THE MAKING OF MINING ENGINEERS.

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It was formerly thought that the necessary and sufficient qualifications of a mining engineer were obtained by spending a certain number of years in practical duties underground. The practical mine manager confined his attention to the management of his men, the development of his mine, and the extraction of pay ore from his stopes. His ore he usually subjected to some crude sort of concentration or selection, and sold to the best advantage. What subsequent process it went through before values were obtained, or what further profits it represented to buyers, were items of trifling interest to him. The rapid advance of science, however, has drawn mining into its vortex, with the result that careful study and observation of all details, combined with advanced methods and improved machinery have revolutionised the industry, and the production of the mines has been increased enormously. Prices of metals have decreased, cost of labor has increased, and mines which were once profitable can no longer be worked with effete methods. One striking feature in later practice is the reduction of ores to obtain the values at the mine itself.

In the midst of all the new improvements in machinery and methods that are being brought out with never ceasing activity, it is advisable for any one in a responsible position to have a thorough training, so that he may understand and be able to discriminate and select the best suited to the conditions existing at his mine. It is difficult to see how the practical miner, who has obtained all his knowledge from a few confined localities, can fulfil this satisfactorily. Yet even in these days, in Australia at all events, every man, however uneducated he may be, believes in his heart, and would induce others to think, that as a mining expert he is at least preferable to what he considers the theoretical man. Quackery and incompetency find a happy hunting ground in mining, and freely exploit it in Australia.

Our Australian mines, more than all others, need scientific management; but that opposite conditions prevail is not difficult to see. All kinds of unsuitable men have charge of our mining concerns, and the ores are treated unscientifically. This tends to show that there is ample room for the employment in the mines of this State of all the mining graduates our university produces, so that it should not be necessary for them to seek employment in other countries.

The profession of mining engineering is decidedly as complicate as any other, not excluding law, medicine, or civil engineerin Legislation protects graduates of law and medicine from competitio with quackery, whilst economic considerations speak so loudly tha trained civil engineers have likewise come to be protected by publ opinion. But academically trained mining engineers have still t wage ware against untrained competitors for positions and appoin ments for which the former alone are suitable. In the minds of th general mining public, there appears to be a wrong appreciation of th training in mining schools. The object of this address is to start vigorous discussion, so that corrective measures can be determine which will help the mining engineer to become so efficient that th public will place full confidence in him, and make the profession a exclusive as any existing.

I will endeavor to outline an investigation and produce some o the impressions that have from time to time occurred to me. It woul be well, first of all, to enquire as to the qualifications that ar necessary for a mining engineer to possess. The name "mining engineer" is often applied to each and every officer employed on th staff of a mine. I think the term is used too profusely, and would b more suitably reserved for those upon whom the greatest responsibilit rests. Many other engineers may be employed upon a mine, such a metallurgical, civil, mechanical, and constructional engineers, and I think the classes should be differentiated in some such way. For th purpose of this address, I will assume that the expression "mining engineer" refers to one who is placed in charge of a mining concern The ideal mining engineer, then, is one who is so taught and practised that he is properly fitted in every way, to take charge of a mine, and superintend all the operations that are likely to be conducted. He should have business knowledge, and be able to run all the affairs on a commercial basis.

Work that goes on at mines is of a very varied nature, and the training for a manager must necessarily cover a wide field. This wil leave him little time to specialise to any great extent. There can be no objection to a manager being a specialist in mining, metallurgy, mechanical engineering, or any other department of the work so long as he is not deficient in any of the qualifications otherwise necessary. Some mines may present features which demand that the manager be specially expert in some particular division. In the majority of instances, the mine manager is also the metallurgist; but in all cases he should possess all the other qualifications necessary for a mine manager.

I do not mean to imply that a manager must himself become a handy man of every trade employed. That would be impossible, besides being not at all necessary. If an expert man of any craft is required, he can easily be procured. The manager is not required to show off at the forge, and is out of place as a pretty hammer man. It is to be desired, however, that he should possess a working knowledge of all the trades, so that he may have a clear idea of what he wants, and see it carried out to his satisfaction. In the case of large mines, specialists are employed to govern each department, and even then the general manager should keep well in touch with all the work

going on. In smaller mines it is desired that the manager be able to control as many departments as possible to save the cost of many highly-paid officials. There can be no doubt that many of the failures of mining enterprise, lost reputations of engineers, and much of the disrepute with which technical training is associated can be traced to the error that is too often observed in those who assume the entire command of a mine when their training or experience has not fitted them for it. The fact that a man has been much esteemed in another capacity must make his one great mistake the more conspicuous. The working miner must similarly make an unprofitable manager. But I do not wish to detract anything from the specialist as regards his value to the industry. There is room for all the various experts; the mining field is incomplete without them.

On the whole, I think the mining engineer should give more than ordinary prominence to metallurgy. He should understand the geology of ore deposits, and methods of underground operations. His engineering knowledge should enable him to design, erect and run ordinary mining plants and machinery, make underground and simple surface surveys, construct light tramways and earthwork dams. He should understand the ordinary trades, such as smithing, fitting, plumbing, building, mining, etc., etc., and he should have business qualifications.

A young man having decided to embrace the profession of mining may not have had any experience of mines before he enters the mining school. If so, he will be apt to form early impressions of the business which would be correct or erroneous according to his temperament and the nature of his studies. As these impressions are often difficult to remove in after life, it becomes a matter of importance that the schools shall adopt correct methods of teaching, and so lead the student on to real knowledge. Now it is possible for a student to imbibe wrong impressions even although the teaching may be sound and true. While learning a great deal of the sciences, he absorbs many current theories of the day regarding matters which are only of scientific interest, and the tendency to elevate a pleasing theory to the dignity of a proved fact is created in his mind, with the result that unconsciously he will form unsound methods of reasoning. It must be continually remembered that mining is an applied science, and that the student is preparing himself to occupy a position of responsibility in an industrial enterprise, in which his employers will have embarked only for commercial reasons. He need not throw overboard all his schemes of scientific research; such work would be healthy exercise for his mind, and may provide stepping stones to results of greater utility. But he should draw a strong line between his business and his research. A student cannot be aware of this pitfall, and it is to be regretted that the schools do not do more to combat it. So we have here a source of danger, the magnitude of which is difficult to gauge. It is due not to too much, but to too little, teaching. Theoretical teaching should always be accompanied by a proper explanation of its intrinsic value, and whenever possible the practical light should be turned on full for the student's guidance. I do not intend to champion the methods much in vogue at some of the smaller provincial schools of mines, in which the chief line of instruction consists in muscular

development, exemplified mainly by the student learning to spall sufficient stone to keep a three-head battery of toy stampers in constant operation. Furthermore, I do not advocate the insertion into the school routine of a period of practical work at a mine, as is practised at some of the great Continental schools. My belief is that such forms of practical teaching are practically worthless. The student's object in attending the schools is to learn to be, not a mullocker or a battery feeder, but an engineer. At the end of his course, he may take a line of professional work in which stamper batteries will play no part, but are replaced by smelter furnaces. Obviously, then, the stone breaking should have been omitted in his course in favor of smelter attendance. It is seldom possible during the teaching stage to predict what class of work the student will subsequently be required to adopt, and I lean towards the opinion that it is not wise to prolong the student life more than is required for lectures and laboratory exercises. The student during spare time should be able to see as much machinery and as many illustrative methods in operation as is possible at the school, and he should visit mining fields during vacations. By these means he is likely to learn, practically as well as theoretically, more than if he had spent an extra year in one or two mines. In either case, he must look to his professional life for practical experience on a larger scale.

The length of the period over which the curriculum extends is a matter for some comment. Some schools require four years, others only two years, whilst the majority, including many of the best esteemed, enforce the medium, or three years. It appears now to be generally recognised that three years is greatly superior to two years, and very little inferior to four years. Two years does not suffice for laboratory exercises, and the proper assimilation of instructions from lectures aud books of reference, so it becomes a system of cram. A four-year course lags unnecessarily over the work. A student can maintain a severer strain of study for three years than he can for four years, and he should be well fitted after three years to conduct advanced studies without professional assistance. The option over the fourth year should rest with him. The matter, too, has a commercial aspect. Against the benefits of the extra year's tuition should be set the cost of that year plus loss of salary. Further, taking the average life of a man as forty-four years, and supposing the student enters the school at twenty years of age, with a four years' course his ratio of professional life to student life will be 5·1; whereas, with a three years' course his ratio will be increased to 7·1. This is a matter of some importance, and I have laid some stress apon it, seeing that it has been at various times suggested to extend the mining engineering course of our university to four years.

I believe that few mining schools bring their curricula vigorously up-to-date. Students should be taught the latest practice. So many innovations are evolved by the professional world that a curriculum which is allowed to exist in stereotyped ease for several years would become unworthy of an advanced institution. We have noted remarkable changes of late years in the metallurgical treatment of ores. Some of the most important improvements have been in the direction of smelting and cyanide processess. American engineers

have changed smelting methods out of all recognition, and with Western Australians have similarly treated the cyanide process. The results thus achieved have practically signed the death warrants of some processes which were in favor but a few years ago, such as amalgamation and chlorination processess for the extraction of silver and fine gold from ores. Many other changes have come about, and some of the old metallurgical processes, though interesting for their chemical reactions are no longer an important factor in the treatment of ores.

A mining curriculum comprehends such an extensive range of subjects that it is impossible to impart a complete knowledge in all of them during the short space of three years, but the student is conducted through the whole range, and left in the end well fitted to amplify his studies during professional life. Those who frame the curriculum must be careful that preference is only given to the main subjects. Others should be treated only in proportion to their true relative importance.

There is room for considerable variation of opinion as to the relative importance of the numerous subjects which go to make up a mining course. We must keep in view that a student does not know beforehand what branch of professional life he is destined to take up, and so must adopt a routine which will prepare him in a general way for any work he may be called upon to carry out. We have then to make a list of all the subjects required, and divide them up amongst the three years, so that each will get what we consider a fair proportion according to its relative importance in the profession. The peculiar facilities by which our school is able to work harmoniously with other branches of the University of Sydney, and the generous donations which we have shared in, have given us the benefits of an excellent teaching staff, and exceptionally well-equipped laboratories and plant. These and the energy of our professors in continually revising and improving the curriculum have brought the school into the front rank among mining schools of the world,

When our Mining School was first formed, it was looked upon as a branch of the School of Civil Engineering, and students attended the civil engineering lectures for instruction in engineering. This has always been a handicap to the mining students. Lectures prepared specially for the civil section could not be quite suitable for the mining section, even although separate lectures for each would run on nearly similar lines in some subjects. So mining students were forced to learn details, which, although intensely interesting, should have been relegated exclusively to civil engineers. A student can only be taught a limited quantity in three years, and all the time spent in learning unnecessary things must lessen to that extent the time available for the study of subjects that mining engineers should know. During late years, however, I have noticed many changes which are in the right direction. The exclusion of such studies as water supply and sewage disposal for towns, location of railways, geodetic, astronomical, and other advanced branches of surveying, and the reduction of some other subjects to the desired limits are to be commended. I would like to see alterations of this kind go further still. The mining section has become sufficiently important to warrant the adoption for it of courses

of instruction in engineering subjects entirely independent of the civil section. Such courses would only include selected subjects, which would not be overdone. I cannot see why the full-fledged graduate must find out only by degrees that he is deficient in necessary knowledge of the trades, the rudiments of business methods, and the construction of mining works, while at the same time it dawns upon him with disheartening reality that he will have no use for the more intricate developments of the theory of thermodynamics, the design of imposing bridge structures, and the discussion as to the most suitable system for refrigerating meat. I propose under the following heads to offer some suggestions which I believe would still further improve the curriculum of the Mining School.

METALLURGY.—This course now consists of eighty lectures. I would increase it by twenty lectures, to be reserved exclusively for special instruction in (1) crushing, dressing and concentration of ores; (2) the extraction of gold and silver from dry siliceous ores by the cyanide process and its modifications; (3) special descriptions of smelting processes for copper and lead ores, with instruction in furnace manipulation; (4) treatment of low-grade copper ores, and (5) treatment of so-called refractory and complex ores, especially those of this State. The introductory course of about thirty lectures could be suitably given during the second year.

ASSAYING AND PRACTICAL METALLURGY.—This now consists of about 930 hours, and probably in actual practice runs into a 1000 hours. I think an improvement could be made by increasing it a little, and by dividing it clearly into two separate courses, giving assaying about 800 hours, and practical metallurgy 300 hours. The assaying course should be started in the second year. The practical metallurgical course would afford instruction in (1) testing ores to determine their fitness for various processes of treatment; (2) practical exercises in cyanidation, and other leaching processes; (3) demonstrations in running metallurgical plants.

MINING.—This course is treated in thirty lectures. I think it is too much cramped, and should be increased to at least sixty lectures, mostly for amplification. About seven lectures should be set apart for teaching business principles, and mine accounts, and more attention is wanted for (1) examination, sampling, and valuation of mines; (2) sampling and purchase of bulk parcels of ores. Ore dressing and concentration should not be treated in this course; it belongs to metallurgy.

PRACTICAL CHEMISTRY.—This ought to be more condensed in the first year. At least one term of quantitative analyses should be included.

DESCRIPTIVE GEOMETRY AND DRAWING.—This course of forty lectures is too elaborate for miners, and need only be treated in a very elementary manner, with about ten lectures. Its importance does not stand in comparison with such a subject as mining.

APPLIED MECHANICS (1st year).—I would reduce this from sixty to about forty lectures, in order to omit a large proportion of the lectures on mechanisms, and to maintain the existing lectures in the elements of materials and structures. (2nd year.)—This course is treated in sixty lectures. I would reduce it to about forty, and omit

(1) at least one-half of the lectures on thermodynamics; (2) at least one-half of the lectures in course B, in which mining students do not require to learn location of roads and railways. The mining lectures already cover tunnelling and timbering. Course B should only instruct in location of pipe lines and earthwork dams, and the elements of other portions of the course B. The existing lectures on steam and other engines are eminently suitable. There should be particular mention of machinery specially used at mines, such as pumps, air compressors, hoists, aerial and surface traction, and elevating and other machinery.

Materials and Structures.—I would dispense with the existing course of thirty lectures, and instead of it institute a course of mining and metallurgical design.

Mining and Metallurgical Design.—This course ought to consist of about forty lectures, to include (1) design of foundations, columns, roofs, buildings, overhead gear of shafts, elevated tramways, ore bins, etc.; (2) design and construction of plant for hoisting, crushing, roasting, leaching, concentrating, smelting, lighting, pumping, and other mine equipments, and the methods of arranging such plant to give harmony and utilise natural local advantages.

Drawing.—This work should deal entirely with mining matters, and could suitably include (1) plans and sections of underground workings, showing their relation to surface surveys; (2) drawings of mining and metallurgical units; (3) designs of complete plants for mining and ore treatment.

Trades Course.—It is advisable to include a small series of about ten lectures to describe the ordinary trades, such as making and laying bricks, fitting, plumbing, and smith work, building, etc.

Visits to Mines.—Students during their three years should be required to visit at least three approved mining fields, and present a thesis on each, describing his impressions of what he has seen.

Collection of Common Ores.—I would like to see a collection of ores as they are usually mined arranged as a set-off alongside the cases of elegant but comparatively rare mineral specimens of the Mining School, to allow students to get more real knowledge of the appearance of ordinary ores in a mine.

I admit that some things included in the above suggestions can be, and usually are, picked up early in professional life. In this respect, I may instance the trades course, and lectures on business principles. But such may not be the case always, and when such teaching improves so much and occupies so little time, I think argument is in favor of their inclusion. But some other subjects naturally belong to the curriculum. In my own experience, I have made a practice of collecting information in detail relating to the erection of mining works, and have been fortunate in getting advice respecting plants erected here and elsewhere, which I have found useful, but which in the ordinary course of things graduates would find difficult to obtain.

I know that it will be said that descriptions of mining works are covered by descriptions through lectures in metallurgy and mining. But why should such an important study as mining design be reduced to mere description squeezed somehow into lectures, already much overcrowded? I quite agree with the practice of describing the main

features of metallurgical works, concurrently with metallurgical processes, and mining with mining lectures in a general way; but I believe a course of separate lectures is desirable to teach, first of all, the complete design of separate parts of ordinary mining plants, and, secondly, the systems of laying out whole plants so as to give harmony and utilise natural local advantages.

I expect it will be said that the subjects I propose to eliminate, although not directly useful to the mining engineer, are useful in a general sort of way, in broadening his views. That is right enough, if it does not do so at the expense of subjects which are directly useful. It is a feature of modern times that one man can only be expert in one profession, and he has to stick pretty closely to set lines to do even that.

Before passing from the Mining Schools, I would like to mention one other matter which I believe is liable to lower the value of the mining degree. Under the regulations, anyone can attend portions of the course at our University, according to his own choice. He is not compelled to take up the whole course unless he wishes to have the degree; but he is given certificates for the subjects he completes. Mine-owners do not understand all this, and even if they are interested to know where the candidate for their position received his training, they are not so conversant with local University matters as to be able to differentiate between a few certificates and a full diploma. If the degree of the Mining School loses any respect because of this, the fault can only lie with the authorities and with the graduates who have allowed it to happen, and have made no attempt to combat it. It seems to me that our graduates should endeavor to correct this. I suppose it would be impossible to prevent students taking up portions of the course, but I think something could be done in respect to altering the certificates so as to show very clearly that the work done is only a portion of that required for the full degree.

To complete his apprenticeship to the mining profession, the graduate must spend a certain amount of time in the mines to become accustomed to the practical application of what he has learnt as a student. As he gets his experience, he gradually becomes more fitted to hold a position of responsibility. There are many ways of effecting this, and there is room for a good deal of difference of opinion in selecting the one which will lead to the best results. The desiderata appear to be (1st) to gain valuable experience, (2nd) to get professional standing. Salary should not be considered a matter of importance in starting out. Sometimes a graduate is able to get a position with good people, in which he is able to see and conduct a large amount of varied work. This appears to me to be the quickest and best means, provided he is alert in grasping information about things he sees. It gives the varied experience, and the professional status, and more would be gained by a year spent in this way, than by two or three years spent in mine jobs such as trucking and hammer and drill work, which at present occupies far too much of a graduate's time, considering there are so many more important things that he should be gaining experience in. Unfortunately, it is not often that good openings are offered; the majority of our men have to start in the mines as laborers, until an opening presents itself. In such cases, the graduate