Commission of Conservation

CANADA

COMMITTEE ON MINERALS

Our Mineral Resources and the Problem of Their Proper Conservation

By

FRANK D. ADAMS, D.Sc., F.R.S.

Chairman, Committee on Minerals, Commission of Conservation

Reprinted from the Sixth Annual Report of the Commission of Conservation

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Our Mineral Resources and the Problem of Their Proper Conservation

OUR natural resources naturally fall under five great divisions, which with the value of their output and export for the year 1913 are shown in the following table :

	Output	Exports
Agriculture (including cattle and dairy products)....	$673,771,500*	$194,930,254
Forests (1912)....................................	182,300,000	43,255,060
Mines..	144,031,047	57,442,546
Fisheries..	33,389,461	16,336,721
Furs...	....	5,235,907

Our manufacturing industries being based on these are here omitted from consideration, as are also our water-powers.

As will be seen, our mines rank third among our natural resources in the value of their output and second in the value of their exports. All these natural resources, except the mines, can by intelligent care and conservation be made to produce a much greater annual yield than at present, while at the same time showing a steady increase in value. These resources—agriculture, forests, fisheries and the fur trade—if properly managed, may be compared to money well invested. They can be made to yield an annual return in interest while the capital remains unimpaired or even increases in value.

Conservation of Minerals

The mineral resources of a country, on the other hand, are in quite a different category—they are like a sum of money or treasure hidden in the ground. It does not renew itself, and every amount abstracted leaves just so much less for future use. When in a country of great extent like Canada, the more accessible deposits become worked out, others are discovered in more remote portions of the national domain and the output is thus maintained or even increased for a series of

*This does not include cattle, no returns for these being made to the Government except in exports.

years. The sum total of the mineral resources is, however, continually decreasing in direct proportion to the vigour with which they are exploited.

Mineral Production in Canada

The earliest explorers to set foot in the Dominion expected to find in it a territory of abounding mineral wealth and they were encouraged in this belief by tales which they heard from the Indians. The first mineral deposits which were made the basis of regular mining operations were the coal beds of Cape Breton, where serious work began in 1720, and the bog-iron ore deposits of the St. Maurice district in the province of Quebec, which were opened up by order of Louis XV in 1733. As the country was opened up to settlement, other mineral deposits were found and other mines developed. The value of the annual production in Canada, however, increased but very slowly in the earlier years. By the year 1886, when the Geological Survey of Canada collected and published the first statistics for which approximate accuracy may be claimed, the output had reached a value of somewhat over ten million dollars, of which about one-third was derived from the coal mines of Nova Scotia. Since that time the rise in production has been rapid, reaching a value of one hundred and forty-four million dollars in 1913. This rapid increase during the past twenty-seven years is shown in the following table :

Year	Value of Production	Year	Value of Production
1886	$ 10,221,255	1900	$ 64,420,877
1887	10,321,331	1901	65,797,911
1888	12,518,894	1902	63,231,836
1889	14,013,113	1903	61,740,513
1890	16,753,353	1904	60,082,771
1891	18,976,616	1905	69,078,999
1892	16,623,415	1906	79,286,697
1893	20,035,082	1907	86,865,202
1894	19,931,158	1908	85,557,101
1895	20,505,917	1909	91,831,441
1896	22,474,256	1910	106,823,623
1897	28,485,023	1911	103,220,994
1898	38,412,431	1912	135,048 296
1899	49,234,005	1913	144,031,047

In comparing the individual items making up the mineral output for the year 1913 with those of the year 1886, it is found that there has been an increase in the output of nearly every mineral substance mined in the Dominion. While the increase has been relatively greater in the group of the metals, it has also been enormous in the case of the non-metallic minerals and especially structural minerals and clay products. The only mineral substances which were mined in larger amount in 1886 than in 1913 are antimony ore, chromite.

manganese ore, baryta, molybdenite, petroleum and phosphates. The output of the first five mentioned of these substances in Canada was never very large and gradually ceased, owing to the fact that the more easily accessible supplies of these raw materials became exhausted.

Nickel and Silver in Canada

During the period under consideration, some extensive and very valuable ore bodies have been discovered in the Dominion, among which may be mentioned the nickel ores of the Sudbury district and the silver ores of Cobalt. The former has now developed into the greatest nickel producing area in the world and is known to contain such enormous ore reserves that the present production can be continued for many years. The Cobalt district, on the other hand, while not discovered till 1903, developed almost immediately into the greatest silver camp in the world, but has already passed its period of maximum production, and although it will for years to come still produce large amounts of this precious metal, is already in a state of decline.

Depleted Mine Areas

This is but repeating the experience of the older countries of the world where what were once great mining regions have become completely exhausted. As instances, the Kongsberg mines of Norway may be cited, which at one time produced great masses of native silver rivalling those now obtained from Cobalt, the lead mines of Great Britain now completely abandoned, the renowned mines of the region of Freiberg in Saxony worked continuously since 1170 A.D., the last of which is now about to be closed down, and the great diamond fields of the Golconda district in India, which no longer yield these precious gems.

In modern times it must be remembered that with the introduction of high explosives and modern machinery, the exhaustion of a mineral deposit is much more speedily attained than in former times when only a relatively small tonnage could be raised annually from any mine.

The discovery and development of mining districts in any country, even although these must be exhausted in time, always attract population and yield wealth to a community in the early stages of its development and are thus frequently of the utmost importance in bringing about the opening up and settlement of tracts of country whose inhabitants subsequently engage in other industries and find other means of support.

Canada's Coal Resources

In Canada, however, our mineral deposits are of great extent and importance. Our coal resources, as shown by the investigations undertaken in connection with the meeting of the International Geological Congress which was held in Canada last year, are among the countries of the world, second only to those of the United States. The geological structure of the Dominion is furthermore such as to lead to the confident belief that as northern Canada is made more accessible by the improvement of means of communication, thus facilitating exploration, large deposits of the metallic minerals will be found in the more remote portions of the Dominion, which, when opened up, will be important factors in the development of all the other latent resources of that great region—so that the mining industry of the Dominion, there is every reason to believe, will continue to grow and to play a very important part in the future history and development of the country.

Results of Wasteful Mining

While we cannot hope to increase our mineral resources by any process of conservation, it is of the greatest importance that, in working them, all waste should be avoided. The losses which have been sustained in other countries from lack of care and thought in this respect are enormous. Dr. Douglas estimates, for instance,—to take only one example—that at the Rio Tinto mines in Spain, in a period of some thirty years, through an unskilful treatment of the ore, about 7,000,000 tons of sulphur, valued at not less than $70,000,000, were wasted, while through modern improvements in the method of handling the ore about 1,000,000 tons of sulphur are annually saved to the world which would otherwise have been burned and served simply to pollute the atmosphere. The same writer points out that only some sixty per cent of the hundreds of millions of dollars yielded by the Comstock lode was recovered at the time, and at first the enormously rich tailings were not even collected, such was the haste of the miners to empty that stupendous deposit which should have made Nevada prosperous for generations instead of whirling the whole country into a mad dance of reckless speculation.

The primary cause of a large part of the waste which has taken place in mining enterprises is over-capitalization. This necessitates a large output at any sacrifice if the dividends are to be paid on the whole amount. Over-capitalization thus demands over-production, which in its turn almost invariably involves waste at some stage of the progress of the metal from the mine to the consumer. On the other hand, a lack of sufficient capital to develop a mineral deposit in the proper manner has in more than one case in Canada led to serious waste, since in the endeavour to make the mine pay the cost of its own development as mining proceeded, only the richer ore was taken out, leaving the leaner portions of the deposit in positions which rendered subsequent extraction difficult or impossible.

Mining of Metallic Minerals

It may be stated, however, that in Canada at the present time the waste which is incurred in working our deposits of metallic minerals is small. It is, as a general rule, to the miner's interest to extract his ore completely and to avoid waste. Certain losses take place in the concentration of ores by allowing values to pass away in the tailings. But in recent years, the methods of concentration have been greatly improved and the tailings are much lower in grade than in former years. It is doubtful whether there is in Canada at the present time any considerable waste in the concentration of metallic ores which can well be avoided. Furthermore, where the tailings, as in certain places in the Cobalt district, while still containing in the aggregate large amounts of metal, are too low in grade to permit of further extraction at the present time, they have, on the suggestion of this Commission, been stored in such a way that if, in the future, it becomes possible to treat them again for the further extraction of their metallic contents, they will be readily available for that purpose.

Mining and Handling of Coal in Canada

The most serious waste which is taking place in the Dominion at the present time is to be found in the mining and subsequent treatment of coal and in connection with our supplies of natural gas. It is to these that I desire to make especial reference at the present time. And here it is first a matter of interest to note how large a saving of coal is being effected by the development of our water-powers.

In Canada, in the year 1913, the water-power available on the turbine shafts of our electric installations amounted to 1,100,000 h.p. Assuming that under average conditions one horse-power hour can be produced in a steam plant from three pounds of coal, then 1,100,000 h.p. calculated on a twelve-hour basis and taking a load factor of 50 per cent, which is a conservative allowance, represents a saving of 2,750,000 tons of coal per annum. When it is remembered that the total output of coal in Canada for the same year amounted to only 15,115,089 tons, these figures are all the more striking. It is also interesting to note that the development of our water-powers is as yet only in its infancy, that an immense volume of power is annually running to waste, and that each horse-power per year that thus runs away unutilized is equivalent to the burning up and destruction of five tons of coal.

Situation of Coal Areas

While Canada contains abundant supplies of coal, the coal beds are chiefly in more or less inaccessible regions. The investigation into the coal fields and coal resources of Canada which was carried out in connection with the meeting of the International Geological Congress held in Canada in 1913, showed that less than one per cent of the coal resources of the Dominion are situated in Nova Scotia and New Brunswick, while 87 per cent lie in Alberta, much of this coal being in very remote districts of that province.

The coal seams which are now being worked are those which contain the coal of the best quality and in the most accessible regions and those which are nearest to what are, and always will be, the great centres of population in the Dominion. They are, therefore, speaking generally, the deposits from which coal can be delivered most cheaply. When coal can no longer be obtained from these districts, or, if for any reason it becomes more difficult to extract coal from them, the price of coal will tend to rise.

In a coal-bearing district the measures usually contain several distinct coal beds, overlying one another and often differing more or less in thickness and quality. If, in opening up such a district, the operators, in order to obtain a large supply of good, cheap coal at once, select without any regard to ulterior consequences a single bed as that which can be most conveniently worked at the lowest operating charges, and rob this seam of its coal solely with the view to the largest immediate output, the workings, after the extraction of a portion of the coal, will crush in, making it very difficult and often impossible ever to secure the rest of the coal in this particular seam or any of the coal in the other beds overlying it. The final result of this method of mining is that a very small percentage of the coal in the area is won and all the rest is absolutely and inexcusably wasted.

Again, there are beds of coal in Canada which are so thick that it is difficult, in fact, in some cases, impossible, to work the whole thickness of the seam at once. Consequently, the upper or lower portion of the seam alone is worked, leaving the rest behind. In such cases, when the workings collapse after the cessation of mining, there is a serious danger of losing the coal in the other portion of the seam. The loss, however, even under these circumstances, can be minimized if a proper and uniform plan of working the seam is adopted from the first.

Again, where there are thin seams of coal alternating or interstratified with thicker beds in a series of measures, the coal in the thicker seams, which are easily and profitably worked, is often extracted, leaving the thinner seams untouched. These—which could be worked at the same time as the thicker seams at a comparatively small cost—when the thicker seams have been removed and the workings have collapsed, are frequently so much shattered that the coal which they contain is forever lost.

Waste in Coal-Mining

In the methods of working a coal-seam which are usually adopted a large part of the coal is left in the mine during the working in the form of pillars for the purpose of supporting the roof. These pillars, in the final stages of the mining of any area, can be in part removed, but a large part of the coal, which may be stated to be on an average 50 per cent of all the coal originally present in the seam, remains in the mine and is permanently lost. By adopting what is known as the "long wall system"—where this is possible—a much more complete extraction of the coal may be secured.

The excessive use of powder also entails a loss of coal owing to the fact that it breaks up the coal and, in this way, develops a relatively very large amount of slack, accompanied with increased danger from fire and explosion.

All these causes of waste are illustrated in the coal-fields of Canada. It may be stated that, in the coal-fields of Nova Scotia, the amount of coal which has been wasted is at least as great as that which has been extracted. This is apart from, and in addition to, the coal necessarily left in the mines under the methods of mining employed. This waste aggregates in amount to tens of millions of tons. It is a satisfaction to note, however, that the greater part of the waste in question took place in the earlier years of the coal-mining industry in this province, at a time when there was no effective government supervision. At the present time, every mining company operating under lease from the Government of Nova Scotia is required to submit in advance the plans which it is proposed to follow in opening up any coal-seam. These plans must be approved by the Chief Inspector of Mines, under whose supervision the actual mining of the coal is also carried out. The waste of coal has thus been greatly diminished and would be reduced still further were it not that in many cases it is now very difficult to introduce the best methods of extraction owing to the condition in which the mines have been left by the early operators.

Coal-Mining in Western Canada

In the great coal-fields of the provinces of Alberta and Saskatchewan, which are now commencing to be opened up and whose mineral wealth is the property of the Dominion Government, by whom the right to mine for coal in certain areas is leased for a certain definite term of years, the experience of the early days of Nova Scotia mining is now being repeated. The Department of the Interior, under the Dominion Government, has mining inspectors whose functions, after the leases have been granted, consist essentially in collecting the royalties on the coal extracted ; the respective Provincial Governments also have mining inspectors whose duty consists in seeing that the mining is carried on in such a way that the lives and limbs of the miners are safeguarded ; but, so long as the royalties are paid and the mining carried on with due regard to the safety of the men, the operators are at liberty to adopt any methods of mining which they please, no matter how wasteful these may be, and without regard to the condition in which the mine will be left when their lease expires. The methods which have been used and are now being employed in many parts of these coal-fields are eminently unsatisfactory in this respect and steps should be taken now in the early days of the development of the coal-fields to render impossible a repetition of the mistakes which are made in the older coal-fields of Eastern Canada. To this end, an officer of undoubted capacity and integrity and with wide experience in the mining of coal should be appointed as Chief Inspector of Mines by the Dominion Government, to whom, among other things, all plans for the development of the coal mines working under lease from the Dominion Government should be submitted in advance, and whose approval of the same should be necessary before the actual work of mining is begun, as is the case in all mines now worked under lease from the Provincial Government of Nova Scotia or from the owners of coal-lands in Great Britain. The mines should also, as in these cases, be inspected regularly by the Chief Inspector, or his assistants, in order to see that the plans which have been approved are being properly carried out.

Power Efficiency of Coal

From the coal which is mined and burned under boilers in the usual manner, only about 12 per cent of the total efficiency is developed. And if, as is usually the case, only 50 per cent of the coal is taken from the mine, there is secured only about six per cent of the total efficiency of the coal contained in the area worked. If the coal is burned in gas producers and if the gas so obtained is used in internal-combustion engines, a higher efficiency amounting to about 30 per cent of the energy in the coal actually mined, or about 15 per cent of the energy locked up in the coal of the whole area, is obtained. This is a distinct advance in efficiency but still represents an enormous waste. It is a waste, however, which at the present time we are unable to avoid.

On the other hand, the coal may be mined for the production of coke for metallurgical purposes. This was formerly made in the so-called beehive furnaces, from which a relatively smaller yield of coke is obtained and all the other products yielded by the coal—gas, tar, ammonia, benzol, etc.—go to waste. In the best modern practice, however, the coal is coked in what are known as by-product ovens from which a larger percentage of equally good coke is obtained and all these other products are saved. About three-quarters of all the coke produced for metallurgical purposes in North America is still made in the old beehive ovens. They flame for miles in Pennsylvania and excite no comment, while the burning of a $1,000 house would draw a mob, and yet the waste is enormously greater. It has been estimated by Messrs. Campbell and Parker of the United States Geological Survey that, at the prices which prevailed in 1907, the value of the by-products wasted in the beehive ovens in that country was a little over $55,000,000, and that, on the other hand, the value of the by-products from the retort ovens in the same year was a little more than one-third the value of the coke produced in them.

In Canada, by-product ovens are used by the Dominion Coal Co. at Sydney and by the Algoma Steel Co. at Sault Ste. Marie, but these are the only ovens of this type in the Dominion.

Coking of Coal in Western Canada

The coke which is used for metallurgical operations in Western Canada is all made in beehive or Belgian ovens. While in these latter the gas given off by the coal is drawn off and may be used for heating purposes, the by-products, as in the case of the beehive furnaces, go to waste. There are at present in Canada, 2,024 ovens which do not save the by-products as against 730 which do save these valuable constituents of the coal. In Western Canada there are 1,935 ovens of the former class and none of the latter.

Mr. F. E. Lucas, manager of the coke ovens of the Dominion Coal Co., estimates the saving effected by the use of the by-product oven to be $1.93 per ton of coke made. This figure will, of course, vary to a certain extent with the locality in which the coke is produced, but it indicates the great additional yield which is secured when coal is coked by modern methods, more especially when the enormous tonnage of coke consumed in modern smelting is borne in mind. In the year 1912, as much as 405,457 tons of coke were made in beehive ovens in Alberta and British Columbia, representing a waste of approximately 12,569,167 pounds of ammonium sulphate and 43,383,899 gallons of tar ; not to mention the benzol, creosote and other minor products and the immense amount of gas which would be available for heating and lighting purposes.

The principal objection which is urged to the introduction of the by-product oven is the expense of installation. But it is hoped that this objection will be overcome wherever possible since, as shown above, the by-products have high economic and market values and there will be a growing demand for them.

The tar is already being used extensively in the Dominion for a variety of purposes, among which may be especially mentioned that of the manufacture of briquettes from slack coal, thus effecting an additional economy in the utilization of this waste product. Ammonia on the other hand is a fertilizer of the greatest value, for which there is a great demand abroad and for which an ever-increasing demand will arise in Canada as the necessity of employing improved methods of agriculture is brought home to farmers. The by-product coke ovens of the United States produced in 1912 ammonia and ammonium sulphate to the value of $9,519,268.

For some years past in England and Germany attention has been paid to the problem of securing the largest possible yield of ammonia from coal during the process of coking. With the methods of coking ordinarily adopted at the gas works in these countries only about one-sixth of the nitrogen in the coal is obtained in saleable form as an ammonium compound. It has been found, however, that, by employing certain improved methods, the yield of ammonia may be increased by as much as 200 per cent.

The immense volumes of gas given off from the coal in the by-product ovens might be readily utilized in connection with associated industries, as, for instance, the burning of cement.

Fuel Supply on the Prairies

One of the most important problems which presents itself at the present time is the provision of an adequate supply of cheap fuel for the population of the Prairie Provinces of Canada. Very large areas of these provinces are underlain by beds of sub-bituminous coal and lignite which are estimated to contain 100,000,000,000 tons of these fuels. As yet, however, practically all the fuel in that portion of the plains east of Brandon is imported from the United States, while that used in the country west of Brandon is brought chiefly from the coal-fields of the Rocky mountains. This entails a long and expensive haul which results in a high-priced fuel, and any temporary interruption of the supply gives rise to a coal famine.

The reason why the mineral fuels of the plains have not been utilized is that they are expensive to mine owing to the absence of supplies of mine timber on the treeless prairies, and they are also of a lower grade than the fuel from the Rocky mountains, containing a large percentage of moisture. They thus have a lower heating value than the fuels from the mountains, and furthermore when, after being mined, they are exposed to the atmosphere, they dry out to a certain extent and in so doing crumble to pieces or even fall to powder, so that they cannot be readily handled and will not bear transportation. Such being the case, if these fuels are to be made available for household use, they must be briquetted, or if they are to be used for manufacturing purposes, they must be either briquetted or used in gas producers.

Scientific Tests of Fuels

A series of trials of Canadian fuels recently carried out by Dr. J. B. Porter and Prof. Durley of McGill University for the Mines Branch of the Department of Mines at Ottawa, show that these fuels of the plains are excellently adapted for use in the gas producer and are thus well adapted for the production of power. The question as to whether they can be briquetted when necessary at a sufficiently low cost to make the enterprise commercially profitable, has not yet been established. Fuels of this general type in Germany are briquetted on an enormous scale, and the United States Bureau of Mines is now investigating the possibility of briquetting the lignites of North Dakota. Any lignite can, of course, be briquetted if a suitable binding material is employed. This, however, entails additional expense, but many of the German lignites and some of those occurring in North Dakota can be briquetted without the addition of any binding material. It is thus very important that an investigation should at once be made into the question as to whether there are not, among the great deposits of fuel underlying the Canadian plains and outcropping on their surface, some at least which can be worked for the production of a cheap briquetted fuel which will stand transportation and thus supply a need ever more insistent as the population of the Prairie Provinces increases. Such an investigation is to be commenced next summer by the Mines Branch of our Department of Mines and the results will be awaited with much interest.

Waste Due to the Smoke Nuisance

Another source of waste in the case of our fuel supplies is represented by the smoke nuisance which is now becoming very pronounced in our large cities. While it is difficult to prevent the smoke rising from the chimneys of private dwellings, this in the cities of Canada is relatively small in amount, for, as a general rule, hard coal is burned for domestic purposes. On the other hand, the immense volumes of smoke emitted from the stacks of many of the great power plants and factories of our large cities as well as by locomotives and steamboats can be greatly reduced or stopped by the installation of proper smoke consumers operated by firemen who have been instructed in their proper use.

Investigations show that such plants, in many cases, not only stop the smoke but pay the owners.

The waste of fuel, however, is but a small part of the loss entailed by the smoke in our cities. It disfigures buildings, impairs the health of the population, renders the whole city filthy, destroys any beauty with which it may be naturally endowed and tends, therefore, to make it a squalid and undesirable place of residence, and this, at a time when economic influences are forcing into our cities an ever-increasing proportion of our population. These conditions press especially on the poor who must reside in the cities and cannot escape from these evils by taking houses in the suburbs. After all, the conservation of humanity is even more important than the conservation of coal.

Checking the Smoke Nuisance

Investigations into the best means of abating the smoke nuisance have been, and are now being, carried on by government and municipal commissions as well as by private individuals in several of the leading countries of the world. Many cities have officials whose time is devoted exclusively to the education of public opinion and the enforcement of existing laws with reference to this matter. The question as to what steps can best be taken to lessen the amount of smoke which is being discharged into the atmosphere in our Canadian cities is by no means a simple one, but the time has come when the Commission of Conservation may very properly make a thorough investigation of the question and ascertain for the benefit of the dwellers in our great cities what can be done to prevent the wholesale pollution of the atmosphere.

Natural Gas Resources of Canada

Natural gas is the most perfect fuel with which we are furnished by nature. It is clean, can be readily piped for long distances and has a very high heating power. Consequently, when it is found in large quantities, it speedily supplants all other kinds of fuel. It is a material, however, which has been produced very slowly and the great volumes of it which are found stored in certain favourable situations within the crust of the earth represent the result of a slow process of accumulation extending over an enormous lapse of time.

The gas, however, is often under great pressure in the earth's crust and, when tapped by bore-holes, frequently escapes in such enormous volumes that persons unacquainted with the conditions of its occurrence are led to believe that the supply is so great as to be practically inexhaustible, or that at any rate the exhaustion of the field is a contingency so far removed in the future that its discussion is a matter of purely academic interest.

Natural Gas in United States

The greatest supplies of natural gas hitherto discovered are those of the United States and these gas-fields are those which are nearest in position to the Canadian fields. The gas-fields of the United States have now been operated for some thirty years and the experience drawn from them is directly applicable to the problems presented by the gas-fields of Canada which are now in a relatively early stage of their development.

What has been the experience in the United States ? It is that within a few years after its discovery the output of gas in one field after another in which the supply was supposed to be inexhaustible is found to be gradually lessening, and in some of the fields where natural gas was at first so abundant that it was the fuel almost exclusively employed in the great factories of the district as well as for private use, the supply is now practically exhausted and it has been necessary to return to coal.

In fields where the supplies have not as yet been exhausted the decline in pressure, indicating approaching exhaustion, has been marked. One of the most rapid declines is that seen in the fields of northern Indiana, where the pressure dropped from 400 pounds in 1886 to 50 pounds in 1902. Thus those fields were practically exhausted within 15 years. McDowell states that three times as much gas was wasted in those fields as was used.

Other instances of quick decline are found in Kansas and Oklahoma. In the latter state the rock pressure of the gas in the Hogshooter field in 1912 fell off at the rate of a pound a day, and only recently the volume of gas yielded by the Copan field, in the same state, dropped in a single year from 300,000,000 feet per day to 100,000,000 feet per day. In Louisiana a similar decline is noted. In a well of the Midway field in California, the 16-inch casing tapped a gas sand at a depth of 540 feet ; the flow was 50,000,000 cubic feet per day for a few days, and then practically ceased.

The experience, in short, has been that no gas field is inexhaustible, but that each has a life extending over a comparatively few years. Consequently, the supply of gas in any district which is fortunate enough to possess one, should be carefully husbanded.

The decline in the yield of the gas-fields of the United States has been greatly accelerated by the enormous waste which was allowed to take place in the earlier years when the gas appeared to be so abundant that it was difficult to persuade people that it would not last forever. Dr. Orton states that in the early days of the

Ohio gas fields the operators tried to believe that the gas was being formed within the earth as fast as it was being allowed to escape or comforted themselves with the aphorism that "Nature would not go back on us." The supplies, however, fell off there as elsewhere.

Waste of Gas in United States

Dr. I. C. White in his address before the great Conference on Conservation held in Washington in 1908 made the following statement with reference to the waste which was taking place in the United States at that time :

> "The blazing zone of destruction extends in a broad band from the lakes to the Gulf and westward to the Pacific, embracing in its flaming pathway the most precious fuel possessions of a continent. No one can even approximate the extent of this waste. From personal knowledge of the conditions which exist in every oil and gas field, I am sure the quantity will amount to not less than 1,000,000,000 cubic feet daily and it may be much more. The heating value of a billion cubic feet of natural gas is roughly equivalent to that of 1,000,000 bushels of coal. What an appalling record to transmit to posterity !"

Dr. David T. Day, of the United States Geological Survey, estimated that, in 1908, about one-half of all the natural gas which was produced by the gas wells in the United States, was wasted.

Mr. McDowell states that the daily waste of gas in Oklahoma by escape into the air is at present equivalent to the destruction of at least 10,000 tons of coal daily, and that 80 per cent of this loss is preventable.

Now in the United States when the horse (or a considerable part of him) has been stolen, the stable door is being shut. Legislation has been passed and so effectively enforced in Indiana, Ohio and Pennsylvania that the waste of natural gas in these states has practically ceased. The laws of Indiana, Ohio, Pennsylvania and West Virginia call for the proper capping of every well when not in use. In other states of the Union, however, where preventive legislation does not exist, the waste is still enormous. It is estimated by the Director of the United States Bureau of Mines that the aggregate waste in the United States at the present time exceeds a value of 50 million dollars per annum, of which 80 per cent might be readily saved.

Sources of Gas in Canada

Natural gas first appears in the statistics of the mineral products of Canada in the year 1892, when the total output had a value of $150,000. In 1913 this had risen to $3,360,000. This comes from the provinces of Ontario, New Brunswick, Saskatchewan and Alberta.

The most highly productive area at the present time is the extreme southerly portion of Ontario, in a strip of territory along the shore of lake Erie, the total product here having a value of rather over $2,000,000, of which about two-thirds comes from Kent county.

The discovery of natural gas in New Brunswick is of much more recent date and the output has risen rapidly in the last few years, having a value in 1913 of $174,006. The field is situated in Albert county and supplies gas to Moncton and Hillsborough.

In Saskatchewan and Alberta gas has been found in places over a wide stretch of country along the line of the Canadian Pacific railway from Medicine Hat to Calgary and thence to the north as far as Pelican portage, about half way between Edmonton and lake Athabaska.

While it is known to have a wide distribution, the gas which has been used so far has been obtained from two fields known respectively as the Medicine Hat and the Bow Island gas-fields. From the former, gas is taken to Medicine Hat and from the latter the gas is piped to Lethbridge and Calgary, 160 miles distant, supplying also intermediate points along the route. The total product of Alberta in the year 1913 had a value of rather over one million dollars.

There is, however, every prospect that new productive gas-fields will in the future be opened up in other parts of the provinces of Saskatchewan and Alberta as well as elsewhere in the Dominion. And having in mind the experience of the United States, definite steps should at once be taken to prevent all waste. It is to be noted that the gas field in Essex county, Ontario, formerly highly productive, has now ceased to yield, and that a falling off in the supply of gas is already seen in certain other Canadian fields.

Waste of Gas in Canada

The most striking case of the waste of natural gas in the Dominion is the great column of gas which has been escaping from the bore-hole put down by the Government near Pelican portage, Alberta, in 1897. The records show that in this well, at 820 feet, "a tremendous flow was struck the roaring of which could be heard at a distance of three miles or more." This gas has been burning like an immense torch almost continuously for the past 17 years.

The district in which this gas is escaping is at present somewhat remote from settlement, but it is a district which is nearer to Edmonton than Calgary is to the great gas wells which supply it, and yet this gas, representing a great accumulation of the finest fuel, which might have formed the basis of important industries in Edmonton, has been for all these years running to waste.

In endeavoring to arrive at some estimate of the waste of gas which has taken place at this well, Mr. W. J. Dick, Mining Engineer of the Commission of Conservation, at my request communicated with Mr. Louis G. Huntley, of Pittsburg, Pa., the engineer who examined the well for the city of Edmonton in 1913. Mr. Huntley writes as follows :

"When the writer visited this locality in 1912, he estimated the flow of the old Government well at something less than a million cubic feet per day. In 1913, Mr. Williams of the Pelican Oil & Gas Co. reported to his stockholders that the well pressure was 225 lbs. per square inch with a flow of about 840,000 cubic feet per day. The writer again visited the well in 1913 in connection with the report for the city of Edmonton, and while more gas was being used for fuel for drilling purposes, the flow seemed somewhat less than the previous year. Mr. Williams would not allow the well to be gauged, however, although it was still blowing into the air through a one-inch pipe.

"While Mr. Williams' statement may have been somewhat optimistic, yet it is reasonably certain that the well was not making more than his estimate, viz., 840,000 cubic feet. Now, in line with Orton's hydrostatic theory of underground pressures, and knowing the difference in elevation of the Dakota sand at Pelican and its nearest outcrop at Boiler rapid to be very close to 500 feet, the pressure would theoretically be 260 lbs. per square inch in the Dakota sand at a depth of 820 feet at Pelican. This coincides very well with Mr. Williams' report of 225 lbs., and it is believed that probably the pressure was not much higher in 1897 than it is at present. However, the flow of gas from this well has decreased very greatly, according to the reports of those who make yearly trips down the Athabasca river. There is no certain way of estimating the original flow of this well when drilled 17 years ago. However, in the writer's judgment, an eight inch hole at a pressure of 260 lbs. would not produce more than a maximum of 5,000,000 cubic feet per day from a sand of the character of the Dakota ; in other words, an average flow of 2,900,000 cubic feet per day for 17 years. This may be regarded in the nature of a maximum figure and is very approximate, due to our assumption of a fairly constant pressure at all times. However, in a sand as uniformly coarse as the Dakota, with a uniform dip to its outcrop at Boiler rapid, it is difficult to imagine a much greater pressure to exist at Pelican than one equal to the hydrostatic head, due to the difference in elevation of the sand at the two points. In all fields far removed from the outcrop of the gas-bearing formation, where many wells are drawing from the same area, a drop in pressure of from 30 to 100 pounds per year is the rule. But with one well only draining the district, and other conditions such as at Pelican, I believe we are safe in the assumption that the pressure was never much above 260 lbs., the flow decreasing due to the greater distance through which the gas must now travel to reach the well."

Taking the amount of gas which escaped daily at 2,900,000 cubic feet, a simple calculation shows that this amounts to 17,994,500,000 cubic feet in 17 years. The average price for natural gas in Canada in 1913 was 16.4 cents per 1,000 cubic feet, which would give $2,951,098 as the value of the gas wasted. Even if this estimate be reduced by 50 per cent, the waste still remains enormous and inexcusable.*

Furthermore, another point must be borne in mind in connection with these supplies of natural gas, and that is that the gas often travels for long distances underground and a waste at one point affects not merely the supply in its immediate vicinity, but often exhausts the supplies of gas in the entire field underlying a great tract of country, so that it is not merely the area about the point of escape which is affected, but the whole surrounding region whose potential development is seriously impaired by the destruction of one of its great natural resources.

Legislation *re* Gas in Ontario

With the single exception of Ontario, no province in the Dominion at the present time requires gas wells, which are not being used to be plugged, and this province has further reduced the waste in the area under its jurisdiction by levying a tax of two cents per thousand feet with a rebate of 90 per cent for the gas that is actually used. The Dominion Government and all the Provincial Governments should at once pass enactments requiring all gas wells which have been abandoned, or are not in use to be plugged. Legislation similar to that in force in Ontario should also be passed by the Dominion Government and the other provinces requiring the payment of a royalty on gas with a suitable rebate for the gas actually used. Natural gas, when discovered enters into direct competition and supplants coal which pays a royalty to the Government and the rebate, if properly adjusted, makes waste unprofitable and, therefore, tends to stop it.

The public should also be brought to realize that there are many forms of waste against which it is difficult to legislate, but which are none the less disastrous. Among these may be mentioned the custom of selling natural gas at a flat rate of so much per burner per month instead of at so much per 1,000 cubic feet. The inevitable tendency of this, as seen in Medicine Hat at the present time, is to

* In a recent article (see *Mine, Quarry and Derrick*, April 14th, 1915) Mr. R. W. Brock, formerly Director of the Geological Survey of Canada, gives a brief history of this well. He points out that the material carried up by the rush of escaping gas from time to time partly plugged the well, and that the well was at one time capped by the officers of the Government, but was later reopened by some miscreant, so that the waste of gas, although enormous, was probably not so great as set forth in the calculation given above.

allow the gas in the street lamps to burn all day, seeing that it costs no more to do so, while at the same time it is easier to let it burn than to turn it out, and the spectacle of gas blazing throughout the day conveys a general suggestion of the abundance of a product which one can afford to waste so lavishly. No company manufacturing coal gas sells it in this manner since they clearly recognize that if they did so the gas would certainly be wasted and all profits would disappear. Natural gas should always be sold at a definite rate per thousand cubic feet. Furthermore, since natural gas has not, as a general rule, a very high illuminating power, the best and most economical results are obtained, if instead of burning a large number of jets as open flames, a relatively smaller number are used with incandescent mantles, which greatly increase the illuminating power of the gas.

Economy may also be practised when the gas is used for the development of power. Thus 80 to 130 cubic feet of natural gas are required to develop one horse-power per hour when the gas is burned under a boiler and the steam produced is used for driving a steam engine of the ordinary type. The same power can be developed with a consumption of 9 to 15 cubic feet per hour in a gas engine of equal reliability and the same cost of maintenance. Hence a great saving can be effected if the gas is employed directly in a gas engine. It must always be remembered that the prevention of waste in the case of our mineral resources is the only true conservation.