

Pamphlet No. 36

First Edition, June 1932
Second Edition, May 1933
Third Edition, May 1934
Fourth Edition, May 1939
Fifth Edition, March 1953

STATE OF IDAHO
C. A. Bottolfsen, Governor

IDAHO BUREAU OF MINES AND GEOLOGY
A. W. Fahrenwald, Director

PROSPECTING FOR GOLD ORES

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PROSPECTING FOR GOLD ORES

INTRODUCTION

This pamphlet was prepared in response to an urgent demand from citizens interested in the up-building of the State of Idaho, and from a host of mining people to whom the low prices of the base metals have brought great distress in recent times and have roused a new interest in the mining of gold, the one metal for which the market does not fail. Unemployed experienced miners are searching for gold, and many inexperienced men wish to learn the art of prospecting. The Idaho Bureau of Mines and Geology has received a constant stream of requests for suggestions and guidance in prospecting, and the correspondence has become so voluminous that pamphlets covering the whole subject had to be prepared for distribution to inquirers.

The first of this series of pamphlets dealt with the search for and the operation of placer mines. ^{1/} The call for it continues and it is now in its tenth edition.

There have been so many questions upon the methods of saving gold that a separate pamphlet has been written by Professor A. W. Fahrenwald upon the recovery of gold from its ores. ^{2/} A fourth edition, revised and brought up to date, has been issued.

THE PROSPECTOR

The prospector of pioneer days has passed into history and has not handed down his skill to the present generation. Up to this century he found practically all of our gold mines. His craft had developed from centuries of experience. Under his methods, the cost of finding our gold was less than it ever is likely to be again. Although often tinged with superstitions and fallacies, such as fantastic theories of nature, faith in the divining rod, and other mystic devices that sometimes caused unnecessary effort and led to disappointments, his conceptions and his methods were on the whole sound and effective, and their revival would be of great benefit to this state.

In pioneer days, placers were the easiest gold deposits to find, to test for value, and to work. Upon them the beginnings of Idaho history were founded. Probably the best placers have been discovered, yet important deposits may remain in out-of-the-way places. Also, most of the gold veins that could be found easily, especially those near the old placer camps, have been developed and operated, but it is believed that gold mines are still to be discovered in central Idaho in regions offering less physical difficulties than confronted prospectors of the old days, on account of new forest roads and trails, the absence of hostile Indians, and the nearness of towns where supplies and equipment can be obtained. Walla Walla was the nearest supply point for the pioneers. Also, deep mining was not done in the early days. The art of recovery of gold has made important advances. Ores not profitable for early may now be successfully treated. All these considerations recommend the search for gold. Some of the reasons for believing that gold remains to be discovered in Idaho will be given, also the surroundings in which it may be found will be described.

^{1/} Staley, W. W., "Elementary methods of placer mining," Idaho Bureau of Mines and Geology, Pamphlet No. 35.

^{2/} Fahrenwald, A. W., "Recovery of gold from its ores," Idaho Bureau of Mines and Geology, Pamphlet No. 37.

The immense profits made up to the last year or two by the great base metal mines had diverted attention from gold mining. Along with this the pioneering spirit had waned, both among miners and financial people. Now that the base metals appear to have been over-developed, it is an appropriate time to stimulate miners and men of money to find new gold. It is needed in the business of Idaho and of the world.

This pamphlet is intended for the use of any one who has the urge to explore for gold, even though he has had no technical training or mining experience.

PREPARATION FOR PROSPECTING

Technical or scientific education, although it would be helpful, is not necessary for the prospector. However highly he is educated, he has to learn by experience. He cannot, by reading books, set forth into the mountains as a full-fledged prospector. The best this pamphlet can accomplish may be to help any man to get started, who has never prospected before, and keep him from making certain mistakes.

Certain personal qualities a prospector must have: Courage, natural resourcefulness, good powers of observation, but, most of all, a tireless patience and physical energy. A new mine is not likely to be found on a summer's holiday or a casual vacation. It was not unusual for the skilled old timers to hunt over great areas many years for veins before anything satisfactory was located, and that was at a time when conspicuous gold veins remained to be discovered.

A knowledge of practical mining is more important probably than geological or engineering education. If it is entirely lacking, one bent upon prospecting should get a job for a time, if possible, around a small mine where there is a variety of work going on, in order to learn how to drill holes by hand and use explosives to blast rock, how to prepare and put in mine timbering, how to sharpen steel, and to do other rough blacksmithing. If such employment is impossible to get in these days when mining jobs are scarce, it would be wise to hire a practical miner for a time, or join one as a partner.

Money for prospecting

Mining financiers and the big mining companies possibly are now more inclined than usual to invest in the exploitation of authentic gold discoveries already located. But they are reluctant, as they always have been, to put up money toward the primary search for new deposits, although gold has extra purchasing power just now, market for it is unlimited, and labor is plentiful.

The prospector should finance himself in the hills, if possible, and thus avoid entangling alliances. In order to do this, it was a common custom in former times to work around the mines somewhere for a part of the year and to use the savings from wages the balance of the year searching in the hills.

Grub stakes

Some men, however, preferred to spend all their time prospecting and sought a friend to supply money for food and equipment. This was the "grub stake." One or more people, having money to spare and a confidence in the prospector, paid the actual cost of the search in exchange for a half interest in anything discovered. The prospector gave his skill and hard work. This idea was elaborated in various ways. Money was advanced sometimes by a group or syndicate. Partnerships in the field work were common, and were very desirable on account of the

possibility of accidents and sickness in remote places. If there were two men working together in the field, the interest of each was reduced to a quarter, but if both men were competent, double the amount of territory could be covered, and, because two heads are better than one, the chances of discovery were increased.

Equipment and supplies

It is a good plan to purchase essential food supplies before starting into the hills. Such supplies can be supplemented from time to time by fish and game, and by fresh vegetables from settlers in the mountains. A man working in the hills consumes as much as four pounds of food a day. Flour, corn meal, beans, ham and bacon, dried fruits, coffee, tea, sugar, canned milk, salt, pepper, butter, and syrup are the essentials to take along.

Caution should be used regarding drinking water. It is not so safe as it once was to drink from every mountain stream. The water of springs and brooks at high altitudes may not be contaminated, but if there are human beings or livestock at any point up stream, it is wise to boil water before drinking it. Springs and wells in the desert occasionally contain injurious or poisonous mineral matter. In desert regions, camp should not be moved until a satisfactory water supply for men and animals is assured in advance.

In Idaho, clothing should be durable and warm, and there should be one or more complete changes. It sometimes snows in mid-summer in the high mountains of Idaho and there are frequent cold rains. Boots are most important of all. Cheap and uncomfortable boots have often defeated the best of intentions in exploration. Strong, water-tight, mining boots, hobnailed for climbing rocks, are the best. Heavy socks are necessary for foot protection.

There should be a tent for shelter of heavy enough canvas to shed hard mountain rains and to retain the heat of a stove in cold weather. A knock-down sheet-iron stove with oven, pipe, and sleeve to protect tent roof is satisfactory for heat, cooking, and drying wet clothing.

The following tools and camp equipment are desirable for one man: One gold pan, mortar and pestle, one good axe, a round-pointed shovel, a good compass, medium sized miner's pick, prospecting pick, heavy jack-knife, magnifying glass, nails, water-tight match box, candles, acetylene miner's lamp with two five-pound cans of carbide, two frying pans, covered kettle, coffee pot, can opener, baking pan, water bucket, small galvanized wash tub, tin plates and cups, knives, forks, spoons, soap, towels, canvas to cover bed and to protect packs when traveling, a reliable antiseptic, roll of gauze bandage, and a few simple household remedies.

A man should not sleep on the ground in northern latitudes. A folding cot is convenient to carry. There should be plenty of warm bedding.

Maps

A good map showing settlements, streams, mountains and trails, should be taken along; also, if possible, a geological map. Most of the geological maps of central Idaho are out of print. They may be consulted in city libraries. The maps have been published by the U. S. Geological Survey, or by this bureau, with reports upon local areas, and are bound in with them.

Transportation

In Idaho, automobiles can now be driven to points within reasonable distance of prospecting territory, although trips of 100 miles or more could be

made beyond the ends of roads if all the possible gold-producing areas were covered. Away from the roads, pack animals (burros or horses) can travel to all points where camps might be established. From camps as headquarters, much rough climbing afoot is necessary. In the Canadian wilderness, where a canoe and man himself take the place of pack animals, all equipment and supplies must be in parcels that can be carried on a man's back over portages.

The airplane has come into common use by government and company geologists in this country, Alaska, and Canada. They are used in connection with mining operations in Idaho to carry mail, light supplies, and men in winter. For ordinary prospecting they are too expensive. They only serve to spot localities for real prospecting on foot. Such places would generally be recognized from the airplane only by a geologist.

THE GEOLOGIST

Probably the geologist's greatest usefulness in the search for gold is to assist prospectors in the following ways:

1. By describing features on the surface that indicate veins.
2. By clarifying conceptions of veins and ore deposits, so that the discoverer may be aided in estimating the possibilities in what he finds and develop or abandon it accordingly.
3. Most important of all, by mapping rocks accurately on the surface and explaining which of them, or which combinations of them, offer the best promise of containing gold veins. In this way, geologists have succeeded in blocking off great areas in which ore is improbable, and in narrowing down to small regions the most favorable spots in which to work.

In cooperation with the U. S. Geological Survey, and independently, the geologists of this bureau are in the field for the purpose of aiding ore discovery and the making of new mines.

A field in which geologists necessarily have a monopoly, and the prospector is practically helpless, is finding ore that does not show on the surface. This they have done in the Tintic district in Utah and in the Butte district. But that is a separate story and does not belong in this pamphlet.

Some of the conceptions of fundamental geological processes, especially those relating to the formation of ores, are outlined because they are being used successfully, particularly in the valuation of prospects. In some cases, this will involve conclusions upon which there are some differences of opinion, but space is not used to set forth all of these. The writer gives what in his belief is the majority view or the present decided trend of opinion in geological science. The difficulty of presenting in brief and simple form such a highly technical subject as the geology of ore deposits is fully realized.

GEOPHYSICS

The study of forces in the earth, such as electricity, magnetism, gravitation, and the transmission of sound and shock, is Geophysics, and geophysical instruments for measuring these things have begun to be successful in finding some of the large invisible and deeply buried mineral deposits, by determining the slight differences between the effects of these forces in such bodies and in ordinary rocks. Hitherto geophysical methods have not been widely useful in the

discovery of ordinary gold veins. Possibly they may be in the future. They have no relation, of course, to the old-time divining rod. The various kinds of apparatus are necessarily of delicate construction, expensive, and require experts to operate them. They are not as yet of much use to prospectors. Geophysical prospecting is mentioned because inquiries indicate that there is a wide-spread impression that such methods have been perfected and are an easy route to fortune, making no longer necessary the labor and hardship of the search for gold. When this time comes, if it does, it will be known and widely published. Secret divining methods and apparatus, represented as operating upon scientific principles not generally known to scientists, are to be avoided.

This pamphlet is restricted, so far as possible, to a description of gold veins, but much of the discussion applies to all metal-bearing veins.

MAIN KINDS OF ROCKS

As this discussion proceeds, it is hoped that the significance of certain rocks may grow upon the reader and that he may have the desire to learn to recognize the main kinds as he finds them in the hills. His first step might well be to study the principal ones mentioned herein in some collection where they are labeled, as at the School of Mines at Moscow.

A rock formation: Any body of rocks that is more or less alike throughout, or one formed at a particular time, or one which is an obvious division of a larger body, is called a formation.

A mineral: This is a term which will be used frequently. In science a mineral is an inorganic body of definite chemical composition. Everything on the earth is a mineral or composed of minerals, except plants and animals, and even they contain in their bodies, along with organic tissues, a great variety of minerals. A mineral may be a solid, liquid, or gas. Miners often restrict its meaning to the substances in ore bodies. They speak of "finding mineral," meaning vein materials or valuable metals. In this pamphlet it refers to any material that is a definite separate unit in rocks and ore deposits.

No attempt will be made to describe either rocks or minerals, or the methods of recognizing them. If attempted, it would be so abbreviated that it would be of little use. The prospector is advised to take into the hills with him a standard book upon this subject that describes minerals and explains methods of determining them by their various physical characteristics or by the use of a blow-pipe outfit; also books upon geology and mining technology might be useful. Such books are listed below:

- William E. Ford: Dana's Manual of Mineralogy, 4th Edition. \$4.00
John Wiley & Sons, New York.
- J. W. Anderson: Prospector's Handbook, 12th Edition. \$2.00
D. Van Nostrand Co., New York.
- A. F. Rogers: Introduction to the study of minerals and rocks
2nd Edition. \$4.00. McGraw-Hill Book Co., New York.
- G. Montague Butler: Pocket Handbook of Blow-Pipe Analysis. \$1.25.
John Wiley & Sons, New York
- M. W. von Bernwitz: Handbook for prospectors. \$3.00
McGraw-Hill Book Co., New York.

- Robert Peele: Mining Engineer's Handbook, 2nd Edition. \$10.00
John Wiley & Sons, New York
- J. E. Spurr: Geology applied to mining, 2nd Edition. \$3.00
McGraw-Hill Book Co., New York
- James F. Kemp: Handbook of rocks, 5th Edition. \$3.00
D. Van Nostrand & Co., New York
- Waldemar Lindgren: Mineral deposits, 4th Edition. \$6.00
McGraw-Hill Book Co., New York

As one reads about rocks, he will note two terms are often used, structure and texture. Structure refers to the shape of a rock mass or of its larger divisions. Texture has to do with the particles of which it is made and the arrangement of them. A bolt of cloth is a rolled-up, sheet-like body in structure, its texture is the weave or fabric of it.

Rocks group themselves into three main classes according to the way they were made: Sedimentary, metamorphic, and igneous.

(1) Sedimentary rocks: Those rocks that have a bedded structure and in texture are composed of worn rock fragments, or of chemical deposits, that generally have been laid down under water, are called sedimentary rocks. The ocean extended at times over parts of the continent that were lower than now. There were also lakes that do not exist today. Some sedimentary beds were spread out by streams, or by winds, over land surfaces. It required great periods of time to make the large bodies of sedimentary rocks, and their bedded forms are due to more rapid accumulation at one time than another, according to the amount of material being moved by storms and streams from high to low regions and ultimately to lakes and seas. The process of breaking down solid rock and moving the resulting loose material from elevated places is called erosion, to be discussed more fully later. The deposition of the material in lowlands and water bodies is called sedimentation; hence, the name sedimentary rocks. Those rocks made up by worn fragments or particles may be of any coarseness or fineness of texture. If composed of boulders and pebbles, they are called conglomerate beds; if of sand, they are sandstones, if of very fine sand, clay, or mud, they are shales.

Another kind of sedimentary rock, referred to above as chemical deposits, is generally a mixture of fine particles of silt cemented by lime, deposited from solution in sea water, often by the aid of minute sea animals that build shells and house their colonies in limy structures. Such rocks may be nearly pure lime. This whole group, pure or impure, is called limestone. It dissolves and effervesces if dilute hydrochloric acid is put upon it. There are other chemically deposited sedimentary beds, but limestone is the most common of them.

The sedimentary beds so far named are usually solid, cemented, and hard, mostly because they have been deeply buried for long periods. We now find them at the surface because they have been uncovered by erosion, which has in some places removed many thousands of feet of overlying beds.

Certain sedimentary rocks, however, are still unconsolidated because they have been deposited more recently and still lie at or near the earth's surface and have not been squeezed and pressed down by a heavy burden of overlying rocks. Of these, there are alluvial deposits spread out over broad valleys and plains during flood stages of slowly flowing rivers. Coarser sand and gravel beds accumulate along swifter streams. Such may contain commercial gold placers.* There are also

* For explanation of placers, see Pamphlet No. 35, Idaho Bureau of Mines and Geology.

comparatively thick layers of wind-blown dust, such as the soil of the Palouse hills, or of wind-blown sand, as in the dunes of barren sea coasts or desert plains. Wind-laid accumulations such as these are never gold placer deposits, but the coarser materials left behind by them along beaches may be richer because the barren sand has been blown away. The enormously rich diamond-bearing beach placers of Southwest Africa have been enriched in this way by winds.

Other unconsolidated deposits along the northern edge of the United States, and all over Canada, were left by the great ice sheet of the Glacial Period, which extended southward from the Arctic country advancing and retreating several times until the main ice sheet finally withdrew some twenty to thirty thousand years ago. Some of these deposits were spread out by the slowly moving ice itself and are given various names such as till, boulder clay, moraines, etc., or they may be grouped under one name, the drift. It is mainly a jumble of great boulders, small pebbles, and fine clay, unassorted and not bedded. It may contain a little gold here and there, but the gold does not pay for the working of such deposits. Vigorous streams that poured from the front of the ice did, however, in places along valleys, sort such material, carried away great volumes of clay and fine sand, and left gravels (placers) that contain enough gold to be profitable. Small mountain glaciers at about the same time, and even in recent times, have existed around mountain summits and in high valleys in Idaho, Washington, Montana, Colorado, Oregon, and California, as they do today in Switzerland. Outwash glacial gravels in gulches and valleys below places where such glaciers have been are profitable placers in some localities where the glaciers wore away parts of gold veins.

(2) Metamorphic rocks: It has been stated that rocks are connected after they have been very deeply buried. Some great rock masses have been buried to depths where they sustained enormous loads of overlying rock, and where the earth was hot, and may also have been subjected to strains caused by movements in the earth's crust. These, when exposed at the surface, have structures and textures decidedly different from their original character. This has been brought about mainly by new crystallization or re-arrangement of rock materials. Thus, a body may be squeezed thinner and caused slowly to flow, or to become banded, by the shifting and re-alignment of minerals. By such processes, shales and shaly sandstones become banded schist; purer sandstones become quartzite; granites become gneiss; limestones turn into marble and serpentine. Heat sufficient to alter existing beds profoundly has been brought up from great depths by large bodies of molten rock, such as the Idaho batholith, now exposed in central Idaho. This will be discussed more fully in the description of Idaho gold ores.

(3) Igneous rocks: As the name implies, heat took part in the making of rocks of this kind. It would be impossible in a brief space to explain everything about igneous rocks; in fact, nobody knows all about them. A few things are fairly well understood and these will be outlined because they have to do with the origin of ore deposits.

The temperature of the earth increases from the surface downward, so also does pressure, merely by the increasing load of rock. Pressure tends to make rock still more solid. At a depth of ten to fifteen miles the heat is great enough to melt most rocks, but pressure generally keeps them solid. In fact, physicists have shown that they are increasingly rigid all the way to the earth's center. But, if pressure is in any way relieved at depths where the rocks are sufficiently hot, they melt. Erosion by its age-long methods shifts the weight of earth masses on the outer shell. A wide belt along the Rocky Mountain system, for instance, became so much lightened at times in the past that heavy masses

of the continental body on both sides crowded against it, and probably at great depth were squeezed beneath it. Under sufficient pressure and heat, it is known as already stated, that rocks slowly flow. Such stresses from the sides of belts lightened by erosion cause upward bending arches and cracks penetrate to great depth, relieving pressure. Rock becomes molten and fluid, and walls up under the arches and bursts out along the cracks, bringing with it the heat of regions perhaps miles below the surface.

The fluid rock is called magma. Great bodies of deep magma that accumulated under broad domes or arches became batholiths when cooled to solid rock. Considerable bodies, formed in the same way, upthrust into existing rocks of the crust are stocks. If the magma filled cracks and fissures, it made dikes; if it pushed in between beds, sills or sheets; if the magma reached the surface along cracks, volcanoes erupted, the magma was blown into the air or poured over the surface as lava. These terms relate mostly to the structure of the resulting rock body. Ore deposits are found associated with all these kinds of igneous rock.

The igneous rocks are also named according to the textures resulting from the way they cooled. Every igneous rock is made up of several distinct minerals, in coarse crystals if they cooled slowly. If they cooled rapidly, they hardened without much crystallization. They are either intrusive or extrusive, terms that express where they stopped on their way up from the depths. The intrusive magmas thrust themselves into rocks that existed before them, but failed to reach the surface and hardened into batholiths, stocks, dikes, and sills. The extrusive magmas are those that poured out on the surface. The kinds of rock in the greater masses that were deep-seated when they were made, the batholiths and stocks are granite, syenite, diorite, gabbro, etc. They are coarse in texture (granitic). Rocks of the same composition in dikes and sills are generally finer grained and are given names that express their finer textures; rhyolite, porphyry, quartz porphyry, granite porphyry, andesite porphyry, diorite porphyry, and many others. These chilled rapidly because they were small volumes of magma in contact with the cooler rocks that they were invading. Porphyries are intrusive rocks in which one or two minerals formed large crystals, while other minerals formed a matrix of smaller crystals. Thus certain crystals stand out conspicuously among the very small ones produced by rapid cooling.

There is a great variety of extrusive or volcanic rocks, also named according to the way in which they came up from the depths: (1) Effusive, those that poured out as fluid lavas; (2) explosive, those ejected violently as rock fragments by the expansion of steam and other gases. The fragmental volcanic rocks of explosive eruptions are called breccias, if coarse, and tuffs, if fine. The fragments may be of intrusive rocks that had hardened below the surface and afterwards were blown out by repeated eruptions from cracks and pipes which they had previously filled. Volcanoes also generally tear off fragments from the walls of the passageways through which they discharge. So the volcanic rock may include in it sedimentary, metamorphic, other igneous rocks, anything met on its way to the surface.

Lavas may vary in texture, from porphyry, with considerable crystalline texture, to glass which is magma that was chilled almost instantly, so that no crystals even started to grow. The name obsidian covers most of the massive glasses. Pumice includes glasses that cooled while full of gas bubbles, so are porous, some of them so light that they will float on water.

No attempt will be made to describe further any of the sedimentary or igneous rocks mentioned. Specimens of them can be found in any good university

geological museum and the eye soon learns to distinguish between the main kinds. The first thing to note is that the principal varieties of igneous rock generally contain sharply defined angular crystals and sedimentary rocks do not, but usually have in them rounded or worn particles. Even though they are fine-grained, a good pocket magnifying lens will show the distinction. Some of the crystalline metamorphic rocks are more likely to be confused with the crystallized igneous rocks, but in the field most of the metamorphic rocks can be recognized by their banded structures. Quartzite usually shows surviving grains of sand. The volcanic glasses are harder than the massive sedimentary rocks like limestone. Limestone, and marble, the metamorphic rock made from it, are easily scratched by a knife.

RELATIONS OF ROCKS AND ORES

Veins and deposits of gold would not be found at all on the earth's surface if, throughout the billion years or more of known earth history, the magmas of some igneous rocks had not at some time pushed up to the surface or toward it in what are now the gold-bearing districts. These magmas brought with them gold and other metals from the great depths, where they really belong in the earth. Strictly speaking, they are out of place on the surface and are there only because igneous magmas and the gases and fluids in them are the special vehicles that give the metals transportation. That gold and many other metals have come up with the igneous rocks has been demonstrated beyond question.

The earth's interior

Physicists and geophysicists in recent years have found methods not only of weighing the earth as a whole, but can detect the differences of weight between separate layers from the surface down. It has been found that there are distinct layers, probably differing from one another because of what they contain, and that they are successively heavier from the outer shell downward. So heavy is the greater part of the deep masses of the earth that we naturally assume that in them the metals are much more abundant than in surface rocks.

Gold ores are associated with the lighter-colored acid or siliceous rocks from the magma-forming layer just below the thick outer crust. Diamonds and the platinum group of metals probably come from a deeper layer with magmas that cooled as dark-colored basic rocks.

Solutions

Solutions will be mentioned frequently, so the term should be defined. A solution is a uniform mixture or combination together of two or more substances. They are usually in definite proportions, because one substance will absorb just so much of another, and, if there is any of it left over, it will drop out of the solution. For example, water will take up in solution just so much sugar and is then said to be saturated with it, and any more put in will not dissolve, but remain in solid form. If the solution is heated, more can be dissolved; as heat is reduced, some will be dropped and will crystallize as a solid. It is important to keep this in mind because different ores were formed at different temperatures in veins by this behavior of solutions.

Ores and magmas

As the magmas crowded upward, came to rest and cooled to solid rock, as batholiths for instance, it is believed that it was still so hot around these hardening rock masses that certain minerals left over as fluid residues refused for a time to crystallize or solidify. Those solutions contained metals such as

gold, silver, nickel, tin, tungsten, iron, copper, lead, zinc, and others. They also contained much silica, which in its solid form miners know as quartz, and smaller amounts of other non-metallic substances, and with them there was a great deal of steam and less amounts of various other gases, also containing some of the metals in solution. The bases were also very useful in supplying the driving power to force the fluids toward the surface wherever they could find a way.

Through fissures, heated ore-bearing fluids, left over as the magmas turned to rock, moved upward, and as they reached cooler rocks along channels of circulation, and, as time elapsed, the metals and other minerals in them began one by one to be deposited from solution. Long before they reached the surface the vein metals had mostly been dropped and the remaining fluid was mainly water with a few substances such as are found around the mouths of the hottest of the hot springs, such as lime, magnesia, carbonic and sulphurous gases, possibly some silica and iron, and in some places quicksilver, arsenic and antimony sulphides.

VEIN STRUCTURE

The routes supplied for ore fluids were cracks formed deep through the outer crust along dikes or wherever the rocks had been strained beyond their strength. Probably the shrinking of deep intruding magmas, as they continued to cool and became rock, was one of the causes of such cracks. In gold-mining districts, we find fractures that cut through older rocks before magmas came up, others that were later than the solidifying magmas and cut the resulting rocks themselves. There are other cracks along which great masses of rock slipped upon one another. These are named faults by geologists and miners. They are generally filled with ground-rock clay called gouge. Miners generally speak of fractures and faults, great or small, as fissures. A fissure may be a simple fracture or a system of fractures more or less complex.

Fissure veins are deposits of mineral matter in or along a fissure or fissure system as just defined. If unusually large or complex, they are called "lodes". A fissure vein is also known as a lead, ledge, or reef, in some districts. A vein may occupy a fault fissure, although in some faults the tight gouge appears to have prevented ore fluids from circulating. In other cases, faults were formed after all magmas had congealed and all ore deposition ended. The majority of gold veins are found in fissures along which there has been no great movement. Miners use the term "true fissure vein". Behind the use of this term is the belief that a vein occupying a well-defined fissure can be relied upon to continue for a long distance down into the earth. It is not a very good generalization, because many important gold deposits are not in big fissures, but in complex, intersecting, small fractures, and great fault fissures are generally barren.

Bedded veins are those that lie along bedding planes. Miners name them blanket veins, if they lie flat. They may lie against sills and sheets that are intruded between sedimentary beds as in Leadville. The mineral deposit may permeate a porous bed or may have eaten into soluble beds (limestones, dolomites and quartzites), dissolving them and replacing them with ore materials.

The rock adjoining a vein is the country rock. It is also called wall rock and the sides of a vein are its walls. If the vein is inclined, the upper wall is the hanging wall and the lower the foot wall.

VEIN MATERIALS AND TERMINOLOGY

A few other terms commonly employed should also be defined. This is not easy in some cases because usage differs in various places.

Ore has a legalized meaning in this country. It is an aggregate of mineral matter containing valuable metals in such quantity that it can be mined and the metals removed from it and sold at a profit. Profitable non-metallic materials like clays, gypsum, salts, etc., are not called ores.

For the material in a vein or deposit which does not yield a profit, mining people use such names as mineralization, vein matter, ledge or lead matter, waste. Veins may be barren of gold in some parts and rich in others. Gangue is the general name for all the minerals that contain no recoverable metals, the unprofitable and waste materials in a vein.

In describing the position of a vein in the ground, two terms are necessary. Its strike is the direction the vein takes horizontally or on a level. The strike is not usually its course or direction on the surface.* The dip has a direction square, or at right angles, with the strike, and is the inclination of the vein downward into the earth. A 90-degree dip is vertical or the dip of a plumb-line, a 0-degree dip is perfectly level. All other angles or dip lie between these.

ZONES

In working downward on a vein, it is found that at certain depths there are changes from one kind of ore to another. From the surface downward each segment of the vein that contains a distinct variety of ore is called a zone. Also a district with many veins usually shows different ores from a center of ore deposition outward to the margins of the district. But practically all veins have two main zones, the zone of oxidation at or near the surface, later to be described, and the sulphide zone containing compounds of sulphur and metals (sulphides). At the time when veins were formed, they were entirely in the sulphide zone, which includes all those ore deposits that were brought up from deep magma regions and have not been changed since they were originally deposited. The zone of oxidation was made afterwards generally with the addition of materials carried down into it. Geologists have termed the original sulphide ores hypogene, but mining people generally call them primary, and ores that formed later, secondary. Geologists name secondary ore supergene. The supergene, or secondary, ores are hypogene or primary ores made over by processed operating at and near the surface. To understand them, the primary or sulphide ores need first to be explained.

Sulphide zone is not an accurate term because it includes many metallic minerals that are not sulphides, but the sulphides are the most important and the most conspicuous, and the name has become established.

SUBDIVISIONS OF THE PRIMARY SULPHIDE ZONE

In the primary sulphide zone, minerals formed in groups at different distances from their sources because of the behavior of ore solutions as they cooled. Geologists recognize three main divisions of the sulphide zone, each having its special minerals. Each main group, when formed, occupied a zone more or less by itself, which was a part of the larger sulphide zone. W. H. Emmons

*See Figure 1

classed these groups as made at various depths and called them the deep, moderately deep, and shallow zones, having in mind their distance below the surface at the time they were deposited. Waddeemar Lindgren, a famous leader in the study of ore deposits, advanced the idea a few years ago that these mineral groups were caused by the decrease of temperature upward when veins grew from solutions. The groups of minerals in ores that were deposited at the hottest points in fissures were formed there because they would stay in solution only when the fluids in which they were brought up were very hot, and those higher up were deposited because they remained in solution until heat dropped to a certain lower point. So Lindgren also divided the sulphide zone into three smaller zones, as did Emmons. The groups of minerals described by the two authors are practically the same.

These three main zones, as now generally recognized by geologists, starting from the greatest depths, are:

1. The hypothermal or hottest primary zone
2. The mesothermal or moderate-temperature primary zone
3. The epithermal or low-temperature primary zone

At least some mention of these zones appears to be called for, because mining people now have some knowledge of them and they are considered in reports upon mining properties. Also a working knowledge of the zones is proving to be more and more useful to geologists and mining engineers in estimating the probable value of newly discovered veins. The prospector, if he is not interested, can disregard the discussion of this subject. He can probably best judge the merits of his discovery by the amount of gold he finds in his vein. Later on, if he thinks he has a valuable gold deposit, he may be wise to employ a geologist, who specializes in mining geology, to give an opinion upon its probable persistence and to estimate its future possibilities. This may help to obtain money for opening it up, or cause him to drop it; if it is promising, help in judicious planning of equipment and development.

Gold is found in all three temperature zones, but in each the ores have special peculiarities. The low-temperature zone best suits the prospector. In it are bonanza ores, as those of Cripple Creek, the Comstock Lode, and Goldfield, Nevada. In such deposits it is sometimes possible to make money from the start with little or no equipment. Single deposits have yielded as much as \$50,000,000; the Comstock deposit nearly \$400,000,000. Such mines are spectacular, but may be short lived. Their ores are geologically comparatively young. They are found in or near volcanic areas.

The ores in the other two zones were deposited at greater depths, where solutions were hotter, are commonly found in much larger bodies than those of the low-temperature zones, but they are generally low-grade. They are difficult for a prospector to finance. Only great amounts of capital can develop them, equip them, and put them into condition for profitable production. Yet when worked on a large scale, they may be immensely profitable and have produced a large part of the world's stock of gold.

Temperature at time of ore deposition and at present

It is to be clearly understood that all this discussion of temperature relates only to the temperature when the veins were being made. Much time has generally elapsed since, except in the case of certain quicksilver deposits

that are still forming. The Comstock Lode and some others remain hotter than the wall rocks, but most of them have cooled down approximately to the natural temperatures of the country rock. The natural increase of earth temperature downward from the surface, however, stops mining work at a certain depth in any district, although ores may still be good in the bottom levels.

Further characteristics of the three zones are briefly as follows:

Epithermal ores

These generally contain open cracks and cavities (vugs or druses) lined with vein minerals. The principal gangue mineral is quartz, sometimes in moderately coarse crystals, but more often encrusting surfaces as very finely crystalline chalcedony, or as non-crystalline opal in vugs and seams. Other gangue minerals are adularia, fluorite, barite, calcite, and gypsum. The quantity of gangue matter is generally small, in some deposits very inconspicuous. The ores in some places, as in Cripple Creek, appear to be little else than country rock with metallic minerals on faces of seams or filling rock pores, with but a small amount of other vein matter. The vein fissures also may be short and irregular or systems of intersecting fractures. This is distinctly the gold-silver zone. There may be a little iron pyrite, but there is generally not much of it. Certain metal compounds are peculiar to this zone, such as the rich tellurides of gold and silver (sylvanite, calaverite, hessite, and the gold-copper telluride goldfieldite), antimony sulphide (stibnite) is found in Cripple Creek and south-central Idaho, as well as mercury sulphide (cinnabar) and bismuth sulphides. Free or native gold, always alloyed with silver, is found in very fine particles in quartz or included in sulphides, and difficult to catch in the gold pan. Residual native and rusty gold is likely to be important in the oxidized ores, as will be explained later. In veins more valuable for silver than for gold, there are complex silver-lead minerals and silver sulphide (argentite).

Mesothermal ores

The main marks of identification of the gold ores of this zone in Idaho are: milky, coarse, crystalline quartz, lime, magnesium and iron carbonates (calcite, dolomite, siderite). There are some unfilled cavities, but less of these than in the low-temperature zone. Veins are likely to be wider and are often of great length and regularity. The quantity of vein matter, especially quartz and other gangue materials, greatly exceeds the amount of these found in ores of the low-temperature zone. The ores contain complex aggregates of various metallic minerals. It is the important base-metal zone. It contains the great majority of the commercial sulphide ores of copper, lead and zinc, in many of which gold and silver are important by-products. Antimony is not generally in the form of stibnite in this zone, but as a sulphide of antimony and copper (tetrahedrite), or of antimony and lead (boulangerite) and in other combinations. Arsenic is found in similar sulphides of arsenic and copper (enargite and tennantite). Important amounts of silver and some gold are contained in these antimony and arsenic minerals. If the deposit is mostly lead sulphide (galena) the by-product is likely to contain more silver and less gold. Silver, though always present in some amount with gold, also occurs separately in a variety of minerals and is a conspicuous product of mines in this zone. All ores of the base metals are usually more valuable for these metals than the associated gold or silver.

Other veins, however, properly to be classed as gold veins and valuable principally for gold may yield a notable amount of copper. Iron as pyrite is

is always present. Gold seems to be a natural companion of iron and copper. So most of the veins primarily valuable for gold in this zone are gold-silver-iron-quartz veins, or gold-silver-iron-copper-quartz veins.

Hypothermal ores

This zone has the following main characteristics: The quartz is coarsely crystalline, compact and generally clear and glassy; gangue minerals peculiar to the zone are feldspar, tourmaline, biotite, hornblende, epidote, garnet, graphite, chlorite; certain metallic minerals such as magnetite, specularite, and ilmenite in gold ores might also be regarded as gangue because they are of no commercial importance. Tin, molybdenum, and tungsten minerals are found in this zone, although tungsten occurs also in other zones. Where any of these exist in quantities sufficient to make an ore, they contain little gold, although it is usually present in some amount. Arsenopyrite, pyrite, and pyrrhotite (magnetic iron sulphide) are the important metallic minerals found with the gold. Particles of gold are enclosed in these and in the vein quartz. Little veinlets of gold, in the best ore, cut across the sulphides and quartz crystals. In such cases, which are common, the vein was cracked and fractured after it was first made and a new generation of gold-bearing solutions flowed through it. This later gold deposition was necessary to make gold ores profitable in many districts. Veins in the same districts not affected by it are too lean to be worked.

Other influences causing downward changes in ores

The downward continuity, or interruption, of any kind of ore is dependent upon many factors besides the temperature zones. Important among these are:

1. Continuity of the same wall rock. Having this, there can be a reasonable expectation that ore will continue downward subject only to zonal changes.
2. Change of country rock. Geologists, by the study of dips and strikes of rock formations, faults and contacts between formations in the vicinity, before mining is carried downward, can often predict whether a vein will cut into or through other formations than that showing at the surface. A change to another wall rock may be beneficial or may make the vein worthless. Soft or pliable rocks like shales or schists yield and adjust themselves to fissuring strains and fissures on them are not likely to be good channels for ore deposition. Harder and stronger rocks that form self-supporting fissure walls and do not crush easily to clay, such as granite, gneiss, many of the volcanic rocks, quartzite, and limestone, supply better channels for circulation and for deposition from ore-forming solutions. A low-temperature vein in volcanic rocks is likely to become poor as it is mined down into underlying sedimentary beds.
3. The amount of erosion that has affected the vein is important and is discussed below:

EROSION OF VEINS

Although apparently slow processes, yet, if given enough time, weathering and erosion do astonishing things. One of the practical results is that low-temperature deposits may have been entirely destroyed and removed. In other

places they have been worn down only a few hundred feet. Although the low-temperature gold ores are among the youngest of vein deposits, yet the time elapsed, since some of them were made, has been 20,000,000 or 30,000,000 years. Hence, if they are in uplifted mountain country, there is a good chance that they have been eroded deeply. In their original form these ores extended 4,000 to 6,000 feet along the dips of veins. If such a deposit shows even an occasional mineral that belongs to the moderate-temperature group, it has been deeply eroded and high-grade gold ore cannot generally be expected to continue far below the surface. In Cripple Creek, at about 3,000 feet depth, base metal sulphides begin to appear and ores assay much less in gold than they did higher up. In some districts there are indications that the moderate-temperature ores may follow in the same vein below the low-temperature zone; as in the Camp Bird vein, San Juan Mountains, Colorado, and certain veins in the Horseshoe Bend - Boise Basin regions, Idaho

Some veins never contained any but ores of the low-temperature zone, as in Goldfield, Nevada. The solutions that made them were not hot enough to bring up the higher-temperature minerals and drop them in the deeper parts of such veins. There was no way to foretell this in workings near the surface. So, if erosion has removed a vein close to the bottom of this zone, very little ore may remain to be mined.

Ores of the mesothermal, or moderate-temperature zone, probably extended before erosion from 5,000 to 10,000 feet along the dips of veins. If a vein is wide, and shows great length at the surface and contains profitable ore with the minerals mentioned as belonging to this zone, with here and there a few minerals of the low-temperature group, it may become an important producer. Then the zone is probably practically intact and can be mined to great depth. There are such veins in south central Idaho. If, on the other hand, occasional high-temperature minerals are found, then very little of the moderate-temperature zone may be left. Such a diagnosis is chiefly useful in the case of ores in which silver minerals and the complex sulphides containing silver constitute the ores. Such ores are not likely to extend downward below the moderate-temperature zone. Therefore, it is important, if possible, to determine how much of this zone has not been eroded and remains to be mined. Mining geologists can in some cases arrive at a good opinion upon this question.

In gold-iron-quartz ores, the determination of position in the zone is less important. It is not serious if one finds he is working near the bottom of the moderate-temperature ores downward into high-temperature gold-quartz-pyrite or simple gold-quartz ores, because the high-temperature ores may also be profitable. Moderate-temperature ores are likely to pass down into high-temperature ores in the same vein. If a prospector finds in a vein ore exposed that belongs near the bottom of the moderate-temperature zone or near the top of the high-temperature zone, it may continue down to great depth. If he finds gold ore in the top of the moderate-temperature zone, he may have a mine that can be worked downward until normal earth heat stops him. This depth in some districts is as little as 3,000 feet; in others, it may be a mile, and in the South African plateau or eastern Canada, mining can be done to as much as a mile and a half below the surface. In the case of high-temperature ores, it is especially desirable to learn, if possible, how deeply erosion has reduced this zone, because below it there will be no commercial gold ores.

Reference has been made to the striking effects of erosion in certain places. In other places, it has done surprisingly little. Some important high-temperature veins are known to have been deposited close to a billion years ago, and one would not expect to find such ancient veins at all. All the

reasons why these ancient veins have not been work away would make a long story, but the principal one is that throughout most of their existence certain areas in which they are found were early reduced approximately to a level, at little elevation above the sea, and were never again lifted into high land where erosion could work deeply upon them. Such ancient veins, thus protected and preserved, are the gold veins of Ontario. Others, equally old, were uplifted with the Appalachian Mountains and have been eroded away "down to their roots." Their gold ores are only remnants and small shoots of formerly more extensive ore bodies. No deep gold mining will ever be done upon such veins.

TELESCOPED VEINS

In some districts, ore was deposited at two or three different times. In such places, after the earliest ores were formed, there has been a long interval of erosion that cut the veins down deeply into the mesothermal zone. Then the circulation of ore solutions was revived and epithermal ore was deposited along openings in the mesothermal ores. Veins containing younger, lower-temperature ore, thus overlapping older, higher-temperature ore, are called telescoped veins. They are, as a general thing, more profitable on account of the repeated deposition in them.

BLIND VEINS

This is the name given by miners to veins that do not extend to the surface. Some blind ore bodies were formed by solutions that encountered barriers on their upward way, such as beds or formations too tight to be passed; other blind veins once appeared at the surface and have since been buried by sedimentary beds (Jerome, Arizona), or by lava beds (parts of the Mother Lode, California). Many such ore bodies have been found, some by accident and a few by geological reasoning. In the great district of Leadville, discovered over fifty years ago, only one minor ore body extended to the surface. The rich, big ones were formed deep in the ground under impervious beds and sills that dammed back the rising ore fluids. These were discovered by sinking shafts at random and driving levels until here and there the miners stumbled upon the ore. Another kind of blind vein is found in Butte, Montana, where rich ores were deposited in certain fault fissures full of clay. Solutions were able, in the time they had to operate before they cooled too much, to work their way upward only to a certain height, by dissolving and replacing the clay with ore. They stopped 500 to 1,000 feet below the present surface. Ores in these have been found at intersections with veins previously discovered or developed by underground work carefully directed by geologists. In other places blind veins are located by drilling.

THE OXIDIZED ZONE

We shall now soon consider the actual things that the prospector must hunt for and find, if he is to open up a mine that contains any of the ores we have been considering. The foregoing discussion, justifies itself because the primary ores of the sulphide zone are, after all, the ultimate objective of the prospector. Upon them the long life of a mine must depend. But they generally cannot themselves be found on the surface, only those things that lead to them by prospecting and mine development.

The ores of the oxidized zone are made from the sulphide ores. When the alteration is complete, they resemble the sulphide ores very little. They may be valuable in themselves or chiefly useful as guides to sulphide ores. In any event they are generally not extensive and are usually found only at and near the surface.

Air is a mixture of oxygen and nitrogen. Its oxygen attacks and combines with most metallic substances and this process is known as oxidation. To learn even roughly how oxides are formed is the best way to understand how they indicate what may be the kinds of more extensive sulphides below.

The sulphides of metals are especially subject to attack by oxygen of the air, which pushes all or part of their sulphide aside and unites itself with the remaining elements in the mineral, forming oxides, if all the sulphur is removed, or sulphates, if part of it remains. The sulphur also combines with oxygen and forms gas. The gas passes into the air or is dissolved in water and washed away. The odor of sulphur gas is usually perceptible around sulphide ore bodies exposed to the air underground. Most of the oxidized compounds of the metals are soluble, and are also carried away from the veins. This is called leaching. The oxide of iron is exceptional and a large part of it remains with the vein.

At and near the top of many veins there are deposits of iron oxide (limonite), powdery or solid, and everything near at hand is more or less stained bright yellow, brown, or red, by the various iron pigments. The iron oxides in and around the top of a vein form the "iron capping," so useful in the search for ores. It is called "iron hat" by the Germans, "gossan" by the Cornish,

and various names having the same meaning in other languages. The iron oxides and the accompanying quartz will contain gold if it is a gold vein in the sulphide zone. If no gold is found in the iron capping, gold is not to be expected deeper in the vein in the sulphide zone.

Some gold veins of moderate-temperature origin have black outcrops where the primary sulphide zone contained manganese minerals, rhodochrosite (the carbonate) and rhodonite (the silicate). The black manganese oxide acts somewhat like iron, is not easily soluble, so clings around the tops of veins.

Another kind of iron stain is due to the weathering of iron-bearing minerals of certain country rocks, especially some of the lavas and porphyrids. This iron stain often looks like vein gossan, but by experience it will be recognized that it is mixed with earthy clay, is generally only a stain with no solid iron oxide, such as is found in gossans. Also, of course, it does not contain vein quartz or other vein minerals.

Quartz resists effects of air and water. Many ores, which underground are made up of bright, shiny, metallic minerals with quartz and other gangue, show at the surface only the iron-stained quartz skeleton, with many cavities where once were sulphides. This is "honey-comb" quartz. The quartz may have become so porous that it has collapsed to sandy "sugar quartz," from the pressure of the vein walls. These two kinds of surface quartz may themselves be rich oxide gold ores, easy to mine, and under them at some depth there is likely to be good sulphide ore.

Weathering is a term much used to include all the effects of air, water, heat and cold; in fact, every influence that affects rocks and ores on the earth's surface. So intense has been the disintegration by weathering, and so striking the "burned" appearance produced by oxidation on some outcrops, that the idea prevails among miners that they have been ejected violently from the hot interior of the earth. They are called "blow-outs," although they are really caused only by exposure to the weather. Such conspicuous effects may indicate a specially promising part of a vein.

THE ZONES OF UNDERGROUND WATER GATHERED FROM THE SURFACE

Water that falls as rain, or melts from snow, sinks, if it can, into the soil and the rocks below. If enough water falls on the surface, part of it percolates downward to make an underground water body, generally called ground water, filling at some depth all the cracks and pores in the rocks, as we find it in wells. The top of this body is called "water level," a bad name because it is seldom level. A better one is used by geologists, the water table.

The gathering zone

All the zone above the water table is called the gathering zone where water is accumulated and carried down to the underground storage. This zone, most of the time, is filled only with air and moisture, but during a storm, and for a time afterward, descending water passes through it. The gathering zone is also the zone of weathering. In it vein sulphides are attacked and oxidized, and these oxidation products (oxides and sulphates) are leached out as they are at the surface. Some of these compounds are carried down to the water table in solution and come out in springs and seepages; some are left in the veins. In copper veins important additions are made to the copper ores just below the water table. Here copper as sulphate is re-deposited as sulphide when a solution of it comes in contact with sulphide minerals. This newly deposited ore is called a secondary sulphide. This is secondary sulphide enrichment of veins. In a gold-copper vein, it may make important copper ores at the water table and just below it, because of the addition of copper, but the gold is very little affected.

Because few things can dissolve it, gold near the surface in veins has the habit of remaining in much the same place it occupied before the sulphides were oxidized. Some of it is, of course, carried away by flowing surface water to make placers, but only as the outcrop of the vein is completely destroyed and scattered down the slopes. The gold just below the surface remains in the vein. It may be washed down the vein by water for short distances along open passages.

Secondary gold enrichment

Gold veins may become decidedly richer in the zone of weathering by the oxidation and removal of worthless material, quantities of heavy iron pyrite for example, thus reducing the volume and weight of vein matter containing the gold. In extreme cases three tons may have been reduced to one, thus enriching ore that was worth, say \$10.00 in gold as sulphide ore to \$30.00 a ton as oxidized ore. On account of all the influences of weathering, it is safe to expect that the oxidized gold and silver ores in a vein will be richer right near the surface than they are a moderate distance below, largely on account of the removal of waste and not by the addition of gold and silver.

Since so many substances are taken into solution and so few are left around the tops of veins, the weathering zone is also named the zone of solution or of leaching.

The zone of circulation and discharge

In this there is circulating ground water. It circulates because there are outlets to the surface, perhaps a long way off, toward which it slowly flows. This zone is important because in it all secondary downward enrichment of the sulphide ores of the base metals is done, but in gold veins this is generally of little importance.

Oxidation is found somewhat below the water table because fresh water is regularly added to it with some entrapped air; also because the water table changes with seasons and rain cycles, and rises at times into the zone of weathering. Various kinds of minerals, besides the metals, are deposited in this zone. For instance, some weathered rock minerals in solution are carried down into it and re-deposited in pores and spaces. So the zone is sometimes called the zone of cementation.

The Stagnant zone

Below the lowest point at which water can escape back to the surface by springs or seepage, there is no reason for it to flow and it is at rest in the vein. The ground waters in this stagnant zone accomplish very little, if anything, in changing the sulphide ores. The free oxygen in the water is used up in the zones before it enters the stagnant zone, so the sulphides in it are not oxidized. There is a bottom to this stagnant water body and below it rocks and veins are dry. There were conceptions in the past among geologists - some argue for them now - that water from the surface reaches down practically indefinitely, or so far as ore deposits go, but deep mines have proved the contrary, and these ideas are now generally abandoned. The rocks are usually dry, except along open passages, below a thousand feet, at less depth in many regions.

Figure 5 illustrates the ground water zones just discussed.

DEPTH OF OXIDATION

Most known veins have been eroded down into the original or primary sulphide zone. In humid climates the water table and the sulphide ores may be close to the surface, also in the great plains where ground water has little opportunity to discharge and lower itself. In mountainous mining regions there is generally a considerable zone of oxidation or weathering beneath the summits and high slopes of mountains and mountain ridges, but very little in valley bottoms where the water table comes to the surface or near it.

In dry or desert climates the water table is deep, or does not exist at all. Oxidation may extend downward irregularly several hundred feet, or along open passage ways in veins to 2,000 or 3,000 feet. The water along such passages is only temporary. The main mass of the vein may remain dry, because the infrequent rain water does not soak into it, neither does air circulate in it; therefore, oxidation is shallow.

If an ore deposit does not extend up to the surface, it may not, of course, be oxidized anywhere. On the contrary, in known cases veins were exposed at the surface and had a normal zone of oxidation in past geologic ages, and were afterward buried by volcanic or sedimentary formations, so that oxidized ores now stand well below the present water table.

In the hot, wet climates of tropical countries, weathering is relatively rapid and at the same time not deep because the water table is high. It is rapid and exceptionally deep in tropical deserts. In polar and northern latitudes, it is very slow and oxidation products may be eroded as they are made. Glaciers stripped off most of the oxidized tops of veins in the northernmost states and over all of Canada. In the 25,000 years or more, since the great continental ice sheet laid bare the sulphides in Canadian veins, they have been oxidized only a few inches from the surface.

GOLD VEIN OUTCROPS

The outcrop, or "copping" is the top of the vein. Its legal name is the "apex." Geologists use the word "outcrop" to mean veins or rocks that project and are actually visible at the surface. The top or apex of the vein, where it is solid or in place, is generally buried by soil or mountain-side slide rock. That is why they are hard to find and why the art of prospecting is necessary.

There may be suggestions of the presence of a vein in topographic or ground surface forms. Some veins, made up mostly of quartz and other minerals that do not yield readily to weathering, are harder to erode than the country rock, and therefore stand above the general surface. These may be covered with soil and loose rock yet form a slight ridge or series of low humps. Other veins, that contain less resistant minerals, or fault clay, or have had abundant sulphides weathered out from them, may collapse or be easier to wash away at their tops than is the country rock. Veins like these may be marked by slight depressions. It happens then, that in crossing an elevated area where overburden is thin, a vein may either stand up above the ground or form a notch or saddle. Hard and soft rock formations standing on edge show the same effects, but where the country rock is a single formation in the district, veins, if of good size, may be clearly indicated in the topography, although buried under considerable overburden.

Belts of iron-stain colors in the soil or wash of low-lying areas may be caused by scattered small particles of iron gossan or capping, and indicate a concealed outcrop.

It was recognized as early as the 15th century, and prospectors in the western states have noticed it also, that some large veins encourage or discourage certain kinds of vegetation, particularly trees, because their disintegrated outcrops make a soil unlike that derived from the country rock. This is occasionally a helpful sign. A strip of different trees, as aspens in a pine forest, or trees smaller or larger than usual, may indicate a vein beneath. However, it may be only a dike or some rock formation unlike the prevailing country rock, or a barren fissure that serves as a water course.

The indications of veins often follow crooked courses on account of the shape of the surface. This will be the case even if the vein itself is straight and regular, but the surface rough and irregular. Figures 1 and 2 show some of the reasons for this.

The dip of the vein where first uncovered may not be its real dip, but at the top may seem to be in a direction opposite to that to be expected from the course of the outcrop. On any hill slope, especially if the country rock is shaly or easily weathered, or thin-bedded and standing on edge, and to some extent whatever the wall rock may be, the top of the vein will be found bent down hill, as shown in Figure 3. The true dip will appear when it is followed down into solid bed rock.

TRACING FLOAT

Buried or mantled outcrops usually can be found only by tracing fragments that came from them. These fragments are float. To learn the kinds of vein float, study exposed outcrops of veins already discovered. Figure 3 shows how float washes down a hill with other loose weathered rock material. Obviously all float will be found below the outcrop where it is moved by storm water or the run-off from melting snow. Much material may be brought down from above the outcrop and may bury it deeply, also cover all float for some distance below the

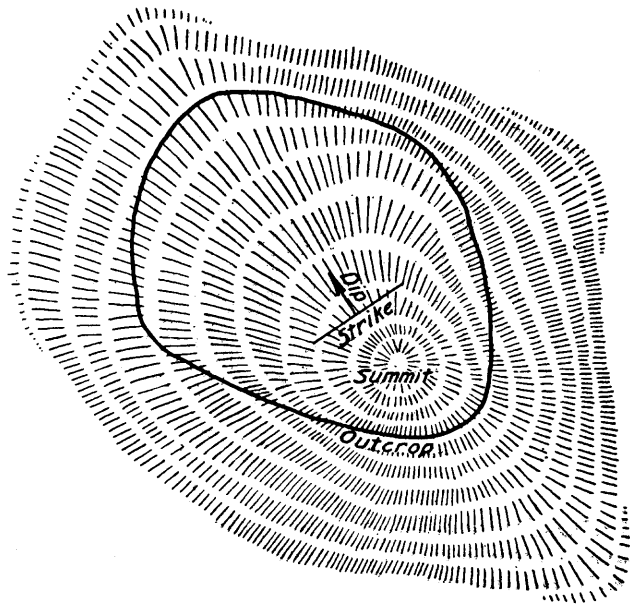


Fig. 1 Showing a vein of straight strike and regular flat dip, so eroded that the remnant left cuts thru a steep mountain and outcrops on all sides of it.

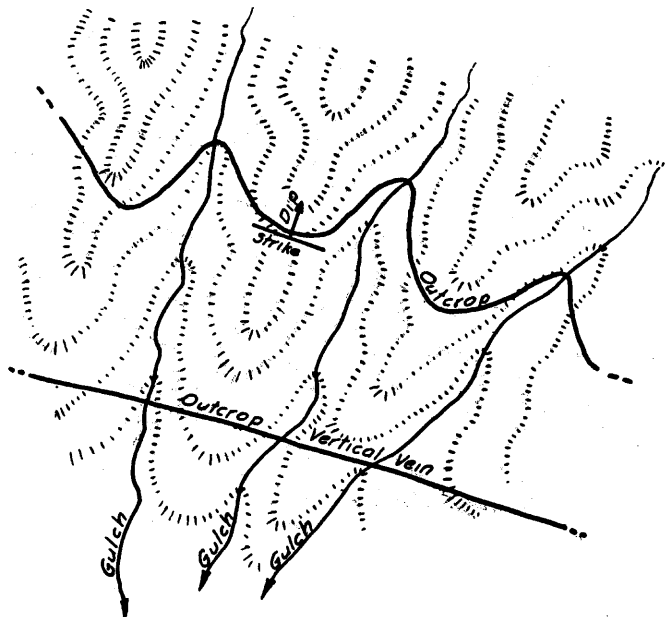


Fig. 2- Showing that a straight regular vein with a decided dip crosses ridges and gutches in a very crooked course, while a vein with a vertical (90°) dip courses across them in a straight line

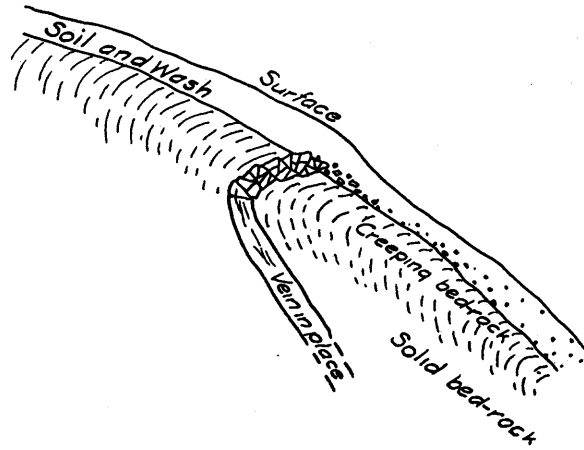


Fig. 3- Showing the effect of bending the vein downhill by downward creep of loosened, somewhat weathered, bed-rock on steep hillsides near the surface

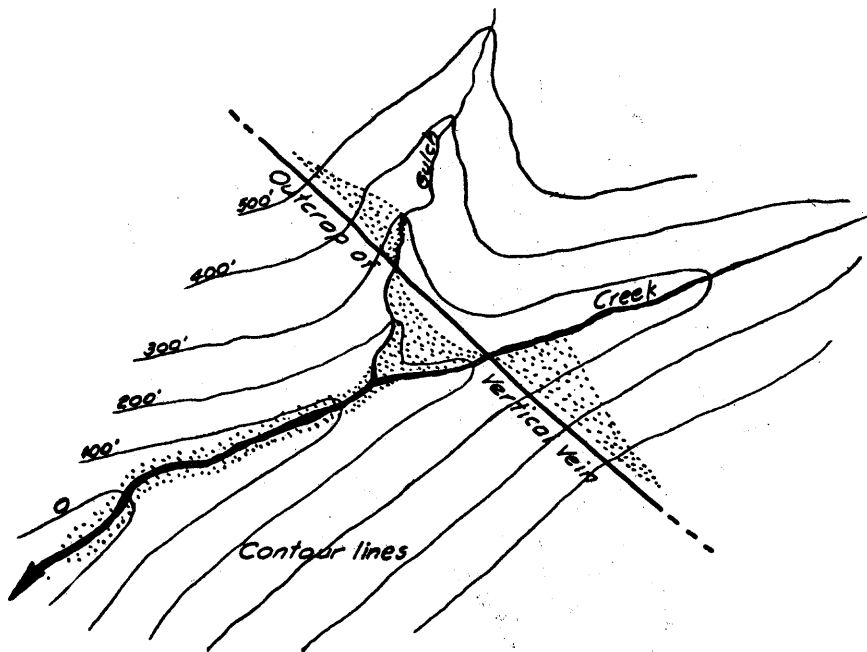


Fig. 4- Dotted areas are those where float from the vein may be found or gold may show in the pan.

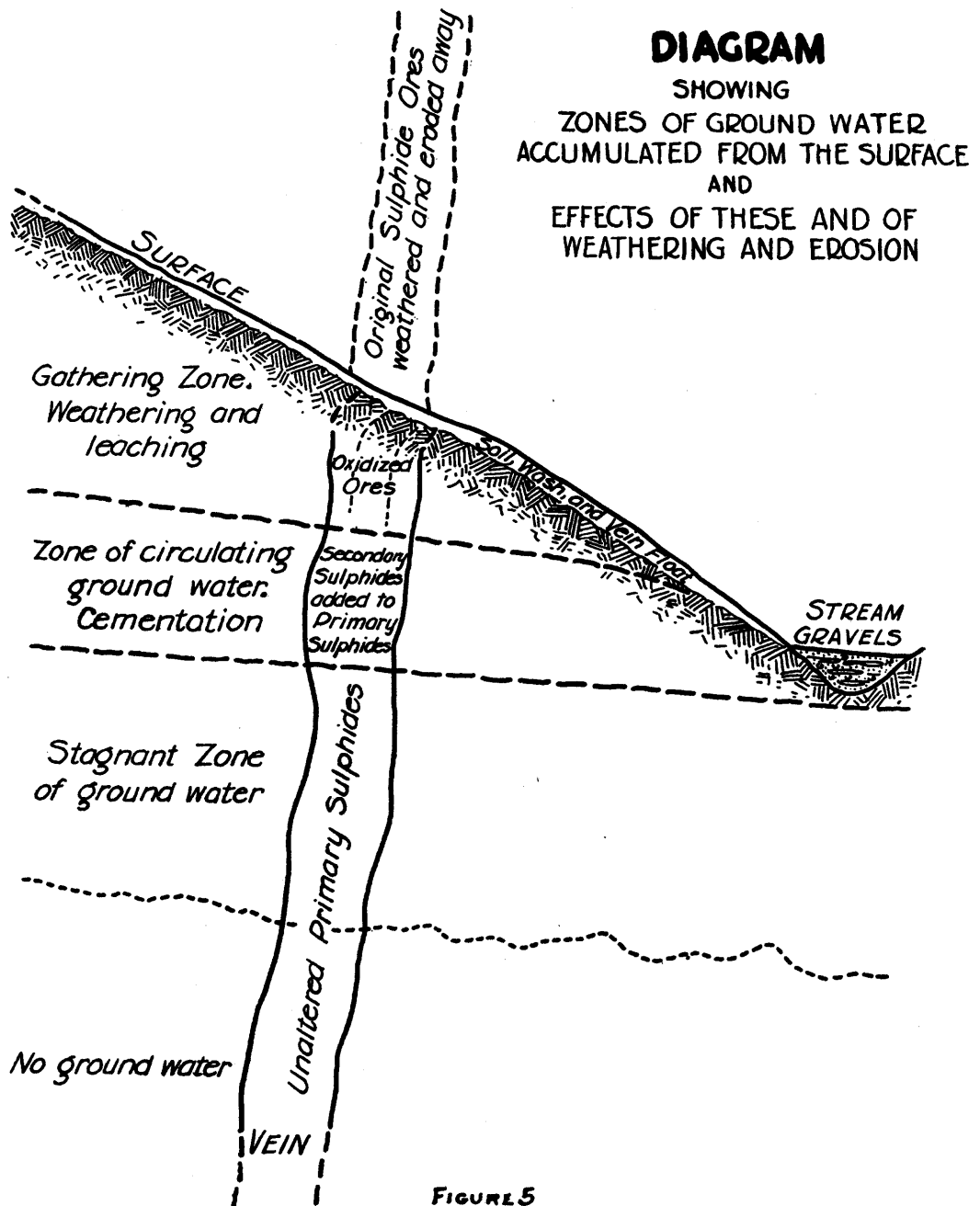


FIGURE 5

outcrop. At some place, down hill, however, float fragments should show on the surface and still more of them be found by a little digging below the surface into the soil. Float on the surface should increase in amount and size of fragments up hill toward the outcrop until a point is reached where it is no longer found. Then a trench should be dug extending up the hillside. It may be shallow so long as it shows float, but where float is found only in the bottom of the soil or wash, it should be deepened to bed rock and carried uphill until the top of the vein is uncovered. On a level surface float may appear in a broad belt and the vein should be found by trenching across the middle of the belt. If the float that is being traced does not show gold when crushed and panned, it may be a waste of time to follow it up to an outcrop.

Tracing float may often be puzzling. It is possible to trace it first on one side than on the other of a vein on different slopes in a hilly country cut by many valleys and gulches. Figure 4 shows such conditions. Contours in this sketch are level lines. Float is carried down a slope squarely across these because that is the direction taken by run-off water.

The gold pan

The gold pan should be used along with the tracing of float. In many places where no quartz float is found, the soil shows the kind of iron fragments and stain that come from vein outcrops. Dumps from the holes of gophers and other burrowing creatures may show float which does not appear elsewhere on the surface. Chunks of quartz float, or samples from the vein after it is found, should be crushed with mortar and pestle and panned. For directions in handling the pan, see Pamphlet No. 35 of this bureau.

Smaller gulches that have not been occupied by glaciers are well worth panning up-stream in the hunt for a vein. Colors of gold may first show up, then float farther up, then still higher both may stop. Then it is time to turn aside and prospect up the hill slopes. (See Figure 4.)

Samples may be packed down the hill and panned in a stream, or a half-barrel or washtub may be placed on the hillside and occasionally filled by buckets when the water becomes too muddy. By the latter method the location of samples is kept clearer in mind, unless the prospector sets stakes and maps the points where he has taken samples that contained gold, as he worked up the hill. Cases are reported of important discoveries which the prospector could not find again at a later date after he had left them, because he had not made an accurate record of their location.

Some exceptional conditions in tracing float.

1. In rugged mountains, there are snow slides (avalanches) that carry down the wash and loose rock with them, sometimes stripping bed-rock bare. These materials, along with uprooted trees and rubbish, are found in summer piled up wherever the slide stopped. These should be recognized and little attention paid to float in them, but the track of the slide up the mountainside may be a good place to look for exposed outcrops.
2. There are also land slides, rock streams, and mud flows, often great masses of loose surface material that, when water-soaked by rains flow down hills and gulches. Float in this material where it came to rest is of no particular use as a guide to the location of a vein, except that it indicates a vein somewhere in the path followed

by the moving material, or above it. If bed-rock has been left exposed along the path of the flow or slide, it should be inspected for a possible uncovered outcrop. Float in the rock flow may have been brought down into the soil and wash of the surface from higher points before the flow took place.

3. Rounded and water-worn float in the gravels of large streams generally will not lead to the outcrop from which it came. Such float may have traveled scores of miles. But, although float in main stream channels is useless for finding the vein from which it has come, panning may show the gravel to be a profitable placer deposit.
4. Glacial till or drift and outwash gravels have been mentioned. Generally float in them is far removed from its outcrops. In Nova Scotia, where drift of the continental glacier is comparatively thin, engineers have found veins by carefully surveying and mapping float localities, determining direction of ice movement by marks on the bed-rock, and thereby guessing the localities of veins fairly accurately, but these methods are too elaborate for ordinary prospecting and too expensive to carry out. Small local mountain glaciers, however, extended down gulches in many places in the high western mountain ranges, south of the continental ice sheet. Float in moraines and out-wash from such glaciers shows that there were vein materials on the ridges where the glaciers had their heads.

SURFACE ORES

If the gold ore found in the outcrop is a weathered low-temperature deposit, high-grade ore may begin at the surface and continue downward into the sulphide zone and be rich there also. This is especially the case in telluride districts, such as Cripple Creek, Colorado. In the outcrops of gold telluride veins, tellurium has been oxidized and carried away as sulphur is from the sulphides, leaving, where the tellurides had been, a brown or powdery residue called "rusty gold," that is easily overlooked. Such gold is difficult to catch in a gold pan and does not combine with mercury (amalgamate). No placers are found in the streams heading in telluride districts, although outcrop ores may be very rich. The powdery gold is too light to settle in flowing water. Gold selenides have been found in Idaho and a selenide vein should weather and exhibit surface ores similar in character to those in telluride veins. Assays are necessary to determine the amount of gold in them.

In certain cases, as already suggested, gold may be concentrated in the oxidized ores near the surface. This is especially true of the sulphide veins (especially of copper) that yield soluble oxides, leaving the associated gold in the zone of weathering. For this reason, there may be gold ores for a short distance down the dip in veins that are not found to be primarily gold veins in the sulphide zone. The great United Verde copper mine in Arizona, at its outcrop was a profitable desert gold mine. Senator W. A. Clark bought it when its owners were working it for gold. He was an experienced prospector, found a great amount of iron capping around the surface, "honey-comb" and "sugar" quartz, occasional flecks of copper stains, and, in the deeper gold workings, seams of secondary copper sulphide, clear signs of a copper deposit below. In the sulphide zone in this mine, gold is an unimportant by-product.

FAVORABLE AND UNFAVORABLE CONDITIONS FOR GOLD ORES

Gold deposits of commercial value are rare. This is the reason why gold is a precious metal. A very large part of the earth's surface can be blocked off and dismissed as unpromising for gold discovery.

Unfavorable conditions

1. Vast regions like the great plains of this and other countries can be dropped from consideration as prospecting territory, because in them there has been no igneous activity.
2. There are certain other large areas where the combination of proper conditions is lacking, as in the Colorado Plateau 1/ occupying western Colorado, the southeastern half of Utah, northeastern Arizona, and northwest New Mexico.
3. Limestone regions usually are not favorable areas for gold prospecting, but may contain important deposits of base metals and silver, if there are intruded igneous rocks in the vicinity.
4. Excessive erosion since veins were formed may have (a) destroyed and removed bonanza low-temperature ores, (b) worn away all ores of every kind, (c) may have lowered the top of the vein from a rich zone into a lean one.

Favorable conditions

1. Igneous rocks must be somewhere near at hand. They may not show at the surface and only a geologist would suspect their existence below it, or they may appear as large, coarsely crystalline bodies (batholiths and stocks), or as dikes, or local bodies of volcanic rocks.
2. Other rocks besides the igneous rocks are also important; in other words, rocks that were there before these and were intruded or invaded by them, for it is in the favorable invaded formations that a great many ore deposits are found. Although some fissures have formed in batholiths and stocks after they became solid, a much greater number extend upward or outward from the igneous masses into the older overlying and surrounding formations. These, if they were the right kinds of rocks, afforded favorable channels for deposition from ore solutions.
3. A small amount of erosion since veins were formed is quite sure to be important. Most rich, low-temperature deposits were deposited comparatively near the surface when they were formed. If the surface has been lowered 5,000 feet or more, there may be little left of them. Erosion has been deep in great valleys and canyons of south central Idaho and has not been great in some cases on high ridges and plateaus, since low-temperature ores were made. The extent of erosion is a less critical consideration in the case of moderate-temperature gold deposits, as has already been explained.
4. The extensions of the Rocky Mountain, Coast, and Cascade ranges in Canada and Alaska contain many large unexplored areas where locally all conditions are right for ore deposits. The glaciers have laid some outcrops here and have covered others with drift. Growths of forest and tundra, the short prospecting season, and the remoteness of likely districts from civilization are real handicaps, but, for men of fortitude, these are good fields for exploration.

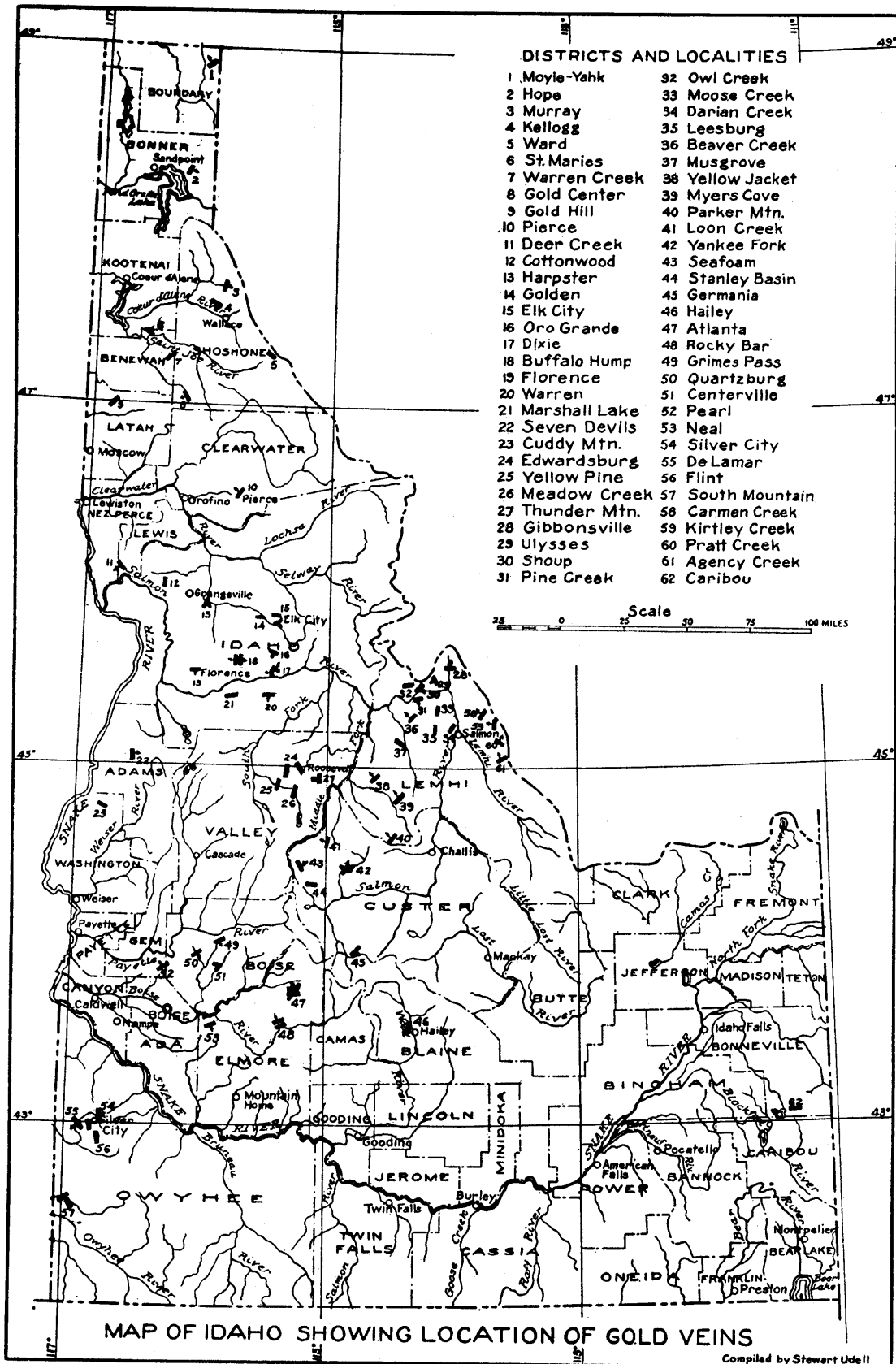
1/ Butler, B. S., Colorado Scientific Society, Proceedings, Vol. 12

5. Although they have been pretty thoroughly prospected, the mountains of Colorado, Utah, Arizona, Nevada, New Mexico, (around the margins of the Colorado Plateau), California, Washington, and Oregon, no doubt contain undiscovered gold veins concealed by drift, wash and slide rock. Very thorough, intelligent prospecting, guided by the fine geological field studies and mapping that have been done lately in Colorado, should be carried on in other states. Gold discoveries will probably result from them.

6. Of greatest interest to the people of Idaho is the excellent field for prospecting in the central regions of the state, so these will be discussed more at length.

PROSPECTS OF GOLD DISCOVERY IN IDAHO

In general, there are present in many places in central Idaho practically all the conditions that have been described in this pamphlet as responsible for gold deposits. The map herewith _____



shows localities where gold was found and produced in some quantity from veins. Districts that have produced gold from placers are indicated on another map in Pamphlet 35, cited above.

IGNEOUS EPOCHS AND GOLD DEPOSITS

In Idaho is one of the world's greatest batholiths. It is now exposed by erosion over large areas, but locally it is still covered by bodies of rock that are remnants of old sedimentary and metamorphic formations invaded by it. One striking effect of the batholith has been the intense alteration of the rocks adjacent to it. A banded rock, made up of thin layers of old metamorphic sedimentary beds with narrow bands of granitic magma injected between them, has been named "injection gneiss." There is so much of this that the rocks immediately overlying the batholith have been grouped under the name "the gneissic shell," although this shell contains other metamorphic rocks such as quartzite, slate, schist, altered limestone, and marble. The gneiss was favorable to the formation of suitable fissures for the circulation of ore solutions. In it gold veins are generally more prevalent than in the other rocks of the shell, or cover, or in the granitic rock of the batholith.

The tendency from recent study by Idaho and Montana geologists is to fix the age of the Idaho batholith at a time around the beginning of the Tertiary period. Until the past few years it has been regarded as much older than that. The next igneous epoch came around the early part of the Miocene in the middle of the Tertiary period. Whatever the age of the batholith, there was a great lapse of time between the batholith invasion and this later epoch.

Two-thirds of Idaho was uplifted at the time when the batholith came in beneath it. In the long interval before the Miocene, it was first a high mountain area, then was reduced to a region of low elevation and small relief as a result of removal by erosion of many thousands of feet of the batholith cover. If gold veins were deposited in the cover rocks by solutions from the batholith magma, they were mostly destroyed and removed in this long period of uplift and erosion.

The Miocene igneous activity was widespread in Idaho, and in other Rocky Mountain states. There were volcanic extrusions of rhyolite and andesite, as around Thunder Mountain, in western Custer County, in Owyhee County, and other parts of south-central Idaho.

In several epochs, contemporaneous with and later than the volcanic extrusions, there were intrusions of light colored porphyries and local granitic stocks. After these intrusions, and after their related gold deposits had been formed, dark colored, basic dikes (lamprophyres, etc.) were intruded in the same areas, commonly in and along the veins. Still later, from time to time almost to the present (as at the Craters of the Moon), basaltic lavas have continued to be poured over the surface in many localities. No gold deposits are related to, or likely to be found, in these younger lavas.

Most of the known gold veins of central Idaho were regarded for many years as having an origin connected with the batholith intrusion. The more detailed geological field study now being done throws doubt upon this. It is possible that the great majority of the veins will be accounted for as originating from the Miocene magmas that solidified in two or three separate epochs as the light colored intrusive and extrusive rocks.

Not having been formed at one time or from the same magmas, and having been variously affected by erosion since they were made, the gold deposits differ

considerably. Some have been eroded down into the mesothermal zones; others only into the epithermal zone. There is a wide difference in the amount of associated silver and base-metal minerals, and in the abundance of gangue.

NORTH-CENTRAL IDAHO

North-central Idaho is taken to include Clearwater County and that part of Idaho County north of the Salmon River. The most important gold veins are in the gneissic rocks, particularly at Pierde, Elk City, Buffalo Hump, Dixie, and Florence. Gold valued at about \$60,000,000 has been produced from both veins and placers in this part of the state. The veins dip steeply and generally strike across the gneissic structure. These and other characteristics will be described by Messrs. P. J. Shenon and John C. Reed in their forthcoming report upon the Elk City-Buffalo Hump region. Most of the veins are of considerable length, but are irregular in width. Commercial ore is mostly in local shoots that follow the swells in the veins. In the granitic rock of the batholith, the veins, or lodes, are in shear zones and consist of more or less parallel interconnecting, narrow, quartz-filled seams.

The primary ores are chiefly gold-bearing iron pyrite scattered irregularly in quartz gangue. In most of the veins, along with the pyrite, occasional crystals of other sulphides are visible (galena, sphalerite, chalcopyrite). In some of the best ores these are microscopic in size and appear only as bluish bands and irregular blotches in the quartz. These contain much of the gold. Many veins are composed mostly of barren quartz (so-called "bull quartz"). The profitable ores are in those parts of veins in which the quartz has been shattered by earth movements, and the cracks filled with younger quartz, sulphides and gold. The undisturbed older quartz is coarse-textured, clear or milky, in places showing comb structure, i. e., quartz vein filling in which the crystals project from the walls across a fissure opening. Native gold is generally seen only in the oxidized ores, although it probably exists deeper in the veins in nearly the same amount, but concealed in the sulphides.

The veins so far discovered in north-central Idaho are mesothermal. Naturally, bonanza bodies are absent, although local small shoots have yielded \$20.00 or more per ton. So far as known, \$3.00 to \$15.00 per ton has been recovered from ore mined and milled in the past.^{1/} Oxidized and partly oxidized ores were supposed to be somewhat richer than sulphide ores, but this impression may be a result of the higher extraction of gold from oxidized ores in the stamp mills of former times. Present-day milling methods can save a high percentage of the gold from both sulphide and oxidized ores, as has been determined in the laboratory of this bureau.

SOUTH-CENTRAL IDAHO

South-central Idaho includes Valley County, adjoining parts of Lemhi, Custer, and Boise counties, southeastern Gem County, and the northerly parts of Blaine and Elmore counties. In eastern Valley and western Custer counties, there are large areas of Miocene volcanic rocks. Later there were dike and stock intrusions. In other areas the igneous rocks of this time were mostly intrusive. The Miocene intrusions were local, yet they are found in a considerable number of places not far apart. This suggests that they came from quite an extensive, but deeply buried, magma reservoir. The larger intrusives (stocks), unlike the batholith, did not greatly alter the invaded rocks and formed no conspicuous gneissic shells.

^{1/} Thomson, F. A., and Ballard, S. M., Geology and gold resources of north-central Idaho, Bull. No. 7, Idaho Bureau of Mines and Geology.

Gold veins in the volcanic territory are epithermal. Southwestward in Boise County, where erosion has been deeper, the majority are mesothermal. In Gem County (Pearl district), they are mesothermal, but some border on the epithermal. The best ore is in shoots where the country rock, along zones of shearing and fissuring, was more than usually cracked and shattered.

The fissures, shear zones, and the intrusive and extensive rocks appear to be arranged in a broad elongated structural area extending from western Lemhi County and eastern Valley County southwest to Gem County. The porphyry dikes and gold veins are in general alignment with the direction of this belt. The country rocks may be any of the older sedimentary formations, the metamorphic sediments, the granitic rocks of the batholith, or the volcanic flows and tuffs. The gold ores of the volcanics contain little silver, but those in the other parts of the belt may have important amounts of silver.

In some gold deposits of the volcanic area, the eye has difficulty in distinguishing mineralized from unmineralized rock. Fissuring may be obscure. The ore may be (1) wide-spread and lying flat in particular beds of lava or tuff, as at Thunder Mountain, (2) the ore may be fine-grained, thin quartz seams, filling simple or complex fractures. Some of the gold is in the form of a selenide. In the vicinity of some of the ore bodies the rocks were somewhat bleached by the hot ore solutions. This may be an aid in prospecting. Generally there is so little to aid the eye that the gold pan and assays are necessary in finding veins.

Underground developments at Meadow Creek near Yellow Pine disclose important bodies of low-temperature gold ore, with stibnite, arsenopyrite and other sulphides, and little gangue, in seams and replacements of country rock along a broad lode. Just north of Meadow Creek are cinnabar (quicksilver) veins containing some gold.

In the high Salmon River Mountain region of Valley County the surface has not been greatly reduced by erosion since the epithermal ores were deposited. Remnants of flat erosion areas that may have been land surfaces, at about the same time the ores were being formed, may be seen on high ridges and plateaus.

Outside the volcanic areas, as in Atlanta, Boise Basin, Pearl, and other districts in the southwest half of the mineral belt, the mesothermal veins show mineralization for several hundred, even thousands, of feet along their strikes. The light-colored porphyry dikes with which the veins are structurally and genetically associated, are probably of the same age as those of the eruption area. The veins contain more gangue, although not large amounts, quartz, calcite, dolomite, barite; also sulphide minerals, galena, chalcopyrite, tetrahedrite, some ruby silver, and locally bismuth minerals. Usually fine gold can be found by panning. Deeper developments in the past few years in the Boise Basin and at Atlanta, on which there is little published information, have shown that there is no secondary gold in the veins near the surface, and that the sulphide ore shoots yield a good profit. Detailed study of Boise Basin is now being carried on by Dr. Alfred L. Anderson for the U.S. Geological Survey and this bureau and a preliminary report is in preparation. A short report by Mr. Clyde P. Ross (Bulletin 846-d) has been published this year (1934) by the U.S. Geological Survey.

OTHER GOLD DISTRICTS

Ores in the Silver City and Delamar districts, Owyhee County, are of the same age as those of the mineral belt just discussed. They are in a volcanic

area that is in alignment with the mineral belt just described, but on the south side of the Snake River Plain these districts have produced an important amount of gold, although they are chiefly famous for their silver.

Considerable gold has been found in placers around Mount Caribou, Bonneville County. There are also gold veins in this district, but they have not had much development.

The Murray district, Shoshone County, is on the northerly border of the great Coeur d'Alene lead-zinc-silver area. There has been a good production from placers in the past. Successful operations are now being conducted on small, but rich, gold veins.

NATIONAL FORESTS

Prospecting may be done in the national forests as on other government land. Forest officials will be found to be obliging and helpful if regulations for fire protection and other reasonable rules are observed.

THE VALUE OF GOLD

The value of gold was formerly fixed at the United States Mint as \$20.67 a troy ounce. The government now pays \$35.00 an ounce for newly-mined gold. Good ore under favorable operating conditions contains 1/15,000 or less of gold by weight, at present price. Therefore, it is not to be expected that it will be visible to the naked eye in ordinary ore. Discovery, development, and mining of gold ore has to be guided by the gold pan, by assaying, or by the appearance of the vein, or by the presence of some significant mineral that accompanies the best ore. One should not be excited over a color of gold because the gold pan is really surprisingly successful in catching gold worth only a few cents per ton of material. This is because gold is so very heavy. Fine specks of gold are "colors." They may be so fine that as many as 2,000 are required to be worth one cent. One cubic inch of gold weighs 10.17 troy ounces, and is now worth about \$356.00. A cubic foot of gold weighs 1184.7 pounds avoirdupois and a cube measuring 15½ inches in each dimension weighs about one ton.

FOOL'S GOLD

Bright iron pyrite and yellow flakes of mica are mistaken for gold by the inexperienced, and are sometimes called "fool's gold." A prospector soon learns to distinguish them under the magnifying glass or by their lighter weight and behavior in the gold pan. Pyrite can be easily crushed to a powder. Gold is malleable and is not crushed if pressed or hammered. A knife blade will cut a bright yellow mark on gold; on pyrite and mica, it leaves a powdery streak.

THE FIRE ASSAY

The fire assay for gold makes a complete recovery of it. There are no mysterious or secret methods that can really get any more gold from a sample than does the fire assay. Fraudulent promotions of processes represented to recover more gold than is shown by assay still continue to be attempted.

WHAT TO DO WITH A VEIN WHEN IT IS FOUND

If it is discovered on the public domain, i.e., land owned by the U. S. Government, a discovery monument should be erected at once, and a notice of location posted on the monument. A discovery shaft or tunnel should then be dug

to a depth or distance of ten feet from the surface. The notice can be very simple, printed upon the face of the post used for discovery monument, or written on paper and put into a tin can for protection against weather and fastened to the monument. Printed forms may be bought at newspaper offices and stationery stores in mining regions, but the written notice will hold the claim. The notice should read something like the following:

"I (or we) hereby locate and claim the Bonanza (or any name selected) lode, running in a course of --- (whatever direction the compass shows), --- feet, from the discovery monument and --- (in the opposite compass direction), --- feet and 300 feet on each side of the lode line. The discovery monument bears --- (compass direction) feet from (a section corner or some permanent natural object)." Dated. (Signed) Locator or locators.

Distances can be measured with a tape or paced. The distances from the discovery each way along the assumed course of the vein must not total over 1,500 feet. The discovery is, of course, on the vein or lode line which is supposed to be the course of the more or less concealed vein on the surface. This line extends along the middle of the claim. The discovery may be anywhere between the two ends. Soon after discovery, the corners of the claim should be marked by posts standing three feet above ground or by rock monuments of the same height. The end-lines of the claim should be parallel or the locator will not secure with the claim the right to follow the vein beyond his side-lines on its dip, under the so-called "Apex" or extralateral law. A vein outcrop is likely to be crooked so that it may be necessary to make bends or angles in the side-lines of the claim. If so, place monuments at these points. Within 90 days, file with the recorder of the district, or the nearest branch of the U. S. Land Office, a notice of location, giving the same information as that shown on the location notice. The locator now owns the claim so long as he does \$100 worth of work on it each year, before July 1st, in developing the vein or improving the property, and files affidavit that he has done this work, or paid this amount of money for wages to employees who have done the work for him.

Patent is desirable whenever the claim is found to be valuable. Patent is a deed from the government which is generally safe from attack. Details of this and other legal procedure may be obtained from a pamphlet "Mining Laws of Idaho," issued by the State Inspector of Mines, State Capitol Building, Boise, Idaho, or a bulletin, "Mining Laws," published by the State Mineralogist of California, Ferry Building, San Francisco, California. (Price, \$2.00).

Development

In the first stages of development, it is wise to stay with the ore in incline shafts and drifts following the vein, and in whatever underground workings that are made, however crooked they may be. The time for more economically designed workings will come later, after the shape of the ore body has been shown.

The prospector should uncover his outcrop at a number of points by pits or benches, then sink a prospect shaft on the dip of his vein at the place of best surface showing, because the ore may lie in the vein in well defined bodies or "shoots." Most veins cannot make profitable production at the start, none really except bonanzas. Work without mining machinery is slow and expensive. Ore may have to be shipped on pack animals. It is advisable to ship out some of the best ore, if panning and assay indicate that it has good value, even though it may not pay all expenses. One or two shipments and sufficient openings on the

vein, to indicate the position of an ore shoot and enable it to be inspected satisfactorily and sampled by others, may be so convincing that money can be raised to procure efficient mining machinery to go deeper in the vein, drive levels, and prove whether the ore continues as an important body. After that, if it does promise a good tonnage, there will be no trouble to sell the mine, or get cash for a part interest, and continue to hold a substantial share in it.

Terms with financiers

Development and final equipment, after discovery of a promising ore body, run into large sums of money. Before beginning to make a profit from a good gold vein, anywhere from \$50,000 to \$250,000 may have to be spent upon it. This expenditure might yield ultimately many millions. Yet, in the beginning, without this money, the property is of no definite value to the discoverer. However, he may be in a position to negotiate for financial help. He may offer to make an outright sale. Some mining financiers prefer this. Others expect the discoverer to join in the speculation by waiting with them for ultimate returns. This would be done by his accepting, in lieu of cash, a proper interest in the corporation that would be organized to develop and operate the property. If he is dealing with trustworthy people experienced in the technicalities of mining, this is a good arrangement. In this way, great mining fortunes have been made.

Some mines are financed, through professional promoters or brokers, by sale of stock to the public. The National Securities Act (1934) tends to protect the public against misrepresentation or excessive promoter's commissions.

Gold mines in western history

The place of gold in the history of the western states is not generally appreciated in these days. The rush of forty-niners to California started the main wave of settlement in the Rocky Mountains and to the west of them. The gold of California had much to do with national reconstruction after the Civil War. Then soon thereafter, the Comstock Lode of Nevada enlarged the group of millionaire mining pioneers, distributed wealth for the upbuilding of California. The early mining fortunes were mainly responsible for the construction of the trans-continental railway and telegraph lines. There was a return wave of California prospectors into the northwest and to these we owe the economic beginnings of Idaho and Washington.

It was interesting to observe in pioneering days the effects of sudden wealth upon individual prospectors. Many of them had wandered over mountains and deserts mostly for the love of such a life. Such men had no permanent interest in conventional communities, sold their discoveries for what they could get in ready cash, had a short fling at the luxuries of cities, then returned to the wilderness. Others found inspiration in the solitudes, acquired abundant physical and mental vigor and a sound philosophy of life. Some of these were men of great vision. They became leaders in business, civil affairs and politics, accelerated the development and civilization of the whole West, and achieved places of honor in the history of the country.