UNIVERSITY OF NEVADA
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PLACER EXAMINATION
PRINCIPLES AND PRACTICE

A thesis submitted in partial fulfillment of the requirements for the degree of Engineer of Mines

by

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PREFACE

As the title suggests, the subject matter in this book deals for the most part with the examination and testing of placers. It is intended primarily as a guide for the professional mineral examiner who examines mining claims located on public lands of the United States.

The book has been divided into eight parts or sections. Parts I and II, which deal with placer-forming processes and types of placers, are intended as a review of placer fundamentals. Other sections bring together the fundamentals of placer investigation and industry-proven testing procedures.

Part VIII is a glossary of the placer industry, setting out more than three hundred placer-related terms and definitions, many of which have not previously appeared in glossary form.

In scope, this book covers problems of placer investigation from initial reconnaissance to computing the value of a blocked-out placer. It is intended to serve as a reference book as well as a manual for day-to-day work. Its use should help the mineral examiner identify his sampling problems and select procedures appropriate to the purpose of his examination and to the deposits involved.

While this book has been prepared specifically for use by Bureau of Land Management personnel, it is hoped that it will at the same time be useful to the mining profession generally.
PART I

REVIEW OF PLACER THEORY
AND GEOLOGY
1. PLACERS DEFINED

In the United States mining law, mineral deposits that are not veins in place are treated as placers so far as locating, holding and patenting are concerned. But for the purposes of this book, the term “placer” is applied to deposits of sand, gravel, and other detrital or residual material containing a valuable mineral which has accumulated through weathering and mechanical concentration processes. Prerequisites for a placer are:

A valuable mineral which is relatively heavy and is resistant to weathering and abrasion.
Release of the valuable mineral from its parent rock.
Concentration of the valuable mineral into workable deposits. This step usually involves water transport.

The term “placer” as used in this book applies to ancient (Tertiary) gravels as well as to recent deposits, and to underground (drift mines) as well as to surface deposits.

2. STUDY OF PLACERS - GENERAL

The study of placers is not simple—it involves many of the disciplines of geology, with special emphasis on the theory and habits of streams. Although the location, size, and shape of a placer will reflect the regional forces of erosion, transportation, and deposition which created it, its final form will be controlled or modified by purely local conditions. As a result, each placer deposit can be expected to be unique in one or more ways and the field investigator should approach his work with this in mind.

All placers begin with weathering and disintegration of lodes or rocks containing one or more heavy, resistant minerals such as gold, platinum, magnetite, garnet, zircon, cassiterite, monazite, etc. It should be stressed that the end richness and size of a placer deposit will depend more on there being an abundant supply of source materials, and on conditions favorable for their concentration, than on the actual richness of the primary source. While the following paragraphs refer largely to gold placers, the principles set forth apply to all types. At the risk of oversimplification, a brief discussion of basic placer-forming processes will be taken up under the following headings:

- Sources of valuable mineral.
- Weathering and release processes.
- Stream processes related to placers.
- Concentration of valuable minerals.
- Preservation of the deposit.

3. SOURCES OF VALUABLE MINERAL

The source of gold or other minerals found in a placer may be one or more of the following:

a. Lodes or mineralized zones.
b. Erosion of pre-existing placer deposits.
c. Low-grade auriferous conglomerates or glacial debris.
d. Magmatic segregations and associated basic rocks.
e. Regional rocks containing scattered particles of valuable mineral.

a. Lodes: Although placers are commonly found in lode mining districts, experience has shown that there is no fixed relation between the richness of the parent lode and the richness or size of resultant placers. Some of the most noted gold mining districts such as Goldfield, Nev., contain no significant placers. On the other hand, some highly productive placer areas are not associated with valuable lodes, the Klondike region being an example. In some cases the lode source may have been completely removed by erosion, while in others, it can be demonstrated that the gold or other valuable mineral was not derived from a single source, but instead, from many small mineralized seams or zones scattered through the bedrock. Although individually unimportant, these smaller sources can collectively furnish substantial amounts of gold.

b. Pre-existing placers: In many localities old placers have been destroyed by erosion and their gold content re-concentrated in present day streams. Excellent examples are found in the Sierra Nevada region of California. Here, in Tertiary times, beginning some 60 million years ago, there existed an extensive river system, a prolonged time of rock decay, and a good balance between erosion and deposition. These factors combined to form
they can be important, as shown by Goodnews Bay platinum deposits where dredging has been carried on since 1937.

e. Regional rocks: Monazite placers of the type dredged in central Idaho, provide an excellent example of a placer mine originating as small, sparsely distributed particles in the country rock. The monazite, which is a rare-earth mineral, is chiefly valuable for its thorium content and is commonly concentrated in regional granitic rocks. Following liberation by the usual weathering processes it finds its way into stream deposits, where because of its moderately high specific gravity, it accumulates in placers along with other heavy minerals. Similarly, most of the magnetite, ilmenite, rutile, garnet and zircon associated with gold placers, could be transported to the regional bedrock where such minerals commonly occur as scattered particles or accessory minerals.

4. WEATHERING AND RELEASE PROCESSES

The first step in placer formation is release of valuable mineral from its parent rock. To the various phenomena which combine to decompose and disintegrate rocks are embraced in the general term “weathering.”

The chief agents of rock weathering are:

a. Ground water.

b. Temperature change.

c. Plant growth.

d. Surface erosion.

5. STREAM PROCESSES RELATED TO PLACERS

Because streams are the dominant agent in the formation of most placer deposits, the field engineer should understand the fundamental processes involved in the movement and deposition of sediments by flowing water. In particular, he should be able to relate stream processes to the mechanics of placer formation. Actually this is a complex subject but several of the more important concepts of stream processes related to placer formation are:

a. Stream bed erosion occurs only when the floor has the ability to transport more material than is being supplied, and conversely, deposition will begin when the stream becomes overloaded or has its velocity sufficiently checked.

b. Temperature: Change of temperature combined with frost wedging plays a part in rock weathering, particularly in desert regions where changes may be rapid and extreme. The effects of frost wedging are readily apparent where it loosens large blocks, but its lesser-known and more important function is the wedging apart of minute rock scales and mineral grains, which in some cases, is an effective agent of rock destruction.

c. Plant growth: Plants contribute to rock destruction and mineral release in two ways:

   1. Root growth forces open and extends surface and near-surface cracks and cavities.
   2. Decaying plants contribute rock solvents to the percolating ground waters. Decomposing vegetation is a very powerful agency of decay and, consequently, wet, humid climates favor the development of deep mantles of decomposed rock and the liberation of placer-forming minerals.

d. Surface erosion: On the steeper slopes surface erosion becomes more effective and, in turn, chemical rock decay assumes a larger role in the weathering process. The rapid surface erosion of relatively unweathered rocks in desert regions can result in the formation of placers, but as shown by Lindgren (1933, p. 219), such placers are not often rich or highly concentrated.

e. Stream conditions wherein the entire bed load is shifted or is agitated sufficiently to allow a downward movement of gold particles may occur only during extreme flood conditions or periods of regional climatic change, many years or centuries apart. Nevertheless, bed scour or movement of the whole contents of a stream bed, or of all except the large boulders, is essential to formation of the typical stream placer.

Longwell, Knopf and Flint (1948) present in concise language, a broad picture of fluvial processes and the movement of alluvial material by streams. Although this reference does not discuss the formation of placers it can serve as a quick review of fundamental principles. Jenkins (1946), in an article titled “New Technique Applicable to the Study of Placers,” discussed stream processes and their relation to placers in...
6. CONCENTRATION OF VALUABLE MINERALS

In theory, the richest part of a placer should be found near bedrock and, because of this, many people think that gold placers invariably are richer on bedrock than elsewhere within the deposit. On this basis, they believe that if indications of value are found in the upper horizons, pay gravel will surely be found on bedrock and countless mining ventures have been launched on this premise. Needless to say, many failed. In practice, it is not uncommon to find deposits in which the pay is scattered through a gravel mass without a significant bedrock enrichment. Some deposits, in fact, have their concentrations at the surface rather than on bedrock. This type of occurrence is explained in the section titled “Flood Gold Deposits.”

Another popular idea is that concentration of gold in a stream is analogous to concentration in a sluice box. But in nature the process is by no means as simple as will be shown in following paragraphs.

a. Bedrock Concentration: The development of bedrock concentrations in simple stream deposits may be generalized as follows: Consider a down-cutting stream in which the bed load of sand, gravel and boulders is progressively shifting downstream and subjected to general agitation during times of high water. During high-water periods some of the smaller and lighter particles will be picked up and advanced by the current, usually in a series of short jumps, while the heavier rocks and boulders roll and slide along the bottom. Each time the bed load moves or is generally agitated, the contained gold particles can work downward toward bedrock. Under favorable conditions this may be quite rapid but in many deposits, such bed movements occur only at long-spaced intervals—perhaps not within the lifetime of any one observer. Nevertheless, it must be realized that without such movement and rearrangement of the entire bed load, a downward migration of the gold would not be possible. Under flood conditions fine gold may be swept up and carried away but once coarse gold has settled to the bedrock it is very difficult for the current to dislodge it. For this reason coarse gold is generally found near its source.

b. Types of Bedrock: The ultimate richness of a placer is dependent to a large extent on the physical characteristics of the bedrock. Slate and jointed rocks, particularly those dipping at steep angles are considered most effective in capturing and holding gold. Compact clay, clayey volcanic tuff and decomposed granite make effective bedrocks. A smooth, hard bedrock such as serpentine is generally considered to be a poor gold saver. In some important placer fields, the pay gravels rest on a false bedrock. In the Folsom, California area, for example, this is usually a layer of volcanic tuff found well above the true bedrock.

Gold works its way into soft or decomposed bedrocks and settles into the cracks and crevices of hard formations. It commonly migrates downward to an extent requiring the mining of several feet of bedrock to effect a complete gold recovery. In some cases, inability to dig a hard, rough bedrock has been the direct cause for failure of dredging ventures. In others, having to dig unexpected amounts of soft bedrock has seriously upset the initial cost estimates. Such possibilities should always be considered when evaluating a placer property.

c. Pay Streaks: Bedrock enrichments known as “pay streaks” usually follow a sinuous course and sometimes have no discernible relation to the present stream channel. A pay streak may split or terminate suddenly and its lateral limits may be irregular or indefinite, its location and eccentricities being dictated by local controls. Bear in mind that conditions which caused the pay streak, particularly in the case of older deposits, may no longer be in evidence. Pay streaks in gravel-plain or similar widespread-type placers are usually less definite than those in stream placers.

7. PRESERVATION OF THE DEPOSIT

Placer deposits do not suddenly come into being but, instead, they are progressively accumulated and enriched by a succession of stream actions and interactions. Although the land forms and
PART II

TYPES OF PLACERS
Perhaps the best known schemes for classifying placer deposits are those by Jenkins (1946, p. 161) and Brooks (1913, pp. 25-32), the former being based on conditions of deposition and the latter on present position of the deposit. The field engineer should acquaint himself with these schemes, particularly that by Jenkins which has been developed in some detail. For the usual field investigation a somewhat simpler classification will be found suitable. This is:

1. Residual placers.
2. Eluvial placers.
4. Bench placers.
5. Flood gold deposits.
6. Desert placers.
7. Tertiary gravels.
8. Miscellaneous types.
   a) beach placers.
   b) glacial deposits.
   c) eolian placers.

1. RESIDUAL PLACERS
A residual placer is, in effect, a concentration of gold (or other heavy mineral) at or near its point of release from the parent rock. In this type of placer the enrichment results from the elimination of valueless material rather than from concentration of values brought in from an outside source. Residual placers may be rich but they are not likely to be large and as a class, they have been relatively unimportant. The “seam diggings” in El Dorado County, Calif., (Clark and Carlson, 1956, p. 435) offer an example of residual gold placers.

2. ELUVIAL PLACERS
Eluvial placers usually represent a transitional stage between a residual placer and a stream placer. Where one type merges into another, they cannot be clearly distinguished. They are characteristically found in the form of irregular sheets of surface detritus and soil mantling a hillside below a vein or other source of valuable mineral. It should be noted that the parent vein or lode may or may not outcrop at the actual ground surface. Eluvial placers differ from residual placers in that surface creep slowly moves the gold and weathered detritus down hill, allowing the lighter portions to be removed by rain wash and wind. As the detrital mass gravitates downhill, a rough stratification or concentration of values may develop but this is rarely perfected to the degree found in stream placers. Eluvial placers are typically limited in extent but there have been cases such as at Round Mountain, Nevada, (Vanderburg, 1936, pp. 133-145) where this type of placer supported large-scale mining operations.

3. STREAM PLACERS
Stream placers are the most widespread type in the Western States and, accordingly, are the type most frequently encountered in mineral examinations. Individual deposits vary so much that few general statements can be made concerning them but for the purpose of this review, they can be conveniently divided into:

a. Gulch placers.
b. Creek placers.
c. River deposits.
d. Gravel-plain deposits.

a. Gulch placers: Gulch placers are characteristically small in area, have steep gradients and are usually confined to minor drainages in which a permanent stream may or may not exist. This type of placer is, as a rule, made up of a mixture of poorly sorted gravel and detritus from adjacent hillsides. Because of steep gradient, the gravel accumulations are often thin and discontinuous. Boulders are commonly found in quantities that preclude all but simple hand mining operations. The gold is likely to be coarse and well-concentrated on bedrock. Gulch placers were usually the first to be found by the early miners and because most can be worked with simple hand tools, unworked remnants of shallow gulch deposits are not likely to contain material that would yield a profit today. The early-day miner was generally well-schooled by experience, and a diligent worker. Any pay gravel that he left was usually cleaned up by the patient Chinese who followed. This was particularly true in gulch placers.

References cited will be found at the end of Part II.
b. Creek placers: In many districts creek placers have been important sources of gold but like the gulch placers most were carefully prospected by the early miners and worked out, where worthwhile to do so. Many of the lower-grade remnants left by the early hand miners have since been exploited by some form of mechanized mining, notably by dragline dredging during the depression years of the 1930's. Creek placers as a group no longer contain significant economic reserves in the Western States but some in Alaska are mined with nonflooding washing plants and moveable sluices utilizing various combinations of hydraulic and mechanical excavation equipment.

c. River deposits: River deposits are represented by the more extensive gravel flats in or adjacent to the beds of present-day rivers and as a class, they have been our most important source of placer minerals. They are generally similar to creek placers but the gold is usually finer, the gravel well-rounded and large boulders fewer or absent. Although the over-all deposit may be low-grade, pay streaks and bedrock concentrations capable of supporting mining operations and other large-scale mining operations are not uncommon. At many places in California, the early miners diverted rivers through tunnels or bypassed the water in flumes to permit mining the river bed. In this manner, many miles of the middle and upper reaches of the principle gold-bearing rivers were effectively cleaned out. The lower reaches of many of these streams were systematically dredged and at one time, where conditions were favorable, gravels returning five cents per cubic yard were dredged at profit. Needless to say, few important river deposits remain unknown in the United States.

d. Gravel-plain deposits: These are somewhat difficult to define as they may grade from river or bench deposits, into flood-plain or delta-type deposits and they can be geologically old, or recent. Gravel plains are found where a river canyon flattens and widens or, more often, where it enters a wide, low-gradient valley. The contained placer deposits are generally similar to those in river deposits except for greater size and a more general distribution of gold. Because gravel-plain deposits are built by tributary stream channels, their gold is apt to have wide lateral and vertical distribution as because of the relatively low velocities of streams flowing over flood plains, the placer are commonly made up of smaller-size gold compared with that found in the main stream deposits. Any larger gold carried by the main channel will likely be dropped close to the upper edge of the flat plain where the stream's velocity decreases and its transporting ability is reduced. Although subject to surface wash and flood erosion, most gravel-plain deposits are relatively permanent. Examples of this type of deposit are the dredging fields at Hammond, and those near Foster, California. Each produced gold valued at approximately $100,000,000.

4. BENCH PLACERS

Bench placers are usually remnants of deposits formed during an earlier stage of stream development and left behind as the stream moved down stream. The abandoned segments, particularly those on the hillside, are commonly referred to as "bench" gravels. Frequently there are two or more sets of benches in which case the miner refers to them as "high" benches and "low" benches. In California and elsewhere, most bench deposits were quickly found by the early miners who proceeded to work the richer bedrock streaks by primitive forms of underground mining. At the time these were referred to as "hill diggings." Following the development of hydraulic mining in the 1850's, many of the larger bench deposits were worked by hydraulic mining and the smaller ones by ground sluicing. During the depression years of the 1930's, much of the so-called "sniper" mining was carried out on remnants of bench gravels and it should be noted that these hard-working individuals seldom recovered more than 25 or 30 cents per day.

5. FLOOD GOLD DEPOSITS

As a rule, finely-divided gold travels long distances under flood conditions. This gold which can best be referred to by the miners' term "flood gold," consists mostly of minute particles so small that it may contain 1,000 to 5,000 colors to be worth 1 cent. With few exceptions such gold has proven economically unimportant. The mineral examiner should recognize the true nature of flood gold deposits so that he can guard against being misled by their seemingly-rich surface concentrations. As a stream sweeps around a curve, the water is subject to tangential forces which cause a relative increase in velocity along the outer radius of the curve with a corresponding decrease along the inside radius. The bottom layer of water is retarded by friction and as a result, it has a tendency to flow sideways along the bottom toward the inner bank. This, in turn, causes sand and small gravel to accumulate in the form of an accretion bar along the inside bank of the curve and where flood-borne particles of gold are being carried down the stream, some will be deposited near the upper point of such bars, as shown in Figure 1. The foregoing is an oversimplification of a complex stream process but the fact is, in streams draining a gold-bearing region, seemingly rich and simple sluicing operations and, by cleaning up the richer spots, a few did fairly well. It was inevitable that some would proceed to install dredges or other large washing plants and launch ambitious mining schemes on the strength of surface showings. Needless to say, following the exhaustion of superficial pay streaks, most of these large-scale mining schemes proved unprofitable. The foregoing is point out because flood gold concentrations must be still to be found and without doubt, new mining ventures will be proposed and attempted from time to time, particularly by advocates of suction dredges. The mineral examiner should learn to recognize flood gold deposits and equally important, he should be fully aware of their pitfalls.

6. DESERT PLACERS

Desert placers in the Southwest occur under widely varying conditions but the forms they are so different from most normal stream placers as to deserve a special classification. When dealing with the usual desert placer the mineral examiner must learn to disregard some of the rules of stream deposition, or at least, be aware that he must learn to apply them with caution. Desert placers are found in arid regions where erosion and transportation of debris depends largely on fast-rising streams that rush down gullies and dry washes following summer cloudbursts. During intervening periods, varying amounts of sand, gravel or side-hill detritus is carried in from the sides by lighter, intermittent rain which is sufficient to move material into the washes but not carry it further. When the next heavy rain comes, a torrential flood may sweep up all of the accumulated detrital fill, or only part of it, depending on intensity and duration of the storm and depth of fill. It should be obvious that the intermittent flows provide scant opportunity for effective sorting of the gravels or concentration of gold. Under such conditions the movement and concentration of placer gold will be extremely erratic. Moreover, where the entire bedload is not moved, any gold concentration resulting from a
7. TERTIARY GRAVELS

Gold-bearing gravels of Tertiary age are abundant in the central Sierra Nevada region of California and to a lesser extent in northwestern California and southwestern Oregon. A few are found in northeastern Oregon and central Idaho. In California, many miles of these ancient river channels can be found in a number of publications among which are those published by the Arizona Bureau of Mines (Wilson and Fansett, 1961), the University of Nevada (Vanderburg, 1936) and the California Division of Mines (Haley, 1923, pp. 154-160).

Tertiary Channels (Clark, 1965, pp. 39-41). This article contains a brief history of mining operations and descriptions of the Tertiary channels of the Sierra Nevada region. Contains indexed map with list of principal deposits and bibliography.

California’s Gold-Bearing Tertiary Channels (Jenkins & Wright, 1934). A condensed but excellent discussion of the origin of California’s Tertiary gravels and related geology. Highlights factors in gold accumulation and discusses methods of geological exploration and prospecting as aids to future exploration work.

Tertiary Gravels of the Sierra Nevada of California (Lindgren, 1911). A classic on Tertiary gravels and related subjects. Most writers on placer subjects have drawn heavily from this source of information and as a result, quotations from and references to Lindgren’s work are prominent in the literature.

The Auriferous Gravels of the Sierra Nevada of California (Whitney, 1880). Discusses in considerable detail, the concepts (circa 1679) of origin and deposition of Tertiary gravels. This book is best suited to advanced study. Also contains maps and excellent descriptions of important Sierra Nevada placer mining districts and offers some of the best available data on individual mining operations of the day. Includes chapters by W.A. Goodyear and W.H. Pettee.

The Ancient River Beds of the Forest Hill District (Brown, 1890). One of many excellent articles describing Tertiary gravel deposits and related mining operations that have been published by the California State Mining Bureau.

Tertiary Gold-Bearing Channel Gravel in Northern Nevada County, California (Peterson and others, 1969). A report on studies of the San Juan Ridge Tertiary channel in Nevada County, California, made as part of the Department of the Interior’s Heavy Metals Program. It describes the geology and physical characteristics of a 15-mile section of this channel and also discusses geophysical investigations of the channel gravel carried out by personnel of the United States Geological Survey. Seismic, resistivity, gravity, magnetic, electromagnetic, and induced polarization geophysical methods were applied and evaluated. 22 pp., maps, illus.

Gold Resources in the Tertiary Gravels of California (Morwin, 1965). Contains summaries of results of investigations conducted by the United States Bureau of Mines under the Department of the Interior’s Heavy Metals Program. It reviews the history of hydraulic and drift mining in California’s Tertiary gravels and the reasons for cessation of large-scale mining of these deposits. The report discusses general geology, the distribution of gold within the gravels, past production, and gold reserves. 14 pp., illus., bibliography.

Most of the foregoing references are of a technical nature and primarily of interest to engineers and geologists. The term “Tertiary gravel” is used broadly to designate extensive gold-bearing gravel deposits laid down in ancient streams approximately 50 million years ago. These often-rich channels were subsequently buried under as much as 1500 feet of younger gravels and volcanic material which effectively sealed and preserved the original placers. The present Sierra Nevada range and its Tertiary deposits have since been elevated by mountain-building disturbances and, today, the dissected channels are typically found as lava-capped segments high above the present streams. Parts of the Tertiary deposits were worked extensively by the hydraulic method during the latter half of the 1800’s and in many places, the richer bedrock gravels were exploited by tunneling operations known as “drift mines”, some of which followed the ancient channels for miles along their subterranean course. Parts of California’s Tertiary channel system remain buried and unexplored; these are believed to contain a large gold reserve, available for mining at some future date.

B. MISCELLANEOUS TYPES

There are other less publicized types of gold placers that are not economically important today, but which might achieve importance at some future date. For this reason a brief discussion and some selected references are offered here.

a. Beach placers: Beach placers may form where gold-bearing gravel is carried into the ocean by streams, or along the wave-cut base of a gold-bearing coastal plain. With exception of the highly productive beach placer deposits discovered at Nome, Alaska, none have been of great importance in the Western States. Typical beach placers along the Pacific coast are found as eratically distributed, somewhat biconcave concentrations or streaks of black sand minerals with varying amounts of finely-divided gold and in some places, with platinum-group minerals. Beach placer black sands can be expected to consist largely of magnetite and ilmenite but significant amounts of chromite are found in some Oregon beaches. In the case of gold-bearing beach placers, the individual black sand concentrations are seldom over 100 feet long or more than a few feet thick. Those found on the active beaches are the result of storm and tidal action, and they come and go with changing conditions of the beach. Some of the most productive placers have been found in ancient, elevated beaches that are now several miles inland.

Beach mining reached its height following discovery of the rich gold placers at Nome, Alaska, in 1898. Here, over two million dollars were produced from a 20-mile section of modern beach about 200 feet wide, and another 15 million from a series of inland elevated beaches. Subsequent discoveries on other Alaskan beaches, and elsewhere along the Pacific coast, resulted in little gold rushes but little production. Some beach placers along the California-Oregon coast have been worked in the past by simple hand mining methods and although a number of large-scale operations have been attempted, none, to this writer’s knowledge, have been successful.

Over the years a number of attempts have been made to mine magnetite-rich black sands for their iron content and during World War II some chromite was recovered from ancient beach deposits in Oregon. (Kasabian and Baber, 1956, pp. 12, 13).
The fundamentals have been well set out by the engineer should know about glacial obscure, is a "glacier" placer. For this reason particularly if its origin is unusual for a miner to assert that a placer directly associated with Glacial deposits: working in the Western States may seldom containing detrital gold.

analyzing beach or marine deposits by the United States Geological Survey normally encountered when sampling and (1962); and by Jenkins (1946). Recent work those by Pardee (1934); Dasher, Fraas and Gabriel (1942); Twenhofel (1943); and California are available, among which are those by Brooks, Alfred H., 1932, Gold placers of California: Bulletin 92, California State Mining Bureau, p. 167.


Jenkins, Olaf P., 1946, New technique applicable to the study of placers: California Division of Mines Bull. 135, Placer mining for gold in California, pp. 149-216.


Gold derived from the outcrops of vein is thus mixed with large masses of barren earth. Attempts to mine gold's glacial moraines, where bits of richly widened scoured float have been found are, for that reason foredoomed failure.

"If a glacier advances down a valley which already contains gold-bearing rock, it is apt to gouge out the entire mass, mix it with much other detritus and deposit it later as useless till. Under such circumstances, however, it merely slide over the gravel and buries it without distributing it.

On the other hand, the streams of glaciers or slowly consuming these moraines have the power to winnow the particles of rock and mineral matter according to size and heaviness. Sub streams may form gold placer deposits in the well-known way by churning the load they carry and allowing the heavy minerals to sink to the bedrock. Placer may therefore be found in the deposits of glacial rivers if there are gold veins exposed in the glaciated area upstream. Nearly all the gravel which has been dredged for gold along the foothills of the Sierra Nevada was deposited by rivers derived from part from glaciers along the crest of the range, but most of the gold was probably picked up in the lower courses of such rivers. Since glacial rivers chafe themselves and build up their channels progressively, their deposits are likely to be thicker and not so well concentrated as those of the more normal graded rivers which are not associated with glaciers.

Where a glacier-related placer is encountered, the field engineer should, as an early step in his investigation, search out and study all available technical literature relating to the glacial history of the region. In particular, he should seek any reliable information on past mining of the deposit or similar deposits in the district, the object being to determine if significant gold concentrations are to be expected and, if so, under what conditions they are likely to be found.

Two districts having glacier-related placers that are well described in the technical literature are now near Breckenridge and Fairplay, in Colorado. At Fairplay (Singerwald 1950), the actual moraines were mined locally but the most extensive and productive placers were found in waste among extend ing away from the true moraines. At Breckenridge (Ransome, 1911, pp. 175-181), beach gravel associated with Pliocene glacial gravel deposits were mined by ground sluicing and hydraulicking while younger gravels derived from glacial moraines have been extensively dredged along the Swan and the Blue Rivers. Both districts are well described in the literature referred to.

In general, glacial deposits that have been scooped from highly mineralized bedrock areas may be expected to contain gold but it will probably have little or no economic value unless resorted by post-glacial streams.

c. Eolian placers: In desert regions the wind may act as an agent of concentration by blowing sand and the lighter rock particles away from a body of low-value material and leaving an enriched surface veneer containing gold or other heavy minerals in a somewhat concentrated state. There have been many cases where wind-caused surface enrichments supported the activities of itinerant miners using hand tools and simple dry washers.

Although commercial-grade eolian placers are not likely to be encountered by today's mineral examiner, he should be aware of their existence and should be alert to their misleading appearance. In other words, when taking near-surface samples from desert placers, he should guard against unintentional salting which could result from the inclusion of non-representative, wind-caused surface enrichments.

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Jones, Olaf P., 1946, New technique applicable to the study of placers: California Division of Mines Bull. 135, Placer mining for gold in California, pp. 149-216.
PART III

SAMPLING AND EVALUATION
If the reader will pause and study Figure 2, he can better visualize the more pertinent placer sampling problems, as they are taken up in the following paragraphs.

1. GENERAL CONSIDERATIONS
   a. Problems: Contrary to popular belief, representative placer samples are seldom easy to obtain and in almost all cases sample results need a large measure of interpretation. Some of the underlying reasons are:
      (1) Large particle sizes to be dealt with. A representative sample should contain all of the constituents of a deposit and in exactly the same proportion in which they occur in the parent mass. But look at Figure 2. This deposit is a mixture of fine sand, pebbles and boulders varying from a few tens of pounds to hundreds of pounds, and in this respect, is typical of many placers. A little study of Figure 2 will show why when dealing with such deposits, it is virtually impossible to take a small sample representative of the whole mass, and why the evaluation of such a deposit can tax the ability of an expert.
      (2) High unit-value of gold. When dealing with the typical placer sample containing a high-value mineral such as gold, any error in mineral content of the sample will be highly magnified in the end result. Consider that in a commercial placer the
relative amount of gold (by volume) may be on the order of one hundred million parts of gravel. 1/ To the mineral examiner this means that a single fly speck of gold in a pan of gravel is equivalent to say, 2 to 5 cents per cubic yard, depending on the exact size of the speck. The amount of small amounts of such gold from overlapping quantities of sand and gravel seldom presents a serious problem; the real problem is to take a sample that is representative in the first place.

(3) Erratic distribution of values. Obtaining a satisfactory placer sample would be a comparatively simple undertaking if the valuable minerals were uniformly distributed throughout the whole mass. In almost all placers, however, the heavy minerals and particularly the gold are more or less segregated. For example, in cases where economic values are confined to pay streaks, these are likely to occur as narrow, discontinuous accumulations with perhaps little or no value in between. Where coarse gold is present it can be expected to be even more erratic in distribution and it will be evident that under such conditions reliable valuation will depend on something more than taking a few small samples and an exercise in arithmetic. In theory, these problems can be overcome by taking samples large enough to offset the eccentricities of a deposit, but to do so, would mean taking samples measured in tons rather than pounds and it is seldom possible to take such large samples in actual practice. Some approach the problem by arguing that if enough small samples are taken, the highs will balance the lows and the end figure will represent the average value of the deposit even though no one sample is correct. This may be statistically true but here again, practical considerations seldom permit taking the number of samples needed to achieve this end.

b. Industry practice: How do the established placer mining companies evaluate prospects? First, the prospecting is put in charge of an employee who has had experience with the type of deposit, mining project involved. Second, the prospecting is presented to any one sample that is representative of the overall deposit and it will be emphasized that the successful placer companies place as much reliance on the experience and insight of their prospecting and management personnel as they do on sample results. If there is a mathematical formula or a general rule which will replace experience-based judgement, the operating companies have not found it.

c. Minerals other than gold. Parenthetically, it should be noted that placer chiefly valuable for minerals such as molybdenite, rutile, cassiterite, ilmenite, etc. are generally not on sample and evaluate than gold placer. There are several reasons. First, the valuable mineral makes up a larger part of the mass. Second, the mineral sought has a relatively low unit value which means that extraneous particles of such mineral (in a sample) may have little effect on the calculated value. Third, deposits containing such minerals are often made up of well sorted, small size detrital materials such as beach sands and, in such cases, the mechanics of sampling may be simplified by permitting the use of auger or jet drills in lieu of churn drills. Speaking generally, the sampler has considerably more latitude when dealing with minerals of low unit value than when dealing with gold and his mistakes are less likely to seriously affect the end results.

d. Other factors to be considered: Many things other than mineral content have a direct bearing on the commercial value of a placer deposit. The mineral value in itself may be of secondary concern where sampling or examination of the lands for example, show unfavorable bedrock conditions, excessive amounts of sticky clay, large boulders or other factors that would adversely affect a placer mining operation. A good sampling program will provide the information needed to evaluate adverse physical conditions, should they exist, but here again experience is needed to interpret the information and make correct decisions.

e. In brief: Placer samples yield limited information. Correct interpretation of this information depends upon the engineer's powers of deduction and experienced judgement, rather than on the rigid application of formulae.

2. SAMPLING GUIDES

For practical reasons, placer sampling incorporates a series of steps which may be carried out one at a time or in some cases are more or less combined. These may be defined as:

a. Pre-sampling reconnaissance.

b. Choosing a sampling method.

c. Number and size of samples.

d. Reconnaisance of the lands.

2. Evalution of results.

The first step can be further divided into three parts which will be discussed here under the following headings:

a. Pre-sampling reconnaissance.

b. Choosing a sampling method.

c. Number and size of samples.

d. Reconnaissance of the lands.

The lands to be sampled merit careful consideration, particularly those from which some production has been made. Where production records are available, they often serve as a useful guide in the selection and interpretation of new samples. Nearby mines should also be visited and examined where possible to do so.

Because the reconnaissance must be tailored to suit the job at hand, no fixed procedures can be set out here. The effort and time required for an adequate job will depend on the examining engineer's experience and perception.

b. Choosing a sampling method: What sampling method should be used? This question comes up early in most placer investigations but there is no easy answer. Because each deposit has unique characteristics there is no single "best" method of sampling and no procedure can be applied universally. In some cases, decisions will have to be made on a sample-by-sample basis but a good pre-sampling reconnaissance will usually indicate if the ground should be tested by means of pits, shafts, churn drilling, or other means. It is a paradox that the very things which are to be determined by sampling are
often things which govern the type of sample to be taken in the first place. This is a "chicken-and-egg" type of situation in which we sometimes cannot tell which comes first. Something, what in mind is the fact that today's placer sampling is expensive. Because of this, the method or sampling program adopted should be no more elaborate than needed to provide the amount of detail and the end accuracy required for a particular determination. For example, the prospector, whose main concern is to expose enough of a "showing" to interest a second party or mining company in his prospect, would be foolish to expend his own time and money attempting to carry out an elaborate sampling program, that is, sampling which any cautious mining company would do over again for their own satisfaction and protection. Very often the first placer sampling is done a cursory nature sufficient only to indicate if further interest in the property is warranted or to serve as a guide in future sampling or exploratory work. Some methods to be considered are:

- Sampling existing trenches.
- Use of hand-dug excavations.
- Machine-dug shafts.
- Backhoe pits or trenches.
- Bulldozer trenches.
- Churn drill holes.
- Bulk samples.
- Grab samples.

The order in which these methods are presented has no bearing on their relative importance or applicability, in a given situation. Their applications are described in the section titled "Sampling Methods." (c) Number and size of samples: When investigating placers, the problem of how many samples are needed and where they should be taken, and how large they should be, is often a perplexing one. Here there is no formula, rule of thumb, or pat answer to be, is often a perplexing one. Here there is no formula, rule of thumb, or pat answer to reliably guide the sampler; in fact, placer sampling procedure may vary not only with the purpose of the examination and, to some extent, with the type of mineral contemplated.

How can the mineral examiner cope with this problem? First, he must know what he is dealing with. Is it a large, regular deposit in which the gold or other valuable mineral is distributed somewhat uniformly? Or, is it a boulder-strewn, stream-type deposit containing coarse, erratically distributed gold? It is a generally accepted principle that the smaller and more uniform the size of the gravel, the more evenly distributed the mineralization, the fewer samples needed. An intelligent estimate of value. What may accept this principle as a fact, the day to which such characteristics affect any size and the number of samples required remains largely a matter of judgement. Put another way, textbooks tell us that ordinary gold ore, the size of the largest piece of rock in the sample determines the weight of sample needed. According to Woodbridge (1916, p. 57) if the upper piece is one inch, the minimum sample weight should be 2,000 pounds. Where the largest piece is two inches, the minimum weight should be 10,000 pounds. etc. If the progressive scale were applied to placer gravels, the requirement weights for type samples would be measured in tons, or more. This points out that sampling procedure based on pure theory are too unwieldy a placer application and, in turn, it shows that the placer sampler must to a large extent on his own judgement and good sense determine what is an adequate-size sample in a given case. Now, consider a simple sample. While a single sample may provide much information about the material it actually penetrates, it runs the risk of providing sufficient information is the valuation of a deposit. Where a single sample is taken its assumed area of influence will reflect the insight or optimism of the viewer. But, how do you measure this influence? There are placer deposits of such a character that it is safe to project sample data seven hundred feet and there are others where its gold distribution is so erratic that a ten-foot projection would be a dangerous assumption. But now suppose we take a second, third, and fourth—or an extended series of samples! Obviously as each sample is taken, its area of influence extends only part way to adjacent areas. This points out that sampling procedure is simple in concept but its objective can seldom be reached in practice. In other words, for practical reasons the desired number of samples can rarely be taken, and in the end, the placer operator must either reject a property or go forward on the strength of a valuation which is not 100 percent reliable and, hence, he must always accept some degree of risk. Realistically then, the number of samples might be considered the number required to hold this risk within acceptable limits. A method for graphically examining this problem has been described by Herr (1916, pp. 261, 262).

As a practical example, consider an actual sampling program carried out by an experienced gold dredging company. In this case the ground had a history of superficial hard mining operations going back many years and the geologic and physical conditions indicated a possible depth and volume sufficient to support a bucket-line dredge. A comprehensive drilling program was needed to determine the average tenor and to define possible contours. As a first step, a 6-inch placer drill was moved to the property and four holes drilled at random points to test the depth, character of material, and to get some idea of its gold content at depth. Results of this preliminary work are adequate and some in which no amount of drilling would suffice. In summary: We can seldom, if ever, predetermine an optimum sampling pattern on the floor of samples required to evaluate a placer. For this reason initial sampling programs should be tentative or at least be flexible enough to accommodate any changes dictated by the work as it progresses. In any case, detailed placer sampling is expensive and for this if no other reason, even the most comprehensive sampling program should progress from a simple beginning to its final form in a series of carefully evaluated steps. Also, it is important that a distinction be made between sampling for the purpose of initial valuation and sampling to block out a finite parcel of mining ground. It sometimes takes only a few judiciously selected samples to determine that a property has no economic value while, on the other hand, an area showing good potential may require a thorough sampling in order to determine the value and other information needed to plan a successful mining operation. Parenthetically, it should be pointed out that there is no final proof of the accuracy of placer sampling because no weighing operation, the mining and metallurgical losses can never be fully identified or measured. This is particularly true in the case of gold dredging.

3. SAMPLING METHODS

a. Existing exposures: During the early stage of a placer investigation a quick answer may be...
TABLE I. The effect of a single small gold particle on placer samples of typical size.
The values shown are those which would result from one small gold particle in a 1-foot sample increment. Values shown are based on gold weights determined by the method of the vendor, and gold at $5 per ounce.

<table>
<thead>
<tr>
<th>SIZE OF GOLD PARTICLE</th>
<th>And Effect on Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Au size of Drill Hole or Channel</td>
<td>20 Mesh</td>
</tr>
<tr>
<td>1/16&quot; dia.</td>
<td>$1.18/cu.yd.</td>
</tr>
<tr>
<td>1/8&quot; dia.</td>
<td>$2.10/cu.yd.</td>
</tr>
<tr>
<td>1/4&quot; dia.</td>
<td>$3.60/cu.yd.</td>
</tr>
<tr>
<td>1/2&quot; dia.</td>
<td>$4.22/cu.yd.</td>
</tr>
<tr>
<td>3/4&quot; dia.</td>
<td>$7.12/cu.yd.</td>
</tr>
<tr>
<td>1&quot; dia.</td>
<td>$35.00/cu.yd.</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>$100.00/cu.yd.</td>
</tr>
<tr>
<td>1-3/4&quot;</td>
<td>$175.00/cu.yd.</td>
</tr>
<tr>
<td>2&quot;</td>
<td>$340.00/cu.yd.</td>
</tr>
</tbody>
</table>

*1 = 186 pans per cubic yard.*

tested to determine if a significant expenditure of time or money is justified for further investigation. At this stage, practical considerations may limit initial testing to a few samples taken from existing exposures such as creek-bed or dry wash, road cut, old mining pits, etc. These can be informative if properly used. Existing exposures are usually tested by panning, particularly where the exposure is small. In most cases the bedrock will not be exposed and the distribution of available sample points will be far from ideal and, in either event, should be obvious that extreme care is needed when evaluating the sample results. On the other hand, the only preparation needed may be the cleaning away of sloughed or weathered material to expose fresh surfaces and, because of this, the use of existing exposures offers a cheap, fast method for preliminary testing.

By themselves, small samples obtained from existing exposures can seldom be expected to indicate the actual value of the ground. They may, however, prove or disprove the presence of gold and, if correctly interpreted, they can indicate the range of valuable values to be expected. Nevertheless, many reports intended to prove or disprove the actual value of placer lands are based on a few pan-size samples taken from existing exposures and offered at face value. Such reports and sample data must always be viewed critically and accepted with reservation until proved valid. The use of the gold-size samples was common practice at the turn of the century when labor was cheap and experienced shaft men were readily available but, today, because of the high cost of labor and a scarcity of experienced men, they are seldom used on a wide scale. But they may still be used to advantage in special situations; for example, by prospectors who expect to find gold, or those who have ground too deep for effective use of pits or trenches. In such cases one or more shafts will usually be put down to test the gravels lying on bedrock. This approach is common where the owner or a promoter's main concern is to convince someone that the property should be more thoroughly prospected by drilling or other means.

Hand-dug shafts are commonly used to check selected churn drill holes and in many cases they are essential to correct interpretation of the overall drilling results. This is taken up in the section dealing with sampling by means of churn drills.

Most engineers agree that where feasible all of the material taken from a test pit or shaft should be washed. If the ground stands well and the walls of the excavation are cut square and parallel, it is an easy matter to determine the in-place volume of material removed and to directly compute its value after washing. An excellent description of a sampling program employing this procedure is found in an article by Sawyer (1932, pp. 381-383). The use of hand-dug shafts to prospect ground worked by the Wyandotte Gold Dredging Company of California has been described by Magee (1937, p. 196). Where an excavation cannot be measured accurately, it will be necessary to weigh the sample material or to measure its loose volume in a box or other container. In either case the indicated gold value will have to be converted to in-place or "bank" value by use of suitable conversion factors.

Where it is not practicable to wash all material, a good approximation of the ground's worth may be made by washing several pans per foot of depth as the excavation advances. But, this method is always risky unless the man in charge is completely impartial in his selection of material for panning and unless he is a trained placer sampler capable of applying experience-based judgement to the findings.

A somewhat similar procedure but one in which the personal factor is in part eliminated may be carried out as follows: Carefully deepen the pit or shaft in uniform, measured drops of say one foot at a time. Just prior to each deepening, to carefully remove a sample by digging below the bottom of the pit or shaft to a depth exactly equaling the distance the bottom is to be dropped during the next deepening step. The minimum-size sample that can be conveniently taken in this manner will be one having a 12 x 12 square cross section but if many rocks are present it may be somewhat larger. A sheet-iron caisson 18 or 24 inches in diameter by about 12 inches long can be used to advantage when the bottom sample must be taken from wet or ravelling ground. This type of sample may be taken from the center of the pit or shaft bottom or from any suitable place but once started, its location should remain fixed. By following this procedure, a progressive sample can be obtained from undisturbed material depth of the main excavation.

Where the excavation walls stand reasonably well, a sample can be obtained by cutting a vertical channel up one side of the pit or shaft. The excavated sample material can be allowed to fall on a canvas placed at the bottom of the pit or it may be caught in a bucket or box held close to the point of cutting. Where conditions permit taking a true channel, the sample volume can be determined by direct measurement but in any case it is best to weigh each sample as a check.

The first step in channel sampling is to clear away all foreign material from the ground surface above the place to be sampled. Next, the sampler selects the sample area by scaling down the face to be cut. Following this, remove any loose material from the bottom of the pit where it might interfere with the sampling operation and finally, check the bottom for bedrock. A piece of heavy canvas or a tarp is then spread at the bottom of the face to be sampled and this is positioned to catch all material falling away.
from the sample cut. Starting at the bottom, a uniform rectangular channel is cut upward to the top of the prospect pit or in some cases, to the top of a particular formation or sample increment. When starting a sample, the cuttings are usually allowed to fall on the canvas but when sufficient room becomes available, it is best to catch them in a suitable box or metal container held close to the point of cutting. As the sample channel advances upward, the cuttings are periodically transferred to one or more sample cans which should be kept in the sampler's possession or under surveillance throughout the sampling operation. In most situations an ordinary prospect pick will be found satisfactory for cutting channel-type placer samples.

How large should the channel cut be? There is no simple answer because like other aspects of placer sampling there may be special factors to consider in each case. Speaking generally, however, it will be found that experienced placer samplers usually cut a size somewhere between 3' x 6' and 12' x 12' in cross section but, contrary to popular belief, there is no minimum or optimum size which by itself will insure an adequate sample.

In ground where the water level is several feet below the surface, it is sometimes possible to sink the pit or small shafts in bedrock using only buckets or water to remove the water. These wet excavations are usually difficult to keep squared up but in any case, some form of ground support may be needed to eliminate the hazard and to minimize sampling error which results when inflowing water causes values in the pit. A simple, easy-to-frame style of cribbing suitable for most shallow work is shown in Figure 3. In loose, water-logged ground it may be impracticable to sink prospect shafts without the use of teleconing steel casements. Certain problems and special procedures associated with caisson work have been discussed by Steel (1915, pp. 66-68) and Dolaney (1942, pp. 48-49).

At first glance the use of hand-dug pits or shafts would seem to be an effective inexpensive way of prospecting shallow placer but this approach is too expensive for general use today, where a high dollar value must be placed on time. Nevertheless, hand-dug excavations intelligently used can serve a useful purpose in that, under favorable conditions, a few well located pits or shafts may indicate the value of a prospect before any great expenditure of money is made.

c. Machine-dug shafts: Machine-dug shafts have been found both useful and economic in a number of instances but they are not a cure-all for placer sampling problems. The equipment used can broadly be divided into two types: rotary bucket drills and clamshell-type excavators. To be effective, either type must be capable of doing three things: (1) dig a hole large enough for a man to enter and inspect the ground or to cut samples from the shaft walls; (2) have a reasonably fast digging rate; and (3) be self-contained, easily mobile and capable of negotiating rough terrain.

Machine bucket drills have been used for many years by excavation contractors, particularly those specializing in foundation test work. Their equipment is usually designed to dig a hole 24 or 36 inches in diameter and to depths of 60 feet or more. The digging unit can best be described as a standard bucket which has two radial openings in its bottom and extending blades extending below the openings. Rubber flaps fitted over the openings allow cuttings and rock to enter; the openings when filled are hoisted. The bucket is rotated by means of a "Kelly" bar which, in turn, is rotated by a ring gear on the drill rig. See Figure 4.

Attempts to adapt this type of drill to placer sampling have met with mixed success but speaking generally, rotary bucket drills have been found useful where the ground is dry and firm and where there are few rocks too large to pass through the bucket openings. On the other hand, they have been found poorly suited to the hard, rocky ground encountered in many gold placers.

The successful use of rotary bucket drills to sample dry placers has been described by articles by Draper (1932, p. 337) and by Prommel (1937). Prommel describes a sampling project in which 1,239 test holes 28 inches in diameter were drilled in 147 days. Their combined depths amounted to 16,705 feet. The cost of this work using two rotary bucket drills was 98.6 cents per foot of hole but this did not include engineering or sample testing charges and, it should be noted that the low cost reflects depression-level prices of 1935.

Two clamshell-type machines designed specifically for placer prospecting are: An air-actuated unit sold under the trade name KLM, and a cable-actuated unit known as the PAR-X Placer Sampler. The KLM is essentially a manganese steel clamshell bucket of 12-foot capacity, fitted with replaceable teeth and actuated by compressed air. The digging unit consists of the bucket, an air cylinder placed directly above the bucket and a 15-foot stem as shown in Figure 5. The combined digging unit which weighs one ton is suspended from the mast of a drill truck by means of a wire line spooled on a suitable hoist. According to the manufacturer, the standard unit digs a round, vertical hole 24 inches in diameter and is efficient to a depth of 100 feet. It is said to dig from 2 to 20 feet per hour depending upon depth, formation, and on whether or not casing is used.

The PAR-X machine differs from the KLM in that the clamshell is attached to a telescoping stem or bucket carrier which limits the depth of hole to about 30 feet. The opening and closing action is controlled by wire ropes. The unit is truck-mounted and, according to Hultt (1941, pp. 55, 56), its digging speed averages 25 feet per day in normal ground. It digs a hole 28 inches square without casing.

Machine-dug shafts are best suited to bulk sampling, that is, sampling in which the entire volume of material removed from the shaft is run as a sample. Where the ground stands well channel samples can be cut from the shaft walls but there is hardly room for a man to work effectively in a 24-inch diameter hole. However, the fact that...
machine-dug shafts can be entered for inspection is a point in their favor, particularly in new fields where little is known about the sub-surface conditions. Something proponents of this method of placer sampling seldom mention is the fact that an uncased, machine-dug shaft passing through alternating hard and soft layers or through ravelling ground will have a non-uniform diameter, that is, it may be appreciably larger in the softer horizons than in the hard. This means that where over-diameter shaft sections occur in ground that is above average or below average mineral value, the end result will be an unintentional salting or an impoverishment of the bulk sample.

To cite an actual case, a dry, desert placer was sampled by means of 24-inch-diameter machine-dug shafts ranging from 60 to 90 feet deep. Both rotary-bucket and Klam-type excavators were used. The valuable mineral was magnetite occurring in the form of blebs in sand. When the completed shafts were entered for inspection, it was found that the shafts had passed through a series of hard calciche-cemented gravels separated by relatively loose sand and gravel strata, and in all cases, the shaft diameters were appreciably larger in the softer materials than in the cemented horizons. Sections were found enlarged to as much as 2 1/2 times the normal 24-inch diameter. If the grade of material throughout the shaft had been uniform this local enlargement would be of no consequence, but it was found that the enlarged sections were often in magnetite-rich sands. As an end result, samples (representing 30-foot shaft increments) contained too large a proportion of the richer material which in effect amounted to unintentional salting. Had this been a gold prospect the errors caused by non-uniform hole size would have been substantial.

Backhoe excavators: The development of compact, tractor-mounted backhoe excavators in recent years has given the mineral examiner a tool which adapts well to many of his placer sampling needs. These go-anywhere, high-performance machines dig, load and backfill. The combination most frequently employed is a hydraulically-operated backhoe unit mounted on the back end of a rubber-tired tractor plus a scraper or loading bucket at the front end. See Figure 6. A typical rig will dig 10 feet deep, reach more than 12 feet from the pivot point and will load into a truck 11 feet high. The backhoe bucket has more than 7,000 pounds digging force and generates a pryout force of 15,000 pounds or more. Most placer ground is handled with ease. A 1 1/2-yard, track-mounted backhoe (Thew-Lorain) has a depth capacity of 27 feet and is available with a range of buckets that provide cutting widths from 12 to 38 inches.

In most areas, this type of equipment is available on a rental basis from contractors who will be found listed in the yellow pages of the telephone book under "excavating contractors." Rental rates vary with locality and machine size but $10 to $14 per hour is not unusual. This price includes the operator. On short-term jobs the charge starts at the time the equipment leaves the contractor's yard so it is well to have the work well planned and laid out in advance. In connection with a placer sampling job near Grants Pass, Oregon, in 1966, thirteen shafts ranging from 4 to 12 feet deep were dug using a tractor-mounted backhoe equipped with a 38-inch "graveyard" bucket. The backhoe with operator rented for $11 per hour. The 13 shafts were dug in 6 hours and the travel time was two hours bringing the total charge to $88. This amounted to a little less than $1 per foot of shaft and provides a good example of the cost and work accomplishment that can be expected when using this type of machine.

In most placer gravels the walls of backhoe-dug pits or trenches stand well and can be sampled by cutting a vertical channel in the face of the standing material. Depending on requirements and conditions, the sample channel can be cut with the backhoe bucket (usually 24" wide) or by hand. Where the presence of much large rock or ravelling ground precludes the use of channel cuts, either all excavated material or alternate buckets can be set aside as a bulk sample. See pages 71, 72.

The tractor-mounted backhoe is probably the most versatile placer sampling tool available to the mineral examiner today.
e. Bulldozer trenches: The use of bulldozers to dig trenches for prospecting shallow placers is too common and too well known to need more than passing mention. Because of its design, the bulldozer is more effective as a pusher than as a digger and for this reason it is best suited to ground less than 10 feet deep and to a working (pushing) distance not exceeding 200 feet. Two types of blade control are in general use: the blade may be raised and lowered hydraulically or it may be operated by a cable control. For digging prospect trenches the hydraulic blade is considered best as it provides a positive downward pressure; in fact, it allows much of the tractor's weight to be put on the blade while digging hard ground. The cable-controlled blade has only its own weight to hold it down and as a result its cutting edge has a tendency to ride over any hard spots in the bottom of the trench.

The cost of bulldozer-dug trenches depends so much on the type and size of machine used and on the depth and hardness of the formation, and the operator's skill; any estimate of working speed or costs must be made on a case-by-case basis. Lorain (1944, pp. 1-8) has tabulated field data for trenching with bulldozers but his 1944 cost figures cannot be used without updating.

Possibly the greatest advantage to be gained in prospecting placers by means of bulldozer trenches, where applicable, is that they permit first-hand inspection of the ground. This makes it possible to visually determine the character and size of gravel to be dealt with and, in addition, the pay or barren sections can sometimes be found by simple inspection and panning of the trench walls. Another feature is that a considerable area of bedrock can be exposed for inspection or testing as compared to pits or drill holes. In many cases, even where the ground is more than 10 feet deep, the results obtained from a few days of trenching with a bulldozer will provide the information needed to decide whether or not a more extensive (and expensive) sampling program is warranted.

f. Sampling with churn drills: Drilling is usually resorted to in deep or wet ground where sampling by means of pits, trenches or shafts is not practical. Many western gold placers, particularly those exploited by bucket dredges, have been sampled by churn drills and it can be said generally that this method adapts well to the dredge operator's need. The basic drilling equipment consists of heavy casing, a chisel-shaped bit suspended from a drill line and a vacuum-type sand pump. The overall operation can be divided into five steps as follows:

- Driving.
- Drilling.
- Pumping.
- Panning.
- Pulling and moving.

The first step provides a measured core of gravel which serves as the sample. The gravel core is obtained by driving the casing (commonly referred to as the drive pipe) into the ground by striking it with a driving block attached to a heavy drill stem. The bottom end of the drive pipe is fitted with an alloy-steel shoe made with a sharp, beveled cutting edge. The effective diameter of the beveled edge determines the area of gravel core cut by the drive shoe as it is forced downward.

A second step breaks up the core and prepares it for removal from the pipe. This is done by chopping the core with the drill bit which is repeatedly raised and dropped by means of a walking beam or crank acting on the drill line. Water is added during the drilling operation and when the material is reduced to a size that will permit pumping, the resultant sludge is removed from the hole with a special vacuum-type sand pump. The cuttings are transferred to a measuring bucket which serves as a check to indicate if excess core is being removed or if extraneous material is running into the pipe.

The cuttings are washed in a rocker and the rocker concentrate is further reduced by panning. The panner counts the gold color recovered from each drive, estimates its weight and enters this information in the drill log. Examples of placer drill logs will be found in Appendix D.

The driving, drilling and pumping steps are successively repeated for each drive (usually 1 foot at a time) until the hole is completed. The engineer in charge then weighs the
combined gold and calculates the value of the hole.

As a final step, the drive pipe is recovered by pulling. The drill is then moved to the next hole.

An illustrated, step-by-step description of the placer drilling process will be found in Appendix 11, to which the reader is referred. The basic equipment is illustrated by Figure 7.

As the pipe is driven downward it will, in theory, cut a cylinder of gravel having an area equal to that of the drive shoe and a length equal to the drive. A short length of core left in the bottom of the pipe to serve as a plug will, also in theory, prevent run-ins of extraneous material when pumping. Assuming ideal conditions and a perfect core, the value of the hole (or the sample increment) would be determined by use of the following equation:

\[ \text{cents per cubic yard} = \frac{W \times V \times 27}{A \times D} \]

in which

- \(W\) = weight of gold in milligrams,
- \(A\) = effective area of drive shoe in sq. ft.,
- \(D\) = length of sample in ft.,
- \(27\) = cubic feet in a cubic yard.

To illustrate the above equation, assume a 32-foot hole drilled with a standard 6-inch drive pipe and 7 1/2 inch (outside diameter) drive shoe with an effective area of 0.3068 sq. ft. Also assume a recovered gold weight of 50 milligrams. As a matter of convenience the gold will be considered 887-fine, which is equivalent to 1/100 per milligram.

Substituting we would have:

\[ \text{cents per cubic yard} = \frac{50 \times 0.1 \times 27}{0.3068 \times 32} \]

Theoretical core rise, estimated weight = 

\[ \text{corrected weight} = \frac{\text{theoretical core rise} \times \text{estimated weight}}{\text{actual core rise}} \]

But in practice a perfect core is rare and the measured core rise and the value of material recovered from each drive will be greater or less than their theoretical amount. When drilling gold placers, any deviation from the norm is important because the basis value calculations on small-diameter holes, any deviation between the theoretical amount of material actually obtained from the sample point in question. Stated simply, if a drivehole increment contains too much or less core its value will have to be downgraded. If it contains too little core its indicated value may be upgraded. Most placer engineers base their adjusting procedures on either the ratio between theoretical and actual core rise, or theoretical and actual core volume.

For this reason, any placer valuation based on drilling should be viewed critically until the qualifications of the engineer in charge have been established. This is particularly true where the original drill logs are not available for inspection, or where drilling cannot be compared against past production from the particular deposit or area.

The Radford factor is applied by substituting 0.27 for "A" in the basic equation where cents per cu. yd. would be:

\[ \text{cents per cubic yard} = \frac{W \times V \times 27}{A \times D} \]

Using our earlier example this equation would become:

\[ \text{cents per cubic yard} = \frac{50 \times 0.1 \times 27}{0.3068 \times 32} \]

The first calculation using the theoretical drive shoe area of 0.3068 sq. ft. for "A" gave a value of 13.7 cents. Substituting 0.27 gave a value of 15.6 cents. It is seen that use of the Radford factor increased the calculated value by 12 percent.

In some cases other factors were applied to decrease rather than to increase the

1) In practice the corrections are usually applied to the estimated gold weight for each drive. The individual corrections are carried forward for use when calculating an end value for the completed hole.
calculated value. Usually, the Radford or other factor was applied to the entire hole, that is, they were not applied on a drive-by-drive basis. It should be obvious that the use of any arbitrary correction factor is hazardous because ground character will vary in different properties and for that matter in different parts of a single drill hole.

Today, considerable difference of opinion exists concerning the validity or use of the Radford factor. It has been mentioned here to alert readers who may not be familiar with placer drilling that many of the placer valuations found in reports, particularly in old reports, have been based on calculations employing the Radford or other arbitrary upgrading factors.

In arctic regions, permanently frozen ground is drilled without casing with exception of a short length at the surface to serve as a collar and tool guide. Sample volumes are determined by measuring the displacement of known quantities of water poured into the hole. Arctic drilling and the special procedures employed have been well described by Doheny (1941, pp. 47-49).

Most placer-type churn drills used in the United States are powered by gasoline engines and designed for use with 6-inch drive pipe and tools. Typical arrangements are illustrated by Figures 8 and 9. Drills in common use are the Keystone Model 70 1/4, a truck-mounted unit for use with 6-inch pipe; the Keystone Model 71, a 6-inch traction drill mounted on a crawler base, the BE 22-T 2/4, a crawler-mounted 6-inch drill; the Hillman Prospector 3/4, a 6-inch truck or crawler-mounted rig and the Hillman Airplane Drill, a compact, skid-mounted machine designed for use with 4 or 5-inch drive pipe. A crawler-type traction drill complete with 40 lengths (about 240 ft.) of drive pipe and the necessary tools will weigh 10 to 15 tons.

1/ Now called "Speedstar", manufactured by Buffalo-Springfield Co., Enid, Oklahoma (successor to Keystone Driller Co.).
2/ Manufactured by Bucyrus-Erie Co., South Milwaukee, Wisconsin.

He provides the information needed by the engineer for “correcting” the indicated values. The panner who should have some technical as well as practical training, often serves as the crew foreman.

As a rule, when prospecting narrow, stream-type deposits the holes are drilled at relatively close intervals along lines laid out at right angles to the general trend of the deposit as shown in Figure 11. Hole spacing along the line is commonly 100 feet or less, while the distance between drill lines is greater, often on the order of 500 feet or more. This type of drilling pattern is designed to search out and delineate relatively narrow pay channels.

In widespread placers, particularly those having a somewhat uniform mineral distribution, holes are usually put down at the intersections of a rectangular grid pattern designed to cover the deposit as shown in Figure 12. The drilling ratio will vary from one hole for every acre to one hole for every 2, 3 or possibly 10 acres, depending on the distribution of mineral, previous experience in similar ground and other factors. In the Folsom, California dredge field the average hole density was about 1 hole for every 4 acres. On the other hand, there are placers...
which cannot be adequately sampled by any amount of drilling. Although a regular drilling pattern may be preferred, there are situations in which an irregular drill pattern should be employed. In any case, it is important to avoid placing the holes in a way that would tend to exaggerate either the higher or the lower-grade area. The selection of a drilling pattern and the initial placement of holes is normally a responsibility of the engineer in charge. Assuming a completed drilling project with favorable results, the next step is to make an overall evaluation. To calculate the yardage and the average value of a deposit which has been drilled on a grid pattern, the drill holes are first connected by imaginary lines to divide the deposit into blocks or triangles. The volume and value of each triangle or block is then calculated using weighted drill hole values and standard ore reserve calculation procedures. The procedural details will not be set out here as they are well known to most field engineers and have been adequately covered in the technical literature. Daily (1962, pp. 86, 87) and Doheny (1942, Part II, pp. 43, 44) have described the applications to placers. In principle, the value of each block or triangle is calculated by the following formula:

\[ V_a = \text{Sum of products } (d \times V) \]

Where \( V_a \) = average value of block or triangle expressed in cents/cubic yard,

\( d \) = depth of each bounding hole in feet,

\( V \) = prospect value of each hole in cents/cubic yard.

A value for the deposit is subsequently arrived at by combining the individual triangles as shown in Figure 13. For the valuation of narrow, stream-type deposits where the holes are drilled at close intervals, say 50 or 100 feet apart on relatively far-spaced drill lines, a calculation based on the mean-area formula is usually employed. This relies on a formula used for making cut and fill estimates in road work in which it is inferred that the volume of a
Step 1—GRAPHIC DISPLAY OF PROSPECT DATA

Step 3—VALUE CALCULATION

TOTAL VOLUME = 2,012,305 cubic yards

GROSS VALUE = $684,065

AVERAGE VALUE = $684,065 x 100

= 34.0c per cubic yard

2/ From Step 2.

Step 2—DETERMINE VOLUME AND VALUE FOR EACH TRIANGLE

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1/ Measured by planimeter.

TOTALS 182,250  2,012,305  $684,065

Step 3—DETERMINE WEIGHTED VALUES

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<th>AVER. DEPTH</th>
<th>WEIGHTED VAL.</th>
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GROSS VALUE = 408,875 cubic yards

AVERAGE VALUE = $408,875 / 1,194 = 34.615 per cubic yard

Step 4—BLOCK VOLUME AND VALUE

Area of line C = 34,615 + 29,378 = 64,000 sq. yds.

GROSS VALUE OF BLOCK = 408,875 cubic yards x $0.195

= $79,370

FIGURE 13. — Use of the “triangle” method for calculating prospect values where deposits are drilled on a grid pattern.
The irregular distribution of gold in placers reflects the small sample area encompassed by the layman. This problem is not necessarily a limitation of placering work, for a few points. One school of thought gives great importance to the supposed superior accuracy of bulk samples as compared to smaller samples such as those provided by churn drills or channel cuts. While bulk sampling per se is a valid method and bulk samples do, in many cases, offer the most satisfactory method of testing erratic, high-value ground, they are at the same time open to certain criticism. For example, bulk samples must be representative of the deposit, a feat not easily achieved where they are few in number. Another important consideration is the fact that all facets of a bulk sampling program cannot have personal supervision all of the time and, for this reason, sampling can be perpetuated with comparative ease. It is important that all such possibilities be considered during the evaluation of bulk sampling results or when considering any actions based on this type of sampling.

**Bulk samples:**

Bulk samples are sometimes used to check the reliability of other types. In placer drilling, for example, shafts may be put down over selected drill holes to establish a correction or "shaft" factor which when combined with experience-based judgment can be used as a basis for adjusting the calculated drill values as a whole.

a. **Grab samples:**

One thing to avoid or to use with caution when investigating placers is the so-called grab sample. This method of sampling relies on a theory that if enough small "grabs" or portions of material are impartially taken and then combined into a single sample, the combined material will be representative of the deposit or of the exposure, as the case may be. But in practice the average person fails to make allowance for the large rock or boulders normally found in bank-run material and, as a result, their grab samples contain a deceptive proportion of fines. Such oversight can cause serious error in the estimated value, particularly when based on a few pans of material.

Every miner examiner will at one time or another run into a situation where systematic sampling is not practicable or is not called for.
for. For example, a property may have no discernible mineralization or mineral-bearing structure, or the mineral examiner may for other reasons be sure that no significant values exist. Here, a few check samples can serve as "written proof" and as such carry far more weight than a bald statement of fact. Grab samples, if fairly taken, serve this purpose well. Grab samples can sometimes be used to check the presence or the distribution of gold in a gravel exposure and thus used as a guide for subsequent sampling and, judiciously used, they provide an excellent check against salting.

Other uses for grab samples could be cited but the novice will be better served by stressing the fact that in unexplored areas they are almost sure to be misleading. With few exceptions, grab sampling cannot be considered a valid method for testing placers.

1. Drift mine sampling: Underground mining procedures are collectively known as "drift mining" where applied to placer gravels. Placers buried under deep masses of low-value gravel or capped by lava flows have been extensively worked in this manner. Drift mining presupposes the concentration of values in a well-defined stratum or channel. Pay streaks in these channels are typically confined within narrow limits, both laterally and vertically, and are commonly related to troughs or other depressions in the bedrock. It is not unusual to find several generations of "pay leads," as the miners call them, within a given deposit where several periods of erosion and deposition have superimposed successive channels over one another. Such complications are usually quite difficult to decipher and speaking generally, drift-mine deposits seldom lend themselves to the usual investigative procedures. These deposits are usually explored by adits or shafts from which drifts are driven into the richer portion of the gravels. Crosscuts are run from the main drifts to establish the pay limit and at the same time to run from the main drifts to establish the richer portion of the gravels. Crosscuts or shafts from which drifts are driven into bedrock. But it is not unusual to find several generations of "pay leads," as the miners call them, within a given deposit where several periods of erosion and deposition have superimposed successive channels over one another. Such complications are usually quite difficult to decipher and speaking generally, drift-mine deposits seldom lend themselves to the usual investigative procedures. These deposits are usually explored by adits or shafts from which drifts are driven into the richer portion of the gravels. Crosscuts are run from the main drifts to establish the outer pay limits and at the same time to block the ground for mining. In the usual drift mining venture, exploration, sampling, development and mining are of necessity integral parts of an overall package.

Typical drift mines are not amenable to sampling with churn drills and the particular task of where the values are confined to sinuous, deeply burrowed pay streaks. In deep ground the cost of close-interval drilling can be expected to outweigh its benefits. Drilling can, however, be of great value in guiding an underground exploration program when dealing with deposits of this type. A relatively few well-placed drill holes may indicate the course of the pay channel, depths and character of the grade of bedrock, etc. This type of information is essential to a success development program where drain tunnels and haulage levels are to be kept below the lowest point of the pay channel. An application of this type of churn drilling at the Vallecito Western drift mine has been described by Steffa (1932, pp. 4-6).

When evaluating drift mines, prospect drifts usually are meager and the mineral examiner should take into account the fact that drift mining, by its very nature, is typically a high-risk venture. He should also recognize that sampling, in the usual sense, may not be practicable.

Hydraulic mine sampling: Determining the mineral value of large deposits of the type worked by hydraulic mining is perhaps the most difficult task faced by today's mineral examiner. A typical large hydraulic deposit presents most of the sampling problems encountered in drift mines plus a few of its own. Anyone familiar with the immense masses of Tertiary gravels that have been partially worked in California's Sierra Nevada region need not be told that detailed sampling of such deposits ahead of mining would be too costly for practical application. The California hydraulic miner is no stranger to mining risks and, for the most part, he concurred with Whitney (1880, p. 360), who said: "... the amount of gold in the gravel cannot be accurately determined by assay or any other proper method. All that can be practically known is the amount obtained in the clean-up." Whitney went on to say: "The miner, by panning a sufficient number of samples, judiciously selected, can form a pretty good idea whether the gravel is likely to pay for working; but this is not by any means the same as ascertaining the exact amount of gold which it contains."

As indicated above many of the early hydraulic operators relied more on qualified estimates of value than on a formal sampling program. Such estimates were based largely on the production records or estimates. A relatively few well-placed drill holes may indicate the course of the pay channel, depth and character of the grade of bedrock, etc. This type of information is essential to a success development program where drain tunnels and haulage levels are to be kept below the lowest point of the pay channel. An application of this type of churn drilling at the Malakoff mine (one of California's largest hydraulic operations) consisted essentially of four shafts and 2,000 feet of drilling along the channel, which, according to Bowie (1885, p. 88), cost a total of $63,956.20. It should be noted that at the time (circa 1880), the expenditure of this great sum for prospecting and sampling was considered somewhat remarkable.

According to Easie (1944, p. 93), the initial prospecting and sampling for a medium-size hydraulic property (150-foot banks) in British Columbia was done hydraulically, with exceptions of a small amount of churn drilling undertaken to determine the course of the channel. In all, six exploratory pits were opened but only one supported a continuing operation. Existing faces in old hydraulic pits can, in some cases, be sampled by conventional means. At the McLeatchin mine in Placer County, California, old hydraulic banks roughly 50 feet in height were sampled by means of vertical hand-dug cuts 2 feet wide by 1 foot deep. The sampling crew worked from long ladders propped against the gravel faces.

A small hydraulic mine on Fox Creek, Alaska, was prospected and simultaneously worked in the following manner. The deposit, consisting of low bench gravels, was superficially tested by panning and its 15 to 20-foot depth was determined by use of 3-inch, hand-driven pipes. Several hand-dug pits and shafts were put down in the more promising areas and those returning the best prospects were expanded into ground sluice cuts. Pay areas exposed by ground sluicing were, in turn, expanded into pits and worked out by hydraulicking. Once a pit was started, the hydraulic mining proceeded from clean-up to clean-up without further sampling. When the ground stopped paying, the pit was expanded in another direction or abandoned. In other words, this was a hand-to-mouth operation (as are many small placer mining ventures) and it illustrates the type and extent of sampling or testing generally relied on for working small hydraulic mines.

In most cases the initial prospect work has been engulphed or otherwise eradicated by subsequent mining and, today in most hydraulic areas, there are few faithful but abandoned pits and their sloughed faces. What does this mean to the mineral examiner? It means that in the absence of prospecting shafts or other openings in the unworked gravels, it is necessary to use what past records are available and a large measure of common sense in making an evaluation.

4. SPECIAL PROBLEMS

1. Large rock or boulders: At this point something should be said about large rocks or boulders—nemesis of the placer sampler. When sampling placers there is a natural tendency to bypass areas of heavy boulders or, at least, to take the finer material from among them without considering the end effect on indicated values. In many cases the effect is the same as salting the sample, a fact which does not seem to be recognized by some mineral examiners. Consider that the gold particles or other valuable minerals in placers are found among the finest-size material while on the other hand, the large rocks or boulders contain no
recoverable values within themselves. For this reason, when the sampler takes too much fine material or fails to make an allowance for valueless boulders, he is likely to report an incorrect, high value. To put it another way, where all bank-run material including boulders will be handled in a mining operation, the prospecting should reflect this fact by including a proportionate amount of large material in the samples.

A direct approach to sampling the type of ground under consideration would be to cut samples large enough to include the fair proportion of large-size rock and thus obtain samples which truly represent the mine-run material, boulders and all. But where the mineral examiner must work alone or where a limit is placed on the size of his samples through the use of hand tools or for other reasons, the taking of very large samples may not be practicable. In such cases, he must settle for something less than optimum size, but he can guard against possible error in his end valuation by first carefully evaluating the problem and, second, adjusting his calculated sample values (if necessary) to correspond with those which might be obtained from a suitably large-size sample.

In practice this can often be achieved by visually estimating the boulder content of a piece of ground and, where needed, inserting a correction factor in the end sample calculations.

Consider a case where it was estimated that 10 percent of the bank-run material was too large to be represented by material taken from a 3' x 6" x 4' channel cut. The 55.9 pounds of material removed from this cut contained 2.70 milligrams of gold. The indicated value based on these weights was 13.3 cents per cubic yard. This can be seen that any sloughing of an uncased drill hole, should it occur in a gold-bearing zone, will tend to upgrade the calculated value by significant amounts. If one knew with certainty how much excess material entered a sample and exactly where it came from, the discrepancies might be appraised and allowances made during the calculation process. But experience tells us that this is not always practicable and that when dealing with the usual gold placer, uncased drill holes just do not give reliable results. More often than not the ground will be over-valued and this seems to be particularly true when rotary drills are employed, especially those using roller-type bits. In one case, placer ground reported to run 20 cents per cubic yard on the basis of samples obtained from rotary drill holes was found to contain 1 1/4 cents per cubic yard when checked by an experienced dredging company using a Keystone placer drill and qualified crew.

The mineral examiner should always view critically any placer evaluation based on gold values obtained from uncased or small-diameter drill holes. Figure 15 shows why, in the case of small-diameter holes, the indicated values are not always reliable. While some gold dredging companies occasionally employ 4-inch churn drills for preliminary prospecting, the 6-inch size equipped with a 7 1/2-inch diamond drive is considered standard. Under certain conditions, small-diameter drill holes may be both practical and adequate. As an example, when evaluating beach-type deposits valuable for their chrome or titanium-bearing minerals it is often possible to rely on small-diameter (say 2-inch) holes for sampling. Here the fine-grained nature of the deposit, the relatively large proportion of valuable mineral and its low unit value combine to eliminate some of the uncertainties normally associated with small-diameter drill holes.

As another example,
6. SALTING

There are two kinds of salting—intentional and innocent. Intentional salting can be defined as the surreptitious addition of valuable material to a sample with intent to deceive. Innocent salting, which can have the same end effect, can be accidental or the result of carelessness or improper working procedures. Although intentional salting is seldom encountered, only the engineer who is constantly alert can feel secure about his sample results. A few of the salting methods applicable to placers are:

- Secreting gold in the material to be sampled.
- Placing gold in sample containers or in the sample itself.
- Secreting gold in the excavating or washing equipment.
- Dropping bits of gold in the pan during final processing.

Where the volume of material obtained from a drill hole or from a channel cut is comparatively small, it takes very little gold to appreciably alter the value. It should be noted that in bulk sampling a substantial amount of gold may be required to achieve the desired effect, but, at the same time, the opportunity for salting may be greater. This is because the larger the sample the more it is handled, and the more it is handled, the more difficult it becomes to provide adequate safeguards or keep it under constant surveillance. Ironically, it may be easier to detect salting after it has happened than to prevent it in the first place.

But there are many precautions that can be taken to discourage salting, most of which require little more than common sense. Some are:

- Keep the exact location of the point to be sampled a secret until the actual cutting begins.
- Clean and carefully inspect all faces before sampling.

7. WHEN SAMPLING FAILS

Not all placer miners lend themselves to the usual forms of sampling and there are some which cannot be sampled by any means short of mining the entire deposit. This problem usually reflects in one of two things: (1) The gold or other mineral occurrence is so erratic that usual sampling or evaluation methods break down hopelessly. (2) There are physical conditions which make sampling impracticable.

Excellent examples of the latter condition can be found in California’s drift mines. Sampling problems inherent in this type of deposit have already been brought out under the heading of “Drift Mine Sampling.” Salting in this type of deposit has relied on the practical application of bits and pieces of information gleaned from limited surface exposures or underground workings. This is another way of saying that the old-time drift miner relied largely on geologic inference tempered by good judgement. Today’s mineral examiner, when confronted by a deposit that cannot be readily sampled, may also have to fall back on his powers of observation and other resources.

Where factual sample data cannot be obtained without extensive and costly explorations, which except in isolated cases will probably never be made, authentic production records will generally be found with a useful source of information. And even where the actual records are not available, it may be possible to obtain enough statistical information from state mining bureau reports or other government publications to ascertain the past production of better-known mining districts and to appraise their remaining potential. To varying degrees, this type of statistical data can be applied to individual properties. Noteworthy examples are found in studies of California’s hydraulic mine reserves (Jarman, 1927) carried out by state and federal agencies, preparatory to construction of the North Fork and Yuba Narrows debris retention dams.

But, the point to be stressed is that sooner or later the miner examiner can expect to encounter a placer deposit where sampling fails and when this happens, it is important that the fact be recognized.

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Also see - Jadhav, Edgar, Hydraulic mining investigations in California (a report of the War Department, Board of Engineers for Rivers and Harbors, dated April 20, 1920):
1. **GENERAL CONSIDERATIONS**

Equipment used for the recovery of placer gold has changed very little over the years and, in general, remains relatively simple. Most devices employ some form of riffled surface to hold the gold or other heavy mineral after it has been separated from the valueless material. The actual separation relies on the ability of heavy minerals to resist the action of moving water while the lighter materials are carried away. In dry washers where a current of air is used as the transporting medium, the same principle applies. Although many have tried, no one to date has devised a gold-saving device or system which can economically replace the ordinary riffled sluices or placer jigs used on today's dredges or in other comparable large-scale placer operations. It is true that sluices may lose some of the fine gold but this is normally offset by their low operating cost and their high unit capacity which combine to return the greatest dollar profit.

When selecting a machine for washing and concentrating placer samples, the first consideration should be whether or not it will indicate the commercially recoverable gold content of the sample. Other desirable features would be:

- Low first cost.
- Easy to maintain or repair in the field.
- Easy to transport and set up for operation.
- Will accept bank-run material without pre-screening.
- Will thoroughly wash and reject the oversize material.
- Makes efficient use of water.
- Will efficiently process small as well as large samples.
- Will effectively reduce the sample to a small-volume residue or concentrate.
- Can be quickly and completely cleaned between samples.

It should again be stressed that no dredge or other large-scale placer equipment saves 100 percent of the values and because of this it is important that the sample washing process indicate the actual returns to be expected from a commercial operation. In this connection it is noteworthy that the pan, rocker, and the sluice when used by experienced placer operators fulfill this requirement.

2. **MINERS' PAN**

The miners' pan, better known as a gold pan, is perhaps the most widely used device for washing small placer samples and from the standpoint of simplicity it has no peer. A separate article describing its use and manipulation will be found in Part V under the heading of "PANNING." In the hands of an expert the pan is both a versatile and a highly efficient concentrator well suited to washing small amounts of gravel but where individual samples weigh more than about 30 pounds, or where a large number are to be washed, something which provides a greater throughput with less expenditure of time and labor is needed.

3. **SLUICE BOX**

Another widely used sample washing device is the ordinary sluice box which in its smaller form is sometimes loosely but erroneously called a "long tom". A sluice in its simplest form is no more than an elongated, rectangular trough fitted with transverse cleats or some other form of riffled bottom. It is operated by essentially allowing a stream of water to carry the sands and gravel over the riffles which, in turn, detain any gold or heavy minerals as they settle to the bottom. Small sluices of the type used for sampling are commonly 8 or 12 inches wide with 6 or 8-inch sides and are usually 6 to 12 feet in length. Construction details and the materials used are largely a matter of personal choice, but the simpler ones are no more than an open-ended trough made of planed 1-inch lumber and provided with cross bracing where needed. Some samplers prefer a sluice made of heavy-gauge sheet metal (made rigid by bracing) and others prefer exterior-grade plywood painted with marine varnish or spar. The longer sluices are usually sectionalized to facilitate transportation. The primary function of a riffle is to retard heavy minerals giving them a chance to settle and, at the same time, to provide pockets in which the values are retained. A well designed and properly...
working riffle will create eddies along its downstream edges and the so-called "boiling" action in these eddies will do two things. First, it will prevent packing of the black sand or other material caught by the riffle, and, second, it will provide a classifying effect which further concentrates the gold and heavy minerals. While this boiling action must be strong enough to prevent packing it must not be so strong that flake or fine gold cannot settle. It should be obvious that proper riffle action is the key to good recovery. An easily built and effective riffle suitable for use in a small sampling sluice can be made from 3/4" x 5/8" wood strips placed across the bottom of the sluice at right angles to the flow, with 3/4" spaces between each riffle bar. The boiling action can be improved by undercutting the downstream face of each bar on a 30-degree bevel. The individual riffle bars are tacked to wooden side rails and the whole assembly held in place by means of cleats and wedges as shown in Figure 17. The riffle assemblies are made a little narrower than the inside width of the sluice and of convenient length.

Figure 17. — Wooden riffle suitable for use in a sampling sluice.

Heavy wire screen of the type used for screening gravel, and expanded metal lath are sometimes used as riffles in small sluices, particularly where much fine gold is present. This type of riffle is usually installed over burlap mats, cocoa matting, or similar rough-surfaced fabric which helps hold the fine gold. Because burlap and cocoa matting are difficult to clean, ordinary canvas should be substituted in sampling sluices. It will be noted that metal webs forming the diamond-shaped openings of expanded metal lath have a noticeable slope in one direction. When the expanded metal is placed in the sluice so that slope faces downstream, small eddies form beneath the overhangs and make excellent gold catchers. Expanded metal riffles do not have large holding capacity, that is, they may recover gold with concentrate, but this is seldom a problem sampling work where close watch and frequent cleaning-up should keep the riffles working efficiently. Hungarian-type riffles, such as those shown in Figure 17, can hold a comparatively large amount of concentrate and for this reason may be preferred wherever the gravel contains much black sand. On the other hand, expanded metal riffles leave a minimum amount of concentrate to be passed at the end of a sample run and in this saving feature makes them easy to clean. Many engineers compensate by equipping the upper 2 or 3 feet of a sampling sluice with Hungarian-type riffles and the remainder with expanded metal riffles.

In commercial-scale placer operations, mercury is usually placed in the riffles to assist holding gold over extended periods of time but small-scale sampling work where clean-up is frequent, mercury is not needed for this purpose and is seldom used.

It should be noted that when a particle of gold, "wets" by mercury, the gold actually penetrates the surface and causes the gold to become brittle. Depending on the size of the gold particle and length of exposure, the penetration may be superficial or complete. The gold is not restored when the mercury is removed and in the case of small gold particles delicate crystalline structure is often induced. It can be seen that amalgamation within the sampling sluice would either impair or prevent a later study of particle size, the surface texture, or other physical characteristics of the gold, any of which could prove important in a placer investigation.

The feed and water flow should be regulated to maintain proper riffle action and it can be said generally that where this is not done more fine gold will be lost by its inability to penetrate the matrix. Where fine gold is to be saved the depth of flow over the riffles should be as shallow as possible while still sufficient to carry off the pebbles and maintain a loose bed between the riffles. To do this the sluice grade is steepened and it can be said generally that the grade for very fine gold should be steeper than for coarser colors. Increasing the grade will, to a point, offset a deficient water supply but, in any case, the riffle action should tell the operator when the proper balance has been reached.

The daily capacity for a sampling sluice varies widely with the type of gravel, degree of cementation, amount of clay, etc. These factors individually and collectively determine the amount of material that a man can prepare for washing in a day’s time and, in many cases, the preparation time will exceed the actual washing time. Under favorable conditions with an efficient sluice set-up, two men can handle 1 to 3 cubic yards per day taking into account time needed for clean-ups between samples, processing the sluice concentrate, logging sample data, etc. When the miner examines washes a placer sample in a small sluice box and fails to find the amount of gold anticipated by the property owner or vendor, it is sometimes argued that he failed to recover the hoped-for value because his sluice was too small or the sample was put through too fast. While it is true that a sluice box crowded beyond its optimum capacity will lose some of the gold, a quick look at the facts will usually show that there is little or no room for argument in most cases.

For example, modern gold dredges provide about 10 square feet of riffle area for each hourly yard of material passing over the gold-saving tables. By direct comparison it can be shown that it would be necessary to feed as much as 10-foot sampling sluice at a rate of 1 1/2 cubic yards per hour to attain this degree of riffle loading. But experience tells us that the rate of feed for a sampling sluice of this size is more likely to be on the order of 1/2 cubic yards per day rather than per hour. It can be seen that in a sampling sluice the riffle area provided for each unit of sample material is considerably greater than the riffle area provided in standard mining practice. In other words, the small sampling sluice usually favors the sample. This is borne out by long experience which shows that a properly constructed and carefully operated sampling sluice will save all of the gold or other heavy minerals which can be economically recovered by standard placer methods.

4. ROCKERS

Rockers are widely used for washing placer samples and under most conditions they are well suited to the needs of the field engineer. It should be noted that since its inception, the American gold dredging industry has, for the most part, used rockers in preference to other types of sample washing equipment. The fact that the rocker has survived in direct competition with a variety of more "modern" or "mechanized" machines which have been introduced over the years attests to the reliability of results which can be obtained.

Rockers are usually homemade and are built in a variety of sizes and designs depending on the ideas and experience of the builder. Figure 18 shows a lightweight rocker which is easily built and is suitable for general use. Individual components are a screen-bottomed hopper for receiving and mixing the feed material, a canvas apron for deflecting the feed to the head-end of
of the rocker, the rocker body which is equivalent to a sluice, and a bed plate or frame upon which the entire assembly is mounted. A rocker may be made any convenient size because within limits, its size will determine throughput capacity rather than its efficiency as a gold savor. Although there are no fixed size criteria, a rocker 1 foot wide by 3 feet long would generally be referred to as "small" and one more than 18 inches wide or 5 feet long as "large." When made of wood (which is usually the case) clear lumber without cracks or flaws must be used and the bottom should be made of vertical-grained stock which will not shed or rough up when scraped. Heavy-duty rockers and those which are in continuous use are preferably made of sugar pine reinforced with metal fittings. Where sugar pine is not available, redwood makes a fair substitute. Rockers made of exterior grade plywood have the advantage of lighter weight and this is strong and durable if the joints are sealed with waterproof glue. The exposed surfaces of a plywood rocker should be protected with marine varnish or spar.

The hopper should be made 1/2 to 3/4 inch narrower than the inside width of the rocker, to results in a bumping action as the rockers are operated and assists scouring and so washing gravel. The amount of open area in the side plate is important. A screen with too much open area allows the fines to pass through too fast and where much sand is present this can cause overloading of the riffles with resultant gold loss. A plate with 1/4-inch holes drilled or punched, an alternate pattern at 1-inch intervals and a 1/2-inch centers will provide a screen with 3 percent open area. This has been found to be about right for small prospecting rockers.

The apron consists of a simple wooden frame covered with loose-fitting canvas or similar material. The resultant sag or "belly" in the apron functions as a gold and black sand trap and when large amounts of material are put through a rocker, the apron's gold-holding ability permits longer runs between clean-ups. In normal sampling work where short runs are made, the apron is less important and is sometimes dispensed with.

Like panning, rocking relies to some degree on gravity-flow. Experience and practice enable these men to concentrate the gold and black sand directly on the smooth wooden bottom of the rocker and, as a final step, to tail out the black sand and bring the gold to a point in a manner somewhat similar to panning. This technique is particularly useful when applied to small-volume churn drill samples and is mentioned here to point out that a properly operated rocker is an excellent gold saver which, unlike the sluice, does not rely on riffles for its effectiveness. But it should be pointed out that a rocker equipped with good riffles will forgive much mishandling and, for this reason, the average person should use them. Parenthetically, it should be noted that even the experienced rocker operator, in certain cases, may find it more expedient to use riffles than to explain to a layman why they are not essential. A simple riffle arrangement suitable for general use can be provided by covering the rocker bottom with heavy-gage expanded metal lath placed over a canvas mat and held down by several transverse strips as shown in Figure 18.

The construction for the various parts of the rocker is as shown in Figures 18 and 19. The length of the rocker handle is important—it should be waist-high to the operator in a standing position. The long leverage thus provided makes it possible to rock the rocker smoothly and maintain a uniform flow of material over the riffles. For this reason, a water hose supplied by a pump or a gravity-flow should be provided where possible. The flow of water obtainable from an ordinary garden hose (about 5 gallons per minute) is usually enough for operating a rocker but where this is not available, two or three barrels of water used in a closed circuit will generally be sufficient for a day's work. When water must be dipped, the water barrel should be placed next to the head-end of the rocker within easy reach of a short-handled dipper. When rocking is periodically stopped to discharge rocks from the hopper, the material passing over the riffles will settle and tend to pack, particularly if much black sand is present. If washing is resumed without first loosening this material, any fine gold that has not penetrated into the riffles will settle and tend to pack, particularly if much black sand is present. If washing is resumed without first loosening this material, any fine gold that has not penetrated into the riffles will settle and tend to pack, particularly if much black sand is present. If washing is resumed without first loosening this material, any fine gold that has not penetrated into the riffles will settle and tend to pack.
After the entire sample has been washed, the concentrate remaining behind the transverse riffles is picked up with the scoop and placed in the upper end of the rocker and then carefully re-washed once or twice with clear water to remove surplus sand and further reduce the concentrate volume. The apron, riffles and canvas mats are then removed and washed out in a pan or tub of water and the combined concentrates panned to a finished product.

Although reference books state that from 1 to 3 cubic yards can be washed in a rocker per man-shift, it should be noted that these figures apply to production-type work and give little indication of what should be expected when processing samples. Experience has shown that one man using a 12-inch x 4-foot rocker similar to the one illustrated in Figure 18 can wash the equivalent of eight 80-pound samples per day where conditions are favorable. This includes the time for clean-ups, panning, and logging sample data. The total amount will, of course, vary with the size or number of individual samples and with the character of material being washed. Material containing much clay can halve this figure whereas loose, free-wash type material may double it. Dredging companies occasionally use large, engine-powered rockers in which the total gravel excavated from a shaft can be washed rapidly and economically. A typical power-driven rocker having a capacity of 5 cubic yards or more per man-shift is illustrated and described on pages 334 and 335 of the August 25, 1923, issue of Engineering and Mining Journal-Press.

These are manufactured by the Denver Equipment Company and known as the “Denver Mechanical Gold Pan” and the “Denver Gold Saver” respectively. The mechanical pan has been well received in the industry over a 30-year period and is generally referred to simply as a “Denver Pan.” It comprises an assembly of three shallow, nested pans 2 feet in diameter, with superimposed screens arranged to wash and reject the plus ¼-inch material. The combined assembly is mounted on a horizontally gyrating base driven by a small gasoline engine and the resultant motion is said to duplicate hand panning. The minus ¼-inch material after passing through the screens, progressively flows over the three pans, one discharging into the next. The uppermost pan is provided with an amalgamating plate, and the two successive pans with special rubber mats or cocoa matting held down by coarse wire screen. Capacity of a single unit ranges up to 12 cubic yards per hour and water consumption is said to be as little as 1 to 2 parts (by weight) per part of gravel which would indicate an average of about 1,000 gallons per cubic yard. Single or double units are available and these can be provided with a scrubber and a trommel-type screen. The largest (Duplex) unit when so equipped has a rated capacity of 4 to 6 bank-run yards per hour and weights 2,100 pounds. The Single (Simplex) unit without the trommel weighs 675 pounds. The Denver Mechanical Gold Pan is sturdy built and is suitable for continuous use such as would be encountered in a mining operation.

The Denver Equipment Company’s second machine, sold under the name of “Denver Gold Saver,” is well suited for general sampling work in that it can be quickly and easily cleaned thus eliminating the danger of carry-over of values from one sample to the next. It consists of a feed hopper, a combined scrubber and trommel to wash and screen out the plus ¼-inch material, a special vibrating molded riffle, a reserve water storage tank and a centrifugal pump with suitable piping, sprays, etc., all powered by a ½ H.P. gasoline engine. The complete assembly weighs 750 pounds and has a rated capacity of 2 to 3 cubic yards per hour.

6. DRY WASHERS

In arid districts where water is scarce or expensive and a “dry” plant is proposed for the recovery of placer gold, a small dry washer may be the logical choice for processing samples. A number of small, hand-powered machines are on the market and most work quite well within certain limits. The Denver Gold Saver, for instance, can wash some 675 pounds. The Denver Mechanical Gold Pan is equipped has a rated capacity of 4 to 6 bank-run cubic yards per hour and weighs 2,100 pounds. Tisel (Simplex) unit without the trommel weighs 675 pounds. The Denver Gold Saver is sturdy built and is suitable for continuous use such as would be encountered in a mining operation.

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This shows the gold to be eleven times heavier than gravel when immersed in water, as compared to 7:1 in air. Simply stated – the relative weight of gold is about 1½ times greater when passing through a wet process than when passing through a dry washer. The lesser ratio in air is not too apparent when processing coarse or “shotty” gold but in no doubt contributes to the dry washer’s often poor recovery of fine or flaky gold.

To respond to dry washing the material treated must be almost completely dry. In most cases 3 percent moisture is considered a maximum. The gold particles must also be completely liberated and free of cementing material such as caliche. In addition, effective separation is usually dependent on use of a closely-sized feed, sometimes not larger than ½" screen-size. One might say that the amenability of a dry placer to commercial-scale placer operation, it might be advisable to process the initial samples with a dry washer. Figure 19 illustrates a type of machine found suitable for this purpose. If all else is equal, the recovery obtained from the dry (sample) washer should indicate the recovery to be expected from the full-scale operation. On the other hand, if the samples are washed in a rocker or other wet device, a suitable recovery “correction” factor may have to be applied to the indicated sample values.

REFERENCES CITED (PART IV)

PART V

PANNING AND ASSAY PROCEDURES
I. PANNING

Panning is a simple operation but, at the same time, it is difficult to describe. Although the subtle techniques of panning vary with the individual and with the material being washed, the overall operation can be divided into six basic steps as follows:

a. Preparation: After filling the pan approximately level full, carefully submerge it in quite water, preferably resting it on the bottom of a shallow pool or tub with the top of the pan just below the water surface. After the material has become thoroughly wet, work over the contents with both hands and break up any lumps. If clay is present, knead and stir the material until the clay is dissolved and floated away. It is important that all clay be eliminated before actual panning begins. Wash off and throw out all large rocks. In this first step the eye and hands substitute for a screen.

b. Suspension and stratification: Commence this stage by grasping the pan with hands on opposite sides and while holding the submerged pan level, twist it back and forth (clockwise and counterclockwise) with sufficient vigor to keep the contents loose. This allows the heavier minerals to migrate to the bottom of the pan and is similar to the action in a jig in which heavy mineral grains are separated from lighter grains by their ability to sink through a semi-fluid bed. If this second step is properly executed, the smallest and heaviest grains will migrate toward the bottom and the larger and lightest to the top. This will allow many of the pebble-size rocks to be manually removed by raking them out of the pan with the fingers.

c. Washing: The third step is one which, depending on the nature of the material being washed, may take on many variations. It is like Step 2 in that the entire contents of the pan are kept in motion, but as stratification of the bed develops, the lighter particles are allowed to escape over the rim of the pan. To do this, raise the pan partially above water and move the hands slightly back of center (allowing the pan to tip forward with the low side away from the panner) and change from the twisting motion of Step 2 to a flat circular motion. While keeping the pan partially submerged and its contents loose, gradually work the lighter-weight material over the low side of the pan. The rate of discharge is regulated by raising or lowering the pan rim and by using a side to side motion along with the flat circular motion. Alternate Steps 2 and 3 and wash until the bed begins to pack or until heavy minerals begin to crowd to the surface.

d. Cleaning: The fourth step involves selectively washing away surface grains and, in effect, it can be compared to the action of wash water on a concentrating table. To prepare the now partially concentrated material for this step, the pan is given a short, quick side to side motion of sufficient vigor to thoroughly loosen the bed and further stratify the material. During this shaking phase the pan is tipped gradually forward until the surface of the mineral bed becomes flush with the lip. At this point the shaking is stopped and the mineral bed allowed to settle. Next, a thin layer of the lighter material is removed by carefully dipping and raising the pan with a forward-and-back motion which will wash off the surface grains a few at a time. The washing can be effectively controlled by use of a somewhat circular motion as well as the forward-and-back dipping motion. When the panner decides that further washing would cause a loss of values, the bed is re-stratified and more light material brought to the surface by repeating the vigorous side to side motion. Repeat the washing and shaking operations until the heavy mineral concentrate is clean or until it is reduced to a volume small enough to permit inspection or removal of the gold. During the finishing steps the panner can save time by raking any remaining pebbles out of the pan with his fingers and flicking out smaller particles with his thumb. These and other tricks come with practice.
e. Inspection and estimating: At the end of the panning operation the original material will normally have been reduced to a small quantity of concentrate consisting mostly of black sand and minerals. After putting a little clear water in the pan, the experienced panner will fan out the concentrate on the bottom of the pan and by "tailing" the gold he can inspect or count the colors. At this point he can estimate the tenor of the sample. There are perhaps as many ways of tailing the gold as there are panners but this is usually accomplished by moving the pan in a way that causes the water to gently swirl around the trough formed at the intersection of the bottom and side of the pan. This swirl of water carries the lighter particles ahead of those which are heavier or finer and with careful manipulation, brings the gold colors into view at the tail of the slowly moving fan of concentrate.

f. Removing the gold: Final separation of the gold from other heavy minerals can be made in a number of ways. Larger pieces can be picked out with tweezers or the point of the knife and small colors or specks can be picked up by pressing down on them with the end of a wooden match or a dry finger tip. Remove the gold by placing the finger top over a vial of water and washing it off with a splash of water. A small globule of clean quicksilver (mercury), if rolled around in the pan, will pick up the gold providing it is untarnished (mercury), if rolled around in the pan, will pick up the gold providing it is untarnished. A small globule of clean quicksilver will roll around the pan and then fill with gravel and submerge in water in the usual way. When the material is thoroughly wetted, lift the sieve slightly and twist it back and forth (under water) until all minus Vi-inch material has passed into the regular pan. The plus Vi-inch material is discarded and the fines which dropped into the regular pan are washed in the usual way. Aside from spending the overall panning operation, the use of a sieve enables the engineer to conveniently inspect the plus Vi-inch rocks and to estimate the proportion of coarse material.

c. Recommended pan size: The average pan should not use a 16-inch pan but instead should use the so-called "half-size" pan which has a top diameter of 12 inches, a bottom diameter of 7 1/2 inches and a depth of 2 inches. The half-size pan level-full weighs approximately 9 pounds compared to about 20 pounds for the standard 16-inch pan. Halving the sample weight by use of the smaller pan not only reduces fatigue, particularly when much panning is to be done, but the fact that it is much easier to carry in the field and to use in a small street or tub is an important consideration. The pan factor for a 12 x 7 1/2 x 2-inch pan is about 400, assuming a 20 to 25 percent gravel swell. Experience has shown that two half-size pans can usually be washed in less time than one full-size pan.

d. Use of perforated pans: Panning, at best, is a tedious, back-breaking job and anything done to speed the operation or improve working conditions will be repaid many times over in the form of more reliable results. The beginner and experienced panner alike can profit by the use of a sieve 1/2 made by drilling Vi-inch holes in the bottom of a pan of the same size and shape as the one used for panning. To use the sieve, place it inside of the regular pan and then fill with gravel and submerge in water in the usual way. When the material is thoroughly wetted, lift the sieve slightly and twist it back and forth (under water) until all minus Vi-inch material has passed into the regular pan.

e. Use of safety pan: Allowing the pan tailings to fall into a second pan generally referred to as a "safety" pan will prevent losing the sample by accident and will greatly expedite repanning where this is called for.

f. Panning large samples: When a large multi-pan sample is to be washed, repanned, and complete each successive pan, it is best to reduce them only to a rough concentrate. The rough concentrates are accumulated and are eventually combined for finishing in the usual manner.

g. Stage panning: Where a large amount of heavy black sand is encountered, a stage-panning procedure can be used to advantage. This is done by panning and repanning to successive high-grade concentrates without attempting to make a complete saving of black sand or values at any one stage. As the proportion of heavy minerals decreases with each successive repan, it becomes progressively easier to make a high-grade concentrate with a low-grade tailing. Usually two or three repannings will make an acceptably clean tailing.

b. Supplemental data: When panning a sample the experienced engineer will note a variety of things among which are: Its amenability to washing, particularly where clay or cementing materials are present; the proportion of coarse to fine material; any evidence of unusual muddy water problems; the composition and angularity of rocks; the relative ease of concentration; the quantity and composition of black sand; indications of valuable or potentially valuable accessory minerals; the size, shape and other physical characteristics of the gold including "rust", tarnish or other factors which would affect its amalgamation. Any of these factors or a combination of them and other important factors in a placer mining operation.

i. Use as a geologic tool: Although the miners' pan is normally associated with gold deposits, it can be profitably employed when investigating a variety of heavy minerals such as monazite, scheelite, magnetite, ilmenite, cassiterite, chromite, etc. In general, it should be borne in mind that with few exceptions the pan can be employed in the study of either lode or detrital-type deposits containing fine or coarse heavy minerals. The use of a miners' pan as a geologic tool has been studied and reported in detail by Martt (1954) and by Theobald (1957).

3. FIRE ASSAY OF PLACER SAMPLES — MISELADING RESULTS

Fire assaying, in essence, is a miniature smelting process which recovers and reports the total gold content of the assay sample, including gold combined with other elements or locked in the ore particles. Because of this a fire assay may report values that cannot be recovered by placer methods and it cannot be too strongly stressed that when dealing with gold placers, the sample values should not be determined by fire assay. Furthermore, no credence should be placed in placer valuations or reports that are based on the results of fire assays. Although this should be common knowledge among mineral examiners, a surprising number seem unaware that fire assay accuracy per se yields misleading results when applied to placers.
There are other reasons: First, consider the small quantity of material used in a fire assay. The usual amount of sample taken for a crucible charge is either 29.166 grams (one assay-ton) or half of this amount. Next, consider that a particle of placer gold only 1/32 inch in diameter may weigh about 1/4 milligram. Now if the bank-run material from which it came averaged 10c per cubic yard, 1/4 the 1/4-milligram gold particle would be contained in about 7½ pounds of sand and gravel. But suppose this same 1/4-milligram gold particle found its way into a 29.166-gram fire assay charge. The resulting assay-value would be 1/4 ounce per ton or about $95 per cubic yard.1/ If it is seen that a single small particle of gold, by placer standards, will cause an intolerable error when injected into a standard fire assay charge.

Experience tells us that with few exceptions no amount of mixing or careful division can produce a fire assay charge representative of bank-run placer material. The practice of first panning a sample to reduce its bulk, and then fire assaying the resultant black sand concentrate does not entirely resolve this problem. Even if we assume that a representative crucible charge could be obtained, the fire assay will detect all gold including that which is locked up in rock particles or is too finely divided to be recovered by placer methods. This in itself precludes the use of fire assays for evaluating placer ground.

In brief, experience has shown that fire assay results applied to placers usually results in a substantial over-valuation of the ground. This fact has been set out by Janin (1918, p.38), Vanderburg (1936, p. 33), Gardner and Allsman (1938, p.61) and others.

4. PROCEDURE FOR DETERMINING RECOVERABLE GOLD IN PLACER SAMPLES

a. Reduce the original sample to a black sand concentrate by panning, rocking, or other suitable means.

b. Place the concentrate in a pan, then count and record the gold colors as No. 3, No. 2 or No. 1 size (Note 1). At this point, manually remove any gold particles which are to be kept in their natural form (Note 2).

c. Add a globule of clean, gold-free mercury (about the size of a small bean) and working over a safety pan reduce the black sand and small-volume concentrate. Near the end of the panning process the mercury may tend to ride over the top of fine-size or hard-packing materials but as this is the size at which all gold should have been picked up by the mercury.

d. Remove the mercury and place it in a 250-ml Pyrex beaker. Add 40 or 50 ml of nitric acid (Note 3) and digest until the mercury globule is reduced to the size of a nailhead. Transfer to a #0 glazed porcelain parting cup, add fresh acid and complete the digestion using low heat if necessary. Fine-size gold will be left as a colorless, sponge-like mass if rapid digestion or boiling is avoided.

e. After decanting off the acid, carefully wash the gold three or more times with warm water. Add a drop or two of alcohol (to prevent spattering) and dry in the parting cup at low heat.

f. Anneal the gold by bringing the bottom of the parting cup to a low red heat. This step will eliminate any residual mercury and is essential when working with very small gold weights.

g. Transfer the annealed gold to a balance pan and weigh. A balance widely used by placer engineers is shown in Figure 20.

5. The described procedure will extract all free gold recoverable by commercial placer methods. With care, extremely low gold values can be determined. Where so-called "rusty" or coated gold is present, provisions should be made to score or otherwise brighten the gold prior to amalgamation. This may be done by rubbing it on the bottom of the pan or adding a few pebbles to the amalgamating jar. Fine grinding or pulverizing should be avoided.

REFERENCES CITED (PART V)


1. DESCRIPTION OF SAMPLES

A mining claim may be validly located and held only after the discovery of a valuable mineral deposit. When it becomes necessary to determine the validity of a claim and the sufficiency of discovery is in doubt, the Government will initiate contest proceedings during which the testimony is given by parties to the contest and their witnesses. During such proceedings, assay certificates or other sample data are submitted as evidence of value, or lack of value. The sample and assay data are important in that the hearings examiner or the court must rely on them to a large extent to determine if a valid discovery has been made.

But numerous decisions have pointed out that in order to fully understand the results of these assays, the method in which samples were taken and tested must be considered. Without such information they have little probative value and, accordingly, are entitled to little evidentiary weight.

In brief, an accurate and systematic record should be kept of each sample through the cutting, processing, and calculation stages. The use of suitable printed forms will expedite the data recording process and, equally important, will serve as a check list and lessen the risk of oversight. Three such forms prepared specifically for BLM use are included in the appendix.

Complete, accurate and signed sample records are in effect legal documents and they should be prepared and preserved with corresponding care.

2. REDUCTION OF SAMPLE VOLUMES

In typical gold placers the variations are so great and the values are so low, any attempt to divide a sample by taking alternate shovels, mechanical splitting, or by other means will invariably yield erratic results. Rather than set out supporting theory which at best would be academic, two examples are offered to show what actually happens. One is based on a laboratory experiment and the other on field practice at an operating mine. First consider the laboratory experiment.

Referring to Figure 21, assume that the bucket of sand weighs 60 pounds and that instead of lead shot it contains 320 particles of placer gold weighing 0.1 milligram each. The initial sample will have a value of $1.60 per cubic yard.\(^1\)

The first split yields two 30-pound samples with indicated values of $1.53 and $1.67 per cubic yard, a spread of 14 cents per cubic yard.

The second split yields four 15-pound samples with indicated values of $1.74, $1.32, $1.46 and $1.88 per cubic yard; a spread of 56 cents per cubic yard.

The third split yields eight 7½-pound samples with values ranging from a low of $1.12 to a high of $2.28 per cubic yard; a spread of $1.16.

The fourth split yields sixteen 3½-pound samples with values ranging from a low of 64 cents to a high of $2.56 per cubic yard; a spread of $1.92.

As splitting continues, the spread in indicated value becomes progressively greater. On the fifth

\(^1\) Using a weight to volume ratio of 3,000 lbs. per cu. yd. and figuring 10 milligrams of gold to the cent.
split, for example, (not shown) the indicated values ranged from 16 cents to $2.72 per cubic yard.

Data from a recent study by the United States Geological Survey (Clifton, 1967) confirm that variances shown in the foregoing example are typical of those found in practice.

The second example has been taken from the prospecting records of an operating company. In this case the gold-bearing gravel excavated from each of 14 shafts was divided as carefully as possible by placing alternate buckets in half "A" and half "B".

In the above tabulation.

The individual halves, averaging 7.4 cubic yards in diameter and ranging from 30 to 40 feet deep.

The following examples show that the splitting of gold placer samples should be strictly avoided unless there is some very special reason to divide a sample or reduce its volume before washing or other treatment. In cases where this must be done, the miner examiner should be fully aware of the erratic and probably misleading results likely to follow. Any divergence from normal procedure should, of course, be noted in the sampling records and in subsequent reporting.

When dealing with fine-size placer materials having a low unit-value, such as magnetite or ilmenite sands, a substantial reduction of the bulk sample or of its concentrate by mixing and splitting is generally a proper procedure and a common practice.

3. REPORTING VALUES

In the United States, the volume of placer material is always reported as bank-measure cubic yards and the value is customarily reported as cents per cubic yard. In addition to the calculated value, the actual weight of gold in bullion, its fineness or estimated fineness, and the price of gold used in the value calculation should be noted on the sample sheets as well as in subsequent reporting.

Minerals other than the precious metals are reported as pounds per cubic yard, percent, or the particular unit customarily used for the commodity in question.

4. COST ESTIMATES

One of the miner examiner's functions is to give a qualified or expert opinion as to whether a given mining claim or mineral deposit has present or potential value. Among the evidence to be examined and weighed in forming his judgment will be the question of costs. In many cases there is a factor so obviously weak that a detailed cost study is not necessary, in fact, it would be useless. Here, a rough approximation based on experience and common sense will usually suffice.

But in other cases a careful consideration of this question will be necessary. If the deposit has not been completely blocked out and sampled, or if the mining method and working rate have not been firmly established, an accurate cost estimate is not possible. In the absence of such development work, all the miner examiner can do is to make a qualified estimate based on comparative data from reliable sources, or from his own experience with similar properties.

Basically, he must decide whether the deposit contains enough gold or other salable mineral to cover:

- Cost of operation.
- Cost of all equipment.
- Royalties or cost of land.
- All exploration, sampling, and pre-operating costs.
- Cost of borrowed capital.
- Cost of start-up delays and contingencies.
- Reasonable profit.

In turn, some of the factors influencing the operating cost will be:

- Type of operation (dredge, hydraulic, sluiceplate, etc.).
- Size and ton of the deposit.
- Character of the gravel and bedrock.
- Water supply.
- Grade of sluices.
- Disposal area for tailings and muddy water.
- Working season.
- Regulatory laws (land restoration, etc.).

If the foregoing are kept in mind and weighed intelligently, a fair cost estimate can usually be made by comparing the subject property with a similar property where mining operations have been conducted and costs established. But just how to obtain these cost data and how to equate them to today's inflated prices is one of the practical problems encountered in applying the comparative cost method.

First, we find that because of the depressed state of the placer mining industry there are few operations from which up-to-date costs might be extracted. Second, anyone who has tried to obtain detailed cost data from a responsible operating company has soon found that such information is considered confidential and seldom released for outside use. While the small operator may be freer with his information, it will usually be found that he did not bother to keep systematic records and his cost figures may be little more than guesses.

This means that for the most part, the miner examiner will have to rely on the few placer cost data available in the technical press, most of which are fragmental and over 30 years old. A list of the more useful and readily available sources has been placed at the end of this section.

To update the older figures, a year-by-year cost index will be needed. The annual index for various classes of construction, construction materials, labor, and machinery can be obtained from Engineering News-Record magazine. The March (quarterly review) issue will be found particularly helpful.

In the absence of comparative data the estimator is on his own. In such cases he may have to work up estimated costs based on a hypothetical operation using a method or combination of methods proven effective in similar deposits elsewhere. This estimating procedure has been illustrated by Staley and Storch in a two-part article titled "Choosing a mining method for gold-bearing gravels." This article has been listed among the selected references which follow.

Examples of 1964 costs are given in Appendix E.

SELECTED REFERENCES CONTAINING PLACER COST DATA

Contains detailed operating data for a typical dragline dredge.

Patman, Charles G., Methods and costs of dredging
nuriferous gravels at Lancha Plana, Alava County, 
Spain. A.A.M.E. Technical Publication No. 1900 
(1945), 35 pp. 1939-1941 costs for a
bucket-line dredge.

Romanowitz, Charles M., Floating dredges used in
mining purposes: Mineral Information Service, 
Vol. 20, No. 7, pp. 62-87, July, 1967. (Published 
by California Division of Mines and Geology. 
Discusses onshore and offshore dredging includ-
ing other minerals. Compares hydraulic
(suction) dredges and bucket-line dredges. Not 
dredging costs in South America and Yako 
Territory. Reviews history of dredging and last 
developments.

Staley, W. W., and Storech, R. H., Choosing a min-
ging method for gold-bearing gravels, Part I: 
Engineering and Mining Journal, Vol. 138, No.7, 
pp. 342-346; also p. 359, July, 1937. Part II: Vol. 
139, No. 9, pp. 43, 44. Sept., 1937. Develops 
hydromatic mining programs and compares costs 
for working a placer (in Alaska) by 
dredging, power drag-scraper, and dredging. 
A good example of a placer cost study.

Thomas, Bruce I., Cook, Donald J., Wolf, Ernest, 
and Krens, William H., Placer mining in Alaska 
County, California: U.S. Bureau of Mines 
Information Circular 7926, 34 pp. 1959. Describes 
mining methods and gives unit operating costs at 
operations where hydraulic and mechanical 
equipment is used with 
non-floating washing plants, including sluicebox 
mining operations.

Thurman, Chas. H., Costs in dragline gold dredging: 
A.I.M.E. Technical Publication No. 1900 (1945), 
6 pp. Compares bucket-line and dragline 
costs. Gives examples of equipment and operating 
costs.

5. UNPROVEN PROCESSES

Many special placer machines or secret recovery 
processes have been "invented" or proposed. 
Some claim the ability to extract microscopic or 
collateral gold from materials that show little or 
no value when tested by fire assay or by the 
normal methods of testing placer material. Oth-
er are intended to recover the varying amounts of 
false gold admittedly lost in large-scale placer 
operations. These devices or schemes seem to 
have an unfailing attraction for miners as well as 
for the general public.

But despite the many "improved" placer 
machines and the new gold-saving methods that 
have been offered, the simple Hungarian-type 
ruff has held its place in the placer industry 
while most of its rivals have been discarded. A 
notable exception is the placer-type jig which has 
supplemented the riffled tables (shakes) in some 
dredging operations and has replaced them in 
others.

It can be said generally that the success of a 
placer operation will hinge on the throughput, a 
high throughput being the key to low costs. In 
other words, the greater the throughput the 
lower the unit cost. Experience has shown that to 
achieve the optimum working rate some recovery 
must be sacrificed, or put simply, it is cheaper to 
lose a certain amount of gold than to save it.

to date no one had demonstrated a placer 
recovery system that can economically replace 
today's methods and equipment. Operating 
economies made possible by the large capacity 
and the simplicity of conventional riffles and 
placer jigs more than offset the dollar value of 
the gold they may lose. On this basis, they yield 
the greatest operating profit.

Even where a new or improved recovery method 
may be shown to possess some potential, if it is 
not yet at the stage where it can be presented as 
a proven method or technique, the mineral 
miner has little choice but to rely on standard 
analytical and recovery methods when making his 
evaluation.

REFERENCES CITED (PART VI)

Clifton, H. Edward, Hubert, Arthur, and Phillips, R. 
Lawrence, Marine Sediment Sample Preparation 
for Analysis For Low Concentrations of Fine 
Dretil Gold: U.S. Geol. Survey Circular 545, 
PART VII

CHECK LIST FOR PLACER INVESTIGATIONS
GENERAL CONSIDERATIONS

An adequate mineral investigation will develop a considerable body of information in addition to that obtainable from samples alone, some of which will be found vital when assessing the actual worth of a prospect. For example: Sometimes most of the value in a commercial placer is found on or in the bedrock; perhaps several feet of bedrock must be taken up to recover the pay. In such cases its hardness and irregularities must be known and failure to consider this has proved fatal to more than one dredging project. Because boulders can be disconuous to a placer operation their maximum size, number, and distribution should always be of prime concern to the mineral examiner. Failure to recognize or properly assess tailings or muddy water disposal problems, where they exist, can prove expensive or cause premature shutdown of an otherwise profitable operation. In brief, physical details often determine the success or failure of a placer as much or more than the mineral content itself. The importance of considering all factors and their possible effect cannot be overemphasized.

Because no two deposits are alike, no rule can be made as to what should be included in a placer check list. Also, the degree of inquiry will vary widely depending on the purpose of the investigation. Where it is clearly evident that a property has no value or prospective value a detailed field investigation may not be required, but even here, sufficient data for a well-informed report should be gathered.

The following check list is intended first as a field guide and second, to show the range of inquiry which may be necessary for an adequate placer investigation. The user should, of course, tailor this list to suit his particular needs.
2. FIELD GUIDE AND CHECK LIST FOR PLACER INVESTIGATIONS

1. Date of examination_____________________________________________

2. NAME OF CLAIM(s) OR PROPERTY ___________________________

3. State________________, County________________________ District

4. Township________________, Range______________________, Section(s)

5. REASON FOR EXAMINATION ___________________________

6. EXAMINED BY

7. Assisted by

8. Others present

9. Number of claims or acres

10. NAMES OF LOCATORS AND PRESENT OWNER

11. Owner's Address

12. TYPE OF DEPOSIT (stream, bench, desert, etc.)

13. Terrain

14. Gradient of deposit: Less than 5% ( ); More than 5% ( ).

15. Is the deposit dissected by deep washes or old workings? Yes ( ); No ( ).

16. Type and extent of overburden

17. Depth to permanent water table

18. Depth to bedrock

19. Kind of bedrock (rock type)

20. Hardness of bedrock

21. Bedrock slope or contour to be expected

22. Are high bedrock pinnacles or reefs in evidence? Yes ( ); No ( ).

Remarks

Remarks

Remarks

Remarks
23. Gravel is: Well-rounded ( ); Sub-rounded or Sub-angular ( ); Angular ( ).
   Remarks __________________________________________________________________________

24. Does gravel contain rocks over 10-inch ring size? Yes ( ); No ( ).
   Remarks __________________________________________________________________________

25. BOULDERS (Max. size, number, distribution, etc.)
   __________________________________________________________________________________

26. Rock types noted in gravel
   __________________________________________________________________________________

27. Predominant rock type (if any)
   __________________________________________________________________________________

28. SAND (kind, amount, distribution, etc.)
   __________________________________________________________________________________

29. Sorting or bedding patterns (if apparent)
   __________________________________________________________________________________

30. STICKY CLAY? Yes ( ); No ( ). Remarks
   __________________________________________________________________________________

31. Cemented gravel? Yes ( ); No ( ). Remarks
   __________________________________________________________________________________

32. Caliche? Yes ( ); No ( ). Remarks
   __________________________________________________________________________________

33. Permafrost? Yes ( ); No ( ). Remarks
   __________________________________________________________________________________

34. Buried timber? Yes ( ); No ( ). Remarks
   __________________________________________________________________________________

35. Hard or abrasive digging conditions? Yes ( ); No ( ). Remarks
   __________________________________________________________________________________

36. Character of gold: Coarse ( ); Flaky ( ); Fine ( ); Rough ( ); Shotty ( ); Smooth ( ); Bright ( );
    Stained or coated ( ). Remarks
   __________________________________________________________________________________

37. Can good recovery be expected by use of riffles or jigs? Yes ( ); No ( ). Remarks
   __________________________________________________________________________________

38. Is recovery said to depend on secret process or special equipment? Yes ( ); No ( ). Remarks
   __________________________________________________________________________________

39. Are black sands said to contain locked gold values? Yes ( ); No ( ). Remarks
   __________________________________________________________________________________
40. Have black sands been checked for valuable minerals other than gold? Yes ( ); No ( ).
   Remarks

41. Distribution of values in deposit (if known)

42. Record or evidence of previous sampling

43. Results of prior sampling (if known)

44. Are old workings in evidence? Yes ( ); No ( ). Remarks

45. Past production (if known)

46. Date of last production or work

47. Reason for quitting

48. Present work (if any)

49. APPLICABLE MINING METHOD

50. Possible cost to bring property into production

51. POSSIBLE MINING COST

52. Dimensions of (physically) minable ground

53. Possible extensions

54. Maximum yardage indicated to date
55. Mining equipment on ground

56. Accessory equipment or improvements on ground

57. Water supply

58. Power supply

59. DOES PROPERTY HAVE ADEQUATE TAILINGS DUMP ROOM? Yes ( ); No ( ). Remarks

60. Would mining in this area come under County, State or Federal water quality control regulations? Yes ( ); No ( ). Remarks

61. Fish and Game regulations? Yes ( ); No ( ). Remarks

62. CAN SETTLING PONDS BE BUILT TO EFFECTIVELY RETAIN OR CLARIFY THE MUDDY WATER? Yes ( ); No ( ). Remarks

63. IS PROPERTY SUBJECT TO RESOILING OR OTHER SURFACE RESTORATION REGULATIONS? Yes ( ); No ( ). Remarks

64. Elevation of property

65. Climate

66. Working season

67. Season governed by

68. Surface cover and its effect on mining

69. Merchantable timber or other surface values

70. Nearest town
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<td>Attach photographs of pertinent features (if available).</td>
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PART VIII

GLOSSARY OF PLACER TERMS
Many of the following terms have universal definitions, that is, they have definitions common to all branches of the mineral industry. On the other hand, some are unique to the placer industry or at least they have placer-related meanings different from those in general use. For example: The term FLotation, as used in the general mining industry, relates to a mineral separation process. But in placer mining, the term FLotation is applied to the minimum water depth needed to move an operating dredge.

It should also be noted that the definitions given here are intended to be descriptive rather than legal, and they should be used accordingly.

Names in parentheses refer to sources as follows:

ACCRETION BAR. A low-level deposit of sand and gravel formed in a stream by gradual addition of new material. Accretion bars are typically formed along the short, or inside radius of curves. See - Skim bar.

ADJUSTED VALUE. A sample value that has been increased or decreased by an amount deemed necessary to offset known variables or other factors that may cause discrepancies in the initially indicated value. In placer drilling, the adjusted value is also known as a CORRECTED VALUE. To be valid, such adjustments must be based on careful diagnosis of sampling problems, and must reflect sound judgement. See - Indicated value.

AINLAY BOWL. A wet, gravity concentrator used for the recovery of gold and other heavy minerals from alluvial materials. It consists essentially of a bowl-shaped vessel, rotated about its vertical axis and provided with circular riffles. Feed entering at the center is carried upward and outward by the flow of water and centrifugal force. Tailings overflow the rim while gold and other heavy minerals are retained by the riffles. A somewhat similar bowl-shaped concentrator is known as the KNUDSEN BOWL.

AIRPLANE DRILL. A compact, engine-powered placer drill designed for use in areas of difficult access. The term AIRPLANE DRILL is actually a trade name which through common use, has become part of the placer vernacular.

ALLUVIAL. 1. Deposited by a stream. 2. Relating to deposits made by flowing water. (Fay)

ALLUVIAL FAN. A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain or meets a slower stream. The fans generally form where streams issue from mountains upon the lowland. (AGI)

ALLUVIAL GOLD. Gold found in association with water-worn material. (Fay)

ALLUVIAL PLAIN. 1. Flood plains produced by the filling of a valley bottom are alluvial plains and consist of fine mud, sand, or gravel. 2. A plain resulting from the deposition of alluvium by water. (AGI)

ALLUVIUM. A general term for all detrital deposits resulting from the operations of modern rivers, thus including the sediments laid down in river beds, flood plains, lakes, fans at the foot of mountain slopes, and estuaries. (AGI)
BANKA DRILL. A placer drill consisting essentially of a flush-jointed casing equipped with a serrated cutting shoe. The casing is rotated by means of a man or animal-powered sweep attached to the upper section. Men standing on an attack platform, chop up the drill core and remove the casing by means of hand-powered lug. Also known as an EMPIRE DRILL.

BAR. A deposit of alluvial material above or below the water line of present streams. Bars may form where the current slackens or changes direction. See — Accretion bar.

BATEA. A wide and shallow, cone-shaped tray, usually of wood, used for panning gold. The label is in common use in Mexico, Central and South America, and Asia.

BEACH PLACER. See Sea-beach placers.

BED LOAD. Soil, rock particles, or other objects, rolled along the bottom of a stream by the movement of the water, as contrasted with the "silt load" carried in suspension.

BEDROCK. The solid rock underlying alluvial gravel, sand, clay, etc., and upon which the alluvial gold rests. In placer use, the term bedrock may be generally applied to any consolidated formation underlying the gold-bearing gravel.

BEDROCK. A deposit of gold-bearing alluvium found in gulches and on slopes that are mainly residual detritus and poorly sorted heavy minerals. Usually of wood, used for panning gold. The base rock is in a mantle of rock debris along the lower slope of alluvial fans along the base of a mountain range or coastal plain along a line of elevated beaches. (Brooks)

BELL. The working face of a prospect drift on the side of a hill. The equipment used may vary from a bell roof to a complete set of 4 or more telescoping units.

BREAKOUT. A point where a ravine or canyon cuts down until it meets the stream below it. Such conditions are not conducive to the formation of placers. Usually applied to buried Tertiary channels. Compare with Outlet, and with Inlet.

BREAKOUT. A point where a ravine or canyon cuts into, but not through, a channel. (Dunn, R. L.) Usually applied to buried Tertiary channels. Compare with Outlet, and with Inlet.

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COBBLE. A smoothly rounded stone, larger than a pebble and smaller than a boulder. (Fay)

CEMENT. The material that binds together the sand and gravel particles in an indurated placer or other formation. The cementing material can be calcareous, silicious, or ferruginous. Also used when referring to the hardened formations as a whole. Cemented gravels must, in some cases, be milled to release their gold content.

CEMENT CHANNEL. A channel depression completely filled with lava, no auriferous gravel. (Dunn, R. L.)

CHALK. Volcanic tuff or ash, largely rhyolitic in composition, is commonly found as an interformational strata or masses in Tertiary channels of California’s Sierra Nevada region. The white, fine-grained and homogeneous beds are locally called “Chalk”.

CHANNEL. A stream-eroded depression in the bedrock, ordinarily filled with gravel. See — Tertiary channel.

CHURN DRILL. A portable drilling machine arranged to successively raise and drop a heavy string of tools suspended from a drill line. By means of the successive blows the formation is chopped up and the hole deepened. The type of churn drill designed for placer sampling is often referred to as a “Keystone” drill or “placer” drill. A hand-powered type, used extensively in South America, is known as a “Ward” drill.

CHURNED GRAVEL. Gravel containing rock or pebbles, cemented together by another mineral substance. (AGI)

COBBLER. A heavy, coarse-woven fabric made of jute-like material and commonly used on the bottom of a shoe to aid in saving its shape.

COLOGNA DRILL. Gold in an extreme state of subdivision. In a true colloid, the individual particles are of almost molecular dimensions.

COLOMBIAN GOLD. Gold in an extreme state of subdivision. In a true colloid, the individual particles are of almost molecular dimensions.

CONCENTRATE, (verb) To separate a metal or other valuable material from the recovery operation. 2. The valuable material resulting from the recovery of gold or other valuable material from the recovery system of a dredge, hydraulic mine or other placer operation. See — Radford factor.

CONCENTRATION. The removal by mechanical means of the lighter and less valuable portions of ore. (Fay)

CONFIDENCE. A particle of metallic gold found in the prospector’s pan after a sample of earth has been washed. Prospectors say, “The dirt gave me so many colors to the pan.” (Fay)

CONCENTRATED. (verb) To separate a metal or mineral from its ore or from less valuable material (round) The product of concentration.

CONFERENCE. The removal by mechanical means of the lighter and less valuable portions of ore. (Fay)

CONFLUENCE. A junction or flowing together of streams; the place where streams meet. (Fay)

CONGLOMERATE. Rounded water-worn fragments of rock or pebbles, cemented together by another mineral substance. (AGI)

CORE FACTOR. In churn drilling, when the casing is driven downward ahead of the drill bit, it should take in a cylinder of gravel having a diameter equal to the effective diameter (cutting edge) of the drive shoe. If the effective diameter of the shoe were the same as the inside diameter of the casing a 1-foot drive would produce a 1-foot core inside the casing. But this is not so. Take for example a standard 6-inch casing equipped with a new, 7½-inch drive shoe. The effective area of the shoe is 44.17 square inches while that of the casing is about 26 square inches. As a result, when driven, the core should rise 44.17/26 = 1.7 or, in other words, there should be a 1.7-foot core rise inside the casing for each foot of drive. Here lies CORE FACTOR 1.7. The core factor will, of course, vary according to the combination of casing and drive shoe used, and it will vary with the amount of wear on a given shoe. The core rise per foot of drive is less commonly referred to as the SHOE FACTOR, but to do so, invites risk of confusing it with other factors or terminology. See — Drive shoe factor; Pipe factor; Casing factor; Drill factor; Radford factor.

CORE RISE. The measured length of the cylinder of gravel entering a churn drill casing as it is driven downward. For example, a standard 6-inch casing fitted with a 7½-inch drive shoe should produce a core rise of 1.7 feet per foot of drive. The difference between the actual core rise and the theoretical rise is sometimes used as a factor for adjusting drill hole sample values.

CORRECTED VALUE. See — Adjusted value.

CRADLE. See — Rocker.

CREEK PLACER. Gravel deposits in the beds and intermediate flood plains of small streams. (Brooks)

CREASE. A small-scale mining method in which the miner removes detrital material from cracks and crevices in the bedrock, usually by means of pry bars and long-handed spoons, and washes the material to recover its gold content. (Fay)

CRIBBING. Close timbering, as the lining of a shaft. (Fay) In placer work, cribbing may be needed to support the walls of shaft or test pits down in loose or wet ground.

CREEK MATERIAL. The tailings from hydraulic mines.

CREEK. Gravel deposits in the beds and intermediate flood plains of small streams. (Brooks)

CREEP. See — Adjacent value.

CREEK PLACER. Gravel deposits in the beds and intermediate flood plains of small streams. (Brooks)

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CREEP. See — Adjacent value.
DRIVE SHOE FACTOR. The depth to which a drill shoe will penetrate without the use of water. The typical dry drive shoe is a 75-inch drive shoe, employed in placer mining, for saving fine gold and silver, by methods requiring furnace heat. Consequently, the gold value indicated by fire assay is not necessarily recoverable by placer methods. For this and other reasons, the gold content of placer material is not normally determined by fire assay. See — Fire assay.

FALSE BEDROCK. A hard or relatively tight formation within a placer deposit at some distance above true bedrock, upon which gold concentrations are found. Clay, volcanic ash, caliche or "till" grade formations can serve as false bedrocks. A deposit may have gold concentrations on one or more false bedrocks, with or without a concentration on true bedrock.

FANNING CONCENTRATOR. See — Trestle sluice.

FINE GOLD. 1. Pure gold, i.e., gold of 1000 fineness. 2. Gold occurring in small particles such as those which would pass a 20-mesh screen but remain on 40-mesh.

FINENESS. The proportion of pure gold in bullion or in a natural alloy, expressed in parts per thousand. Natural gold is not found in pure form; it contains varying proportions of silver, copper and other substances. For example, a piece of natural gold containing 150 parts of silver and 50 parts of copper per thousand, and the remainder pure gold, would be 800-fine. The average fineness of placer gold obtained in California is 883.

FLAKY GOLD. Very thin scales or pieces of gold. A standard iron flask contains 76 pounds of mercury.
FLAT. An essentially level gravel bar or deposit along the banks of a river.

FLUO-GOLD. The finest gold dust, much of which will float on water. (Fay) Flour gold. Particles of gold so small and thin that they float on and are liable to be carried off by the water. (Fay) See — Flood gold.

FLOOD GOLD. Fine-size gold flakes carried or redistributed by flood waters and deposited on gravel bars as the flood waters recede. Flood gold sometimes forms superficial concentrations near the flood channel of accretion bars. See — Float gold.

FLOOD PLAIN. That portion of a river valley, adjacent to the river channel, which is built of sediments during the present regimen of the stream and which is covered with water when the river overflows its banks at flood stages. (AGI)

FLOATATION. The minimum working draft of a dredge. When a dredge "digs flotation" it excavates the ground to the minimum depth required for floating the dredge. This is usually done when passing through tailings or moving between nearby working areas.

FLOUR. The finest gold dust, much of which will float on water. (Fay) Flour gold, such as that found along the Snake River in Idaho, commonly runs 3 million colors to the ounce.

FOATED MERCURY. (QUICKSILVER). The finely granulated condition of quicksilver, produced to a greater or less extent by its agitation in the flotation process. The coating of quicksilver with what appears to be a thin film of some sulphide, so that when it is separated into globules these refuse to reunite. Also called Sickening and Flouring. (Fay)

FLUVIAL. Of, or pertaining to rivers; produced by river action, as a fluvial plain. (Fay)

FLUVIAL MARINE. Formed by the joint action of river and tide, as in the deposits at the mouth of rivers. (Fay)

FLOOD GOLD. A substance which resembles gold; usually pyrite, a sulphide of FeS2.

FREE GOLD. Gold uncombined with other substances. Placer gold. (Fay)

FREE GOLD ASSAY. A procedure carried out to determine the free gold content of an ore. In case of placer material, a procedure to determine the amount of gold recoverable by gravity concentration and amalgamation.

FREE-WASH GRAVEL. Gravel that readily disintegrates and washes in a sluice. Long, clay-free gravels such as those found in accretion bars are generally free-wash gravels.

GIANT. See — Hydraulic giant; also Intelligent.

GLACIAL. Pertaining to, characteristic of, produced or deposited by, or derived from a glacier. (AGI)

GLACIOFLUVIAL. Of, pertaining to, produced by, or resulting from combined glacier action and river action. (Fay) See — Fluvio-glacial.

GOLD DUST. A term once commonly applied to placer gold, particularly gold in the form of small colors.

GOLD PAN. See — pan.

GOLD-SAVING TABLES. The sluices used aboard a dredge are customarily called gold-saving table, rather than sluice boxes.

GRADE. 1. The amount of fall or inclination of the vertical in ditches, flumes, or sluices; usually measured in feet per mile. 2. The grade of a bedrock, or depth of water under a bedrock, or bedrock grade, which is the slope of the water surface over which the water flows. 3. The height of a column of water in a reservoir, or the vertical distance from the bottom of a stream or pond by means of feet below the intake point of (the pipe) would be said to be working with a 200-foot head.

HEAVY GOLD. 1. Gold in compact pieces that appear to weigh heavier in proportion to their size. 2. Rounded, "shotty" or "muggy" gold.

HEAVY MINERALS. The accessory detrital minerals of a sedimentary rock, of high specific gravity. (AGI) The black sand and schist common to placers, would more properly be called a 'heavy-mineral' concentrate.

HIGH-GRADE. 1. Rich ore. 2. To steal or pilfer ore or gold, as from a mine by a miner. (Fay)

HIGH-GRADE. One who steals and sells, or otherwise disposes of high-grade or specimen ores. (Fay)

HIGH TENSION SEPARATOR. A machine, essentially consisting of a rotating drum, upon which a thin layer of dry sand or mineral grains are fed, and an electrode suspended above the rotating drum, or rotor. The electrode furnishes a high voltage discharge at high current flow. High tension separators employ a high rate of electrical discharge to separate various minerals according to their relative conductivity. Some are pinned to the rotor while others are attracted toward the electrode, with a resultant "lifting" effect. The pinning and lifting effects, imparted in varying degrees to different minerals, flattens or heightens their respective trajectories as they leave the rotor. Adjustable splitters placed in the trajectory are employed to cut selected minerals or groups of minerals from the thus stratified stream of materials. High tension separators differ from electrostatic separators in that the latter employ charged fields with little or no current flow. High tension separators are extensively used for separating heavy minerals recovered from beach sands, monazite placer, etc.

HILLSIDE PLACERS. A group of gravel deposits intermediate between the creek and beach placer. Their bedrock is slightly above the creek bed, and the surface topography shows no indication of benching. (Brooks)

HORN SPOON. See — spoon.

HUMPHRYS SPIRAL. See — Spiral concentrator.

HYDRAULIC DREDGE. A dredge in which the material to be processed is excavated and elevated from the bottom of a stream or pond by means of
a pump or a water-powered sump. Large hydraulic dredges may be equipped with a digging ladder which carries the suction pipe and a motor-driven cutter head, arranged to chop-up or otherwise loosen material directly in front of the intake pipe. Dredges having this configuration employ a deck-mounted suction pump and they may carry the mineral recovery equipment on board the dredge or on another vessel. Alternatively, they may transport the excavated material, by means of a pipe line, to a recovery plant mounted on an independent barge or on the shore. See — Jet dredge; also bucket-line dredge.

HYDRAULIC ELEVATOR. A near-vertical pipe employed in hydraulic mining to raise excavated material from the working place to an elevated sluice, or to a disposal area, by means of a high-pressure water jet inducing a strong upward current in the elevator pipe. See — Rubel elevator.

HYDRAULIC GIANT. The nozzle assembly used in hydraulic mining. The giant is provided with a swivel enabling it to be swung in a horizontal plane, and it may be elevated or depressed in a vertical plane. Nozzle sizes range from 1 to 10 inches in diameter and the larger sizes are provided with a deflector, enabling them to be moved with little effort. In California, giants discharging as much as 15,000 gallons per minute in a single stream at a nozzle pressure of over 200 pounds per square inch, have been used. The giant is also known as a "Monitor". Both terms stem from manufacturer's trade names. See — Intelligent.

HYDRAULIC MINING. A method of mining in which a bank of gold-bearing earth or gravel is washed away by a powerful jet of water and carried into sluices, where the gold separates from the earth by its specific gravity. (Fay)

HYDRAULIC MONITOR. See — Hydraulic giant.

HYDRAULIC DRILL. A churn-type drill employing a string of reciprocating hollow rods equipped with a drill bit. Water is pumped through the rods and discharged from the suction intake is normally hand-held and is I

INCHES OF WATER. A common expression denoting the quantity of water (in miners' inches) available or being used in a placer operation. See — Miners' inch.

INDICATED VALUE. The value of a placer sample, derived by formula, before making adjustments to compensate for excess or deficient core rise, in the case of churn drilling; or before applying shaft factors, boulder factors, or other empirical corrections. See — Adjusted value.

INLET. The point where a channel is cut off by a ravine or canyon on the upstream end. (Class. R.L.) Usually applied to buried Tertiary channel. Compare with Breakout; and with Outlet.

INTERLLIGIANT. The trade name for a hydraulic giant that is provided with water-powered pipe and cylinder arrangements to control its vertical and horizontal traverses. Some models can be diggered for automatic operation and can be used in a preset arc or pattern. See — Hydraulic giant.

IRON SAND. 1. Magnetite or ilmenite-rich sand. 2. Black sand concentrate containing an abundance of magnetite.

JET DREDGE. A form of hydraulic dredge, jet dredging equipment may range from a simple, self-contained pipe-like venturi containing riffles, that is carried by a diver and operates entirely underwater to larger and more elaborate surface units carried on inflated rubber tubes or styrofoam floats. These devices, operated by one or two men, are similar in two ways: 1. They rely on a water jet and venturi effect to pick up unconsolidated stream-bottom materials and carry them to a gold recovery device, usually riffles. 2. The suction intake is normally hand-held and is guided by a diver working on the stream bottom. The typical jet "dredge" contains a small or modest capital outlay and is typically used for recreation-type mining. See — Hydraulic dredge.

JET DRILL. A churn-type drill employing a string of reciprocal hollow rods equipped with a drill bit. Water is pumped through the rods and discharged from the suction intake is normally hand-held and is I

LIGHT GOLD. Gold that is in very thin scales or flakes or in pieces that look large as compared to their actual size. Also called "beach gold". Compare with Black sand concentrates.

LOW GRADE. A term applied to ores relatively poor in the metal for which they are mined; lean ore. Compare with Breakout; and with Outlet.

LOW-TIDE Line. A term used in California for the low-tide line, as distinguished from beach placers. Compare with Low-tide line, as distinguished from marine placers.
MUCK. (Alaska) A permanently frozen overburden that thawed before dredging is possible.

MOSS MINING (Mossing). The gathering of moss.

MORAINE. An accumulation of earth, stones, particles of gold being carried downstream by similar vegetation.

MONITOR. See — Hydraulic giant.

MINERS' PAN. See — Pan.

MINERS' SPOON. See — Spoon.

MINING CLAIM. That portion of the public mineral lands which a miner, for mining purposes, takes and holds in accordance with the mining laws. (Fay) A mining claim may be validly located and held only after the discovery of a valuable mineral deposit. See — Discovery.

MONAZITE. A phosphaté of the cerium metals (cerium, didymium, lanthanum) and other rare-earth metals. Monazite-bearing alluviums have been mined for their thorium content (by dredging) in Idaho and elsewhere.

MONITOR. See — Hydraulic giant.

MORAINE. An accumulation of earth, stones, boulders, etc., carried and finally deposited by a glacier. A Moraine formed at the lower extremity of a glacier is called a TERMINAL Moraine; at the sides, a LATERAL Moraine, in the center and parallel with its sides, a MEDIAL Moraine, and beneath the ice but back from its end or edge, a GROUND Moraine. (Fay) Placer gold is found in some glacial Moraines and deposits of reworked Morainal material, that is, material reworked by streams; some have been dredged and worked by placer methods.

MOSS MOUNTING (Mossing). The gathering of moss from the lichen-covered gold-bearing streams for the purpose of burning or washing it, to recover its gold content. Under certain conditions, moss or similar vegetation will capture and hold small particles of gold being carried downstream by flood waters. See — Flood gold.

MUCK. (Alaska) A permanently frozen overburden overlying placer gravels in the interior of Alaska. It is composed of fine mud, organic matter and small amounts of volcanic ash. It varies in depth (thickness) from seldom less than 10 feet to 100 feet or more in places. This overburden (muck) must be removed and the underlying gravels thawn before dredging is possible.

MUCK, MINERS' SPOON, MINERS' PAN

MINING CLAIM. Portion of the public mineral lands which a miner, for mining purposes, takes and holds in accordance with the mining laws. (Fay) A mining claim may be validly located and held only after the discovery of a valuable mineral deposit. See — Discovery.

MONAZITE. A phosphaté of the cerium metals (cerium, didymium, lanthanum) and other rare-earth metals. Monazite-bearing alluviums have been mined for their thorium content (by dredging) in Idaho and elsewhere.

MINES' PAN. See — Pan.

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MINES' PAN. See — Pan.

MINES' SPOON. See — Spoon.
RADIOACTIVE BLACKS. A group of dark colored, radioactive materials that are naturally occurring in the earth's crust. When these materials are extracted from the ground, they can pose a hazard due to their radioactivity. 

QUATERNARY GRAVELS. Gravels deposited during the Pleistocene Epoch. These gravels are typically found in river valleys and fluvial terraces and are a significant source of valuable minerals.

PROSPECTING. 1. Used to qualify work merely intended to discover a pay lead in a drift mine, or to locate the channel. (Dunn, R. L.) 2. (generally) prospecting for new deposits. 3. Drilling a known placer deposit to determine its value or delineate a minable area.

QUATERNARY GRAVELS. Gravels deposited from the end of the Tertiary, to  and including the present time.

QUICKSILVER (or Quick). See — Mercury.

RADFORD FACTOR. An arbitrary factor used by some engineers in the calculation of drill hole volumes and in turn, the drill hole values. This factor is based on an assumption that due to wear, etc., a 27%-inch drive shoe will take in 0.27 cu. ft. of core per foot of drive instead of the theoretical 0.306 cu. ft. In other words, it assumes a core weight of 1100 cubic yard per foot of drive. Using this factor, the equation for calculating the drill hole value becomes: value of recovered gold in terms of gold and silver in the gravel mass. (Fay) 3. A shallow extending across the bed of a stream. (Fay) 4. The area of bedrock containing valuable minerals. When water under pressure is used to remove the chopped-up drill core from a working place or in a sample to make it appear richer in mineral. It is done with intent to defraud. 2. Unintentional or innocent salting. The unintentional or accidental enrichment of a sample through erroneous procedure or carelessness, without intent to defraud.

SAMPLE. A portion of the ore systematically taken, by which its quality is to be judged. (Fay)

SAMPLING. Cutting a representative part of an ore deposit, which should truly represent its average value. Honest sampling requires good judgement and practical experience. (Fay) Parachute, it should be noted that in the case of gold placers, the high unit-value of gold, its extreme dilution within the gravel mass and its typically erratic distribution are factors which individually or combined, make it virtually impossible to obtain a truly representative sample. To this extent, the usual definitions of sampling do not apply to gold placers.

SAND PUMP. A special plunger-type vacuum pump used to remove the chopped-up drill core from a churn drill hole.

SAUERMANN EXCAVATOR. See — Slackline scraper.

SCALY GOLD. Small, rounded, flattened gold particles; usually quite thin in proportion to their diameter.

SCHIST. A crystalline rock that can be readily split or cleaved because of having a foliated or parallel structure. (Fay) Schist beds, because of their rough, platy structure, generally make excellent gold catchers.

SEISMIC CHARACTERISTIC OF, resembling, pertaining to, or having the nature of schist. (Fay)

SEA-BEACH PLACERS. Placers reconstituted from the coastal plain gravels by the waves along the seashore. (Brooks)

SEAM DIGGINGS. (California) Residual deposits consisting of decomposed bedrock filled with irregular seams of quartz containing gold. In California, seam diggings have been worked by the hydraulic method.

SECOND-FOOT. A unit of water measurement equivalent to one cubic foot per second or 448.03 gallons per minute. Commonly used to report the flow of streams.

SELF-SHOOTER. See — Booming.

SHAPER FACTOR. A correction factor applied to drill-hole values after a shaft has been sunk over 107
the drill hole. The factor is based on the difference in values obtained from the drill hole and from the shaft; the shaft value generally being considered the more reliable of the two.

SHINGLE. A fine-grained rock formed by the
slackline scraper. Consists essentially of a
sick mercury. See — Floured mercury.

SHINGLE SCRAPER. SLATE. A fine-grained rock formed by the
the flatter pebbles and cobbles in a
stream deposit will often come to rest with their
uppermost edge leaning slightly down-stream. This
'shilling' effect is used by placer miners to determine
the direction of flow of ancient streams and it
can be particularly useful when working
drift mines. Beach gravel, especially if consisting of
flat or flattish pebbles.

SHOE FACTOR. See — Drive Shoe factor.

SHOTTY GOLD. Small granular pieces of gold
resembling shot. (Fay) Any small, more or less
rounded gold particle that is somewhat
equidimensional rather than platy.

SICK MERCURY. See — Floured mercury.

SKIM BAR. An area near the upstream end of an
shotty gold. Small granular pieces of gold
resembling shot. (Fay) Any small, more or less
rounded gold particle that is somewhat
equidimensional rather than platy.

SKIM BAR. An area near the upstream end of an
shotty gold. Small granular pieces of gold
resembling shot. (Fay) Any small, more or less
rounded gold particle that is somewhat
equidimensional rather than platy.

SLACKLINE SCRAPER. Consists essentially of a
head tower and a movable tail tower or tail block.
Beach gravel, especially if consisting of
flat or flattish pebbles.

SLUICE BOX. An elongated wooden or metal
hopper arrangement at the head-end of a sluice
box. A burrodr is generally used to put
gold-bearing gravel onto the sluiceplate, from
where it is washed into the sluice by water issuing
from a large pipe or by means of a small hydraulic
plant.

SNIPER. An individual miner, usually a transient,
who plows a living from gravel remnants at
worth working except by someone content with
very modest gains. He usually works with simple
hand tools and washes his gravel in a short sluice
or dip box. Being transient and generally
innocuous, he seldom owns or leases the land he
works.

SODIUM AMALGAM. Mercury that has been
treated with small amounts of metallic sodium to
increase its affinity for gold and other metals.

SPECIFIC GRAVITY. The specific gravity of a
substance is its weight compared with its
weight of an equal bulk of pure water. For
example, placer gold with a specific gravity of
about 19 is 19 times heavier than water. The
specific gravity of a mineral largely determines its
susceptibility to recovery in simple gravity
concentrators such as sluice boxes.

SPECIMEN GOLD. Nuggety gold or other forms
suitable for the manufacture of natural-gold
jewelry or for some special properties.

SPIRAL CONCENTRATOR. A wet-type gravity
concentrator in which a sand-water mixture
flows down a long, spiral shaped launder
separates into concentrate and tailings fractions.
The concentrates are taken off through ports
while the tailings flow to waste at the bottom. The
HUMPHREY SPIRAL, which employs this
principle, is widely used for recovering heavy
minerals from beach sands.

SLICKENS. A word sometimes used to designate
the finer-size tailings, or mud, discharged from
placer mine. Sometimes synonymous with Sims
SLUDGE. The fluid mixture of chopped up ox
and water that results from the drilling action its
churn drill hole. When the sludge is pumped into
the hole, it becomes the sample for the particular
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section of hole that produced it.
TERTIARY CHANNELS. Ancient gravel deposits, often auriferous, composed of Tertiary stream alluvium. Tertiary gravels are abundant in the Sierra Nevada gold belt of California where many have been covered by extensive volcanic eruptions and subsequently elevated by mountain uplifts, and are now found as deeply-buried channels, high above the present stream beds.

TEST PIT. See — Pitting.

THAW POINTS. Water pipes driven into frozen gravel, through which water at natural temperature is circulated for weeks or months, to thaw the ground ahead of dredging. Where used in Alaska, points are usually spaced 16 feet apart. Once thawed, the ground does not freeze again and thawing is usually carried one or two seasons ahead of the dredge.

TIGHT GRAVEL. A hard, or compact gravel that is not cemented, but requires something more than normal effort to excavate. Compare with CEMENTED GRAVEL.

TILL. Nonsorted, nonstratified sediment carried or deposited by a glacier (AGI).

TOP WASH. A deposit of gravel, not in a channel on the bedrock, but resting on cement overlying the bottom deposit. (Dunn, R. L.)

TRACE. A very small quantity of gold; usually a speck too small to weigh. In reporting samples it is abbreviated to pg.

TRESTLE SLUICE. A movable steel sluice constructed on a skid or track-mounted trestle; usually provided with a hopper, grizzly and wash water system, and fed by a dragline or similar excavator. Also called an ELEVATED SLUICE.

TROMMEL. A heavy-duty revolving screen used for washing and removing the rocks or cobbles from placer material prior to treatment in the sluices, gold saving tables, or other recovery equipment.

TROY OUNCE. The one-twelfth part of a pound of silver or other precious metals. (Fay) The ounce designated in all assay returns for gold, silver, or other precious metals. (Fay)

UNDERCURRENT. A large, flat, broad, branch sluice, placed beside and a little lower than the main sluice. This apparatus is ruffled like the sluice, but being much wider than the latter, allows the water to spread out in a thin sheet on its surface, thereby so abating the velocity of the current that the very fine gold, including the rust particles, is more apt to be caught here than in the sluice. (Fay) Undercurrents are usually fed with fine-size material taken from the main sluice by means of a grizzly placed in the sluice bottom, near the discharge end.

UPPER LEAD. (pronounced lead) A pay lead in a top wash or in the gravel deposit considerably above the bedrock. (Dunn, R. L.)

VALUES. The valuable ingredients to be obtained, by treatment, from any mass or compound; specifically, the precious metals contained in rock, gravel, or the like. (Fay)

VOLUME FACTOR. The volume of sample which should be taken into a churn drill casing for each foot of drive. For example, a standard 6-inch drill pipe equipped with a new, 7½-inch drive shoe will theoretically take in a volume of 530 cubic inches, or 0.306 cubic foot per foot of drive. See — Core factor; Drive shoe factor; Drill factor.

WARD DRILL. A lightweight, hand-powered churn drill widely used in South America, particularly in remote areas where access is difficult and manpower is cheap. The drilling tools are suspended from a tripod and the reciprocating motion provided by a simple spudding arm known as a “Diablo.” Sometimes referred to as a HAND DRILL.

WASH. 1. A Western miner’s term for any bank, surface deposits of sand, gravel, boulders, etc. 2. The dry bed of an intermittent stream, sometimes at the bottom of a canyon. Also called Dry wash. 3. To subject gravel, etc. to the action of water to separate the valuable material from the worthless or less valuable; as to wash gold. (Fay) In drift mining (California), the term “Wash” is used indifferently in describing channel gravel, volcanic mud flows, or masses of lava boulders. (Dunn, R. L.)

WASTE. Valueless material such as barren gravel or overburden. Material too poor to pay for washing.

WATER TABLE. The upper limit of the portion of the ground wholly saturated with water. This may be very near the surface or many feet below it. (Fay)

WEATHERING. The group of processes, such as the chemical action of air and rain water and of plant and bacteria and the mechanical action of changes of temperature, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil. (Fay)

YARDAGE. 1. The number of cubic yards of gravel mined or put through a washing plant in a shift or a day. 2. A measured block of gravel.

YIELD. The quantity or gross value of minerals extracted from a deposit.

YOUTH. See — Erosion cycles.

ZIRCON. A mineral of widespread occurrence as small crystals in igneous rocks. Composition, zirconium silicate, ZrSiO4. Because of its resistance to weathering, and moderate specific gravity (4.68), zircon is a common constituent of the black sands associated with gold placers.
APPENDIX A

PLACER SAMPLING FORMS
Sample No. 11

Date

State

County

Serial No.

Claim

Legal description: Sec., Twp., Range

Type of deposit:

Type of sample: Dimensions of cut:

Place taken:

Reference tie:

Photograph:

INTERVAL

FORMATION

to

to

to

to

to

Bedrock: No( ) Yes( )

Overburden: Feet

Water level

ft.

Sample Weight: Gross lbs. Net lbs.

Sample Volume: loose measure ( ) bank measure ( )

Boulders: No( ) Yes( ) Aver. size Max. size Est. % of bank-run

Cement: No( ) Yes( ) Remarks

Clay: No ( ) Yes( ) Est. % Remarks

Caliche: No ( ) Yes( ) Est. % Remarks

Hard digging: No( ) Yes( ) Remarks

Sampled by

Title

Others present

Time: Arrive Depart Weather

Remarks:

Place sketch on back of this sheet.

Carry this number forward to PROCESSING RECORD SHEET, which see.
PLACER SAMPLE
PROCESSING RECORD

Sample No. 1/ Serial No. 

Dry Weight lbs.; Volume ; How measured 

How Processed 

Processed by 

Processed by 

Others present 

Visible gold 1/ #3 colors; #2 colors; #1 colors. No visible gold ( ) 

Gold weight milligrams Estim. fineness 

Gold removed: Manually ( ); By amalgamation ( ); Other 

Character of Gold: Fine or flaky ( ); Coarse or shotty ( ); Smooth ( ); Rough ( );

Remarks 

When panning, does Gold tend to ride over top of black sand ( ); or stay down on pan ( );

Remarks 

Does Gold amalgamate readily: Yes ( ); No ( );

Remarks 

Weight of black sand in sample lbs. black sand per cubic yard 

Amount of black sand is: Large ( ); Medium ( ); Small ( );

Screen was used in washing process: No ( ); Yes ( ); Size of openings 

% Oversize; % Undersize;

Remarks 

Material washed: Easy ( ); Normal ( ); Difficult ( );

Remarks 

Muddy water indicated by washing: Little ( ); Moderate ( ); Much ( );

Grade of sluice or rocker in./ft.; Source of wash water 

Notes:

1/ Number the same as FIELD RECORD sheet, which see.
2/ #3 colors consist of gold particles weighing less than 1 milligram.
#2 colors weigh between 1 and 4 milligrams.
#1 colors weigh over 4 milligrams.
Weigh and note individual colors weighing 10 milligrams or more.
### FIELD LOG

**SHAFT NO.**

**LOCATION**

<table>
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<tr>
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<td>Hoist</td>
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</table>

**NOTES:**

- **DEPTH**
- **VALUE**
- **W. L.**
- **B. R.**

---

### APPENDIX B

**GOLD PRICE AND VALUE DATA**
U. S. PRICE OF GOLD

<table>
<thead>
<tr>
<th>Date of Law</th>
<th>Value Per Fine Oz. Troy</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2, 1792</td>
<td>$19.393939</td>
</tr>
<tr>
<td>June 28, 1834</td>
<td>$20.689656</td>
</tr>
<tr>
<td>Jan. 18, 1837</td>
<td>$20.671835</td>
</tr>
<tr>
<td>Mar. 4, 1900</td>
<td>$20.671835</td>
</tr>
<tr>
<td>Jan. 31, 1934</td>
<td>$35.000000</td>
</tr>
<tr>
<td>Mar. 17, 1968</td>
<td></td>
</tr>
</tbody>
</table>

U. S. Treasury regulations published in the Federal Register on March 19, 1968, allow domestic gold producers to sell newly mined gold to persons regularly engaged in an industry, profession, or art, who require gold for legitimate, customary, and ordinary use, or persons hold Treasury gold licences. The price of such gold is no longer regulated by the Treasury. The price of monetary gold remains fixed at $35.00 per ounce. The U.S. Mint will no longer purchase gold in the private market or sell it for industrial, professional or artistic uses. The private holding of gold by U.S. citizens continues to be prohibited except pursuant to existing regulations.

TROY WEIGHT (FOR GOLD & SILVER)

- 1 pound troy = 12 oz. troy = 5760 grains = 373.2417 grams
- 1 ounce troy = 20 pennyweights = 480 grains = 31.1035 grams = 31,103 milligrams
- 1 pennyweight = 24 grains = 1.5551 grams

VALUE OF GOLD, c PER MILLIGRAM

\[ \frac{\text{Price} \times \text{fineness}}{31,103} \]

Example:

Gold @ $70 per ounce and 825-fine.

\[ \frac{70 \times 825 \times 0.1}{31,103} = 0.185 \text{c per mg.} \]

MILLIGRAMS OF GOLD EQUIVALENT TO 1c

\[ \frac{1}{0.185} = 5.4 \text{ mg. equivalent to 1c.} \]
GOLD FINENESS AND VALUE EQUIVALENTS (based on $35/oz.)

<table>
<thead>
<tr>
<th>FINENESS</th>
<th>TROY OZ.</th>
<th>PENNEYWEIGHT</th>
<th>GRAIN</th>
<th>MILLIGRAM</th>
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</thead>
<tbody>
<tr>
<td>1000</td>
<td>$35.00</td>
<td>$1.75</td>
<td>7.29c</td>
<td>0.112c</td>
</tr>
<tr>
<td>975</td>
<td>$34.12</td>
<td>$1.71</td>
<td>7.11c</td>
<td>0.109c</td>
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<td>$33.25</td>
<td>$1.66</td>
<td>6.93c</td>
<td>0.107c</td>
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<td>$32.38</td>
<td>$1.62</td>
<td>6.74c</td>
<td>0.104c</td>
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<tr>
<td>900</td>
<td>$31.50</td>
<td>$1.57</td>
<td>6.56c</td>
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<td>$1.05</td>
<td>4.38c</td>
<td>0.067c</td>
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</tbody>
</table>

To figure the value of gold at any price or fineness:

New price x Fineness x 0.112 = c per milligram

New price x Fineness x 7.29 = c per grain

New price x Fineness x 1.75 = $ per penneyweight
WATER REQUIREMENTS

The source, amount, and delivered cost of water are important elements in a placer operation. In many cases they determine the type of equipment or mining method used. Water estimates for new or proposed operations are generally based on experience or working data obtained from comparable operations.

The water required for various working methods varies widely and depends on many factors. Examples that follow are intended only to show the possible range.

a. Rockers: A steady flow of 4 or 5 gallons per minute is sufficient to operate a small (1' x 4') rocker. Water can be dipped from a barrel where steady flow is not available. Net water consumption may be as low as 50 to 100 gallons per cubic yard, if carefully saved and reused.

b. Small-scale hand mining: Where material is loosened by picking, and shoveled into a sluice box by one or two men, 170 to 225 g.p.m. are required for a 12-inch box with steep grade.

c. Ground sluicing: Water duty varies widely but may range between 1/10 and 3/4 cubic yard per miners' inch-day at small mines. This would be equivalent to about 22,000 to 162,000 gallons per cubic yard.

d. Hydraulicking: Water duty varies widely and reflects the coarseness of gravel, degree of cementing, height of bank, grade of bedrock, available head, etc., and is commonly between 1/2 and 7 cubic yards per miner's inch-day. This would be equivalent to about 2,000 to 32,000 gallons per cubic yard. The better efficiencies are obtained at large, well-equipped mines. Small, 1 or 2-monitor mines operated by individual owners or lessees, usually have a water duty of less than 1 cubic yard per miner's inch-day.

e. Stationary washing plants: These are typically owner-operated plants, fed by a dragline or a small power shovel. Most employ a trommel or other screening device ahead of the sluice. Incomplete figures indicate a range of 650 to 2,000 gallons per cubic yard.

f. Moveable washing plants and dryland dredges: In same category as stationary plants and same remarks apply. Water requirements ranging from 480 to 3,200 gallons per cubic yard have been noted. Plants equipped with Ainsley bowls (in place of sluices) generally have good water economy.

g. Dragline dredges: Net water required for washing gravel and maintaining the pond is governed by the amount of clay, porosity of the gravel, and other factors. Wash water which is commonly supplied by an 8-inch centrifugal pump working against a 40-foot pressure head, may range between 570 to 2,500 gallons per cubic yard.

h. Bucket-line dredges: Water in circulation aboard a dredge may range from 3,500 g.p.m. to over 10,000 g.p.m. depending on digging capacity of dredge and type of material being washed. Dredges usually are provided with independent high pressure and low pressure water systems, the high pressure being used for screen sprays and bucket nozzles, and the low pressure for the gold-saving tables and general service. When working in land-locked ponds, a fresh water input of 1,000 g.p.m. to more than 2,000 g.p.m. will be needed to replace muddy water which must be pumped out of the pond (to prevent excessive mud build-up) and to maintain pond level.
UNITS OF WATER MEASUREMENT

1 gallon (gal.) = 231 cubic inches.
   = 0.1337 cubic feet.
1 gallon of water weighs 8.33 pounds.
1 million gallons (m.g.) = 3.0689 acre feet.
1 cubic foot (cu. ft.) = 1728 cubic inches.
   = 7.48 gallons.
1 cubic foot of water weighs 62.4 pounds.
1 acre foot (ac. ft.) = amount of water required to cover
   one acre one foot deep.
   = 43,560 cubic feet.
   = 325,850 gallons.
   = 12 acre inches.
1 gallon per minute (g.p.m.) = 0.00223 cubic feet
   per second.
   = 1440 gallons per day (24 hrs.).

1 million gallons
per 24 hours (m.g.d.) = 1,547 cubic feet per second.
   = 695 gallons per minute.
1 cubic foot
per second (sec. ft.) = 7.48 gallons per second.
   = 448.8 gallons per minute.
   = 666,272 gallons per day (24 hrs.).
   = .992 acre inch per hour.
   = 1.983 acre feet per day (24 hrs.).
64 miner's inches (legal value) in
Arizona, California, Montana
and Oregon.
50 miner's inches (legal value) in
Idaho, Kansas, Nebraska, Nevada,
New Mexico, North Dakota,
South Dakota and Utah.
36.4 miner's inches in Colorado.
35.7 miner's inches in British
Columbia.
1 miner's inch (mi. in.) = 11.25 gallons per minute when
equivalent to 1/40 second foot.
   = 9 gallons per minute when
equivalent to 1/50 second foot.
1 miner's inch day (24 hrs.) = 16.200 gallons when
equivalent to 1/40 second foot.
1 miner's inch day (24 hrs.) = 12,960 gallons when
equivalent to 1/50 second foot.

APPENDIX D
PLACER DRILLING DATA
Setting Up The Drill

The drill is placed in the desired location for the hole, leveled, and the derrick raised. One end of the sand line is attached to the vacuum sand pump; the other end is placed over the sand line sheave in the derrick and attached to the sand line drum. The drill line is placed over the crown sheave of the derrick, passed through the walking beam, and attached to the mainline drum, the cable socket being on the other end of the line.

For most placer operations, a string of tools usually consists of a rope socket, a stem, and a bit. When assembling a string of tools, lay the stem on the ground at the front of the drill; screw on the rope socket with the attached cable; then screw the bit on the lower end of the stem. A light wire brush and gasoline is recommended to clean the threads before assembling. A few drops of light oil are desirable on the threads.

Great care must be exercised in assembling a string of tools to see that the joints are tight. Screw the tool joints up by hand, then apply tool wrenches and set the joint up firmly by means of the chain wrench bar. Remember, most fishing jobs are due to improper setting of joints.

Many drillers use a stone in polishing the shoulder portion of the box and pin, before assembling. After a joint has been set up perfectly solid, a mark is sometimes made with a sharp cold chisel, half on the pin collar and half on the box. Each successive time this joint is screwed up, the mark on the box should go a little farther past the mark on the pin collar. By this method one can check and see that the joint is set up firmly. If, at the next fitting the joint does not go far enough, it is indicative that there is dirt on the face of the joint — or in the threads, which dirt must be removed.

After the stem and bit have been assembled, the tools are hoisted, the operator being careful not to kink the cable where it enters the socket. Check the frame to see that the tools hang directly above the center line of the drill and approximately 24 inches out from the front of the drill. You are now ready to start the hole.

Starting a Hole

At the site marked for drilling, a hole is dug approximately 16 inches deep. The gravel removed is examined to see whether it contains gold. A drive shoe is placed on one end of a length of drive pipe and a drive head on the other.

After carefully measuring the length of the pipe and shoe they are placed in the hole in a vertical position with the drive shoe on the bottom. Dirt is packed around the pipe to hold it in position. Where long lengths of casing are used, a well is usually dug directly in front of the drill. This is very difficult to do in wet ground.

Driving The Pipe

The tools are lowered, allowing the bit to enter the casing, the drive clamps are clamped on the square of the bit. It is important to see that the drive clamp bolts are kept tight. Loose nuts mean certain breaking of bolts.

The engine of the drill is started and operated at slow speed. The drive clamps are lowered to within three inches of the drive head, the spudding lever is moved to the "On" position, and the casing gently tapped into the ground. The impact blow and feed are adjusted by gently raising the brake lever.

If the top soil is valueless, the pipe is driven to gravel. When the drive head reaches a point a few inches from the ground, it is removed and another length of pipe is carefully measured and coupled to the first length, care being taken to couple the pipe so that they butt in the center of the coupling. The drive head is then placed on the top of the next section of pipe and the operation resumed, core in the meantime is being removed as the pipe is driven deeper.

Whenever pipe is added, the threads are carefully cleaned and then greased with graphite and linseed oil and securely tightened by means of chain tongs. It is very important to grease the pipe and not the couplings. The portion of the thread one-quarter inch back from the end of the pipe is the part usually lubricated.
As soon as the hole has reached a depth sufficient for the bit and stem to enter the casing, the drive clamps are removed. Records are made of the depth of the drive pipe and also the core. By starting at the bit and measuring back along the stem, the total length of pipe is marked with chalk or a piece of string on the line. The stem is lowered into the pipe and the distance between chalk mark and the top of the pipe represents the core remaining in the hole.

DRILLING PROCEDURE

DRILLING proceeds in the following manner: The driller measures and reports the length of core to the piston. This, and the depth of casing in the ground, are recorded in the log book.

Water is poured into the casing, the spudding lever thrown in the "On" position, and the core chopped up. Some operators place a spoonful of lye in the drill hole when churning. Lye cuts any grease from the fine sand, and prevents it floating away.

When the core has been lowered into the pipe, and the depth of the remaining core checked and recorded in the log book, the tools are raised. The drive clamps are bolted on and the operations repeated. After the first driving, the clamps are bolted in the top square. It is impossible to do this at the start as it would strike the core when driving.

PUMPING OUT THE CORE

THE TOOLS are hoisted out of the pipe and help of line of the driving by means of the tool grip. When the tools are being hoisted, a bucket of sand is usually poured on the rope and stem to wash any values that might be clinging to the tools. The sand pump is raised by pulling on the sand lever. When the lever is released, a brake keeps sand drum from turning, and holds the pump in position. When the sand pump lever is half in between the brake position and the hold position, the drum is free, allowing the pump to fall freely to the bottom of the hole.

When the pump is at the bottom of the hole, the piston type plunger is at the bottom of the pump. When pulling on the sand drum lever, the plunger is raised, creating a strong vacuum, sucking in the sand, mud, cuttings, etc. The efficiency of a sand pump depends on the speed with which the plungers raised.

The foot valve in the bottom of the pump prevents material from escaping. Holding the sand drum lever to keep the annulus engaged, brings the pump containing the core to the surface. Engineers very often drop a 2½-foot length of pipe in the hole without its operator's knowledge, and the count them after the pumping is done. It is common practice to pump the pipe at the bottom of the hole to free and after driving. In bored ground it is often possible to pump the core immediately after driving. When the two pumpings are made before and after driving, they are caught in the same bucket and concentrated in one operation. This is common practice in pumping to drive the core out of the hole.

When prospecting a deposit having sand, mud, cuttings, etc. The efficiency of a sand pump is increased by using sand. The top of the sand pump is usually poured on the rope and stem to wash any values that might be clinging to the tools. The sand pump is raised by pulling on the sand lever. When the lever is released, a brake keeps sand drum from turning, and holds the pump in position. When the sand pump lever is half in between the brake position and the hold position, the drum is free, allowing the pump to fall freely to the bottom of the hole.

When the pump is at the bottom of the hole, the piston type plunger is at the bottom of the pump. When pulling on the sand drum lever, the plunger is raised, creating a strong vacuum, sucking in the sand and mud, cuttings, etc. The efficiency of a sand pump depends on the speed with which the plungers are raised.

In extreme instances where the burden of jarring the pipe is too great for normal blow delivered and the upward tension of a hand hoist line is insufficient, a pipe pulling ring should be used. By placing the ring on the casing-head and handing it up the flange on the ring, a tremendous upward pressure is added to the pipe, creating a ring on the end of the pipe that starts the pipe upward.

PIPE PULLING WITH CASING SPEAR

A SPECIAL FEATURE of the Hillman Drills is their remarkable pipe pulling ability. Using a top puller, the operation of pulling the pipe is as follows: The pipe is removed from the top of the driving head. The knocking head is placed in the spudding position and the string of tools is raised far enough so that by means of the spudding action they are thrown at the driving head. A sharp blow is obtained rather than a pull. This is exactly the reverse action of pipe driving, the blow being directed at the lower face of the driving head instead of the top of the driving head.

The operation of pulling the pipe, by means of the spear, is as follows: The spear is set on the rod, thus the pipe pulling ring on the rod is driven upward. The string of tools is assembled, consisting of a rope socket, a stem, a set of four jaws, a string of long stroke jars and the trip casing spear. The jaws of the spear are set by using the spear furnished with the spear for pulling back the jar and compressing the spring. The spear is then removed. The string of tools is then lowered into the casing. Pulling is usually done from the last length. When the spear is in the last length of pipe it is hoisted up and the jars into the casing. The spear is placed in the spudding position and the string of jars jarred upwards. To release the casing, the spear is struck a sharp blow from the top. This causes the spear to strike the top of the jars, which releases the spear. The tools are then hoisted out of the casing. The lengths of casing out of the ground are uncoupled and the operation repeated.
TREATMENT OF THE CORE

WHEN the sand pump is hoisted out of the casing, the helper, or panner, grasps the lower end of the pump, walks back from the drill, and lays the lower end on the saddle of the dump (or mud) box. The bail end of the sand pump is then lowered into the bottom of the dump (or mud) box. When the pump in this position the foot valve is approximately on an even height with the panner's eye. While the pump is in this jackknifed position, it is thoroughly washed both inside and out. A dipper, formed by fastening a handle on a gallon tin can, is used for pouring water in the foot valve and flushing out the material. The pump is hoisted and jackknifed in the other position. The lower end of the pump on the previous washing is now the top. The second washing is not always essential, but it is advisable, especially when working in rich ground. Directly below the lower end of the mud box is located a tub containing the volume bucket.

MUD BOX OR DUMP BOX

THE LEGS and sides of the dump box are made of surfaced fir, two inches by four inches. The trough is formed of 16-gauge steel. The top end of the box is welded solid. The lower end is also welded and fitted with an adjustable gate which can be set to control the flow into the volume bucket and avoid splashing.

THE VOLUME BUCKET

THE Volume Bucket, holding one cubic foot, is 13½ inches in diameter and 12 inches in height. The measuring stick is calibrated in tenths and hundredths of a cubic foot. A good practice is to measure the total quantity of material dumped from each hole and to compare the results from all holes drilled in similar material. A fair average can be obtained and used as a check on each separate property. Some operators calculate twenty cubic feet of material so measured to represent one cubic yard actually drilled.

THE SAMPLE BOTTLES

FOR handling samples, some of the companies use small bottles similar to a wet plaster cup. The cover is made of aluminum all of the screw type. The top of the cover is flat and has a dull finish, similar to a salt shaker. The cover fits snugly and is weighted to prevent any very legible on this type surface. The Line Number, Hole Number, Depth, and the panner's signature are all written on top of the bottle.

TREATMENT OF GOLD

A FEW of the operators take the bottles of concentrate from the hole, carefully pan them down as far as possible, dry them, remove the magnetic material with a magnet, blow the remaining black sand and concentrate with mercury, then carefully panning off the black sand. This is usually sought in another pan and checked to see that no colors have been lost. The samples are then usually placed in bottles marked for future reference. At this time it is well to qualitatively inspect the contents of the pan and black sand for platinum or unusual minerals which are apt to be found in placer deposits. There are times when the gold does not readily amalgamate, due to oil or grease from the sand pump, pipe joints, vegetation, et cetera. Adding a little caustic potash usually eliminates this trouble. To heat or to a point as hot as the lamp will allow. The operation removes the moisture and burns away any pipe joints, vegetation, et cetera. Adding a little caustic potash usually eliminates this trouble. To heat or to a point as hot as the lamp will allow. The operation removes the moisture and burns away any

LOG BOOK

The following data is usually recorded on the log sheets:

1. Name of property
2. Location
3. Date
4. Line Number
5. Hole Number
6. Elevation
7. Time: Entries are made in this column of the time each sample is taken and recorded.
are helpful in determining the cost of prospecting similar ground.

8. Depth of the cutting edge of the drive shoe: The last item in this column is the total depth drilled.

9. Depth of pumping: Care must be taken to see that pumping is not continued farther than within two inches of the lower edge of the drive shoe until bedrock has been reached or when a boulder is encountered. Notation should always be made when drilling below the shoe.

10. Entries are made of each individual drive.

11. The rise of the core in the pipe for each drive: This is the distance from the bottom of the drive shoe to the top of the core.

12. Core after pumping: The amount of core left in the pipe is naturally less than before pumping. This is the distance from the bottom of the drive shoe to the top of the core and is termed the plug. It usually varies from two to four inches.

13. The length of core removed: The difference between the core before pumping and the core after pumping shows the rise of the core in the pipe. Some operators use this in computing the volume. Volume computed by this method is known as the core volume by pipe measurement.

14. Volume Bucket measurement. This is exactly as the name implies, the volume as measured in the volume bucket.

15. Classification of colors: The number of colors are classified in the No. 1, No. 2, and No. 3 sizes. No. 3 is the finest and consists of all particles weighing less than one milligram. No. 2 is the gold consisting of all particles weighing between one milligram and four milligrams. No. 1 gold is any particle weighing over four milligrams. These are recorded on the lines opposite the depths of drive, so that the various pay streaks will be known.

16. Estimated weight of gold: The panner becomes very proficient in estimating weight. He records the weight of the different colors in this column, and the quantity of gold of each color is weighed in the panner. This is helpful in following pay streaks.

17. Formation: The nature of the formation corresponding with the various depths is also noted. Very often the pay streak has a distinctive color and it is advisable to make a notation of this. The size and quantity of boulders have a definite bearing on how the property should be worked. Properties containing an unusual amount of clay require special washing equipment to prevent the clay from going through the boxes and picking up the gold. Some properties contain black sand which has a tendency to pack in the riffles and decrease the amount of material which is handled.

18. Depth and nature of overburden: Very often the overburden is removed by a different method than that used for working of the gravel. Information such as buried logs, large boulders, etc., have a definite bearing on the cost, and records should be made of them.

19. Labor conditions, transportation facilities.

20. Depth of the pay gravel.

21. Depth to bed rock.

22. Nature of bed rock.

23. Depth of pay in bed rock.

24. Diameter of the drive shoe.

25. Theoretical volume of the core removed.


27. Weight of gold in milligrams (mg.).

28. Fineness of the gold.

29. Constant used in making calculations.

30. Value in cents per cubic yard.

31. Price of gold at which values were computed.

32. Signatures of the driller, panner and helper.

A list of abbreviations is included at the top of the log sheet which simplifies the recording.
### DRILLING REPORT

<table>
<thead>
<tr>
<th>Name of Property</th>
<th>CENTS PER CU. YD.</th>
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<tbody>
<tr>
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<tr>
<td>Line No.</td>
<td>Hole No.</td>
</tr>
<tr>
<td>Location of Hole</td>
<td></td>
</tr>
<tr>
<td>Depth of Tails</td>
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</tr>
<tr>
<td>Depth of Overburden</td>
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<tr>
<td>Depth of Gravel</td>
<td></td>
</tr>
<tr>
<td>Depth of Bedrock</td>
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</tr>
<tr>
<td>Depth of Dredge Section</td>
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<tr>
<td>Depth of Hole: Casing</td>
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<tr>
<td>Gold @ Cents per Ounce per mg.</td>
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<tr>
<td>Black Sands: Much Some Little</td>
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<tr>
<td>Size Casing</td>
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<tr>
<td>Size Shoe</td>
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</tr>
<tr>
<td>Volume from Shoe Constant</td>
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<tr>
<td>Volume from Core Rise</td>
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<td>Volume from Core Bucket</td>
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<tr>
<td>Volume from Water Displacement</td>
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<tr>
<td>Volume for Estimate</td>
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<td>Gold, Actual Wt.</td>
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</tr>
<tr>
<td>From</td>
<td>To</td>
</tr>
<tr>
<td>From</td>
<td>To</td>
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### CROSS SECTION OF MATERIAL

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<td>Surface</td>
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<td>Bedrock</td>
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<tr>
<td>Water Level</td>
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### SUMMARY SHEET

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<tr>
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<tr>
<td>Falling Hrs.</td>
</tr>
<tr>
<td>Moving Hrs.</td>
</tr>
<tr>
<td>Repairs Hrs.</td>
</tr>
<tr>
<td>Delays Hrs.</td>
</tr>
<tr>
<td>Total Time Hrs.</td>
</tr>
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### CUMULATIVE VALUE

<table>
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<tr>
<th>DEPTH TIMES VALUE</th>
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<tbody>
<tr>
<td>VALUE CENTS PER YARD</td>
</tr>
<tr>
<td>VALUE AT $</td>
</tr>
<tr>
<td>WEIGHT, IN TONS</td>
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</table>

### SAMPLE NUMBER

### POSITION

<table>
<thead>
<tr>
<th>DEPTH FEET</th>
</tr>
</thead>
</table>

### TOTAL

### REMARKS
To determine the value in cents per cubic yard, multiply the number of Mgs. of gold recovered from the hole by the factor shown in the following table, which corresponds to the depth of hole, 100 milligrams of gold are recovered.

The value of the hole would be found as follows:

$$\text{Value per cu. yd.} = \frac{\text{Mg. recovered} \times \text{price per Mg.}}{100}$$

The factors are based on the following values:

- **Price of Gold per Ounce:** $35.00
- **Fineness of Gold:** 1000

This value is equal to $K \times Mg.$ recovered, where $K$ is the proper multiplying factor. The factors are based on the following values:

| Depth to Bedrock | 6' | 7' | 8' | 9' | 10' | 11' | 12' | 13' | 14' | 15' | 16' | 17' | 18' | 19' | 20' | 21' | 22' | 23' | 24' | 25' | 26' | 27' | 28' | 29' | 30' | 31' | 32' |
|------------------|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 6 ft. drive shoe | 3.34 | 2.19 | 1.65 | 1.07 | 0.80 | 0.66 | 0.55 | 0.47 | 0.41 | 0.36 | 0.32 | 0.29 | 0.26 | 0.24 | 0.22 | 0.20 | 0.18 | 0.17 | 0.16 | 0.15 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 |
| 7 ft. drive shoe | 3.09 | 2.05 | 1.47 | 1.00 | 0.76 | 0.62 | 0.51 | 0.45 | 0.40 | 0.35 | 0.31 | 0.28 | 0.26 | 0.24 | 0.22 | 0.20 | 0.19 | 0.18 | 0.17 | 0.16 | 0.15 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 |
| 8 ft. drive shoe | 2.86 | 1.83 | 1.29 | 0.90 | 0.71 | 0.59 | 0.49 | 0.43 | 0.39 | 0.35 | 0.31 | 0.28 | 0.26 | 0.24 | 0.22 | 0.20 | 0.19 | 0.18 | 0.17 | 0.16 | 0.15 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 |
| 9 ft. drive shoe | 2.59 | 1.57 | 1.10 | 0.80 | 0.66 | 0.54 | 0.45 | 0.40 | 0.36 | 0.31 | 0.28 | 0.25 | 0.23 | 0.22 | 0.20 | 0.19 | 0.18 | 0.17 | 0.16 | 0.15 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 |
| 10 ft. drive shoe | 2.37 | 1.36 | 0.94 | 0.70 | 0.59 | 0.49 | 0.40 | 0.36 | 0.32 | 0.28 | 0.25 | 0.23 | 0.22 | 0.20 | 0.19 | 0.18 | 0.17 | 0.16 | 0.15 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 |
| 11 ft. drive shoe | 2.17 | 1.17 | 0.81 | 0.61 | 0.51 | 0.43 | 0.35 | 0.31 | 0.28 | 0.25 | 0.22 | 0.21 | 0.19 | 0.18 | 0.17 | 0.16 | 0.15 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.09 | 0.08 | 0.07 | 0.06 |

**Depth to bedrock**

**Drive shoe**

**Volume (in cubic yards)**

**Theoretical value**

Using the theoretical value, suppose that from a drive hole using a 7/4" drive shoe, 100 milligrams of gold are recovered. From the table of multiplying factors on the preceding page, find opposite the depth of 40 feet the factor 2475. Also suppose the relative fineness of the gold is 900. The value of the hole would be found as follows:

$$\text{Value per cu. yd.} = \frac{100 \times 0.2475 \times 900}{100} = 22.3c per cubic yard.$$
<table>
<thead>
<tr>
<th>PROSPECT DRILLING FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>6&quot; Drive Pipe</strong></td>
</tr>
<tr>
<td>Inside dia. 5.761&quot;</td>
</tr>
<tr>
<td>Cross-sectional Area</td>
</tr>
<tr>
<td>Volume in Cu. In. per Ft. depth</td>
</tr>
<tr>
<td>Volume in Cu. Ft. per Ft. depth</td>
</tr>
<tr>
<td>Volume in Cu. Yds. per Ft. depth</td>
</tr>
<tr>
<td>26.0666</td>
</tr>
<tr>
<td>.3127997</td>
</tr>
<tr>
<td>.00670433</td>
</tr>
<tr>
<td>547.9632</td>
</tr>
<tr>
<td>.0171086</td>
</tr>
<tr>
<td>.0117447</td>
</tr>
<tr>
<td>88.00'</td>
</tr>
<tr>
<td>Theoretical rise in 6&quot; drive pipe using a 7½&quot; drive shoe driven to a depth of one foot ............................................. 20.3'</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>7½&quot; Drive Shoe</strong></td>
</tr>
<tr>
<td>Cutting Edge dia. 7½&quot;</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>8&quot; Drive Pipe</strong></td>
</tr>
<tr>
<td>Inside dia. 7.625&quot;</td>
</tr>
<tr>
<td>Cross-sectional Area</td>
</tr>
<tr>
<td>Volume in Cu. In. per Ft. depth</td>
</tr>
<tr>
<td>Volume in Cu. Ft. per Ft. depth</td>
</tr>
<tr>
<td>Volume in Cu. Yds. per Ft. depth</td>
</tr>
<tr>
<td>45.6636</td>
</tr>
<tr>
<td>.5479632</td>
</tr>
<tr>
<td>.0117447</td>
</tr>
<tr>
<td>74.6621</td>
</tr>
<tr>
<td>.0184867</td>
</tr>
<tr>
<td>.0120321</td>
</tr>
<tr>
<td>52.08'</td>
</tr>
<tr>
<td>Theoretical rise in 8&quot; drive pipe using a 9%&quot; drive shoe driven to a depth of one foot ............................................. 19.6'</td>
</tr>
</tbody>
</table>

**APPENDIX E**

**GENERAL INFORMATION AND COST DATA**
**APPROXIMATE WEIGHTS OF EARTH AND GRAVEL**

<table>
<thead>
<tr>
<th>Type of Material</th>
<th>Loose Measure 2,200 lbs. per cubic yard</th>
<th>Rank Measure 3,000 lbs. per cubic yard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary Gravel</td>
<td>Dry Gravel</td>
<td>Loose measure</td>
</tr>
<tr>
<td></td>
<td>Ordinary Earth</td>
<td>Dry Earth</td>
</tr>
<tr>
<td></td>
<td>Sand and Gravel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clay</td>
<td></td>
</tr>
</tbody>
</table>

- Data precludes the formulation of specific rules. The following figures should be used with this in mind.

**APPROXIMATE SWELL OF EARTH AND GRAVEL**

- Ordinary Gravel: 20 to 30%
- Cemented Gravel: 40%
- Sand and Gravel: 15%
- Gravel and Clay: 35%
- Loam: 20%
- Dense Clay: 50%

The volume increases shown here may change appreciably under varying conditions, the amount of swell being influenced by the moisture content, size of gravel and its ratio to sand, and other conditions.

**GRAIN SIZE**

The average diameter of particles in millimeters is as follows:

- Boulders: Greater than 256 mm (10")
- Cobble: 64 mm to 256 mm (2" to 10")
- Pebble: 4 mm to 64 mm (3/16" to 2")
- Sand: Greater than 2 mm
- Silt: 2 mm to 1/16 mm
- Clay: 1/16 mm to 1/256 mm
- Silt-clay: Less than 1/256 mm

**CHARACTER OF PLACER GOLD related to DISTANCE FROM SOURCE**

It is generally recognized that the shape and angularity of placer gold may serve as a measure of distance traveled. The heavier and more hackly, the nearer the source. The more water-worn and scaly, the further it has traveled from its source. While this can be accepted as fact, the near-absence of statistical data precludes the formulation of specific rules. The following figures should be used with this in mind.

<table>
<thead>
<tr>
<th>Distance from Source</th>
<th>Nature of Gold 1/</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 miles</td>
<td>Rough nugget</td>
<td>Magnetite</td>
</tr>
<tr>
<td>8 miles</td>
<td>Small nugget, water-worn</td>
<td>Ilmenite</td>
</tr>
<tr>
<td>11 miles</td>
<td>Fine granular</td>
<td>Garnet</td>
</tr>
<tr>
<td>25 miles</td>
<td>Fine scaly</td>
<td>Zircon</td>
</tr>
</tbody>
</table>

**HEAVY MINERALS FOUND IN WESTERN GOLD PLACERS**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetite</td>
<td>5.2</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>5.6</td>
</tr>
<tr>
<td>Garnet</td>
<td>4.3</td>
</tr>
<tr>
<td>Zircon</td>
<td>4.7</td>
</tr>
<tr>
<td>Hematite</td>
<td>4.9</td>
</tr>
<tr>
<td>Chromite</td>
<td>4.6</td>
</tr>
<tr>
<td>Epidote</td>
<td>3.2</td>
</tr>
<tr>
<td>Olivine</td>
<td>3.3</td>
</tr>
<tr>
<td>Limonite</td>
<td>3.6</td>
</tr>
<tr>
<td>Rutile</td>
<td>4.2</td>
</tr>
<tr>
<td>Pyroxine</td>
<td>3.3</td>
</tr>
<tr>
<td>Monazite</td>
<td>4.9</td>
</tr>
<tr>
<td>Platinum group metals</td>
<td>14</td>
</tr>
</tbody>
</table>

Gold, platinum, magnetite, ilmenite, chromite, garnet, zircon, rutile and monazite, when found in placers, may be far from their source. Copper minerals, galena and sphalerite are rarely found in placers, and where found, are usually not far from their source.

The black sand content of gold placers in the Western United States is commonly between 5 and 20 pounds of black sand concentrate per cubic yard of gravel.
**APPROXIMATE MINING COSTS, 1964**

<table>
<thead>
<tr>
<th></th>
<th>Bucket-line dredge</th>
<th>Dragline dredge</th>
<th>Hydraulic</th>
<th>Drift</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11c - 22c per cubic yard</td>
<td>22c - 45c</td>
<td>25c - 45c</td>
<td>$9.00 - $18.00</td>
</tr>
</tbody>
</table>

**BUCKET-LINE DREDGE COST, 1964**

<table>
<thead>
<tr>
<th>Annual capacity, million cubic yards</th>
<th>Bucket size, cubic feet</th>
<th>Maximum digging depth below water level, feet</th>
<th>Weight, tons</th>
<th>Cost per ton, erected, dollars</th>
<th>Cost, erected, dollars (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.4</td>
<td>22</td>
<td>150*</td>
<td>5,000</td>
<td>1,300</td>
<td>65</td>
</tr>
<tr>
<td>10.4</td>
<td>27</td>
<td>120</td>
<td>4,000</td>
<td>1,270</td>
<td>5.5</td>
</tr>
<tr>
<td>6.9</td>
<td>18</td>
<td>100</td>
<td>3,000</td>
<td>1,400</td>
<td>4.2</td>
</tr>
<tr>
<td>3.9</td>
<td>10</td>
<td>80</td>
<td>2,000</td>
<td>1,600</td>
<td>3.2</td>
</tr>
<tr>
<td>3.0</td>
<td>8</td>
<td>50</td>
<td>1,300</td>
<td>1,650</td>
<td>2.4</td>
</tr>
<tr>
<td>2.2</td>
<td>6</td>
<td>40</td>
<td>700</td>
<td>2,000</td>
<td>1.8</td>
</tr>
<tr>
<td>1.6</td>
<td>4</td>
<td>25</td>
<td>460</td>
<td>2,175</td>
<td>1.0</td>
</tr>
</tbody>
</table>

* A bucket-line dredge of this digging capacity has not been built; bucket size may be restricted by engineering requirements.

**FLOATING GRAVEL WASHING PLANT COST, 1964**

<table>
<thead>
<tr>
<th>Annual capacity, million cubic yards</th>
<th>Trommel size</th>
<th>Weight, short tons</th>
<th>Cost per ton, erected, dollars</th>
<th>Cost, erected, thousand dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>54-inch diameter, by 20 feet</td>
<td>76</td>
<td>1,380</td>
<td>105</td>
</tr>
<tr>
<td>1.5</td>
<td>72-inch diameter, by 47 feet</td>
<td>207</td>
<td>1,210</td>
<td>248</td>
</tr>
<tr>
<td>3.0</td>
<td>120-inch diameter, by 63 feet</td>
<td>488</td>
<td>1,270</td>
<td>620</td>
</tr>
</tbody>
</table>

3/ Washing plant for dragline dredge.
### Lengths

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mile</td>
<td>8 furlongs</td>
</tr>
<tr>
<td>1 furlong</td>
<td>120 yards</td>
</tr>
<tr>
<td>1 chain</td>
<td>33.3 yards</td>
</tr>
<tr>
<td>1 station</td>
<td>66 feet</td>
</tr>
<tr>
<td>1 rod</td>
<td>16.5 feet</td>
</tr>
<tr>
<td>1 yard</td>
<td>3 feet</td>
</tr>
<tr>
<td>1 vara</td>
<td>33 inches (approx.)</td>
</tr>
<tr>
<td>1 foot</td>
<td>12 inches</td>
</tr>
<tr>
<td>1 link</td>
<td>7.92 inches</td>
</tr>
<tr>
<td>1 inch</td>
<td>0.0833 feet</td>
</tr>
</tbody>
</table>

### Square Measure

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 township</td>
<td>36 sq. miles</td>
</tr>
<tr>
<td>1 sq. mile</td>
<td>160 acres</td>
</tr>
<tr>
<td>1 acre</td>
<td>4,840 sq. yards</td>
</tr>
<tr>
<td>1 section</td>
<td>640 acres</td>
</tr>
<tr>
<td>1 Lode Claim</td>
<td>600 ft. x 1,500 ft.</td>
</tr>
<tr>
<td>1 Placer Claim</td>
<td>3305.78 sq. rods</td>
</tr>
</tbody>
</table>

### Cubic Measure

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cubic yard</td>
<td>27 cubic feet</td>
</tr>
<tr>
<td>1 cord (wood)</td>
<td>4 x 4 x 8 ft. =</td>
</tr>
<tr>
<td>1 ton (shipping)</td>
<td>40 cubic ft.</td>
</tr>
<tr>
<td>1 cubic foot</td>
<td>1.728 cubic inches</td>
</tr>
</tbody>
</table>

### Weights (Commercial)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 long ton</td>
<td>2,240 lbs.</td>
</tr>
<tr>
<td>1 short ton</td>
<td>2,000 lbs.</td>
</tr>
<tr>
<td>1 pound</td>
<td>16 ounces</td>
</tr>
<tr>
<td>1 ounce</td>
<td>16 drams</td>
</tr>
</tbody>
</table>

### Troy Weight (for Gold and Silver)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 oz. troy</td>
<td>1 lb. troy = 0.823 pounds av. = 5760 grains</td>
</tr>
<tr>
<td>16 oz. av.</td>
<td>1 lb. av. = 7,000 grains</td>
</tr>
<tr>
<td>31.1035 grams</td>
<td>1 oz. troy = 20 pennyweight = 480 grains</td>
</tr>
<tr>
<td>20.350 grams</td>
<td>1 oz. av.</td>
</tr>
<tr>
<td>1 kilogram</td>
<td>2.2046 lb. av.</td>
</tr>
<tr>
<td>1 pennyweight</td>
<td>24 grains = 1,555 grams</td>
</tr>
</tbody>
</table>

### Dry Measure

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 bushel</td>
<td>4 pecks</td>
</tr>
<tr>
<td>1 peck</td>
<td>8 quarts</td>
</tr>
<tr>
<td>1 quart</td>
<td>2 pints</td>
</tr>
<tr>
<td>1 bushel</td>
<td>1.2455 cubic feet</td>
</tr>
</tbody>
</table>
### Metric and U.S. Weights and Measures

#### Lengths

<table>
<thead>
<tr>
<th>Metric</th>
<th>U.S. Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles</td>
<td>1.6093 Kilometers</td>
</tr>
<tr>
<td>Yards</td>
<td>0.9144 Miles</td>
</tr>
<tr>
<td>Feet</td>
<td>0.3048 Yards</td>
</tr>
<tr>
<td>Inches</td>
<td>0.0254 Feet</td>
</tr>
</tbody>
</table>

#### Areas

<table>
<thead>
<tr>
<th>Metric</th>
<th>U.S. Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sq. mile</td>
<td>2.59 Acres</td>
</tr>
<tr>
<td>Acres</td>
<td>0.4047 Sq. miles</td>
</tr>
<tr>
<td>Hectares</td>
<td>1.196 Acres</td>
</tr>
<tr>
<td>Sq. yard</td>
<td>0.8361 Sq. feet</td>
</tr>
<tr>
<td>Sq. feet</td>
<td>0.1076 Sq. yards</td>
</tr>
<tr>
<td>Sq. inch</td>
<td>0.007044 Sq. mile</td>
</tr>
<tr>
<td>Sq. cm²</td>
<td>0.002586 Sq. inch</td>
</tr>
<tr>
<td>Sq. mm²</td>
<td>0.0000000025866 Sq. inch</td>
</tr>
</tbody>
</table>

#### Volume

<table>
<thead>
<tr>
<th>Metric</th>
<th>U.S. Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu. yard</td>
<td>0.765 Cu. feet</td>
</tr>
<tr>
<td>Cu. feet</td>
<td>0.0283 Cu. inches</td>
</tr>
<tr>
<td>Cu. inch</td>
<td>0.0283 Cu. centimeters</td>
</tr>
<tr>
<td>Cu. meter</td>
<td>1.308 Cu. yards</td>
</tr>
<tr>
<td>Cu. cm³</td>
<td>1.057 Cu. feet</td>
</tr>
<tr>
<td>Cu. mm³</td>
<td>1.000 Cu. inches</td>
</tr>
</tbody>
</table>

#### Liquid Measure

<table>
<thead>
<tr>
<th>Metric</th>
<th>U.S. Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. gallon</td>
<td>3.785 Litres</td>
</tr>
<tr>
<td>Imperial gallon</td>
<td>1.2099 U.S. gallons</td>
</tr>
<tr>
<td>Liter</td>
<td>0.2642 Gallons</td>
</tr>
</tbody>
</table>

#### Weights

<table>
<thead>
<tr>
<th>Metric</th>
<th>U.S. Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pound</td>
<td>0.453 Kilograms</td>
</tr>
<tr>
<td>Kilogram</td>
<td>2.2046 Pounds</td>
</tr>
</tbody>
</table>
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Dip, 104
Lead, 103
Length of sampling sluice, 53, 55
Lindgren, Walser, cited, 5, 14
Line system, for prospect drilling, 37, 39
Dip, 104
Lead, 103
Regional uplift, preservation of placers by.

Regional uplift, preservation of placers by.

Regolith, 111

Regolith, 111

Regolith, 111

Regolith, 111

Regional uplift, preservation of placers by.

Regional uplift, preservation of placers by.

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