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HISTORY OF COAL RESEARCH IN THE MINES BRANCH/CANMET

1907 - 1977

W.J. Montgomery, E.R. Mitchell, J.C. Botham

T.E. Tibbetts and B.J. Whalley

COAL RESOURCES AND PROCESSING LABORATORY

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Early Years 1907 - 1919

In 1906, Dr. A.P. Low, Director of the Geological Survey of Canada proposed the investigation of Canadian coal deposits along the lines of those used by the United States Geological Survey. At that time, no government department had the necessary laboratory facilities, and it was decided that the work should be carried out at the Department of Mining Engineering at McGill University under the supervision of Dr. J.B. Porter head of the Mining Department. The Department of Mines was created on April 27, 1907, and the responsibility for the aforementioned work transferred to the Mines Branch in Ottawa under the directorship of Dr. Eugene Haanel. These surveys were completed in 1910, and the final report(1) comprising seven volumes was published between 1912 and 1916. These volumes included information on field sampling, crushing and preparation data, washing and cleaning tests, coking and steam boiler trials, producer and gas engine trials as well as chemical analysis and miscellaneous investigations on sixty-seven different coals ranging from Cape Breton to Vancouver Island.

Concurrent with this work, an exhaustive study of the peat deposits of Ontario and Quebec and methods for their exploitation was started by Dr. Haanel as a source of fuel for central Canada. The work was initiated as a result of "rapidly vanishing deposits of anthracite coal as well as the limited deposits of bituminous coal in the United States". (Summary Report of the Mines Branch 1907-1908). In the light of our present knowledge of United States coal resources there would appear to have been undue alarm.

To insure satisfactory functioning of the Mines Branch, the Fuel Testing Station was completed in 1910 providing laboratory facilities equipped with Korting and Westinghouse gas producers (for peat and coal), a Korting gas engine, a Babcock and Wilcox marine water tube boiler, chemical laboratories, and grinding and crushing equipment. The station was designed for the complete investigation of Canadian coals as well as for the distillation of petroleum and carbonaceous materials. The staff at that time (consisting of 7 engineers and 3 laboratory assistants) was engaged in coal sampling and analysis, boiler trials and gas producer tests on various coals and peat.

As a result of recurring shortages and interrupted supplies of American anthracite in the latter part of the First World War and in the post-war period, attention was turned to the development of native Canadian fuels for domestic heating purposes. In 1918 the Peat Committee, a joint enterprise of the Dominion and Ontario governments, was formed to develop a domestic fuel from peat.*

In 1918 the Lignite Utilization Board was formed, as a joint enterprise of the Dominion, Manitoba and Saskatchewan governments, to try to produce a suitable domestic fuel from carbonized Saskatchewan lignites. Considerable preliminary investigation was carried out at the Fuel Testing Station on the carbonization and briquetting of this material. A plant that was built in 1921 by the Lignite Utilization Board at Bienfait in Saskatchewan was subsequently sold to private interests in 1929. A point of considerable interest is that this same plant is still producing briquettes made from carbonized lignite today[2].

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*Considerable experimental work was carried out at the Alfred bog with the assistance of the Mines Branch from 1920 to 1924. Although large scale equipment for digging and harvesting peat was developed, it was not found possible to produce a fuel that could compete economically with coal or coke (3).

Post World War I

Following the conclusion of the First World War, more staff and equipment became available and the investigations of the Division were extended. In this period, a comprehensive series of tests of Canadian coals for use in domestic hot-water heating equipment was carried out[4] with a view to the possible replacement of imported American anthracite by Canadian coals. In this same connection an investigation was also conducted in cooperation with the Dominion Fuel Board of the possible substitution of by-product coke for anthracite. It was proposed that coke plants be established at various points in the areas of acute fuel shortage. The results were published in Mines Branch Report No. 630, Coke as a Household Fuel in Central Canada, by J.L. Landt, 1925.

In the post war period there was considerable interest in the production of a domestic coke which would be more reactive than that available from by-product ovens, and as a result a series of pilot scale low-temperature carbonization tests, on various coals were carried out. The test program indicated that in addition to the production of a suitable coke that the yield of tars was increased. To prove the feasibility of the process, a shipment of Sydney coal was sent to South Wales in 1928 for full scale tests by the Illingworth low-temperature process. Whereas satisfactory results were obtained no low-temperature carbonization plants were developed in Canada. At this time there was also a revival of interest in the lignite of northern Ontario, but after extensive carbonization, briquetting and combustion tests it appeared that the deposits would not be an economic source of fuel even for northern Ontario[5].

In 1929 the Fuels Division was reorganized, provided with additional facilities, and moved into a new laboratory building, the "Fuel Research Laboratories" at 562 Booth Street. The original Fuel Testing Station had become too small for the activities and staff. The new building provided office and laboratory space to undertake all types of small and pilot-plant investigations on solid, gaseous and liquid fuels. Included in this building was a commercial-scale pulverized-fuel steam generating plant, experimental domestic heating equipment, and a briquetting and coal washing plant. A full-scale commercial-size by-product oven with scrubbing and by-product recovery equipment was erected at the rear. In the ensuing years, tests were made in this coking equipment for the production of gas and by-product cokes for domestic heating[6] [7]. Continuing the high-temperature coking survey started in 1924, coking tests were made on coals from both United States and Canada with the objective of making reliable information available for the use of coal producers and providing a guide for operators of by-product coke plants on the choice of suitable coals for production of gas and coke.

With the increasing use of pulverized fuel for steam raising, a comprehensive series of tests on Canadian coals was made in a commercial-sized pulverized-fuel-fired furnace to comparatively assess them and provide such data as would enable the use of lower grade and smaller sized coals otherwise deemed difficult to market[8]. In addition, a comprehensive list of analyses of domestic and imported coals and cokes[6] [7] was periodically published to assist both the producer and consumer of solid fuels.

In the period before the Second World War, a survey of the chemical and physical properties of Canadian coals was undertaken, and the results presented in a series of reports, R.I.C.S. No. 1-199. Considerable laboratory investigational work was conducted on the following: grindability of coals coal friability[9], tests on coal for predicting the physical properties of coke made in commercial ovens, briquetting[10], the analysis of naphtha and

natural gases from Alberta, an analytical survey of Canadian crude oils[11], and examination of the more accessible oil shale deposits in Eastern Canada. Because of the lack of sources of natural petroleum, a study was undertaken of possible sources of substitute liquid fuels and this resulted in the installation of a laboratory for small-scale high-pressure experimental hydrogenation tests. This process produced gasoline of a high anti-knock rating and was applicable to such materials as bitumen and coal, and in addition, could also be used to make such products as benzene and toluene from coal. A whole series of Canadian coals were tested to determine the oil yields by the hydrogenation technique[12]. This work was subsequently extended on an increasing scale to include tests on crude oils and bitumen from the Alberta bituminous sands.

Considerable work was also carried out during this period on coal classification studies with the view to drawing up a coal classification system based on more than 1,000 coal analyses[13]. The Division assisted in drawing up government specifications for the purchase of coal and in the analyses of coal and coke purchased by various government departments. A gradual increase in the staff of the Division took place, and immediately prior to the Second World War there were 20 professional members and 14 technical assistants.

The War Years 1939 - 1945

The Fuels Division, like other organizations, was naturally much affected by the Second World War. The ordinary activities gave way to war problems, some members of the staff enlisted in the Armed Forces and several members were seconded to wartime organizations such as the Coal Controller's Office, Oil Controller's Office, Department of Munitions and Supply, etc. In addition to the large amount of work involved in the testing of solid and liquid fuels, and the preparation of certain materials of military significance

for the Armed Services, several purely wartime investigations were conducted concerning the production of an activated charcoal from the carbonized residues of peach nuts, anthracite, and certain Canadian low-volatile coals, as a substitute for the cocoanut charcoal used in Service gas masks.

On behalf of the Coal Emergency Production Board, the Division supervised the organization and functioning of the various peat fuel projects sponsored by the Board in the Province of Quebec. Some 1,000 tons of air-dried peat fuel were manufactured in demonstration equipment. Another project was the development of methods for fluxing the ash of American buckwheat anthracite coals so that they could be used to better advantage in domestic blower installations to replace low-ash-fusion Welsh anthracite no longer available in the Canadian market.

Post World War II

After the war a gradual expansion of activities of the Division took place as more staff and equipment became available. The war had interfered with the program of fuel research, and past events had emphasized the importance of such research and the risk of too great a dependence on imported fuels. Owing to the increasing importance of liquid fuels, hydrogenation investigations were resumed on an extended scale and at much higher pressures than had been used previously to improve the quality of products obtained. In 1945 contact was maintained with the Office of Synthetic Fuels in the United States, and first-hand information on hydrogenation was obtained from documents captured in Germany. In 1944, a Royal Commission was set up to conduct a "full inquiry into the Coal Industry in Canada" and considerable assistance was given to the Commission by members of the Fuels Division in the preparation of its report(14).

In the field of combustion engineering, Canadian coals were tested for use in industrial power plants. Another investigation which evaluated the factors affecting the suitability of Canadian fuels for automatic domestic heating equipment indicated the suitability of certain Western Canadian high-ash-fusion, low volatile coals for use in anthracite-type conversion stokers. Numerous comparative tests were conducted on automatic oil-fired and coal-burning equipment for domestic use. A combustion project was undertaken in 1950 in collaboration with the Locomotive Development Committee of Bituminous Coal Research Inc. in the United States in which 27 Canadian coals were tested in a cyclone combustor to assess their suitability for the coal-fired open-cycle gas turbine. This work was completed in 1950, and was followed by a project in collaboration with McGill University to develop an indirectly fired, exhaust-heated cycle, coal-burning gas turbine. Development and testing of this exhaust-heated cycle was completed by the end of 1956. It was hoped that the results of this work would stimulate industry to undertake the development of a prototype power unit.

Since 1946 the physical and chemical properties of Canadian coals have been continuously monitored. Commercial coal surveys in Eastern and Western Canada are conducted periodically to provide information for the revisions of the Analysis Directory of Canadian Coals, (a report first published in 1945). Coal-preparation and cleaning-performance tests were conducted with commercial-sized equipment in the field and with small-scale equipment in the Division's laboratories.

A survey was made of the coking properties of Western Canadian coals to provide information for the establishment of metallurgical plants in the western provinces. Much attention was paid to briquetting to permit the utilization of the small sizes of coals that are difficult to market in their natural state. This work resulted in the development of briquettes suitable for stoker use. Investigations were made into the blending of fine coal with ore fines to

produce briquettes for use as feed for smelters and reduction plants. Reports of this work are given in a series of FRL Reports, No. 1-263.

Western Research Laboratory

To assist the coal producers in Western Canada, a regional laboratory was created in Calgary in 1951 to work on problems relating to coal preparation, beneficiation, briquetting and collection and analysis of coal samples. In 1956, the laboratory was transferred to Edmonton where space was provided by the Alberta Research Council. Work in these new facilities was directed primarily to briquetting and the cleaning of fine friable coals. The laboratory developed and later patented an atomizing apparatus for dispersing viscous binders used in briquetting. A process was developed from studies made on binderless briquetting and subbituminous and lignitic coals.

Research carried out on the cleaning of 1/4" x 0 coal fines included the construction of a 2 tph DSM (Dutch State Mines) hydroclone pilot plant to clean coals from Alberta and British Columbia, and as this work progressed a 3 stage system was developed and successfully used on Minto coal. As a direct outcome of these laboratory investigations of cyclone operating variables the CWC (Compound Water Cyclone) was developed and patented. The pilot plant was then converted to the CWC concept and with further work a measure of automatic control was developed. From the prior research a multiple 2 inch diameter unit (CWC-2M) was developed for cleaning materials of 10 mesh top size. This was also patented. Commercially produced units of this design are used today in the United States to reduce sulphur to acceptable levels, and in Australia in the beneficiation of coking coals.

The laboratory was again moved during 1965-1966 and relocated at Clover Bar outside Edmonton where work related to pollution control was under-

taken in addition to modification of the pilot plant to a capacity of 5 tph. During 1967-1968 assistance was provided to western coal mines in adit sampling and in the preparation and washing of bulk coal samples for coking tests in the Ottawa laboratory. Studies were made of sulphur reduction and dewatering of fine coal from Nova Scotia using oil assisted dewatering techniques in slugging cyclones, and an investigation made of spontaneous combustion of lignite storage piles in Saskatchewan.

In January of 1973 a 10 tph portable plant was set up at the Lingan mine to demonstrate the applicability of the EMR process for sulphur reduction on Cape Breton coals. This work resulted in the construction of a 100 tph plant for the recovery of coal from 3 local dumps in the Stellerton area for power plant use.

In addition to the beneficiation and sampling work carried on in these laboratories a coking facility was set up in 1973 under the direction of the Carbonization Group in Ottawa to carry out carbonization studies on western Canadian coals.

Carbonization Laboratory, Ottawa

Coke is the highest single conversion cost item in steel-making. The average coke rate in Canada in 1975 was 1020 pounds per net ton of hot metal. Reduction in coke rate can be achieved through better quality coke, thereby conserving the coking coal requirements. There is a need for research studies to achieve this and broaden the scope of metallurgical coals.

The Canada Centre for Mineral and Energy Technology (CANMET) has evaluated the coking properties of Canadian coals periodically during the past fifty years in accordance with changes in the pattern of the market

requirements for metallurgical coals. The facilities of the Energy Research Laboratories (ERL) now include pilot plant laboratories in Ottawa and Edmonton. Support analyses and testing are caaried out in the Ottawa laboratory. CANMET has the only facilities available in Canada to fully evaluate the potentials of coals for the manufacture of coke and is one of the few centres on this continent with such a broad scope of testing. The facilities serve almost exclusively the technological needs of the Canadian coal and steel community concerning coke-making.

Research studies and investigations in carbonization and related fields currently in progress at the CANMET laboratories may be broadly grouped into four areas, namely: resource evaluation, innovations to conventional coke-making, new methods of coke-making and iron ore reducibility.

For the past 15 years, ERL has been associated with the evaluation of the coking potential of Canadian coals from producing mines and also the evaluation of coal samples from exploration studies related to the development of new coal seams. Complete analyses and pilot-scale coking tests are avail- for almost 1,000 adit samples. The samples were obtained by industry and cleaned to their market specifications. In most cases industry has also supplied maps with a scale of 1000 ft to the inch to pinpoint the location of each sample tested. Most of the information has now been computerized and subsequent information on Canadian coals will be collated, coded and entered into the computer on a routine basis. This data bank is readily available and represents a significant contribution to information concerning the quality of coking coals in relation to a national inventory.

The Canadian Carbonization Research Association (CCRA) is an example of industry-government co-operation in planning and cost-sharing of research

and development in the carbonization field, for the overall benefit of the nation. The CCRA was formed in 1956 and its members comprise the four integrated Canadian steel companies, the only merchant coke plant, most of the producers of coking coals and a tar processing company. A technical committee of CCRA meets regularly with ERL to plan research studies of mutual interest to the coal producer and the coal consumer. The current priority project pertains to self-reliance in the use of Canadian coking coals. The quality of Canada's coking coal reserves will be examined in relation to their potential use by the Canadian steel industry.

The Canadian Coal Petrographers Groups was formed in 1974 to bring together the Canadian petrographers with the purpose of applying the use of coal petrography to the evaluation of the coking propensities of Canadian coking coals (particularly the Cretaceous coals of Western Canada). The group relies on the expertise and service of ERL and others in developing their specialized area; they are also affiliated with CCRA. Since their formation, considerable progress has been made in the special application of petrography to Canadian coals and their efforts will be invaluable in the evaluation of coals from small samples such as from exploration drilling programs.

Canadian Combustion Research Laboratory (CCRL)

The Canadian Combustion Research Laboratory (CCRL) and its research program were conceived in 1952. The program as originally described, addressed energy problems 10 and 20 years ahead and continues to do so today, but on an expanded scale that reflects growing national needs. Simply stated, it is a program of translating fundamentals to engineering practise in all phases of

fuel combustion for the efficient production of useful heat and electricity and at the same time minimizing impact on the environment.

Until pilot plant facilities were constructed in 1957, the embryo staff, comprising four people, carried out extensive combustion experiments in government heating plants to solve pressing problems with coal. Today, a staff of 22 have a well-equipped pilot plant containing, amongst other things, a model of a utility steam generator for phenomenological combustion studies and a flame-research tunnel furnace which are unique in the world.

An important part of CCRL's present program is participation in the fundamental research program of the International Flame Research Foundation, located at Ijmuden, Holland. This has proved to be a valuable scientific base for many of CCRL's in house pioneering projects involving all fuels and some combinations of fuels.

Over the years, CCRL has undertaken studies with pulverized coal, oil and other fuels in its research boiler (a model of a utility steam generator) to develop design parameters for industrial-scale equipment and to solve problems beyond the capability of the engineering community. This has been a popular and valuable service to energy oriented industry especially to-day when large power generating stations must substitute low-grade and low-quality coal for the type originally burned; to substitute coal for oil; and to design new plants for low grade, unknown coals.

The flame research tunnel furnace is extremely useful in controlling flame details such as shape, temperature and radiation for any solid, liquid and gaseous fuel and for any application ranging from steel ingot heating, through steam generation, to cement and lime kiln firing. This too, is proving to be a valuable facility and expertise for industry's present and foreseeable

needs relating to substituting fuels, optimizing fuel efficiency and reducing pollutant formation.

CCRL did some pioneering work in the preparation and combustion of coal-in-oil fuel which is rapidly gaining popularity because it is a strategy whereby 35% coal can be burned in equipment originally designed for oil and natural gas.

In another program, fuel additives are evaluated for their potential to improve combustion, to reduce pollution, to reduce fireside ash deposits and to reduce both high-temperature and low-temperature corrosion. The mechanism of ash deposition and fireside corrosion have been the subject of many years of research and patents are held on a successful fuel-oil additive that controls these phenomena.

Many thermodynamic systems analyses have been performed over the years and this includes domestic heating systems. As a result, an efficient oil-fired warm air furnace is being developed starting with CCRL's new, soot-free, blue-flame burner with modulated fuel firing and a distinctive furnace with electronic controls programmed by a microprocessor.

Because of the need to substitute coal for premium fuels and to protect the environment in the years ahead, CCRL has developed a laboratory fluidized-bed combustion facility for coals, char and wastes having especially difficult combustion properties. One of the first applications of fluidized bed technology being promoted by CCRL is coal drying while burning washery rejects at a coal washing plant.

Automobile fuel efficiency and pollution emissions under road operating conditions have been evaluated after developing an on-board instrument package.

Conservation, which is largely the application of fuel efficiency technology, is a major part of the CCRL activities and this will continue as premium fuels become increasingly difficult to get.

Protecting the environment, also, has been a major activity because minimizing pollutant emissions is inseparable from fuel efficiency studies. CCRL undertook a plume dispersion research program for which a distinctive aerial probing technique was developed. As a result, CCRL has the most complete knowledge of the dispersion capacity of Canadian air sheds and has the leading expertise, based on empirical data, for estimating chimney heights in these air sheds.

The development of specialized probes, sampling systems and continuous monitoring instruments is, probably, the most important single factor in advancing combustion science and technology. It is also significant that reliable empirical data are required for mathematical modelling, a science of the future.

Finally, demands for consulting services in the above and related subjects are a significant activity. This has grown, because of the energy crisis, to include waste-heat recovery, garbage and waste incineration and district heating in a technological matrix having attractive energy conservation potential.

COAL RESOURCE EVALUATION LABORATORY

Increasing energy demands and complexities of supply have prompted formalization of the activities in CANMET concerned with the quality of Canadian coal resources. The Coal Resources Evaluation Laboratory (including a field laboratory at Sydney Nova Scotia*) has evolved as the centre for qualitative assessment of those resources in Canada. Data are available from a member of joint Federal-Provincial coal resource inventory programs.

Projects of the laboratory have been concerned with the chemical and physical properties of coals as mined and as prepared for the market.

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*A satellite laboratory was established in Glace Bay, Nova Scotia in 1965 and subsequently was moved to Sydney in 1967 to aid in cooperative projects with the coal mine operators and governments in Nova Scotia and New Brunswick.

Quality trends have been established and the potential of new coals to meet exacting specifications have been determined.

In 1975, Canada and Nova Scotia signed an agreement to jointly undertake an inventory of the Nova Scotia coal resources. This laboratory was immediately involved in the qualitative assessment, a program to run to 1977. Preliminary assessments have been made in New Brunswick and a full scale inventory requiring complete physical and chemical analyses is now underway.

The lignite resources of Saskatchewan have been reevaluated and this laboratory was responsible over a five year period for the generation of a substantial coal chemistry data file and the development of computer programs for easy access to and manipulation of the data.

The evaluation and recommendations for the laboratory's study of coal mine waste banks in Nova Scotia played a large part in the establishment of a coal processing plant to reclaim the coal.

The laboratory is the responsible agent of EMR for assessment of the potential resources of peat in Canada with a view to the possible use of peat as an energy source.

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