WILLIAMS

PRECIOUS METAL
ORE DEPOSITS

DEPARTMENT OF THE INTERIOR—U. S. GEOLOGICAL SURVEY
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POPULAR FALLACIES

REGARDING

PRECIOUS-METAL ORE DEPOSITS

BY

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INTRODUCTORY.

The tendency to generalize from incomplete data is a failing to which the practical miner, in common with the theorist, must sometimes plead guilty. The latter is often too ready to formulate a law from a narrow range of observation; too prompt in offering an explanation for each new phenomenon. The former, whose work brings him in contact with varied occurrences in nature, rightly enough forms his conceptions and expectations from what he has seen and knows—and he is indeed a keen observer—but often reasons from too limited a base line. On the one hand, the study of mineral deposits has been clogged by a mass of premature hypotheses; on the other, the search for and development of mines often have been conducted under the bias of preconceived prejudice. Besides the unconscious and ineradicable reliance on *a priori* methods and doubtful analogies, there is another important source of error which is common to all branches of inquiry. Some one puts forth a suggestion; it may be the sheerest piece of guesswork, but it finds its way into print, floats with the current literature of the subject, and by virtue of iteration becomes accepted as fact without perhaps ever having been seriously scrutinized. These are the causes which explain most of the popular misconceptions that have gained circulation regarding precious-metal deposits.

The work of the mining geologist in large part consists in demolition; in clearing away the rubbish of overthrown errors to obtain foundation room on which slowly to build a sound structure; in sifting and weighing a mass of speculations in the search for material. On the practical side, the progressive miner learns that the features of a single district or of a few localities may not be an unfailing index to the characters of all other deposits; but he is at times hampered by established prejudices which have all the weight of precedents. Fortunately the spirit of modern investigation tends rather to the collection of facts than to speculation. It is now understood that, given sufficient data, the laws evolve themselves; and that the reversal of the logical sequence, putting the theory first and then searching for facts to fit it, tends only to hopeless perplexity.

It is not the purpose of this paper to offer new information. The aim is simply to put on record a few typical misconceptions which have had more or less currency; to trace their origin and compare them with admitted facts. All of the prejudices cited have an economic bearing. Several are obsolete, while others are fast disappearing. None are quoted as having received universal or absolute credit.

LOCAL PREJUDICES AGAINST CERTAIN FORMATIONS AND IN FAVOR OF OTHERS.

Propylite.—In no direction are unsafe generalizations pushed to such an extreme as in the question of country rock. It is only natural that miners should regard with favor wall rocks similar to those to which they have been accustomed, particularly if they have studied them in especially prosperous camps. Thus the Comstock miner, leaving that district for new fields, keeps a sharp lookout for those particular varieties of "porphyry" found in the Comstock east country, to which von Richthofen gave the name of propylite, and of which the leading type is that commonly and descriptively known as greenstone. For some years subsequent to the opening of the Washoe mines there was a strong temptation, wherever by any stretch of imagination an analogy could be traced, to claim for the wall rocks of new districts the true Comstock characteristics. Not a few geologists, too, extended the search for propylite, and identified it in various scattered localities, many of which are not known to be metalliferous. Propylite has somewhat lost its prestige, and is generally considered to cover a group of eruptive rocks which are now classed under other names.

Granite.—Solid granite was for a long time thought to be a most unlikely country rock for precious-metal ores. This prejudice perhaps arose from the fact that certain mines located in the granite of the Sierra Nevada, above the gold belt, had not proved profitable. Subsequently, the developments at Reese River, and in many districts of Montana and Idaho, showed that good mines could exist in granite. If, however, the granite was of unusual color and texture, or very much decomposed, the prejudice against it was evaded by calling it syenite, diorite, or "bastard granite;" and if these names could be maintained, the prospects were considered good.

Granite and slate.—Auriferous contact veins, having a granite foot wall and a slate hanging wall, have been in demand among another class, whose partiality was founded on the successful experience of a number of gold mines of this type in California. This combination is not a very common one, or more would have been heard of it. All contacts, it may be remarked, are generally preferred to veins in a single rock, perhaps not without reason, notwithstanding the probability that contact veins, in the nature of things, are usually more limited in extent than fissure veins in homogeneous rock—excepting, of course, the type of fissures known as gash veins.

Limestone.—Limestone was once a most unpopular rock, being considered unreliable as an ore-producer, and having the additional disadvantage of yielding base ores which, in the early stage of American metallurgy, were always regarded with disfavor. Such ores, even if relatively rich, were subordinated to free-milling ores of lower grade, up to the time when improved methods of chloridizing-roasting prior to amalgamation caused the reduction of a large class of these ores to be accomplished at more reasonable rates. The vast extension of the smelting industry and the growth of the railway system have enabled other base ores to be sold and transported to the large smelting works, where they are easily reduced in mixed charges. As to the question of the reliability of ore deposits in limestone, it may be said that continuous veins are rare; but, on the other hand, many of the largest bodies of metallic minerals, as at Leadville and Eureka, are found in this rock, while connected series of bonanzas often occur, thus fairly offsetting the advantages of the plainly marked fissure veins of the igneous rocks.

Limestone and quartzite.—A combination which is still in particular request as a promising country for argentiferous lead ores is that of limestone and quartzite, a prejudice which probably began at Eureka. In other districts this has been borne out by valuable discoveries; but there are also important silver-lead deposits not belonging to this formation.

Sandstone.—A rock which had not been thought of as a possible home of ore is sandstone. When the discoveries at Silver Reef were first announced, the reports were received with general incredulity on this account, and also because the geological age of the strata was not considered to be a favorable one; but when bullion was actually produced from sandstone ores, a reaction set in, and sandstone for a time received marked attention, even in places where the associated rocks held forth no promise of lending mineral impregnations to it.

THE SUPPOSITION THAT THE RICHNESS OF MINERAL VEINS USUALLY INCREASES WITH DEPTH.

This belief was at one time accepted by many; but has latterly lost weight, and is now held by but few practical men. Carried to its logiical extreme, it gave rise to a vague idea that, if only explorations could be pushed far enough, the original source of the ores would perhaps be reached, and that here would be found a treasury of metallic masses.

In support of this wild notion, even the unexplained terrestrial density was quoted as a favorable argument. Its origin seems to have been twofold. With some it undoubtedly sprang from the once generally accepted idea that all vein deposits are formed by the precipitation of the precious-metal contents of heated *rising* waters or vapors. Certainly there is little in the conditions of known mineral occurrences to substantiate this assumption as an invariable explanation, much indeed to disprove it; but once granted that ores are deposited solely by currents ascending from great depths, it was only natural, perhaps inevitable, to infer that the greatest concentration must take place at points nearest the source; that from and above the level where the rising currents first meet with cooling, reducing, or other precipitating agencies sufficiently potent the resulting deposition should be found in a steadily declining ratio; and that the culmination of enrichment should be sought for at the point where the mineral-charged waters are first fully subjected to precipitating agencies—or in other words, at considerable depth, since such reducing agents as organic substances are known to act far from the surface, provided channels exist from the latter downwards, while the conditions of pressure, heat, etc., are similarly deep-seated. This conception is gradually being supplanted by what is known as the lateral-secretion theory, which as a working hypothesis is not only more flexible, but also more in consonance with observed facts. Lateral secretion, as now understood, is not limited to an inflow and precipitation in even approximately horizontal planes; the theory ascribes the deposition simply and naturally to solvent waters reaching the vein from ground comparatively near, and more reasonably flowing from higher grades downward than being ejected by pressure from great depths. In many cases, however, the currents may pass through siphon-like openings, the head or pressure being supplied by accumulations of cool and comparatively pure water collected at some distance from the seat of mineral deposition; but in passing from point to point probably reaching a considerable distance from the surface, there gaining in temperature, and thence again rising in fissures by hydrostatic pressure. If convection is assumed as the means of establishing circulation through great vertical distances, the natural result would seem to be a tendency to approximately uniform precipitation.

The second cause of the spread of the idea probably was based on a misunderstanding of the economic conditions. Miners rightly enough wish to prove the question of permanence in depth, which is of paramount importance in projecting large enterprises involving expensive plant. A vein which has been extensively exploited, and proved to continue strong and metalliferous as it goes down, is evidently more valuable than undeveloped croppings which may pinch at short distances. But because a mine has been explored far below the surface, and found to be rich at its lowest developed point, this does not furnish a basis for assuming that the mere fact of depth is a factor of its local richness at any given level. (*a*)

The thickness of the earth's crust which has been explored, or can be, by mining operations, is necessarily very limited. Increase of heat, or water, or mechanical difficulties, place the prospective boundary of the unknown at some few thousands of feet. As to the conditions below this limit only inferences can be drawn. A few mines have been pushed to a distance of 3,000 feet from the surface, and a very limited number have slightly exceeded this depth. The amount of exploration which has been carried on, however, gives no ground for supposing that richer and more abundant ores are to be looked for far from the surface than at or near it. Fortunately for the miner, the weight of the evidence is rather in the other direction. Very many veins have been found whose croppings and upper portions yielded largely, but which failed in depth, even after persistent search far below the profitable horizons. It is seldom that a mine is abandoned immediately after its workings have passed through the bonanza region. Usually a mine which has given promise is worked at a loss long after its available ores have been exhausted. Hundreds upon hundreds of abandoned mines in various parts of the country have passed through a similar history. Some exceptionally large and productive veins have been worked through alternate zones of richness and barrenness, and have been developed to such an extent as to exhibit very clearly the conditions prevailing over a wide range in depth. Such, for example, is the great Comstock lode, which, for a space of nearly four miles in length, has been opened and thoroughly explored to depths ranging to between 2,500 and 3,000 feet. A longitudinal section of this vein shows that the productive ore bodies have been scattered without any semblance of regularity in occurrence. The largest extent of barren ground, however, lies at the bottom of the exposed portion, though small seams of highly concentrated ore have been met with at the lowest points. In this case, which presents the largest exposure, and has been more carefully studied than any other in this country, there is found to be absolutely no rule either as to the concentration of the ores or size of the ore bodies which can in any way be ascribed to causes dependent on depth. Many of the famous vein mines owe their reputation to ore bodies which were encountered in the uppermost horizons. Such, for example, are the Custer, of Idaho; the Grand Prize, of Nevada; the Horn Silver, of Utah; and many others. In the Owyhee district, Idaho, a group of veins exists which yielded fabulously in their upper levels, and though worked for hundreds of

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a Mr. G. F. Becker, in discussing the geology of Idaho, observes: "If any rule can be established in regard to the relations between richness and depth, it is rather that veins grow less rich and strong; though strong veins, probably as a rule, continue metalliferous to a greater depth than mining can ever be carried; but the cases in which veins grow better in proportion to the depth reached are certainly very exceptional." (Census report on "The Statistics and Technology of the Precious Metals.")

feet below their paying portions, have given only disappointment. The Leopard mine at Cornucopia, Nevada, at one time a large producer, was prospected in depth at great expense after its bonanza had been exhausted. Every miner will recall numerous instances in point.

Ore from the croppings of veins is almost invariably more docile than that extracted from deep workings. Atmospheric action decomposes the base, rebellious compounds, and leaves the precious-metal ores in a state of comparative freedom; while organic substances reduce the gold and sometimes the silver minerals to the metallic state, so that they are more readily extracted by metallurgical processes. Often mines which show the most facile ores at the surface change within a short distance to a character which involves a complete alteration in the methods of reduction, with a corresponding increase in cost of plant and in expense of working. Besides the greater freedom of surface ores, there are reasons why they should also be sometimes richer. As the degradation of the accompanying rocks proceeds, the lighter matrix is decomposed and washed away, while a concentration of the heavy minerals takes place, and they are left nearly *in situ*. Thus, just at the surface, an accumulation of metallic minerals may occur, representing the partial contents of large masses of ore which have weathered and disappeared.

THE PREJUDICE AGAINST "SPECIMEN" MINES.

This has reference more particularly to gold mines. It may seem singular to the lay reader that practical miners should object to veins because of their unusual richness, but the prejudice is one which is not altogether unfounded. In the history of the California mines, a number of claims like the Cedarberg, Chariot, and others, which yielded very handsome gold specimens, such as are worked into jewelry and souvenirs, have been very disappointing; while on the other hand the ore of many of the famous and most productive mines hardly ever contains gold sufficiently coarse to be seen by the naked eye. It is a fact that the bulk of the gold production from deep mines in California has come from low-grade ores. The average yield per ton in 1880 was only $16.10. The vast low-grade auriferous deposits of Dakota, which have been so remunerative, are still lower in tenor, the average yield during the same period being only $6.33 per ton. Very many large mines, both in California and Dakota, have been worked at a good profit on ore which carried much less gold; the low tenor being offset by the size of the deposits, and by peculiar facilities for working and milling them. So that on the whole the idea of richness being opposed to quantity does not seem entirely unreasonable. There are, however, enough exceptions—prominent among which is the Standard mine, of Bodie—to throw some doubt upon the reliability of the prejudice as a working rule. As a matter of economy in mining and in milling, it is evidently better to have one ton of $100 ore than twenty tons of $5 ore.

In a much less degree, a similar prejudice has existed against exceptionally high-grade silver ores, though in this case the feeling is apparently groundless. It is true that the richest silver ores are usually found in narrow veins, or in very small pay-streaks in the large veins; but here the same question of relative economy in working must be considered. Besides, many of the most successful mines have been opened on veins of high-grade ores, and such ores do not always occur in very small quantities. It is only necessary to cite as examples the Ontario, Eberhardt, Silver King, Manhattan, and Custer mines, all of which have derived their yield from ores which are far richer than the average.

THE PREJUDICE IN FAVOR OF CERTAIN STRIKES AND AGAINST OTHERS.

A very considerable proportion of American precious-metal miners have received their education directly or indirectly from the California mines; that is, many miners operating in other portions of the country have either gained their practical experience from actual work in and observation of the typical vein mines of California, or have become familiar with the mode of occurrence of these deposits by contact with old California miners and by reading the published accounts of the California mines. For a long time the tendency to generalize irrationally led to a belief that a northwest and southeast course was a prime characteristic of valuable and permanent mines wherever located, and that the wider the divergence from the favorite direction the less the probable worth of newly discovered veins. A few noteworthy exceptions had to be admitted, however—as, for example, the Comstock lode, which tends nearly north and south throughout its productive portion. Still, to illustrate the predilection for the northwest-southeast strike, the well-known story may be cited of a celebrated expert's having reported adversely upon a Utah mine, simply on the ground that its vein ran east and west, in the face of a fair surface exposure of ore, arguing that a mine with such a strike was unreliable. In this case the slighted mine subsequently proved to be a profitable one.

Nature does not bind herself to any such empirical restrictions. The only approach to a positive regularity of occurrence which has been shown by the actual facts is that as faulting fissures naturally strike with the general trend of uplifts, and the latter are parallel over considerable areas because formed by similar and possibly contemporary dynamic causes, the veins of this class are often found in parallel belts following the lines of upheaval. So, on the west flank of the Sierra, a large number of northwest-southeast veins are encountered; in the Great Basin, where a marked parallelism of the Basin ranges occurs, many important north-and-south veins are met with; while in Idaho a preponderance of northeast-southwest fissures appears. In each case the determining cause seems to be the structural peculiarities of the mountain chains. It is not difficult to understand why a faulting fissure should follow a line approximately parallel with the trend of a range, for it is only at right angles to that direction that there is room for a slide or upheaval to take place unless, indeed, the main rib be fractured, a somewhat violent supposition. There are other classes of "vein" deposits which cannot be safely ascribed to faulting, and these suggest different explanations; yet, except where mountain sculpture is largely the result of erosion, the fissures very commonly have a strike parallel to the axis of the chain and a dip conforming to the original slope of the mountains, though diverging more or less from the surface contour.

Whatever theories are formulated as to the origin of mineral veins, it is certain that an arbitrary strike is not now considered an essential item in the equipment of a successful mine.

THE PREDILECTION FOR "TRUE FISSURES."

A certain unaccountable glamour seems to hang about the term "true fissure." Many famous mines are undoubtedly true fissures in the fullest sense; the fissure generally being the result of a fault. But, on the other hand, a large number of valuable deposits have been found which could not, by any elastic use of the name, be called "true fissures." Such, for instance, are the pegmatite veins and the Black Hills gold conglomerates. The truth seems to be that a large and strong quartz vein requires a correspondingly extensive fissure for its formation. It may or may not be metalliferous, while, on the other hand, small local segregations and replacements may contain ores in such a state of concentration as to compensate for their limited extent.

THE BLOCK SYSTEM OF UNDERGROUND PROSPECTING.

The plan of development which has been practised in certain very large and important veins, by opening drifts in or parallel to the course of the ore channel and cross-cutting from the main drifts at intervals of 50 to 100 feet, thus dividing off the ground exposed into blocks, is one which results in an apparently methodical and workmanlike system. By following it the main openings are kept straight, and when a large body of ore is struck its extraction is much facilitated by the plan of operations which has been conducted during the prospecting period. Unfortunately, however, there are few mines which can be economically opened and developed in this way. The system appears to be the only one feasible in cases like that of the Comstock lode, where the width of the ore-bearing ground is very considerable and the ore occurs in detached bodies, giving few indications of their presence until the mass itself is struck. A company having large capital and extensive plant often proceeds to develop narrow veins on the same plan, when the more natural and practical method would be to strictly follow the vein on each level, provided good working ground is found on the course of the vein itself, and to keep all workings, such as upraises and winzes, within or as near as possible to the ore region. The objections to this method are that the workings are crooked, and often extremely tortuous; that the distances from point to point are sometimes considerably increased, and that the appearance of the mine, to one who has been accustomed to the system of cross-cutting in blocks, is wanting in the regularity of the latter method. On the whole, however, the chances of finding ore, and at all events of missing as little of it as possible, are much increased by working so far as practicable entirely in the ore channel. It should be remembered that the only objects of mining at all are in the first place to find and in the second to extract ore. The latter part of the work can be easily enough managed after the development has proceeded to such an extent as to show reason for changing the system of openings in any way. It certainly seems absurd to proceed to open a mine on the grand scale which would be appropriate in handling enormous bonanzas, when, by adopting the more economical method, a small but certain profit could be assured. The Mexicans, who are miners born, and not by education, and who have the keenest instinct for following indications of ore, limit the size of their prospecting drifts to the smallest possible dimensions, so that often they have the appearance of burrowings rather than of systematic mine openings. It is not necessary to adopt their system in its entirety, nor to carry it to that extreme which results in the making of gopher holes through which a man has to pass on his hands and knees; and on the other hand it is perfectly feasible, having once found ore in quantity, to stope it out and raise it by our most approved methods. But there is no doubt that much could be learned in the way of economy and practical success from the primitive and despised but very efficient methods of mining of the Mexicans.

In working argentiferous lead deposits in limestone, cross-cutting in blocks is a most uncertain means of prospecting, for the stringers and pipes which serve as leaders to the main bodies are easily missed by drifts; and unless the galleries are very numerous and close together, unexplored places are left which might contain profitable ore bodies. At Eureka, Nevada, the two opposite systems have been pursued in the same district. The Richmond Company has, as a rule, conducted its prospecting operations on the plan of following ore indications, with little regard to the regularity of its drifts. The Eureka Consolidated Company adjoining has pursued the course of laying off their ground in blocks and cross-cutting for ore. These cases, however, show little to decide the question of relative success, for both companies have been very fortunate, and the cross-cutting system, owing to the immense size of the ore bodies, has been followed under exceptionally advantageous conditions. Where ore exists in such large masses, it is not a difficult matter to find it, no matter what system be adopted; but it is safe to say that in most lead-mining districts blind cross-cutting would be neither the safer nor the more economical plan.

A parallel extravagance is sometimes committed in locating shafts at too great a distance in the hanging-wall country from the outcrop of veins of medium dip; the object being to develop the ground at the greatest possible depth by a single shaft. Very often, in cases where the underground features are not well known, the more sensible plan would be to follow the vein down by an incline on the dip. Having once struck a bonanza of size sufficient to warrant it, the sinking of a vertical shaft in the proper place becomes a simple matter, and the cost of pushing shafts and other openings in barren country rock is justified by the developments; but in exploiting claims which can only be classed as prospects, the shortest and most economical means should be pursued. Mining on the grand scale is being steadily supplanted by more practical and less pretentious means.

THE PREJUDICE AGAINST BEDDED DEPOSITS AND VEINS OF SMALL DIP.

Up to the time when the value of the Leadville deposits was fully established there existed a strong and pretty general dislike to what are called, with implied depreciation, "blanket lodes." A blanket lode, in the vocabulary of the miner, is one which extends in an approximately horizontal direction or has an average dip not exceeding some 20° to 25°. Two circumstances operated to create this prejudice. One was the uncertainty of title arising from the United States mining law, which was designed to cover locations of mineral deposits (in place) of the class best known in 1872, when the law was drafted—*i. e.*, veins of considerable dip. A comparatively flat dip carries the lode soon beyond the vertical side lines of a 1,500 x 600 foot claim, and into an adjoining location. If continuity below the surface is proved from the croppings of the first claim, the case is usually a clear one; but it often happens that a connection is not easily traceable; sometimes, too, owing to the configuration of the surface, a bed or vein may crop a second time at some distance from the original point. In such instances the question of title frequently becomes a vexed one, and much litigation ensues. This could be avoided by the adoption of "square location" laws, but such a plan is not in general favor.

The second cause was the unfortunate history of some of the earlier discovered blanket lodes, in which the ore deposits did not extend over large areas; and, being shallow, were soon exhausted. The disappointments of White Pine, the most prominent instance in point, undoubtedly had much influence in shaping prevalent opinion.

So far as economic considerations are involved, the flat deposits—other things being equal—have much the advantage over vertical veins and those of a steep dip. It is cheaper to work ore bodies which from their outcrop descend at gentle angles from the surface than to explore deep veins. The cost of hoisting and pumping is so much less (though that of stoping may be slightly greater) that when the workings have extended to some distance from the first shafts, it is not a very expensive matter to sink new shafts at convenient points, as the plant necessary for working such deposits need not be heavy in comparison with what is required in veins of extreme dip. A blanket lode corresponding in plane surface area with the Comstock, for instance, could have been explored and worked at a fractional proportion of the outlay necessitated by the latter. As further examples, it need only be considered what would have been the history of Silver Reef, if the sandstone strata had been tilted into a vertical position; or even how much more disappointing the results at White Pine would have been, had the ore, instead of being so accessible, extended vertically downwards in sheets of the same thickness and extent.

A very unpractical idea, and one doubtless unconsciously accepted, which appears to have taken possession of the uninitiated, is that imposing and correspondingly expensive hoisting works are a necessary feature of a successful mine. Certainly there is something very fascinating about the appearance of these heavy works, beside which the tunnels, short shafts, and light plant of even the most profitable flat mines seem wholly insignificant.

THAT THE APPEARANCE OF ORES IS A TRUSTWORTHY INDEX OF THEIR VALUE.

This caption may seem self-evidently absurd to the experienced miner. It is intended, however, to cover only certain marked peculiarities of ores which are sometimes relied on as indices of their contents in cases when no assays are applied, and when the actual precious-metal ore is obscure. It will be sufficient to cite a few instances of the most common delusive characteristics.

Argentiferous galena.—Many persons still believe that the relative silver tenor of galena may be estimated in a rough way by the color and fineness of the grain. It is difficult to trace the source of this belief; but the fact remains that a microgranular, "off-colored," finely disseminated galena is an especial favorite of many miners and prospectors; while "chunky" galena of the typical pure lead-gray color and luster, fracturing in large cubes, is not as a rule expected to contain much silver. The idea is generally taken on faith. The assumed fact might naturally be accounted for on the probability that pure galena (which is merely another term for galena richer in lead, but poorer in accidental impurities, including silver) would be apt to form larger crystals; while the impure (and richer) varieties would crystallize imperfectly. The variation from the standard hue might also be presumed to be a ground for inferring impurities (such as silver). However plausible this explanation may be, the facts do not warrant any reliance on these distinctions as a test of relative value. The examination of a very large number of specimens, and the communicated experience of other observers, have convinced me that the exceptions are entirely too numerous to prove the rule. Suites of galena specimens from the Wood River mines, Idaho, would alone suffice to dispel the illusion. These ores embrace a wide range in variety of appearance, with a rather unusual uniformity in the silver tenor. For example, solid galena from the Idahoan mine, having a coarse structure which produces large slabs of mineral, assays between 125 and 150 ounces of silver per ton. Another mine in this region, the Mayflower, shows a steely close-grained galena, containing more or less antimony, and sometimes apparently admixed with fine, fibrous stibnite. This occurs associated with a more regular galena; but between the two pronounced varieties there is little to choose as to their relative silver contents.

Auriferous pyrite.—In the same way it is often asserted that barren pyrite, or pyrite containing gold in too small quantity to be workable, may be distinguished from the richer pyrites by its brighter color and larger cubes. There may be somewhat more reasonable ground for this belief than in the case of argentiferous galena; but the known exceptions are very numerous. Finely disseminated pyrite is often confounded in practice with marcasite and mispickel; so that comparative results are to be regarded with some suspicion, except in cases where the gangue mineral is thoroughly identified. In this connection it may be remarked that the argentiferous pyrite found in the Grand Prize, Belle Isle, and other mines of Tuscarora, crystallizes in large cubes and is of very bright color. On the other hand, it is quite true that most of the exceptionally large pyrite crystals, such as reach, say, an inch cube in size, are usually practically barren of either gold or silver.

"*Lively*" *quartz.*—A rusty, decomposed, and honeycombed quartz, especially in gold-bearing veins, is a favorite which is often disappointing. Prospectors speak of it as "lively"—that is, a promising gangue. A dull, tough, and solid quartz, carrying no pyrite nor oxide from pyrite, is in some places locally known as "bull" quartz, and is in especial disfavor. Many of the rich Arizona gold ores, however, are to be classed in the latter category; and the high-grade doré ore from the croppings of the Custer mine in Idaho, although unusually exposed to weathering, is a very tough, agate-like quartz. Decomposition and marks of infiltration are characteristic of most mineral veins (including poor ones), but it is by no means safe to judge of relative richness by these signs alone.

The prejudice in favor of weather-stained, decomposed quartz probably arose from the fact that the standard of excellence in mines was established by the showing from exposed croppings of certain of the best known and earliest discovered of the California gold veins. A miner whose experience had been gained in such mines would naturally look for similar indications in the quartz elsewhere. As has been observed in a preceding section, the ore immediately at the surface is apt to be richer than that found a few feet below. Many mines which show "lively" quartz at and near the surface contain in depth a "dead" quartz which has been protected from atmospheric decomposing agencies.

As regards the marks of infiltration, and their bearing on richness, it should be noted that the most perfect quartz crystals occurring in vugs, or open fissures, are generally barren themselves, though they may be accompanied by rich ores; in fact, the handsomest specimens of quartz crystals are not found in gold mines.

From the appearance of different varieties of quartzose ores, it may be distinctly inferred that two distinct methods of vein enrichment are proved—(1) a deposition of the precious metals simultaneously with the quartz; and (2) a secondary infiltration of the partially decomposed quartz, which may have been originally barren, by solutions charged with gold and silver. In some cases both causes may have operated in the formation of the same vein, thus giving rise to marked differences in the appearance of the ore.

Stains mistaken for silver minerals.—Some pyritous gold ores are deeply stained by certain valueless minerals which, prior to assay, are often assumed to be silver-bearing. Many a custom mill has earned a bad reputation by not being able to extract silver from ore which did not contain it; the shippers of small lots of ore being careless in the matter of sampling and assaying, and assuming any bluish or blackish stains to be silver minerals. One of the most frequent causes of deception is the occurrence of very finely disseminated mispickel. This mineral, when sparsely scattered in microscopic particles through a white quartz, gives it a bluish-black tinge, such as is seen in many low-grade argentite and stephanite ores. Other minerals, not so readily recognized before the blow-pipe as mispickel, produce similar effects. Tyndall has emphasized the fact that minute particles of matter of very different kinds give similar hues to the medium in which they are diffused, though when in mass they may present contrasted colors. This occurs to a certain extent with minerals finely disseminated in quartz.

In Colorado, where telluride ores, such as sylvanite, hessite, petzite, and coloradoite, form a notable source of the precious metals, there is a tendency to call strange or obscure minerals "tellurides," the cause evidently being the known fact that the true tellurides are, next to metallic gold and silver, the richest of ores. In Utah, Idaho, and Arizona the popular determination of azurite and malachite stains is "bromide of silver" or sometimes "chloro-bromide;" the fact being that bromides and chloro-bromides are really of infrequent occurrence, though so often reported. Lead ocher, in the same way, occasionally becomes "iodide of silver."

Chloride ores.—Horn silver, in aggregations large enough to be tested with a knife, is easily identified. But in the greater part of chloride ores the mineral is recognized with difficulty, and may entirely escape the notice of one not familiar with the local characteristics. The miners become wonderfully expert in the ability to judge and sort the ores to which they are accustomed; but very frequently systematic assays are the only reliance in selecting ore for stoping and for the mill. Cerargyrite finely diffused in quartz or "vein porphyry" is apt to escape detection altogether, unless its presence is indicated by associated minerals more readily recognized. When cerargyrite in this diffused state is the only metallic mineral in an ore, a hand-specimen which would give fair assays might seem to the stranger to be a palpable hoax. It is evident that the assayer to whom a fragment of common grindstone had been sent for assay by a waggish prospector, and who returned in his report a high value in silver, had been familiar with this class of ores, and may not after all have been so ignorant as the story has represented him to be.

Sulphide ores.—As a rule it is much easier to estimate the probable tenor of these ores by merely looking at them than in the case of chloride ores. There are, however, two important exceptions: first, when the ore mineral is masked by large quantities of more prominent but worthless metallic minerals; and, second, when free milling silver ore, such as argentite, is so microscopically diffused in the gangue as not to perceptibly affect its color. The low-grade "sugar quartz" of the Comstock is an instance of the latter class. Some of this contains so little metal that it will not pay the expense of milling; while another portion, presenting an apparently identical appearance, having the same granular texture and whiteness, may be sufficiently rich to yield a fair though small profit above the cost of extraction and milling. Those most familiar with this ore are often puzzled by it, and are obliged to rely largely upon assays.

In developed mines and districts, the obscure ores do not give much trouble; for the means of assay are at hand, and the miners have become practised in judging them. In new regions, however, the case is different, and the most experienced prospectors are often misled by the appearance of the ores.

It would be unfair to infer, from the confusing and irreconcilable prejudices and partialities which have had more or less sway, that the whole subject of precious-metal mining is involved in doubt and perplexity. On the contrary, a great deal of solid fact is now established, room for which has been gained only by clearing away a mass of misconceptions. Much remains to be learned; in fact, the study of precious-metal deposits is only beginning. But whatever the explanation of geologic features, or the theory of the genesis of ores, it must be admitted that on the purely practical side great advances have been made. Each year less money and less effort, relatively speaking, are thrown away on guesswork or hopeless undertakings than in the year preceding; and as the wondrous varieties and possibilities of occurrence are becoming better known, the whimsical notions of earlier days steadily disappear. The best miner is least trammeled by prejudice and rule of thumb. And is it not safe to add that the best geologist is he who frankly admits that his science is still in its infancy? Unquestionably all occurrences are governed by law, and it is, perhaps, not visionary to hope that the precious-metal deposits may be as well understood at no very distant day as the coal and iron beds are now, in spite of the greater complexity of the former. But, for the present, it is surely best to meet the issue squarely and confess that even this stage is far from having been attained.