Some Features of the Geological Department of the Anaconda Copper Mining Company

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*The Anaconda Copper Mining Co., of Butte, has developed its geological department into an important branch of its organization. This has been the result of a number of factors, but perhaps the chief influences have been the character of the Butte orebodies and the methods of mining required for their development and extraction.

The Butte ores are contained in rather narrow veins in granite (quartz-monozite, to be exact). Widths range commonly from 2 to 20 ft. These veins are cut by at least six successive series of faults, the earlier of which also contain ore-shoots. Thus either in plan or in section the veins are broken and displaced at frequent intervals, the direction and amount of movement varying with each fault, but almost always being enough to throw the ore outside of the drift or raise. When it is considered that the high grade of the ore makes important the recovery of every fragment of vein, and also that many of these faulted fragments are too small to be hit by haphazard cross-cutting, the necessity for an understanding of the structure becomes apparent. From the mine operator's viewpoint it is essential to know promptly which way to turn a working; he is little interested in microscopic details of rock-alteration or theories concerning the source of mineral solutions.

ORGANIZATION. In 1900, an early date as mining geology goes, H. V. Winchell and D. W. Brunton organized a geological department for the Anaconda company, realizing that only the complete compilation of geologic data would solve the problem of fault-structure to the degree necessary for the proper aid to mining operations. The work thus begun has been greatly enlarged in scope and improved in detail under the direction of Reno H. Sales, chief geologist since 1906. F. A. Linforth, who in recent years has been in special control of the work in the Butte mines, has contributed many of the refinements of methods now in use. His paper presented at the Butte meeting of the A. I. M. E. in August 1913, gives an excellent outline of the work as conducted at that time. I follow his article in many points.

REQUIREMENTS OF MINING GEOLOGY. The geological department has thus from its formation kept for its prime objective the helping of the mine foremen and superintendents through a knowledge of the structure of the ground. Its members have realized that the geologist should be the servant of the man who is responsible for the work of the mine. As a result of 20 years of experiment and progress, it has come to regard the following points as essential:

First, friendly co-operation and mutual respect between mine foremen and geologists. The geologist must be familiar with the foreman's plans in order to advise him intelligently, while the foreman must appreciate the value of geologic advice, and be prompt to seek it when in difficulty.

Second, prompt geologic examination of all new workings, in order that suggestions may be made without loss of time. Much useless work is thus prevented.

Third, accuracy in underground observation. Details of structure or of mineralization must be recorded exactly as they appear in the ground—big faults distinguished from minor slips; sequence of veins and faults at intersections properly interpreted; and important minerals, such as secondary chalcocite or primary chalcocite, observed and noted. To take notes properly frequently involves long study under very unfavorable conditions of air, water, ground, etc. Hazy or indefinite notes are only less useless than erroneous ones. If the geologist is not clear in his own mind as to which way the mineralization trends, or as to which of two faults is the intersected, and which the intersector, he should settle the point in the mine, with the evidence before him, and not use indefinite notes as a refuge.

Fourth, immediate platting of notes, and particularly of structural features, upon general geologic maps and sections, in order that the new evidence may be studied in its proper relation to that already accumulated. While I have just pointed out that decisions as to detailed structure must be made underground, it does not follow that general ideas can be correctly gained from that viewpoint. It is one of the most vital features of the work of the department that such general ideas are formulated only upon a study of all available details, each detail as accurate as it can be made by careful work with pick and compass. It is particularly important that one should not let his judgment underground be influenced by what he expects to find. Often a big fault does not come where it is expected; the reason will be discovered in due time.

Fifth, a smoothly-working system whereby conclusions reached by a study of geologic data are translated promptly into terms of mine operations.

METHODS. The means by which these fundamental ends are obtained have been described by Mr. Linforth, but may bear repetition here. Co-operation with foremen is a matter of state-of-mind. The geologist must be humble in spirit. Often the foreman knows more about

*A paper presented at the Western annual meeting of the Canadian Mining Institute in November 1919.

the geology of his mine than he can express in the geological language of professors. Generally he can teach the geologist much about mining methods. Experience would indicate that geologists who have used 'muck-sticks' in their past are apt to have a healthy state of mind in this respect.

Promptness has been secured by enlarging the force of geologists until each man can cover his territory in somewhat less than one month. Many foremen would like more frequent visits. Important faces are visited after each round. It has been found that while a geologist experienced in work at Butte can map correctly 25,000 ft. of workings per month, this gives too little time for the study of special problems in the mines, and does not permit enough trips with the foremen and bosses. At present I should judge that the members of the department cover about 6000 ft. of workings each per month.

Underground notes are taken on loose-leaf sheets on a scale suitable to the amount of detail desired, usually either 20 or 50 ft. to the inch. Colored pencils are used. Red represents vein mineralization, the ore being shown in darker color than the gangue. Blue is used for fault-gouge, light blue for slightly crushed rock, and heavy dark blue for strong clay selvage. With these conventions it is possible to make a drawing that absolutely reproduces the appearance of the face or back of a drift, showing to anyone familiar with the scheme the intensity of mineralization, amount of faulting, direction of drag, etc. The necessity of accurately reproducing the appearance of the ground is greater stimulus to careful observation. In this respect the Anaconda system is superior to others in which mere conventional symbols, such as red dots or crosses, mark the position of ore, or ruled lines of uniform width indicate faults. The fine distinctions which are perceptible underground should appear on the geological maps withe equal clarity. Unimportant details such as joint-planes, etc., should be ignored.

In Butte, geological maps are based upon the coordinate system used by the mine-engineers. Sufficient sets of convenient size are made to cover the entire district in checker-board manner. The maps are on tracing-cloth, with a separate sheet for each level. In addition to the regular working-set on a scale of 50 ft. per inch, sets on scales of 100 and 200 ft. to the inch are maintained. Mine-foremen are provided with 100-ft. maps covering their own mines, and these are kept up to date by the department. It is of prime importance that the foremen should have for daily use a set of maps on which the geologic structure is shown. The expense entailed by the preparation and maintenance of these foremen's sets is more than repaid by the saving in underground work which results from their use. Cross-sections, generally on a 100-ft. scale, are made at sufficiently close intervals to cover all details of structure. In many parts of the district a cross-section every 100 ft. is essential. It has become axiomatic among members of the department that the preparation and study of these cross-sections is one of the most fruitful methods of using the geologic data. It may be stated without reservation that even those most accustomed to using maps and thinking in terms of three dimensions seldom fail to profit by the use of cross-sections. Many an unexpected orebody has been found through their assistance. They are too seldom employed in general.

In order to transmit to the proper officers the geologic conclusions reached, a system of 'recommendation sheets' is employed. These sheets are made out by each geologist as he reaches his conclusions. They carry the following information: mine, level, description of recommended work, object of recommended work, approximate distance to be run, date of recommendation, result (to be filled in later). The recommendations of the subordinate geologists are submitted to Messrs. Sales or Linforth for approval, and if endorsed, are forwarded to the mine-foremen for execution. Duplicate copies are filed for the information or action of the general superintendent. It has been found desirable to keep each foreman supplied with a large number of recommendations for each working level, in order that he may carry out the suggested work at the time most convenient to his general operations. Recommendations requiring immediate action are appropriately marked.

CONCLUSIONS. This outline covers the routine work of the Anaconda Geological Department. I have purposely emphasized those features in which I believe it to excel—for instance, the close co-operation with the men in the mines, the accuracy and detail of the notes taken, and the concentration of attention upon the structure of the ground. Its excellence in these lines may be attributed both to the special problems of Butte geology and to the good leadership and direction which have solved them.

The problems which other mines present to the geologist are not always the same as those of Butte. In some districts mining operations depend less upon structure, and more upon such matters as the genesis of the ore and its association with certain rocks. But the correct interpretation of these points cannot be made without the preliminary work of thorough and detailed mapping of the veins, rocks, and faults. From this structural work alone can the succession of geologic events which have created and localized an orebody be worked out in the proper sequence, and upon this knowledge alone can underground prospecting and development be successfully conducted. With the recent great and justified expansion of the use of the microscope in geological study it is perhaps well that conditions in Butte have combined to prevent this from resulting in a neglect of overalls and pick as essential tools of the mining geologist.

JAPAN has forged ahead to leading position among the foreign countries using American copper, a total of 117,354,241 lb. having been exported there during the nine months ended March 31. This is all the more interesting when it is realized that not a single pound was sent to Japan in the corresponding period last year.