IDAHO'S MINERAL INDUSTRY

...... the first hundred years
Mr. E. F. Cook  
Director  
Idaho Bureau of Mines & Geology  
Moscow, Idaho

Dear Dr. Cook:

I deem it a pleasure and a privilege to have the opportunity to extend my personal congratulations on a most worthwhile and informative production to the Idaho Bureau of Mines & Geology and to yourself as its Director and to the Idaho Mining Industry who have contributed greatly to the material in this book. I am quite certain the citizens of Idaho, especially our younger people, will find a great deal of invaluable information and historical data in this book as well as having the opportunity of becoming better acquainted with the mining industry of Idaho which has been in the past and will continue in the future to be such an important segment of our economic growth and development.

This is a splendid book and I am sure you will have widespread acceptance and appreciation for this compilation.

Sincerely,

[Signature]

GOVERNOR

RES:k
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WHY THIS BOOK WAS WRITTEN

A. J. Teske

In 1963 the state of Idaho will commemorate the centennial year of its creation as a Territory of the United States.

It is particularly appropriate at this time to recall and recognize the important role which the mineral industry* has played in the remarkable growth and development of the state's economy during the past 100 years.

As preparations proceed at the state and community levels for commemorative celebrations of the historic occasion, it becomes increasingly apparent that the people of the state are fully cognizant of the fact that it was mining which provided the solid foundation and cornerstone upon which Idaho's economy was built. Many celebration plans are being fashioned around a central theme of the bustling and picturesque old mining camp.

At the same time, however, many citizens of Idaho, particularly the younger group and newer residents, may not be aware of the continuing important contribution which the mineral industry is making to the state's economic growth.

They recognize that Idaho's economic community is basically dependent upon its wealth of natural resources, but they are inclined to think in terms of the famous Idaho potato or the extensive and growing timber products operations.

Their concept of mining may remain oriented to the historically romantic aspects of the industry which have long since been superseded by advances in technology because of the changing raw materials requirements of our national economy.

Perhaps these young and new Idahoans have been told that mining is the state's third most important industry in terms of dollar value of production. They may also know that Idaho ranks first in the nation in production of silver, second in lead, and among the top three states in zinc. But are they aware of its tremen--

*In recognition of the growing diversity of mineral commodities produced in Idaho, many of them nonmetallic minerals that are not "mined" in the way that most of us think of mining, the term mineral industry--instead of mining industry--is used in this book. As an illustration: no one would speak of "mining" sand and gravel, yet sand and gravel constitute a valuable part of Idaho's mineral production.
dous potential for production of other lesser-known, but increasingly important metals, such as tungsten, antimony, cobalt, columbium, tantalum, thorium, and others? Do they realize the growing significance of its vast resources of nonmetallics--phosphate rock, limestone, clay, sand and others--that has resulted from improvements in technology and from the expansion of near by markets along the West Coast?

The purpose of this book is to clarify some of the misconceptions about the mineral industry, to point up its vital role in the state's as well as the nation's economy, to review its technological progress over the years, and to stimulate interest in its achievements as well as its problems.

It has been written in non-technical terms in the hope that it will find its greatest use as a text and reference book for students and social science teachers in secondary schools. Each individual chapter was prepared by a person well-qualified in the subject matter, with a bibliography of reference books appended to encourage more extensive reading and study.

It is realized that a book of this size can do little more than provide a general explanation of the fundamentals of the mineral industry, but if it proves sufficiently useful and interesting to encourage further inquiry into the activities and complexities of modern-day mining it will have achieved its intended objective.
Elemental phosphorus produced at this plant of the Monsanto Chemical Company near Soda Springs (and at a similar plant of the Food Machinery and Chemical Corporation near Pocatello) ultimately finds its way into a wide variety of products, some of which are illustrated below.

- Phosphate is used in oil and gasoline additives.
- A major use of phosphate is in detergents.
- Most toothpastes are more than half phosphates, which serve as polishing agents.
- Phosphates are basic ingredients of baking powder and self-rising cake mixes.
IMPORTANCE OF MINERALS IN EVERYDAY LIFE

Charles W. Sweetwood

What are minerals?

The student of the science of our earth, the geologist, will tell you that a mineral is a naturally occurring substance having a definite and uniform chemical composition with corresponding characteristic physical properties. At first, such a definition might possibly appear to be nothing but a mouthful of meaningless words, or it may make a mineral appear to be almost insignificant. But wait! Is it possible that within these few words there might lie the key that can unlock the door to full realization and appreciation of the tremendous impact our mineral natural resources have upon our very existence?

The entire earth's crust is composed of the subject of the definition—minerals. As put to use by man, minerals have, for many centuries, had fantastic and profound influences upon his existence, well-being and progress. Today, as the result of the hundreds of thousands of applications of minerals by our industries for mankind's use and consumption, you depend upon them as never before in history.

You may ask: How do I "depend" upon minerals so much? What is the importance of minerals in my life: If the use of minerals and mineral products have assumed such large proportions, then why is it that many people hardly realize a "minerals industry" exists?

Are miners odd fellows?

To answer these questions, it might be interesting to first ask several questions of you. For example, what mental image comes to your mind if you are asked to define the term "mining" or to describe "a mine": Do you think of the bewhiskered old prospector panning for gold with his faithful burro by his side? The old abandoned hole-in-the-ground in a television western movie that always manages to cave in at the proper time? The typical western ghost town? Or, do you think of modern-day symbols of highly mechanized industry? Are the people associated with mining a mysterious collection of "odd" individuals that are nothing more than gamblers, get-rich-quick dreamers and thrill seekers who seem never to be down-to-earth realists like everyone else?

True, those that make geology and mining their life rarely seem to be where everyone else is—in towns, cities, factories, or offices. They are commonly "up in the hills" somewhere, apparently not even a part of our civilization or everyday way of life. The mining property or operating mine with which these people are concerned is also commonly situated away from large metropolitan areas. The mine usually blends in with the scenery to the extent of hardly even being recognizable as an industrial center unless, of course, it is situated on or near a main
thoroughfare of traffic. All of this adds to the mystery of mining and, as such, seems to help obscure the facts that actually surround every one of us during every minute of our lives.

If mysteries or obscurities surround our minerals industry and the people that make it what it is today, we have only our massive industrial complex to blame. The average individual, in this accelerated age, has precious little time for subjects and problems that do not seem to affect him directly.

From the earth comes our wealth

Let us first look at our "way of life"--a way of life of freedom and an abundance of necessities, luxuries, happiness, and wealth. We know that such convincing progress could not be possible without our American industrial giants. Do we fully realize that our industrial successes could not be possible without a progressive, energetic, and highly mechanized mineral industry? The basic wealth of the United States today is built on the firm foundations created by our mineral industry and the wealth of mineral resources available to us. Every material thing purchased, used, or consumed is either originally removed from the earth or grown upon it.

If our emphasis, here, is upon those things that originate from mineral raw materials, what, then, of the importance of matter that must be classified as "vegetable" or "animal", or would be derived from these organic sources. However, look around again and realize that if all minerals should suddenly be taken away from us, we would find ourselves in the midst of a chaos of organic waste rather than what had just been our comfortable and familiar surroundings. Concrete, brick, stone, plaster, wallboard, wiring, tile, fixtures, appliances, roofing, plumbing, complex mechanical modes of transportation, and myriads of new cloths and decorations would all be gone. Our "way of life" would have evaporated before our eyes. Realize, too, that even the original "vegetable" and "animal" materials used by all of us have been grown and developed through the use and assistance of the very same minerals that directly surround us.

Ice is a mineral!

All of this mineral wealth envelops us so completely everywhere in America that even such vitally important life-sustaining minerals as heating fuels and water are available virtually everywhere, by the mere flip of a switch or the turn of a faucet. It seems to be a rare mineral indeed that is not commonplace to most of us--a commonplace to the point where the individual is not even aware of how dependent he has become upon our mines, quarries, and wells. Think, again, of your comfortable surroundings--this time of the modern appliances you use daily in your home. The radio, telephone, television, record player, clocks, furnace, stove and, of course, the refrigerator. Look inside the refrigerator and observe the uses minerals are put to in the construction of the refrigerator box, refrigeration system and insulation. Don't ignore the food cartons, food wrappers, glass jars, plastic containers and the supply of delicious foods enriched with body-
building minerals. Oh yes, please don't overlook the insignificant miracle of man's
genius—the ice cube—a ready made molded mineral, awaiting your instant pleasure.

Progress and development designed to make useful minerals readily available
to everyone's daily use have made rare minerals of yesteryear common minerals of
today. Today's rare minerals will become quite common to us all in the future.
Even the rare or precious minerals fashioned into jewelry are, for the most part,
not nearly so rare or precious as in the days gone by when only the very wealthy
could afford such luxuries as diamonds, gold, and silver.

The unromantic minerals

We can see now that today's mineral industry is not by any means confined to
procurement of the various gemstones and such familiar metals as gold, silver, lead,
zinc, iron, and aluminum. This industry has long since graduated from the prospec-
tor and burro period, to one of amazingly diversified interests, aims, and goals. A
very complex network of scientific and economic developments have provided us with
an economic environment suitable to the use of many hundreds of various types of
"industrial" minerals. This environment has materialized almost entirely without
the "romantic glitter" that usually accompanies the mining, milling, and marketing
of the more familiar metals. Instead, new industrial products have been developed
or previously established uses expanded because of either consumer demand or
improved manufacturing techniques. The products that eventually reach the indi-
vidual (the consumer) frequently contain several industrial minerals and chemicals,
treated to form the desired end product. The minerals or compounds contained
within the finished product lose their original identity completely, behind a much
more familiar "brand" name. In this respect even the very familiar metals of iron,
lead, zinc, copper, and others are becoming so thoroughly camouflaged in new
alloys with trade name identifications that the true composition of the final product
is known only to the metallurgist or chemist.

A presentation of all of the minerals vital to the foundation of our vast economy
would be quite impossible here. The industrial minerals used by all of us are far too
many and the compositions of each too complex. It may be of particular interest,
however, to elaborate upon a few of the well-known and important minerals that affect
our everyday lives and which, at the same time, are possibly the least obvious to us.

Is there clay in your candy?

Paper, of one type or another, is used by millions of people daily. Many types
of paper (for writing, magazines, miscellaneous office uses, food cartons, etc.) con-
tain large amounts of kaolin clay—as much as 25% of the total—as a filler and/or
coating on the surface of the paper. These same kaolin clays are used as a filler
material in many other familiar products: rubber, oilcloth, linoleum, paint, plaster
and plaster products, textiles, window shades, calcimine, crayons, soaps, polish-
ing compounds, toilet and tooth powders, and chocolate candy bars. Clay is also
used in the manufacture of whiteware-sanitary ware, electrical porcelain, white pot-
ttery, and high heat-resistant liners for jet and rocket engines and missile nose cones.
Stoneware, earthenware, tableware, floor tile, and wall tile all contain kaolin clay.

Or quartz in your pints?

The minerals quartz and feldspar (together with trona in the processed form of
soda ash) provide us with our common glassware. Quartz, as the source of silica, is
so much in demand by industry that a list of its individual uses, applications, and future needs would fill a separate book.

**Phosphate: improves dirt or removes it, as you wish**

Phosphorus, has been with, and within, all forms of life since the beginning of time but it was not until 300 years ago that the element phosphorus was actually discovered by man. An alchemist was looking for the "Philosopher's Stone" that would turn base metals into gold. It was a common belief among alchemists of that day that the good yellow metal could be made to grow in a mine, like potatoes in a field, if only they could find the proper fertilizer. The alchemist was right, he did find fertilizer; but not for gold. Though he didn't know it, he found something much more important--one of the three absolute necessities for plant and animal growth: nitrogen, potash, and phosphorus. The alchemist's metallurgy was excellent and has not been basically improved upon even after three centuries. Today, phosphate rock (containing the mineral, collophanite) has become a vital part of our lives, though few realize that its value as a staple of life is far greater than gold. Its basic use is as a plant food fertilizer. The raw material is also processed to provide, first, elemental phosphorus, and then, any one of the many "poly-phosphates" for chemical industry application. It reaches the individual consumer in many forms; a few of which are: insecticides, incendiaries, phosphorus alloys, ceramics, as a catalyst in oil refining agents, in photography, in dental and silicate cements, as a human and livestock food supplement, as a water softening agent, and at last but by no means least, as the basic constituent of the modern household dish and clothes washing detergent.

**The fossil fuels**

Coal has long been and remains today one of our greatest sources of energy. It is upon coal that the machine age chiefly depends for strength to do its daily work. Petroleum, of course, also contributes heavily to our energy requirements as does the all important mineral, water. However, coal either directly or indirectly reaches into almost every phase of our daily life. Thousands of products are either created by, or assisted in their manufacture by, coal in one form or another. It has been instrumental in the development of our great metals industry, to mention only one of its many demands. From this, our greatest reserve of energy, has come the products of diversified alloys wherein such alloy elements as beryllium, boron, chromium, cobalt, columbium, copper, manganese, molybdenum, nickel, phosphorus, silicon, titanium, tungsten, vanadium, and zirconium are widely used.

**Idaho's mineral Big Three: lead, zinc, silver**

Our great State of Idaho has long been famous as one of the nation's leading metal producers; principally of lead, zinc and silver. These metals are, of course, some of the more familiar ones to all of us and their production and availability seems to be frequently taken for granted by most. Unfortunately many of their common uses and new applications seem to be recognized by only a very few.
The value of Idaho mineral products to farmers and ranchers is illustrated not only by the abundant use of phosphate fertilizer on farmland but also by the use of zinc in galvanized roofing, barbed wire, and fencing. Steel, coated with zinc and exposed to normal atmospheres, forms an insoluble, adhering impervious layer of zinc carbonate that resists further attack. About one-third of all the zinc used in the United States each year goes into galvanized products.

Lead, the almost invariable companion of zinc in nature, also has many uses around the farm and home. It is found in the storage batteries of cars, trucks, and tractors; in the tetraethyl lead of premium gasoline; in paints, in solder and ammunition.
Lead, for example, is well-known for its density and workability. It has been used for many years in the manufacture of storage batteries, as a covering for electrical cables, in ammunition, solder, lead-foil and as a bearing and pipe metal. Most of the industrial uses of lead center around its workability and capacity to withstand chemical attack. In recent years, lead has realized an important application in nuclear shielding against certain types of radiation, particularly against gamma rays. Lead has the advantage of being the densest of any common metal and thus has become vital to the success of the nuclear age. We must not overlook the importance of lead in the chemical industry, particularly as the colorless heavy liquid—tetraethyl lead—that forms the active ingredients of the principal anti-knock components added to gasoline to improve their anti-knock qualities and efficiency. Tetraethyl lead is used in both the premium and the regular grades of gasoline; consequently it is used by all of us to assist us in our daily transportation needs. Annually over 170,000 tons of lead are consumed in the United States alone in gasolines.

Zinc also has many familiar uses in our every day life. Among these is in the galvanizing of steel and iron to form a thin metal coating capable of warding off the attack of elements for long periods of time and to enhance the life of steel sheets, tubes, wire or cloth. Zinc is another metal used largely in alloys, particularly in the manufacture of brass and various other metal casts. It has become an integral part of such products as battery cans, glass jar tops, photo-engraving sheets, in many phases of the automotive industry and as a pigment in the chemical industry. One of the principal uses of zinc today is as the major component of die-casting alloys which are used extensively throughout industry for mass-production casting of basic parts of the final product. The handle of your car door, for example, is very likely cast from a zinc-base alloy, but few of us recognize the work-horse metal because of the thin cover-coat of decorative chromium.

Silver is one of the metals known earliest to man and has been more commonly recognized for its monetary use and in the arts. It has been traditionally required for centuries for coinage and monetary reserves but, more important, silver is highly malleable and ductile and ranks first among the metals in the conductivity of electricity and heat. It resists corrosion and, when alloyed with copper, forms sterling silver ideal in the fabrication of tableware, jewelry, insignia and novelties. Industrially, silver is very much in demand in the photo and electroplating industry. Silver is being used more and more in industry as a solder and within brazing alloys in joining pipes, electrical connections and forming mechanical assemblies. Silver compounds are necessary for caustic astringents and antimicrobial purposes in medicine. Not to be overlooked is the increasing demand for silver in dental fillings and in surgery as sutures, wires and plates.

Although lead, zinc and silver are vitally important to our national economy, so, of course, are the other familiar metals of iron, aluminum, copper, tin, mercury and antimony. These familiar metals and the almost never-ending list of nonmetallic minerals, help to form our present way of life. The Machine Age of our time and the Space Age just beginning will permit us to be continually surrounded
and influenced by our gigantic industrial era. It has swept us up in the frenzy of progress and we must advance with it to strive for a more substantial security and national wealth.

It has been said that there is "nothing new under the sun". Perhaps this old adage is true. As we look back in history we find that the first materials used by primitive man were nonmetallic substances—flint, chert, quartz, quartzite, soapstone, and limestone. Clay was widely used first for pottery and later for brick. How long ago man began using minerals for tools and weapons is hard to say, but 30,000 years is not an unreasonable estimate. We use these very same mineral materials today in almost unbelievable quantities. So let us modify the old adage to say "because there is nothing new under the sun, modern man creates new uses for old materials". Thus, our present day "industrial era" terminology should also be modified to say that we are living in a modern "industrial minerals era". Without the "old" nonmetals and the "old" metals we could not fashion our "new" modern tools and products that exemplify progress.

Even as each man, woman and child, as a consumer, is basic to the mineral industry of our state and nation, so is the mineral industry basic to our national economy.

For further reading


Hydraulic mining was widely used in the early days. Jets of high-pressure water from hydraulic monitors undermined the gravel banks and washed the gold-bearing material into long sluices in which the gold was recovered. The scene above shows a placer mine near Idaho City about 1897.
HISTORY OF MINING IN IDAHO

Merle W. Wells

The story of Idaho is the story of its vast wealth of natural resources and the gradual development of its economic community through the utilization of these resources.

The first settlers were principally trappers and mountain men interested only in the abundance of beaver and other valuable fur-bearing animals, and missionaries seeking to convert the Indian natives to the ways of Christian civilization.

Resource use was confined largely to products of the wilderness—game animals as a source of food for the Indians and furs which could be acquired by trapping or trade with the Indians.

Early pioneers seeking new homes and new opportunities in the West found Idaho little to their liking. For many years travelers along the Oregon Trail regarded the desert wastes in the southern part of the state largely as a hazard in their travels to the promised land along the western seaboard. The extensive stands of timber in the mountains and the generous, dependable water supply went virtually unnoticed because there was no market to supply with wood or other products which could be made from the timber, land and water power available.

Interest in the Idaho wilderness had to await the discovery of some resource that had sufficient inherent economic value to make its location in relation to markets a secondary and relatively minor consideration. That resource was the most sought-after of all mineral products from biblical times—gold.

The gold rush to Idaho starts

It was the hypnotic lure of gold that brought the first rush of settlers to Idaho and their prospecting efforts brought the subsequent discoveries of silver and lead, which formed the basis of the state's initial economy.

Gold was known in Idaho for a number of years before careful prospecting of the Clearwater country led to the beginning of mining and to the creation of Idaho Territory. A Hudson's Bay Company fur trapper is reputed to have been aware of gold in Boise Basin as early as 1844, but if that be the case he neglected to do anything in the way of mining. An army explorer noticed gold in Salmon River not long before 1860, and a prospecting party on the Coeur d'Alene panned some gold in the summer of 1860. More important, though, was a find by E. D. Pierce, February 20, 1860, on the North Fork of the Clearwater. The other discoveries were not followed up, but Pierce went out to the new town of Walla Walla, where he soon equipped a party of prospectors, and began to examine the Clearwater
with some care in the fall of 1860. The Clearwater gold rush ensued.

**Pierce and Elk City settled**

Thousands of gold hunters joined the stampede to the Nez Perce mines on the Clearwater and on Salmon River. While there were a few good claims around the original discovery of Pierce, most of the miners wanted to do better, so they extended their search throughout all the surrounding country. Mining was hard work indeed, and the average miner made the hard trip to the gold fields to reap huge profits if he could. Most of the gold hunters were not much interested in working hard just for wages—**even for high wages**—in a country where the cost of living was so great that they would not get any further ahead than if they had stayed at home. Scattering out to the south they came across some pretty good placer ground around Elk City, which was established in mid-1861. The big excitement that season, however, followed a find that all the prospectors had been dreaming of: in a high basin soon to be known as Florence, a lucky miner really could make a fortune. No longer would it be necessary to work for wages. As soon as the word got out, just about everyone in the Nez Perce mines took off for Florence.

**Through the snow to Florence**

Even before winter set in, fabulous reports of recovery of gold began to compete with Civil War news for space in the columns of newspapers in Oregon, Washington and California. The most successful miners claimed to make hundreds of dollars a day—**at least on their better days**—and Salmon River definitely was the place to go in the spring of 1862. More than ten thousand eager prospectors flocked to that inaccessible mountain basin by June of that year, even though an exceptionally cold winter with deep snow had made the trip hazardous in the extreme, and had brought the curse of famine to those who had remained in camp throughout the hard winter. As matters turned out, the riches of Florence were denied to all but a fortunate handful who had the high-paying claims. Less than a third of those who had overcome the hardships of the trip could find work as miners in any capacity, and even though there was considerable opportunity for merchants, packers, expressmen, saloon keepers, or gamblers, the camp was flooded with far too many seekers of sudden wealth. The surplus prospectors of necessity had to go out to hunt for other rich mines. One of these parties from Florence crossed Salmon River to discover the important camp of Warren early that summer and other miners from Florence pushed farther south to discover the still more important mines of Boise Basin on August 2, 1862.

At the same time, another group of prospectors who had come from the East—but had been unable to descend the nearly impassable Salmon River Canyon to Florence—were diverted to the Upper Missouri where they found good diggings in East Bannock and laid the foundation for Montana. The rush to Florence, in fact, proved to be instrumental in bringing the mining expansion that justified, (1) the creation of Idaho Territory the following year, and (2) the division of the originally huge Idaho Territory in order to establish Montana in 1864.
IDAHO'S MINING HISTORY

1865 - Reports of Cœur d'Alene mineral discoveries, May 27, led to a gold rush there, but no gold was found until after 1866.

1866 - J.H. tenison located a Cœur d'Alene quartz mine, April 25, but no gold was found until after 1866.

1867 - Murray was surveyed Jan. 22 and soon replaced Eagle City as the center for the Cœur d'Alene gold rush. The discovery of the Tiger Mine near box, May 2, followed immediately by the Dilator Mine, marks the beginning of lead-silver operations in the Cœur d'Alene.

1868 - The old Idaho (C.C.A.), known as the Leaf AMI, eventually the deepest lead-silver operation anywhere at Mullan, July 7. A miner at the Idaho (C.C.A.) located the Idaho Mine near Wallace, Aug. 30. The Yankee (C.A.) discovered the Idaho Mine near Wallace, Aug. 30. The Yankee (C.A.) was a prolific producer for 40 years, until deep workings reduced its output to negligible amounts. The Idaho Mine near Wallace, Aug. 30, was a notable discovery near the Idaho Mine near Wallace, Aug. 30, and is considered one of the most important discoveries in Idaho history.

1869 - C.F. Smith discovered the Basin Gold Claim near Wallace, Sept. 10.

1870 - C.F. Smith discovered the Basin Gold Claim near Wallace, Sept. 10.

1871 - The Idaho City Mining District was organized in 1871.

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1900 - The Idaho City Mining District was organized in 1871.

1901 - The Idaho City Mining District was organized in 1871.

1902 - The Idaho City Mining District was organized in 1871.

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1904 - The Idaho City Mining District was organized in 1871.

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1906 - The Idaho City Mining District was organized in 1871.

1907 - The Idaho City Mining District was organized in 1871.

1908 - The Idaho City Mining District was organized in 1871.

1909 - The Idaho City Mining District was organized in 1871.

1910 - The Idaho City Mining District was organized in 1871.

Map courtesy Idaho Historical Society
Warren, Boise Basin, and Owyhee

Far more permanent and productive than Florence, the mines of Warren, and particularly of Boise Basin and the neighboring South Boise, Atlanta, and Owyhee districts, enjoyed a spectacular boom in 1863 and 1864. Many more miners could be accommodated in the Boise region, and most of Idaho’s population concentrated there at that time. Just as the Clearwater and Salmon River mines had led to the starting of the important city of Lewiston in North Idaho, the Boise-Owyhee mines were responsible for the early development of Boise as a service community and as a base for operations. Soon irrigated farms began to spread over the near by valleys to supply the mines, and Idaho’s economy gained a broader and more secure foundation.

Establishing a mining district

Whenever a new mining area was discovered, those prospectors who came in to settle and work, commenced by establishing a new mining district. This was done in a miners’ meeting, which elected officers, adopted mining laws and regulations, and arranged for the recording of claims. This system, brought to Idaho from California, was designed to give each miner (as long as there were not too many miners for the ground available) a chance to have his own operation—usually with a few partners—rather than to have a small group of original discoverers monopolize the entire district. Claims were limited to a size that small groups of individuals could manage, at least so long as there were no special problems to be overcome. Many mines, however, were of such nature that they could not be worked by a few partners; those that could be handled only as a large operation by a major company with extensive capital, heavy equipment, trained management, and a substantial labor force often were held back. Eventually enough small claims would have to be consolidated (normally by purchase) into a group of a size sufficient to justify the large investment necessary to begin development.

Placer and lode mining

Two kinds of mining—placer and quartz lode—were practiced in many of the early Idaho districts. Before gold can be mined, it comes up in solution through great fractures in the surface rocks of the earth, where it is deposited in veins of quartz. At times, gold-bearing quartz veins are eroded away into creek or river beds where the vein material is ground up by the streams, and the gold is freed. Since gold is much heavier than the vein quartz and other rock, it rapidly works toward the bottom of the gravel under the stream of water. There it is concentrated near bedrock—the solid rock that underlies all the loose gravel, dirt, and other such material that covers the surface of the earth. Placer miners take gold from the stream beds by (1) digging through the surface gravel to find the deeper gold-bearing gravel that lies near bedrock, and (2) running the gold-bearing gravel through a rocking or sluicing device to separate out the gold. If, however, the miner can trace placer gold upstream to the vein from which it originally came, and can find some of the gold-bearing quartz still in place, he may commence a quartz lode mine. Lode miners, however, have to run tunnels into gold-bearing
veins, get the quartz out of the hill, and then remove the gold from the quartz. Individuals or small groups of men may engage in placer mining, but lode mining, of necessity, is ordinarily a large company operation.

Placer miners often are thought of as having spent their days in the diggings hard at work panning gold. As a matter of fact, very little placer ground actually was worked by panning: the process of sending acres of gravel through a gold pan, one pan at a time, simply was not very practical. Panning was used for sampling while prospecting, and sometimes for separating gold from sand in the final stages of recovery. Even at best it took some five to ten minutes to swirl the sand and gravel out of each pan to save anywhere from five or ten cents to possibly a dollar's worth of gold. Ground that would run even as high as six or eight cents a pan was pretty good; anything very much higher than that was exceptionally fine indeed. It took relatively little imagination for miners to perfect better and faster methods to handle large quantities of placer ground.

Availability of water determined the exact method of placer operation. If water was limited and had to be used sparingly, or had to be saved and used over, a rocker was employed. If a reasonably good stream could be brought through a ditch to the placer ground, a system of sluices was preferred; running water then did the work of carrying sand and gravel over riffles which trapped the heavy gold. The relative advantage of the sluice over a rocker, and of a rocker over a gold pan was substantial. One experienced miner, hard at work for a regular ten-hour day with a standard California gold pan, could manage about one yard of gravel—one hundred pans per day. If he made only five cents a pan, he would get $5.00 a day—and that was anywhere from five to ten times better than labor was paid in ordinary jobs at the time. Two men, however, could put three to five yards (three to five hundred pans) of screened gravel through a rocker in a day, and one man could process ten yards with a sluice. Since, in terms of one man's labor, sluicing was easier work, and was at least four times as fast as using a rocker, and ten times as fast as using a pan, sluicing was preferred whenever it was possible.

Much of the placer ground lay in flat stream bottoms where the slope that the stream ran down had insufficient fall to permit use of sluice boxes. Such areas could not be worked economically in the early days, but gold deposits in old stream beds on higher ground often were sluiced—and in many cases they could be washed down by great streams of water brought in through long ditches. As the ditches grew longer they gained more and more elevation over the mining ground, and the water in them obtained sufficient head so that it could be directed against hillsides under enormous pressure through hoses with large nozzles. Such a system was called a hydraulic giant. Great pits dug out by hydraulic giants still are visible in various parts of Idaho—most notably near Elk City and in the Boise Basin.

Lode mining almost invariably demanded more capital, labor and equipment than was necessary for placer operation. Even the effort necessary to set up hydraulic giants did not compare with the expenditure required to develop a major lode mine. Placer miners were two steps ahead of quartz miners at the very be-
Silver City, Idaho, about the year 1900

Early scene in Wardner, Idaho. The boys on Noah Kellogg’s burro are Jerome Day, Sam and Frank Poteet.
ginning; gold in placer deposits already had been washed from the quartz vein inside the hill, and the veins had been ground up by erosion so that the gold was free to be separated from the sand and gravel. Lode miners had to do their prospecting where gold-bearing veins cropped out on an exposed hill, and then had to tunnel underground to reach the mineral lode. Large zones of vein material had to be blasted from inside a mountain and to be hauled through access tunnels or shafts to the surface. And once the gold-bearing quartz had reached the surface, it still had to be crushed to a powder to free the gold. Only then could the separation of the gold from the resulting sand—the same final operation as was needed in placer mining—take place. Blasting hard rock was a slow, expensive matter, especially prior to the introduction of dynamite in 1868.

**Early milling methods**

Early processes for milling quartz ore left much to be desired. Early Idaho quartz miners had the choice of incredibly slow arrastres or faster expensive stamp mills. Arrastres were assembled locally and were operated at low cost, but they could handle only high grade ore, and not very much of that. Stamp mills could be freighted in with great effort from Chicago or from San Francisco, but often as not the company's resources would be exhausted trying to get the mill to the mine. Then it frequently turned out that quartz could be mined fast enough to keep an arrastre going, but not fast enough by the mining methods then available to feed a stamp mill. Lode mining and milling proved to be a difficult operation at best.

**Lode mining more permanent than placer**

Stable communities with an air of permanence grew up in Idaho as the result of lode mining. Some placer operations—particularly those that employed hydraulic giants—lasted long enough to support local towns over a period of years, but ordinarily the white miners soon sold their worked-out placer ground to the Chinese and went on to something else. The Orientals, willing to work harder for decidedly less profit than the Whites would accept, kept up placer production in most of the early Idaho gold camps for many years. The Whites, though, were reluctant to accept them, and the Chinese generally were not admitted until a district was about played out. Their contribution to Idaho's development usually has gone unrecognized.

Partly because many of the early attempts to develop gold-quartz properties resulted in failure, lode mining lasted much longer than placer mining. Then, too, freighters, blacksmiths, engineers, and many other workers had to be supported to keep a lode mine going, and the capital investment in a gold-quartz venture was relatively high. Complicated litigation over the ownership and over the financial management of many of the more valuable quartz properties kept attorneys and courts busy for years, but delayed actual mining. Lode mines could not be worked out hastily for the most part, and lode mining did much to support Idaho during the formative years of the State's economy.
Idaho's early great mining boom, which had really got underway with the stampede to Florence in the spring of 1862 and the still greater rush to Boise and Owyhee in 1863 and 1864, began to slow down considerably in 1866 and 1867. Important quartz discoveries near Placerville late in 1862, and Rocky Bar and Silver City in 1863 and at Atlanta in 1864 led to widespread use of arrastres in the summer of 1864 and to a rash of stamp mills the next summer. Stamp milling, however, proved to be undertaken prematurely by most companies, and in 1866 there were enough major stamp mill failures to discourage promotion of lode mines seriously. Some of the companies were mismanaged; few, if any, had gone to the trouble to develop their properties sufficiently to make sure they would have enough ore to keep a large mill supplied when one was available. Furthermore, all of the Idaho quartz properties were remote from railroads and most lacked access roads suitable for bringing in heavy freight. Reliable labor could be obtained only with great difficulty and at extra expense in the more inaccessible camps, and generally the companies underestimated their costs during the planning stages so that they lacked capital to carry their operations through to the point that there was any return on their heavy initial investments. Then, too, there were enough frauds and swindlers involved in promoting the early lode mines that, with some notable failures in South Boise and in Owyhee in 1866 and 1867, the whole business got a bad name.

During the years of painful adjustment in lode mining after the initial stamp mill failures of 1866 and 1867, the early placer excitement waned for the most part. There were some important new discoveries in central and in south-eastern Idaho--Leesburg in the summer of 1866, Loon Creek in 1869, and Caribou Mountain in 1870 particularly--to keep the mining advance going. More widespread use of hydraulic giants made possible some large placer production at the hands of a relatively few miners. Superintendents of quartz mills, however, now resorted to a widespread practice of "gouging" their properties: they sacrificed orderly development of their mines to strip out the best high-grade ore, thus keeping up a hand-to-mouth production with unfortunate later results. Too often the practice of gouging, or "high-grading" as it is termed in miners' language, was associated with company failure to pay freighting bills or labor costs: an Owyhee miners' union was organized, in fact, in the fall of 1867 in an effort to get regular paydays instead of having the workers wait for their mine to get into production before they were paid. The practice had arisen of trying to pay all development costs, including labor costs, out of current production, with a percentage commission for superintendents; aside from encouraging gouging, the system was shortsighted and hampered long-range production. Mines would suspend work when a particularly good streak of ore was mined out. Then shafts would fill with water, tunnels would cave, and resumption of mining could be managed only with difficulty. There were, however, some bright spots during the age of gougers: the celebrated Poomau mine near Silver City, together with some other notable Owyhee properties, were rich and extensive enough to produce millions for a decade before the general mining collapse in Owyhee which followed the failure of the Bank of California in San Francisco, August 8, 1875. But most major gold-quartz production, even for the old established camps, was reserved for the decade or so beginning about 1886, when lode mining finally overcame the
Photograph taken at the Hercules Mine near Burke, Idaho, in 1901, shortly after the discovery of that famous mine.

How the pioneers of Idaho mining lived---at the Hercules mine in 1901 with the first ore shown on the corner of the table.
obstacles that had retarded the industry for 20 years.

**Yankee Fork, Vienna, and the Wood River mines**

Even in the blackest days of the gloom that came with the general mining collapse resulting from the financial panics during the era of gouging, there was plenty of cause for optimism among quartz miners. Important new finds—especially some major quartz locations on Yankee Fork in 1876—continued to encourage prospectors and by 1879 Indian hostilities were at an end. The Bannock War of 1878 and the Sheepeater War of 1879 had cleared the way for opening important new mining areas. It then began to look as if an 1878 discovery at Vienna on the Upper Salmon was only the beginning of a major new thrust into the Wood River country. The new mines on Wood River, though were primarily lead-silver. In the long run, the mining of base metals which got underway in Idaho after 1880 on Wood River became more important even than gold-quartz mining. But there still was a bright future for gold-quartz enterprises after 1880.

**New discoveries bring in railroads**

The transfer of exploration interest to base metal deposits which came with the Wood River rush of 1880 became still more pronounced after the Coeur d'Alene district gold rush of 1884 led to great North Idaho lead-silver discoveries in 1885 and 1886. Though not unlike gold-quartz mining in many ways, base metal mining for copper, lead, or zinc required an even more substantial industrial development. Smelters, which came to Wood River not long after 1880, were a necessity, and railroad transportation was imperative for successful operation. It was no coincidence that the Union Pacific took time out, while constructing its main line westward through the Snake River Valley in 1882, to build a Wood River Branch to Hailey and Ketchum; similarly before serious production of the Bunker Hill and Sullivan and other great lead-silver mines of the Coeur d'Alene district could get underway, a railroad had to arrive—and the mines that were served first by the railway had a head start even over those that had been known sooner. The transformation that came over Idaho in the decade after 1880—new railways, new cities, new farmlands, and new people by the tens of thousands—is associated to a considerable degree with the new opportunities in mining. Later interest in copper mines around Mackay and the Seven Devils indicated that base metal mining would not be limited to lead-silver possibilities of Wood River and the Coeur d'Alenes.

**Idaho becomes a state**

With the coming of the railway, introduction of capital in abundance (including major British investments in Rocky Bar, Atlanta, Silver City, and Bonanza, for example), and improvements in methods of operating, gold-quartz mining really came into prominence by 1886. And, since the Wood River mines also were flourishing at that time, the long-awaited general success of underground mining had arrived. Placer mining in 1862 and 1863 had been responsible for Idaho's creation as a territory; now gold-quartz and base-metal mining contributed substantially in enabling Idaho to secure admission as a state thirty years after mining had commenced. Great profits were realized from a number of important operations, although
the collapse in the price of silver in 1890 had an adverse effect upon several major districts.

With state admission in 1890, the mining commonwealth of Idaho gained more influence in national affairs. And in large measure that influence was directed toward obtaining a monetary program more favorable to mining. During the twenty-year battle for free coinage of silver, Idaho was counted among the foremost advocates of bimetallism, and after 1890 became one of the leading silver states. In the national election of 1892, when Idaho had a chance to vote for President of the United States for the first time, the state went Populist in an effort to endorse free silver. And the silver issue continued to dominate Idaho politics for the rest of the decade, with the result that old party alignments were shattered. The handful of politicians who failed to put the silver question before any other issue simply were retired altogether.

**Labor troubles in the Coeur d'Alenes**

A combination of increasing freight rates and low metal prices immediately after statehood brought severe strain to Idaho miners, particularly to the new lead-silver bonanzas of the Coeur d'Alenes. One unfortunate outgrowth of the economic crisis there was a long, violent struggle between the mine owners' association and the miners' union. Open warfare commenced in 1892 with a clash that culminated in the dynamiting of the old Gem Mill at Burke, and resumed with the blowing up of the Bunker Hill and Sullivan concentrator at Wardner in 1899. A long interval of federal-military occupation brought an end to the battle in North Idaho, although the fight resumed in the courts in 1906 and 1907 after the assassination of Frank Steunenburg, who, as Governor in 1899, had proclaimed martial law in the Coeur d'Alene district.

**Coeur d'Alene district becomes one of world's greatest mining areas**

Although mining did not dominate Idaho's economy in the 20th Century in the manner of the early years of the settlement of the territory, the greater part of Idaho's mineral production was reserved for the later period. Improved transportation and more efficient methods helped miners to increase their production as the years rolled by. Placer ground only partly workable in the 19th Century yielded to efficient dredging in the 20th Century. And the lead-silver-zinc operations in the Coeur d'Alene district provided wealth far beyond the gold production of the earlier years. The Coeur d'Alene country, in fact, turned out to be one of the great mineral areas of the world. The newer silver bonanzas of North Idaho surpassed even the fabulous Comstock Lode and silver was only one of the major minerals in the Coeur d'Alene district.

Many of the old producers in various parts of the state eventually were worked out, but a favorable price for gold kept precious metal production substantial during periods of economic depression--especially the great depression of the 1930's.
Labor troubles in the Coeur d'Alene mining district erupted into violence in 1892. On July 11 of that year, a pitched battle at the Frisco Mill ended when the strikers destroyed the mill by sending giant powder down the flume into the mill. Martial law was declared and troops were brought into the district to enforce order.
Jet aircraft, satellites, and missiles like the Titan (LEFT) require metals that can withstand high temperatures and high stresses. Columbium, beryllium, and zirconium are examples of such space-age metals.

Beryllium is a metal of great promise. Not only is it light and strong, but it has the lowest absorption of thermal neutrons of any structural metal; consequently, beryllium is one of the important metals used in nuclear reactors like the Engineering Test Reactor (RIGHT) at the National Reactor Testing Station near Arco.
Idaho's mineral contribution to victory

Although gold mining was a casualty of an all-out war effort in 1942, when that industry was suspended as the result of a government order, other mining in Idaho contributed substantially to war production. During World War II Idaho led the nation in the production of tungsten and antimony, two metals vital to the war effort.

Impact of the nuclear and space age

After the war a number of almost unheard-of new minerals came into importance as the search for answers to the unique metallurgical problems of the nuclear and space-age reached critical proportions.

Idaho's contribution to the domestic supply of radioactive uranium for the atomic energy program has been relatively minor up to 1960, but with the change of emphasis in that program to peace-time uses of nuclear energy, there has developed a substantial interest in the State's extensive deposits of thorium, a metal which has great potential value in the operation of breeder reactors. Several companies are currently engaged developing these ore deposits and doing research on the metallurgical problems involved in converting the ore to usable mineral form.

The space age has focused primary attention on many of the lesser known metals and minerals which have the physical characteristics—lightness, tensile strength, heat resistance, etc.—so critical in the construction of missiles, rockets and other vehicles involved in the conquest of outer space.

For several years Idaho provided more than 99 percent of the domestically-produced supply of columbium-tantalum oxides from a vast placer deposit in Bear Valley. This dredging operation also turned out substantial proportions of the domestic production of many of the rare earth minerals—many of which have unique properties that can be used to great advantage in the conquest of space.

In recent months another of the strategic space-age minerals, beryllium, has been found in widespread beryl occurrences in the south-central part of the State. Whether or not these deposits are commercial, within the limitations of current metallurgical knowledge of this metal, remains to be determined, but the extensive research now underway to develop improved processing techniques is virtual assurance that Idaho's beryl resources will figure importantly in the space age.

At the same time Idaho's more prosaic nonmetallic resources have assumed a greater stature in the State's economy. Since 1948 a number of major expansions in the 40-year old phosphate industry have materialized, greatly increasing the processing facilities for this most important source of mineral wealth in the southeastern part of the State.
A century of mining in Idaho has left the state with a major industry that has gone through a number of important transitions—from early placers to gold-quartz mining, then to base-metal mining, and finally, in addition, to the development of important nonmetallic minerals. Whether in peace or war, Idaho’s mining production still makes an important contribution not only to the state’s economy, but to national industrial development as well.

For further reading


History of the State of Idaho by Cornelius J. Brosnan, Scribners, New York, 1918.

History of Washington, Idaho, and Montana by Hubert H. Bancroft, San Francisco, 1890.


Silver Strike by William T. Stoll, Boston, 1932.
ABOVE: New developments in Idaho mining include the completion of a new Mines Building at the University of Idaho, half of whose cost was paid by the mining industry.

ABOVE: A new success story: The Lucky Friday mine, near Mullan, where years of hopeful exploration have paid off in one of Idaho's richest silver mines.

BELOW: The new Bunker Hill phosphoric acid plant at Kellogg combines a byproduct of metal mining, sulfuric acid, with a nonmetallic commodity, phosphate rock, to produce a fertilizer material.

ABOVE: Idaho's newest phosphate mine, near Georgetown, owned by Central Farmers Fertilizer Company, recently came into production.
AN EVER-CHANGING INDUSTRY

The day of the burro is gone

The mineral industry in Idaho, like other parts of the American economy, has undergone great changes since its founding 100 years ago. The lone prospector and his burro have all but disappeared from the scene. The real prospector of today usually works for a large company as part of an exploration team; he uses complex technical devices in his search for hidden ore bodies. Corresponding changes have occurred in mining and ore-processing techniques. Furthermore, the modern prospector may be searching for mineral deposits that were not valuable in the old days—deposits of limestone, clay, or phosphate, for examples. The old prospector walked past these, and properly so. Only with modern industrial developments have such deposits become valuable.

Changes in exploration techniques

In unexplored regions, a few large ore bodies (valuable mineral deposits) may be exposed at the earth's surface. Their exposure is largely a matter of chance; the forces of erosion have cut down just far enough to bring them to the light of day. Such ore bodies are readily found; most of those exposed at the surface in this country were found early in our history. From 1850 to about 1900 prospectors examined virtually every square mile of country in which bedrock was exposed, and most of the major deposits now being mined were discovered in that period.

This is not to say that the prospector's day is done. Many deposits of minerals that have only lately become valuable because of changing technology are exposed at the surface, and will be found by the prospector. However, known, large, surface-cropping deposits of the important minerals will be exhausted in the not-too-distant future; these deposits must be supplanted by new deposits.

Now, if some deposits were exposed by chance, during erosional lowering of the earth's land surface, it follows that others are near the present surface, but not yet exposed. Still others lie at greater depths. How can these be found? Much scientific research has been done in seeking the answer to this question. It is in the attempt to find such hidden deposits that exploration techniques have changed drastically. Special techniques of many kinds have been devised.
Geologic analysis is one important approach. Suppose that one studies in great detail all the geologic features that are associated with a known large ore deposit. Included here might be the design or pattern of folded formations; the pattern of faults (breaks in rock along which movement occurs); the kinds of rock present; and the kinds of rock alteration that occur. Now, if one can, by careful geologic mapping, find another area that has most or all of the geologic characteristics of the major ore deposit, then this second area may be tested by drilling or other means to see if ore is present. This approach has been spectacularly successful in finding several ore bodies in the Coeur d'Alene district.

Geophysical methods are also very widely employed. Differences in physical properties between ore bodies and surrounding rocks permit discovery of many hidden ore bodies.

Valuable mineral deposits are generally heavier than adjacent rocks. Delicate instruments have been perfected that can detect the presence of heavy rocks beneath the earth's surface. Areas underlain by such heavy rocks may be tested by deep drilling. In a few areas in the world, major deposits have been found by this gravity method; for example, a major chromite ore body in Cuba.

Ores or rocks that either consist of or contain magnetic minerals may be detected by instruments that measure differences in the strength of the earth's magnetic field from place to place. Many variations in application are possible and have led to the wide use of the magnetic method of geophysical exploration. Large bodies of iron ore in Brazil and Labrador have been discovered in recent years by magnetic methods.

Differences in electrical conductivity between ore bodies and surrounding rocks permit the discovery of such ore bodies by electrical prospecting methods. Natural electric currents may be measured, or electrical currents supplied by generators or batteries may be introduced into the ground, and their effects measured. Many ore deposits have been found by electrical methods. Electromagnetic studies may also be made in conjunction with electrical studies, and they provide information not available from electrical studies alone. In this method, the variation in strength of magnetic fields set up by electrical currents is studied.

Seismic methods consist of measuring refraction or reflection of artificial earthquake waves induced by controlled explosions. These methods have their greatest utility in the petroleum industry and have not been much used in exploration for other minerals.

Ores of radioactive metals, such as uranium, thorium, or radium, may be detected through their radioactivity. Geiger counters and scintillometers have been widely used in the search for uranium in recent years. Their use is severely limited, however, by the fact that a few feet or yards of overburden absorb the radiation.

In recent years much geophysical work has been done from the air, either by plane or by helicopter. A single flight may be simultaneously record data on magnetism, gravity, and radioactivity. Combinations of geophysical methods are generally of
more use than one method alone; moreover, several geological interpretations are commonly possible, and must be tested against the local or regional geology. Finally, to determine whether or not ore is present, drilling of chosen sites is necessary.

Photogeology has become a powerful exploration tool in recent years. Rock formations and structures are plotted on air photos by stereoscopic study; land surface forms and vegetation patterns are used in the geologic interpretation of the photos. This approach permits the geology of an area to be worked out with fair to good accuracy, much more quickly and cheaply than by older methods of surface mapping.

Geochemical methods of exploration have also been developed. Natural waters and many plants contain trace amounts of different metals. By appropriate chemical tests of stream, spring, or well water, and of the ashes of plant branches, stems, or leaves, the metals present may be measured. Such knowledge, compiled for a region, may lead to the discovery of hidden ore bodies, because the plants and waters near such deposits may show high concentrations of the metals contained in the deposits.

The mode of discovery of new ore deposits has changed drastically over the past hundred years. The individual prospector, systematically checking every likely looking outcrop of rock stained by iron oxide (suspected of being a gossan or "iron cap" on a vein) has largely disappeared. The latter part of this hundred years has seen the evolution of modern team exploration in which geologists, geophysicists, and geochemists cooperate. Data gathered by all of these scientists are analyzed and likely places of ore occurrence, deduced from the data, are tested.

Modernization of mining methods

Methods of mining have changed as drastically as methods of exploration; mining machinery is complex today and requires skilled labor for its operation.

Changes in underground mining methods

Early mining in Idaho was slow and laborious. Drilling was done with hand steel and doublejacks. A chisel-edged steel bar was driven into the rock and rotated slightly after each blow of an 8-pound hammer (the doublejack). This was slow, hard work, as a little practice will prove. After a number of holes were drilled, powder was inserted and a "round" blasted down. Then the muck (broken rock and ore) was loaded into a wheelbarrow or a small mine car on rails and pushed or drawn by animal to the ore bin at the surface. Hoisting of ore was done with crude, animal-powered windlasses or steam-powered winches. Steam hoisting was being used in the Buffalo Hump district in 1903.

In the early days, timbers for underground support were fashioned with hand tools. About 1915, concrete and steel began to come into use for underground support, in part replacing wood. Concrete was used and still is used for support of
Dredge of Porter Brothers Corporation, in Bear Valley, Idaho, dredging minerals containing columbium, tantalum, uranium, and the rare earth metals.

clined rotating screen-barrel, which separates the coarse boulders from the finer sands and gravel that contain the gold. A jig is a shaker-box, with a screen bottom, partly filled with steel shot. When gold-bearing gravel and sand are passed through the top of the box, while the box is being shaken, the gold and other heavy minerals sink through the shot and through the screen at the bottom. The sand and fine gravel "float" across the top of the shot layer and out of the box. Such devices as those described above have removed much of the labor from placer mining and reduced the cost, so that large low-grade deposits can be worked for their gold or other valuable mineral content.

For small placer deposits, the dragline-washing plant combination has proved to be an effective mining combination. The dragline is used to dig the gravel and load it into the washing plant. The washing plant is an inclined, rotating "screen-barrel", through which the gravel is passed and washed. The fines are taken off below the barrel, and, most commonly, passed over a small metal sluice box, mounted on the plant, to recover the gold. On larger plants, jigs may be used. In 1957, in the Elk City district, an operator using a dragline and washing plant, was mining gravel at a profit that contained as little as 18¢ per cubic yard in gold.

Under present law in Idaho, placer miners are not permitted to pollute streams. This means that the mining operation must be dammed off from the main stream as completely as possible. Further, the gravel removed in mining must be backfilled and the disturbed ground replaced to conform reasonably with previous natural contours. Application of these practices has demonstrated that placer mining will henceforth, instead of destroying valuable pasture and agricultural lands, return these lands to their former condition, after the valuable minerals present in the underlying gravels have been removed. Recent extensive dredge mining operations in Bear Valley serve as an excellent model of an operation being conducted in conformity with all the practices required by the law. Here the operator has replaced topsoil and reseeded the dredged area to produce pasture land superior to that in use for grazing before the dredging was done.

Modernization of ore-processing methods

Early-day milling practices were about as laborious as the mining methods. Stamp mills, jigs, and tables were the devices in common use to extract the valuable minerals from ores. Stamp mills are large, vertical, mechanical hammers for crushing ore. Stamp mills were in use in the Boise Basin as early as 1864. They are very little used now except in small "shoe-string" operations. Jigs have been described earlier. Tables are gently inclined, flat, shaking devices with small strips nailed on horizontally. When finely crushed ore and water are passed over them, during gentle side-wise shaking, the heavy, valuable constituents are separated from the light gangue materials. Gangue is the miner's term for waste rock.

Gyratory crushers have largely replaced stamp mills. Electrically driven rod mills and ball mills are used for fine grinding of the ore. Finely ground ores
from such mills, for many metals, are then most efficiently treated by flotation. In the flotation process, finely ground ore particles cling to froth bubbles of certain reagents and float, whereas gangue sinks. The ore-bearing froth is skimmed off and the valuable minerals thereby recovered. Flotation replaced gravity concentration in the Coeur d'Alene mining district about 1916.

New separation methods have come into use in Idaho recently. At Lowman, where placer concentrates from Bear Valley are treated, electrostatic and electromagnetic processes are used. Certain minerals, depending on their conductivity, may be separated from others upon being passed over electrically charged rotating drums or belts. Others, depending upon differences in magnetic susceptibility—the degree to which they are attracted by a strong electromagnet—may be separated upon being passed through a strong magnetic field.

The increasing importance of nonmetallic minerals

Because of changing technology, and increasing consumption of mineral products of many kinds, the dollar value of nonmetallic ores produced in the United States has in recent years exceeded that of metalliferous ores. It seems certain that this will continue to be so in the foreseeable future. Although Idaho is one of the few states whose mineral production is still mainly in metals, even here the upward trend of nonmetallic production is notable.

In the early days of Idaho mining, gold, silver, lead and zinc were the principal valuable mineral commodities produced. Silver, lead, and zinc are still our most important minerals, but gold production has fallen to less than one percent of the State's total. On the other hand many mineral commodities are produced now that had little or no economic value in 1870.

Phosphate, discovered in Idaho in 1906, has become steadily more important in the past 15 years. In the last few years significant amounts of such mineral commodities as beryl, cement rock, gypsum, monazite, uranium, mica, clay, antimony, barite, perlite, diatomite, cobalt, tungsten and nickel have been produced in Idaho. And unglamorous sand and gravel has become an important member of Idaho's mineral family.

Idaho also has reserves of minerals that contain zirconium, beryllium, rare earths, uranium, titanium, tungsten, cerium, columbium, tantalum, thorium, and cesium. These minerals have great economic potential. They are variously used in jet engine parts, atomic energy applications, and other numerous special industrial applications.

Ground water is a vital nonmetallic mineral commodity whose value cannot generally be expressed in terms of dollars and cents. The cost of water is gradually increasing as supplies become more scarce and it must be brought from greater depths or distances to the place of use. Most of the United States is currently using water at a rate greater than the natural rate of recharge by precipitation. Unless new
Even in Idaho, one of the few states in which the value of metal production still exceeds the value of nonmetallics, the industrial minerals are of increasing importance. The growth of industrial centers and the development of highways to link them depend on the availability of construction minerals like cement rock (ABOVE: Plant of the Idaho Portland Cement Company at Inkom), pumice (RIGHT) and sand and gravel (BELOW).
sources of water can be found by careful geologic ground water studies and other kinds of scientific research, water shortages will be increasingly serious in many parts of the nation. Idaho is blessed with ground water supplies that, for the immediate future, appear adequate to meet the needs of a growing state.

Need for scientists and engineers in the mineral industry

From the foregoing discussion it can be seen that the mineral industry is much more complex than it used to be. Mineral deposits are harder to find, and mineral exploration requires the knowledge and use of complex equipment, as well as a mind well trained in the basic sciences. Mining and milling are also more complex and require trained engineering personnel for installation and supervision.

Mineral products are being consumed at a great and growing rate. In the future, more people will be required to find and extract much larger amounts of mineral products from the earth, than are now engaged in these activities. By and large, they will have to be highly trained in order to succeed. There will be more opportunities in the mineral industry, but the opportunities will increasingly be open only to well-trained earth scientists and mineral engineers.

For further reading


Mining Geology by H. E. McKinstry, Prentice-Hall, 1948.

At the loading facility of the Ballard Mine phosphate ore is screened, weighed and loaded into trucks. These trucks, each carrying about 72 tons of phosphate ore, travel on a special highway to Monsanto Chemical Company’s elemental phosphorus plant near Soda Springs, Idaho.
MODERN MINING METHODS

After discovery of a promising mineral deposit, extensive geological and engineering work must be done to determine its shape, size and quality, or grade, which is the term commonly used in referring to the percentage of metal or mineral content. Once these factors are determined an extremely important decision must be made by the engineers in charge. They must decide which of several mining methods to use in extracting the ore from the earth's crust. All mining methods vary in detail, but all fall into two categories: underground and open pit*.

Underground mining methods

Wherever a mineral deposit is found so deep below the surface of the earth that the removal of the overlying material would be impractical; or, wherever the depth of the deposit is significantly greater than its length or width, underground mining methods are used. Underground mining presents many problems not found in open pit mining. Therefore, underground mining usually requires a fairly high-grade ore deposit in order to be profitable--especially if the mine is very deep.

The deep mines in Idaho are famous throughout the world. Dozens are located throughout the State. However, a concentration of deep underground mines is found in the rich Coeur d'Alene mining district in the northern part of the State. This district covers an area of about 300 square miles and includes the towns of Wallace, Wardner, Kellogg, Mullan, Burke, Osburn, and Silverton. Some mines in the Coeur d'Alenes have been producing steadily for over 50 years, thus making the district one of about a dozen mining regions in the world where more than a billion dollars worth of ore has been removed from the earth.

*One important exception, placer mining, warrants a separate classification. Placer deposits form a relatively very thin layer on the earth's surface. They most often are sand and gravel with minute quantities of one or more valuable minerals such as gold, platinum, monazite, ilmenite, zircon and rutile. To be economically successful, most placer deposits require handling huge volumes of material in a short time. Dredges and draglines (see chapter IV, Transitions in the Industry) are the most widely used placer mining equipment. The minerals which can be economically recovered from a placer deposit are always more dense than the waste material. Therefore, separation of the extremely small valuable portion from the main body of material is always based on the fact that the small, heavy particles will settle much faster in water than the larger, lighter particles. The dredge or dragline digs the material and dumps it into a controlled stream of water which passes over some type of separation device. Riffles, slots or corrugations that are placed along the bottom of the path of the mineral laden water catch and retain the heavy particles where they fall.
The Bunker Hill mine as an example

The great Bunker Hill mine in Kellogg, Idaho, which is owned and operated by the Bunker Hill Company, is a typical example of modern day mining in the Coeur d'Alenes. It is the largest lead mine, in terms of production, in the United States and it is also a major producer of zinc and silver. The first shovel of rock was moved about 75 years ago, and since that time over 24,000,000 tons of ore have been extracted from its workings. The mine now contains over 100 miles of underground passageways that are, or have been, used to get to the working areas. The lowest mineral producing zone in the mine is over 5,000 feet below the surface, and yet the bottom of the ore is not in sight—it extends down even deeper into the earth's interior.

To picture how the ore is removed from the Bunker Hill it is well to visualize the problem which faces the men operating the mine. The ore body consists of several well defined veins of lead, zinc, and silver minerals with small quantities of copper and gold. These veins appear to be steeply inclined cracks in the earth's crust that have filled with minerals during several periods of geologic activity. The problem is this: the valuable minerals must be completely removed while, at the same time, a minimum of waste material is handled. In other words, mining must be highly selective. Why? Simply because the cost of moving a pound of waste is the same as that for a pound of ore. Unless great care is taken the total cost to mine the ore could exceed the price for which the minerals could be sold.

The problem is complicated by natural phenomena. The ground surrounding the veins is generally weak or unstable and will not stand without artificial supports once the minerals are removed. Ground water continually drains into the workings and must be pumped to the surface. The temperature of the rock increases with depth and, consequently, the mine air must not only be replaced with fresh air from the surface, but some of it must also be refrigerated in order to provide a tolerable temperature in which men can work efficiently.

The development of an underground mine

To gain a clearer picture of the mining procedure it is necessary to follow the sequence of operations, starting at the surface. First, a vertical or inclined opening called a shaft is driven to a desired depth. It must be located in worthless country rock, because only ground weakened by the cracks or faults in which mineral deposits occur will provide trouble-free operation. Unfortunately, therefore, nothing that is removed has any value. The main shaft in the Bunker Hill mine is over 5,000 feet deep. To cite a familiar comparison: a ride to the bottom of this shaft on the cage or elevator would be about five times as long a ride to the top of the Empire State building. The enormous underground hoist which lifts and lowers men, ore and materials in this shaft is an engineering marvel. It is the largest underground hoist in the United States, and one of the largest in the world. Installed in a spotless underground room which is three stories high, the hoist's two cable drums are twice as high as a man and are capable of carrying one and one-quarter miles of heavy steel cable.
A slice of the earth cut at right angles to the Bunker Hill mine would appear as shown above. Once the shaft reaches the desired depth, work proceeds horizontally. A drift about 8 feet square is driven to follow the ore vein. The vein is bordered by two walls of worthless country rock. The wall above the vein is the hanging wall; the one below is the foot wall for the length of the orebody. At selected intervals other horizontal openings (crosscuts) are driven at right angles from the drift to the hanging wall (in the drawing above, the crosscut has been filled with waste rock). At the same time raises are driven upward on the vein to block out the ore for mining.

Then stopping operations begin to remove the bulk of the ore deposit. The miner and his helper drill small-diameter horizontal holes into an exposed face of ore. The holes are loaded with dynamite and the round is set off. The broken ore or muck is scraped to the ore chute where it drops to the drift below. Large timbers are put in place to prevent the walls and roof of the stope from caving into the working area. The timbers form the outline of a cube about six feet on a side—the same size as the portion of ore that was removed—and are called a square set.

An underground ore train operates in the drift, and periodically picks up several carloads of ore from the ore chute. The ore is delivered to the shaft and hoisted to the surface. When the last scraperload of muck has been taken from the stope, the miner sets up his drill and the process is repeated. Soon a cut or slice of ore has been removed across the entire width of vein from one raise to the next. Mining progresses upward as successive cuts or slices of ore are removed.

As successive slices of ore are removed the weight of the hanging wall and ore becomes so great the timbers begin to collapse. Therefore, waste rock is used to fill the mined out portions as soon as it is practicable.

The timbers are never recovered. The mining method briefly described above is just one of several underground methods in use today; it is called the timbered cut-and-fill method.
ABOVE: A relatively new development in mining is the use of wire screens like the one shown above to control rockfalls. The screen is held in place by rock bolts driven into shallow holes previously drilled in the rock. — Mining World photo.

BELOW: After the dust from a blast has cleared away, the broken ore is scraped to a raise where it drops to ore cars on the drift below. The cars are then pulled to the shaft by a battery-powered locomotive, and the ore is then hoisted to the surface. The scraping operation is shown in the picture.
Once the shaft reaches the desired depth, a working station is excavated and work proceeds on horizontal plane. A drift, which is a horizontal opening about 8 feet square, is driven to follow the ore vein. The vein is, of course, bordered by two walls of waste rock; and these walls are inclined at an angle ranging from fairly flat to nearly vertical. In mining terminology the wall above the vein is known as the hanging wall, and the one below is called the footwall. The drift is driven in the vein adjacent to the footwall for the length of the ore body. At selected intervals other horizontal openings (crosscuts) are driven at about right angles from the drift to the hanging wall. At the same time raises are driven upward on the vein to block out the ore for mining.

Getting out the ore

When a sufficient tonnage of ore has been blocked out stoping operations begin. Stoping is the procedure of removing the bulk of the ore deposit. Although some ore is removed in drifting and crosscutting, the mine does not begin to "pay" until efficient stoping methods can be put into use.

In stoping, the ore is removed in about 6-foot cubes. The miner and his helper drill small-diameter horizontal holes into the exposed face of ore. Light-weight, air-powered percussion drills penetrate the ore quickly. After sufficient holes have been drilled in a definite pattern and to the correct depth, they are loaded with high-grade dynamite. This expensive high explosive must be used in order to keep to a minimum the production of undesirable gases resulting from the explosion. Everyone leaves the blasting area and the round is set off. Drilling and blasting in all other mine work follows the same general routine.

After the gases from the blast have been replaced by fresh air from the mine's ventilation system, the broken ore, or muck, as it is commonly called by miners, is scraped or sluiced to the chute compartment of the raise where it drops to the drift below. Large pieces of timber are then put in place to support the walls and roof of the stope and prevent them from caving into the working area. The timbers form the outline of a cube about six feet on each side—the same size as the portion of ore that was removed—and are called a square set. Many of the shafts, drifts, crosscuts and raises must also be held in shape by timber, steel or concrete supports. Often great crushing weight must be resisted to keep mine workings open. In fact, if the supports were not maintained by constant repair and replacement, the workings would soon cave and much of the ore might be lost.

An underground ore train operates on track installed on the floor of the drift, and periodically picks up several carloads of ore from the ore chute. The ore is delivered to the shaft and is hoisted to the surface.

As soon as the last scraperload of muck has been taken from the stope, the miner sets up his drill and the process is repeated. Soon a cut or slice of ore has been removed across the entire width of vein from the one raise to the next.
Mining progresses upward as successive cuts or slices of ore are removed. Gravity plays an important role since broken ore is always dropped to a drift below.

**Ground support**

As successive slices of ore are removed the weight of the hanging wall and ore becomes so great the timbers begin to collapse. Therefore, waste rock is used to fill the mined out portions as soon as it is practicable. It is the waste there-after that withstands the ever-increasing pressure. The timber is never recovered. In more recent years a method of sand fill has been developed. This method involves the use of finely crushed rock (mill tailings) which is mixed with water and returned to the mine workings through pipes to serve as waste fill for the excavated areas in the stopes. The mining method briefly described above is just one of several underground methods in use today; it is called the timbered cut-and-fill method.

**Rockbolts** have come into wide use in recent years. In using a rockbolt, a hole of appropriate size is drilled into the back (the roof of an underground opening). A steel rod, threaded on one end and split on the other, is inserted into the hole, split end up, with a wedge in the split. The rod is then driven into place with a heavy hammer or a pneumatic hammer and firmly seated. A drilled steel plate is placed over the threaded end of the bolt, and a nut is screwed on and drawn up tightly. In some situations such rockbolts replace timber, hold the rock better, and cost less. Furthermore, smaller openings may be driven (timber takes a lot of space), still further reducing mining costs.

A mine is literally a "beehive" of activity, because several different mining operations may be going on at the same time. Some miners may be driving a drift or raise; some installing supports; others extending the shaft, while many are mining in the stopes. In addition, part of the labor and engineering force is doing work which, although it may not directly move a pound of ore, is vitally necessary for the mine's continued operation. Ventilation and pumping are just two examples.

**Ventilation and pumping**

To provide fresh air throughout the maze of shafts, drifts, raises, and stopes, a network of huge fans circulate large volumes of air through the mine each minute. This means that the mine fans push or pull tons of fresh air down one shaft, through the workings, and out another shaft during every eight-hour shift! At the Bunker Hill mine, for example, about 2,900 tons of fresh air are pumped through the workings each shift as compared with a total daily production of about 2,200 tons of ore.

The steady flow of ground water into the mine openings never ceases. Pumping must go on continuously, even when the mine is not in operation. At the Bunker Hill an average of 1,300 gallons of water is pumped out of the mine each minute of every day, 365 days a year. Great damage would result to the mine if this pumping were interrupted for any length of time. Large portions of the mine would soon be flooded.
ABOVE: Miners placing timbers for support of walls and roof of stope.

ABOVE:
Pumping must go on continuously to prevent the slow but steady flow of water from flooding the mine. Here is an underground pumping station where water is lifted several hundred feet to the surface.

RIGHT:
Ventilation of mine workings is of utmost importance. Pictured is one of a network of large underground fans used to supply fresh air to the mines. The weight of air pushed or pulled through the mine each day exceeds the weight of ore removed.
Ventilation and pumping systems require planning, installation and maintenance, which can only be accomplished by the efforts of many people and the expenditure of large amounts of money. This is true of all phases of mining. Considerable sums of money often must be risked before a mine, even a good one, returns a cent to its owners. And, during the entire life of the mine, wealth must be put back into the ground in the form of ground supports, power to operate mining equipment and explosives—to name just a few examples.

Workers, engineers and management are always searching for new ways to cut costs. They are mindful of the latest developments in mining equipment and the newest advances in mining technology.* National meetings are held to promote a fruitful exchange of ideas. Many monthly magazines are published for the sole purpose of improving mining efficiency.

**Safety**

Last, but far from least, mining companies have made steady improvements in their safety record since the turn of the century. Accident prevention has saved tens of millions of dollars and inestimable human suffering. It has proved to be the most worthwhile cost-reduction plan of all. Today, working in an up-to-date metal mine like the Bunker Hill is only slightly more dangerous than driving an automobile! Good as the record is, the attitude today is not one of complacency. Everyone interested in mining is striving to make it even safer.

**Open-pit mining methods**

An ore deposit can be mined most easily and cheaply by open-pit mining methods provided it lies close to the surface, and its length and width are greater than its depth. Even very low-grade deposits can be extracted economically in open-pit mining because the efficient use of large equipment enables mining men to move huge volumes of material quickly at low cost.

Idaho has several open-pit mining operations. Two of Idaho's major non-metallic mineral producers, J. R. Simplot Company and Monsanto Chemical Company, provide excellent examples. Simplot and Monsanto mine phosphate rock and phosphatic shale which are chemically processed to supply superphosphate fertilizers, phosphorus and other phosphoric compounds. These substances lack some of the glamour of the metals, but they are vital to industry, agriculture and to the nation's economy. Important as it is, phosphate rock nevertheless has a very low market price. Production costs are critical; a few cents per ton increase in mining costs

*At present the Coeur d'Alene mining district is the center for testing one of the newest innovations in mine support techniques—precast reinforced concrete drift sets. The sets have been designed, installed, and thoroughly tested by the U. S. Bureau of Mines in cooperation with the University of Idaho's College of Mines and the Idaho mining industry. In the future it is probable that similar sets will be used in many mines throughout the world.
could seriously decrease the amount of material available for removal and processing because those few cents might represent the difference between profit and loss for the operating company.

The Gay mine

The phosphate mine which is controlled and operated by Simplot about 30 miles north of Pocatello is known as the Gay mine. It is the largest of several mining properties operated by the company. The mine started operations in 1946, and now supplies most of the company’s annual production of over 1,000,000 tons of phosphate rock and phosphatic shale.

The phosphate-bearing rock at the Gay mine forms a layer, or bed, about 30 to 40 feet thick that is tilted slightly from the horizontal. This bed is covered with up to 150 feet of worthless soil and rock termed overburden.

Before the mineral deposit can be mined, the overburden must be stripped off. Giant diesel-powered scrapers swing into action and gouge 50 tons out of the earth each load. The waste is transported to some nearby valley, or it is used to fill an excavation made by earlier mining operations. Each year Simplot removes enough waste to make a pile of rock and dirt one block square and 35 stories high! The total weight of waste moved, in fact, amounts to more than four times the weight of phosphate rock and phosphatic shale mined. It is not difficult to understand why mine operators are on the lookout for new developments in earth-moving equipment. Every improvement which reduces the cost of moving waste results, as do all increases in mining efficiency, in more complete utilization of the mineral reserves.

In most open pit mines the ore must be drilled and blasted, just the same as in underground mining. Some pits are fortunate enough to be able to use very low-grade explosives which reduce costs appreciably. At the Gay mine, the ore can be dug without any blasting. Therefore, when a sufficient area of ore has been exposed, large diesel-powered shovels and trucks are put into use immediately. The high-capacity shovels, which are taller than a three-story building, stand on the upper surface of the bed underlying the phosphate rock and scoop a roomful of ore at a time into waiting trucks. As soon as the last of the ore drops into a truck, the driver starts his trip to the railroad loading area where the ore is transferred to a special type of railroad car. Simplot’s Gay mine supplies the raw material for both the company’s super-phosphate fertilizer plant and for the elemental phosphorus plant of Food Machinery and Chemical Corporation, both near Pocatello.

The Ballard mine

At Monsanto’s Ballard phosphate mine, special trucks are used to carry the ore to the company’s elemental phosphorus plant in Soda Springs, about 11 miles away. The trucks are truly enormous; they are believed to be the largest high haulers in the country. Each truck can carry 75 tons of ore. The combined weight of the truck and its load is just about the same as the weight of a B-52 bomber.
In fact, the truck’s weight and size are so great that the company has constructed a private highway from the mine to the plant. The road is fenced, and several underpasses along the route permit farmers to move machinery and stock from one side to the other without crossing the right-of-way. Where the road crosses the State Highway and also where it crosses a county road, red and green traffic lights have been installed. Pressure pads located on the Monsanto road 500 feet from the intersections cause the signals to turn red to public traffic. The crossings have been designed to comply with State Highway Engineers' recommendations in order to afford the public optimum safety.

The new road and huge trucks represent just one more step in increasing mining efficiency. Four of the new carriers do the work of 15 smaller trucks formerly used in the operation—at less cost. Through the adoption of this improved haulage system the Monsanto Company was able to double its reserves of mineable phosphate rock.

For further reading

Books on mining methods:


Mining magazines:

Engineering and Mining Journal, McGraw-Hill, 330 West 42nd St., New York 36, N. Y.

Mining Congress Journal, American Mining Congress, 1102 Ring Bldg., Washington 6, D. C.

Mining Engineering, American Inst. of Mining, Metallurgical and Petroleum Engineers, 29 W. 39th St., New York 18, N. Y.

Mining World, Miller Freeman Publications, 500 Howard St., San Francisco 5, California
Books of general information on mining:


First Book of Mining, (grades 3 to 6 in elementary school) Franklin Watts, Inc., 699 Madison Ave., New York 21, N. Y.

Underground Riches, (grades 5 to 9), William Morrow Co., 425 Fourth Ave, New York, N. Y.
Ore from a mine is crushed in large machines like the gyratory crusher shown at the LEFT, then ground to still finer size which allows much of the waste material to be removed by mechanical processes. The concentrates from the mill are sent to a smelter (ABOVE), where pure metals are produced.
MODERN MILLING AND SMELTING METHODS

Joseph Newton

After ore has been mined it must be treated by various processes of extractive metallurgy to separate the valuable metal, refine it, and cast it into shapes (pigs, ingots, cakes, or bars) suitable for marketing. We shall consider some of the methods used in Idaho to recover lead, zinc, and silver, but first let us define and discuss a few terms.

Ore and gangue minerals

The minerals from which valuable metals may be extracted are known as ore minerals, and the valueless minerals commonly mixed with the ore minerals in nature are called gangue minerals. The ore minerals constitute almost 100 percent of the ore in certain high-grade iron ores; on the other hand, the ore mineral in commercial gold ore may comprise only a few thousandths of one percent of the total.

Most ore minerals are chemical compounds of a metal; the most important minerals of the metals lead and zinc are respectively galena (lead sulfide) and sphalerite (zinc sulfide). In a few instances (notably gold) the ore mineral is the uncombined elemental metal.

Ore today may be waste tomorrow

Ore may be defined as a mineral aggregate (rock) from which a metal or metals may be extracted at a profit. Thus an ore is a sometime thing; what is valuable ore today may be just worthless rock next week. There are no handbooks or textbooks that can be consulted to determine whether a given specimen is ore or not. In fact, a hand sample of rock is not properly ore at all, because we cannot extract and sell the small amount of metal it contains at a profit. The definition of ore must encompass the entire ore deposit, because its commercial value depends upon many things besides its mineralogical composition—its size, its geographic location, its geologic setting, and the market prices of the metals it contains.

Some mines use what is called an "economic cut-off" to distinguish "ore" from "waste." In a particular lead mine for example, it may not pay to mine any rock that contains less than 1.0 percent lead. The manager must visualize an invisible but very real "assay wall" which bounds the ore bodies in his mine. If the price of metal goes up it may be possible to mine ore containing 0.75 percent lead, and the walls of the ore body will expand accordingly; if the price of metal goes down, the assay walls may close in at an alarming rate.
Milling of Bunker Hill ore

Many different metallurgical processes are employed in treating ores after they have been mined; we shall describe the methods used by the Bunker Hill Company in Idaho's Shoshone County.

The ores from the Bunker Hill mine (and other mines in the Coeur d'Alene district) are lead-zinc ores in which the principal ore minerals are galena (lead sulfide) and sphalerite (zinc sulfide). The first step in the treatment of these ores is to separate these valuable minerals from one another and from the valueless gangue. The lead and zinc concentrates are then dispatched to the lead smelter and the zinc leaching plant respectively; the gangue tailings may be sent to a tailing pond or put back underground to help fill the cavities left when the ore was mined.

This process of mechanically separating the ore into two or more fractions is known variously as milling, ore dressing, mineral dressing, or beneficiation. By whatever name, it is the key to the successful treatment of most ores, because it is relatively cheap and it produces high-grade concentrates for subsequent chemical treatment.

Milling includes two essential operations: (1) crushing and grinding to liberate the various species of minerals from one another, and (2) concentration to separate the minerals into commercial concentrates and worthless tailings.

Ore from the Bunker Hill mine contains about 7 percent lead as galena, 2.5 percent zinc as sphalerite, and about 3 ounces of silver per ton of ore. When speaking of gold and silver, we always refer to weights in ounces, and assays in ounces per ton. These are not the ordinary avoirdupois ounces which run 16 to the pound; they are troy ounces. A troy ounce is larger than an avoirdupois ounce; there are 14.59 troy ounces in an ordinary pound and 29,167 of them in a ton. Our 3-ounces-per-ton assay, then, means that the ore contains about 1 part silver in 10,000 parts of ore or 0.01 percent.

Crushing and grinding the ore

About 2,200 tons of ore enter the Bunker Hill mill every day, and it comes from the mine in chunks which are up to 12 inches in diameter. Before the minerals can be successfully separated, all this ore must be crushed and ground until it is as fine as confectioner's sugar.

Preliminary crushing is done in two stages by large crushers; the crushed ore is "minus one inch" which means that it will all pass through a screen with one-inch openings. This crushed ore is stored in a bin holding 2,000 tons; from here it is fed to the ball mills which do the final grinding.

Three large ball mills grind the crushed ore to the required size, and each of them will grind about 750 tons per day. Ball mills are large cylinders which rotate on a horizontal axis. Each mill contains about 40 tons of steel balls; each ball...
ABOVE: Grinding section of the Bunker Hill mill, showing spiral classifiers, large cylindrical ball mills, and a smaller cylindro-conical regrind mill.

BELOW: Froth of galena-laden bubbles in lead flotation cells at the Bunker Hill mill.
weighs about 10 pounds, and the tumbling action of this ball load pulverizes the crushed ore in the mill. Water is fed into the mill with the ore so that the ore particles form a pulp (ore slurry or suspension) with the water; this pulp can be handled almost like a liquid, and the ore particles remain in a solid-water pulp for all the rest of the milling operation.

Pulp overflows from the ball mill and goes to a classifier which separates it into sands and slimes. The slimes are minerals which are ground fine enough to pass on to the concentration stage; the sands include the particles which are still too coarse, and they are returned to the ball mill for further grinding. The ball mill and classifier form a closed-circuit unit and no particle of ore can escape from the circuit until it is small enough to "overflow" the classifier.

Grinding wears away the steel balls and the steel lining of the mill so that new balls have to be added continually, and the mills must be re-lined at regular intervals. Bunker Hill ores consume about 2 pounds of steel for every ton of ore; thus about 2.5 tons of steel are ground up every day.

The final product of the crushing and grinding cycle, then, is the classifier overflow—a solid-water pulp carrying the minerals which have been ground sufficiently fine. This pulp flows to the flotation cells where the minerals are separated.

Concentrating the ore minerals

Many methods are used for concentrating ores; the method used by Bunker Hill is differential flotation. This is the almost universal method for treating lead-zinc ores.

Pulp from the classifiers goes to a conditioning tank where certain chemical agents are added which react with the surfaces of some of the minerals to form an oily, water-repellent coating. After conditioning, the pulp flows through a bank of flotation cells. The reagents added in the conditioner react selectively with galena; the galena minerals receive a water-repellent "overcoat," and all the other minerals are unaffected. Only small amounts of reagents are needed—as little as a few hundredths of a pound of reagent per ton of ore in many cases. In addition to the collectors and conditioners which modify the mineral surface, a small amount of a frothing agent is added to the pulp; this will produce a stable froth on the surface of the flotation cells.

The flotation cells contain agitators ("Propellers") which keep the pulp stirred up and also draw air into it; the air bubbles rise through the pulp and form a froth above the pulp surface. The water-repellent surfaces of the galena particles cling to the rising bubbles; the galena is collected in the froth; the other minerals remain suspended in the pulp.

The froth on a flotation cell resembles the froth or lather of soap, but it differs from soap suds in two important ways. First of all, each bubble is
covered or "armored" with a layer of galena particles. In the second place this froth is more "brittle" than soap suds and the bubbles break readily. Revolving paddles sweep the froth into a launder, and a spray of water breaks down the bubbles and washes the pulp on to the thickeners.

This pulp contains the lead concentrate; it is allowed to settle in thickeners to remove most of the water and then filtered to remove all but about 10 percent of the water. This filter cake is the finished lead concentrate ready to go to the lead smelter; it is a stiff black mud consisting largely of fine galena particles.

This process is known as differential or selective flotation because it is possible to produce two or more different concentrates from an ore. After passing through the lead circuit, the "de-leaded" pulp is treated with reagents which make the zinc sulfide (sphalerite) flotable. Then it enters another bank of flotation cells (the zinc circuit) and here the bubbles proceed to remove the zinc mineral from the pulp. The froth is thickened and filtered and this filter cake is the zinc concentrate; it is also a stiff mud, brown in color, and lighter in weight than the lead concentrate.

The pulp flowing from the last cell in the zinc circuit contains the non-flotable minerals or the tailing; this is pumped to the tailing pond where the solid material settles out.

**Products of the mill**

From the initial 2,200 tons of coarse rock entering the mill every day, the following three fractions are produced:

<table>
<thead>
<tr>
<th>Product</th>
<th>Weight, tons</th>
<th>Pb %</th>
<th>Zn %</th>
<th>Ag oz/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead concentrate</td>
<td>160</td>
<td>67.0</td>
<td>6.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Zinc concentrate</td>
<td>65</td>
<td>1.5</td>
<td>55.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Tailing</td>
<td>1975</td>
<td>0.2</td>
<td>0.25</td>
<td>0.2</td>
</tr>
</tbody>
</table>

The combined weight of the concentrates is equal to about 10 percent of the original ore, so that 90 percent of the mill feed is sent to a tailing pond as waste. The separations are never perfect—there is some zinc in the lead concentrate, lead in the zinc concentrate, and small amounts of all three metals in the tailings. Most of the silver in the ore appears in the lead concentrate.

**Lead smelting and refining**

**Roasting and sintering**

The lead concentrate is mixed with limestone flux, zinc plant residues, and other materials, and treated on Dwight-Lloyd sintering machines. The damp mixture
of these finely divided solids is spread on moving pallets in a layer about 4 inches deep. These pallets are like little flat cars; they have grated bottoms and they move over a suction wind box which draws air down through the charge. Immediately after charging, each pallet passes under an ignition furnace which "lights" the top of the charge; as the pallet continues to pass over the wind box, the charge burns from top to bottom very much like a cigar burns from one end to the other. When the pallet reaches the end of the line, the combustion zone has passed entirely through the charge, the pallet drops over the end of the line, dumps its load, and returns on the under side of the line to be charged with another load of concentrate and flux.

Sulfides are combustible, and the lead sulfide burns with the evolution of considerable heat; most of the sulfur goes off as SO₂ gas and most of the lead is converted to lead oxide. This process, then, does two things: (1) it roasts the concentrate; that is, it burns out the sulfur and converts the lead to an oxide, and (2) it sinters the charge to convert the mixture of fine powder into a porous cellular cake or biscuit. The coarse chunks of sinter are then fed into the lead blast furnace.

**Blast furnace smelting**

A lead blast furnace is a vertical shaft furnace with a rectangular cross-section, and the walls are hollow steel plates through which water is circulated (water jackets). Bunker Hill's blast furnace has a cross-section of 72 inches by 242 inches, and it will produce about 300 tons of lead a day.

The charge enters the top of the furnace, and this charge consists almost entirely of Dwight-Lloyd sinter and coke. Air is blown in through tuyeres (air ports) near the bottom of the furnace and as soon as it enters the furnace it reacts with the coke in the charge column. The resulting reducing gas (CO) sweeps up through the charge and reduces the lead oxide to metallic lead; the heat generated melts the lead and also the unreduced oxides (silica, lime, alumina, and iron oxide) to form a liquid slag. Both molten lead and slag trickle down and collect in two layers in the crucible below the tuyere level; here the lead is withdrawn continuously from the bottom of the crucible and the slag is tapped at intervals. The slag consists of the unwanted "gangue" minerals together with the necessary fluxes to form a fusible slag. It is easy to see that it would be prohibitive to smelt the lead ore directly because of the large amount of heat and flux that would be needed to handle all the gangue minerals which the mill puts in the tailing pond.

**Slag treatment**

The lead blast furnace charge contains a large amount of zinc—this comes both from the lead concentrate and from the zinc plant residues. Zinc is not reduced to metal in the lead blast furnace; it remains oxidized and is held in the slag, and lead blast furnace slags may contain as much as 15 percent zinc. After tapping, the molten slag is poured into a zinc fuming furnace and a mixture of powdered coal and air is blown through the slag bath. The zinc is reduced to metal
which vaporizes; as soon as the vapor issues from the molten slag it reoxidizes to form very small crystals of zinc oxide fume; this is carried away in the gas stream and filtered out in bag houses. The collected fume is commercial zinc oxide for which there is a ready market.

After de-zincking the slag is ready to be discarded; it is granulated by pouring into a large volume of cold water and sluiced to the slag dump.

**Lead refining**

The crude lead or **bullion** that issues from the blast furnace contains small amounts of other easily reduced elements such as copper, tin, antimony, arsenic, gold and silver. The three important steps in refining lead are **drossing**, **softening**, and **desilverizing**.

**Drossing**

Crude bullion from the blast furnace is superheated well above its melting point; some impurities become less soluble as the metal cools and separate out as a dross which can be skimmed from the lead surface. The principal action in the drossing kettles is simply cooling, but the operation may be aided by blowing steam through the bath. When the lead contains copper, elemental sulfur is stirred into the lead in the drossing kettles; this combines with the copper and brings up a copper sulfide dross.

**Softening**

Lead from the drossing kettles is pumped to a continuous softener where the bath is oxidized with air and the base-metal impurities (antimony, tin, arsenic) removed as oxides. Antimony and other elements make lead hard and brittle so that we use the term **softening** to denote their removal.

**Desilverizing**

Drossing and softening will remove practically all of the base-metal impurities, but leave gold and silver dissolved in the lead; lead must be softened before the gold and silver can be removed.

Zinc will form insoluble compounds with gold and silver which rise to the surface of the kettle and can be skimmed off. Softened lead is treated in the desilverizing kettles by stirring slab zinc into the molten lead and skimming the resultant crusts which rise to the surface. Gold reacts even more readily than silver, and Bunker Hill first treats the bullion with a small amount of zinc to remove all the gold with some of the silver (degolding) and then adds more zinc to bring up the rest of the silver. The silver crusts formed in the second operation are virtually free of gold.
Gold and silver crusts are essentially alloys of lead, zinc, and the precious metals. They are treated by first distilling off the zinc and then oxidizing (cupelling) the lead. If the crusts are silver crusts, this treatment yields pure molten silver ready for casting into bars. If they are gold crusts, the cupellation yields a gold-silver alloy (dore bullion), and the metals are parted by dissolving the silver in sulfuric acid, and then re-precipitating the dissolved silver.

The silver refinery is an important part of the lead smelter; not only are gold and silver present in the lead-zinc ores, but gold and silver concentrates are purchased by the company and added to the blast furnace charge. Molten lead is a very efficient solvent for gold and silver. In fact the standard analytical method (fire assay) for gold and silver utilizes the same method; the gold and silver are collected in a rain of molten lead. This method is accurate enough to detect 0.01 ounces of gold per ton, or 1 part in 3 million.

**Dezincking**

After desilverizing, the lead still contains about 0.5 percent zinc (saturation zinc). This is removed by distillation; the bullion is heated in a closed kettle under vacuum and the zinc boils out and condenses on the cool lid over the kettle. After dezincing, the market lead is cast into pigs or ingots for sale.

**Zinc leaching**

Idaho zinc concentrates cannot be treated in the same fashion as lead concentrates. If we roast zinc sulfide to the oxide, we can reduce this oxide with carbon, but the temperature required is above the boiling point of zinc; consequently the metal does not form a liquid which can be collected in a crucible, but escapes as a vapor with the furnace gases. In many parts of the world, zinc is reduced in this fashion in retorts or special blast furnaces; the zinc is recovered by condensing the metal from the issuing gases.

At the Bunker Hill plant (as at other plants in the West) zinc metal is recovered by leaching and electrolysis; this is radically different from any furnace reduction method.

**Roasting**

The zinc concentrates from the mill are roasted in a flash roaster. The dried zinc concentrates are ground dry in a small ball mill and then sprayed into a hot chamber on a current of air. Here the sulfides burn much like pulverized coal, and the residual particles of zinc oxide fall onto a hearth at the bottom of the furnace. Most of the sulfur passes off in the roaster gases as SO₂.

Flash roasting removes sulfur but it does not sinter or agglomerate the charge. The roasted product, called a calcine, is a finely-divided, dust-like product.
Leaching

The calcine is agitated in leaching tanks with a strong, hot solution of sulfuric acid which takes the zinc into solution as zinc sulfate; it also dissolves some iron, arsenic, copper, cadmium, and other impurities in the calcine. Leaching is continued until all the acid is used up (the solution is neutralized) and when the neutral point is reached, iron and arsenic precipitate from the solution. The solution is then agitated with zinc dust to precipitate copper, cadmium, and any other element less "noble" than zinc. Finally, if necessary, the solution can be treated with organic reagents to precipitate cobalt if any is present.

The neutralization and purification yield a strong solution of zinc sulfate that is practically "chemically pure"—there is no free acid left, and all metals except zinc have been removed.

Leaching does not remove any lead or silver from the calcine; the leached residue containing these metals is filtered and washed and returned to the lead smelter where it enters the blast furnace via the Dwight-Lloyd sinter.

Electrolysis

Purified leach solution goes to the electrolytic tank house where it is electrolyzed between anodes of a lead-silver alloy and aluminum cathodes. These electrolytic tanks are wet storage batteries in reverse—instead of generating an electric current by chemical reaction, the electric current forced through the cells causes a chemical reaction. Zinc sulfate is decomposed, and the zinc metal deposits in a thin sheet on the aluminum cathodes; for every molecule of zinc sulfate thus destroyed, a molecule of sulfuric acid is formed in the electrolyte. Thus the solvent is regenerated and can be used again for leaching.

A small amount of zinc sulfate is formed in the roasters; this is water soluble and goes into solution without consuming acid. When it is electrolyzed, however, an equivalent amount of acid is generated. This gain of acid from water-soluble zinc just balances the acid losses so that it is never necessary to add any new acid to the leaching—electrolysis circuit.

The aluminum cathodes are removed about every 7.5 hours and the thin sheets of deposited zinc stripped from them. These are melted down and the metal is cast into slabs.

Bunker Hill zinc is extremely pure and regularly contains 99.99 percent zinc. The secret of this high purity is the careful purification of the zinc sulfate leach solution; this is so free of other metallic elements that there is nothing that can precipitate with the zinc and contaminate it.

In a sense, the lead smelter and zinc plant operate in opposite ways. The lead smelter reduces a crude metal which must be carefully purified and desilverized; the zinc plant does the refining first, and then reduces the metal.
ABOVE: In this cell room of the Bunker Hill zinc plant special high-grade zinc (99.997% pure) is deposited electrolytically onto aluminum plates.

BELOW: Stacking lead blocks at the Bunker Hill lead smelter. Each block weighs one ton.
Weighing silver bars at the Bunker Hill Smelter. Each bar weighs about 92 pounds and is worth nearly $1100 at the present market price of silver; however, 1550 silver dollars can be made from each bar, since a dollar contains only 70 cents worth of silver (0.773 of a troy ounce).

More than half of the silver produced in the United States comes from Idaho mines; the main producers are the Sunshine, Galena, Bunker Hill, and Lucky Friday mines.
Smelter products

Bunker Hill treats many ores and concentrates from other mines; some of these are silver and gold concentrates. We think of Bunker Hill primarily as a lead and zinc producer, but almost everything of value in the incoming ore and concentrate is removed and marketed in one form or another. Let us list the principal products and by-products of this complex industrial plant.

**Lead**—Market lead which has been softened and desilverized is cast into various forms: 1-ton blocks, 100-pound pigs, or 25-pound sectional ingots.

**Zinc**—Bunker Hill zinc slabs are all Special High Grade Zinc and contain better than 99.99 percent zinc.

**Silver and gold**—Any silver or gold that enters the system finally winds up in the lead bullion; if it is originally in a zinc concentrate, it enters the blast furnace with the zinc leaching residue. Although the tonnage of silver is small compared to that of lead or zinc, the value is so great that we can hardly classify it as a "by-product".

**Zinc oxide**—Zinc in the blast furnace slag is recovered and sold as zinc oxide. If necessary, of course, this could be used as feed to the zinc plant.

**Copper**—Small amounts of copper in the ores are recovered in the lead drosses and in the precipitates from purification of zinc solution. These high-copper by-products are usually sold to copper smelters.

**Antimony**—Most of the antimony comes out in the skims from the lead softener. These skims are stored and then smelted in a small furnace to produce antimonial lead ("hard" lead).

**Cadmium**—Cadmium is recovered in two places—first from some of the furnace fumes in the lead smelter, and from the purification of zinc sulfate solutions. These by-products are treated to yield pure metallic cadmium in two cadmium plants—one at the zinc plant and another at the lead smelter.

**Sulfuric acid**—Sulfur-rich gases from the zinc flash roasters are fed to an acid plant where they are converted to commercial sulfuric acid.

**Phosphoric acid**—Bunker Hill has just completed a plant to use some of its sulfuric acid for the production of phosphoric acid and phosphate fertilizers.

**Metal tonnages**—Here are the total tonnages of metals produced by Bunker Hill in the more than 40 years that its plants have been operating:
Lead  2,500,000 tons
Zinc   240,000 tons
Copper 35,000 tons
Antimony 26,000 tons
Cadmium  750 tons
Silver 500,000,000 troy ounces
Gold   500,000 troy ounces

Treatment of phosphate rock

The mining and processing of phosphate rock is one of the most important of Idaho's mineral industries. We cannot classify such processing as "metallurgical" because phosphorus is not a metal; however, the physical and chemical processes used are similar to the "milling" and "smelting" of metallic ores, and the two industries are closely related because the by-product sulfuric acid from lead and zinc roasting is used in making phosphate fertilizer.

Phosphate rock--The "ore" in this case is in the Phosphoria Formation, widespread over western United States and Canada; the largest and most economically attractive of the Phosphoria deposits are in Idaho. The mineral containing the phosphorus is a complex "secondary fluorapatite"--it is made up of calcium oxide (lime), calcium fluoride, and phosphorus oxide (P₂O₅). In composition, this mineral is very similar to the material that makes up the bones and teeth of men and animals. In most of the Idaho deposits the phosphate mineral is in the form of small spheroidal oolites; these are mixed with silts, clays, and limestones. High-grade beds consist almost entirely of these oolites and assay about 32 or 33 percent P₂O₅. Low-grade beds contain fewer phosphate oolites, and more silt, clay, or limestone.

Beneficiation--The beneficiation of Idaho phosphate rock (ore dressing) is not nearly as elaborate as the treatment given to lead-zinc ores; much of the rock is mined and sent directly to chemical processing.

Some Idaho rocks can be treated by selective grinding and desliming. If the rock is ground gently (by attrition grinding) the relatively hard oolites remain intact but the accompanying silt and clay disintegrate so that they can be washed away from the oolites to leave a high-grade concentrate. This is about the only method that has been applied to Idaho rock. In Florida and other places, more elaborate (and expensive) processes such as flotation are used to beneficiate phosphate rock.

The common practice in Idaho is to mine only those beds which are high enough in grade for direct chemical treatment; the low-grade beds are stripped away and discarded. Even though we have a large reserve of high-grade deposits, it is usually necessary to mine the low-grade beds in order to get at the high grade. Because the low-grade rock must be mined anyhow, it would be very desirable to have a simple process for concentrating or "upgrading" this low-grade rock to give a marketable product. It is likely that research will develop such a process eventually.
Phosphate rock processed in the electric furnaces of the Food Machinery and Chemical Corporation plant near Pocatello (ABOVE) emerges as elemental phosphorus, ultimately finding its way into foods, washing compounds, and a host of other products.

Phosphate ore destined for final use as fertilizer goes through chemical treatment in the J. R. Simplot Company plant near Pocatello (BELOW), which has recently been enlarged to meet the increasing need for fertilizer in the Pacific Northwest.
Fertilizer manufacture--Raw phosphate rock not only resembles bones and teeth in chemical composition but it is equally insoluble in water. To be of any value as a fertilizer, the phosphorus must be rendered soluble or "available" so that it can be picked up by plant roots. The most important method for doing this is to treat the raw rock with sulfuric acid.

Super-phosphate fertilizer is made by mixing finely ground raw phosphate rock with enough sulfuric acid to give monocalcium phosphate, $\text{CaH}_4(\text{PO}_4)_2 \cdot \text{H}_2\text{O}$ and gypsum, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. This mixture contains 16 to 20 percent $\text{P}_2\text{O}_5$.

Concentrated ("double" or "triple") super-phosphate is made in two steps. First the raw rock is treated with enough sulfuric acid to convert all the phosphorus to water-soluble phosphoric acid. This is then separated from the gypsum and undissolved residue, and the liquid phosphoric acid is used to treat a second batch of raw rock to form the monocalcium phosphate. "Triple" super-phosphate contains 40 to 48 percent $\text{P}_2\text{O}_5$.

Rock for fertilizer manufacture should contain at least 31.5 percent $\text{P}_2\text{O}_5$. In most cases it is more economical to haul the raw rock to the source of sulfuric acid rather than vice versa. The smelters at Trail, B. C., and Anaconda, Montana, have operated fertilizer plants for many years to use their by-product acid; Idaho's Bunker Hill Company has just completed construction of a fertilizer plant at its smelter in Kellogg.

Elemental phosphorus--Detergents and many other commercial chemicals are compounds of phosphorus. The best raw material for making such chemicals is pure elemental phosphorus.

Elemental phosphorus is made by "smelting" raw phosphate rock. The rock is mixed with coke to reduce the oxide to the element much as coke reduces lead oxide to metallic lead in the blast furnace. However, the "smelting" of phosphorus differs from lead smelting in two important respects:

1. Electric furnaces are used. The heat necessary is supplied by electricity and the coke is used only as a reducing agent. In the lead blast furnace the coke is a fuel as well as a reducing agent.

2. The furnace temperature is well above the boiling point of phosphorus so that it is not feasible to collect liquid phosphorus at the bottom of the furnace. The phosphorus goes off with the other furnace gases, and is recovered in a condenser.

There are very few other volatile elements in phosphate rock that will vaporize and then condense with the phosphorus; the product, therefore, is very pure.

Electric furnaces can treat lower-grade rock than that required for fertilizer manufacture by the acid process. Much of the elemental phosphorus goes to the manufacture of detergents, food additives, and other industrial chemicals; some
however, is also used to manufacture fertilizer.

**For further reading**


Mineral deposits must be mined where they are found. In 1953 tungsten was discovered in the Wildhorse Creek region of southern Custer County; the photo above was taken from the access road built to develop the deposit. Even if such a find led to the erection of a surface plant like that shown below, the area involved would still be small.
MINERAL ECONOMICS

Unique economic factors

Localized occurrence

Many of the operational and economic problems of the mineral industry are unique. Mineral resources have fixed locations—they must be mined where they occur or be left to the future. In other words, ore is where you find it (and it may not be ore until a lot of development work has been done). Even such abundant and widespread mineral commodities as coal and oil underlie only a small fraction of our land. The proportion of the earth’s surface that is underlain by other important minerals is infinitesimal. For example the molybdenum deposit at Climax, Colorado, is included in less than one square mile, but for many years 85 percent of the world’s molybdenum came from the Climax mine. A similar proportion of the world’s nickel originates in the Sudbury district of Canada, and most of the world’s sulfur has been produced from a few small areas in Louisiana and Texas.

Exhaustibility

Minerals are a nonrenewable resource. Each individual deposit has its limits and if it is worked long enough it must sooner or later be exhausted. The mineral industry contrasts sharply in this respect with agriculture and the forest industry. There is no second crop of minerals.

Increase of costs with depth

The continued extraction of minerals from nearly any deposit leads to increasing costs as the material is mined from greater and greater depths. The cost of raising oil in a flowing well is a few pennies a barrel; as the oil field becomes depleted and it is necessary to raise the oil by pumping the cost rises to about $1.00 per barrel.

Replacement hazards

It is never certain that a company, having exhausted a deposit, can discover another deposit to take its place. The search for new deposits is never-ending but their discovery is infrequent and requires much skill, a great expenditure of money, and a share of luck. Because of the world-wide depletion of deposits of the common minerals, the actual cost of replacing them (that is, finding new deposits of the same minerals) is constantly increasing.

Even when a deposit is discovered its shape, size, and grade—and therefore its value—can never be completely known until it has been exhausted. The difficulty of geologic interpretation may require a constant search for extensions of ore throughout the life of a mining property. Similarly the rapidity with which some deposits are used up makes it essential to discover new ones.
Expendable and nonexpendable minerals

Expendable minerals are those that are destroyed by use or made into a form in which they cannot be recovered. Coal and petroleum are expendable minerals. Nonexpendable minerals are those that can be recovered and re-used many times, such as gold and iron. Some of the gold stored at Fort Knox may have been a part of the treasure of the ancient pharaohs of Egypt. A mineral such as lead may be both expendable and nonexpendable in different uses. For instance, lead used as tetraethyl lead, an antiknock compound in gasoline, is blown out through millions of tailpipes into the atmosphere whence it cannot be recovered; it is expendable in this use. But lead used as plates in storage batteries is recovered and re-used; it is nonexpendable.

Mineral taxation

Ad valorem taxes

The fact that exploration for, and production of, minerals from the ground differ radically from other types of business activity is reflected in tax laws applied to the mineral industry.

Ad valorem taxation (taxation proportional to value) is extremely difficult to apply equitably to a mineral property, for the true value of a mineral property can seldom be determined until the deposit is mined out. Ad valorem taxation of most kinds of real estate is roughly proportional to benefits from government by the owner of the real estate. Not so with mineral property, which may be in an otherwise unpopulated area where the need for public services by the miners is small and not at all in proportion to the value of the property.

Local taxation of mining property in Idaho is not on the ad valorem basis. The Idaho tax is a "cash receipts less cash disbursements" tax, based on a combination of gross and net proceeds. It is a tax that enables a community dependent upon mining to have tax revenue even when the mines may be losing money.

Severance taxes

Thirty-one of the 50 states have laws which authorize the levy of some sort of severance tax upon business enterprises engaged in the severance or extraction of natural resources within their borders. The products so taxed range from oil and gas to shrimp and bullfrogs. The amount of tax may be measured by the quantity of the natural resource extracted (for example, at a rate of two cents a pound), or it may be assessed as a percentage of the gross or net profits or as a percentage of the gross value of the ore. In the early history of the United States when most of the population was dependent upon farming, fishing, and so on, the severance tax developed logically from the common practice of imposing license fees on all persons enjoying various privileges on public lands, such as cutting timber, mining coal or grazing cattle.
Taxing the physical volume or quantity of production (or the gross proceeds) provides ease and economy of administration but it imposes arbitrary discriminatory burdens on different producers within a state and between states, because it makes no allowances for differences in extraction costs among producers, and it may be imposed in one state and not another. It also results in waste by forcing abandonment of deposits of low-grade minerals which, without the tax, could have been mined and sold at a profit. To partially meet these objections, some states authorize certain deductions from gross proceeds. The Idaho severance tax (called the mine license tax), for example, is essentially a net proceeds tax, because deductions representing the cost of extracting and processing ore are allowed.

Depletion allowances

Depletion allowances are peculiar to the mineral industry. These deductions from income are allowed for tax purposes in recognition of the fact that a mining company is depleting its capital with every ton of ore produced and that it deserves to recover the capital value of the wasting ore deposit through tax allowances on much the same basis that a manufacturing company is allowed to recover (as a depreciation allowance) the capital value of a piece of machinery or a plant as it wears out. The difference in the way depletion allowances are applied arises because of the impossibility of calculating the capital value of a mineral deposit at the time of its discovery, when there is no way of knowing the size and grade of the deposit. To overcome this difficulty, which became acute during the period from 1918 to 1932 when depletion allowances were based on discovery value, depletion allowances are granted as a percentage of gross annual income, limited to 50 percent of net income in any one year. In other words, if there is no profit, there is no depletion allowance. Various percentages are used for different commodities, having been established by the U. S. Congress at various times starting in 1926. The percentages are presumably designed to give about the same revenue as would be obtained under discovery depletion; since the discovery value of an oil well or a metal mine is in general much greater than that of a sulfur or coal deposit, so are the percentages higher for oil and metals than they are for the common nonmetallic minerals.

The future

Skyrocketing demand

Before another 100 years have passed the world will have two to five times as many people in it as it now has. Many of these people will be in newly industrialized countries and, in consequence, will consume mineral resources at a higher rate than do the people in those countries now. This combination of rapidly increasing population and increasing per capita consumption of mineral commodities means a skyrocketing demand and an increasing world-wide shortage of metals and minerals.
Conservation of mineral resources

The mushrooming demand will be met. Mineral resources in the broad sense will never be exhausted, because the earth’s crust to an average depth of several tens of miles is made up of minerals. However, the economic use of minerals will increasingly demand the practice of methods of conservation. Conservation in the minerals field means wise use. It entails:

1. Highest possible extraction from the ground;
2. Highest possible extraction from the ore;
3. Use of low-grade and hard-to-process ores;
4. New sources for old minerals;
5. Substitution, where possible, of more abundant minerals for the scarcer minerals;
6. Highest possible re-use of metals;
7. Increasing effort in the search for new deposits;
8. Increasing research into the use of minerals that so far have little or no use.

In all the above, the single unifying factor is research. Improvement in technology, based upon advances in science, is our most important mineral conservation measure. For example, gradual improvement in oil refining allowed the production of three times as much gasoline from a barrel of oil in 1940 as was possible 20 years before. To furnish the U. S. with its normal quota of gasoline in 1940 by the older process would have required 50 percent more oil than was produced in that year by the entire world. As an Idaho example: the reserves of phosphate rock at the Monsanto mine in southeast Idaho were recently doubled in quantity by improvements in ore handling from the mine to the processing plant, underlining the fact that ore is an economic term and that ore reserves may be increased by technological advances without any new discovery of mineral.

Advances in geophysical and geochemical techniques of prospecting give hope that important new discoveries of deeply buried mineral deposits will be made. The ocean floor may be dredged for manganese, the ocean waters processed for a variety of minerals. Granite itself may become an ore body of the future because of the concentration of certain strategic metals in portions of granitic masses. Harnessing of atomic power to underground blasting, advances in ore-handling and processing will allow use of mineral resources not now economic to mine. Metallurgical advances will allow the economic extraction of aluminum from clay, and oil from shale. "New" metals like hafnium, beryllium, columbium, tellurium will come into prominence as uses are found for them.

In short, advances in earth science and minerals technology under the impetus of increasing demand will produce the minerals the world will need.
The position of the United States

For some mineral commodities it is now cheaper for the United States to import from relatively rich foreign deposits than it is to produce these minerals at home. For example, it costs about 5 cents a barrel in direct production costs to produce oil in Arabia, whereas it costs $1.00 per barrel to produce oil in the continental United States. The average ton of foreign lead and zinc concentrates laid down at a U. S. smelter today contains twice as much lead, zinc, and silver as our own domestic concentrates arriving at the same smelter.

This situation is only temporary, however. The skyrocketing demand for minerals the world over means that the high-grade, low-cost, easily discovered foreign deposits of today face early depletion just as surely as our own domestic bonanzas have been depleted within the last 100 years. Within a very few years U. S. industries will be forced to seek domestic sources of supply for much of the raw material now being imported, or pay higher prices for foreign ore, or develop substitutes. In the fast-approaching day of world-wide mineral shortage, our nation will have a secure mineral resources position only if it has advanced knowledge in earth science and know-how in minerals technology.

For further reading


The prospector-burro team of a hundred, or even fifty, years ago has given way to fast, modern methods of mineral exploration. Airborne crews and equipment speed exploration and make it more thorough than ever before.
POlITICAL AND SOCIAL ASPECTS OF MINING

A. J. Teske

Success stories in the mining industry make up an important chapter in the story of the growth and development of Idaho.

Unfortunately, these stories become so glamorized during repetition over the years that they tend to create a widespread impression in the minds of the general public that the development of a lasting mining enterprise involves little more than the discovery of a commercially valuable deposit of some type of metal or mineral.

To use the vernacular—you strike it rich and you have it made. That's an all-too-common concept, but it is a far cry from an accurate one.

As we have seen elsewhere in these pages, the economic problems involved in developing a raw prospect to a steady producer of ore are many and varied.

There are also numerous political and social problems which have a serious impact on exploration and mining activity.

Fluctuations in metal prices

Perhaps the outstanding characteristic of the metal mining industry, not only in Idaho, but wherever it is established, is its instability. Much of this "feast or famine" aspect is caused by economic factors, but ordinarily there are political overtones directly involved.

Extreme fluctuations in price and production are the rule rather than the exception in the metal mining industry. In part, these fluctuations are due to the nature of the industry. Suppliers of basic raw materials such as metals are among the first to feel the pinch of economic recessions and depressions because the buyers of their products begin to curtail their purchases at the first sign, or even forecast, of a decline in economic activity. They trim their production to coincide with sales, even to the extent of closing down the plant if necessary, and try to get by on the inventory of metals they have in stock.

A decline in demand for raw materials forces prices downward and puts the miner in a serious dilemma. If he maintains his rate of production while demand is low he is forced to tie up more and more of his liquid capital in metal stocks. If he curtails his output, he ordinarily increases unit costs per ton since overhead and mine maintenance costs remain almost constant. Thus, production costs rise at the same time the selling prices are dropping, and the producer finds himself in a double-edged squeeze.
In some situations these economic difficulties are aggravated by political complications. The two World Wars and the Korean conflict are excellent examples of this aspect of the problems of the mineral industry.

History provides ample evidence that periods of war and international dissensions have coincided with the most productive eras that metal-mining operations have ever experienced.

Under a war-time economy the demand for metals shoots upward at an almost fantastic rate in the effort to supply the sinews of combat—the guns, tanks, ships, planes and other items that are essential to success in battle. At the same time, enemy submarine activity renders hazardous and uncertain the obtaining of normal supplies from overseas sources. This brings government officials and the general public to a realization that the only dependable sources of supply are those obtained from domestic resources and it becomes official government policy to encourage maximum production from within our borders.

Then comes the normal aftermath of post-war adjustment. Demand recedes to the level of normal requirements for the civilian economy and mines which were encouraged to get into production at the high war-time prices find they cannot operate profitably at the more normal post-war prices. In the past it has been demonstrated that only the larger, more financially stable mine operators can survive this period of readjustment. Others fall by the wayside, their ore reserves reduced to submarginal quality by virtue of the inexorable squeeze of lower selling prices and the increased cost of production—the inflation—which has customarily resulted from the impetus of a war-time economy.

**Demonetization of silver**

These basic economic difficulties have not been the only problems which have operated to handicap the normal development of Idaho's and the nation's metal mining industry. There have been numerous others almost wholly political or social in their inception. For example, the demonetization of silver in 1879, long before Idaho was admitted to the union, was largely the result of a political controversy over the relative merits of the gold standard for monetary systems and the bimetallic standard of gold and silver. The discovery of substantial new silver deposits in the Western Hemisphere was a substantial factor in determining the supremacy of gold in this political struggle, because the increased production therefrom destroyed the established monetary ratio of silver to gold. But the resulting demonetization of silver, with its depressing impact in the world silver price, was a severe blow to silver producers, including the operators of exceptionally rich mines in the Silver City district of Owyhee County in Idaho.

**Changing public-land philosophy**

Another problem which has tended to retard the development of the mineral industry in Idaho and throughout the West has been the changing philosophy of the government with respect to the administration of public lands.
For many years after the acquisition of vast tracts of western lands through the Louisiana Purchase, the annexation of Texas and similar transactions, it was the policy of the government to encourage by every possible means the transfer of as much of these lands as possible to private ownership. It was this policy that prompted the adoption of the homesteading laws and the general mining laws of 1872, under which any citizen was permitted to acquire possessory rights to any ore discovery simply by posting the ground in accordance with simple regulations and filing notice of the mineral location with the proper local officials.

Mine prospecting and exploration under these liberal laws became a substantial factor in the pioneering and gradual development of the immense expanse of western lands, as the history of Idaho amply demonstrates. This was generally recognized by Congress and the federal authorities, and practically all legislation affecting the public lands, such as the establishment of the national forests and the homestead grazing act, were so worded as to protect the right of mineral entry.

However, as the West became more developed and populated, it became evident that slow but definite change in social philosophy toward the disposition and utilization of public lands was taking place. Perhaps the first official evidence was the passage of the Mineral Leasing Act of 1920. Under this law the ownership of all deposits of coal, phosphate, sodium, oil, oil shale and gas was vested in the United States government and these deposits were made available for development and commercial exploitation only on a lease basis, with royalties payable to the federal government on all production.

The advent of the New Deal in the early 1930's brought with it an almost revolutionary change in the political and social concepts affecting the mineral industry.

Some of the New Deal innovations were decidedly beneficial to some branches of the mineral industry. The abandonment of the gold convertibility standard, with an accompanying increase in the official gold price from $20.67 to $35.00 an ounce, for example, was a tremendous stimulus to revival of the gold mining industry. And the enactment of the silver purchase law was unquestionably advantageous to producers of silver.

However, there were other basic social concepts inherent in the New Deal philosophy which operated to discourage and hamper development of mineral resources.

Important among these concepts was the attitude that the public lands and their natural resources were by their nature the heritage of all the people and that it was a primary function of the federal government, as custodian in the name of all the people, not only to prevent this heritage from passing into private hands but also to enhance it whenever and wherever possible by reacquisition of the lands that had formerly passed into private ownership.
The result was the adoption of increasingly stringent regulations and restrictions on land use, mostly by administrative regulation rather than law. It became difficult to acquire title to mining claims through the normal process of patenting. The raising of capital for mine exploration and development through the sale of corporate stocks became increasingly difficult under the federal security laws.

The "have-not" idea

Also a distinct handicap to the normal growth and expansion of the mineral industry was the prevalence of a "have-not" philosophy with respect to mineral resources in official government circles. It became a widely accepted assumption in Washington that this nation had already used up a substantial part of its mineral resource wealth and would have to look to foreign countries for the supplies necessary to sustain our national economy. A natural development from this assumption was the acceptance of free-trade principles and the adoption of the reciprocal trade laws.

War stimulates both domestic and foreign mineral production

The war years of the early 1940's brought unprecedented demands for mineral products of all types and every conceivable means at the disposal of the government—price subsidies, furloughing soldiers for mine labor, financial assistance—were utilized to achieve the maximum possible output of minerals from domestic sources. Under this government stimulus many old mines in Idaho and throughout the West were brought back into production. Nevertheless, critical shortages of many strategic metals continued to handicap the all-out war effort and it was necessary for the responsible government agencies to look to foreign sources and encourage production in any country that could make its vital products available to the Western Allies. For example, uranium was needed for the highly secret atomic bomb project and it was widely assumed that this country was a "have-not" in uranium ore resources. Essential supplies were therefore obtained from African mines where uranium was found to be present in minute amounts in ores mined principally for gold.

This reliance upon foreign sources for strategic and critical products during the war years was a natural and logical application of the spirit of cooperation and mutual interdependence which characterized the prosecution of the war by the Western Powers. It also fitted conveniently into the pattern of expanded world trade visualized by the architects of the reciprocal trade program which had been official government policy for several years.

Thus, when hostilities were terminated, the groundwork had been laid for the popular acceptance of the principles of internationalism and mutual security which found official expression in the establishment of the United Nations, the Interna-
tional Monetary Fund, the General Agreement on Tariffs and Trade and other similar organizations.

Out of these developments have come many of the basic problems now facing the Idaho mining industry, all the result of political decisions and government policies over which the industry has no control.

Some of the decisions were temporarily beneficial to the nation's mining industry, as, for example, the stockpiling program which was undertaken in the post-war years to assure the adequacy of supplies of strategic and critical minerals for national defense in the event of another world conflict. This program provided a convenient market for the expanded production and kept prices from dropping sharply during the adjustment to normal levels of economic activity.

After the war, we continue to encourage foreign mineral production

However, this same fear of a shortage of metals for national defense prompted other government activities that have been detrimental to the interests of the domestic mining industry. Foreign production was stimulated and encouraged wherever possible through loans, purchase contracts, technological assistance and various other means. At the same time foreign aid was dispensed freely and widely throughout the world and more than half a billion dollars of this aid went for the development of foreign mineral production. A further complication arose from the reduction of tariffs on metals which were negotiated by our government under the General Agreement on Tariffs and Trade.

The result was a substantial increase in foreign production of various metals and much of this additional production was channeled into U. S. markets because of the lowered tariff barriers. Surplus supplies tended to push prices downward. Meanwhile costs of production in this country were rising steadily because of inflation.

Thus, under the new post-war government, policies of trade expansion and mutual security, the domestic mining industry, including the metals-producing branch in Idaho, found itself increasingly squeezed by the cost-price pinch and unable to maintain its customary share of domestic markets in competition with foreign producers.

The Korean conflict brought brief relief in the form of war-level demand and higher prices, but it also resulted in more feverish efforts to stimulate free world production. The adverse effects on domestic mines were therefore aggravated, and the steadily mounting tensions of the "cold war" persistently prevented effective policy revisions that would repair the damage that this country's mining industry had sustained.

Idaho's silver and gold production have also been adversely affected by government policies that reflect basic political considerations.
Gold production stopped by war and fixed price

The initial blow to gold producers came in 1942 with the issuance of War Production Board Order L-208, which had the intent of forcing the miners employed by gold mines into transferring to operations concerned with the production of metals more essential to the war effort. Gold mines were compelled to suspend operations for the duration. By the time the order was rescinded after the war, production costs—wages, supplies, equipment, etc.—were so inflated that most of the properties found it impossible to resume operations at a profit and the situation has become increasingly worse as the inflationary spiral has curled upward in succeeding years. The federal government, meanwhile, has retained its official price of $35.00 per ounce, and has strongly resisted all pressures for an upward adjustment because of the international complications involved in revaluing the dollar to a level more in line with its reduced purchasing power.

Silver producers aided by Silver Purchase Act

Silver producers have had the benefit of an assured treasury market for their production since passage of the Silver Purchase Act of 1934 and during most of the subsequent years the treasury buying price has been consistently above the world market price.

The government has also enjoyed substantial benefits from the silver purchase program because its purchase price has always been substantially below the monetary price of $1.29 an ounce.

Provisions of the purchase law require that silver producers be paid for their deliveries to the treasury through the issuance of silver certificates, which are in the nature of warehouse receipts for the silver delivered, in that the silver is placed in the treasury reserve as security or backing for the paper certificates issued in payment therefor. However, the silver placed in reserve is valued at the monetary price of $1.29 an ounce, whereas the government returned to the producer only a part of that amount.

Since the 1946 amendment of the silver laws the silver producer has been receiving 70 percent of the monetary price, or 90.5 cents an ounce. From 1939 to 1946 the Treasury price was a fraction above 71 cents. The difference between the purchase price and the monetary price has been classified as seigniorage and credited to a "free-silver" account which has been available for the minting of subsidiary coins—half dollars, quarters and dimes.

But hurt by a later amendment

Following enactment of the 1946 amendment this free-silver fund has also been available for sale to the Treasury for not less than the purchase price, and it is this feature of the law that has contributed to the problems of producers.
ABOVE: Windrows of gravel along the South Fork of the Clearwater River resulting from dredge operations at a time when leveling of tailings was not required. The gravel shown here was worked for its gold content: much of the recent dredging in Idaho has been carried on for the recovery of uranium, thorium, columbium, tantalum, and rare earths.

BELOW: Leveling of dredged ground in Bear Valley, Idaho. After smoothing of the tailings, topsoil, removed before dredging, was replaced and seeded. Present state law requires construction of settling ponds to clarify water used in dredge mining, and the replacement of disturbed watercourses after dredging.
For more than 10 years world-wide consumption of silver has exceeded world-wide production by a substantial margin. During most of that period the supply deficiency has been made up with silver made available through the demonetization of silver coins in foreign countries endeavoring to solve internal financial difficulties. In recent years, however, this source of supply has been largely absorbed through industrial markets and, with demand continuing to exceed supply, there have been increasing purchases from the U.S. Treasury free silver fund. It has been the policy of the Treasury Department to sell to industrial users for 91 cents an ounce. This policy has depleted the “free silver” fund considerably and has had the effect of establishing a “ceiling” on the open market price because consumers can fill their requirements through Treasury purchases and do not have to force up the open market price through competitive bidding for supplies.

Silver producers have repeatedly questioned the advisability of this policy. They have also repeatedly questioned the equity of holding the seigniorage charge at its present 30 percent level in view of the more-than-50 percent increase in costs they have had to absorb since the 1946 amendment was passed. Like the gold miner they are caught in a squeeze between rising costs and a fixed price which can only be adjusted by political action.

Additional political problems confront the mining industry because of factors inherent in the nature of the industry.

Land-use conflicts

Mining operations involve the extraction of ore resources found for the most part on and beneath public lands.

As we have explained earlier, it was for many years official government policy to encourage the exploration for the development of mineral resources through liberal mining laws which permitted the acquisition of claims with a minimum of restrictions.

The rapid development of the West which resulted from this policy created new problems of increased population and mounting demands of the public lands and the resources they contain. As a consequence it has been found necessary to encourage more judicious use of natural resources through conservation practices that require more government supervision and control in the administration of public lands.

Since varying uses of land in a given area are not always entirely compatible, as, for example, lumbering operations and wilderness recreation, a concept of multiple-use has been adopted as administrative policy in an effort to adjust and adjudicate the demands of conflicting interests with the objective of assuring the maximum possible use of the land over the longest period of time for the greatest number of people.
This policy has meant increasingly restrictive regulation in the acquisition of mining claims and the carrying out of exploration, development and production activities. The mining industry, generally speaking, has cooperated in the application of this policy, in the interest of the public welfare. They have found, however, that other groups and interests claiming rights on the public domain are exerting pressure for special consideration in requesting the setting aside of areas of the public lands for the exclusive use of the interests they represent. Particularly active in this regard are the recreation enthusiasts who seek through legislative action the establishment of more national parks, wilderness areas, and fish and game refuges.

Such single-purpose set-asides within the public domain are detrimental to the mining industry, and other commercial interests, such as the forest products industry, the livestock industry, and others, which in the West must rely upon the resources on the public lands in order to maintain their enterprises.

Similarly the growing demands upon western water resources have had a serious impact on the mining industry. Increased restrictions on dredging operations have been found advisable and controls over stream pollution are becoming increasingly restrictive. The additional costs of production involved in complying with today's regulations present a constant challenge to mining operations in seeking to maintain their competitive position in product sales.

Still another political problem with which the mining industry is persistently confronted is that involving the equity of taxation policy.

It is readily apparent that mining--and the oil production industry--are unique among industries in that they entail an extremely high risk element in becoming established and, once established, are required to constantly use up their principal capital asset, which is the ore deposit or oil pool on which they rely for their production.

Governmental recognition of these peculiarities many years ago led to the formulation of the policy granting to both the mining and oil industries a "depletion" allowance in the computation of their net income for tax purposes.

For the past 30 years or more this depletion allowance for "wasting asset" industries has been studied and analyzed repeatedly by numerous congressional committees and special survey groups who have consistently found the principle involved justifiable. There have been some adjustments in the rates, and alternative methods of determining the allowance on a cost or percentage basis are now provided.
Equally persistent efforts are encountered, particularly at the state level of
government, for the levying of a gross severance tax on all mineral production.

These unrelenting threats to the economic welfare of mining operations create
an atmosphere of uncertainty which discourages the launching of new enterprises in
this field.

From this brief discussion, it is readily apparent that many of the most pres-
sing problems confronting the mining industry in 1960 are rooted in governmental
policies and decisions.

Perhaps the greatest single political obstacle to progress in the mining indus-
try in this country is the continuing lack of a clear-cut national policy on conser-
vation and utilization of mineral resources. Without a clearly defined and fixed
general policy which assures a favorable climate for operations, it is unlikely that
the capital investment and technological application essential to the success of
new mining enterprises will be forthcoming.
Methods of processing silver ore have greatly changed in the past 100 years. The sketch at the top shows a water-driven arrastre, an early-day device to grind and concentrate silver and gold ore; the photograph shows the modern mill at the Sunshine Mine near Kellogg, the greatest silver mine in the United States.
IDAHO'S MINERAL INDUSTRY TODAY

E. F. Cook

Idaho's mineral industry in 1960 is slowly recovering from a production slump caused by a drastic decline in the prices of lead and zinc, two of the state's leading mineral commodities. Figures for 1959 show a total mineral production valued at $70,209,000, up 9 percent from 1958 but down from an all-time peak of $82,795,000 in 1951.

For the second consecutive year silver was Idaho's leading mineral commodity in 1959, followed closely by lead, and then by zinc. The increasing importance of nonmetallic minerals in Idaho's economy was indicated by the fact that sand and gravel and phosphate rock occupied the fourth and fifth positions.

Mineral production records for Idaho have been kept since 1863. In the 97 years since that time Idaho has produced about $2,500,000,000 in mineral wealth, 87 percent of which consists of five metals: lead, zinc, silver, copper and gold. Today only the first three of these metals remain important. With the closing of the cobalt mine in Lemhi County, copper—an important by-product of the cobalt mining—has fallen to an insignificant figure; gold now accounts for only one-half of one percent (0.005) of the state's mineral production.

Although we may think of the bonanza days of Idaho's mining industry as those years around the turn of the century, more than half of the state's mineral production has come from the ground since 1938. In 1959, Idaho led the nation in the production of silver, cobalt, columbium and tantalum, and was second in the production of lead and zinc. During certain years of the 1940's Idaho also led all other states in tungsten and, later, antimony.

An important development in Idaho's mineral picture in the past few years has been the increasing percentage of the total production represented by commodities other than the major metals mentioned previously. The "other commodity" share, which includes phosphate and construction minerals as well as strategic metals like columbium, has risen from 11 percent in 1950 to 30 percent in 1959.

Idaho is one of the five remaining states in the nation that derive the bulk of their mineral production from metals. As a consequence our mining industry is painfully responsive to fluctuations in the national economy, to changes in strategic commodity requirements, and to foreign competition—to fluctuations in the national economy, because metals change in price more quickly and more widely than do nonmetallic minerals in response to economic factors; to changes in strategic commodity requirements, because most of Idaho's metal production is essential to defense and because it is to a considerable extent replaceable for ordinary use by substitutes; and to foreign competition, because metals and their concentrates can be economically transported for great distances, whereas most nonmetallics cannot.
<table>
<thead>
<tr>
<th>Mineral Type</th>
<th>1958</th>
<th>1959</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short tons</td>
<td>Value (Millions of dollars)</td>
</tr>
<tr>
<td>Antimony</td>
<td>677</td>
<td>2/</td>
</tr>
<tr>
<td>Barite</td>
<td>2/</td>
<td>2/</td>
</tr>
<tr>
<td>Iron ore (usable)</td>
<td>27</td>
<td>3/ 0.02</td>
</tr>
<tr>
<td>Cobalt</td>
<td>1,539</td>
<td>3/ 571</td>
</tr>
<tr>
<td>Columbium-tantalum (oxide)</td>
<td>199</td>
<td>2/</td>
</tr>
<tr>
<td>Copper</td>
<td>9,846</td>
<td>5.18</td>
</tr>
<tr>
<td>Abrasive garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td>0.55</td>
<td>0.56</td>
</tr>
<tr>
<td>Lead</td>
<td>1,600</td>
<td>0.01</td>
</tr>
<tr>
<td>Mercury</td>
<td>53,603</td>
<td>12.54</td>
</tr>
<tr>
<td>Mica (sheet)</td>
<td>100</td>
<td>0.60</td>
</tr>
<tr>
<td>Nickel</td>
<td>29</td>
<td>2/</td>
</tr>
<tr>
<td>Phosphate rock</td>
<td>1,446,000</td>
<td>5.65</td>
</tr>
<tr>
<td>Pumice and volcanic cinder</td>
<td>108,000</td>
<td>0.17</td>
</tr>
<tr>
<td>Rare-earth metals concentrate</td>
<td>692</td>
<td>2/</td>
</tr>
<tr>
<td>Sand and gravel</td>
<td>6,879,000</td>
<td>6.40</td>
</tr>
<tr>
<td>Silver</td>
<td>547</td>
<td>14.44</td>
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<tr>
<td>Stone</td>
<td>1,391,000</td>
<td>1.79</td>
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<tr>
<td>Titanium concentrate</td>
<td>2,223</td>
<td>2/</td>
</tr>
<tr>
<td>Zinc</td>
<td>49,725</td>
<td>10.14</td>
</tr>
</tbody>
</table>

Value of items that cannot be disclosed:
Cement, gem stones, gypsum, peat (1958), tungsten (1959), uranium, and values indicated by footnote 3.

1/ Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
2/ Figure withheld to avoid disclosing individual company confidential data.
3/ Incomplete total, fire clay and bentonite included with items that cannot be disclosed.
The problems facing Idaho's mineral industry arise (1) from continued competition from foreign metal producers; (2) from uncertainty of technical developments and rate of market expansion in such strategic metals as columbium, tantalum, cobalt, thorium, titanium, beryllium, and zirconium; (3) from the need to upgrade and process low-value bulky mineral commodities like phosphate and clay, in order to produce marketable products and overcome a somewhat unfavorable market location; and (4) from the unpredictability of government actions affecting the industry.

In the face of these problems the Idaho mineral industry is going ahead with expansion and improvement programs unprecedented in its history. The multimillion-dollar program of the Bunker Hill Company to modernize its lead smelter and its zinc plant; plans of the same company to build a large fertilizer plant at Kellogg; the development of the Bovill clay deposits in Latah County by J. R. Simplot Company for production of ceramic-grade clay and glass sand; the pilot plant operations on Latah County clays as a source of aluminum by the Anaconda Company; extensive exploration and development for thorium in Lemhi County and for uranium in the Stanley district of Custer County; the completion of a modern-high-speed mine haulage road by the Monsanto Chemical Company near Soda Springs; and the development of a new multimillion-dollar phosphate mine and processing plant in southeastern Idaho by Central Farmers Fertilizer Company, are all marks of a hopeful, energetic industry.

Along with these development programs the industry has supported the training, in Idaho, of the earth scientists and mineral engineers that are needed in modern exploration, mining, and processing. The industry, in a time of recession for metal mining, raised a quarter of a million dollars to match a state appropriation for a new building for the College of Mines of the University of Idaho. The College trains geological, mining, and metallurgical engineers, both on undergraduate and graduate levels; in addition it has non-engineering curricula in geology and geography. The new building will also house the Idaho Bureau of Mines and Geology, the state agency that is charged with research on Idaho minerals, with the aim of promoting their orderly, efficient, and complete utilization.

The past ten years have seen a number of changes in the Idaho mineral production picture. The major changes are: an increase in the value of nonmetallic mineral production, including a spectacular gain in phosphate production; a decrease in the value of antimony, gold, lead, and zinc production, this decrease being partly offset by an increase in the production of silver, mercury, columbium, tantalum, cobalt, and copper.

The future of Idaho's mineral economy consists of three elements:

(1) the nonmetallic minerals, production of which is almost certain to grow steadily but not spectacularly, as an increasing population in the Far West provides an expanded market;

(2) the rare or strategic metals, the future in any one of which
is difficult to predict, depending as it does on technological developments and security needs of the nation. In the long run, however, production can only go up, and in any one of these metals it may skyrocket, given a technologic breakthrough or a sudden need;

(3) the Big Three--silver, lead, and zinc--production of which should remain about steady or even gradually increase over the next few years.

The Idaho mineral industry is looking forward, not back. New mineral deposits are being found, new processes for extraction and processing of mineral commodities are being developed. The application of increasing amounts of scientific and technologic know-how to problems of mineral exploration, mining methods, mineral processing, uses of metals and minerals, and market analysis should make the mining industry grow along with other major segments of Idaho's economy.
OTHER USEFUL INFORMATION

Idaho’s mineral production, 1860-1960

In the first century of the Idaho mining industry over $2 1/2 billion in mineral wealth was produced. The staff of the U. S. Bureau of Mines Albany (Oregon) office of Mineral Resources has compiled and tabulated Idaho mineral production statistics for the period 1863-1959. Records are not available for production in 1861 and 1862; however, fragmentary records are the basis for an estimate of about $12.7 million for those two years, all in gold. Adding the 1861-2 estimate and the preliminary figures for 1960 to the Bureau’s totals allows the following summary of Idaho’s 1860-1960 mineral production.

METALS:
- Lead: 947,425,000
- Silver: 536,532,000
- Zinc: 453,894,000
- Gold: 205,109,000
- Copper: 70,781,000
- Tungsten: 32,000,000
- Antimony: 17,300,000
- All others: 27,496,000

Total metals $2,290,537,000

NONMETALS
- Sand and gravel: 77,000,000
- Phosphate rock: 70,500,000
- Stone: 44,750,000
- All others: 40,269,000

Total nonmetals $233,019,000

Total production $2,523,556,000

The complete tabulation prepared by the U. S. Bureau of Mines is given on the following two pages. The years shown mark the first and last years for which production was recorded; the commodity was not necessarily produced in all intervening years. Some mineral values are not included because of lack of information. Many ores contain valuable minor constituents, such as arsenic, bismuth, cadmium, selenium, tellurium, gallium, and germanium. The quantities sometimes are not known and sometimes, though known by analyses, are not accounted for metallurgically in early processing stages or credited to mine or origin.
### Idaho's Mineral Production - 1860 to 1960

#### Metals

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Quantity</th>
<th>Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold - ozs.</td>
<td>8,289,060</td>
<td>$193,256,503</td>
<td>1863-1959</td>
</tr>
<tr>
<td>Silver - ozs.</td>
<td>703,567,760</td>
<td>524,730,241</td>
<td>do</td>
</tr>
<tr>
<td>Copper - short tons</td>
<td>166,678</td>
<td>68,183,325</td>
<td>do</td>
</tr>
<tr>
<td>Lead - do</td>
<td>6,897,659</td>
<td>937,894,412</td>
<td>do</td>
</tr>
<tr>
<td>Zinc - do</td>
<td>2,179,702</td>
<td>444,285,691</td>
<td>do</td>
</tr>
<tr>
<td>Antimony - do (antimony content)</td>
<td>44,912</td>
<td>17,300,000</td>
<td>1932-1959</td>
</tr>
<tr>
<td>Chromium - short tons</td>
<td>25</td>
<td>911</td>
<td>1942 only</td>
</tr>
<tr>
<td>Iron ore - long tons</td>
<td>25,870</td>
<td>150,000</td>
<td>1891-1959</td>
</tr>
<tr>
<td>Mercury - 76 pound flasks</td>
<td>28,977</td>
<td>5,785,313</td>
<td>1917-1959</td>
</tr>
<tr>
<td>Tungsten - short tons, 60% WO₃ basis</td>
<td>18,737</td>
<td>32,000,000</td>
<td>1911-1958</td>
</tr>
<tr>
<td>Manganese - short tons, 35% or more Mn</td>
<td>7,554</td>
<td>96,121</td>
<td>1926-1943</td>
</tr>
<tr>
<td>Manganese - short tons, 10-35% Mn</td>
<td>3,631</td>
<td>28,497</td>
<td>1926-1941</td>
</tr>
<tr>
<td>Cobalt - pounds (cobalt content)</td>
<td>14,022,868</td>
<td>1/</td>
<td>1952-1959</td>
</tr>
<tr>
<td>Columbium-tantalum - pounds (oxide content)</td>
<td>1,167,564</td>
<td>1/</td>
<td>1953-1959</td>
</tr>
</tbody>
</table>

In addition to the above, production is recorded for ores and concentrates of titanium (ilmenite) (1951-1959), uranium (1957-1959), zirconium (1958), rare earth and thorium minerals (1948-1959), beryllium (1953-1958), vanadium (1944-1954), and nickel (1953-1959, recovered together with cobalt). Quantities and values for these commodities cannot be listed because of confidentiality of figures for some of the years. The total value of these commodities and of the commodities having a footnote 1/ in the list above is approximately $20,000,000

1/ Figure must be withheld to avoid disclosing individual company confidential data.
## Idaho's Mineral Production - 1860 to 1960

### Nonmetals

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Quantity (short tons unless otherwise stated)</th>
<th>Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>500,000</td>
<td>$750,000</td>
<td>1896-1959</td>
</tr>
<tr>
<td>Coal</td>
<td>50,000</td>
<td>125,000</td>
<td>1887-1959 do</td>
</tr>
<tr>
<td>Garnet</td>
<td>49,292</td>
<td>2,113,662</td>
<td>1940-1959 do</td>
</tr>
<tr>
<td>Gypsum</td>
<td>19,063</td>
<td>58,092</td>
<td>1936-1959</td>
</tr>
<tr>
<td>Mica</td>
<td>1,100</td>
<td>1,000,000</td>
<td>1888-1959 do</td>
</tr>
<tr>
<td>Phosphate rock - long tons</td>
<td>13,500,000</td>
<td>60,750,000</td>
<td>1905-1959 do</td>
</tr>
<tr>
<td>(sold or used)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumice</td>
<td>1,320,000</td>
<td>2,110,000</td>
<td>1905-1959 do</td>
</tr>
<tr>
<td>Diatomite</td>
<td>980</td>
<td>12,839</td>
<td>1927-1944</td>
</tr>
<tr>
<td>Lime</td>
<td>120,000</td>
<td>975,000</td>
<td>1905-1941 do</td>
</tr>
<tr>
<td>Sand and gravel</td>
<td>104,500,000</td>
<td>70,000,000</td>
<td>1909(?)-1959 do</td>
</tr>
<tr>
<td>Stone</td>
<td>35,500,000</td>
<td>42,500,000</td>
<td>1888-1959 do</td>
</tr>
</tbody>
</table>

In addition to the above, production is recorded for barite (1922-1959), cement (1929-1959), fluorspar (1951-1953), gem stones (1907-1959), and peat (1954-1959). Quantities and values for these commodities cannot be listed because of confidentiality of figures for some of the years. The value of these commodities is approximately $31 million.
Publications about mining and mineral resources

Books, pamphlets, and maps


Magazines

ENGINEERING AND MINING JOURNAL
330 West 42nd Street, New York 36, N. Y.
MINING WORLD
500 Howard Street, San Francisco 5, California
MINING CONGRESS JOURNAL
Ring Building, Washington 6, D. C.

Sources of information

IDAHO BUREAU OF MINES AND GEOLOGY
MOSCOW, IDAHO

for mineral identification, mineral resource information, advice on prospecting and development; list of publications free on request.
IDAHO MINING ASSOCIATION
Boise, Idaho ----------------- for general information on mineral resources and production in Idaho.

U. S. BUREAU OF MINES

U. S. GEOLOGICAL SURVEY
Spokane, Washington ----------- for general information; for free list of publications write Director, U. S. Geological Survey, Washington, D. C.
Salt Lake City, Utah
Boise, Idaho