Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

CANADIAN METALLURGICAL FUEL RESEARCH LABORATORY BUILDING NUMBER TWO THE C. STEWART PARSONS BUILDING

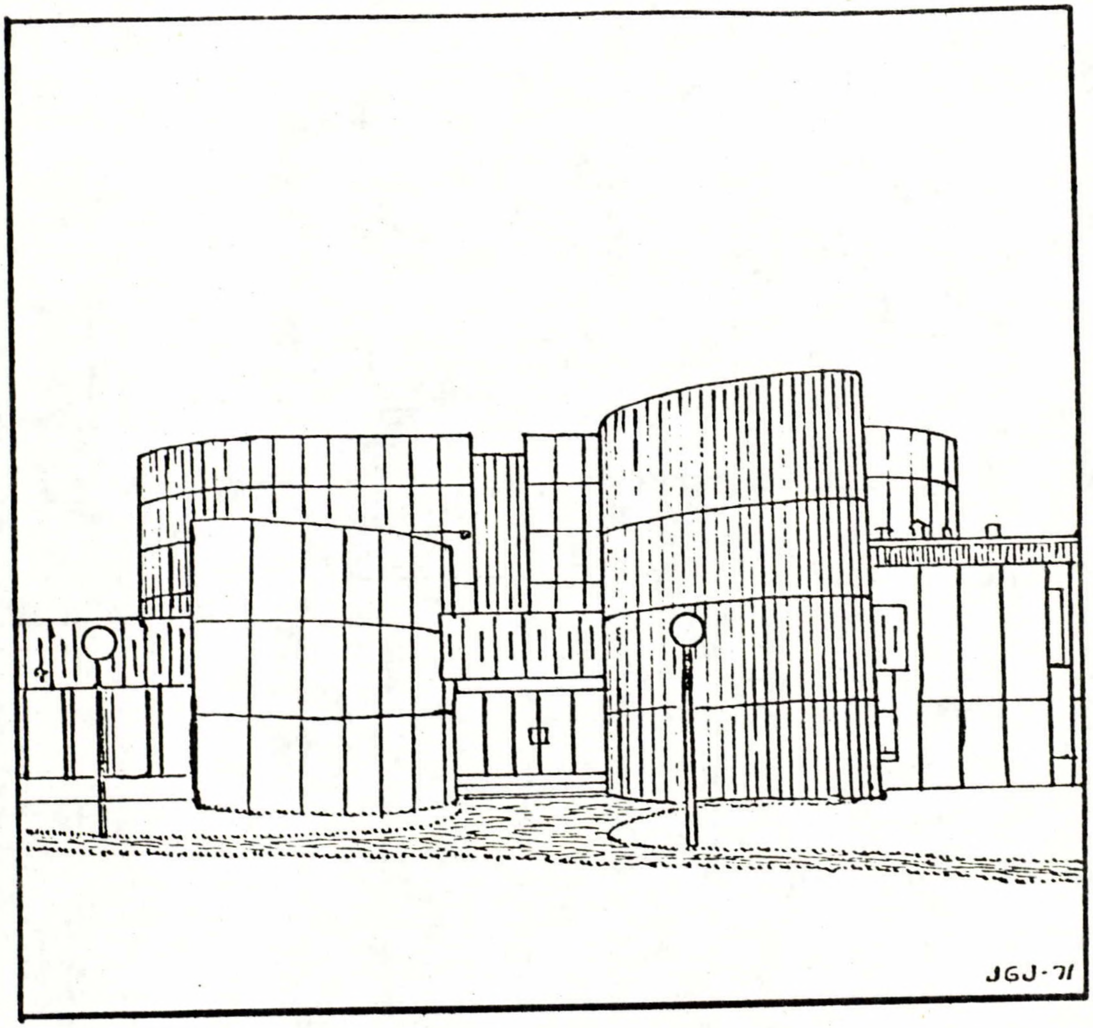
J.G. Jorgensen

Canadian Metallurgical Fuel Research Laboratory

August 1976

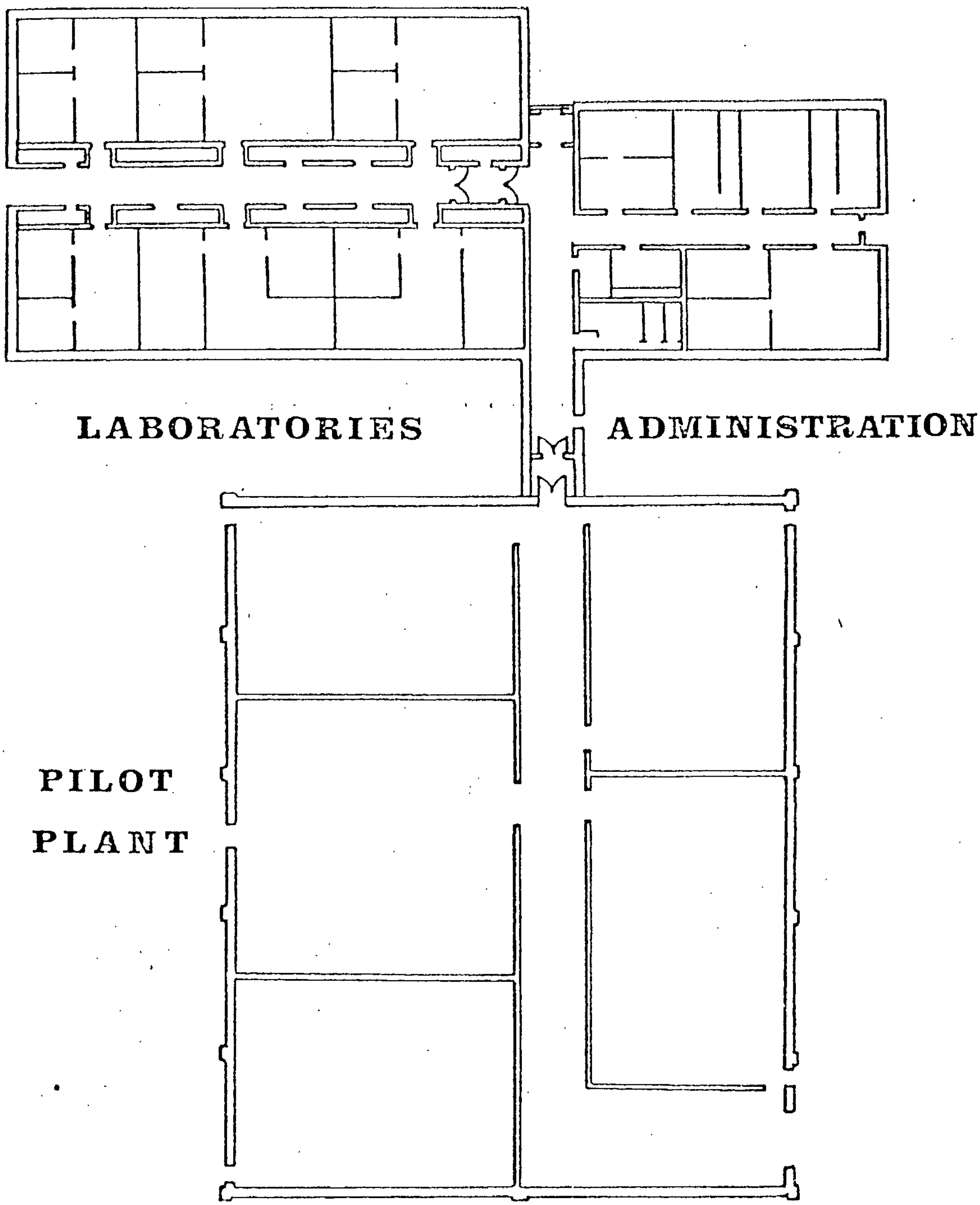
ENERGY RESEARCH PROGRAM
Energy Research Laboratories
Report ERP/ERL 76-75 (TR)

CANADIAN METALLURGICAL FUEL RESEARCH LABORATORY



THE C. STEWART PARSONS BUILDING

Plan of Building Number Two



CONTENTS

INTRODUCTION

The world's requirements for iron and steel are increasing at an ever expanding rate and the traditional blast furnace method of smelting iron ores to crude iron is assured of being the major route for the next 15 - 20 years. Metallurgical coke manufactured by the heating of coking coals in the absence of air (carbonization) is a vital ingredient in the blast furnace raw material mix but the overriding problem facing the steel industry is the increasing shortage of prime coking coals. Research activities falling within the CANMET Energy Research Program are, in general, oriented towards meeting this shortage, especially in the Canadian context.

The Canadian Metallurgical Fuel Research Laboratory is the best equipped laboratory in Canada to study aspects of coal carbonization and the true requirements of Canadian industry as a whole are taken into account in planning research projects by Government-Industry technical co-operation in the Canadian Carbonization Research Association. Of particular interest also is the storage in a computer memory of carbonization data from Canadian coals tested in Building No. 2, providing a valuable source of information for resource assessment.

The facilities available are described in the remainder of this report and research programs are classified under the following general headings:

- Innovations to Conventional Carbonization
- New Coking Methods
- Conversion of Non-Coking to Coking Coals
- Processing of Canadian Coals
- Application of Coal Petrography and Coke Microscopy to Coke-Making

Research programs are also underway relating to the transportation of coking coals in pipelines in slurry form with water or oil.

Finally, consideration is being given to the iron ore component of the blast furnace burden, as described under "Metallurgical Research", these activities falling within the CANMET Minerals Research Program.

CARBONIZATION OPERATIONS

In this section, studies on the coking characteristics of coals in relation to conventional slot-type ovens are undertaken. In addition, research programs concerned with improving existing techniques in commercial practice are carried out providing industry with information at the pilot-scale level.

The slot-type test ovens located in the pilot plant are:

1. The 18-inch chamber movable-wall oven with a charge capacity of 700 pounds
2. The 12-inch movable-wall ovens with a charge capacity of 500 pounds
3. The $5\frac{1}{2}$-inch oven with a charge capacity of 30 pounds

The sample is prepared to a given specification regarding moisture content and size consist, then the necessary amount is charged into the oven, the walls of which are heated to a pre-determined temperature. This temperature is raised at a controlled rate as the test proceeds, simulating commercial practice, and when the charge has been fully coked, the oven is opened and the resultant coke "pushed" and quenched. The coke is then evaluated for size and strength characteristics, which are important qualities from the point of view of commercial use.

During the coking process, due to the nature of the coal blend, sometimes excessive pressure develops which can result in structural damage to the commercial coke oven walls. It is therefore necessary to measure the pressure generated by the charge and this is done by means of the movable-wall test oven.

The $5\frac{1}{2}$-inch oven is ideal for carrying out many research studies, the results obtained from it giving a good indication of what might be expected from the large-scale ovens. It is thus very useful in clearing the ground work in complicated investigations before proceeding to the pilot-scale level.

In addition to the slot-type ovens listed above, there is a sole-heated oven. This oven is designed to measure the degree of expansion or contraction exhibited by the sample during the coking cycle. As could be inferred, the charge is heated only from the floor or "sole" of the oven. This information is useful in forecasting whether a blend, due to insufficient contraction, is liable to create difficulty during the operation of "pushing" the oven at the end of the coking cycle.

PETROGRAPHY SECTION

Petrographic techniques have become of increasing importance in the evaluation of coking coals, particularly in the technological sense of predicting the strength of the resultant coke. Optimum blends of various coals to produce high quality metallurgical coke can be calculated from petrographic data, thereby reducing the number of expensive technical-scale coke oven tests. This technique also has the advantage of broadening the scope of application of the evaluation of small samples (e.g. drill core samples from exploration work).

The petrographic laboratory includes facilities for sample preparation, where the coal or coke can be crushed to the proper grain size, mounted in an epoxy resin pellet, with one surface polished free of scratches and relief.

In the analysis room the maceral composition of the coal is determined with a Leitz Ortholux-Pol microscope. The reflectivity of the major macerals is determined by using a Zeiss Research microscope coupled to a PMI Digital Display Photometer.

In addition, the resultant coke and non-conventional formed coke can be studied under the microscope and characterized as to pore size and distribution, wall thickness, assimilation of inert components, cracks and fractures and reflectivity. Photomicrographs are frequently taken to illustrate unusual characteristics of the coal or coke.

COAL TREATMENT AND RHEOLOGICAL TESTING OF COAL

A. Coal Treatment

The Coal Treatment Section is concerned with the processing of coal from the time it leaves the mine until it is ready for utilization. This includes such general headings as transportation, coal cleaning, agglomeration and sample preparation.

The Section is responsible for coal preparation conducted at the Energy Research Laboratories and presently has facilities for the cleaning of coal by float-sink and flotation methods; crushing of coal and coke, size consist determinations of coal, coke and other minerals by dry, wet and sonic methods; and briquetting and agglomeration of coal and other materials and minerals.

In addition the Coal Treatment Section prepares coal and coke samples for further testing by other laboratories of the Division.

B. Rheological Testing

The Rheological Laboratory has facilities to conduct bench-scale tests to determine the caking and coking properties of coal. The following bench-scale tests are performed:

(a) Free Swelling Index - ASTM D720

(b) Gieseler Plasticity - ASTM D2639

(c) Audibert-Arnu Dilatation - ISO 349

(d) Ruhr Dilatation German Standard - DIN 51739

The laboratory records all coal and coke samples submitted from the carbonization programs for physical testing, chemical analysis and rheological testing.

RESEARCH AND FACILITIES SECTION

Whilst the greater part of the activities in Building No. 2 relate to the CANMET Energy Research Program, in particular with respect to coal carbonization, there is a continuing effort in the field of iron ore reduction which falls under the Branch Minerals Research Program. These latter studies compliment the former in that coke-making has necessarily to be considered in the overall context of iron and steel manufacture as well as in the context of the availability of coal supply.

An experimental simulation of the ironmaking blast furnace shaft has allowed assessments to be made on the effects of such extraneous materials as zinc and alkalies on blast furnace burden performance. Currently, the work is being extended to consider interactions between formed coke and iron ore (in the form of pellets) in the chemical conditions pertaining to blast furnace smelting. With respect to iron ores alone, proposed methods for the testing of iron ores based on International Standards specifications are being evaluated; this work is particularly relevent in relation to Canada's annual iron ore export tonnage.

Of particular interest in the Minerals Program is a joint venture between the Federal Government and the Province of Alberta to develop the low-grade iron ore deposits of northwestern Alberta. Previous attempts have generally been unsuccessful but the approach taken in Building No. 2 is to make liquid iron directly from a combined briquette of coal and the ore using a low-shaft reactor. The scale of experimentation has been at one ton per hour of product, providing meaningful results in terms of scale-up. Success of this investigation provides an alternate route to ironmaking suited to the particular situation in the Prairie Provinces.

Other related investigations at the bench-scale are undertaken from time to time. For instance, a new process route has been proposed for the production of ferrochrome from the chromite deposits of the Bird River area, Manitoba.

Again, in relation to the behaviour of the raw materials coke and iron ore in the blast furnace shaft, studies are continuing on coke reactivity using a modified solid-state oxygen sensor. This activity may be extended to include the breakdown properties of coke at temperatures in excess of 1000°C which are encountered in the bottom part of blast furnaces.

The transportation of raw materials from mine site to shipping terminals or steel plants is a major economic factor in the cost of the final product. Technical investigations are continuing on the possibilities and problems connected with moving coal through pipelines in slurries with water and oil.

Non-Conventional Coking

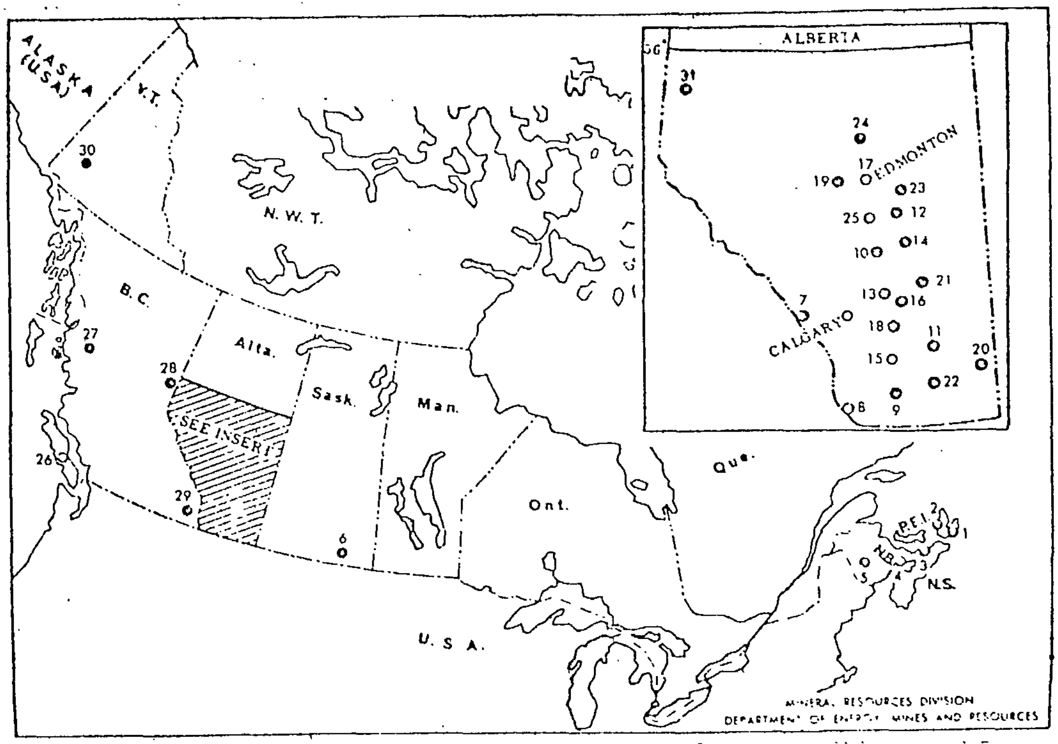
The activities of non-conventional coking in Building No. 2 refers to the production of metallurgical coke destined for the iron blast furnace by means other than the conventional method of charging the slot-type coke oven with coking coal blends. At this time CMFRL has formed coke and formed coal projects that may be defined as non-conventional coking. Formed coke is a "preformed" carbonaceous agglomerate (pellet, briquette, extrustion, etc.) that has undergone thermal processes to make it acceptable for iron blast furnace use. Formed coal refers to the partial briquetting of a conventional coke oven charge in order to increase coke quality and/or to utilize a non-coking coal in the charge.

Both of these projects are being undertaken because of the possibility of using potentially cheaper non-coking coals for cokemaking, such as those found in Alberta and Saskatchewan. Formed coke processes offer further incentives because of their ability to reduce pollution from coal carbonization, operate continuously or intermittently, and possibly decrease capital and operational costs.

At present, the main effort in non-conventional coking is being applied to (i) the development of formed coking equipment (particularly that suited to hot briquetting), (ii) investigations of the experimental variables associated with formed coking, (iii) assessment of the utilization of Canadian coals in formed coking processes, (iv) the partial briquetting of coke oven charges with the inclusion of non-coking coals, and (v) the use and development of laboratory test methods to predict the potential application of different coals to non-conventional coking.

Appendix I

Map of the Location of the Main Coal Areas in Canada



Nova Scotia
(Bituminous Coal)

1. Sydney
2. Inverness
3. Pictou
4. Cumberland

New Brunswick
(Bituminous Coal)

5. Minto

Saskatchewan
(Lignite)

6. Souris Valley

Alberta
(Bituminous Coal)

7. Cascade
8. Crowsnest
9. Lethbridge

(Sub-bituminous Coal)

10. Ardley
11. Brooks

Alberta (Cont'd.)
(Sub-bituminous Coal)

12. Camrose
13. Carbon
14. Caster
15. Champion
16. Drumheller
17. Edmonton
18. Gleichen
19. Pembina
20. Redcliff
21. Sheerness
22. Taber
23. Tofield
24. Westlock
25. Wetwaskiwin

British Columbia
(Bituminous Coal)

26. Vancouver Island
27. Northern District, Western
28. Northern District, Peace River
29. East Kootenay

Yukon Territory
(Bituminous Coal)

30. Carmacks

APPENDIX II

Canadian Coking Coals

Canadian deposits of coking coal are found in two widely separated areas: in the Atlantic provinces, and in Western Canada (particularly the Cordilleran region). There are many differences in the occurrence and mining of coking coals in the United States and Canada. Whereas the largest reserves of coking coals in the United States are in the Appalachian area in the east, Canada's largest reserves are in the west, particularly in the foothills belt of the Rocky Mountains.

It is estimated, on a conservative basis, that in Alberta and British Columbia some 15 billion tons are available of recoverable coal of coking grade down to 2500 ft. of cover in seams not less than 3 ft. thick. The Crowsnest Basin in southeast British Columbia is the largest coal-bearing area and is said to have some 23 seams, 10 of which vary from 5 to 25 ft. in thickness; its reserves of coal are estimated to be in excess of 4 billion tons, of which a large part is believed to be coking quality.

In the Atlantic provinces the Nova Scotia reserves are the principal ones but they are substantially smaller, amounting to about 1 1/2 billion tons of recoverable coal down to 4000 ft. of cover in seams of 3 ft. and over.

It is noteworthy that there are contrasts in physiographical and geological features between the eastern and western coal deposits in Canada and also with the deposits of the Appalachian area of the United States. The

Western Canadian deposits are of Cretaceous age and occur in tightly folded structural basins, with seams faulted and pitching from near horizontal to a high degree of inclination. Some stripping of these seams has taken place at elevations of 6000 to 7000 ft. above sea level, in very moutainous country. On the other hand, in the Maritimes the deposits are of Carboniferous age and are not so deformed as in the West. In Nova Scotia, the deposits extend, with a moderate pitch, to unknown distances under the Atlantic ocean. The only flat seam presently mined is under shallow cover in New Brunswick; it averages about 24 in., but this coal is not used for coking.

Historically it is rather significant that the first printed record of coal in America is contained in an article by Nicholas Denys published in Paris in 1672 referring to the existence of coal in Nova Scotia. In the following year the French explorers Joliet and Marquette discovered coal in the Mississippi Valley, and this was published in Marquette's Journal of 1681. Records indicate that the first coal mining operation on this continent was started by the French military authorities near Louisburg when the famous fortress of Louisburg was built in the year 1720. It is believed that this coal made its way to the New England states prior to the opening of mining operations in the state of Virginia in 1750. The coal deposits in question are the high volatile coking coals of Cape Breton which in later years helped develop the steel industry of Eastern Canada.

APPENDIX III

STAFF

Canadian Metallurgical Fuel Research Laboratory

Building Number Two

Mr. J.C. Botham - Manager

Dr. D.A. Reeve - Assistant Manager

Mrs. L. Freeland - Secretary

0.1 Petrography Section

J.G. Jorgensen - Head

R.C. Guenette

0.2 Coal Preparation and Rheology

T.A. Lloyd - Head

L.A. Ficko
J. St. James
G. Dicks
R.K. Graham
V. O'Connor
K.W. Flatt

0.3 Carbonization Operations

W. Gardiner - Head

Z.J. Tazbir
R.R. Bell
P. Couturier
R. Dowdall
I. Foran

0.4 Research and Facilities

Dr. D.A. Reeve - Head

Dr. W.R. Leeder
Dr. J.F. Gransden
Dr. J.T. Price
N.J. Raney
D.D. Cameron
A. Dykstra
M.J. Malette
K.F. Hampel