SCIENCE

NEW YORK, DECEMBER 25, 1891.

THE RELATIONS OF GEOLOGICAL SURVEYS TO SUCCESSFUL MINING.[1]

THE subject assigned to me for presentation to-night is, The Relations of Geological Surveys to Successful Mining. Other papers have been read to you and addresses have been made descriptive and eulogistic of the mineral resources of Missouri. It remains for me to present to you how such an organization as I have the honor to direct aids in their development. It gives me pleasure, gentlemen, to appear before you to discuss so fertile a theme as this. I would that I had time to attempt to do it full justice. I feel also gratified in being asked to do so before such a body of mining and business men, because we geologists are often led to believe that, among you busy men of affairs, there is sometimes a feeling that a scientist is a poor sort of creature anyhow, who spends his time hunting fossils or learnedly ventilating elaborate theories which nobody knows how to make use of. This we feel, of couree, is all wrong, and especially that you are all wrong, and hence such opportunities as this, where we can stand up and make it quite clear to you how you are all wrong, without your having a chance to reply, are always to be coveted.

But before we can proceed to do this let us understand what we are going to talk about. First, then, what is meant by the term "mining" in this connection? Mining, strictly speaking, is a process of excavating certain materials from the ground. With such actual mining of ore I must confess that our work has only indirect connection. This must be left to the judgment, energy, and perseverance of the miner, and the success of any mining venture is always largely dependent upon his genius in overcoming the difficulties encountered. But over and above this, the magnitude and importance of a mining industry is dependent first upon the nature of the materials mined, and second upon the extent to which these materials are used. I take it, therefore, that the sense in which it is meant that mining shall be considered upon this occasion is the broad one embracing all that is concerned, not only with the production of minerals, but also with their complete utilization; or, briefly, I will define it as the exploitation and the utilization of the mineral possessions of an area. The question now stands, therefore, what are the relations of a geological survey to these ends? To properly answer this it first becomes necessary to consider what are the fundamental requirements for the successful exploitation and utilization of the materials considered.

Manifestly the first thing necessary for the inception of mining is the discovery of the existence of the materials worthy of mining. It seems so perfectly clear that there can be no mining of a material without the presence of that material, that I would not say even these few words on so self-evident a statement, did not such facts as Missouri's tin mines and Arkansas's gold mines seem to stare me in the face in refutation of my proposition. Still, I will not yield my point, but merely elucidate it by adding that attempts at mining can always be made, as many of you doubtless know to your sorrow, without any foundation whatsoever.

Second, and next in importance to the discovery of existence for the development and sustenance of a mining industry, is the determination of the quantity and distribution of the material to be mined. A substance may exist, but it may be in such a small quantity as to be unworthy of consideration, as are, I fear, the tin ores of the United States. Or it may exist in large quantity, but be so disseminated or diffused as to be unattainable with profit, as is the gold which occurs in places, in the sands of northern Missouri. Finally, it may be both in large quantity and concentrated, but inaccessible, either by reason of its existence at excessive depths, as are some coal beds, or by reason of topographic isolation or geographic remoteness with absence of means of transportation, as are some of the iron and other ores of this State.

Third, in addition to the facts of existence and distribution, that mining may attain its fullest vigor and soundest prosperity it is necessary that the qualities and capabilities of the materials be exhaustively determined. This is important in both a negative and a positive way, according to whether the results prevent useless undertakings or direct enterprise in the right direction. An ore may be abundant and its distribution well known, yet it may be so lean, or so injured by impurities, as to be of low value, or even entirely worthless. A building-stone may be of handsome appearance and may be obtainable from the quarry in large blocks, yet when exposed to the condition of atmosphere and temperature of a large city, it may deteriorate rapidly. A superior clay may be used for ordinary purposes for which an inferior product would answer just as well, and a determination of its qualities may lead to its increased use for many other purposes, with enhanced value.

Different coals are put to different special uses. The determination of the essential properties of any one coal will lead to its ultimate use for all the purposes it is best adapted to. An uncommon but valuable material may lie neglected in great quantities, simply because its capabilities are not appreciated. This was the case for many years with the anthracite coal of Pennsylvania, which was practically ignored simply because people did not know how to burn it; a material which is now mined at a rate of nearly fifty million tons per year.

Fourth, and finally, as a necessary supplement to the dertermination of the existence, distribution, and properties of materials, is the dissemination of the knowledge in a way which will reach those who should know, and in a manner which will command their attention. If the knowledge of the existence of useful materials is confined to an individual or to a small circle, their development will be slow. The information must reach the right ears for the full effect to obtain; and not only that, it must reach those ears in the right way or it is not credibly received. The world is too full of vague rumors, of bubbles and booms, for startling or even all rational seeming statements to gain ready credence. People are more inclined to be incredulous of such good news than credulous, unless it is backed by well-known authority.

Thus reviewing what I have said so far, four fundamental requirements for the development and sustenance of a substantial mining industry are:

1. The discovery of the existence of the materials.
2. The discovery or determination of their quantities and distributions.
3. The discovery or determination of their qualities and capabilities.
4. The proper dissemination of the knowledge of these facts.

These being granted as fundamentally necessary for the development of mining, it follows that any work having for its object the accomplishment of these ends is, in intention at least, a contributor to the success of such industry. That conclusion follows logically and is necessary; the degree to which it is a contributor depends upon the extent to which it attains its objects. The relations of a geological survey to successful mining will hence be well displayed by a consideration of the manner in which it contributes to the four ends specified.

First, then, with relation to the discovery of the existence of

[1] An address delivered by Arthur Winslow, State Geologist of Missouri, before the Inter-State Mining Convention, held in Springfield, Mo., Dec. 15-17, 1891.

materials, how and to what extent does a geological survey accomplish this? Well, to answer this question satisfactorily we must first determine what is meant by the term "discovery." The date when the existence of any one material first became a fact in the consciousness of man can never be stated. It is probable that the gold in California was known to exist by the aborigines, merely as glittering particles or nuggets of undetermined properties, long before the "white man" made the fact of its existence known, or, as we say, discovered it. It is probable that many a block of silver ore was seen and handled unrecognized by the pioneer long before mining first began. Again, it is probable that the primeval savage of California both knew of the existence of the gold and was familiar with its general properties and value, yet from the isolation and barbarism of his surroundings the fact of existence was never made through him the property of the civilized world. Hence, so far as its effect on civilization is concerned, we must define discovery of existence as that event whereby a material is brought to the knowledge of an individual who recognizes it and who has a conception of its value, and who transmits the fact of existence to the world. Such a work of discovery constituted a large part of the functions of the early explorations throughout the country of the earlier geological surveys. The more general facts of existence were then sought after, knowledge was so imperfect. This was the necessary foundation for further investigation for future development. Nowadays the work of geological surveys is tending more to the solution of other questions.

With reference to Missouri as a whole, it may safely be said that we do not look for the discovery in the future of the existence in considerable quantity of a single mineral substance of great economic value, the existence of which is not already known. But though, in this large sense, such is, strictly speaking, true, in a narrower sense, and in the sense that the existence of materials in special localities is being brought to the knowledge of men who will recognize them and make the facts known to the world, discovery is still in progress in the State and constitutes an important part of the work of the geological survey. Discoveries of this kind of iron-ores, zinc and lead-ores, clays and coals, and other materials have been made throughout the State during the past year, and the results will be published in the forthcoming reports. Such discoveries are made by all well-conducted geological surveys, and they are thus extensive contributors to the first requirement for the development of a mining industry.

The discovery or determination of the quantities and distribution of materials is, however, nowadays recognized as one of the principal directly economic functions of a geological survey, and it is the work requiring the highest attainments and the most studious and exhaustive investigation. The science of geology is here called into play, and the knowledge accumulated during many years by multitudes of observers is applied for the solution of the problems. The mere existence of a material may be determined by any one with a small stock of knowledge and a rambling search. The quantity and distribution can generally be deduced only from a host of facts gathered with close and patient observation, and then studiously and logically handled. It is first an inductive and then a deductive process. The general laws and facts of geology have to be known before a correct diagnosis can be made. Therefore, just as a physician can best treat a patient if he knows his structure, constitution, and habits well, so a geologist can best accomplish his results if he knows thoroughly the geological structure of the area he is examining, and the laws governing its phenomena. Hence it has come to be recognized in theory, and is accepted in the best practice, that the most valuable and far-reaching results are attained when the fundamental facts of the geology of an area are mastered. A due regard for logic demands that the general principles shall be established before we attempt the solution of particular cases. To illustrate, most of the rocks exposed in Missouri and adjacent States are what are called clastic or sedimentary rocks, and occur in strata, or layers, piled upon each other like the leaves of a book. Each layer is, however, not co-extensive with the area of the State, but generally the uppermost occupies the smallest area, and those underlying it protrude beyond it successively in constantly expanding zones, so that their limits are defined on the map by a series of roughly concentric lines, or, as has been said by Lesley, like the grain lines of a polished piece of wood, planed at a low angle across the grain.

Some minerals of value frequently characterize certain strata or formations; this is especially the case with coal, iron, and clays, and sometimes with lead and other ores. Hence, if the distribution of these strata is once defined, through the study of the geology, the value of the knowledge as a guide to prospecting for all future will be readily appreciated. This definition of the areas of the strata or geological formations is hence recognized as an important duty of a geological survey. Here it is that fossils are of use. Some fossils are restricted to certain strata, or, more exactly speaking, different strata have different faunal characteristics; hence, fossils become ear marks which help us to recognize outcrops as belonging to certain formations and lead us to a correct classification of the scattered occurrences. For example, suppose that over a coal bed worked at a point, A, is a bed of limestone characterized by certain fossils. At a point, B, is another coal mine, and the question arises as to whether the bed at B is the same as that at A. Or, in other words, have we at B one or two coal beds, a question of much economic importance. A close examination in the creek bed below the outcrop of coal at B reveals the existence of a limestone bed with the same fossils as those found over the coal bed at A. Hence, the inference is direct that that the coal of A underlies the coal of B, and will be found on investigation.

In working out the distribution of the geological formations on the ground this end is the immediate and controlling one to the field geologist, and its economic value is not always in his mind; and to a still smaller degree is the fact ordinarily appreciated by the layman; hence the former's operations are frequently regarded, by those of ultra utilitarian minds, as mildly idiotic. In illustration, an assistant of mine on the Arkansas survey, a capable and well-trained man, was at one time engaged in tracing the outcrops or limits of a certain stratum of sandstone in the coal measures of that State. He stopped one night at a farmer's house for lodging. After the evening meal, the host and his guest having settled themselves in front of the blazing log heap of a fire, which all Arkansas travellers enjoy, the farmer, learning the vocation of his guest, thought he would seize the opportunity to obtain some useful information. "Well, my friend," he began, "have you discovered any mineral about here?" "No," answered the young man, who was somewhat shy and non-communicative. "Not found any!" echoed the farmer; "well, now, that's too bad. Don't you think you will find some soon?" he questioned. "No," again answered the young man, who was strong in monosyllables. "Haven't found any and don't expect to find any, !" ejaculated the somewhat astonished questioner; "well, what do you stay here for, then?" "I am not looking for mineral," was the young man's brief reply. "Not looking for mineral!" exclaimed the dumbfounded and now somewhat irate farmer; "then what in the name of creation is your work good for?" Here, then, were two men at loggerheads simply for lack of a little explanation. The young man was tracing a stratum, which, when transferred to the map, would define the area of an important coal bed. Absorbed in the immediate object of his work, he lost sight of a part of its outcome; he was in one sense engaged in the actual "discovery of mineral" without being entirely conscious of it. A few words of explanation might have made all clear.

These illustrations will suffice to explain how the determination of the general facts of stratigraphic structure are of broad economic value. The definitions of the members of the oil-sand group, in Pennsylvania, of the Trenton limestone in Ohio, permitted the intelligent and rapid development of the oil industry.

Similarly the determination of the sources of our ore bodies, of their modes of formation is of fundamental importance, is indispensable for the construction of the correct theory of their distribution, which alone will lead to their full development, and which will prevent waste through expenditure in the wrong direction. I could illustrate this in detail, but time will not permit, and I think the principle is already made clear. Such are some of the

discoveries of geologic science; these are the results which we strive to express in our maps and reports, over and above the details of occurrence. The latter serve as a means for attaining the former and are necessary for that purpose. They are gathered sedulously in the field and are studied in the office. Thus, in the office, are most of the discoveries of modern science made. The facts of observation are our mediums, the laws of reasoning are our divining rods and witch-hazels. The determination of the qualities and capabilities of materials we have recognized as an important pre-requisite to the full development of a mining industry. Such work is also properly made the function of a geological survey. Some materials show on their faces, from mere inspection, what their value is; such being the case with most of the zinc and lead ores of this region. Others need more or less elaborate tests for the fact to be determined. Iron-ores may appear and be rich in iron contents, yet they need to be analyzed to determine the amounts of sulphur, phosphorus and silica, which they contain before their capabilities can be predicted. Mineral waters need similarly to be analyzed before their beneficial qualities can be known. Coals and clays need similar treatment, and in addition they should be subjected to exhaustive tests, on a working scale. An analysis of a building stone yields little knowledge as to its capabilities, and here the thorough experimental test is alone capable of demonstrating just what the value of the stone is. The analysis and tests above enumerated are either actually or prospectively part of the work of the Geological Survey, and most valuable results have been reached, especially with the clays of the State, which will be incorporated in future publications. That the additional information thus acquired concerning the mineral deposits of the State will contribute to their further development seems indisputable.

Finally, in what way does a geological survey disseminate knowledge concerning these materials and is this way an effective one? A geological survey, if properly organized, is composed of professional men of scientific attainments and of undoubted integrity; it is an official organization, and its examinations are made disinterestedly, and on the truthfulness of its results depends the reputation of its members. Its publications are widely circulated; they are designed to be used by the professional man and also by the layman; being official, and coming from such a disinterested and qualified source, the results are accepted generally without hesitation by the capitalists or manufacturers. Such influence and acceptance could never be reached by reports emanating from owners of property or other interested parties, nor would the judgment of such concerning theories of distribution or quality command respect, unless emanating from well known expert sources; thus the capital and enterprise necessary for the inception of such undertakings would be slow to follow such guidance. Hence, a good geological survey constitutes the best of advertising mediums, if you choose to call it such; advertising what is genuine and good, but never stooping to indiscriminate booming.

But another means of disseminating information exists, over and above that of publications. Some people are not reached by reports, either because they are not given much to reading, or for lack of access to the publications. They may come to the State, or even be in the State, knowing little or nothing of its natural features and products. In such cases, a State museum is the most effective means of conveying information; a museum which shall contain not only specimens of materials, but maps, models, views, diagrams, and reports concerning all that is of interest in this connection; the materials in which shall be so arranged as to convey clear ideas, not only of what is in the State, but where it is, how it occurs, and how much there is of it; which shall be supplemented by the presence of trained men, familiar with the State, who can guide the stranger in the right direction.

In conclusion, I would say a few words concerning the educating influences of a geological survey among the citizens of the area in which it operates. Through its publications, through the intercourse with its members, and in other ways, a vast amount of information is absorbed by the people concerning the land they live in and its products. This information they apply unconsciously in their various operations. It prevents them from being led into hopeless enterprises, it leads them to discountenance extravagant expectations and to recognize charlatantry, it brings them to appreciate the truly useful and valuable, and it supplies them with a source of advice which many are otherwise destitute of.

Finally, if their serious attention is aroused, they are soon brought to see in all nature that surrounds them, a wonderful relationship of parts, to read the history of a wonderful succession of events; they begin to hear the "sermons of the stones," which ever after become replete with interest and significance, exercising refining influences and acting as healthy stimulants to intellectual effort.

NOTES AND NEWS.

THE Geological Society of America will hold its winter meeting in Columbus, Dec. 29–31.

— From a report on mine ropes to the French Government, it appears that hemp or aloes ropes are almost exclusively used for all depths of shaft in Belgium. The makers guarantee the ropes to last one and a half to two and a half years, and should they fail earlier, a twelfth to a twenty-fourth of their cost is deducted for every month short of their stipulated duration. Steel-wire ropes, according to *Invention*, should be of crucible steel having a breaking strength of 70 to 76 tons per square inch. Large pulleys are more necessary for wire than for hemp ropes, the smallest diameter permissible being 1,300 to 1,400 times the diameter of the wire in the rope, if of iron, and 2,000 times if of steel. For mining purposes wire ropes are best made with a hemp core being more flexible.

— Poisoning by mussels is a well-known fact. Such poisoning appears in chronic form in Tierra del Fuego, mussels being abundant on the shores, and other kinds of food rare, so that the natives eat large quantities of the former daily, both of bad and of good quality. According to a doctor of the Argentine fleet, M. Segers, as *Nature* reports, the mussels are rarely injurious at their maximum time of growth, which corresponds with full moon, but when the moon wanes, they become poor and often poisonous. The poisonous quality apparently results from the death of a large number at this time, and the putrefaction of their bodies yielding ptomaïnes which are absorbed by the surviving mollusks. In any case, the Fuegians are often attacked by a liver complaint, consisting in atrophy of the organ, with jaundiced color of the skin and tendency to hæmorrhage; and M. Segers believes this is due to mussel poisoning. He finds sulphate of atropine an efficacious antidote.

— According to the *Lancet* a noteworthy difference between the present outbreak of influenza and those experienced last spring and the original epidemic of the winter of 1889–90 is the comparative slowness of its diffusion over the country. It was, in November, mainly confined to two widely separated parts of the kingdom, Cornwall and the eastern counties of Scotland. It is remarkable that children are attacked almost as much at adults. It is reported to be very prevalent in St. Petersburg and Berlin, while at Hamburg it reached "alarming proportions," and the weekly mortality of the city and its suburbs exceeded the average by 280. In France it is especially prevalent at Bordeaux, where many deaths among the aged have occurred. It has also appeared in Paris. In showing some patients to his students a few weeks ago, Professor Gerhardt of Berlin said, "The morbid symptoms which we comprehend under the collective name of influenza have repeatedly been observed before, and several epidemics of the so-called 'grippe' (those of 1847 and 1876, for instance) are on record. Such a pandemic, however, as prevailed two years ago had not occurred for a generation, and we had to deal with something quite new and unknown. It came to us from the East. In May, 1889, it broke out in Bokhara, rapidly overran Russia in Asia, and came to St. Petersburg in September. The disease spread rapidly all over Europe, radiating over the provinces from Berlin, Vienna, Paris, and London, and remaining mostly three or four weeks, never more than two or three months, in one place. Its course ran unmistakably from east to west; from us it went to America