed lines in the northeastern and northwestern parts of the map respectively. Bear Valley Creek drains to the northeast via the Middle Fork of the Salmon. The geologic map (fig. 2) covers only the southern part of the Valley (south of the B in Bear). Poker and Bruce Meadows are in the vicinity of V in Bear V. Elk Meadow is west of the R in Bear.

There are three principal broad valley floor areas in the Bear Valley district, (fig. 1): Big Meadow, in the upper part of Bear Valley; Poker, Bruce and other meadows in the lower part of Bear Valley; and Elk Meadow, along a major tributary to Bear Creek on the west. The Bureau's 1951 drilling program was centered in Big Meadow, where 42 holes were drilled in a grid on 500-foot to 2,000-foot centers (fig. 2); 20 holes were scattered along Bear Valley Creek and its tributaries below Big Meadow. During the same season a number of holes were drilled downvalley from Big Meadow by Porter Brothers Dredging Company of Spokane, Wash. During the summer of 1952 Porter Brothers acquired leases on virtually all of the Big Meadow placer ground and, through the claim owners, access to the preliminary results of the Bureau drilling in that area. Additional large samples were taken in 1952 by representatives of the Company for experimental work this winter on methods of recovery of the constituents of the radioactive black minerals. If the results are satisfactory, the Company plans to begin dredging operations in Big Meadow in 1953.

A placer deposit with radioactive blacks and monazite in the Whitehawk Basin, just west of Whitehawk Mountain (fig. 2), was drilled during October 1952, by the Cosumnes Gold Dredging Company of San Francisco, Calif. Plans for development of the property depend on analysis of the samples, now under way.

Field laboratory data, maps and sections for the 1951 Bureau of Mines drilling in Big Meadow, and locations only for the holes drilled by Porter Brothers in 1951 and by the Bureau of 1952, have been made available by R. H. Storch, engineer in charge of the Boise office of the Bureau of Mines.

Because Big Meadow is the only part of the district for which a workable body of subsurface data is at hand, this report will deal with geologic relations in the upper part of Bear Valley, drawing on the remainder of the district only for comparison or contrast as to conditions bearing on the origin of the Big Meadow deposits.

Thanks are due to R. H. Storch, E. J. Carlson, and M. H. Kline, of the Bureau of Mines, for cordial cooperation at every stage of the study. The work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

BED ROCK SOURCE OF THE PLACER MINERALS

Rock types

The geologic map of Idaho (1947) indicates that the Bear Valley district is situated in the central part of the Idaho batholith. Pending study with the microscope, the country rock may be described loosely as including three types; namely, medium-grained and coarse-grained granite and granite porphyry, with all intergradations between them. Pre-batholithic rocks and other metamorphic types are represented only by a few remnants of schist. The granitic rocks are cut by aplite dikes and pegmatite dikes and stringers which make up as much as 5 percent of some large ledge outcrop areas, as in the cirque walls around the north side of Whitehawk Mountain (fig. 2). The field relations indicate that the pegmatites and aplites are close together in age, and that both were formed during or shortly after the consolidation of the granitic rock. A distinctly later system of porphyry dikes, ranging from acidic to basic in composition, occurs throughout the district. Crosscutting relationships in a typical porphyry dike swarm are well exposed in cirque walls on the north side of Red Mountain (fig. 2).

Monazite

On the basis of examination of pan concentrates from weathered phases of the various rock types it is evident that the monazite occurs as an accessory mineral in the granitic country rock, and that its distribution is not related to the distribution of pegmatites and aplites, nor to the later porphyry dikes. In general, monazite favors the coarser-grained porphyritic granites as opposed to the medium-grained types, but it may or may not occur in either. We have not been able to develop reliable field criteria for distinguishing between monazite-bearing and monazite-free granite; hence the distribution of the monazite must be "mapped with the pan". This makes for slow progress because the samples must be carried from the uplands to water for concentration; the samples taken to date are much too widely scattered to serve as a basis for a map showing the content of monazite in the granite. For purposes of this report it can only be stated that the distribution is erratic, that the monazite content of disintegrated granite and residual soil in the richer areas in Bear Valley does not approach that of the richer areas in Long Valley (see TEM-473), and that the overall monazite content of the granite in the Bear Valley district is much less than in the Long Valley district. It is unlikely that even the best placer ground in the Bear Valley district could be worked for monazite alone.

Radioactive blacks

Some pan concentrates from Bear Valley contain a group of dark minerals distinctly different from the common black heavies. In pans of residual soil on the outcrop of the parent rock these minerals are tabular and prismatic crystals as much as 1 cm in greatest dimension. The most common type is characterized by an irregular, criss-cross crack pattern on the crystal faces, a glassy conchoidal fracture, and high Geiger counter readings. These properties, and a statement by E. J. Carlson to the effect that samarskite and euxsenite have been identified in the Bureau of Mines drill hole samples, suggest that the minerals are members of the series of uranium-bearing rare earth columbates and tantalates. Because we have no chemical analyses, and only a field inspection knowledge of the physical properties, the actual identity of the minerals is not known, and it seems best to refer to them loosely as "radioactive blacks".

The radioactive blacks are rare or absent in most parts of the district. In the few areas where they have been found in relative abundance they occur in the weathered mantle in association with pegmatite float. Residual soil in the richest area known, in the Casner and Howard Creek drainage basins (figs. 2 and 3), contains as much as 1 pound of radioactive black minerals per cubic yard. Stream bed materials from the same area consist largely of pegmatite debris and contain as much as 4 pounds of radioactive blacks per cubic yard, but of a large number of pegmatite specimens examined, only four included one or more radioactive black crystals. It appears that the radioactive blacks originate in pegmatite as opposed to the granitic country rock or the other dike rocks, and that their relative abundance in the soil is the result of a weathering concentration from very lean parent material.

Figure 3, Air photo of the Big Meadow area.

Bear Creek flows northward to the north end of Big Meadow, and thence northeastward thru a narrow (post-Illinoian) valley to the northeast corner of the photo. The curving ridges west of the central part of the meadow are Wisconsin moraines; the lower ridges at the north end are Illinoian moraines and bed rock (see geologic map). The white line in the southwestern part of the photo is the road to the Whitehawk Mountain lookout. The embayment on the east side of the meadow, opposite the Whitehawk road, is the fan of Casmer Creek. Howard Creek is the large tributary entering the narrow part of the meadow from the east near the southern border of the photo.

On the other hand, many areas of pegmatite float and outcrop yield no radioactive blacks. The implication is that their occurrence is limited to a certain special type of pegmatite dike differing from other pegmatite dikes in the same area, or perhaps that they occur in all of the pegmatite dikes in certain restricted areas. Which of these hypotheses is correct is not known (1) because it is difficult to associate the disaggregated radioactive blacks in the mantle with individual dikes; (2) because of the comparative rarity of radioactive blacks in the pegmatite matrix, even in the richest areas; and (3) because there is no clearly defined difference in mineral associations or structural characteristics between pegmatite dikes that contain radioactive blacks and those that do not. More work in detail, including trenching of the soil cover, close sampling, and use of better radiometric equipment will be needed if these details of mode of occurrence of the radioactive black minerals are to be worked out.

For present purposes it is sufficient to know that the radioactive blacks in the Big Meadow deposit were derived from a poorly defined belt trending westerly across the southern part of Big Meadow, with by far the richest feed from the drainage of Casner and Howard Creeks. Reconnaissance panning indicates that the Whitehawk Basin may be fed from another "hot spot" along the same general belt.

PLEISTOCENE DRAINAGE CHANGES

The glacial deposits

The Bear Valley district was occupied in part by alpine glaciers during two late Pleistocene stage. ./ As a rule, early Pleistocene glaciers were much more extensive than those of the late Pleistocene in the Northern Rockies, but no evidence of early Pleistocene glaciation has been found as yet in the Bear Valley district. In so far as the geology of the placer deposits is concerned, the deeply weathered areas beyond the limits of the late Pleistocene ice tongues may be considered to be non-glaciated.

The deposits of the younger of the two late Pleistocene stages are little modified by weathering and erosion. Hummocky terminal moraines and boulder-strewn lateral morainal ridges as much as several hundred feet in height define clearly the maximum extent of the ice; two to four minor morainal loops mark pauses in retreat or re-advances of each glacier. Closed depressions, some of which are occupied by lakes, are characteristic features. While there may be a question as to substage assignment, these moraines are certainly Wisconsin in age (fig. 2).

In marked contrast, the depositional topography of the older of the late Pleistocene moraines has been so greatly modified by erosion that they cannot be recognized as such on the basis of form. Closed depressions have been filled or drained. Of the original morainal boulders, only the most resistant ones of dike rocks survive as surface boulders. Because the topography on the older deposits blends with that of the non-glaciated areas, the maximum extent to the glaciers may have been somewhat greater than is indicated on figure 2. In degree of weathering and erosion, these deposits are comparable with those of the Illinoian, or perhaps the Iowan or Tazewell substages of the Wisconsin, in the Midwest; they are designated on figure 2 as Illinoian (?).

Origin of Big Meadow

Distribution of cirques indicates that the ice accumulation was limited chiefly to the northern and northeastern sides of the higher peaks, generally above 8,000 feet. The longest Wisconsin ice tongue originated in a large cirque area on the north side of Red Mountain and flowed northward down the valley of Cache Creek for about 5 miles, terminating about a mile short of Bear Creek (fig. 2). The Illinoian Cache Creek glacier was much larger, spreading westward into the valley of Mase Creek, and advancing to the present position of Bear Creek along a wide front. The relations suggest that Bear Creek assumed its present position in this area along the terminus of the Cache Creek glacier. There is no direct evidence as to whether the pre-Illinoian valley lay to the southeast, or to the northwest, with the stream flowing via the present Bearskin Valley to Elk Creek. (See possible axes of the pre-Illinoian valley, fig. 2.) In the former case the valley was blocked and buried by the Cache Creek glacier, and in the latter case by the Bearskin glacier.

Wisconsin glaciers from composite cirques on the east side of Whitehawk Mountain advanced in several tongues to the west border of Big Meadow but did not enter the valley floor. Several lines of evidence indicate that an Illinoian tongue from the Whitehawk divide blocked the original valley of Bear Creek at the north of Big Meadow and diverted the stream eastward to its present narrow valley. The approximate position of the axis of the filled valley at the point of diversion is indicated on the geologic map.

Because the divide at the head of Bear Creek (Bear Creek–Clear Creek divide, fig. 2) was low, Bear Creek itself had no headwater glaciers and there was no trunk glacier in upper Bear Valley. Big Meadow is a segment of the upper valley, filled with alluvium more than 100 feet thick as a result of blocking of the main stream by an ice tongue from the Whitehawk divide. The relationships are not self-evident because the drainage changes are Illinoian in age, and the Illinoian moraines are so deeply eroded that they are not readily distinguishable from topography developed on bed rock.

The northeasterly trending (post-Illinoian) segment of the Bear Valley is narrow compared with the Big Meadow segment and the broad meadow areas of the lower valley. The stream is meandering on a valley floor and the valley sides are graded with respect to it; the narrow valley segment is, in other words, wholly unlike the gorges usually associated with Wisconsin drainage changes. The valley floor alluvium is shallow, but thick fills may be expected at points where the present valley crosses pre-Illinoian drainage lines.

EFFECTS OF GLACIATION ON THE SUPPLY OF PLACER MINERALS

Disintegration of the matrix

The effects of glaciation on the supply of placer minerals, at the source, is most clearly brought out by contrasts between areas of Wisconsin glaciation and the non-glaciated areas. In the latter the granitic country rock on interfluves is disintegrated to depths ranging from a few feet to several tens of feet, depending on slope and other factors. The stream bed materials consist of pegmatite debris, aplite and porphyry dike rocks; the granite that makes up perhaps 99 percent of the drainage basin is represented only by coarse sand. In areas of Wisconsin glacial erosion the granite is only slightly or moderately disintegrated to shallow depths; granite pebbles are overwhelmingly dominant in Wisconsin moraines and outwash gravel. Evidently the granite does not survive the slow passage through the zone of weathering and creep in the normal lowering of interstream areas; it is supplied to streams as sound rock only when it is forcibly plucked from ledges by glacial action. The relationship is so consistent that it may be taken as a rule of thumb that gravel consisting dominantly of granite pebbles is glacial outwash.

Granitic rock in Illinoian moraines and outwash is generally disintegrated at the surface, but the degree and depth of weathering, while more advanced than in the Wisconsin deposits, is very much less than in the nonglaciated areas.

As might be expected, the thoroughly disintegrated granite, in place, consistently yields larger pan concentrates than the Illinoian glacial deposits and these, in turn, yield larger concentrates than the Wisconsin glacial deposits. Because the heavy mineral content of the bed rock varies considerably, a few samples would mean little; it is the consistency of the relationship in many samples from all parts of the district that is significant. In view of this relationship it is clearly not coincidental that the areas in which the placer mineral content of the bed rock that yielded a high concentrate are limited to the nonglaciated parts of the district—areas of correspondingly high values in the bed rock could not be distinguished as such by ordinary panning methods in the glaciated areas. The same lack of freeing of the minerals from the matrix that prevents their concentration in the pan also prevents their concentration in the stream beds; a good supply of the placer minerals requires, not only the presence of the minerals in the rock, but also thorough disintegration to make them available for concentration. The distribution of late Pleistocene glaciers thus ranks with the distribution of values in the bed rock as a controlling factor in the localization of the placer deposits.

Eluvial enrichment

In a few suites of samples taken at various depths in vertical cuts in weathered granite the placer mineral values are highest at the grass roots and decrease downward. Because all of the granite in these suites is thoroughly disintegrated, some factor other than the freeing of the minerals from the rock matrix must be involved. The relationship is taken to mean that there is a concentration of the placer minerals at and near the surface as a result of decomposition of feldspars and ferromagnesian silicates, and selective removal of the decomposition products in solution, by downward movement of colloids, and by rain wash.

This type of eluvial enrichment, which depends on chemical decomposition, is much slower than mechanical disintegration. None was found and none is to be expected in the Wisconsin deposits, where the granite is generally sound. Even in the Illinoian deposits, where the granite is more or less completely disintegrated near the surface, there is little eluvial concentration of the placer minerals at the grass roots. Strong eluvial enrichment by selective weathering and removal is essentially limited to the nonglaciated areas.

Concentration of durable minerals in the zone of weathering on a given hill slope does not mean that there is no erosional removal of these minerals as the slope is lowered; it means only that the durable minerals are removed at a slower rate than the other constituents of the mantle. Theoretically, the ideal conditions for a rich supply of placer minerals are (1) a long period of slope lowering accompanied by eluvial enrichment, followed by (2), a change in any of the factors controlling slope development, of such nature as to accelerate the movement of the weathered mantle to the streams.

These theoretical considerations bear directly on the origin of the Big Meadow deposits. As indicated earlier, the greater part of the Big Meadow fill was deposited as a result of the blocking of Bear Creek by Illinoian ice; the fill is therefore largely Illinoian in age. Several lines of evidence indicate that the pre-Illinoian period of erosion under "normal" climatic conditions was enormously longer than all of post-Illinoian time. In the parts of the district that were occupied by Illinoian ice the enriched mantle formed during this long period was removed by glacial erosion that scoured deeply into fresh bed rock, that is, under conditions unfavorable for stream concentration of placer minerals. (See below.) It is virtually certain on the basis of studies elsewhere that the effect of Illinoian glacial climates, beyond the limits of the ice, must have been a quickening of downslope mass movement of the weathered mantle, particularly by solifluction. It therefore seems likely that the placer minerals in the Big Meadow fill were not merely supplied by weathering and erosion concurrent with their deposition; they were probably drawn from a reserve in an enriched mantle of pre-Illinoian age, delivered to the streams at an accelerated rate under Illinoian periglacial climatic conditions.

Concentration in graded and aggrading streams

Concentration of placer minerals in stream beds is effected largely by scouring and redeposition of the channel materials during annual fluctuations of discharge, each time with some winnowing out of the lighter fractions of the bed load. In adjusted streams that are neither aggrading nor degrading, this sorting process, repeated annually over a long period of time, may develop bed concentrates far richer than the average of the load supplied annually from the drainage basin. In the aggrading stream, on the other hand, this type of sorting is less effective because some part of each year's load is "permanently" deposited in the accumulating fill, where it is not subject to reworking. As the amount of material "permanently" deposited in a given segment per year approaches the amount of material shed into that segment per year from the local valley sides or from the next upvalley segment, the sorting approaches zero. The degree of concentration of placer minerals in stream beds is inversely proportionate to the rate of aggradation.

Relations in the major depositional basins

Other things being equal, the placer values in a given stream deposit in the Bear Valley district vary directly with the degree of disagregation of the placer minerals from the rock matrix, directly with the extent of eluvial enrichment of the weathered mantle by selective decomposition and washing, and inversely with the rate of aggradation. The principal "other thing" is the bed rock content of placer minerals; local variations in values in the bed rock can be mapped in the non-glaciated areas, but the bed rock values cannot be determined by ordinary panning methods in the glaciated areas. On the basis of various combinations of these factors, the stream deposits range all the way from those that are virtually barren to those with the high values.

The Elk Meadow deposits consist chiefly of an aggradational fill of granite pebble outwash from large glaciers in the Bearskin and Porter Creek drainages. Bed rock values are poor in the parts of the Elk Creek drainage basin that escaped glaciation. The placer minerals are rare even in the channel materials of stable streams now engaged in reworking the Wisconsin aggradational fill. There are no drilling data.

The deposits of the lower Bear Valley meadow areas include phases from several sources, formed at different times and under different conditions. For the most part, the deposits are aggradational fills of outwash gravel from glaciers that converged on Bear Creek from the east and west below Big Meadow and from ice tongues that occupied the valleys of Pole, Wyoming, Cold, and Fir Creeks. So far as is known, there are no bed rock sources for radioactive blacks in the local drainage, but it is possible that some exist in the areas of glacial erosion and deposition. There is at least one general source (upper Bear Valley) and it is likely that pre-Illinoian deposits of Bear Creek may carry fair values. The more or less randomly placed drill holes show a wide variation in placer mineral content, but the tenor is said to be generally low. It is possible that an analysis of the drilling data, when it is available, may lead to discovery of additional deposits.

Because the minor drainage basins tributary to Big Meadow on the east and south were not glaciated, and because the bed rock content of the placer minerals is high in some of the drainages, Big Meadow includes the best placer ground in the district. The fill consists of intertonguing deposits of the main and side streams, formed at different times and under different conditions for placer mineral concentration. The relationships outlined above provide a basis for an interpretation of the distribution of values revealed by the Bureau of Mines drilling.

DISTRIBUTION OF PLACER VALUES IN BIG MEADOW

Source and limitations of the drilling data

Field and laboratory procedures in use by the Bureau of Mines have been described fully by M. H. Kline (Evaluation of monazite placer deposits, RMO - 908, 1952); they are outlined here only to the extent necessary to explain the meaning of the graphs in the accompanying sections (figs. 4 and 5).

The churn drill cuttings are dried and screened in the field and the weight of the plus 1/8 fraction, estimated percentages of boulders, gravel, sand, and clay, and other data, are logged at 5 foot intervals. The minus 1/8 fraction of each five-foot sample is bagged for study in the Boise field laboratory.

In the field laboratory the samples are screened and the minus 1/8--plus 1/16 fraction is weighed, checked with a Geiger counter, and discarded if not radioactive. The minus 1/16 is tabled and the weight of the heavy mineral concentrate is recorded. Magnetite is removed from a 10-gram split of the concentrate, and the percentage weights of ilmenite, garnet, zircon, and monazite are estimated under a binocular microscope. On the basis of this visual estimate, the amount of monazite in pounds per cubic yard is calculated. The monazite values so determined have been plotted to the left of each drill hole in the sections (figs. 4 and 5).

The radioactivity of the concentrate is then determined with a Geiger counter; and, on the basis of comparison with the radioactivity of a corresponding volume of pure monazite from the same district, the amount of monazite that would be equivalent to the radiometric count is calculated and recorded in the logs as "equivalent monazite", expressed in pounds per cubic

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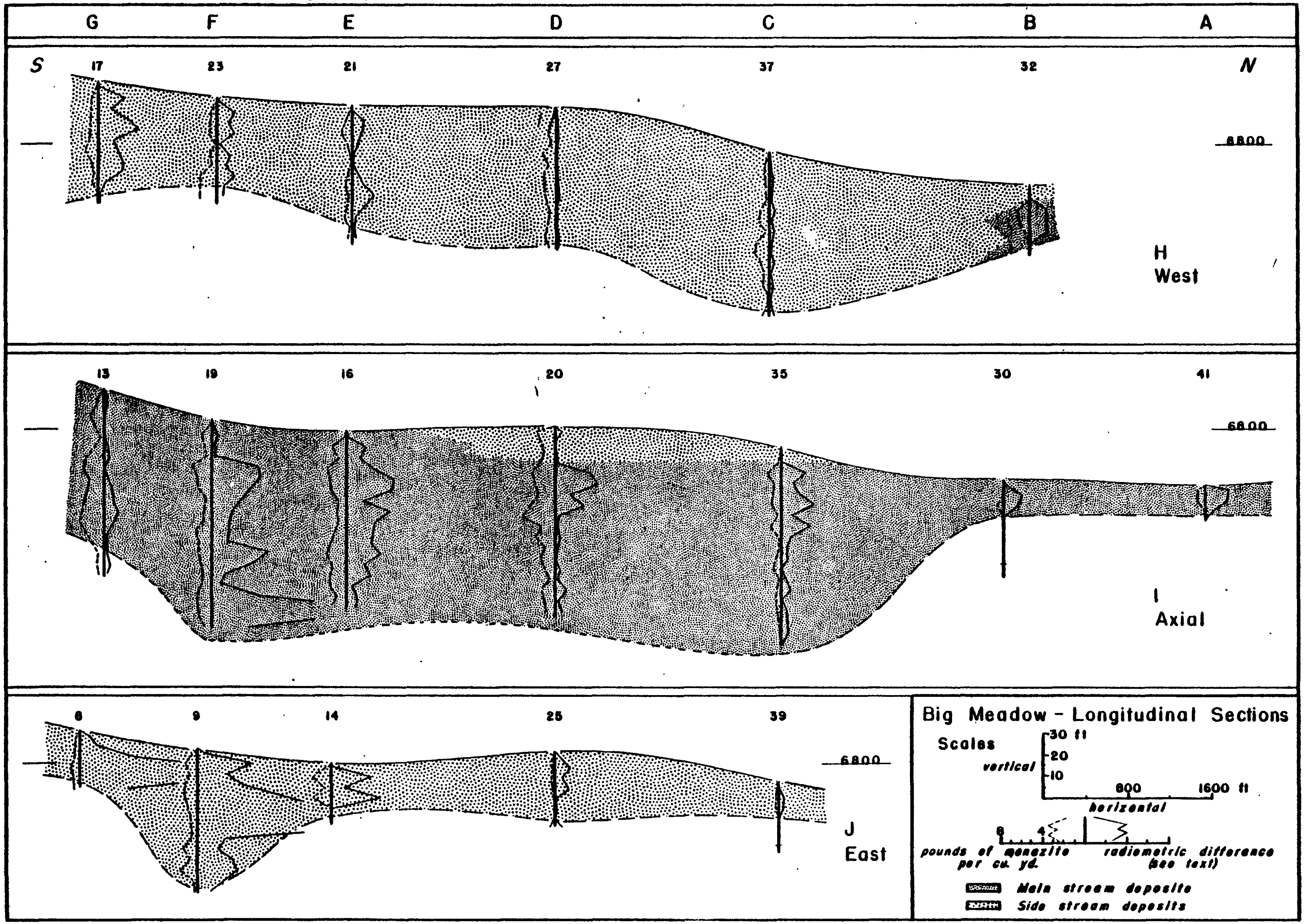

FIGURE 5

yard. The difference between the amount of monazite determined visually in the sample and the "equivalent monazite" is presumably due to the presence of other radioactive minerals. This figure, which we call the "radiometric difference" for lack of a better term, is plotted to the right of each drill hole in the sections on the same scale as that used for monazite.

It should be noted that because most of the radioactive blacks in Bear Valley contain uranium and give higher readings than an equal weight of monazite, the "radiometric difference" is not in any sense a direct measure of the amount of radioactive blacks in the concentrates. It is simply a figure that may be, under favorable circumstances, roughly proportional to the amount of radioactive blacks.

Because this group of minerals, as loosely defined here, includes some species (as columbite) which are not radioactive, and because there is a wide range in the uranium and thorium content of other members of the group, the "radiometric difference" is not necessarily proportional to the amount of radioactive blacks in the samples. There would be a direct relationship in a given deposit only if it were established by mineralogic work and chemical analyses that each of the several streams that contributed to the deposit carried the same relative quantities of the same mineral types. If, for example, the feed from one stream carried an exceptionally high percentage of columbite, the relative abundance of columbite in the part of the placer deposit would not be expressed by the "radiometric difference" in the graphs.

The actual value of the placer deposits depends, not on the amount of the radioactive black minerals, but on the metals that can be extracted from them at a profit. Within the limits of accuracy of the sampling and field laboratory procedures, the radiometric difference provides a measure of the uranium plus thorium content and nothing more. For reasons given above, it may or may not be roughly proportional to the columbium, tantalum, and rare-earth content. The terms "rich values" or "poor values" are used loosely in the discussion to follow, merely to avoid such cumbersome expressions as "materials with high (or low) radiometric count." Evaluation of the metal content of the deposits will depend on chemical analysis of the samples now in progress by the Bureau of Mines.

For purposes of working out the geologic origin of the Big Meadow deposit we are concerned primarily with criteria for distinguishing between units within the fill that were deposited by the main stream and each of the lateral tributaries. In search for such criteria we have calculated and plotted the quantities of all of the associated minerals reported in the logs (magnetite, ilmenite, garnet, and zircon) against monazite content and "radiometric difference", but there is no clear cut correlation from hole to hole or with determinations of associated minerals and values in pan concentrates taken from the present streams. The discussion of the associated mineral problem is reserved for the final report; for the moment without independent checks, the correlation between the modern stream materials and the deposits in Big Meadow can be based only on monazite and radiometric count as reported in the logs.

Explanation of the sections

The positions of individual sections have been adjusted on the sheets of cross sections (fig. 4) and longitudinal sections (fig. 5) so that the drill holes in each line are in their correct position with reference to the holes in adjacent lines. It should be noted in this connection that the locations of the holes on the geologic map are only approximate. The geologic map was compiled from air photos without ground control, and the drill holes have been plotted on the basis of a few tie points between the geologic map and the Bureau of Mines drilling map.

The elevations of the collars of the holes were scaled from Bureau of Mines drilling sections. The surface profiles, between the holes, have been sketched on the basis of stereographic study of the air photos. Irregularities in the slopes of the longitudinal profiles are due in part to the presence of side stream fans.

A short horizontal dash at or near the base of the drill holes indicates the level at which bed rock was reported. Some of the deeper holes did not reach bed rock. The rock surface as drawn in the sections is based on the logs except that in some places (as in the vicinity of hole 30, line B) it is drawn at a shallower depth because of the likelihood that the barren material in the lower part of the hole is weathered granite rather than alluvium. The shallow level at which bed rock was reported in hole 11, line F, may indicate a hill of which there is no evidence in the adjoining sections, or it may be that the drill encountered a boulder or a bed of cemented alluvium; the latter interpretation is adopted in section F. The rock floor between the holes is entirely hypothetical; the holes are widely spaced, and there is room between them for topographic features of large size. Differences in the shape of the valley from section to section are probably due to buried inter-tributary spurs.

The shallow sections along lines A and B are believed to be representative of the post - Illinoian valley. The bed rock in these sections is shown deepening westward toward the axis of the original valley of Bear Creek.

Distribution of values along the west side

The part of the Big Meadow fill deposited by side streams from the west is generally low in grade. (See cross sections A through G, fig. 4, and the west longitudinal section, H, fig. 5.)

Monazite values are low, and the radioactive black minerals are very rare or absent in streams entering the valley in the latitude of sections C and D, which show very low values in the west side fill. It will be noted on the geologic map that Wisconsin ice tongues heading against the Whitehawk divide advanced to the margin of the valley floor in this area, and that Illinoian glaciers were still more extensive. The surface of the fill slopes upward with increasing steepness to the base of the Wisconsin moraines; the material, encountered in the upper parts of the western holes on lines A, B, C, and D, which is practically barren, is probably Wisconsin outwash. It is suggestive, in this connection, that the barren material in these lines extends to the axis of the valley as though the main stream had been forced to the east by the flush of outwash gravel. The subjacent material, which makes up the bulk of the fill and contains somewhat better values, is tentatively considered to be Illinoian outwash, but the evidence does not warrant a line on the section between the two depositional units.

As indicated earlier, the placer mineral content of the bed rock cannot be determined by ordinary panning methods in drainage basins, such as these, that were completely occupied by ice. Whatever the tenor of the bed rock, the conditions of deposition of this part of the Big Meadow fill were such that low values would be expected.

Holes 23 in section F and 17 in section G show a much higher content of radioactive blacks than those farther north (See section H), and the streams entering Big Meadow in this latitude carry fair values. Only the headwater parts of these drainages were occupied by Wisconsin glaciers; neither the extent of the Illinoian ice nor the exact location of the source of the radioactive blacks has been determined. It is likely that the fill consists of material derived by normal erosion processes from non-glaciated parts of the drainage basins, more or less diluted by outwash from the headwater glaciers.

Hole 21 (line E) is in an area that probably received both outwash from the northwest and normal alluvium from the southeast at different times during the accumulation of the fill.

Distribution of values along the east side

The location of holes with exceptionally high values in radioactive blacks in lines E, F, and G, and especially in the east longitudinal section, J, indicates that the rich feed is from Casner Creek; all of the best holes are on the Casner Creek fan. The good values in holes 18 and 20 (line D) are best interpreted as material from the same stream, moved downvalley by Bear Creek. The bed rock source area from which the radioactive blacks were derived is indicated by a pattern of crosses on the geologic map (fig. 2).

The eastern holes in lines C and D, north of Casner Creek, show poor values. The eastern holes in lines A and B are in Bear Creek material; there is no drilling record of the material contributed by the side streams in the latitude of these sections. Pan concentrates from all the streams that enter Big Meadow north of Casner Creek show low values, and the residual soil and bed rock in their drainage basins are correspondingly poor. Because all of these streams drain non-glaciated terrain under conditions favorable for a maximum yield of placer minerals, it is evident that the sharp contrast between their low yield and the very rich yield from the Casner Creek drainage is a matter of difference in the bed rock content of the placer minerals.

There are no deep cuts on the Casner Creek fan to provide exposures in which deposits of different age might be distinguished. Because the most important single causal factor in the accumulation of the Big Meadow fill was the blocking of Bear Creek during Illinoian time, the greater part of the Casner Creek fan deposit is probably Illinoian in age, perhaps with a surficial mantle of Wisconsin material. In any case, the deposit is an aggradational fill. As indicated earlier, aggradational conditions are much less favorable for maximum concentration of placer values than stable stream conditions. The richness of the deposit, from base to top, is believed to be due to an accelerated movement of an enriched pre-Illiniolan eluvial mantle to the streams under rigorous climatic conditions during the Illinoian glacial stage and perhaps also during the Wisconsin stage.

Distribution of values in the axial area

Geologic interpretation of the deposits in the axial part of the valley is difficult because of the intertonguing that may be expected between material from the east, from the west, and from upvalley, and especially because the materials from these different sources may be mixed in all proportions, either by streams themselves, or artificially in 5-foot samples that happen to include parts of two depositional units. The difficulty lies in the fact that interpretation must be based wholly on the reported values, with no independent checks on derivation on the basis of associated minerals or pebble types, and with no evidence as to possible big differences in age of the depositional units cut by the drill. An example will illustrate the nature of the problem and the way in which the geologic interpretation bears on the practical question as to what lies between the drill holes.

The difference between the fair to good values in the upper parts of holes 20 and 35 (section I) and the very poor values in the lower parts of these holes may be interpreted as reflecting a difference between main and side stream deposits, respectively.. Cross sections C and D, which illustrate this assumption, explain the absence of any drill hole record of main stream material in depth by the simple expedient of placing it between the holes. This is of course a possibility, but it ought to be questioned because it has an economic implication; it suggests that there may be a body of main stream material with good values somewhere in depth in this part of Big Meadow.

An alternative hypothesis is that the lower lean material was deposited during a period of rapid aggradational filling, when the activity of the main stream as an agent of transportation was distinctly subordinate to the spreading of fans by the side streams; under these conditions the material deposited by the main stream in any segment of the valley would be largely of local derivation, merely reworked by the main stream. According to this hypothesis the lean material in the lower parts of holes 20 and 35 would be main stream deposits that are poor in values because virtually all of the rich feed from Casner Creek was deposited on its own fan. This hypothesis is illustrated by section I, which shown a rapid downvalley decrease in values in the main stream deposits in the deeper parts of the fill.

The tendency for side stream dominance during rapid aggradation, in its extreme development, might involve the formation of swamps or lakes along the main streams as a result of coalescence of tributary fans from opposite valley sides, with complete stoppage of transportation by the main stream. Section C and D, modified by removal of the hypothetical main stream deposits in depth, so that the side stream deposits join in the axis of the valley, would illustrate this concept.

According to either of these views, there would be no good values in depth in the northerly parts of Big Meadow, except perhaps channel deposits on the rock floor, formed under stable stream conditions prior to the beginning of aggradation. The fair to good values at shallow depth in the northern sections (A, B, C, and D) would be from Casner Creek and perhaps Howard Creek (see below.), worked on down the valley by Bear Creek under conditions of stability or slow aggradation after the episode of rapid aggradational filling.

Deposits in the filled valley north of Big Meadow

Nothing is known as to the sequence of events that caused the diversion of Bear Creek from its pre-Illinoian valley at the north end of Big Meadow. The possibilities range from (a), maintenance of its pre-Illinoian level by Bear Creek until this part of its valley was blocked directly by an Illinoian ice tongue from the Whitehawk divide, to (b), filling of the valley by the stream itself as a result of a greatly increased load of Illinoian outwash gravels and accelerated erosion in parts of the drainage basin not occupied by Illinoian ice, before the Whitehawk glacier reached the valley. In the first case, the fill would consist chiefly of Illinoian morainal material; in the second it would consist of alluvium capped by moraine. The actual history probably lies somewhere between these two extremes. In any case, it seems unlikely that the fill contains values of commercial grade. Pre-Illinoian Bear Creek gravels that may lie on the bed rock floor are probably too deeply buried for economic recovery.

This pessimistic conclusion is based wholly on theory, and it could be wrong. The existence of the old valley was not known when Big Meadow was drilled; the fill that lies in it should be tested, perhaps by additional holes to the west on lines A or B.

Deposits of Howard Creek

The richer phases of the Big Meadow fill blocked out by the Bureau of Mines drilling were supplied by one stream, Casner Creek. But the average of values in radioactive blacks in pan concentrates in the drainage of Howard Creek, next to the south on the east side of the valley, equal or exceed those of the Casner Creek drainage. (See fig. 2.) Because the channel gravel of Bear Creek between the mouths of Howard and Casner Creeks carries good values, and because the conditions in the Howard Creek drainage were similar to those in the Casner Creek drainage during the emplacement of the valley fill, it seems reasonable to believe that there should be a rich Howard Creek phase of the fill, corresponding with the rich Casner Creek phase.

The Bear Creek valley floor narrows abruptly south of the mouth of Casner Creek, and the narrow part of the valley lies to the east of the axis of Big Meadow. (See figs. 2 and 3.) The deepest hole (13) on the southermost cross section (line G) is near the western side of Big Meadow. Four holes (1, 2, 4, and 5) drilled in the narrow part of the valley to the south encountered bed rock at shallow depths and show fair to poor values. (See fig. 2 - these holes are not included in the sections.) It seems likely that these holes are on the east side slopes of old filled valley, and that the axis of that valley lies west of the axis of the present narrow valley. It is important to note, in this connection, that the position of the bed rock-alluvium contact along the west side of the narrow valley is not known; low forest-covered spurs in this area may consist in part of Illinoian moraine. If so, the low grade deposits in hole 13 may be Illinoian outwash, with little or no admixture of Howard Creek material. In any case, it is evident that additional drilling is needed in the vicinity of the mouth of Howard Creek.

Deposits in the valleys of Casner and Howard Creeks

Pan concentrates from the channel alluvium of Casner and Howard Creeks are in general richer in radioactive black minerals than those in Bear Creek, probably because the rich feed from these streams is diluted in Bear Creek by barren detritus from other sources. The alluvium in these valleys is probably too shallow for operation of a large dredge, but if the yardage and tenor are good, suitable mining methods can be developed. The Casner and Howard Creek alluvium, and the eluvial blanket on interstream surfaces in their drainage basins, should be tested in any comprehensive evaluation of the reserves of the district.

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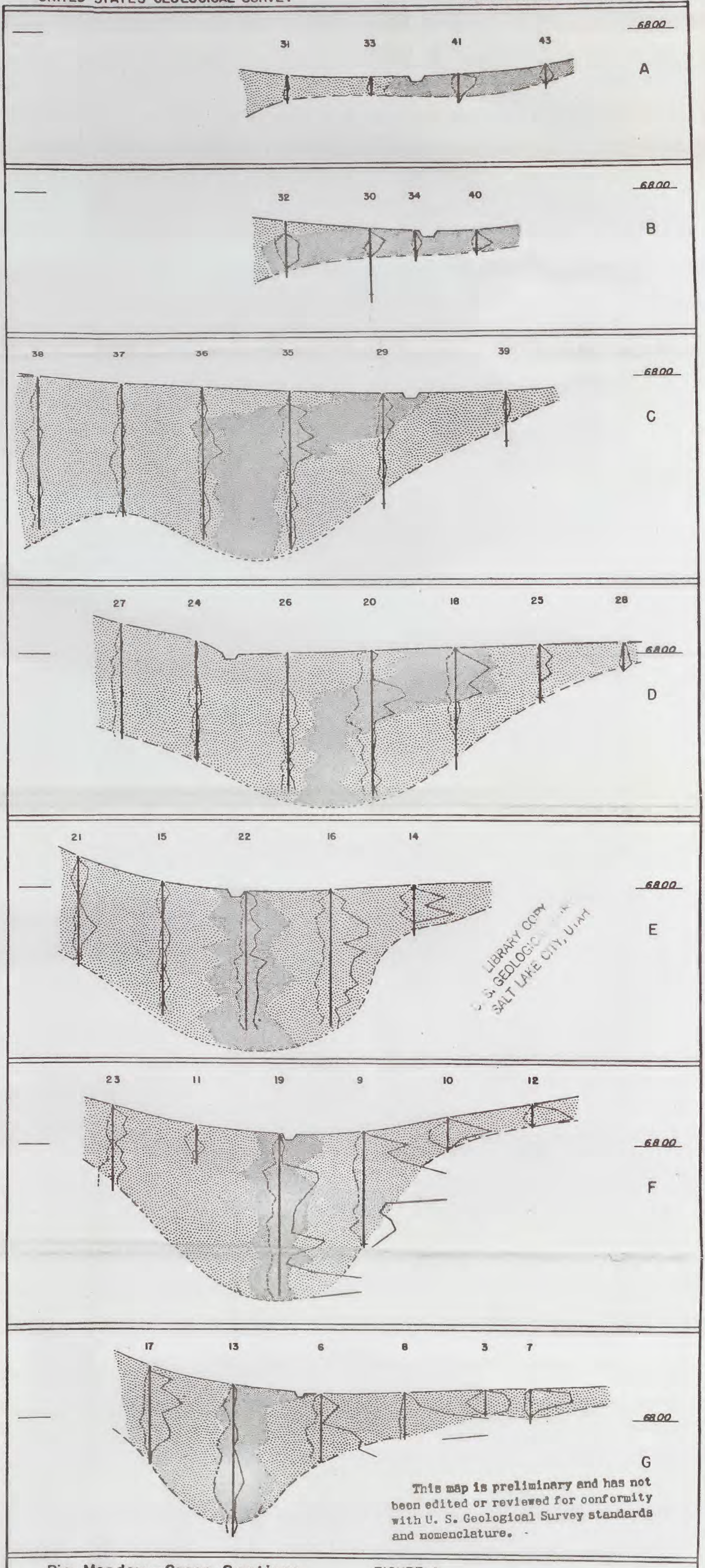

This map is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

Big Meadow—Cross Sections

FIGURE 4

Scales

vertical: 30 ft., 20, 10

horizontal: 400, 800 ft.

8 4 — *pounds of monazite per cu. yd.* — *radiometric difference (see text)*

Main stream deposits

Side stream deposits

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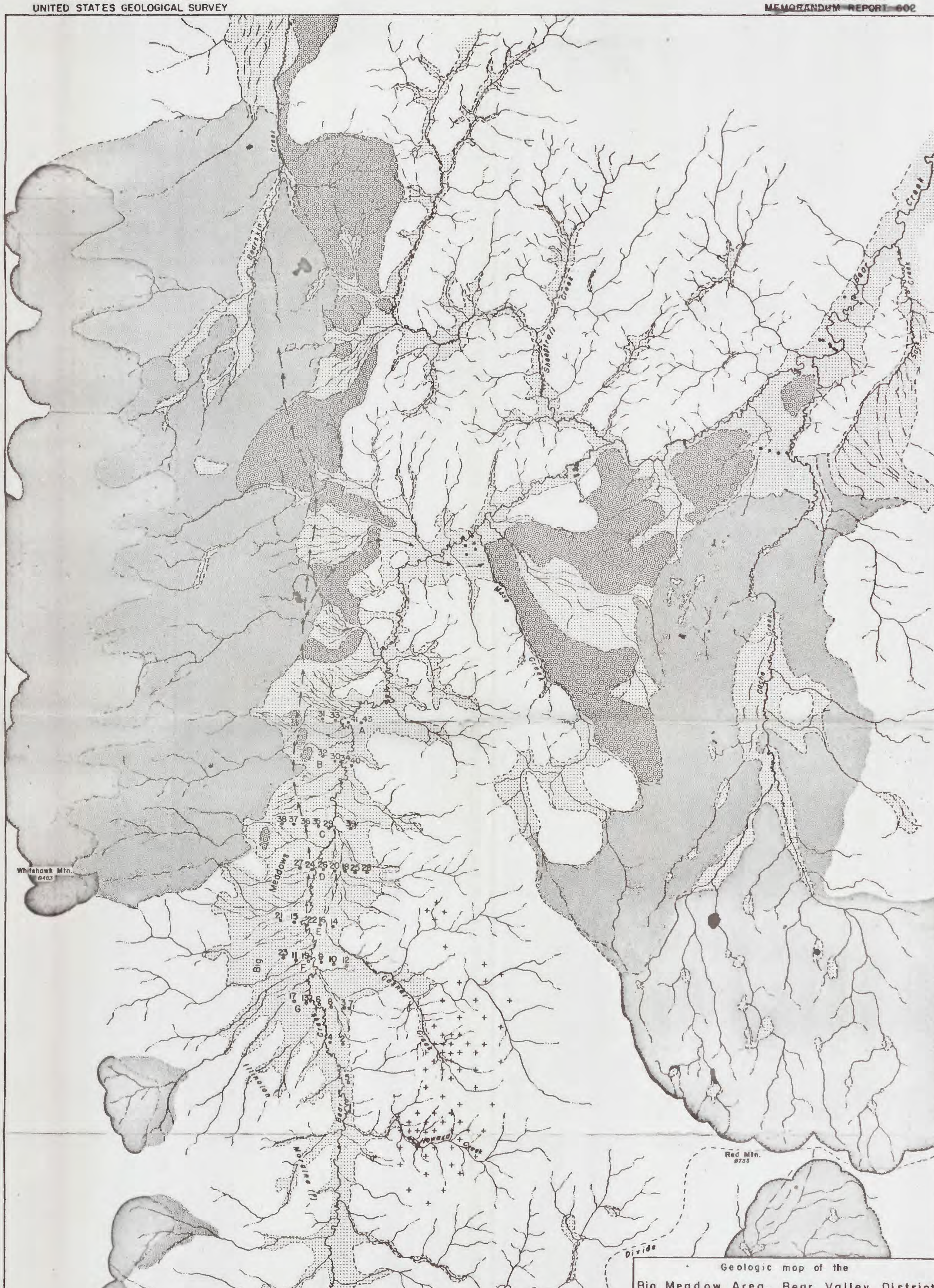

FIGURE 2

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