USE OF GEOLOGY IN MINING

Paper Read by J. E. Spurr, of the United States Geological Survey, Before the International Mining Congress, Today.

Following is the paper on "The Application of Geology to Mining," read in the congress by J. E. Spurr, a member of the United States geological survey before the Mining congress:

There was formerly a wide gap between the scientific geologist and the practical mining man. Neither understood enough of the other's work. The geologist, secure in his knowledge of some scientific principles, was amused at the many blunders and crude theories of the prospector and miner; and the miner, keenly alive to the pedantry of the college professor and his frequently obvious ignorance of things as they really were in nature, was inclined to scorn the man of science.

It is not to be denied that this lack of human sympathy was chiefly the fault of the geologist. Geology is a new science, and mining geology, as we now understand it, is very young; and let us say 30, 40 or 50 years ago there was not nearly so much known on the subject as now. Yet many of the scientists of that day may have been tempted by vanity or money to go beyond their scope and to make confident predictions and conclusions in regard to ore bodies; and these predictions were often on entirely insufficient grounds, as was in many cases soon proved by actual mining. This genus of so-called mining experts is yet alive and even relatively numerous, but they are coming to be recognized as having the same standing in their profession as the quack traveling doctor does in the medical world. One may have sad experiences with fake doctors, yet he will not scorn the services of the competent specialist; and so it is now in mining geology.

Happy-go-lucky Method Going Out.

The present close and ever-progressing amalgamation of geology and mining into mining geology is due to the simultaneous progress of both. The perfection of the principles of mining have been brought about by diligent research into every branch of the subject. Happy-go-lucky methods are fasing into disfavor, and everything is being brought as far as possible to a scientific basis. So the intelligent miner has come to realize that the geology of his mines is a complicated and valuable science, the advantages of which are grasped only by the most persistent study.

At the same time, geologists have been making rapid progress during the last few decades toward a complete understanding of those departments of geology especially connected with ore deposits. The old-time geologist was paleontologist, petrologist, stratigrapher and philosopher, and was ready to consider himself a mining geologist during his leisure moments. The modern geologist, with the necessary previous training in the other branches of geology, devotes his chief energies to his chosen work and succeeds in becoming practical as well as theoretical, just as the modern miner has succeeded in becoming scientific as well as practical.

Rapid Development in America.

This development, though strongly marked in Europe, has nowhere had a more rapid growth than in the United States. The refinement of mining methods which has put the American miner in the foremost rank, has led to his calling for help to solve the knotty geological problems of the mines. First, it has been the United States geological survey which has responded to the call and has sent its men to help the miners in their study and to receive as their recompense a more profound acquaintance with their own specialty. This work has been greatly increased of late years and is constantly being enlarged. The names of Hague, Emmons, Becker, Lindgren, Van Hise, Weed, Kemp, Ransome and many others are familiar to the mining world.

The successful mining geologist must have a thorough acquaintance with the principles of geology, and at the same time understand the general principles of mining; and he must be able to judge nicely where the two come together. Every miner is by force of necessity a geologist, for no matter what his work, he is constantly obliged to confront geologic problems; but as his knowledge and training is apt to be too slight, his deductions and theories are apt to be wrong. There is no bolder theorist than many a practical miner. I remember having had told me by a prominent Western mining man, now dead, that a certain fault was no fault because it had slicken sides along it. He said he never knew slickensides to occur along a fault. Now, wrong geologic principles, crudely deduced or only imagined, are among the most dangerous things to successful mining, but carefully reasoned out by a trained and experienced mind they are essential to proper exploitation.

You Have to Know a Lot.

One does not ordinarily realize how often the most unlikely principles of geology have highly important economic applications. A general knowledge of the nature and origin of sedimentary and igneous rocks, of the process of erosion and deposition, of movements within the earth's crust (producing folding, faulting and mountain-making), of the chemical processes carried on by waters and vapors at the surface and underground—even the study of land forms and in what ways they were produced—these may all have their bearing.

It is important to understand the fact that in a series of different rocks ores may come to be deposited in certain beds in preference to others and one must understand the reason for it. The bed in question may be porous, like a sandstone, and therefore afford a channel for circulating metal-bearing waters and provide open spaces for the deposition of minerals from them. Or the stratum may be especially impermeable to water, so that mineralizing solutions, either ascending or descending, cannot find a passage, but spread out above or below and there deposit what they carry. Such is the case with some compact shale beds. Or a stratum may be otherwise especially fitted for the depositions of minerals, as a bed of limestone, which in certain cases is very susceptible to replacement, and so would be chosen in preference to more refractory rocks. Or a stratum may have some other chemical peculiarity which will precipitate the contained metals from traversing waters. For example, a bed containing organic matter will often reduce ore deposition; a bed rich in iron may precipitate gold from solutions.

Important Distinctions.

It is important to be able to disinguish between a bedded ore deposit, contemporaneous with the sedimentary rocks in which it occurs, and one of subsequent introduction. In the first case, the ore will invariably follow its regular horizon, while in the second, we must be always expecting it to deviate or occur in other forms. The latter caution must be maintained in regard to those original bedded deposits which have undergone secondary concentration by circulating waters. Such waters, besides concentrating the ore within the parent bed, are likely to carry it out and form ores at a greater or less distance away from it.

Where ores occur in bed form, it is important for the miner to be able to trace and recognize the same bed in different places. Ore-bearing strata sometimes extend as such for long distances, as is the case, for example, with the iron-bearing stratum of the Mesaba range, in Minnesota, or it may be of limited extent, the ore disappearing with some change in the physical or chemical conditions. The relation of an ore-bearing bed to other beds lying above and below should be studied. Often where the important stratum is not exposed at the surface or concealed by debris, the recognition of a bed having a known relation to the ore bed leads to the discovery of the latter and its contained ore deposits.

Knowledge of Fossils.

Some knowledge of fossils is often of value for the recognition and tracing of a stratum containing valuable minerals, especially in separated districts. This is so because beds having the same physical appearance may and do occur in many ages, while perhaps only in one were the finer conditions for producing deposits of valuable minerals fulfilled.

Passing to the study of igneous rocks as applied to ore deposits, we find a field of some importance. In fact, it is even true that miners have always been disposed to give to the different varieties of igneous rocks a significance as regards ore deposits which they have hardly deserved. The proper identification of such rocks is a puzzle to the miner. It is necessary to be able to distinguish an igneous from a sedimentary rock and this can in most cases be easily done. But the finer distinctions are generally of slighter importance. Formerly, the knowledge of igneous rock was much less than now. To take a single example, Baron Richthofen described propylite many years ago as one of the principal volcanic rocks at the Comstock lode. On account of the association of this rock with the wonderful mineral riches of the Comstock lode, it became a favorite with miners, who called everything propylite that they possibly could. Since then the investigations of Becker of the United States geological survey and others, have shown that the rock is simply an altered andesite.

All this may appear to be really on the subject of what a knowledge of igneous rocks cannot do. But you must remember that it takes a profound knowledge of these rocks to know what they do not stand for as well as to know what they do stand for.

Broader Rock Divisions.

A general knowledge of the broader rock divisions, such as the granitic, dioritic, dibaastic and perioditic rocks, is necessary to the finished mining man. It is proper to know the general distinction between the rhyolitic, andesitic and basaltic rocks. Terms like porphyry, syenite, trachyte, phonolite, amygdaloid, dolorite, felsite, greenstone and serpentine are used daily by the miner, and he should know exactly what he means when he uses them. He should know that igneous rocks occur either in fundamental great bodies or are intrusive or are poured out on the surface as lavas.

It has long been a matter of observation that there is the very closest connection between most igneous rocks and ore bodies. Probably nine out of ten ore deposits have some visible connection with a body of igneous rock. In general, also, a country free from igneous rocks has a scarcity of ores. There are reasons for this relation.

Of the different forms of igneous rocks, intrusive rocks are perhaps the most favorable for bringing about ore depositions. A study of the conditions of ore depositions with igneous rocks will show that ore bodies should be chiefly expected along or near the contacts, especially those of intrusive rocks; after these the past or present channels of water circulation should be investigated.

There are some metals that show a preference for igneous rocks. This is a point upon which we are continually gaining new information. Chromium ore deposits are hardly found, save in very basic dark rocks, such as peridotites. Platinum is chiefly found in place in similar very basic rocks. Tin, on the other hand, is always found in or in connection with granite. I believe that gold in the form of gold quartz shows a decided preference for silicious rocks, especially granites.

Dynamic and Structural Geology.

Let us turn to the study of dynamic and structural geology, the consideration of the forces which produce changes and movements in the earth's crust. One of the most important forms of movement is the bending and breaking of rocks, particularly noticeable in strata. The study of the arrangement and structure of these bent and broken rocks is very important in mining problems.

For example, if a certain bed is ore-bearing, it is of great use to be able to trace it after it has been folded and faulted. Any ore body may be more or less completely faulted and the recovery of the ore body beyond the fault plane is one of the chief puzzles of the miner in many districts. But this is not always an easy thing to do, as many can testify. We cannot look into the earth and see all the folds and faults. We have only certain rock outcrops at the surface, certain data in the mines, and from these we must construct the whole as near as we can. For mining purposes, measurements and calculations must be as accurate as possible.

In these Western states, it has seemed to the writer that in some districts at least nine out of ten shafts and tunnels have had no result; and probably eight out of the nine would not have been begun had the promoters some idea of the geological structure and the nature of the ore deposits in each particular district. A rich mine is struck somewhere; the surrounding land is taken up; the district is boomed; capital pours in, and before you know it the country is full of holes. Then the boom subsides, the holes are abandoned; the few intelligent or lucky men open their mines and the district settles down to the humdrum of a steady producer; but in many places it appears to the observer an open question as to whether more money has been sunk in the ground or taken out of it.

Use of Geometry.

Some geometrical conceptions must be cultivated in this department of mining geology. Take, for example, the comprehension of the attitude of a vein or bed as judged from its surface outcrops. The uneven surface cuts beds, dikes, faults or veins at all angles, and the intersections, which constitute the outcrop, are infinitely varied. A bed or fault having a straight strike may have an outcrop which will describe all kinds of curves as represented on the geologic map. On cross sections, faults are generally represented as cuts in a vertical vein plane; but the real displacement may be in any direction, and sections to show this must be made in a plane which includes the line of movement. So firm is the old incorrect idea of a fault being a vertical movement in the stratified rocks that I have heard people doubt whether a differential movement along a bedding plane was a fault at all. The absurdity of this idea is apparent. Suppose that the bedding fault cut and separated an ore body, would the mining engineer have any doubts about its being a fault then?

It is economically important also to determine the relative ages of faulting and ore depositions in each case. Complicated instances may happen. To take a not too difficult example a period of faulting may occur, followed by ore deposition which may be partly along the faults; then a second period of faulting may displace the ore bodies and also the earlier faults.

If an ore deposit has been formed before folding and faulting, then the displacements of the rocks affect to the same extent the ore bodies, and the continuation of ores interrupted by a fault can be confidently predicted at the same horizon at the other side. If the opposite is true, then no such caluclation can be made. The ore bodies will be unbroken, and although they may be interrupted along the fault lines, for reasons connected with their depositions, yet their continuance on the other side cannot be assumed.

Common Complicated Case.

A specially complicated and very likely case is where faulting and folding go on for a long time slowly and contemporaneously, with a continual slow process of ore deposition. The first ore deposits may be subsequent to the first faults and folds, but they will be disturbed by the latter movements; yet these latter faults may be chosen as the locus for newer ore deposits. These may be broken by still more recent movements. In such cases, only careful examination can direct exploition most economically.

Where two water courses intersect, be these courses two faults, two joints, the intersection of a joint or fault, a joint or fault with a porous stratum or anything else, there the ore is likely to be most freely deposited. This is the explanation of most ore shoots or chimneys.

The application of geology to placer mining is also varied. In 1896 I was in the Yukon country where the rivers have cut down through an old plateau, leaving at various heights terraces which are portions of former valleys. I reasoned that since the present beds of these streams contain gold-bearing gravels the terraces must also be auriferous. In my report, published by the United States geological survey, I advised miners to prospect these high terraces and since then many profitable bench diggings have been found.

ON THE SNOWY TRAIL.

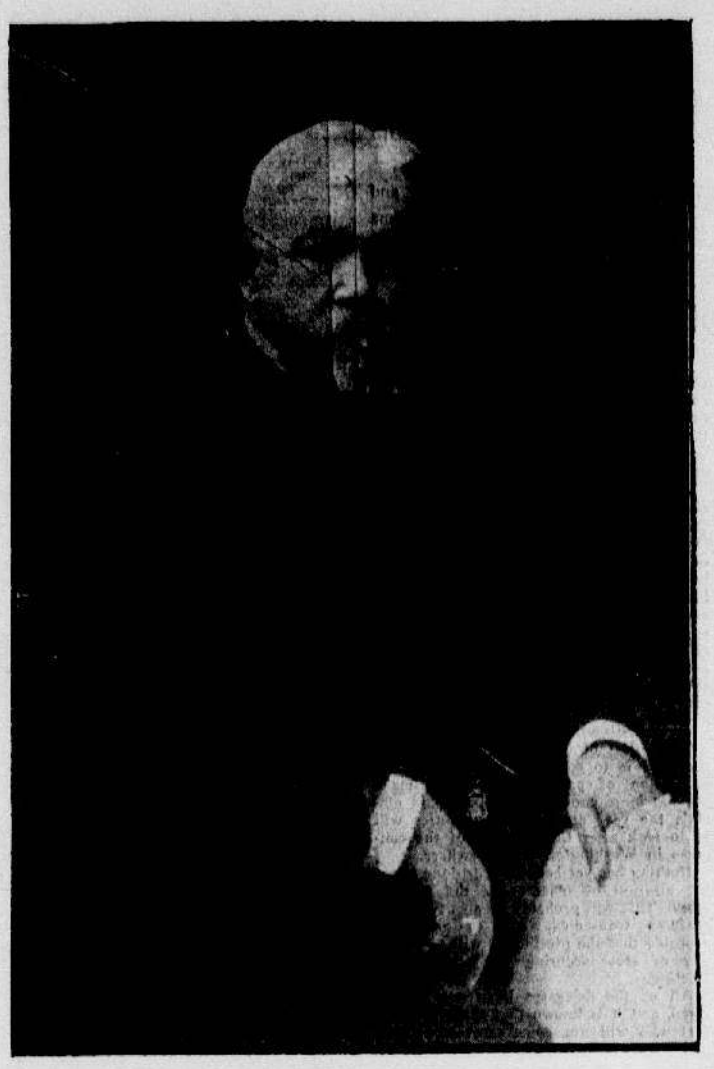
Crossing Main Range of Rockies Between Horse Prairie and Salmon on Thunder Mountain Road.

ON THE SUMMIT.

Crossing the State Line Between Montana and Idaho on the Way to Thunder Mountain.

FIRST CANDIDATE FOR PRESIDENCY APPEARS

JOHN TEMPLE GRAYSON,



Member of the Executive Committee of the Mining Congress Who Is of Baker City, Oregon.

Colonel John T. Grayson of Portland, Oregon, is one of the delegates to the International Mining Congress who has had a thorough experience in mining in all its branches, and has operated mines in all sections of the Americas.

The colonel has recently purchased the Gold Hill property in the "Boise Basin," in Idaho, and is arranging to place modern machinery on that property.

Colonel Grayson is being pressed by his many friends among the delegates to accept the position of president of the International Mining Congress.