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ART. IV.—ON THE NECESSITY FOR PRELIMINARY SCIENTIFIC TRAINING FOR CIVIL AND MINING ENGINEERS.—BY EDWIN GILPIN, M. A., F. G. S., MINING ENGINEER.

(Read. Feb. 11, 1878.)

IN view of the attempt now being made to establish a Nova Scotia School of Science and Technology in this town, it may not be out of place to attempt to anticipate the objections that will be raised against it by those who have not considered clearly its aims; and to endeavour to show the advantages that its training would confer on those who, in a few years, by the irresistible march of time, must become rulers and leaders of our country.

I would be glad indeed to explain and show how wide-spread

and directly felt, would be the advantages of having among us men more skilled to apply practically, physics, mechanics, agriculture, natural history; and even to investigate that most important, yet least understood field, the world beneath the waters, whence we draw our harvest of the deep; such an important item to a people whose land borders on two oceans, and is intersected by the largest lakes and rivers of the world. But I must leave that to abler hands than mine, and touch only on what I am best acquainted with—the professions of the Civil and Mining Engineer. These two professions are of great antiquity, although the records of their achievements are too frequently obscured in the annals of conquest and intrigue. The ancient aqueducts and harbours of Europe and Asia form striking monuments of the value attached to the services of the Civil Engineer engaged in those two most important duties, the supplying of towns with fresh water, and the formation of commodious harbours at points of commercial and strategical importance.

The enterprise of an English traveller has recently re-opened the historical mining district of Midian, and certainly from his account of the richness of its mineral resources the “old men” deserve credit for their selection of a good mining ground.

Still the progress of these twin professions was very slow, and it appeared at one time as if the art of the continental Coal Miner was doomed to extinction, for it became very evident that with the appliances of the day it would soon be impossible to raise the water of the coal mines from a depth materially exceeding that already reached by the workman.

The discovery of steam however has changed all this, and opened to the Civil and Mining Engineer a vast and unlimited field. To the one it gave the Railway and its accessories of bridges, tunnels, and the improvement and deepening of rivers and harbours at points hitherto undreamt of. To the other it furnished a powerful agent for deepening and extending the subterranean galleries, and by its economical application afforded scope for a vehement and yet well regulated extraction of minerals, so that it is not unusual to see an English Colliery

raising over one thousand tons of coal daily. And by its aid, more or less directly applied, minerals are smelted which were before considered valueless; all the labours of the metallurgist are facilitated, and his products correspondingly cheapened.

We thus find that these professions have widely extended their aims, and now call to their assistance and use practically every item of knowledge that has been gathered about the composition and laws of the earth, the waters and the atmosphere—electricity—chemistry—geology—the laws of fluids—the yet almost unknown currents of the air,—all are pressed into the service of the Civil and Mining Engineer, and we are irresistibly led to the thought that their preliminary training must correspond in liberality and breadth to the importance of the subject they are to deal with.

Few, perhaps, except a professional man, can detect and account for the imperfections in the practice of the subject he is interested in, and I can hardly hope to take you all behind the scenes this evening; but the leading facts to be noticed are quite familiar to you all.

When the scant production of Canada is considered, and the preponderating importance of agriculture and the fisheries, the first and most natural question is, whether these professions are important enough to require any special training for those intending to engage in them; in short, would it pay to give our engineers a better training than that at present in their reach.

When a practical question is to be dealt with in a practical manner, figures may perhaps convey a clearer impression than any mere assertion.

The value of the minerals raised in Canada for export and home consumption for the year ending June 30, 1876, was, on a rough estimate, \$4,038,000.

The readiest way of estimating the value of the Civil Engineering profession is from a consideration of the number of miles of railway annually built in the Dominion. From figures furnished to me I believe the amount under construction in 1877 to be about 1000 miles, which would involve an expenditure of over \$5,000,000. The amounts paid for private and preliminary

surveys must also be very large. The value of the railway iron imported during the years 1875-76 was \$3,951,000.

If then we have two items amounting to an annual value of \$8,000,000, no one can justly say that he would advise any negligence in the education of those who are to expend and control such large sums of money.

Many easy going people say that the Engineers that we have now are quite good enough for all the work required, and that their education is properly regulated.

Usually when a young man is destined for the profession of a Civil Engineer, he is sent out on a surveying party, and after serving an indefinite time as axeman and chainman, which is quite unnecessary, and moreover frequently injurious from unavoidable association with men of indifferent character,—is gradually advanced to leveller and transit man as he acquires the necessary manipulative skill and quickness in the practical part of his profession, and not from his knowledge of the principles on which the Engineering art is founded.

And this is unavoidable, for the young Engineer is generally away from books and lecture rooms, and after a hard day's work is little disposed to sit down to severe study; and his chiefs have seldom the time or inclination to give him the necessary assistance. The consequence of this is a blind adherence to the formulæ of a text book, and a certainty of failure when obstacles of an unusual nature are encountered.

How many Engineers, for instance, are able to calculate the dimensions and strains of an iron bridge, or to investigate its working strength when erected by a contractor.

The study of Geology (excepting palæontology beyond the outlines) is an useful aid to the Engineer. Under this heading he would acquire a knowledge of the properties of various limestones, concretes, mortars, etc., and of the rules guiding their selection and action. The choice of localities likely to contain stones, etc., suitable for building purposes is one of no small practical value, and the field geologist can give many valuable hints on this point. The careful railway projector or contractor would gladly gather any information that would enable him to

form an idea of the hardness and state of aggregation of the rocks and soils likely to be met in tunnels, cuttings, etc.

In one or two instances a slight acquaintance with Geology would have effected a large saving of expense in bridge-building on the Intercolonial Railway, as for instance the Miramichi and Restigouche Bridges, and an instance of the neglect of the physical effects of sloping rock surfaces was shown on the Eastern Counties Railway. As the Engineer is forced in the pursuit of his profession to spend much of his time in the forests and mountains, an acquaintance with mineralogy will always prove an interesting occupation for his leisure moments; his collections, especially when made in untrodden lands, will always prove valuable; and by a fortunate discovery he may secure an independence for himself.

The systematic study of the effects of river currents and tides on the deposition and removal of diluvium, is one of great value and almost indispensable to a permanent and economical opening and improvement of harbours. An interesting instance of this is furnished by the almost complete destruction of Port Hood harbour by the winds and tides of the Gulf of St. Lawrence.

Take again the case of a very respectable body of men who are extensively engaged in the laying off and division of property—the land surveyors. Who has watched an ordinary land surveyor, with an antiquated compass gravely running out a set of farm lines, and not noticed with admiration how bravely he conceals his fear of local or daily variations of the compass. The care with which the chaining is carried up hill and down, and the gravity with which ten per cent. is added to the distance measured, irrespective of the nature of the ground passed over would be amusing if it were not for the thought of the trouble entailed on the future tenants of the properties. In many cases extensive blocks of farms have been surveyed, and no date given, nor any reference made to the astronomical North. The consequence of this is that endless troubles arise when attempts are made to find the boundaries of old properties; which as a rule are either imperfectly or not at all marked on the ground. And

the remark made to me by an eminent barrister that the "land surveyors were his best friends," is fully justified.

The surveying compass is liable to several errors, which in ordinary practice cannot be sufficiently guarded against to allow of accurate work. The magnetic variation can be readily provided for if the surveyor confine his work to a limited district, otherwise frequent observations are requisite. Daily variation and local attraction are almost beyond regulation, and it is not uncommon to find that the brass work of the compass contains such a quantity of iron as to make the indications of the needle valueless on certain courses. The variation of the seasons is also another source of annoyance. This variation amounted in a compass survey made during the summer under my superintendance to a difference of 32 ft. at the end of a two mile course, between the same line as run on a fixed course in May and October, starting from the same point and using the same compass. There are other sources of inaccuracy to which I will refer further on, but those above mentioned are quite sufficient to condemn the compass as an instrument of precision.

Surely it would be worth while establishing a Chair of Civil Engineering, were it only to provide competent men for surveying and valuing our public and private lands. This is a point that should be taken hold of by the various Provincial Governments, and no surveyor should receive a commission unless he is able to make his surveys with the transit theodolite from the true meridian, and to chain his lines properly within a variation of two feet in every mile.

I believe that the importance of accuracy in land surveying has been understood by the Manitoba and Ontario Governments, and that there the public and private lands are required by law to be surveyed by men of higher standing than those filling corresponding situations in the other Provinces. I would even go further, and would advocate that no man should be allowed to practice as a civil engineer except he hold a certificate of competency. And without in any way wishing to detract from the necessity for field work which is indispensable in this case, it appears to me that the certificate should include a course of col-

legiate instruction, extending over at least two years, the subjects taught being the same as those found in the calendars of the various foreign schools of science where civil engineering is taught.

I think I am safe in saying, that were a school of civil engineering founded by the various governments, that in a single year after its graduates had passed into the field, in charge of work, its cost would be more than repaid by the money saved by the avoidance of such blunders as had been previously committed, through ignorance of principles which the proposing engineer can learn only before he is occupied in the practice of his profession.

I have already noticed the value of the mineral exports of the Dominion,—when we consider more particularly the mining profession it may not be amiss to add a few other items directly referring to it.

The value of the iron, raw, partly and completely manufactured, entered for duty or free, in the Dominion for the year ending June 30th, 1876, was.....\$12,111,838
 Of the coal..... 3,230,060
 Of the lead, copper and other minerals..... 1,707,802

\$17,049,700

or over one-fifth of the total imports—and this it must be remembered in a year of unusual business depression.

I do not wish in any way this evening to touch on political matters, as a school of science can have no connection with any party divisions, for its graduates are educated solely for the advancement of the material prosperity of the country; but I think I may say that we should all hope for the hour when our mineral resources shall become so developed that we will not be under the necessity of importing these articles.

The value of the raw minerals annually raised in the Dominion will itself naturally lead to the contemplation of the training of those who are to discover fresh ores, open new mines, and manage those now in operation. And the question arises, will their duties be more satisfactorily and economically performed if the standard of their education is raised.

It is generally said that people prefer buying their own experience to getting it second hand for nothing. It will, however, not interfere with this feeling to cite the case of England. Here the cry was raised that the coal supply was not going to last much longer, but it was found that the alarm was groundless. However, there was evidence to show that coal was being mined in a slovenly and wasteful manner, and now a manager of a coal mine must hold a certificate of competency.

If in England such a precaution is necessary, where the mining profession is adorned by some of the brightest intellects of the day, how much more requisite must it be in Colonies, where carelessness and want of economy almost become proverbial.

Large as our Coal and other resources are, they have a limit, in some cases very clearly defined; and we are drawing on deposits which can never be renewed.

As our minerals are in many cases a source of direct revenue to the Provincial and Dominion Governments, the agents of the companies working them should be regarded in the light of stewards, who should not be permitted to waste the treasures of the earth which are held for the common good of all.

The limits of this paper would be unduly extended were I to enter fully into the various points which show that the mining interest of the Dominion demands a better standard of education for those who are to enter its ranks. But I think that the consideration of a few leading points is all that is required to lead the public to entertain those views on the subject which have already forced England to take a practical precaution.

The proper planing of the levels and galleries of coal mines, in order to maintain a steady out-put for a number of years, and to extract as much as possible of the coal, is a problem requiring, in an unusual degree, a combination of practical knowledge and mathematical calculation. This includes a proper proportioning of the size of the pillars of coal left to support the roof according to the thickness and nature of the overlying strata, a judicious arrangement of the ventilating galleries, and the proper preservation of the roads left for drawing out the coal. The consideration of all these points on a scale at once

permanent and economical, demands much laborious calculation. As a consequence of a neglect of these points it is common to see expensive shafts, etc., abandoned, and a heavy outlay incurred in sinking new ones, when proper forethought would have made one answer all purposes.

Under this heading may be classed a custom which has recently crept into our gold mining. Within the last few years numerous gold areas, and partly worked mines have been let on short leases to men paying a percentage rent. The effect of this is a superficial working of the richer parts of the auriferous veins, which on being abandoned fill with water, and become a burden to future operators, who are forced to mine at a greater distance from the surface. Gold mining in Nova Scotia will, I am afraid, never pay until it is conducted systematically and on a large scale, as is the case in Australia and California. Mr. Selwyn, the Director of the Canadian Geological Survey, who has had a large experience in Australian gold mining, in a conversation with me last summer on this subject, expressed similar views founded on a careful examination of the veins, and the conditions under which they occur.

Take again the case of underground surveying. In the Dominion this is nearly always done with the magnetic compass. In addition to the errors already referred to in connection with this instrument, it is liable to the attraction of iron rails, etc., under ground, and to a serious source of error arising, I believe, from the presence of various ores of iron in a decomposing state. It may be considered indispensable that, in order to ensure accuracy in mining plans, the theodolite must be used, and the inclined measure properly reduced to the horizontal. Unless these points are carefully attended to now, in the future old plans will prove practically useless, and all miners will be liable to serious dangers when approaching abandoned workings.

The systems of ventilation are another point to which every attention should be directed, and constantly as the workings of coal mines are extended, we hear of increased trouble from this source.

I would only weary you if I went further, and merely leave

those among my hearers who are interested in coal and other properties, to recall the cases they have noticed themselves of neglect of the above fundamental principles of mining. I am myself acquainted with a mining engineer in this Province who has ruined three collieries by his want of skill.

It is at this point that collegiate learning steps in and extends the engineer's knowledge of each special branch of his profession. I do not wish in any way to underrate practical training, for in mining no man can rise even to mediocrity unless he has been through the mill himself. No mining school can supply this want, and he leaves it provided only with a general knowledge of his profession which may divert into any particular channel, to be perfected by practice and accumulation of experience.

At present there are more specialists in mining than in almost any other profession. And it is frequently the case that an expert manager of a mine is unable to survey, or arrange his workings, or on moving to a new district is at a loss to meet the change of conditions under which his work is usually to be carried on.

The mining school meets this difficulty as well as it can be met in the closet. It gathers and presents to the student all the methods of mining adopted in the principal districts, the various engines, pumps, etc., used in every country, and so on, through all the branches of his education. Finally the pupil should leave with his education directed chiefly to the systems employed in his own country, and yet carry with him the most valuable points connected with foreign mining.

It is almost too soon yet to judge of the practical working of the system of certificated managers adopted in England. The intending pupil spends five years, I believe I am correct, in a coal mine, and then passes an examination to entitle him to his certificate as a competent engineer. This system is open to the great objection that the education is comparatively limited, being confined generally to one district, and the pupil is ignorant of all but coal.

An instance of what the adoption of this system among

ourselves would lead to, occurred to Mr. Selwyn and myself last summer. We were standing at the mouth of a coal mine in this Province, and noticed that in the excavated debris of a gallery there were specimens of clay ironstone, similar in appearance and quality to the famous blackband of Scotland. On enquiry we found that no one connected with the practical working of the mine was aware that a bed of iron ore was being passed through.

Were it possible to establish, as would be most desirable, a system of certificated mine managers throughout the Dominion, I would suggest a modification of the English plan, and would require the attendance of the pupil for a fixed time at a school of mining. Here the points more particularly studied would be mathematics, including trigonometry, algebra, etc. A general system of geology, more particularly of the Dominion, a general knowledge of palæontology, to enable him to judge of the age of the strata he may find minerals in—which has frequently an important bearing on the probable permanency of the deposits. Mineralogy, and the use of the usual re-agents and tests for detecting the presence of metals, etc. Metallurgy, the composition, etc., of the most important ores, their concentration and reduction. Wet and dry assaying. Surveying and drawing of plans, and finally the most comprehensive course of mining that can be presented to him.

After passing a satisfactory examination in these subjects he should be compelled to spend a certain time as a mining pupil, and then be entitled to a certificate, after undergoing a second examination of a more practical nature than the first.

I have not ventured to suggest any details for the more effective carrying out of this scheme, as they could be decided on only after careful and lengthy consideration of the necessities of the various mining districts.

If as is the general case throughout the country, the minerals are held by the Government as a source of revenue, the public are not wrong in requiring that their exploration be managed by men directly under its control, and as well educated as possible. By this means there will be increased confidence in mining enterprises, when it is known that they are conducted by men liable

to lose their certificates if guilty of carelessness ; and the fact of their proper education will equally lessen the liability to error.

ART. V.—ON THE GOLDEN EYES, OR GARROTS IN NOVA SCOTIA.
 BY J. BERNARD GILPIN, A. B., M. D., M. R. C. S.
 (Read March 11, 1878.)

SUB-GENUS BUCEPHALA, BAIRD.

Bucephala	clangula,	Coues.
Bucephala	americana,	Baird.
Anas	clangula,	Linn.
Fuligula	clangula,	Bon.
Clangula	vulgaris,	Richardson.

The Common Golden Eye.

Bucephala	islandicus,	Baird.
Anas	islandicus,	Gmelin.
Clangula	barovii,	Richardson.

Barrow's Golden Eye.

Bucephala	albeola,	Baird.
Anas	albeola,	Linn.
Fuligula	albeola,	Richardson.

Spirit Duck.

Thus we find that the genus *Anas*, formed by Linnæus to include these species, has been since sub-divided into *Fuligula*, *Clangula*, and *Bucephala*, and that the specific *Clangula*, also given to the common Golden Eye by Linnæus, has been justly restored to it by Coues, though disallowed by Richardson and Baird. In the Barrow's Golden Eye, Baird has justly restored Gmelin's first specific *Islandicus*, though Richardson had named it after his friend, the Secretary of the Admiralty.

There are many circumstances making Digby Basin a chosen resort during fall and winter, for many species of migratory sea birds. Its easy access from the rough tides of the Bay of Fundy, its sheltered basins and broad wide flats, with their shallows teeming with life, and scantily covered by a warm brackish tide of mixed river and ocean water. Flying before the heavy south-westers, numerous sea birds find themselves swept up the Bay of Fundy, and then almost imperceptibly swept through the nar-