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STATE OF IDAHO

C. A. BOTTOLFSEN, *Governor*

Idaho Bureau of Mines and Geology

A. W. FAHRENWALD, *Director*

Elementary Methods of Placer Mines

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Moscow, Idaho
April 27, 1934

Dr. John W. Finch

Director, Idaho Bureau of Mines and Geology

Sir:

Material is submitted herewith for a pamphlet on placer mining methods for the more or less inexperienced prospector. The object throughout this discussion has been to present the material in as non-technical language as possible. This is thought to be necessary because of the inquiries received in the past in the Bureau office from so many who have not had technical training.

An elaborate discussion of the geogolical principles involved in the formation of gold placers is not attempted because it is not considered to be essential to the purpose of this paper.

No attempt has been made to give a complete bibliography of placer mining. Books or articles which are non-technical and easily understood by mining people make up the bulk of the list. Also, a point was made to include books easily obtainable. It is realized that a number of the government publications have been out of print for some years; however, they may be obtained from some libraries.

This paper is not meant to be a treatise on alluvial mining. The experienced miner or one of means is referred to the more extensive works on this subject.

Since the publication of the third edition of Pamphlet No. 35, the present edition has been enlarged to include a discussion on undercurrents as a means of removing fine gold, amalgamation procedure, operation of dry placers, and other minor details suggested by inquiries.

It is hoped that this paper may serve the prospector and contribute to the furthering of the mining industry in Idaho.

Respectfully yours,

W. W. STALEY

Mining Engineer, Idaho Bureau of Mines and Geology

BRIEF HISTORY OF ALLUVIAL MINING

Alluvial mining is thought to be the oldest mining method. Records left by the ancients mention it as the means used for obtaining gold and silver. Of the many mining methods for obtaining valuable minerals, alluvial mining presents the least difficulties. There is very little, if any, drilling or blasting necessary. For this reason the early miners confined the greater part of their attention to alluvial mining. The people of ancient Egypt, many centuries before the birth of Christ, washed gold from the stream beds of the surrounding country*.

Most of the important gold-producing areas of the world were discovered because of placer operations. Among these may be mentioned California, Colorado, South Dakota, Idaho, Alaska, and the Yukon territory in America. South Africa and India are important foreign districts.

The early methods of extracting gold from the sands and gravels in which it occurred were confined to panning and the use of rather crude forms of rockers and sluice boxes.

GEOLOGY OF ALLUVIAL DEPOSITS

Placer deposits in Idaho are masses of loose gravel and sand, containing gold and other valuable minerals.

Substances Likely to Occur in Placers

While the word "placer" usually causes one to think of gold, it must be remembered that many other substances may be found in placers. Of importance among these are platinum, gems, silver, tungsten, tin, and minerals containing the rare metals.

Formation of Placers

The gold found in placers originally existed in place as deposits of various forms in areas intruded by igneous rocks. In some cases, it was deposited in the igneous rock itself in finely disseminated particles; in other cases, it other cases, it was originally in quartz veins, cutting through the igneous and other rocks and formed as a result of the igneous intrusions. Due to disintegrating processes (change of temperature, wind, rain, earth movements, and chemical action) the rock containing the gold has been reduced to such a state that it is easily broken and the gold freed. Through the action of running water and of glaciers in some instances, the gold-bearing rock is transported away from its source. The moving water causes the heavier gold particles to work slowly toward the bottom of the stream bed. On reaching bedrock, or hard pan, the gold moves slowly down stream until it lodges in crevices, cracks, or other irregular openings in the stream bed.

Placer deposits may be moved many times, depending upon the volume of water and the velocity with which it is flowing, and this generally depends upon the rising and subsiding of that particular part of the earth's crust. There is no fixed rule as to where the gold is apt to occur in the stream bed. The velocity of the stream is not the same at all points in its cross section. Points where the bed has widened, with resultant decrease in velocity, are the most favorable. The reason for this is that the gold is given the chance to settle to the bottom, when velocity of water decreases. Placers may be found in old dry stream beds. At the time of this formation, water was, of course, present. Later disturbances may have caused the stream to change its course. Or climatic conditions may have been responsible for its drying up.

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* Lock, A. G., Gold: Its Occurence and Extration.

Wilson, E. B., Hydraulic and Placer Mining.

There have been very few instances. where the gold in a placer deposit has been traced back to its source. The reason is that the source has been either completely eroded away, or has been deeply covered with other material, such as lava flows, sediments, etc., or the gold may have traveled great distances. It has been rather definitely proven that there are cases where placed gold was found over one hundred miles from its original source.

Classification of Placers

A. H. Brooks* considers that there are three conditions operative in the formation of placers: (1) The occurrence of gold in bed rock to which erosion has access, (2) the separation of the gold from bed rock by weathering or abrasion, (3) the transportation, sorting, and deposition of the gold-bearing material derived by erosion. His statement is as follows:

> "The distribution and origin of the gold in bed rock, involving as it does the study of ore deposits, although of first importance to the study of placers, can here be only briefly discussed. Of equal importance and more closely related to the genecis of placers in the consideration of the agencies leading to the separation, sorting and deposition . . . . In the text-books emphasis has usually been laid on the two types, the residual placer and the transported or true placers, without full recognition of the fact that the former often represents an intermediate stage between the bed rock source of the gold and the true placer.
>
> The transportation, sorting, and deposition of material furnished by the weathering of rocks, the most easily understood of geologic phenomena, are all important agencies in placer formation. . .
>
> A logical classification of the placers should be based, first, on genesis, second, on form. The primary grouping, according to origin, would be "residual placers," "sorted placers," and "re-sorted placers." The residual placers are those in which there has been no water transportation, the concentration of the gold being due solely to rock weathering. The gold of the sorted placers is the result of transportation, sorting,, and deposition by water. Placers of the third group are those in which the gold has passed through two or more cycles of erosion before its final deposition. Those of the first class are practically all of one type. The sorted and resorted placers embrace many subordinate types, named according to the form of occurrence. The following list presents the larger groups and the more important of the subordinate types:

1. Residual placers.
2. Sorted placers.
    a. Hillside
    b. Creek and gulch
    c. River-bar
    d. Gravel plain
    e. Bench
    f. High bench

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* The Gold Placers of Parts of Seward Peninsula, Alaska. U. S. Geological Survey **Bull. 328.**

3. Re-sorted placers.

a. Creek and gulch

b. Beach

c. Elevated bench

A brief description of the more common types listed above follows*.

Residual Placers

These are placers in which the gold is accumulated in place by the disintegration of the rock containing it. It is not transported from its original source.

Hillside Placers

These are very old deposits, occurring on the tops and sides of hills. They may have been left in this elevated position because of earth disturbances which lifted the area above the former stream bed, or the original stream which deposited them may have changed its course or have meandered to a new bed.

Creek Placers

These are the best known and most productive placers. Brooks† has described this form of placer as follows:

"The pay streak in these deposits is usually on bed rock, though it sometimes is found on a clay which overlies the rock. Where no clay is present the gold is found not only on the bed rocks, but also where the rock is broken the gold has worked its way down into the joints and crevices. Streams are often found to have a layer of clay on bed rock, which gradually thins out up-stream and finally disappears entirely. The presence of the clay on bed rock usually indicates that no gold will be found in the weathered rock below, as the impervious layers prevent the gold from working its way down."

The entire width of the stream should be tested as the pay streaks are very irregular. They usually run parallel to the direction in which the water is flowing.

Gulch Placers

These are very similar to creek placers, except that there is now very little, if any, flowing water present.

River-bar Placers

These are bars of gold-bearing sand or gravel that have been laid down by large streams or rivers. The gold is usually distributed throughout the bar. There is often more fine (flour) gold than coarse. The deposits are usually very low-grade as compared to creek placers.

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* The Gold Placers of Parts of Seward Peninsula, Alaska; Bull. 328, U. S. Geological Survey.

Longridge, C. C., Hydraulic Mining; The Mining Jour. London.

† Brooks, A. H., Reconnaissance in the Cape Nome and Norton Bay Regions, Alaska; Special Publication, U. S. Geol. Survey, 1901, p. 140.

Bench Placers

These are more or less ancient placers, occurring in bench or terrace form, on sides of valleys or courses of ancient streams, from 50 to 300 feet or more above the present stream level. The presence of well rounded gravel is indicative of material carried and sorted by water. Figures 1 and 2 illustrate creek and bench placers.

Position of Gold in Deposit

In general, the various sized particles of gold or other placer minerals will be found in the following section of the stream when the water has flowed continuously in one direction:*

1. The coarse gold will be deposited in the upper part of the stream.
2. The finer gold will be deposited in the lower portions of the stream.
3. The richest and coarsest gold will be deposited in the layers of comparative coarse gravel wash.
4. The finer gold will be deposited in the finer sandy drifts.
5. The best gold should occur in the layers of wash containing black sand and pebbles of magnetite or other heavy mineral.
6. On a favorable bottom, gold will be ordinarily lodged on the down side of a bar of rock running across the bed of a stream.

Associated Minerals

Black sand (magnetite, an oxide of iron) is nearly always found in placers with gold. Its presence or absence is not positive proof of the presence or absence of gold. Ilmenite (an iron titanium oxide) resembles magnetite to a large extent. It is usually present. Garnet (ruby sand) and zircon commonly occur in gold placers. In Alaska†, and in at least one locality in Idaho, cinnebar (mercury sulphide) has been found in gold placers. Scheelite (calcium tungstate) and cassiterite (tin oxide) have been found in some places. Pyrite is commonly found, and by the inexperienced prospector may be confused with gold. A very simple test quickly distinguishes between the two. Pyrite is very brittle. A slight pressure between two hard surfaces reduces it to fragments. Gold is simply flattened without breaking. Biotite mica, which has altered to a bronze color, is sometimes confusing. It is readily told from gold by the readiness with which it breaks when bent back and forth.

SAMPLING OF PLACER DEPOSITS

Before any extensive operations are attempted, the placer deposit should be sampled. This, of course, applies where large scale sluicing, dredging, or hydraulicking, is contemplated, and not where the gold pan, rocker, or some such elementary process is used.

There are two general methods of sampling; test pits and bore holes. Test pits are most profitably used in shallow deposits (probably not deeper than 25 feet). For greater depths the churn drill should be used. The test pit or shaft gives a more accurate sample. It covers a larger area; the gold contained in the gravel is removed with the gravel with very little concentrating of gold as the bottom of the shaft is approached. With the churn drill it is difficult to prevent concentration

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* Longridge, C. C., Hydraultic Mining, p. 12 (1910).

† The Gold Placers of Parts of Seward Peninsula, Alaska, Bull. 328, U.S.G.S.

of gold. The final choice between the two methods rests with the cost. If the shafts must be timbered, or water pumped out, the bore hole method may be far cheaper.

The material removed from the shaft or the bore hole is panned, sluiced, or amalgamated, to remove the gold. The gravel is weighed, or its weight calculated, from the size of the opening from which it came. The recovered gold is weighed and expressed in cents per cubic yard.

Care must be taken against "salting" the sample, i. e., getting gold into it that does not belong there.

To determine the grade of fineness of the gold, it will be necessary to send a sample to an assayer. Placer gold varies between about $17.00 worth of gold per ounce to almost pure gold, the present price of which is $35.00 per ounce. It is found nearly always alloyed with varying amounts of silver.

In sampling or working a deposit, one must be sure that he has reached the real bed rock before abandoning the claim. Figure 3 illustrates this. It will be noted that the gold has been deposited in alternate layers with clay. This indicates changing condition of deposition.

DESCRIPTIONS OF THE SIMPLER MINING METHODS AND APPARATUS

The size of the gold to be recovered has an important bearing on the details of the appliance to be used. Finely divided gold is much more difficult to save than the coarser variety.

The following table will give some idea of the size of gold particles and their values.*

Nuggets

Coarse gold—that which remains on a 10-mesh screen (ten openings per linear inch).

Medium gold—that which remains on a 20-mesh and passes a 10-mesh screen (about 2200 colors to 1 oz.)

Fine gold—that which passes a 20-mesh and remains on a 40-mesh screen (about 12,000 colors to 1 oz.)

Very fine gold—that which passes a 40-mesh screen (about 40,000 colors to 1 oz.)

Flour Gold

Purington quotes examples of finely divided gold:

170 colors to 1 cent (314,500 to 1 oz.).

280 colors to 1 cent (436,900 to 1 oz.).

500 colors to 1 cent (885,000 to 1 oz.).

Of the many methods that are used for recovering gold from placer deposits there are only three that merit description in so far as the prospector is concerned. In the order of simplicity, the construction of the apparatus and operation of these three methods follow.

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* Young, G. J., Elements of Mining, 2nd Ed. (1923) p. 400.

Panning

The ordinary sheet-iron gold pan varies from about 10 to 18 inches in diameter at the top. The depth is about three inches. The ordinary 10-inch frying pan with the handle removed is quite often used. This pan holds about five pounds. The 18-inch pan holds about 25 pounds of dirt. Figure 4 illustrates the gold pan.

The gold pan is made of stiff sheet-iron. The inner surface must be kept clean and bright, and free of grease. Some pans are made with a copper bottom. Copper amalgamates readily with mercury. By rubbing mercury on the copper bottom, fine gold is retained through amalgamation.

Operation of Pan

The pan is filled about two-thirds full of dirt and placed under water. While in this position the contents are stirred or "kneaded" with both hands. This procedure is necessary to break up the lumps and to free the gold from clay-like material. As the disintegration proceeds, the large stones and pebbles are thrown out. When the material has been thoroughly broken up and the large rocks removed, the pan is taken in both hands for the panning operation. The position of the hands is slightly back of the middle of the pan. This permits the pan to be inclined down and away from the operator. The pan is now raised until it is just covered with water. It is now given a slight oscillating, circular motion, with the result that the contents are shaken from side to side. This motion keeps the lighter material in suspension and washes it out of the pan. It also enables the gold and heavy minerals (magnetite, etc.) to work their way to the bottom of the mass. This operation is continued until only the gold and black sands are left. This material is now dried and the magnetitie removed with a magnet. Other material, such as stream tin and heavy non-magnetic minerals, are separated from the gold either by amalgamating the gold or by picking out the gold, piece by piece. The separation of gold from the mercury used in amalgamation will be discussed later in this paper.

Peele*, Wilson†, and Longridge‡, state that about 100 pans of dirt are the most that can be panned by an experienced miner in 10 hours. Assuming that placer gravel weights 135 pounds per cubic foot, and that the gold pan holds 15 pounds, 100 pans would be equivalent to about 11 cubic feet or 4/10 of a cubic yard. With the large pan (18 inch diameter), a good panner may handle one cubic yard.

Rockers

There are many forms and sizes of rockers. The rocker handles about three to five cubic yards of material per 10 hours, its capacity depending upon the size of the gold and the amount of clay present. Large amounts of clay slow the operation down. It is necessary that all the clay be washed free of the gold, otherwise, the fine gold is floated away. The sketch shown as Figure 5 illustrates a convenient form of knockdown rocker.**

Description of rocker:

The inside of one side of the rocker and an end view of the rocker is shown.

A—Cleats for holding the back of the rocker.

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* Peele, R., Mining Engineer's Handbook, 1st Ed., vol. I, p. 755 (1918)

† Wilson, E. B., Hydraulic and Placer Mining, 3rd Ed., p. 63 (1918)

‡ Longridge, C. C., Hydraulic Mining, p. 181, (1910) (The Mining Journal, London)

** Storms, W. H., How to Make a Rocker; Eng. & Min. Jour., June 24, 1911, p. 1243.

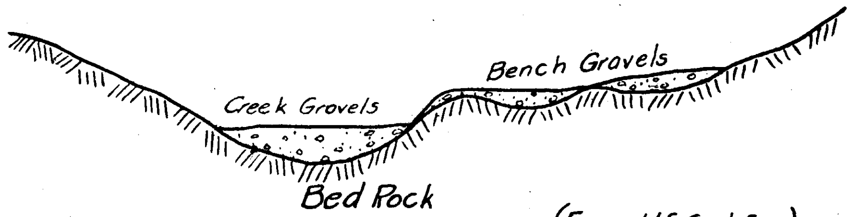


Fig. 1.

(From U.S. Geol. Sur.)

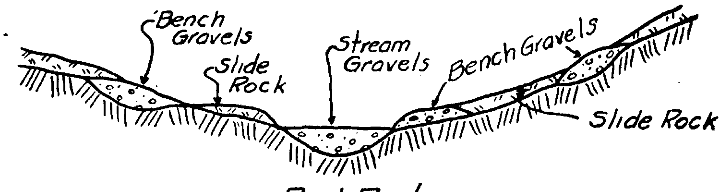
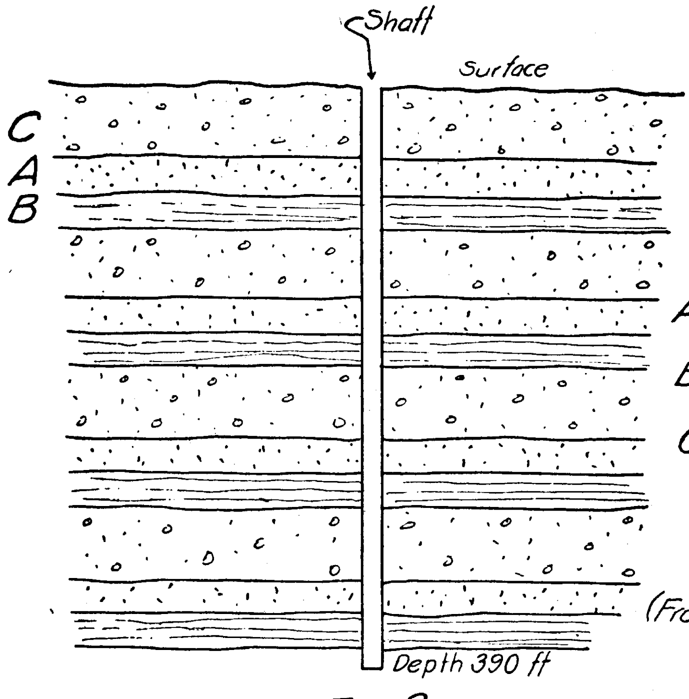


Fig. 2.

(From U.S. Geol. Sur.)



A is the gold bearing gravel
B is impervious layer or false bottom
C is gravel

(From "Hydraulic Mining" C. C. Longridge)

Fig. 3.

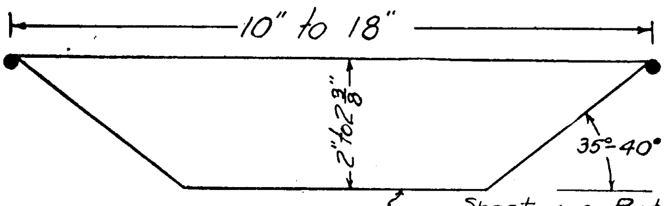


Fig. 4-Gold Pan

B—Cleat for holding bottom of rocker, L.

C—Cleats for holding back of rocker

D—Cleat for holding canvas apron frame.

E—Cleats for holding brace at top of rocker.

F—Cleat for holding sieve box.

X—Bolt holes for ½ inch iron bolts u-ed in holding rocker together.

I—Riffles ¾ inch high by 1 inch wide.

K—Rockers.

H—Handle for rocking apparatus.

L—Bottom board of rocker.

M—Spike projecting 1½ inches to prevent rocker from slipping down grade.

The bottom board, L, of rocker should be in one piece. This is to prevent leakage of fine gold which might occur if twopoorly fitted boards were used. Material of construction is preferably finished ¾ inch. The six ½ inch rods should have nuts and washers for the ends. This permits tearing the rocker down for transportation purposes.

The dimensions of the sieve box are as shown in the sketch. It should just fit loosely in the top of the rocker. The bottom is made of heavy sheet iron perforated with about ½ inch diameter holes.

The apron is a framework made of 1 inch by 1½ inch material well fitted together and covered with canvas. The canvas is not stretched tight, but allowed to sag somewhat at the bottom. This gives a slight depression in which gold is caught.

The grade or inclination of the rocker is obtained as follows:

Two heavy planks are firmly placed on the ground such a distance apart that each of the rockers will fall about in the center of a plank . The planks must have holes in them to receive the spike in the bottom of the rockers. The plank under the front or discharge end of the rocker is placed two inches lower than the rear plank. This arrangement, therefore, gives a drop of two inches in three feet. The grade is influenced directly by the following conditions:

1. Rapidity with which material can be fed to the rocker.
2. Amount of clay present.
3. Fineness of gold.

If the gravel is finely bound together with clay, the grade should not be less than two inches. If very little clay is present, and the gold is not too fine, the grade can be increased. In any event, the grade must be such that the clay is completely removed from the gold before the discharge is reached, and if the gold is very fine it should be given a chance to settle. In cases of very fine gold and considerable clay, it might be advisable to add one more riffle.

Operation of Rocker

For the operation of the rocker much more water is required than for the gold pan. Where there is a shortage of water, it is usually better to carry the gravel to a point near the source of water. The gravel is placed in the screen box and the rocker is shaken back and forth with a vigorous motion. At the same time, water is poured over the gravel, or a small stream of water is permitted to run over it. If

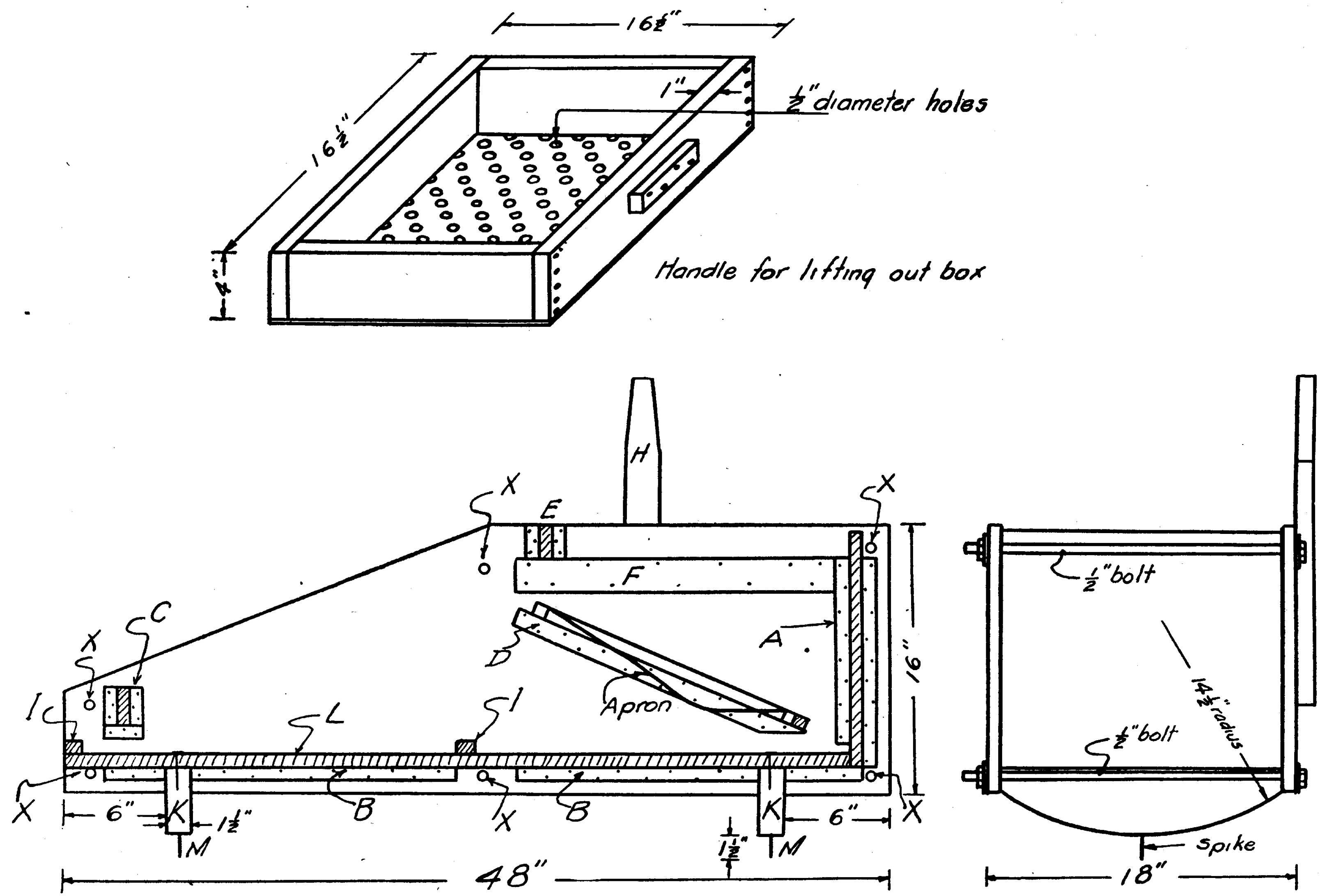


Fig. 5.-Knock Down Rocker

(From The Eng. & Min. Jnl.)

water is scarce, the discharge can be caught in a small pool and rinsed. Good judgment must be exercised in the use of water. If too rapid a flow is used, the smaller gold particles will be washed over the riffles and lost with the discharge. At the same time, sufficient water must be used to completely disintegrate the gravel and remove the clay. An attempt should be made to keep a fairly steady stream flowing rather than an intermittent, surging supply. The amount of water must be sufficient to carry the tailings over the riffles. The motion of rocking is a quick jerk with a sudden stopping of the motion. The heavy sands must not be permitted to build up back of the riffles. If this is allowed, the gold will wash over these sands and be lost.

Clean Up

The canvas or blanket forming the apron is rinsed off in a tub of water two or three times a shift. The gold and sands back of the riffles are removed as often as thought necessary. The concentrates are dried and the gold removed in the same manner described under panning.

The rocker is not very efficient. It permits the handling of more material than does the gold pan. Mercury some times is placed back of the riffles to catch some of the fine gold.

When the over-size material is removed from the sieve box, it should be inspected for nuggets before being discarded.

The tom or long tom is sometimes used in place of the rocker. It is illustrated in Figure 6. Six to twelve foot sluice boxes are used. One man shovels the gravel into the head box, others lift out boulders with pitchforks and break up the lumps of clay. Clean up is made in the same manner as for the rocker.

Sluices

In the use of sluice boxes two conditions may arise. First, where the box rests on the ground, the second, where it is necessary to elevate the sluice on trestles, necessitating also the elevating of the gravel. Only the first case will be discussed. The construction of the boxes and the manner of retaining the gold are the same in either case.

Material

The material from which the sluices is made is rough-finished lumber. There are some instances, such as dredging and large scale hydraulicking, where metal boxes are used. In many cases the box will be made of lumber which has been hewn out by the prospector himself.

Dimensions

The sluice is made up in sections. These sections vary from 12 to 16 feet in length, depending upon the locality. Twelve-foot sections are the most common. The width varies from one-foot to five feet, but is usually between 12 and 18 inches. The depth is from eight to ten inches. The boards from which the boxes are made are about one and one-half inches thick.

Construction

The boxes are made of rough lumber. For ordinary work the following dimensions are sufficient:

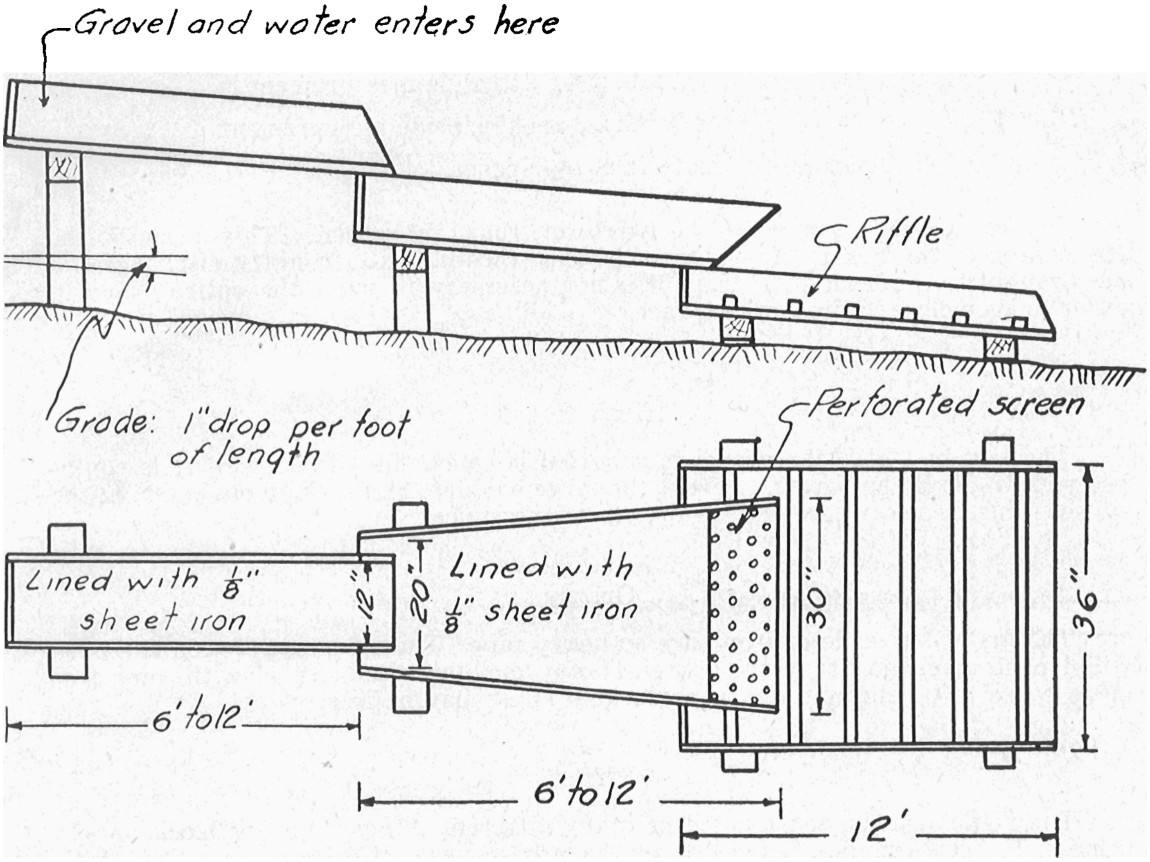


Fig. 6.- Tom

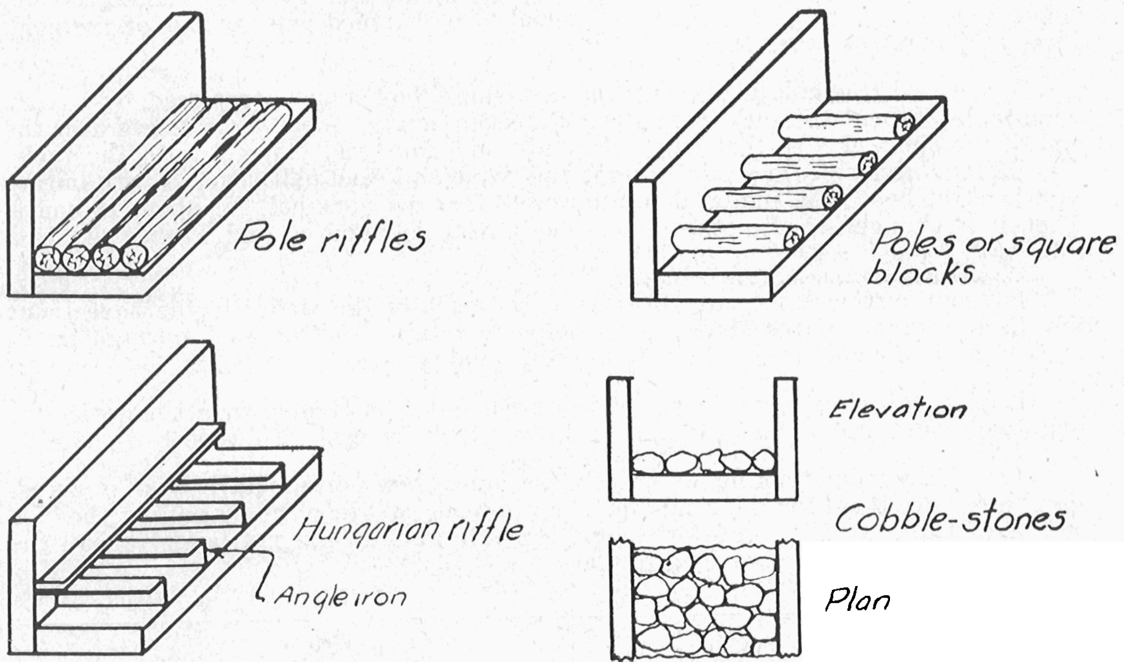


Fig. 7.- Various Types of Riffles

Length:	12 feet
Width:	1-foot inside measurement
Depth:	8 inches inside measurement
Thickness of material:	1½ inches

One end of each box should be narrower than the other. This permits the telescoping of the boxes. As the gravel bank recedes, boxes from the discharge end are brought to the head end. Thus, it is not necessary to move the entire sluice in order to keep close to the working face.

Head Box

The box in which the gravel is shoveled is called the "head box." It is equipped with a grizzly or bars to prevent the large boulders and rocks from entering the sluice. This is also where the water enters the sluice.

Grizzly

The grizzly is made of iron bars or heavy pipe. The spacing between the bars will depend upon the size of the gravel. If only medium sized gravel with very few large rocks to be encountered, a perforated sheet may be used.

Riffles

The riffles can be constructed of many different things: Wooden blocks, angle irons, poles, cobblestones, boulders, etc., have been used. They may run the length of the box or across it. Figure 7 shows some of the riffles in common use. The boxes are shown with one side removed.

In Figure 8 is shown a section of a sluice. The number of boxes making up the sluice depends upon the amount of material to be handled and the size of the gold. Fine gold requires more time to settle.

When real fine gold is present, the last sluice box may be replaced by a very wide table* (about 16 feet) from 10 to 20 feet in length. A screen is placed over the end of the sluice box so that only the sands and fine gold can get onto the table. The table is divided into sections eight feet wide and each half covered with burlap tightly stretched. The material is allowed to flow over one-half for about 12 hours. Then it is changed to the other side. The burlap is removed and washed off in a tub.

In some instances, mercury may be placed back of the riffles in the boxes near the discharge end of the sluice. This helps to retain the fine gold through amalgamation. If the gold is not clean, it will not amalgamate.

It may be necessary to elevate parts of the sluice on trestles or other devices to maintain approximately a grade of six inches drop for each twelve feet of sluice.

The riffles should not be fastened in the sluice box permanently as it is necessary to remove them for the clean up. They may be held in place by nailing the side boards of the box to the ends of the riffles. The nail should not be driven all the way in. Or they may be wedged in place.

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* Longridge, C. C., Ibid. p. 194.

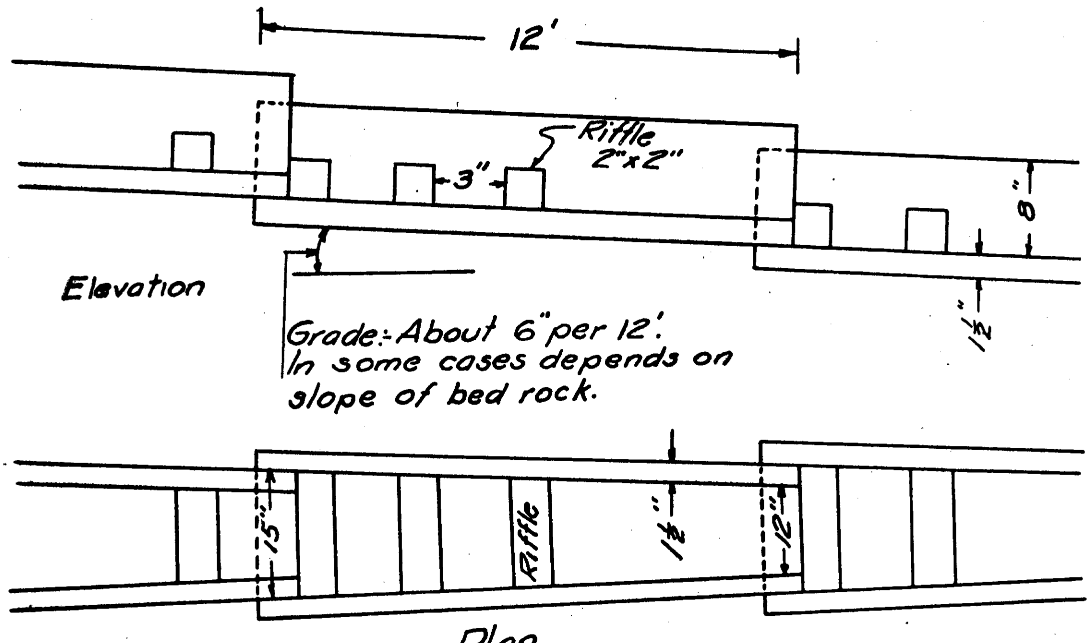

Fig. 8.- Section of sluice

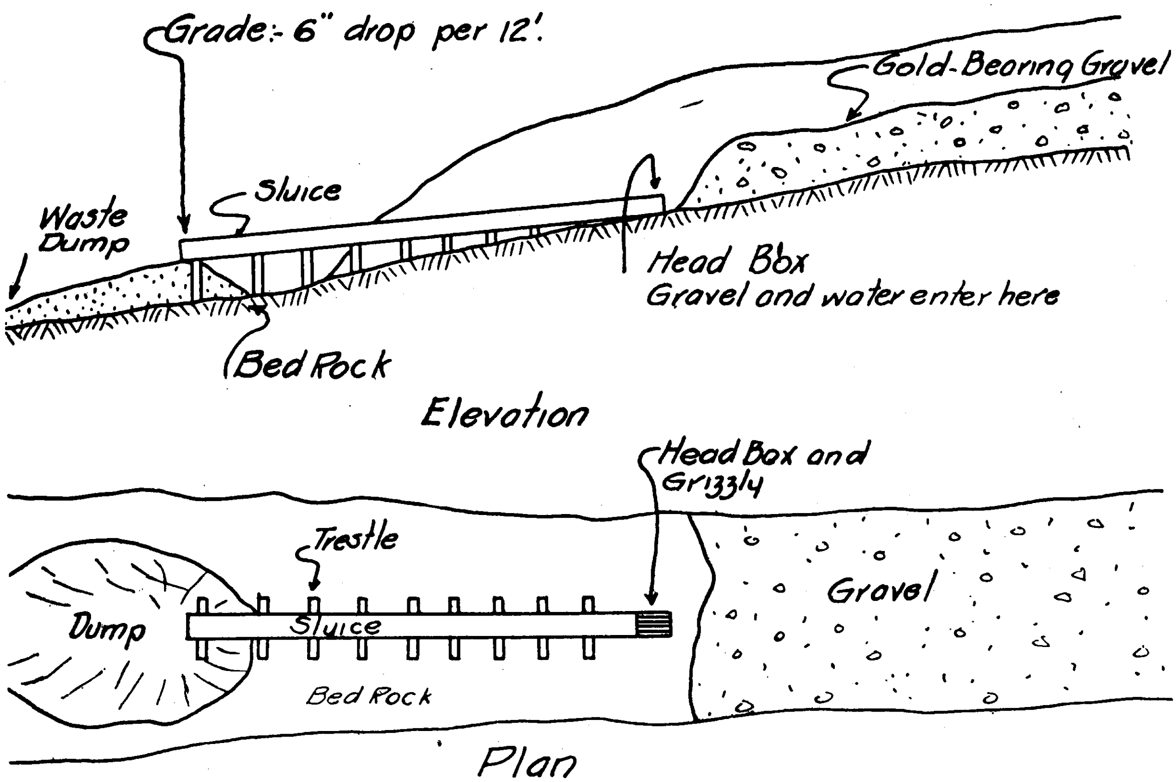

Fig. 9.- Sluice lay-out.

Clean Up

The frequency of the clean up depends upon the richness of the gravel being washed. It may vary from a few days to the entire season. The first few riffles should be cleaned up at least once every two weeks. In making the clean up the gravel is discontinued and a stream of water, just large enough to wash the heavy sands, mercury, and amalgam, is permitted to flow down the sluice. The riffles are taken up and the sand washed down the sluice. Occasionally, the contents are scraped with a spoon. All cracks and crevices are thoroughly cleaned. Blankets and burlap that may have been used are washed in a tub.

Operation

In order to use a sluice, plenty of water must be available as a continuous stream is run through the system. If sufficient water is not at hand, it is useless to construct the sluice. For large scale operations, water may be brought to the gold-bearing deposits by means of a flume.

The gravel is shoveled onto the grizzly at the head box and the water run over it. The over-size is raked or shoveled off to one side. The amount of water flowing down the sluice should be just enough to wash the gravel, passing through the grizzly, over the riffles, and out the end of the sluice. For this reason, the grizzly bars should not be spaced too far apart. If so, the velocity of the water may have to be so great as to prevent the settling of the fine gold. When the wodden riffles become so worn that they no longer hold back the heavy sands, they should be replaced. This condition exists when the riffles become rounded or are worn thin.

Figure 9 illustrates the method of working a gravel bed where it is not necessary to elevate the material.

RECOVERY OF FINE GOLD*

Very fine gold is usually recovered in one of two ways or a combination of both. These methods are the use of undercurrents and gold-saving tables. The essential difference between the two is that the tables are usually covered with carpet, burlap, hides, matting, or some similar mateial, and quite often have a flatter grade than do the undercurrents proper. They are also much wider.

Descriptions of these two additions to the main sluice follow.

Undercurrents

The conditions existing in the operation of the main sluice do not permit the settling of the fine gold. This is because of the comparatively high velocity necessary to move the large quantity of gravel and sand, and to prevent them from lodging and building up back of the riffles. It is essential that everything larger than the very fine gravel (about ¼ inch in size and preferably nothing larger than coarse sand, be excluded from the undercurrent. This is accomplished by inserting a grizzly or perforated iron plate near the end of the sluice and above the trough leading to the undercurrent.

The undercurrent consists of a series of shallow wooden sluices. Their width is eight to ten times the width of the main sluice. This fulfills one of the main requirements of the undercurrent, **a large decrease in velocity of the water.** The length of the undercurrent is two to four times its width. For example, a main sluice

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* Longridge, C. C., Ibid, pp. 264, 266.

Wilson, E. B., Hydraulic and Placer Mining, p. 145.

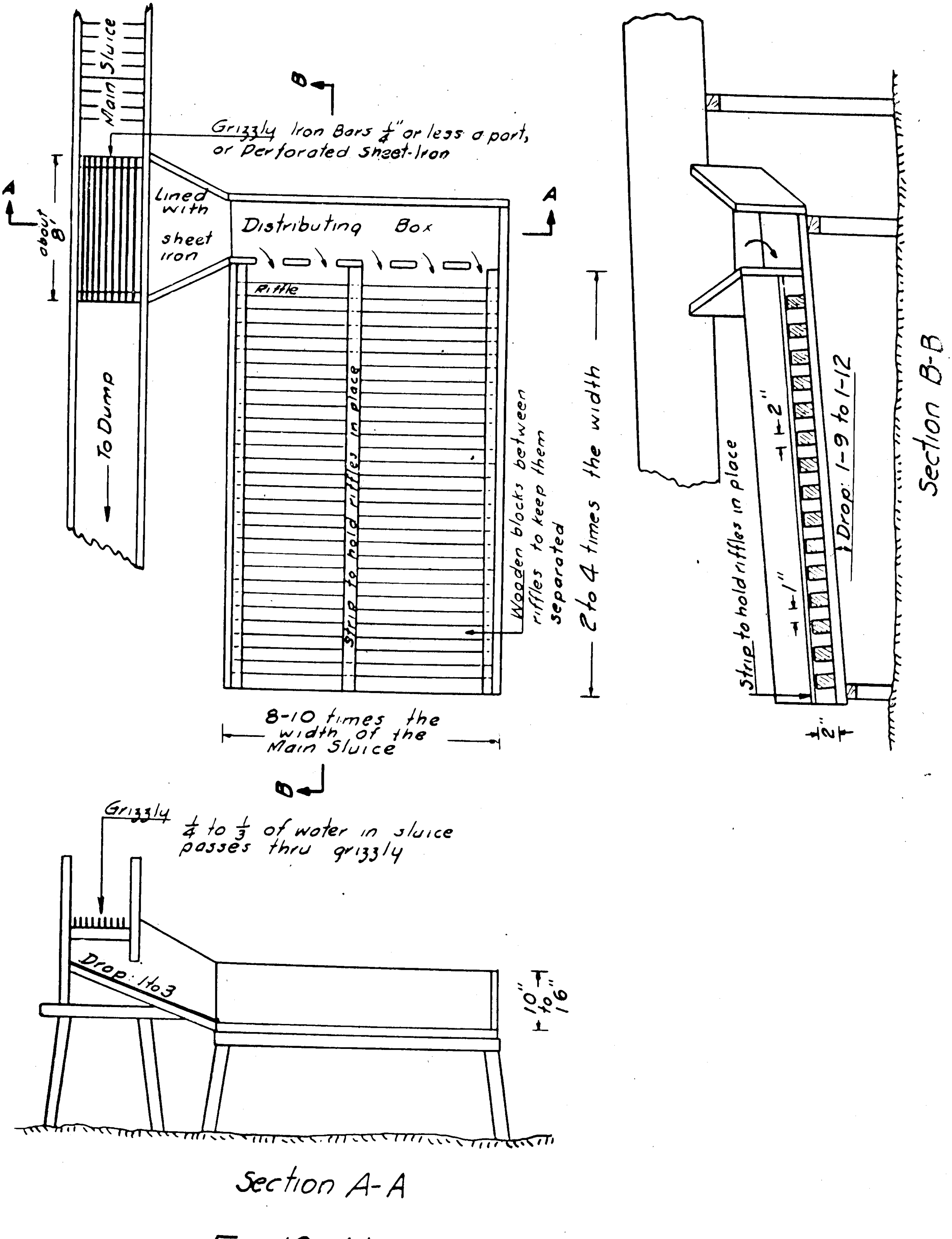

Fig. 10- Undercurrent

12 inches wide should require an undercurrent of about 8 feet in width and about 20 feet long. The bottom of the undercurrent is made of planks about one and one-half inches thick. The joints must be tight. The sides are about 10 inches high. The bottom must be thickly covered with riffles. Material used for the riffles may be wooden strips, cobble stones, blocks, etc. They are spaced about one inch apart and are about two inches deep. The grade varies from one-foot drop in 12 feet of length to one-foot in nine feet. The exact grade depends on the type of riffle, size of gold, amount of water flowing, etc., and must be determined by experimenting with the conditions present. In some cases, the lower riffles of the undercurrent are replaced by an amalgamating plate.

It is very necessary that the sandy material flows over the undercurrent in a thin layer. Wide experience has shown that about ten per cent of the gold is recovered on undercurrents. In many instances, of course, it is much greater.

Figure 10 shows a sketch of the undercurrent.

Gold-Saving Tables

The construction of tables is identical with undercurrents with the exception of the material used for riffles. Burlap, carpet, blankets, hides, etc., are used. They are held in place by tacks and chicken wire, and, in some instances, by means of wooden strips. Only the fine sands should be permitted to pass over the gold tables, and they should do so in a thin film. The clean up is made by removing the covering and washing in a tub. At the end of the season the covering should be burned and the ashes panned for gold.

If wooden blocks are used on the undercurrent, they should be burned at the end of the season.

RECOVERY OF GOLD FROM SANDS‡

As the gold dust is mixed with more or less sand, iron, and other materials, it is necessary that it be cleaned. The larger pieces of foreign material are picked out by hand; the iron and magnetite are removed with a magnet. The finer sand can be removed by blowing it away. However, if this is done, there is danger of loosing the very fine gold.

If mercury has been used, the amalgam formed is softened with an excess of mercury and the mixture stirred. This procedure causes the base material to rise to the top where it can be skimmed off. The excess mercury is removed from the cleaned amalgam by squeezing through a chamois skin or strong, cotton cloth.

Cleaning Heavy Sands

The heavy material from the sluices, and from cleaning the gold dust and the amalgam, may contain other metals or minerals besides gold and amalgam. The most important of these are native copper, silver, platinum, iridosmine, monazite, pyrite, marcasite, hematite, chromite, galena, cinnabar, cassiterite, wolframite, scheelite, barite, and stibnite. Of the rock-forming minerals, the following may be present: Magnetite, ilmenite, rutile, garnet, zircon, tourmaline, and other.

As platinum does not amalgamate with the mercury, it will be left behind in the sands when the gold is amalgamated. The sands should, therefore, be carefully examined for flakes of platinum.

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‡ Wimmler, N. L., Placer Mining Methods and Costs in Alaska; U. S. Bureau of Mines Bull. 259 (1927), p. 125.

When the fine gold is rusty or coated with materials which prevent is from amalgamating, it may sometimes be cleaned by agitating with a solution of cyanide and lye in a clean-up barrel.* This operation takes from 20 minutes to several hours, and then may not prove effective. The gold is brightened up by this procedure. The mercury may be added in the barrel at the same time.

Use of Cyanide†

If the cyandide is used too carelessly, solution of the gold will result. Solutions of certain strengths dissolve the gold more readily than others.

Maclaurin§ has found that the greatest amount of gold is dissolved in a solution of potassium cyanide of 0.25 per cent strength. A safe means of using cyanide is to make up a colution of one ounce of 98 per cent potassium cyanide to one-half gallon of water, and then use four ounces, or about one-half teacup, of this solution to 10 gallons of water.††

Retorting the Amalgam

If a retort is available, the cleaned amalgam is broken and packed loosely into the retort, which should have the inside coated with clay, chalk, or paper. The retort should not be more than three-quarters full. The cover must be fitted on tightly and sealed with either an asbestos gasket or with clay. The heating of the retort must progress slowly, the volatilization of the mercury not starting for about an hour. The iron pipe leading from the top of the retort must be kept cool by wrapping it in wet sacks. Water must continually be poured on the sacks. A dark red heat is about the proper temperture; at the end of the progress the temperature should be raised to a cherry red. The condenser pipe should not be put into a vessel of water. If this were done, and should the fire die down, the water would rush into the retort and cause a dangerous explosion. The retort must be allowed to cool gradually before opening. The outlet of the retort should be out of doors as the mercury fumes are very poisonous.

The small balls of amalgam obtained by the prospector are usually placed on a shovel and held over the fire to drive off the mercury. This should be done out of doors, and care should be taken that one does not breathe the fumes.

USE OF MERCURY IN PLACER MINING

Mercury may be used at various points in placer operations.

1. Back of the riffles in the main sluice.
2. In grooves or back of riffles on the undercurrent.
3. On the amalgamation plate at the discharge end of the undercurrent, or amalgamation plate in the sluice when only relatively fine material is passed through the boxes.
4. In the clean-up of the sluice-line.
5. In barrel amalgamation for dirty gold.
6. In the gold pan, either as liquid mercury or mercury-coated copper bottom.

Most of these applications may be in use at the same time.

Items 1, 2 and 6 are self-explanatory.

The following procedure may be followed for preparing the amalgamation plate.**

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† Thomson, F. A., Stamp Milling and Cyaniding, 1st Ed. (1915), Chapters 8 and 10.

§ Maclaurin, J., The Dissolution of Gold in a Solution of Potassium Cyanide; Jour. Chem. Soc. (London), vol. 63, 1893, pp. 724-738; vol. 67, 1985, p. 199.

†† Wimmler, N. L., Ibid, p. 217.

* See Page 21.

** Vary, R. A., Amalgamation Practice at Porcupine United Gold Mines, Ltd., Timmins, Ont.; U. S. Bureau of Mines I. C. 6433 (March, 1931)

Amalgamation Plates**

The preparation of the amalgamation plates is done in the following steps:

1. Copper plate is thoroughly scrubbed with a solution of sodium hydroxide or lye to remove all signs of grease.
2. Wash the plate in clear water.
3. Thoroughly wash the plate with a dilute solution (about one ounce to one gallon of water) of sodium cyanide or potassium cyanide. This treatment should be continued until the copper surface is clean and bright.
4. Rub mercury on the plate with a whisk broom. When this is finished, there should be no copper showing, nor should the mercury be present in such excess that it appears in small wavelets or pools. The surface should appear moist and not dry and hard.
5. The mercury surface should have occasional treatment with the cyanide solution and fresh mercury should be added. Mercury amalgamates best with gold if there is already present a small amount of this metal. It is desirable, therefore, that a small amount of clean gold be added to mercury which has not as yet been used for amalgamating purposes.
6. Mercury should be shaken occasionally on the top of the plate during operations if the surface shows signs of becoming dry and hard.

Cleaning Amalgan from Plate*

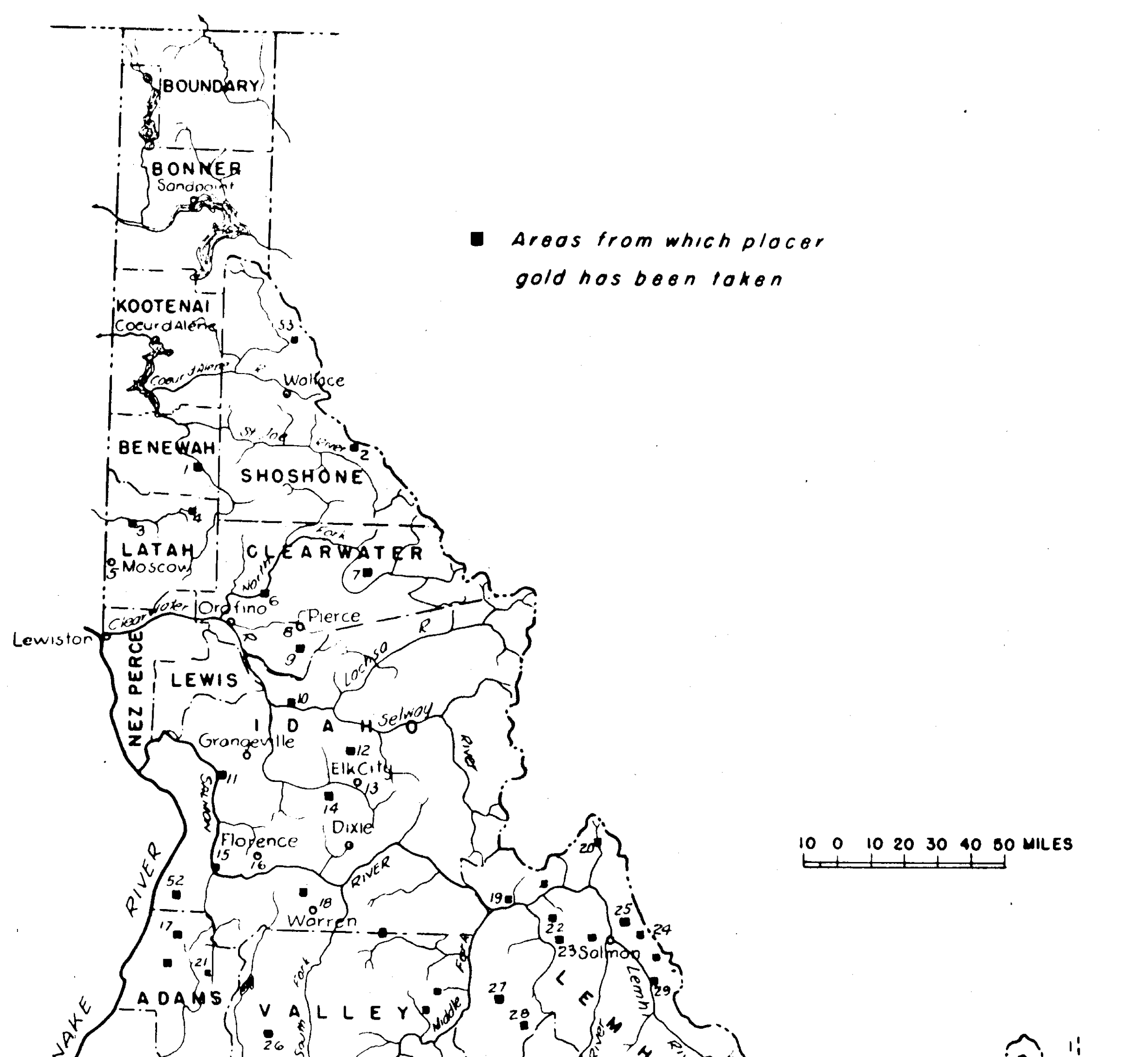
1. Remove all particles of sand by sluicing down with clear water.
2. Brush the plate well with a stiff whisk broom, working from the bottom of the plate toward the top. If the surface is dry, mercury should be rubbed on before this is done.
3. Amalgam and mercury are taken from the top of the plate. The excess mercury is squeezed out through a heavy cotton cloth, or chamois skin, and the hard amalgam is retorted.
4. If the plate is too dry after the clean-up, mercury is shaken on and rubbed in. Then, starting at the bottom and working from the center toward the sides, the excess mercury is brushed to the top of the plate.
5. Washing with the dilute cyanide solution may be necessary to brighten up the surface after the clean-up.
6. In making the clean-up, care must be taken not to rub the plates too clean.
7. It is well to have a mercury trap (a deep, narrow trough) at the bottom of the plate to catch mercury and amalgam which break loose from the surface.

Sluice

In cleaning up the sluice, mercury may be used in the tub or receptacle in which the concentrates are caught. The wet material is thoroughly mixed and stirred with the mercury. This also applies to the use of mercury in the plain iron gold pan.

** Idem.

* Vary, R. A., Ibid.



MAP OF IDAHO SHOWING LOCATION OF PLACER AREAS

Clean-up Barrel

The clean-up barrel is necessary when the gold is dirty and does not amalgamate easily. Concentrates, mercury, and weak cyanide solution† are placed in the barrel with a number of large (about 3-4 inches in diameter), clean rocks. The purpose of the rock is to polish the surface of the gold. The barrel is slowly rotated for an hour or more, depending on the condition of the gold. The cyanide solution must be very weak, otherwise the gold will dissolve and be lost. Sufficient mercury should be added to prevent the formation of a hard amalgam. The amount depends upon the quantity of gold present, and is best determined by experimenting.

Recovery of Gold from Amalgam

If the amalgam from the sluice, plate, or other source, is pasty or hard, sufficient mercury should be added to soften it. Then place the amalgam in a chamois skin and squeeze out the excess mercury. The greater the pressure, the more mercury is separated. A certain amount of gold remains dissolved in the mercury. It can only be obtained by distilling off the mercury. The amlgam is placed in an iron retort, which is gradually raised to a red heat. The mercury distills out, leaving behind impure gold. A retort may be constructed from a piece of iron pipe which has been threaded and plugged at one end; the other end is fitted with a union and condenser pipe bent so that the cooled mercury will run out the end. Wet burlap or cloth is wrapped around the condenser pipe. The end of the pipe should not be put under water.

DRY PLACER EQUIPMENT

Machines for operating dry placer deposits, so far as is known, have not been very successful. If a high grade deposit is available, and the gold fairly coarse, a fair saving may be made. The greater part will be blown away or will pass through the screen into the waste discard. The California Division of Mines Quarterly for April, 1932, contains information upon dry placer machines.

PLACER MINING IN IDAHO

The accompanying map shows the localities in which placer gold has been found in Idaho. **No assertion or prediction is made in this paper that gold may still be found in these localities.** In the early days of prospecting, Idaho was quite thoroughly worked over. It is not impossible that some pockets or streams were overlooked, or that in the years that have passed the gold lost in early operations has been reconcentrated. For this reason, the above mentioned map is included as a guide for the use of the inexperienced prospector for whom this brief paper has been written.

LIST OF MINING DISTRICTS TO ACCOMPANY SKETCH MAP OF IDAHO*

On the accompanying map no attempt has been made to show all of the streams or towns. To have done so would have caused unnecessary congestion. So far as the writer was able to determine, the map is reasonably complete in indicating the areas of known production of placer gold. An erroneous conclusion should not be drawn concerning this map. The map is not included as advocating that gold at the present day will be found in the various areas shown. It may be of help to the prospector in so far as a search for gold in a known territory may prove more fruitful than where placer gold has never been found. This should not, however, prevent further prospecting of districts which in the past have proved unfavorable.

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† See Page 18 for making cyanide solution.

* Hill, J. M., The Mining Districts of the Western United States; U. S. Geological Survey Bull. 507 (1912).

PLACER MINING DISTRICTS OF IDAHO

No.	County	Mining District
1	Kootenai	Camas Cove (Tyson)
2	Shoshone	St. Joe
53	Shoshone	Beaver (Coeur d'Alene)
3	Latah	Gold Creek (Potlatch)
4	Latah	Hoodoo (Blackbird)
5	Latah	Moscow
6	Clearwater	Burnt Creek
7	Clearwater	Moose Creek
8	Clearwater	Pierce
9	Clearwater	Musselshell Creek (Weippe)
10	Idaho	Maggie
11	Idaho	Salmon River Placers (Simpson)
12	Idaho	Newsome
13	Idaho	Elk City
14	Idaho	Orogrande
15	Idaho	Salmon River Placers (Simpson)
16	Idaho	Florence
18	Idaho	Warren
52	Idaho	Crooks Corral
17	Adams	Black Lake
21	Adams	Meadows
19	Lemhi	Mineral Hill (Shoup)
20	Lemhi	Gibbonsville
22	Lemhi	Mackinaw
23	Lemhi	Leeburg (Arnett Creek)
24	Lemhi	Kirtley Creek
25	Lemhi	Pratt Creek
27	Lemhi	Yellowjacket
28	Lemhi	Gravel Range (Forney)
29	Lemhi	McDevitt
26	Boise	Gold Fork (Roseberry)
31	Boise	Payette River Placers (Jacobs Gulch)
32	Boise	Deadwood
34	Boise	Quartzburg (Idaho Basin)
35	Boise	Centerville (Idaho Basin)
36	Boise	Idaho City (Idaho Basin)
37	Boise	Monroe Creek
41	Boise	Twin Springs
30	Washington	Monroe Creek (Weiser)
33	Custer	Stanley Basin
38	Elmore	Atlanta
40	Elmore	Highland Valley
39	Ada	Black Hornet (Highland Valley, Shaw Mountain)
42	Ada	Snake River Placers
43	Owyhee	Snake River Placers
45	Owyhee	Snake River Placers
44	Blaine	Soldier
48	Blaine	Snake River Placers
46	Cassia	Snake River Placers
47	Cassia	Snake River Placers
49	Bingham	Snake River Placers
50	Bonneville	Snake River Placers
51	Bonneville	Mt. Pisgah (Caribou)

APPENDIX

IDAHO STATE MINING LAWS RELATING TO PLACER DEPOSITS*

For the benefit of those who are not familiar with the State mining laws regarding placer locations, the reproduction of part of the law is given here. If greater detail is desired, the reader is advised to get a copy of the Mining Laws of the State of Idaho which may be obtained from the State Mine Inspector, Boise, Idaho.

Placer Claims

Paragraph 5535 (3221) Location of placer claims. Placer claims, as mentioned in section 2329 of the Revised Statutes of the United States, may be located for the purpose of mining deposits and precious stones after discovery of such deposits.

Paragraph 5536 (3222) Monuments: Notice: Excavation: Record of notice. The locator of any placer mining claim located for the purpose of mining placer deposits or precious stones must, at the time of making the location, place a substantial post or monument, as is required in the location of quartz claims, at each corner of the location, and must also post at one of the same a notice of location containing the date of the location, the name of the locator, the name and dimensions of the claim, the mining district (if any) and county in which the same is situated; and must also give the distance and direction from said post or monument to such natural object or permanent monument, if any such there be, as will fix and describe in the notice itself the location of the claim. Within 15 days after making the location, the locator must make an excavation upon the claim of not less than 100 cubic feet, for the purpose of prospecting the same. Within 30 days after the location, the locator must file for record in the office of the recorder of the county, or the deputy recorder of the mining district in which the claim is situated, a substantial copy of his copy of notice of location, to which must be attached an affidavit such as is required in case of quartz claims.

Extracts from United States Code Compact Edition
(Title 30, Chapter 2)

Paragraph 35. Placer claims conforming entry to legal subdivisions and surveys: Limitations of claims. Claims usually called "placers," including all forms of deposit, excepting veins of quartz, or other rock in place, shall be subject to entry and patent, under like curcumstances and conditions, and upon similar proceedings, as are provided for vein or lode claims, but where the lands have been previously surveyed by the United States, the entry in its exterior limits shall conform to the legal subdivisions of the public lands. And where placers are upon surveyed lands, and conform to legal subdivisions, no further survey or plat shall be required, and all placer-mining claims located after the 10th day of May, 1872, shall conform as near as practicable with the United States system of public-land surveys, and the rectangular subdivisions of such surveys, and no such location shall include more than 20 acres for each individual claimant, but where placer claims can not be conformed to legal subdivisions, survey and plat shall be made as on unsurveyed lands; and where by the segregation of mineral land in any legal subdivision a quantity of agricultural land less than 40 acres remains, such fractional portion of agricultural land may be entered by any party qualified by law, for homestead purposes.

Paragraph 36. Same: Subdivisions of 10-acre tracts; maximum placer locations. Legal subdivision of 40 acres may be subdivided into 10-acre tracts; and two or more persons, or associations of persons, having contiguous claims of any size, although such claims may be of less than 10 acres each, may make joint entry

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* Mining Laws of the State of Idaho (May 8, 1929).

thereof; but no location of a placer claim, made after the 9th day of July, 1870, shall exceed 160 acres for any one person or association of persons, which location shall conform to the United States surveys; and nothing in this section contained shall defeat or impair any bona fide preemption or homestead claim upon agricultural lands, or authorize the sale of the improvements of any bona fide settler to any purchaser.

IDENTIFICATION OF MINERALS COMMONLY OCCURRING WITH GOLD IN PLACER DEPOSITS *

For the benefit of those who are not familiar with the minerals listed on the following pages of this report, the ensuing information is presented.

Amalgam

An alloy of gold and quicksilver and frequently silver. May contain copper. Color, silver white. Usually liquid but may be solid if there is an excess of gold and silver.

Barite

Heavy spar. Barytes. (Barium sulfate). Brittle. Hardness equals 2.5-3.5. Specific gravity equals 4.3-4.6. Color, white; also may be yellow, gray, blue, red, brown, or dark brown. Transparent to opaque. Characterized by high specific gravity, insolubility in acids, and cleavage.

Cassiterite

Tin stone. Stream tin. Tin ore (tin dioxide). Brittle. Hardness equals 6-7. Specific gravity equals 6.8-7.1. Color, brown or black, sometimes red, gray, white or yellow. Distinguished because of high gravity, hardness, and infusibility.

Chromite

(Iron oxide and chromium oxide.) Brittle. Hardness equals 5.5. Specific gravity equals 4.3-4.6. Has a metallic luster. Color, between iron-black and brownish-black. Sometimes feebly magnetic. Insoluble in acids.

Cinnebar

(Mercury sulfide.) Hardness equals 2-2.5. Specific gravity equals 8. Has a metallic luster. Color, cochineal-red, brownish-red, and lead-gray. Powder has scarlet color. Characterized by its color and high specific gravity, and softness.

Copper

Very ductile and malleable. Hardness equals 2.5-3. Specific gravity equals 8.8. Has a metallic luster. Color, copper-red.

Galena

Galenite. Lead glance (lead sulfide). Usually occurs in cubes. Hardness equals 2.5. Specific gravity equals 7.5. Has metallic luster. Color, lead-gray. Distinguished by color, softness, high specific gravity, and usually cubic cleavage.

Garnet

(Silicates that may contain calcium, magnesium, iron, aluminum, manganese, chromium, or titanium). Usually occurs in crystal-line form. The variety grossularite may be massive without apparent crystal form. Brittle to tough when massive. Hardness equals 6.5-7.5. Specific gravity equals 3.1-4.3. Has a resinous luster. Color, red, brown, yellow, white, apple-green, black; some bright red and green colors; white, when finely powdered.

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* Ford, W. E., Dana's Textbook of Mineralogy. 3rd Ed. (1922).

Gold

Very malleable and ductile. Hardness equals 2.5-3. Specific gravity equals 15.6-19.3. When pure, equals 19.3. Has a metallic luster. Color, gold-yellow, sometimes silver-white; rarely orange-red. Usually alloyed with silver in varying amounts. Distinguished from pyrite and mica by softness and malleability, high specific gravity, and insolubility in acids. Chalcopyrite and pyrite may be confused with gold. They are both brittle and soluble in nitric acid. Usually occurs in placer deposits as flattened scales.

Hematite

(Iron oxide.) Specular hematitie would be the variety most likely to be found in placers. Brittle. Laminated flaky structure. Hardness equals 5.5-6.5. Specific gravity equals 4.9-5.3. Has a metallic luster. Streak has cherry-red or reddish brown color. Color, dark steel-gray or iron-black, or red. When sample is scraped with a knife, small, black, sparkling flakes drop.

Ilmenite

Menaccanite. Titanic iron ore. (Iron titanium oxide.) Occurs in placer as grains. Hardness equals 5-6. Specific gravity equals 4.5-5. Has a somewhat metallic luster. Streak is black to brownish red in color. Color, iron-black. Very slightly magnetic.

Magnetite

Magnetic iron ore. (Iron oxide.) Brittle. Hardness equals 5.5-6.5. Specific gravity equals 5. Has metallic luster. Streak, black. Very strongly magnetic. Sometimes is a magnet itself. Distinguished by being readily attracted by a magnet.

Marcasite

White iron pyrite. (Iron sulphide.) Brittle. Hardness equals 6-6.5. Specific gravity equals 4.9. Has metallic luster. Color, pale bronze-yellow. Streak, grayish or brownish black. Has lighter color than pyrite.

Monazite

(Cerium, lanthanum, thorium phosphate.) Usually occurs in grains. Sometimes flattened. Brittle. Hardness equals 5-5.5. Specific gravity equals 4.9-5.3. Has a resinous luster. Color, hyacinth-red, clove-brown, reddish or yellowish brown. Slightly transparent.

Platinum

(Alloyed with iron, iridium, rhodium, palladium, etc.) Usually in grains or scales. Malleable and ductile. Hardness equals 4-4.5. Specific gravity equals 14-19. When pure, 21-22. Has a metallic luster. Color, whitish steel-gray; shiney. Occasionally magnetic (if high in iron). Distinguish by color, high gravity, malleability, and insolubility in acids.

Pyrite

Iron pyrite. (Iron sulphide.) Brittle. Hardness equals 6-6.5. Specific gravity equals 4.9-5.1. Has metallic, glistening luster. Color, a pale brass-yellow. Streak, greenish black or brownish black. Quite often occurs as cubes.

Rutile

(Titanium dioxide.) Brittle. Hardness equals 6-6.5. Specific gravity equals 4.25. Has metallic luster. Color, reddish-brown to red; sometimes yellowish, bluish, violet, black. Powder, pale brown.

Scheelite

(Calcium tungstate.) Brittle. Hardness equals 4.5-5. Specific gravity equals 5.9-6.1. Color, white, yellowish - white, pale yellow, brownish, greenish, reddish. Powder, white.

Silver

Ductile and malleable. Hardness equals 2.5-3. Specific gravity equals 10.1-11.1. Pure, 10.5. Has metallic luster. Color, silver white; sometimes gray to black from tarnish. May contain some gold, copper, antimony, bismuth, or mermucy.

Stibnite

Antimonite, antimony glance. (Antimony trisulphide.) Hardness equals 2. Specific gravity equals 4.5. Metallic luster, sparkling appearance on fresh surface. Color, lead-gray. Streak, lead-gray.

Tourmaline

(Boron and aluminum silicate.) Brittle. Hardness equals 7-7.5. Specific gravity equals 2.9-3.2. Luster, vitreous to resinous. Color, black, brownish-black, bluish-black; may be blue, green, red, white, or colorless. Usually has a triangular-looking cross section.

Wolframite

(Iron, manganese tungstate.) Brittle. Hardness equals 5-5.5. Specific equals 7.2-7.5. Luster, sub-metallic. Color, dark grayish or brownish-black. Streak, nearly black. Sometimes weakly magnetic.

Zircon

(Zirconium silicate.) Brittle. Hardness equals 7.5. Specific gravity equals 4.7. Color, colorless, pale yellowish, grayish, yellowish-green, brownish-yellow, reddish-brown. Streak, uncolored.

EXPLANATION OF TERMS

The relative hardness of a mineral can be determined as follows:

The finger nail scratches minerals with a hardness of 2.

Those with a hardness of 3 are easily cut with a knife.

Minerals with a hardness of 4 are rather easily scratched with a knife.

Those minerals with a hardness of 5 are scratched with difficulty by a knife.

Hardness of 6 is barely scratched with a knife, but easily with a file. These minerals scratch glass.

Minerals with a hardness of 7 (for example, quartz) or over, scratch easily, but are barely scratched with a file.

In determining hardness, use is made of the following:

The finger nail was a hardness of 2.

A copper cent has a hardness of about 3.

The ordinary pocket knife is just over 5.

Ordinary window glass has a hardness of 5.5.

A piece of an unglazed dish, plate, or cup, is suitable for determining streak. Or the mineral may be finely powdered.

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* Publications especially interesting and instructive.

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Finch, John W., Prospecting for Gold Ores; Pamphlet No. 37. (1932)

Fahrenwald, A. W., Recovery of Gold from Its Ores; Pamphlet No. 37. (1932)

For chemicals, mineral collections, blow-pipe outfits, etc., The Denver Fire Clay Company, Denver, Colorado, and the C. M. Fassett Company, Spokane, Washington, are suggested.