Report No. 66

THIRTY-FOURTH

ANNUAL REPORT

OF THE

RESEARCH COUNCIL OF ALBERTA

1953

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The following report, the Thirty-Fourth Annual Report of the Research Council of Alberta, was submitted in March 1953, by Dr. N. H. Grace, Director of Research, to the Chairman of the Council, the Honourable G. E. Taylor, Minister of Highways and Minister of Telephones. The Chairman submitted the report to the Premier of Alberta, the Honourable E. C. Manning, who tabled it in the Legislature.

The offices and laboratories of the Council are situated in the buildings of the University of Alberta. Requests for information and reports should be addressed to the Secretary, Research Council of Alberta, University of Alberta, Edmonton, Canada.

MEMBERS OF COUNCIL

*The Honourable G. E. Taylor, Minister of Highways and Minister of Telephones. Chairman since December 14, 1953.

The Honourable Dr. J. L. Robinson, Minister of Industries and Labour, Chairman to October 29, 1953.

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Mr. O. C. McIntyre, Edmonton.

Mr. R. D. Purdy, Calgary, to March 1953.

Mr. F. V. Seibert, Edmonton.

†Mr. G. H. Sissons, Medicine Hat.

*Honourable G. E. Taylor, appointed Chairman December 14, 1953 to replace Hon. Dr. J. L. Robinson, deceased.

†Mr. G. H. Sissons, appointed May 1, 1953 to replace Mr. R. D. Purdy, deceased.

The Council operates under the Research Council Act of 1930 as amended 1943, 1945 and 1950.

The offices and laboratories of the Council are in the University of Alberta. The Secretary of Council is W. A. Lang.

TECHNICAL ADVISORY COMMITTEE

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Dr. J. D. Newton, Professor of Soils, the University.

Dr. P. S. Warren, Professor of Geology, the University.

Mr. W. A. Lang, Secretary of Council, Secretary.

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†Mr. H. H. Somerville, Deputy Minister, Department of Mines and Minerals.

*Retired from Technical Advisory Committee, March 1953.

†Appointed June 1953.

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   Mr. J. A. Davidson, representing The Coal Operators' Association of Western Canada.

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   Mr. J. S. Charlesworth, Gasoline and Oil Testing Laboratory.

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   Mr. G. A. Collins, Geologist.

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Mr. W. E. Bowser, Federal Experimental Farms Service.

Mr. W. Odynsky, Senior Soil Surveyor.

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Dr. O. J. Walker, Chemist, Department of Chemistry, the University.

Dr. D. R. Stanley, Engineer, Associated Engineering Services Ltd., Edmonton.

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Mr. J. C. Mahaffy, Solicitor, Calgary.

Mr. L. H. Bussard, Superintendent of Schools, Lethbridge.

2. *Agricultural Co-ordinating Committee on Soil Classification, Surveys and Research:*

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Mr. J. W. Judge, Deputy Minister, Department of Municipal Affairs, Alberta.

Dr. A. Leahey, Principal Pedologist, Experimental Farms Service, Ottawa.

Dr. A. G. McCalla, Dean, Faculty of Agriculture, the University.

Dr. J. D. Newton, Director, Alberta Soil Survey, the University.

Mr. P. M. Sauder, Manager, St. Mary River Development, Lethbridge.

Dr. C. C. Spence, Economics Division, Canada Department of Agriculture.

Mr. V. A. Wood, Director of Lands, Department of Lands and Forests.

Dr. L. B. Thomson, Director, Prairie Farm Rehabilitation, Regina.

Mr. R. M. Putnam, Assistant Deputy Minister, Department of Agriculture, Alberta, Secretary.

Dr. N. H. Grace, Director of Research.

STAFF OF THE RESEARCH COUNCIL

Administration and Office Services:

N. H. Grace, Director of Research.
W. A. Lang, Secretary of Council.
Miss K. S. Wark, Accountant.
Mrs. S. M. Stewart, Technical Stenographer, to July 9.
Miss J. M. Simpson, Technical Stenographer, from June 13.
Mrs. J. K. Vander Velde, Stenographer, to August 31.
Miss K. A. Thompson, Stenographer, from May 4 to December 31.
Mrs. B. Johnson (part), Stenographer.
Miss Joan Powers, Stenographer, from August 19.
Miss F. L. Haney, Stenographer, from December 21.
S. J. Groot, Draftsman-Compiler.

Coal:

W. A. Lang, Chief Research Chemist.
N. Berkowitz, Research Chemist.
R. M. Elofson, Research Chemist, from October 5.
J. C. Wood, Research Chemist, from July 11.
J. D. Campbell, Paleobotanist, from May 11.
J. S. C. Dunn, Assistant Research Engineer, to December 31.
J. F. Fryer, Assistant Chemist.
J. L. Carveth, Assistant Research Engineer, to April 10.
B. O. Krueger, Technician, to July 11.
H. Rempis, Laboratory Assistant, to July 3.
Wm. Dammeyer, Technician, from April 6.
B. Brouwer, Laboratory Assistant, January 19 - May 23.
J. F. Vaneldik, Laboratory Assistant, from August 20.

Oil Sands:

K. A. Clark (part), Research Engineer.
D. S. Pasternack, Senior Research Chemist.
G. W. Hodgson, Senior Research Chemist.
Miss J. Scott, Assistant Chemist, to August 25.
B. L. Baker, Assistant Chemist, from October 6.
R. Wandio, Laboratory Assistant, to December 31.
Miss A. L. Roginsky, Research Assistant, April 1 - August 31.

Gasoline and Oil Testing:

J. S. Charlesworth, Senior Chemist.
E. Tipman, Assistant Chemist.
Miss G. M. Rymer, Assistant Chemist.
M. L. Eger, Technician, April 10 - November 30.
W. R. Reed, Laboratory Assistant, from November 9.
Miss Jill Webster, Technician, from December 7.
Miss M. V. Raines, Laboratory Assistant, May 4 - September 5.

Natural Gas:

D. Quon (part), Research Engineer.
W. K. Schmidt, Assistant Research Engineer.
W. R. Musgrove, Research Assistant, May 16 - September 30.

Industrial Projects:

J. Gregory, Industrial Engineer.
H. A. Spencer, Mechanical Engineer, from July 2.
G. S. Crawford, Ceramic Engineer, from July 2.

Geology:

G. A. Collins, Geologist.
A. G. Swan, Assistant Geologist, to November 15.
P. J. S. Byrne, Clay Mineralogist, from June 15.
L. A. Bayrock, Assistant Geologist, from April 27.
V. Sweetnam, Assistant Field Geologist, April 27 - August 31.
A. W. Aunger, Assistant Field Geologist, May 1 - August 24.
L. G. Bartlett, Laboratory Assistant, from December 7.

Soil Survey:

Wm. Odynsky, Senior Soil Surveyor.
A. Wynnyk, Assistant Soil Surveyor.
M. D. Scheelar, Assistant Soil Surveyor, to July 27.
A. M. F. Hennig, Assistant Soil Surveyor.
A. W. Henley, Assistant Soil Surveyor, to May 16.
W. F. Van Tyen, Assistant Soil Surveyor, to April 30.
K. C. Stewart, Field Assistant, May 1 - September 30.
D. Graveland, Field Assistant, May 11 - September 30.
D. W. Smith, Field Assistant, May 11 - September 30.
H. A. Williams, Field Assistant, June 1 - July 31.
H. O. Ritchie, Soils Assistant, from October 19.
F. J. Disney, Cook, May 25 - September 30.

Irrigation and Solonetzic Soils:

A. L. Mathieu, Research Assistant.

Highway Research:

W. M. Rea, Assistant Research Engineer, October 21 - November 15.
K. A. Millions, Assistant Research Engineer, from November 16.

Biological Cycles:

D. Stelfox, Assistant Zoologist, to August 31.

Hatchability of Turkey Eggs:

Miss R. O. A. Renner, Research Assistant.

The following members of the Faculty of the University of Alberta co-operated in the work of the Council:

Dr. K. A. Clark, Oil Sands.
Dr. E. H. Gowan, Ultraviolet Solar Radiation.
Dr. G. W. Govier, Natural Gas Research.
Dean R. M. Hardy, Highway Research.
Dr. J. D. Newton, Soil Survey, and with Dr. T. A. Toogood, Irrigation of Solonetzic Soils.
Dr. Wm. Rowan, Biological Cycles.
Dr. D. R. Clandinin and Dr. A. R. Robblee on Hatchability of Turkey Eggs.
Dr. L. W. McElroy, Grass Silage.

ANNUAL REPORT
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This report describes the main features of Council's research program on natural resources during the calendar year 1953. Progress was achieved in the broad continuing program which was modified in certain respects to meet the needs resulting from the present rapid industrial development in Alberta. The Industrial Projects section has been enlarged and assumed the responsibilities of the Technical Information Service for Alberta formerly conducted by the National Research Council. While every effort has been made to conduct effective applied coal research of immediate significance, it has become apparent that development of the potential of Alberta's tremendous coal reserves necessitates a co-ordinated broad program including projects of a somewhat long-range character; consequently highly-trained staff has been acquired for work on coal constitution and alternative utilization schemes. A clay laboratory has been established for basic and applied investigations on Alberta's clay and certain non-mineral resources. A relatively high staff turnover with the loss of certain key personnel has hampered work in some projects. It has, however, been possible to strengthen the research effort of other projects by the addition of staff and acquisition of modern research equipment.

The broad program on coal research includes problems on constitution and paleobotanical aspects, chemical studies on humic acids, interactions between coal and liquids in an ultrasonic field and pyrolisis in the presence of chain-inhibiting reagents. Applied problems include the chemical analysis of Alberta coals, studies on determination of volatile matter, investigation of use of coals in domestic stokers, coal cleaning, studies on surface moisture of coal and theoretical studies on briquetting. Investigation of the trace metals in oil-sands oil and other Alberta oils suggests that the occurrence of these metals may serve as a precise correlative property for crude oils: it has been concluded that cretaceous oils in general have a common origin. Studies are proceeding on the properties of heavy oils and the viscosity behavior of wet oil dispersions containing mineral matter. The Gasoline and Oil Testing Laboratory has continued its survey of the quality of Alberta gasoline, conducted studies and tests for various Alberta government departments and for industry and has done research on viscosity of aviation oils at low temperatures and the deterioration of aviation gasoline on storage. Studies on natural gas have included work on the partial oxidation of butane and the production of carbon black.

The Industrial Projects section during the year provided Alberta coverage for the Technical Information Service formerly operated by the National Research Council. Systematic calls have been made on industry and information and advice made available. The geological program included a Pleistocene study in the area of east-central Alberta, the boundaries of the Coteau and Viking moraines were delineated; studies in the northeastern corner of Alberta in regions where active uranium staking has occurred; a clay laboratory has been established; work was continued on the differential and thermal analysis of carbonate minerals; and, Council staff has maintained contact with the field parties doing exploration work in oil-sand permit areas. The soil survey section, participating in the work of the Alberta Soils Survey, completed a reconnaissance survey of the Grande Prairie sheet. About eight townships remain to be surveyed in this area, after which a report will be published on the Sturgeon Lake and Grande Prairie sheets. The exploratory survey of the area adjacent to the new Whitecourt-Valleyview highway has now been completed, some 1,350,000 acres being covered this year. A report and map on the area is being prepared. Irrigation research on the solonetzic soils of the proposed Red Deer irrigation area is providing basic information on the response to irrigation of various soil treatments. The Highway Research program was concerned with the fundamental nature of the action of lignosol in the prevention of frost heaving; the effectiveness of lignosol cannot be solely accounted for on the basis of the increase in viscosity of the soil moisture - lignosol solution in the treated zone, possibly dispersing and surface tension alteration properties are also important factors. Other chemicals including sodium hexametaphosphate were found to be effective in preventing frost action. The investigation of biological cycles has now entered a "crash" period as predicted by earlier work on the ten-year cycle; however, a substantial body of data, including crop and gizzard contents of nearly 1,000 samples of Hungarian partridge, pheasants and various grouse, has been developed and several publications on the extensive work in this whole connection are now in various stages of preparation. The joint sponsorship of the Provincial Department of Agriculture and Council permitted a continuation of studies on factors relating to the percentage hatch of turkey eggs and also provided experimental trench silos, these two projects being conducted by the University. Solar ultra-violet measurements have been continued.

The past year has seen action by Council on several broad problems of common public concern, including the establishment of a committee to study the merits of fluoridation of public drinking water and the holding of a round-table conference on industrial pollution. In view of the wide interest in the subject of soils and the number of federal, provincial and other parties concerned in related topics, Council appointed the "Agricultural Co-ordinating Committee on Soil Classification, Surveys and Research". This committee is under the chairmanship of the Deputy Minister of Agriculture and held one meeting during the year.

The research program of the Council owes much to the co-operation received from government and university departments and from various individual concerns. Special mention is made of the assistance of the National Research Council in making technical

information available in Alberta, of the collaboration with the Federal Department of Mines and Technical Surveys in work on fuel, and the Federal Department of Agriculture, Experimental Farms Services, in surveys and research on soils. The Department of Economic Affairs has placed office space in Calgary at the disposal of Council's engineers. The foregoing co-operation and assistance are gratefully acknowledged, along with the services of all who serve on Council's advisory committees.

COAL

The currently severe, and undoubtedly continuing, competition against coal by oil and natural gas has, in the past few years, brought about a significant shift of emphasis in modern coal research. While it is accepted that coal will remain a valuable primary fuel and an important source of energy, it is recognized that research on coal must not merely attempt to develop more efficent and attractive means for its traditional uses, but that it must also endeavor to find new applications. Apart, then, from a continuous re-examination of established processes in the light of improved fundamental knowledge, the general coal research pattern tends to devote progressively more attention to the chemical potentialities of coal.

In keeping with these trends, and convinced that such re-orientation of coal research is justified both by the present status of the coal industry and by the unquestionable potential importance of coal within the framework of the national economy, the Research Council of Alberta formulated, towards the end of 1952, three broad research programs which were to concern themselves with:

1. a paleobotanical study of the flora and biological origin of Alberta coal measures;
2. investigations into the chemical and colloid structure of coals; and
3. exploration of possible new chemical uses for coal.

To implement these plans, Council reinforced the coal research staff available in 1952 by one physical chemist, two organic chemists and one paleobotanist (all at Doctorate level), and devoted considerable effort towards establishing and suitably equipping the necessary laboratory space.

At the same time, however, Council remained cognizant of the importance of other aspects of an overall coal research program. The routine analytical and applied researches carried out during 1952 were, accordingly, maintained (and expanded where necessary), and though one project (that concerned with cleaning of fine coal) had to be curtailed owing to staff changes, satisfactory progress generally can be recorded.

Analytical Testing

Throughout the year under review, the Coal Research Laboratory continued its practice of undertaking complete analyses upon channel samples taken from newly-opened Alberta mines and from established mines in which operations have entered a new and hitherto uncharted working area. Such samples are collected and submitted to Council by courtesy of officials of the Mines Branch, Provincial Department of Mines and Minerals, and analytical data relating to them have proved invaluable in enabling Council to

work towards a comprehensive catalogue of Alberta coals and in providing (through Council) potential coal consumers with practical information as regards rank, type and properties of Alberta coals entering the market.

Concurrently with these analyses, a number of coal samples received from the Department of National Defence were tested in order to check the quality of solid fuels purchased for Army, Navy and Air Force installations. In addition, analyses were made of materials submitted to the Coal Laboratory by other departments of Council, and a considerable amount of work was also expended upon efforts to adapt a Scholes calorimeter bomb for the determination of sulphur in oils. The results of this latter investigation, however, are regarded as unsatisfactory.

Determination of Volatile Matter in Coal

As part of its program of analytical investigation, the Research Council of Alberta designed and built, in 1929, a vertical electric tube furnace for the determination of volatile matter contents of coal. This furnace, which was considered to offer certain advantages over those used in other laboratories, was redesigned in 1953 and used for a systematic study of the factors influencing reproducibility of results relating to the volatile content of low-rank coals; this aspect still presents a difficult problem. In its current form, the new furnace permits a substantially easier operation, but some difficulty has been encountered in maintaining constant tube temperature throughout the day; the variability is thought to be due to voltage fluctuations in the main power supply and can probably be corrected by the incorporation of a voltage stabilizer or suitable high-temperature thermostat. In the meantime, however, evidence has been obtained to show that "sparking", i.e., ejection of coal particles from the containing crucible during the rapid heat-up (a characteristic difficulty experienced with low-rank coals), can be greatly reduced, and in some cases completely suppressed, by increasing the moisture content of the charged coal. Other factors now known to influence reproducibility are:

(a) the size and composition of the crucible,
(b) the rate at which the crucible is elevated into the furnace,
(c) the rank of coal, and
(d) the size consist of the charged coal.

It is, accordingly, planned to continue current studies in this field and to extend measurements to a series of typical Alberta coals recently secured through the courtesy of the Mines Branch, Department of Mines and Minerals. When the projected investigations are completed, it is Council's intention to submit a full report upon them for consideration by the American Society for Testing Materials and by the International Standards Association. These two bodies are currently studying possible standard procedures for the determination of volatile matter, particularly of low-rank coals.

Stoker Investigations

During 1952, a 14-inch rotating, self-cleaning grate, domestic stoker and ancillary control and recording equipment were installed in Council's laboratories in order to permit an evaluation of the combustion characteristics of typical Alberta coals under practical conditions. This program has been continued in 1953 and has now

been completed. In all, 16 tests with a series of seven coals were carried out: of the coals, two were classed as subbituminous C, three were subbituminous B, one was high-volatile C bituminous, and one was medium-volatile bituminous (cf. ASTM classification). The test procedures were those indicated in the Annual Report for 1952.

The results show that all test coals except that of highest rank, i.e., the medium-volatile bituminous coal, will give satisfactory performance in the stoker. However, two minor limitations were noted: at feed rates corresponding to theoretical heat inputs exceeding about 150,000 B.t.u./hr., a slight but definite decrease in combustion efficiency was found, and a similar decrease was observed when the size of coal was reduced from 1¼x½-inch nominal stoker size to minus ¼-inch. It is, therefore, considered that the usefulness of the 14-inch stoker would be confined to small and medium size family dwellings; for larger installations, efficient operation would demand a proportionately larger stoker and furnace.

Coal Cleaning

Owing to staff changes, Council's investigations of fine-coal cleaning by means of a Driessen cyclone had to be discontinued in June 1953. Prior to this, however, considerable progress had been made along the lines indicated in the Annual Report for 1952. The feasibility of using a coal-water slurry of suitable concentration as the separation medium was confirmed, and it was demonstrated that cleaning efficiencies in this medium can, under appropriate operating conditions, closely approach the theoretical values. A paper reporting experimental data so far available was read at the Annual Convention of the CIMM, held in Edmonton in April 1953.

It is now proposed to reopen the investigation on a laboratory scale, and to examine in greater detail the effects of cyclone shape and dimensions. While the geometry of the Driessen cyclone is known to have a pronounced influence upon cleaning efficiencies, quantitative information on this point is still sparse, and it is felt that no hard and fast conclusions about the cyclone's applicability and efficiency are possible before this gap in present knowledge has been filled. At the same time, it is intended to investigate the properties of dense media other than magnetite or coal slurry.

Water-Retention Studies

In 1951, Council commenced a study of water retention by coal in order to obtain information about moisture sorption during wet cleaning, the effect of surface and interstitial water on storage and handling properties of coal at temperatures below 32°F, and the relative efficiencies of additives capable of significantly reducing the amount of adhering water. This investigation was continued throughout 1952 and finally completed in the summer of 1953; the results have been reported in an M.Sc. thesis to the University of Alberta.

Broadly speaking, it was established that whilst the amount of interstitial moisture taken up by any one coal, when immersed in water, can be predicted by means of a capillarity equation, interstitial moisture is normally very small compared to the quality of water held superficially on the coal. This surface moisture can be reduced by oil-treatment of the coal, but the amount of oil required

for a given reduction depends critically upon the specific surface area of the coal, and the oil-treatment would, therefore, not be practical in the case of very fine coal unless great importance is attached to simultaneous dust- and freeze-proofing. There is, moreover, an indication that the efficacy of the oil-treatment decreases with time owing to evaporation of lighter oil fractions from the protective film.

On the other hand, oil-treatment does improve handling characteristics of coal at temperatures below freezing point, and this (coupled with the reduction in surface moisture which it produces) may under certain conditions justify the process.

It was also shown that untreated frozen coal attains a maximum strength as the temperature falls, and that the temperature at which this is reached varies with the size consist of the coal: in general, the finer the coal, the lower the temperature. Equations connecting the freezing strength with temperature and size have been developed, but these apply only to closely-sized coal and are, therefore, of limited usefulness.

Briquetting

Owing to limitations imposed upon Council by its present inadequate accommodation, the practical coal-briquetting and coal-balling programs, referred to in the Annual Report for 1951, have remained in abeyance. In fact, with most of the required laboratory-scale work already completed in earlier years, these programs are likely to be resumed only when satisfactory pilot-plant space becomes available. Nevertheless, it has been possible to undertake some work bearing upon the fundamentals of briquetting: a theoretical study of the basic variables involved in briquetting with and without binders has led to a paper contributed to the Third Biennial Briquetting Conference held at Banff, Alberta, on August 31-September 2, 1953, and a second paper, dealing with laboratory investigations concerning the production of coke from brown coal briquettes, has been published in "Brennstoff-Chemie." These publications, when viewed in the light of results obtained in connection with a study of the colloid properties of selected Alberta coals, have thrown up several important aspects of briquetting that do not appear to have been investigated hitherto. It is, accordingly, Council's intention to explore them as soon as the staff and laboratory-space situations improve. Among them are, first, the possibility of extending the range of coals suitable for binderless briquetting by a pre-softening treatment and, secondly, a study of the fundamental relations between coal and binders.

Coal Constitution

As mentioned before, Council's studies of coal constitution were systematized towards the end of 1952 by the creation of a specialized research team. Since three out of the four members of this team did not take up their duties until the summer of 1953, little more than preparatory work could be undertaken so far, but some of this merits recording.

In connection with the projected paleobotanical program, Council can report that an appropriate laboratory has been set up and partially equipped, and that some progress has been made in the development of suitable maceration and softening techniques. Aimed

at the isolation of micro-fossils and at the preparation of sections suitable for an in situ study of micro-structure, these techniques must necessarily be extremely flexible if they are to be applicable to the wide range of coals occurring in the province. When fully developed, it is planned to employ them in a long-term study devoted to tracing the shifting species-composition of the flora represented in the Alberta coal measures and to elucidating the biological genesis of these deposits.

Progress has also been made in setting up an organic chemistry laboratory which will concentrate upon a study of the chemical constitution of coal and humic acids and, in particular, upon a detailed investigation of products obtained from interactions between coal and liquids in an ultrasonic field and from pyrolisis of coal in the presence of chain-inhibiting reagents. A review paper dealing with the chemical potential of coal was read at the annual convention of the CIMM in April 1953 and published in the CIMM Bulletin and Transactions of September 1953.

Fundamental studies of the colloid structure of Alberta coals, which were commenced late in 1952, were also continued during 1953, and data relating to the total accessible surface areas of Alberta coals (obtained by a heat of wetting technique) are now available for a representative coal series. In general, the varitation of surface area with coal rank assumes the same form as that previously found with British and British Commonwealth coals.

Using the heat of wetting method, it has further been shown that pressures of the order of those obtaining in coal seams are adequate to cause a very substantial and irreversible compression of the coal substance and a significant decrease in its accessible surface. The available information suggests that a reformulation of the concept of "coal rank" may result from this work.

Finally, measurements have been made of the absorption of oxygen by three Alberta coals at 25° and —40°C. The results confirm that coal is an essentially thermolabile solid which, on cooling, contracts in such a manner as to render its accessible pore volume progressively smaller as the temperature falls.

Information on Coal

Reference has already been made to a number of papers prepared during the year by members of the coal staff. In addition, a report is in preparation on the stoker investigation and progress has been made in the revision of Report No. 35, "Coals of Alberta—Their Occurrence, Analysis and Utilization". A pamphlet, "Alberta Coals —What You Should Know About Them", prepared by the Research Council of Alberta in co-operation with the Fuels Division, Federal Department of Mines and Technical Surveys and the Dominion Coal Board, and published by the Alberta Department of Economic Affairs, is now ready for distribution.

OIL SANDS

Oil Sand Exploration Activities

The Research Council has kept in touch, during the year, with the field parties of oil companies doing exploration work on oil-sand permit areas. Visits to the camps have demonstrated the interest of the Council and excellent relationships between company and

Council workers have been established. Each side understands the other's objectives and both are pulling together to advance knowledge about the oil sands resource.

Reports have been received from the oil companies on explorations during 1952. The contained data have been studied to discern general characteristics of the oil-sand formation that are emerging from the growing fund of information.

A large and increasing amount of core samples has been turned over to the Research Council. As a result, the Council is faced with two problems. One is to find storage space for the samples. The other is to decide upon, and then to carry through, the studies that should be made of the core material. As a start on the latter problem, a detailed examination of one core is being undertaken. This work is in the hands, mainly, of the Geology Section.

Trace Metals

The remarkable uniformity observed for the occurrence of vanadium, and nickel in various samples of oil-sand oil from very widely scattered points suggested that the occurrence of these metals might serve as a precise correlative property for crude oils in general. In this connection, the trace-metals work heretofore confined to oil-sand oil was extended to include many other oils found in other Cretaceous reservoirs of Alberta. The list of oils studied was believed to be typical of the Cretaceous oils of the province—it included oils ranging from the heaviest to the lightest—from the Lloydminster to Joseph Lake.

The examination of the concentration of these trace metals in the Cretaceous oils showed that the oils were remarkably uniform for the most part. The uniformity was manifest by an essentially constant value for the ratio of vanadium (oxide) to nickel (oxide) at about 3.45 to 1. While the ratio for the metals for each of the oils was essentially the same, the actual metal concentration in each of the oils appeared to be nearly directly related to the specific gravity of the oils, to the sulphur content of the oils, and to the carbon residue of the oils. The vanadium oxide concentration thus varied from 374 p.p.m. for oil-sand oil to about 6 p.p.m. for Acheson Lower Cretaceous oil; the corresponding nickel oxide concentration varied from about 94 p.p.m. to about 2 p.p.m. for the same two oils.

The first phase of the trace-metals work on the Cretaceous oils thus gave a very strong indication of the uniformity existing between oil-sand oil and the other Cretaceous oils of the province.

The second phase of the trace-metals work was concerned with the mode of occurrence in the oils of the trace metals, and with the consideration of the importance that such knowledge would have regarding the origin of the oil-sand oil. In the heaviest oils there is a relatively high concentration of porphyrin structures with respect to the vanadium and nickel content whereas in the lighter oils there is much less porphyrin relative to the vanadium and nickel content. In view of this, it was concluded that the Cretaceous oils in general, and oil-sand oil in particular, cannot be regarded as residue (by evaporation) oils, but rather must, for the most part, be regarded as "young" oils with the oil-sand oil the youngest, and the Acheson-type the oldest.

A paper on the trace metals in the oil sands and other Cretaceous oils of Alberta was read at the annual general meeting of the Cana-

dian Institute of Mining and Metallurgy, Geology Section, Edmonton, April 1953.

Additional trace-metals work was undertaken when the study was extended to the Devonian crude oils of western Canada. Particular attention was directed to the D2 and D3 producing horizons and the results indicate that Devonian oils in general are entirely different from the younger Cretaceous oils. The results tend to be scattered with the vanadium oxide to nickel oxide ratio lying in the range of 0.1 to 1.0. Unlike that for the Cretaceous oils, the ratio was not constant and appeared to increase with increasing specific gravity of the oils.

The one Cretaceous oil which appeared not to fit into the general Cretaceous pattern was the Joseph Lake oil. On the other hand, the Joseph Lake appeared to fall more closely in the pattern emerging for the Devonian oils, and the conclusion was drawn that the Joseph Lake oil, in all probability, arose from Devonian source rocks, but failed to remain in a Devonian reservoir rock and "escaped" to an overlying Cretaceous Viking sand reservoir. Subsequent private communications with other investigators have revealed that the same conclusion had been reached through other methods of approach.

Shut-down of the pile at Atomic Energy of Canada Limited in the fall of 1952 and its subsequent overhaul during the greater part of 1953 has made it necessary to postpone the proposed work on radiation analysis of trace metals in oils to the 1954-55 period.

The Origin of Oil: Porphyrins in Plankton, Bituminous Shales, McMurray Formation

A continuing interest in the trace-metal carriers, the porphyrins, has persisted during the past year. Little has been accomplished toward the actual identification of the porphyrins beyond the study of proper chromatographic procedures for the precise isolation of the compounds involved. At the present time, attention is being directed to the problem of the origin of the porphyrins and, hence, the origin of the oil. In this matter, samples of plankton have been collected by the Institute of Oceanography at the University of British Columbia and forwarded to this laboratory for detailed chemical study. It is proposed, and work is under way at the present time, to examine the plankton life for its porphyrin content with particular attention to be paid to the trace metals to be found in association with the porphyrin structures. In this manner, it is expected that important information will be obtained regarding the manner in which the particular metals now found in the porphyrin structures entered the oil substance.

Since the local Devonian oils are believed to have arisen from the Duvernay and Ireton bituminous shales found adjacent to the oil-bearing reefs, samples of those shales have been obtained from the Petroleum and Natural Gas Conservation Board so that an examination of them might be done with the end in view of using the presence or absence of the porphyrin structures as evidence of the manner of evolution of the Devonian oils.

If the Duvernay and Ireton shales can be related to the Devonian oils by means of a detailed study of the porphyrins, it is also reasonable to believe that a similar study might throw considerable light on the oft-suggested possibility that the shales within or at least

closely associated with the oil-sand sands were the source rocks for the oil-sand oil. It is hoped to integrate this work with that being done in the geology section of the Research Council.

Properties of Separated Oil—Storage and Handling

A knowledge of the properties of the wet, separated oil is needed for the design of equipment for the transport and storage of this oil from a hot-water separation plant. This product is a dispersion of water in oil containing a variable quantity of mineral matter—sand, silt, and clay. It is produced at a temperature of about 85°C and, in storage, its temperature would fall to that of the atmosphere. The viscosity behaviour of the dispersion has an obvious bearing on its transportation and on the settling, through it, of mineral matter, especially in storage. A start has been made at studying the viscosity behaviour of the dispersion. But since the wet, separated oil is a complex system, the start is being made using a simple oil-water dispersion that can be clearly defined. An M.Sc. candidate has undertaken the study. The problem can be stated as the determination of the rate of fall of solid particles through a two-phase liquid system.

The work done on this project to date consists of familiarization with the literature; design, accumulation, construction and erection of apparatus. The procedure calls for the use of irradiated steel balls, and negotiations have been in progress with Chalk River authorities for many months regarding the irradiation of the balls. Considerable delay will be experienced with this matter for some time yet because of the interruption of the pile operation both at Chalk River and Brookhaven.

However, during the time required for the preparation of the complete assembly of equipment for measuring the rate of fall of solid particles, experimental work will be carried out regarding the magnitude of the interfacial tension existing between the two phases under the various conditions of temperature and relative concentration pertinent to the rate-of-fall studies. For the most part, the apparatus required for this part of the study is now on hand.

Study of the "Heavy Oils" of Alberta

An outline of the purpose and value of this investigation, and the method to be followed in carrying out the work, was given on page 18 of the Thirty-third Annual Report of the Research Council of Alberta, 1952. Since this is a continuing investigation, it is not considered necessary to repeat the outline at this point.

The bunker fuel produced during the partial cracking of oil-sand oil at varying temperatures and rates of heating was split up into a number of fractions by means of solvent extraction. Good progress has been made in carrying out various analyses on these fractions, although even the analytical work was beset with unforeseen difficulties. For example, in carrying out molecular weight determinations using the benzene cryoscopic method, inconsistencies in the initial results were found to be due: (a) to variations in the temperature of the room during the course of the day, and (b) to aging of the benzene from day to day. Since the room temperature in any one day varied as much as 8°C. (14°F.), many controls were necessary in order to obtain acceptable results. In all, 174 determinations were made, each requiring up to two hours. If a constant-

temperature room had been available, it would have resulted in a considerable saving of time.

Due to the fact that some of the fractions were partly insoluble in benzene, other methods will have to be used to determine their molecular weights.

The determination of carbon and hydrogen in the various samples is nearing completion; determination of the sulphur and volatile contents and swelling characteristics have been started. This will be followed by determination of degree of unsaturation, softening point, and penetration.

The results to date on this project appear to be of sufficient value and interest to warrant the extension of this study to oils from the "heavy oil" fields of Alberta. This would enable comparisons to be made with oil-sand oil from both a fundamental and a practical standpoint.

GAS AND OIL TESTING

During 1953, there was a substantial increase in the volume of test work carried out by the Gasoline and Oil Testing Laboratory for the Department of National Defence, for departments of the Alberta government, for industrial firms, and for other sections of Council. A further series of tests was made on a Defence Research project covering the storage of aviation gasoline, and an extensive study was undertaken in connection with the use of a purple dye for the marking of gasoline under provisions of the Fuel Oil Tax Act.

Two gasoline surveys were carried out; one covered the winter months of 1952-53, the other, the summer months of 1953. These surveys were restricted to samples of gasolines purchased at filling stations in the cities of Calgary and Edmonton. While a larger coverage would have been desirable, the results of the analyses do indicate the general level of gasolines sold in the province. The data have been compiled and will be published as Mimeographed Circular No. 16, "Alberta Motor Gasoline Surveys, 1953".

NATURAL GAS

Work on two projects reported in the Annual Report for 1952 was continued in 1953. These investigations are: (1) the partial oxidation of butane, and (2) the production of carbon black.

The Partial Oxidation of Butane

The primary purpose of this investigation was to block out roughly the experimental conditions under which substantial yields of oxygenated organic products may be produced from the gas phase partial oxidation of butane. Pressure, reaction times and inlet gas compositions were the variables studied. With the reactor used and an ambient temperature of 725°F., the optimum yields were obtained under the following conditions: a pressure of 115-135 psia, a reaction time of about 1.5 seconds, and an oxygen and butane inlet concentration of around 4.0 mol. per cent each (the rest being nitrogen). A carbon conversion to useful products of as high as 20 per cent was obtained in one pass. The bulk of the oxygenated organic compounds formed (mainly methanol, ethanol, acetaldehyde) contained only one or two carbon atoms, indicating that the carbon-carbon bond was the main point of attack in the butane molecule. Several other interesting features about the reaction were noted. In all cases, there was an induction period of 0.5-1.0 second before the

reaction started. Once it did start, the reaction proceeded so rapidly that the reactor could not dissipate the resultant heat of reaction. Consequently, the reactant stream temperature reached peaks as much as 75 Fahrenheit degrees higher than the ambient bath and inlet temperatures. The bulk of the reaction took place at or near this temperature peak; after it had passed, presumably the oxygen content had been reduced to such a low value that no further oxidation occurred and direct quenching was unnecessary. Oxygen concentration was found to be more critical than butane concentration in controlling the reaction. Unquestionably, reactor design (particularly its heat transfer characteristics) plays a large role in determining the course of the reaction.

As a result of these studies, a new reaction system was designed and built. It has the following improved features:

1. The complete temperature profile in the reactor can be obtained (instead of at five fixed positions as in the old reactor).
2. The heat transfer characteristics of the reaction system can be varied without affecting the other variables. Conversely, the reaction time can be varied without changing the mass velocity. The new reactor is of the variable-length type.
3. All inlet streams (butane-nitrogen-oxygen) are now preheated in the reactor bath itself, assuring uniformity and better control of inlet temperatures.

The Production of Carbon Black

Some twenty experimental tests covering a range of conditions were made in the carbon black furnace. These tests, of short duration, were carried out at temperatures of 2250°F. and 2500°F. at space velocities of 0.123 to 0.560 second, corresponding to nominal contact times of 0.28 to 1.25 seconds and gas inlet-to-diffusion ratio of 0.9 to 2.0, considerably lower than that used by Pidgeon in his original experiments. Preliminary tests were performed on the carbon black products and a few samples from representative runs were sent to major rubber companies for further testing in rubber samples.

The tests, while unsatisfactory in some respects, did show that carbon black of a quality comparable to furnace thermal black could be produced in substantial yields (40-60%) in a tubular furnace. They also showed that from a mechanical and operational viewpoint a reaction tube mounted horizontally was not satisfactory. Continuous and extended operation was not possible with the original furnace.

A new vertical tube furnace has been designed and is now under construction. It will be located in the new Engineering Building where an equipment-well space allows for the location of the furnace on one floor and the collection system and control instrumentation on a lower floor. A number of improvements, notably in the air supply, the collection system and the method of tube mounting, have been incorporated in the new design.

A report, "The Manufacture of Carbon Black from Natural Gas —Technical and Economic Features, and the Significance to the Province of Alberta", was published as Mimeographed Circular No. 15.

GEOLOGY

The Geological Section has undertaken four field investigations and two major laboratory studies during the past year.

Field Work, Northeastern Alberta

A geological field party operated north and east of Chipewyan, Alberta, making detailed studies of selected areas that had been staked for uranium. Transportation in the area is by aircraft on floats or by small boat along the shore of Lake Athabasca. All traverses were on foot, and pace and compass mapping was carried out.

The oldest sediments observed were the Tazin series that are predominantly slate, cherty slates and minor altered volcanics or greenstones. Gneissic and granite pebbles were found in a Tazin conglomerate but the base of the series was not observed.

On the north shore of Lake Athabasca between Big Bay and Sand Point the Tazin slates are exposed along the shore and grade northerly by regional metamorphism to a metamorphic-migmatite complex that occupies the major portion of the area mapped. The total thickness of Tazin slates exposed is less than one thousand feet but the group is known to be many times thicker outside the map area.

Granite migmatites, granites and coarse pegmatite complexes were found in close proximity to Tazin-type sediments but nowhere were intrusive relationships between the igneous and highly folded sediments observed.

Grey granite at Fidler Point contains many inclusions of sedimentary slates and has other characteristics that indicate an igneous derivation. The field relationships between the grey granite and the pink orthoclase quartz granite is obscured by a deep valley separating the two rock types west of Fidler Point.

At the eastern edge of Allison Bay and extending east along the shore for five miles, coarse simple pegmatite constitutes the major rock type. Traced east, the coarse pegmatite is replaced as the rock type by an apalite intruding volcanics and fine-grained metamorphic rocks.

The Athabasca series—sandstones, arkose and conglomerate—overlie the igneous-metamorphic complex unconformably in the area west of Fidler Point.

The thin basal conglomerate and red arkosic sandstones are preserved in valley depressions, being protected from glacial ice advancing down the axis of Lake Athabasca by northerly striking granite ridges. Where the cover of the Athabasca series preserves the surface below the basal conglomerate, an oxidized and deeply weathered surface of granite and migmatite is exposed in sections. In surface plan where the basal conglomerate has been removed, but erosion has not been deep enough to remove the weathered granite, the product of the chemical breakdown of the ferro-magnesian minerals leaves an iron-stained surface. These weathered zones have been mistaken by some prospectors for the gossans that are produced by weathering of sulphide mineralization.

Topography

The country north of Lake Athabasca and east of the Slave River is a region of low rocky hills and ridges separated by depressions which are occupied by lakes and swamps. The area is of low relief with small spruce, pines and poplar.

Glaciation has imposed a complex lineation upon the region. Major ice advance paralleled the axis of Lake Athabasca in the south and east while other ice advanced from N. 60 E. along the boundary with Northwest Territories. Strike of bed rock varies from north to south in the north-central region to N. 50 E. in the Chipewyan area.

At Leggo Lake in the central area, ice advance did not coincide with structural trends and the resultant topography has the major axis of the lakes parallel to the bed rock strike direction of north-south while minor bays have been plucked to the southwest of the lakes by the advance of the ice from the northeast.

Near Chipewyan townsite glacial advance paralleled the bed rock trend and a steep cliff section of granite remains as remnants of strike joints or minor faults.

Economic Geology

Claims have been staked for uranium along the north shore of Lake Athabasca and at Meyers, Leyland and Leggo Lakes in the north-central portion of the Precambrian outcrop area in Alberta. It had been brought to the attention of the survey that samples taken from north of Fidler Point and Leggo Lake had returned positive chemical assays for uranium oxide. Based on this limited information, special attention was placed on those two areas to attempt to ascertain the nature of the uranium mineralization.

Allison Bay

Four miles, north 40° east, of Allison Bay, yellow stains were observed over an area 30 feet by 400 feet and, at one locality where surface blasting had been undertaken, a radioactive anomaly was found that reached a maximum of ten times background count on a geiger rate meter. The rocks were granitic with visible quartz-orthoclase and minor ferro-magnesian minerals. No expression of faulting was visible but deep valleys with steep walls which parallel the structural trends in the area may be traces of local faults or strong joint surfaces.

Hayes Group, East of Sand Point

This group has staked along the contact of the Tazin slates with their metamorphic equivalent a migmatite complex. In the slates, introduced quartz forms, fine stock-works and flecks of specular hematite were found. Small anomalies in the radioactive background count were recorded.

In the more competent migmatites and granites that occur a quarter-mile north of the shore, the introduced white quartz form veins (outcropping on the cliff section) which are visible from the lake. These last-mentioned veins, which are more continuous than the quartz stringers in the slates, are quite barren of sulphide mineralization.

Fidler Point

On Fidler Point and west of the Hayes group, claims have been staked along the contact of the Tazin slates and migmatite. In this area, Athabasca sandstones that occupy valley depressions in the Proterozoic surface have been protected, by unfractured ridges on Fidler Point, from erosion by glaciation. The ridges have their axis at an oblique angle to the advance of glaciation down the Lake Athabasca depression. The sandstone formation has a basal conglomerate that includes highly weathered ferro-magnesian minerals and red-orange-stained clays. These oxidation and erosion products have been mistaken by some prospectors for uranium alteration products. No radioactive geiger anomalies were found on the Fidler Point properties.

Fishing Lake Group, North of Fidler Point

These mineral claims were visited by traversing north from Fidler Point over migmatite rocks of a pink orthoclase-quartz type. Along the north shore of Fishing Lake a prospector for the group outlined the deposit.

The radioactive anomalies occur in mylonized or crushed rock zones along an east-west strike. Minor amounts of yellow uranium alteration products were visible at the most westerly occurrence. It has been reported that at more easterly points that were not visited the alteration products are more continuous and radioactive anomalies of a higher order have been found.

Leggo - Charles Lakes Area

Ninety claims have been staked around Leggo Lake and in the area to the southwest of the lake. These claims were staked during the winter of 1952-53 and spring and early summer of 1953, and certain surface trenching completed.

Iron-stained gossan resulting from weathering of iron pyrites and minor chalcopyrite is visible at the southwest of the bay.

A geiger rate meter survey of the gossan zone did not outline a radioactive anomaly. The minor pitchblende stringers, one-quarter inch wide, which had been reported were probably removed from the surface by blasting and sampling.

The rocks of the area are of a granite type described as a quartz orthoclase gneiss which has been crushed. Fractured zones with minor mylonite are developed along a northeasterly strike.

Field Work, Oil Sands - Athabasca River Area

Exposures north of McMurray that contained kaolinitic clay on the Devonian waterways surface below the McMurray formation were investigated. Exposures of oil sands that indicated faulting had taken place in post-Cretaceous time were examined close to Pierre Creek, a small tributary of the Athabasca River. The area 34 miles west of Bitumount near Gardiner Lake was surveyed; here Upper and Lower Cretaceous rocks overlie the McMurray formation and at one time covered the now-exposed oil sands in the Athabasca valley. Geological features of interest are grooves or striations with a direction of N. 60 E. and extending on both sides of the Ells River for from five to ten miles. The Cretaceous section of the 60 linear miles of the Ells River offers one of the best exposures of these rocks

and the section is of interest because of its proximity to the outcrop area of Precambrian rocks to the northeast on the Firebag River.

The lineations in the Gardiner Lake area are of glacial origin, indicating at least that the final advance of the ice front was in a direction S. 60 W. North of the grooves are large morainal hills—recessional moraines—with a boulder content indicating the advance of the ice was not eroding or plucking the limestone outcrop area to the east of Bitumount. Lack of lime tillstones indicates that the Athabasca Valley area was covered by at least 2,000 feet of ice before the final ice advance that deposited the Gardiner Lake moraine during its ablation.

The Ells River section can be temporarily correlated with the Athabasca River section:

Athabasca River Section		*Ells River Section*	
La Biche shale	1100′	Black shale	1000′
Pelican sandstone	40″	Sandstone	100′
Pelican shale	90′	Shale (dark grey)	
Grand Rapids sandstone and shale	280′	White-grey sandstones, shale and lignite beds	
Upper Cretaceous			
Lower			
Clearwater shale	275′	Clearwater shale	
McMurray sandstone	180-135′	McMurray sandstone	

On the lower reaches of the Ells River, the McMurray formation is exposed in complete section. Upon superficial observation, the upper portion of the formation is low-grade oil sands containing many ironstone doggers or concretions as thick (2-10′) bands. This horizon occurs immediately below the Clearwater shale and indicates a change of sedimentary environment.

The lower McMurray sands contain a medium oil content. Eighteen miles up the river, the limestone of the Waterways formation occurs below rich oil sand. Pictures and samples were taken along the two-mile outcrop of the Waterways formation, the east contact of which appears to be vertically faulted, the east side moving down to return the McMurray sands to river level. In addition to the above, Council staff followed field operations of companies holding oil-sand permits working in this area.

Bentonite Studies

During the academic year 1952-53 a fundamental mineralogical investigation of montmorillonite, the chief constituent of bentonite, was carried out at the University of Illinois by the Council officer who conducted a bentonite survey in Alberta in 1952. Forty montmorillonite samples, including twenty collected in Alberta, were subjected to X-ray and differential thermal analysis. It was found that the majority of the Alberta samples were of the sodium type, i.e., they held sodium as their dominant exchangeable cation. With two exceptions, their gel-forming properties were very poor. The widely-believed concept that sodium montmorillonites have good gel-forming properties, therefore, requires modification. It is apparent from these results that conventional beneficiation procedures

cannot be expected to improve the properties of these Alberta bentonites.

The main part of the investigation consisted of preparing organic-montmorillonite complexes and subjecting them to X-ray and differential thermal analysis in the hope that fundamental differences in the montmorillonites would be reflected in differences in the organic complexes. The samples used for the study were selected on the basis of purity and minor variations in the preliminary data. Fifteen samples were chosen, of which four were from Alberta. Complexes were prepared with ethylene glycol, piperidine, and dodecylamine by treating the montmorillonite with an excess of each compound. Ethylene glycol entered between unit sheets displacing the water normally held in this position. The piperidine and dodecylamine also entered between unit sheets displacing interlayer exchangeable cations.

The X-ray analyses of the ethylene glycol complexes showed a constant basal spacing of 17 Angstroms for each sample. This corresponds to the adscription of two molecular layers of glycol between each unit sheet of the montmorillonite. The piperidine and dodecylamine both gave basal spacings which varied from one sample to the next. This variation is considered to be controlled by some variation in the fundamental nature of the montmorillonite. For each sample, the higher orders of the basal reflections occurred at non-integral positions, indicating an intimate intermixture of components of differing basal spacings. These differing basal spacings reflect different amounts of organic compounds absorbed between unit sheets which in turn reflect some variation in the nature of the montmorillonite. In other words, each montmorillonite is an intimate mixture of two or more components. These components are similar in general structure, as shown by the X-ray diagrams of the untreated samples and the similarity of their adsorption of ethylene glycol. The differences probably are of a chemical nature, but may be due to minor structural variations.

The differential thermal curves of the ethylene glycol complexes showed a variable series of partly superimposed endothermic peaks followed by a single exothermic peak at 300 to 400 degrees centigrade. The remainder of the curves resembled those of the untreated samples. The initial endothermic peaks could not be correlated from one sample to the next. They were interpreted as being due to removal of oxygen or hydroxyl ions from interlayer glycol, the removal occurring at different temperatures for the different components of the montmorillonite. These observations lend further support to the hypothesis that every montmorillonite is a mixture of components of similar structure. On the basis of the discrete initial endothermic peaks, the components of the mixture differ from one another in a stepwise rather than gradational manner.

The differential thermal curves of the piperidine showed a series of broad exothermic peaks up to 800°C. superimposed in the curves of the untreated minerals. These are interpreted as being due to successive burning off of interlayer piperidine from different components of the mixture making up each sample. No other logical interpretation could be derived for the observed results.

The differential thermal curves of the dodecylamine complexes were all similar. Once again, the similarity may be interpreted in

terms of the essential structural similarity of all the components in each sample.

On the basis of the foregoing evidence, the hypothesis that every montmorillonite is a complex and intimate mixture appears to be fairly well established. The probability of similar mixing in other three-layer clay minerals should be kept in mind when dealing with clay materials.

The various organic complexes were analysed for high temperature phases after heating to 1000°C. The untreated samples yielded beta quartz, spinel or mullite as the high temperature phase. After treatment with dodecylamine and piperidine, the montmorillonite became more refractory and in several cases yielded a different high temperature phase. The usual change was from beta quartz before treatment to mullite or spinel after treatment with piperidine or dodecylamine.

Pleistocene Survey, East-Central Alberta

The subject of the field work was to establish variations of the surface covering tills in the area of east-central Alberta. Two moraines are present in the area: the Coteau moraine and the Viking moraine. The boundary of the Viking moraine is more or less a line running through Willingdon, Vegreville, and Sedgewick. The Coteau moraine overlaps the Viking moraine in the area of Lloydminster and continues southeast in the province of Saskatchewan.

The area was thoroughly investigated and a number of samples were collected for laboratory analysis.

The boundary of the Coteau ice advance was found in the area of Lloydminster. This part of the ice border was mapped up to ±¼ to ½ mile for a distance of 20 miles. The location of the mapped boundary is located between:

N.W. corner of Sec. 13, Twp. 49, R. 2, and
S.E. corner of Sec. 20, Twp. 51, R. 3.

The approximate trend of the boundary is N. 40 W. This trend was extrapolated to the northwest and the border was established by field checking for another 30 miles (±2 to 3 miles for the east-west limits). The total boundary thus has been traced for a distance of 50 miles.

The Viking moraine was also investigated and it was found that the eastern part of the moraine shows only a thin cover (4′-5′) over bedrock (Ribstone Creek and Lea Park formations).

The depth of leaching of carbonates was not conclusive in the differentiation of the two tills (Viking and Coteau). Hand sample topographic maps, soil maps, topography (as observed in the field), in addition to hand sample variations and erratics were used as an aid in mapping the Coteau boundary.

Two tills were found in the Viking moraine area and an additional one east of the Coteau border. The following stratigraphic relationship was established by hand sample variations in sections which contained more than one till:

Coteau till
Viking till (brown till)
Grey till

The correlation of the above tills with the grey and brown tills

of the ideal Big Bend section at Edmonton was mainly carried out by hand sample similarities.

The western border of the Coteau moraine is marked by outwash gravels which may be of economic significance. It was noted in the field that a number of good gravel pits are located in the outwash region of the Coteau moraine. It is suggested that some prospecting probably could reveal new gravel deposits in the area. At the present time, gravel is of great importance in the area because of the numerous road constructions.

Vertical profiles of soils are being studied to find variations in the mechanical and mineralogical composition of the Viking and Coteau tills.

Differential Thermal Analysis of Carbonate Minerals

The Annual Report of the Research Council of Alberta for 1952 refers to the investigation of carbonate rock systems by thermal analysis techniques that had been undertaken by Council in that year. This work was continued in 1953 and the results presented to the University of Alberta as the thesis requirement for a Master of Science degree. In the investigation, a study was made of the variables inherent in differential thermal analysis. Rate of heating was found to be an important factor in obtaining the maximum data on a thermal curve.

It was shown that the thermo-electric voltage generated during the first stage in the dissociation of a particular dolomite sample remained constant when the specimen weight exceeded a certain value. From the differential thermal analysis of dolomitic limestone and synthetic dolomite-calcite mixtures, the area of the lower-temperature dolomite peak and the concentration of dolomite calculated from the chemical analysis have been shown to be proportional.

Improved thermal curves of cerrusite were contributed which, due to increased thermal response and reduced rate of heating, have been interpreted in accordance with known chemical data.

HIGHWAY RESEARCH PROJECT

The program undertaken by the Highway Research Project included the following objectives:

1. a continuation of the studies to determine the fundamental nature of the phenomenon by which migration of soil moisture to the frost line is prevented by lignosol;
2. an investigation of the possibilities of using chemicals other than lignosol to prevent frost heaving and the development of frost boils;
3. the treatment of one or more severe frost-heaving locations on Alberta main highways.

A further separate objective of the project was to study the problem of the treatment of black soil-drift material to make it satisfactory for use in rebuilding highway embankments.

The hypothesis, that the effect of lignosol in preventing migration of soil moisture to the frost line was due to viscosity effects, was found to be incorrect. Further, it was proved that the complete effectiveness of the lignosol could not be accounted for on the basis of the increase in viscosity of the soil moisture - lignosol solution

in the treated zone. It appears likely that the dispersing and/or alteration properties of the lignosol are also important factors.

Several other chemicals were found to be effective in preventing frost action. Calgon (sodium hexametaphosphate) was proven to be equally as effective as lignosol. To a somewhat lesser degree, sugar beet molasses was also found to be effective. Several aerosols were effective in varying degrees. However, one or two of the aerosols appeared to accelerate frost action.

None of these chemicals, however, would be as economical to use as lignosol. Sugar beet molasses presents interesting possibilities because it is produced in the province. However, its cost is about the same as lignosol, its effect not quite so good, and it is more readily leached out of the soil. It appears that it would have to be stabilized as an insoluble compound if it is to be a practical treatment to prevent frost action.

It was not found possible to treat bad frost-heaving locations on the Alberta highways last winter. However, observations were continued for the third winter on the locations previously treated on the main line of the C.N.R. west of Edmonton. Some evidence of loss of effectiveness of the treatment was apparent. No work was done directly on the treatment of black soils, but work now under way on stabilizing the lignosol solution has distinct possibilities in the treatment of these soils.

SOILS

The Alberta Soil Survey Committee is Council's advisory committee on soils and is responsible for planning the joint program conducted by soils staff of the Dominion Experimental Farm Services and the Research Council of Alberta through the chairmanship of the Professor of Soils of the University. The project on "Irrigation Research" on the projected Red Deer Irrigation area at Youngstown involves the co-operation of officers of the Dominion Experimental Farms Services at Lethbridge, the University, and the Research Council with support from the Provincial Department of Agriculture.

Soil Surveys

Council survey activity was largely concentrated in the Peace River area of the province. A reconnaissance survey of the Grande Prairie sheet completed the field work on some 750,000 acres. About eight townships remain to be surveyed on this sheet, after which it is proposed to publish a report on the Sturgeon Lake and Grande Prairie sheets. An exploratory soil survey has now been completed of the area adjacent to the new Whitecourt-Valleyview highway. This exploratory information was obtained by pack-horse surveys on an area of some 1,350,000 acres in 1953, or more than half of the area which consists of townships 61 to 68 inclusive in ranges 14 to 26 inclusive west of the fifth meridian. This exploratory survey was commenced in 1952 in anticipation of requests for information regarding the agricultural possibilities of the area adjacent to the highway. A report and map of this entire area will be prepared in the near future.

Various special projects were effected by staff during the year. A brief general report was prepared by Council's chief soil surveyor on the soils and area to be traversed by a party of M.L.A.'s touring

the Peace River region in July. Special field trips included the area south of Valleyview where land surveyors were subdividing townships 65 and 66, range 21. This area was traversed on foot and preliminary soil survey sketches of the area were made and forwarded to the Department of Lands and Forests. Council's surveyor, with members of the British Columbia soil survey and the chief federal pedologist, made an inspection and correlation trip from Fort St. John, B.C., to Whitehorse, Yukon, for the purpose of establishing a uniform system of soil classification and to determine the character and probable extent of arable land adjacent to this portion of the highway. Late in the season, a field trip was made south of the mapped area in the Peace River region in an effort to determine the boundaries of the podsolized soil zone. Numerous samples were collected during the summer for chemical study; some 16 monoliths were collected in the Peace River district for display mounts.

Reports

1. "Soil Survey of the High Prairie and McLennan Sheets." Report No. 17 of the Alberta Soil Survey. This report was made available for distribution in June 1953.
2. A Report on Public Lands open for Settlement in the Fringe Area of Central Alberta was completed and is now available for distribution. This report was prepared by the Department of Lands and Forests and the Research Council of Alberta.

For purposes of reference and interest, the following brief mention is made of projects of the Alberta Soils Survey conducted by federal or university staff.

A detailed survey was made of some 104,000 acres in the Bow Island area and some 32,000 acres in the Medicine Hat area of the St. Mary project. A similar survey was made of some 46,000 acres in the southern part of the Red Deer irrigation project. Further detailed surveys involved 7,000 acres of seepage or alkali land in the Monarch area and 25,000 acres in the Raymond-Magrath area. The checking and sampling in the Rocky Mountain House region was completed this summer and a map and report on the area are being prepared. Other projects included further work on the Edmonton sheet, and survey of certain Indian reserves, and illustration stations; assistance also was rendered to land assessors.

Irrigation Research on Solonetzic Soils

A large proportion of the projected Red Deer irrigation area consists of hardpan (solonetzic) soil, and we have had practically no experience with this type of hardpan (Hemaruka) soil under irrigation. It was, therefore, deemed necessary to carry out experimental work on this soil to see if it can be made to produce crops successfully under irrigation before spending large sums of money on irrigation development.

Experimental irrigation plots were established southwest of Youngstown in the spring of 1952 by the University Department of Soils and the Research Council of Alberta in co-operation with the Dominion Experimental Farm at Lethbridge.

The project is carried on in close co-operation by provincial and federal workers. It was decided: (1) that the federal experimental plots at Youngstown should be used chiefly to study the consumptive use of water on Hemaruka soils under varying cropping

conditions; (2) that the provincial plots and experiments would be devoted chiefly to studies of the physical characteristics of the soil and methods of correcting, if possible, the undesirable features of the soil when subjected to irrigation.

Review of Work Started in 1952

The "A" plots, each 16'x45', were laid out and treated as follows: (1) dry check, (2) irrigated check, (3) deep cultivation, (4) barnyard manure, (5) sulphur, (6) gypsum, (7) krilium. One series of seven plots is used for continuous grain production and two similar series for a grain and sweet clover rotation. Quadruplicate replication was obtained by using four ranges of each series of plots. Within each series, the plots are randomized.

Treatments and seeding of barley in 1952 were delayed and the growth was poor and uneven, masking effects of soil treatments.

The Lethbridge station plots at Youngstown were designed to include one series in continuous grass, one series in continuous alfalfa, and four series in a rotation. A standard fertilizer, ammonium phosphate 11-48-0, is applied to half of each plot each year, and different numbers of irrigations are applied to different plots each year. In 1952, all plots were seeded down to barley.

Work Done in 1953

The "A" plots were seeded to wheat in 1953 and more satisfactory yields obtained in spite of late seeding caused by a wet spring. The yields have not as yet been analyzed statistically but they show some interesting differences.

The "B" plots were broken and seeded to barley in 1953 on an area of land west of the dam. The area was fenced and some barley yields taken to study the original variability of the soil. The following cultural treatments are being applied:

1. deep cultivation—using a caterpillar and a frost breaker and ripping the soil to a depth of two feet or more;
2. deep plowing—using a caterpillar and a breaking plow and plowing the soil to a depth of 18-20 inches;
3. alfalfa—continuous;
4. shallow deep-cultivation—using farm machinery and farm tractor power;
5. check—normal cultivation.

These treatments will be used for dry land plots as well as irrigated. Each plot is 40x40 feet and the treatments are in quadruplicate. Cultivation was done this fall.

Suitable agricultural equipment obtained during the year for this work has included a Ford tractor and plow, cultivator, disc, mower, blade, press drill and fertilizer attachment.

A number of farms in the Youngstown general area which are irrigated with water from local sources were investigated with special reference to the character of the soils irrigated. Of eight irrigated farms visited, only two had Hemaruka soil (solonetzic hardpan soil developed over marine shale). In one of these cases, the farmer irrigates only five to ten acres of pasture and garden, and in the other case the farmer finds it advisable to irrigate every second year only because the soil becomes hard and impervious if

irrigated every year. Investigations of other locally irrigated farms will be carried out next year.

Co-ordination of Work on Soils

Council established during the year the "Agricultural Co-ordinating Committee on Soil Classification, Surveys and Research" in order that all the varied work relating to Alberta's soil be conducted as effectively and efficiently as possible. Mr. O. S. Longman, Deputy Minister, Department of Agriculture, is the chairman of this committee which has a membership from the various federal and provincial agencies concerned with the problems related to soils.

INDUSTRIAL PROJECTS SECTION

The Industrial Projects section maintains a technical service for new and established industry in all its phases. Studies are undertaken of the feasibility of establishing new industry in the province. Assistance is provided either directly or through other government departments to industry considering entering Alberta as a field of operations. A Technical Information Service is maintained for manufacturing industry now established in Alberta. Research and testing is undertaken for industry not having its own facilities for such work. The staff of the section was expanded in July from one to three engineers to broaden these functions by the combined experience of the men and by their ability to cover a greater field of service.

Studies of Industrial Possibilities

A valuable service for encouraging industry to enter this area is the preparation of reports indicating the feasibiilty of establishing various new industries. The basis for subjects of investigation may be obtained from studies of our mineral resources, the by-products of other industries or from a consideration of products being brought into Alberta in sufficient quantity to suggest the possibility of their manufacture here. The Industrial Projects Advisory Committee has recommended the following subjects for study: secondary petrochemical industries, sulphur, sulphuric acid, chlorine, wood products, pesticides, dehydrated foods and wood wastes.

Industrial Development

As industrialists investigate the possibilities of establishing in Alberta, the industrial projects section is constantly being brought into the picture. The section assists the treatment of inquiries received by the Industrial Development Branch of the Department of Economic Affairs from interested industrialists on resources of Alberta, manufacturing processes, and markets. Through the Industrial Development Branch or directly, interviews and discussions are constantly held with such visiting parties. Some of the potential industries discussed last year included those to manufacture cement, lime, gypsum, expanded products of shales, clays, perlite and vermiculite, rock wool, polythene film, chemical specialties, asphalt products and glass.

Technical Information Service

The Industrial Projects Section of the Research Council of Alberta took over on January 1, 1953, the field work for the province of Alberta of the Technical Information Service of the

National Research Council. Technical Information Service was established in 1945 to make available technical information to manufacturers in Canada. Representatives were placed in the various provinces to make systematic calls on industry and to submit problems to the central office of Technical Information Service. The following list indicates the nature of inquiries handled:

1. Methods of manufacture with special reference to new products and equipment, or to products and equipment not at present made in Canada.
2. Manufacturing difficulties and methods for overcoming them.
3. Types of equipment best suited to the inquirer's type and scale of business and their sources of supply.
4. Methods of construction, both industrial and domestic; heating; thermal insulation, etc.
5. Corrosion, including the nature, application and value of protective coatings, both metallic and organic.
6. Source of raw materials or semi-manufactured components either in Canada or in other countries.
7. Possible substitute materials, their advantages or disadvantages and sources of supply.
8. Properties of chemical compounds, metals and alloys, etc.
9. Utilization of waste materials.
10. Industrial health hazards, fume disposal, fire and explosion hazards, etc.
11. Methods of handling and packaging materials.

The inquiries may be sent to Ottawa for treatment or may be processed locally. The major sources of information for T.I.S. inquiries at Ottawa are the staff of information officers of Technical Information Service, the N.R.C. laboratories and library, other government departments such as the Bureau of Mines or Forest Products Laboratory, or any other authoritative source. Information for locally handled inquiries is obtained from the experience and files of the staff of the Industrial Projects section and the university departments and library. During the first ten months of the year, the section has made 340 calls on industry resulting in 222 inquiries of which 102 were submitted to Ottawa and 120 treated locally. To indicate the nature of the type of inquiries handled, a few examples are listed: specifications for roofing compounds, oil sludge recovery, manufacture of 2, 4-D, radiator corrosion, sulphur sources, cracking of ceramic ware, drainage for home construction and problems in furniture manufacture.

Research and Testing

A function of increasing importance is that of performing research and testing for industry. Tests were carried out on bloating characteristics of clays, shales, perlite and vermiculite to determine their suitability for the production of light weight aggregate. Clays from two sections of the province were tested for brick-making characteristics. Tests were made on asphalt-mineral mixtures to determine whether required specifications were met. Arrangements have been made to undertake tests on welded specimens for corrosion possibilities for a major construction concern at Edmonton.

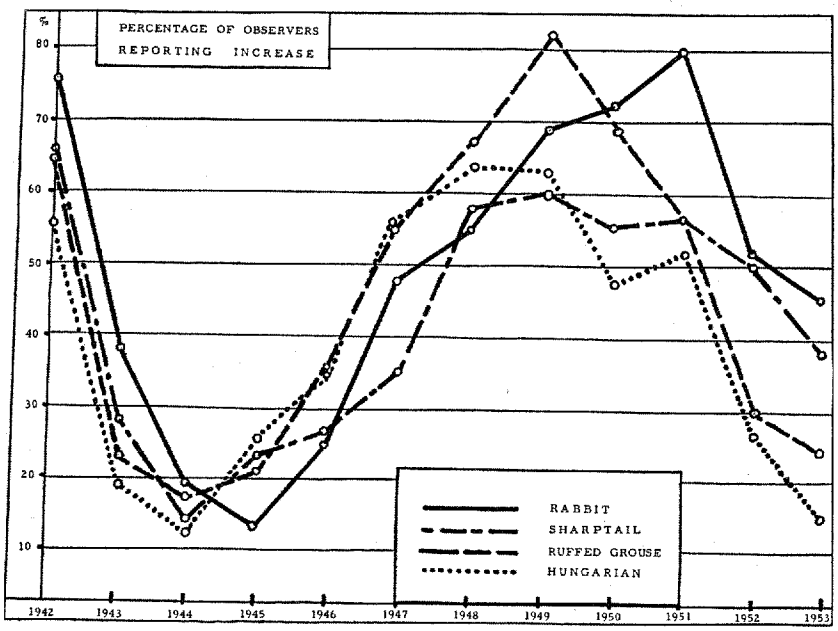
Various tests have been performed upon request of the provincial Purchasing Agent to assist him in his purchases.

Research and test work is expected to assume greater importance as facilities to carry it out improve.

BIOLOGICAL CYCLES

The Ten-year Cycle appears to have reached its predestined collapse as the accompanying graph, based on eleven years of questionnaires, illustrates. This finding is in keeping with hunting returns as ascertained at checking stations during the current season. The general situation applies also to other species involved.

In view of this rapid decline, post-mortems have been made on only 245 birds and rabbits as against 753 of last year. The clinical picture, however, remains the same: no disease or disease organism that could sweep the boards has been discovered.



Experimental

In view of the abundance of rabbits last fall in a few selected spots where they appeared to have reached their peak numbers, the enclosure at Cooking Lake was kept amply stocked but, despite their vitamin-enriched diet and such dense cover, thanks to heavy rains, that predatory birds had no chance of victimizing the inmates, the captive population died off without producing any progeny as far as could be determined. In October, a single survivor remained. This agrees with the censuses of particularly good rabbit areas in the Cooking Lake district where it is difficult to find any rabbits at all.

At Anzac, a collaborator has continued to make records on grouse and rabbits, both of which have been practically nonexistent during the past year. These meticulous observations will be invaluable when it comes to a final summing-up of the completed cycle. Laboratory studies included a survey on vitamin D from chemical

analyses of the femurs of rabbits, and on vitamin A using the livers of all rabbits obtained. Both these investigations are, at the moment, of doubtful significance and difficult to interpret. Analyses have been made on the crop and gizzard contents of nearly 1,000 Hungarian partridges, pheasants, and various grouse.

Publications

Since the collapse in the ten-year cycle has occurred, it has seemed opportune to "clear the decks" in the matter of publication. A series of papers is in preparation. A request article, "Reflections on the Biology of Animal Populations", is to appear in an early issue of the Journal of Wildlife Management.

Acknowledgments

This investigation owes much to the co-operation received from the Game Department, the Provincial Veterinary Laboratory, various sportsmen, questionnaire recipients and, in particular, to certain individuals.

ANIMAL SCIENCE

The two following investigations in the Department of Animal Science of the Faculty of Agriculture, University, have been sponsored by the Provincial Department of Agriculture and the Research Council.

Factors Affecting the Percentage Hatch of Turkey Eggs

The experiments conducted this year were designed to investigate the effect of "management factors" on the percentage hatch of turkey eggs. The results appear to indicate that the selection of males for the breeding pen may influence the subsequent hatching results. A comparison of the reproductive performance of breeders which were fattened indicate little trend. There was an indication that the production rate of the thinned breeders may have been increased. The addition of vitamins and unidentified factors to the breeding ration resulted in an increase in fertility and hatchability in both the thinned and fattened breeders. The effect was greatest in the case of the thinned birds. It is proposed to make a study of the effect of body fleshing and carriage of the tom on fertility and hatchability. It is also proposed to study the possible effect of breeding on reproductive performance.

Grass Silage Project

Two trench-type silos, each with a capacity of approximately 40 tons, and six small experimental concrete tower silos, each of approximately 1,100 pounds capacity, were built on the University Farm. The trench silos have been filled with a mixture of alfalfa and timothy. No preservative was used in the first silo, while in the second, ground barley was used as a preservative. This silage will be used in an experiment involving three lots of ten yearling feeder steers. The experiment is set up in such a way as to yield information on the relative rates and economy of gain of steers fed roughage as follows: (1) hay, (2) silage with no preservative, (3) silage with a preservative. The grain ration will be the same in all three lots. The six small experimental silos have been filled twice so that we now have samples of silage prepared in these silos under twelve different treatments. These samples will be used largely for analytical studies.

Analytical work will involve the determination of moisture, dry matter, protein, pH, lactic, acetic and butyric acids, volatile bases and carotene. The analytical work to date has been limited almost entirely to mastering the techniques of analysis.

SOLAR ULTRA-VIOLET RADIATION

A report on the solar ultra-violet measurements made in Edmonton since 1946 was given before some 25 members of the World Meteorological Organization, which met in Toronto during August and part of September. After considerable discussion, a "sub-commission" in radiation was formed and E. H. Gowan was named a member. Every encouragement was given to the work on solar ultra-violet and it was agreed that the Council and the University of Alberta should continue the routine measurements now being taken. An extension of the work on stability of sensitive receivers was suggested, and also a calibration in energy terms. Checks of the spectral responses of individual photocells are desirable, and it is hoped that apparatus to do this will soon be available in the University.

The observation program continues. The instrument at the Edmonton Meterological Station registers the medium range centred on 3,300 Angstroms. This is supported by the Council and the co-operation of the meteorological staff is very good. Two other ranges, centred at 3,050 and 3,600 Angstroms, are being measured by equipment belonging to the University. The comparison of integrating methods in terms of convenience, simplicity of operation and cheapness continues.

FLUORIDATION

Council appointed a committee, in January 1953 to undertake a study of the question of fluoridation of municipal water supplies. This committee made a detailed study of the extensive scientific literature on this subject with particular attention to the results from various controlled experiments; however, most careful consideration was directed to all available information, favorable or opposed in nature. The committee substantially concluded its study of the subject in December and is proceeding forthwith to prepare a report of its findings for submission to Council.

INDUSTRIAL POLLUTION

Rapid increase in population and industrial development in Alberta have been considerations suggesting the desirability of anticipating insofar as possible some of the problems of industrial pollution encountered by older heavily industrialized areas. Consequently, a round-table discussion on this subject was called and attended by representatives from a number of industries, municipal and provincial government departments, and the University. It was recommended by the representative gathering that establishment of an advisory committee on industrial pollution by Council would seem to be a timely development.

LIST OF PUBLICATIONS

of

RESEARCH COUNCIL OF ALBERTA

EDMONTON, ALBERTA

ANNUAL REPORTS OF COUNCIL

No. 3 (for the calendar year 1920); pp. 36. **(Out of print.)**
No. 5 (for the calendar year 1921); pp. 86. **(Out of print.)**
No. 8 (for the calendar year 1922); pp. 64. **(Out of print.)**
No. 10 (for the calendar year 1923); pp. 76. **(Out of print.)**
No. 12 (for the calendar year 1924); pp. 66. **Price 35 cents.**
No. 16 (for the calendar year 1925); pp. 65. **Price 35 cents.**
No. 20 (for the calendar year 1926); pp. 53. **Price 25 cents.**
No. 22 (for the calendar year 1927); pp. 49. **Price 25 cents.**
No. 24 (for the calendar year 1928); pp. 53. **Price 35 cents.**
No. 25 (for the calendar year 1929); pp. 65. **Price 35 cents.**
No. 26 for the calendar year 1930); pp. 76. **Price 35 cents.**
No. 27 (for the calendar year 1931); pp. 53. **(Out of print.)**
Nos. 28, 29 and 32 (for the calendar years 1932-1934); pp. 90. **Price 35 cents.**
No. 33 (for 1935); pp. 43. **Price 35 cents.**
Nos. 37-43 (for 1936-1942). Not published.
No. 44 (for 1943); pp. 14. **Price 5 cents.**
No. 45 (for 1944); pp. 18. **Price 5 cents.**
No. 47 (for 1945); pp. 21. **Price 5 cents.**
No. 50 (1946); pp. 28. **Price 5 cents.**
No. 51 (1947); pp. 28. **Price 5 cents.**
No. 54 (1948); pp. 27. **Price 5 cents.**
No. 55 (1949); pp. 26. **Price 5 cents.**
No. 60 (1950); pp. 39. **Price 5 cents.**
No. 62 (1951); pp. 31. **Price 5 cents.**
No. 64 (1952); pp. 40. **Price 5 cents.**
No. 66 (1953); pp. 41. **Price 5 cents.**

REPORTS—FUELS

No. 10A (1923); COMBUSTION OF COAL FOR THE GENERATION OF POWER, by C. A. Robb. **(Out of print.)**

No. 14 (1925); pp. 64. ANALYSES OF ALBERTA COALS, with 18 maps and 2 charts. By E. Stansfield, R. T. Hollies, and W. P. Campbell. **(Out of print.)**

No. 35 (1944); pp. 174. COALS OF ALBERTA—THEIR OCCURRENCE ANALYSIS AND UTILIZATION, by Edgar Stansfield and W. Albert Lang. In six parts. **(Out of print.)**

Parts I-V—Occurrence, classification, production, special tests, general properties, preparation, utilization and combustion. **(Out of print.)**

Part VI—Analytical and technical data by coal areas. **Price 50 cents.**

No. 46. ALBERTA COALS AND AUTOMATIC DOMESTIC STOKERS. Edgar Stansfield and Colin A. Genge. **Price 20 cents.**

No. 65 (1954); REVISED COALS OF ALBERTA. (In preparation)

REPORTS—ROAD MATERIALS

No. 18. THE BITUMINOUS SANDS OF ALBERTA, by K. A. Clark and S. M. Blair.

Part I (1927)—Occurrence, pp. 74. **(Out of print.)**

Part II (1927)—Separation, pp. 36. **(Out of print.)**

Part III (1929)—Utilization, pp. 33. **(Out of print.)**

No. 53 (1949); THE ROLE OF VERY FINE MINERAL MATTER IN THE HOT WATER SEPARATION PROCESS AS APPLIED TO ATHABASKA BITUMINOUS SANDS, by K. A. Clark and D. S. Pasternack; pp. 22. **Price 15 cents.**

No. 57 (1950); DETERMINATION OF VISCOSITIES AND SPECIFIC GRAVITIES OF THE OILS IN SAMPLES OF ATHABASKA BITUMINOUS SAND, by S. H. Ward and K. A. Clark; pp. 21. **Price 15 cents.**

No. 58 (1951); THE COMPONENTS OF THE BITUMEN IN ATHABASCA BITUMINOUS SAND AND THEIR SIGNIFICANCE IN THE HOT WATER SEPARATION PROCESS, by D. S. Pasternack and K. A. Clark; pp. 14. **Price 15 cents.**

REPORTS—SOIL SURVEY DIVISION

No. 23 (1930); PRELIMINARY SOIL SURVEY ADJACENT TO THE PEACE RIVER, ALBERTA, WEST OF DUNVEGAN, by F. A. Wyatt and O. R. Younge; pp. 33 and colored map. Scale 1 inch to 4 miles. **(Out of Print.)**

No. 31 (1935); PRELIMINARY SOIL SURVEY OF THE PEACE RIVER-HIGH PRAIRIE-STURGEON LAKE AREA, by F. A. Wyatt; with colored map. Scale 1 inch to 4 miles. **(Out of Print.)**

No. 56 (1950); SOIL SURVEY OF THE RYCROFT AND WATINO SHEETS, by Wm. Odynsky and J. D. Newton; pp. 84 and 2 maps.

No. 63 (1953); SOIL SURVEY OF THE HIGH PRAIRIE AND McLENNAN SHEETS, by Wm. Odynsky, A. Wynnyk and J. D. Newton.

REPORTS—GEOLOGICAL SURVEY

No. 1 (1919); FIRST ANNUAL REPORT ON THE MINERAL RESOURCES OF ALBERTA, by J. A. Allan; pp. 104. **Price 25 cents.**

No. 2 (1920); SECOND ANNUAL REPORT ON THE MINERAL RESOURCES OF ALBERTA, by J. A. Allan; pp. 138+14. **(Out of print.)**

No. 4 (1921); GEOLOGY OF THE DRUMHELLER COAL FIELD, ALBERTA, by J. A. Allan; pp. 72, and 6-color map (Serial No. 1). **(Out of print.)**

No. 6 (1922, Part I): GEOLOGY OF THE SAUNDERS CREEK AND NORDEGG COAL BASINS, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 76 and 2-color map (Serial No. 2). **(Out of print.)**

No. 7 (1922, Part II); AN OCCURRENCE OF IRON ON THE NORTH SHORE OF LAKE ATHABASKA, by J. A. Allan and A. E. Cameron; pp. 40; two maps (Serial Nos. 3 and 4). **(Out of print.)**

No. 9 (1923); GEOLOGY ALONG BLACKSTONE, BRAZEAU AND PEMBINA RIVERS IN THE FOOTHILLS BELT, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 48, and 6-color map (Serial No. 5). **(Out of print.)**

No. 11 (1924); GEOLOGY OF THE FOOTHILLS BELT BETWEEN McLEOD AND ATHABASKA RIVERS, ALBERTA, by R. L. Rutherford; pp. 61 and 8-color map (Serial No. 7). One inch to two miles. **(Report out of print, map available.)**

No. 13 (1945): GEOLOGY OF RED DEER AND ROSEBUD SHEETS, by J. A. Allan and J. O. G. Sanderson; pp. 109. Two geological maps in 8 colors. Scale one inch to three miles. Serial No. 8 Red Deer Sheet and No. 9 Rosebud Sheet, now out of print. Replaced by Map No. 9A, combination of Maps No. 8 and 9. Scale one inch to four miles. **Price 75 cents.**

Map No. 10 (1925); GEOLOGICAL MAP OF ALBERTA, by J. A. Allan. In 14 colors. Scale one inch to 25 miles. **(Out of print.)**

No. 15 (1926); GEOLOGY OF THE AREA BETWEEN ATHABASKA AND EMBARRAS RIVERS, ALBERTA, by R. L. Rutherford; pp. 29 and 3-color map (Serial No. 11). One inch to two miles. **(Report out of print, map available.)**

No. 17 (1927); GEOLOGY ALONG BOW RIVER BETWEEN COCHRANE AND KANANASKIS, ALBERTA, by R. L. Rutherford; pp. 46 and 9-color map (Serial No. 12). Scale 1 inch to 1 mile. **(Report out of print, map available, 25 cents.)**

No. 19 (1928); GEOLOGY OF THE AREA BETWEEN NORTH SASKATCHEWAN AND McLEOD RIVERS, ALBERTA, by R. L. Rutherford; pp. 37 and 3-color map (Serial No. 13). Scale 1 inch to 3 miles. **Price 10 cents.**

No. 21 (1930); GEOLOGY AND WATER RESOURCES IN PARTS OF PEACE RIVER AND GRANDE PRAIRIE DISTRICTS, ALBERTA, by R. L. Rutherford; pp. 80 and 6-color map (Serial No. 14). Scale 1 inch to 4 miles. **(Out of print.)**

No. 30 (1934); GEOLOGY OF CENTRAL ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 41 and 10-color map (Serial No. 15). Scale 1 inch to 10 miles. **(Out of print.)**

Map No. 16 (1937); GEOLOGICAL MAP OF ALBERTA (Coloured), by J. A. Allan. Scale 1 inch to 16 miles. **(Out of print.)**

Map. No. 17 (1939); GEOLOGICAL MAP OF ALBERTA (Black and white), by J. A. Allan. Scale 1 inch to 32 miles. **Price 5 cents.**

Map No. 18 (1940); COAL AREAS OF ALBERTA, by J. A. Allan. Scale 1 inch to 20 miles. **Price 25 cents.**

No. 34 (1943), in five parts by J. A. Allan; pp. 202. **(Out of print.)**

Part I—General Geology of Alberta, pp. 37, and geological map No. 17, scale 1 inch to 32 miles. **Price 50 cents.**

Part II—Rock Salt Deposit at Waterways, pp. 19. **(Out of print.)**

Part III—Geology of Alberta Soils, pp. 87. **(Out of Print.)**

Part IV—Relief Model of Alberta and its Geological Application, pp. 9. **(Out of Print.)**

Part V—Coal Areas of Alberta, pp. 36, and Map No. 18, scale 1 inch to 20 miles. **(Out of Print.)**

No. 48 (1946); GEOLOGY AND COAL OCCURRENCES OF WAPITI-CUTBANK AREA, ALBERTA, by J. A. Allan and J. L. Carr; pp. 43 and map (Serial No. 19). Scale 1 inch to 3 miles. **Price 50 cents.**

No. 49 (1947); GEOLOGY OF HIGHWOOD-ELBOW AREA, ALBERTA, by J. A. Allan and J. L. Carr; pp. 75 and 6-color map (Serial No. 20). **Price $1.00.**

No. 52 (1949); GEOLOGY OF RIBBON CREEK AREA, ALBERTA, by M. B. B. Crockford; pp. 68 and 5-color map (Serial No. 21). **Price 50 cents.**

No. 59 (1951); GEOLOGY OF CARBONDALE RIVER AREA, ALBERTA, by W. H. A. Clow and M. B. B. Crockford; pp. 70 and 11-color map (Serial No. 22). **Price 50 cents.**

No. 61 (1951); CLAY DEPOSITS OF ELKWATER LAKE AREA OF ALBERTA, by M. B. B. Crockford; pp. 102 and 2-color map (Serial No. 23). **Price 50 cents.**

REPORTS—RURAL ELECTRIFICATION

No. 36 (1944); pp. 107. RURAL ELECTRIFICATION IN ALBERTA, by Andrew Stewart. (Not available for distribution.)

Appendix I (1944); pp. 77. (Not available for distribution.)

Appendix II (1944); pp. 115 with maps. (Not available for distribution.)

CONTRIBUTION SERIES

This series comprises papers submitted to technical societies or journals by members of the technical staff. They are not available for general distribution; but can be consulted in the original publication cited.

No. 1—Fuel Investigations of the Research Council of Alberta (1919-1940), by W. A. Lang. Trans. Canadian Institute of Mining and Metallurgy, Vol. XLV, 1942, pp. 27-44.

No. 2—Humidity Data Expressed in Grains Water Vapour per Pound of Dry Air, by Edgar Stansfield. Canadian Journal of Research, A 21, 1943, pp. 51-55.

No. 3—Alternative Fuels for Motor Vehicles, by W. A. Lang, The Engineering Journal, August 1943, pp. 449-454.

No. 4—Hot-Water Separation of Alberta Bituminous Sand, by K. A. Clark, Trans. Canadian Institute of Mining and Metallurgy, Vol. XLVII, 1944, pp. 257-274.

No. 5—Some Physical Properties of a Sample of Alberta Bituminous Sand, by K. A. Clark, Canadian Journal of Research, F 22, 1944, pp. 174-180. **(Out of Print.)**

No. 6—Purification of Silica Sand—Alberta Tar Sands Suitable for Glass Manufacturing, by E. O. Lilge, Canadian Chemistry and Process Industries, Vol. XXIX, July, 1945, pp. 480-482. **(Out of Print.)**

No. 7—Bituminous Sands of Alberta, by K. A. Clark, The Oil Weekly, August 13, 1945, pp. 46-51. **(Out of Print.)**

No. 8—Asphaltic Road Oils from Alberta Bituminous Sand, by K. A. Clark, Canadian Chemistry and Process Industries, Vol. XXIX, September, 1945, pp. 616-618. **(Out of Print.)**

No. 9—Research and the Coal Industry in Canada, by W. A. Lang, Trans. Canadian Institute of Mining and Metallurgy, Vol. XLIX, 1946, pp. 51-62.

No. 10—Recent Work of the Research Council of Alberta, by E. Stansfield, Bulletin Canadian Institute of Mining and Metallurgy, No. 406, February, 1946, pp. 121-128.

No. 11—Some Recent Conceptions of Coal Structures, by A. McCulloch, Canadian Chemistry and Process Industries, November, 1947. **(Out of Print.)**

No. 12—Elimination of Water from Wet Crude Oil Obtained from Bituminous Sand by the Hot Water Washing Process, by K. A. Clark and D. S. Pasternack, Part I—Continuous Settling at Atmospheric Pressure, Part II—Continuous Settling Under Pressure; Evaporation. Canadian Chemistry and Process Industries, January, 1948 and November, 1947. **(Out of Print.)**

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