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History of the Geological Survey of Canada, 1930-1959

By H.M.A. Rice

Transcribed by M-F. Dufour

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Most instances in the text where there appear mistakes in spelling or grammar have been preserved and are followed by (sic); [?] is used to denote instances where there is some confusion arising from the text and; other words appearing in square brackets have either been added to help the flow of the narrative where text was missing or bracket author's notes.

1930-1935
by HMA Rice

History of GSC

General Situation

This is the period of the Great Depression, the "dirty thirties". No individual or organization was unaffected and the mining industry, with whom the Geological Survey is so closely linked, was no exception. Through 1930 it was spreading far and wide, crossing international boundaries and oceans. But it took time to penetrate every domestic cranny and its full impact on the mining industry did not show until 1931.

In that year manufacturing was sharply curtailed with a consequent loss of demand for materials, and the output of the mines and smelters began to accumulate in huge stockpiles of unwanted metals. Prices dropped and mines with marginal operations had to close down. By the spring of 1932 mineral production was 18.2% lower than it was a year ago. And worse was to come.

The only bright spot in the mineral industry was gold. The greater the financial difficulties of nations, the greater the demand for gold reserve[s] and gold became the only metal for which the demand became greater than the supply. For years prior to the war the price of gold had been pegged at $20 an ounce but this arbitrary price could no longer be maintained in the face of the growing demand and before long the price rose, even to $35 an ounce. Unlike other branches of industry, gold mining boomed and this to some extent offset the depressed state of most other branches of the industry.

By 1933 there were signs of industrial recovery. Surplus stocks of base metal[s] began decreasing and some demand for base metals reappeared, albeit at a very low price. The mining industry met the challenge with boldness and initiative. To operate at the prices being paid for metals the cost of mining and processing the ore had to be extremely low. This necessitated a highly efficient operation and, even more, the devising and employment of new techniques, both to extract the ore from the ground and the metal from the ore. In both of these an increasingly important role was played by that offspring of the Geological Survey, the Mines Branch.

1934 saw continued improvement and by 1935 base metal prices were starting to recover and the mining industry operating at 1929 levels.

Note (I am sure you will be able to do a much better job on the depression, which was after all a national and international matter. All I have tried to do is to jot down some aspects of it that particularly affected the GSC. The Section needs considerable expansion if it is to fit properly into world history.)

Work of the Geological Survey

The situation in the mining industry naturally had a profound effect on the work of the Geological Survey. As soon as industry started to get into difficulties the Survey responded by concentrating harder than ever on matters that might directly and immediately benefit it. Nonetheless it is interesting to note that the nature of the work being done remained substantially unchanged, only the work itself was done in places where the results might be of immediate use. Areas including operating mines or known ore deposits, or less well known areas that reconnaissance had shown to hold exceptional promise (sic). Gone were the days of Robert Bell whose advice on the operation of individual deposits was regarded as a prime duty of the Survey. The operators and their staff could do this themselves now and as they themselves were better trained, their needs were broader and more fundamental. It is indeed interesting that at no time was real pressure brought to bear on the Survey to perform the kind of duties so strongly advocated by Bell and the mining men of his time, even under the totally abnormal stress of the worst depression in history.

As profitable base metal mining became virtually impossible, however, the attention of the Survey was directed to work that might help the oil and gas production and the coal mines, which were both reasonably active, and particularly the gold mining industry, which was actually booming.

By 1933 Government expenditure had been rigidly reduced and with it the Survey appropriation. The number of field parties was greatly curtailed, many of the officers went out in pairs and areas were selected that could be investigated without the need for extra help and at the lowest possible cost. The following list of geological parties fielded each year tells the story:

Field parties
1930 – 42
1931 – 41
1932 – 35
1933 – 20
1934 – 24

Reorganization

For some years a certain dissatisfaction had developed with the administration of the Geological Survey by Dr W H Collins, who had been its Director since 1920. Collins was a first class geologist and at his best tramping through the bush with a hammer and a note book. It was soon apparent that he lacked the breadth of vision to administer a large and complex organization like the Survey and frequently became involved in minute operational details that would have been far better left to his subordinates. By 1934 the situation was further complicated by Collins' failing health.

At this time reorganization within the Government had resulted in the elimination of the Department of the Interior, leaving its head, F C C Lynch, without a job. (What was Lynch, Director, Deputy Minister?, I forget). It seemed a good opportunity to provide the Geological [Survey] with [a] better administrator and Lynch with a suitable position. Lynch of course had no scientific training and there was evidently some reluctance to displace Collins and appoint him Director. The expedient was therefore hit upon to create a new unit, the Bureau of Economic Geology of which the Geological Survey was a part. Lynch became Director of the Bureau and Collins remained Director of the Survey but relieved of most of his routine administrative duties. Indeed as Collins' health continued to deteriorate until his death early in 1937, G A Young, the Chief Geologist, assumed more and more of the responsibility for planning and directing the technical work of the Survey with which of course Lynch was totally unfamiliar.

Note: (I recall it said that in 1933, when Collins was still in sole control, a senior geologist could not get a pencil out of stock without a note bearing Collins' signature. There was even another story current when I joined the staff that Cooke had requested 6 pencils and that Collins had reduced it to 3 saying: "How can a man use 6 pencils at once!" There was certainly a good deal of dissatisfaction among the geologists when I joined but Collins was then so clearly a dying man that it was voiced with some restraint. Of course with Lynch at the helm we generally felt we had jumped out of the frying pan into the fire. But we can deal with Lynch and GA in the next section.)

<u>General Nature of Work</u>

It has been said already that the task of supplying the immediate needs of the mining industry must be the primary goal of the Survey at this time of crisis, and consequently the work of the Survey changed as the objectives of the mining industry shifted. In 1930 the Survey, although always conscious of the need to keep economic objectives to the forefront, laid even more stress on it. Long range projects were abandoned in favour of those that might lead to more immediate results.

By the next year, however, it was apparent that any effort spent to help the mining industry to find and develop more base metal deposits would be of little immediate value and, like industry, the Survey concentrated its attention on the finding and development of gold deposits, on the fuels, and on asbestos for which there was a continuing demand. Perhaps no better way can be found to express the nature of the Survey's work than to list the titles of some of the reports that appeared at this time: — in 1932, <u>Oil and Gas in Western Canada</u>, <u>Gold Occurrences of Canada</u>, <u>Studies of Geophysical Methods</u>, <u>Manganese Deposits of Canada</u>, <u>Rare-element Minerals of Canada</u>. Also the titles of papers appearing in the Summary Report for that year, Part A may be regarded as typical: <u>Placer and Vein Gold Deposits of Bakersville, Cariboo District, BC</u>, <u>Geology and Placer Deposits of Quesnel Forks Area, Cariboo District, BC</u>, <u>The Mining Industry of Yukon</u>, <u>Whitewater Gold Belt</u>, <u>Taku River District, BC</u>, <u>Zeballos River Area, Vancouver Island, BC</u> (noted for its extremely rich gold mines), <u>An Occurrence of Vanadium-</u>

bearing Rock on Quadra Island, BC, and Cadwallader Creek Gold Mining Area, Bridge River District, BC. To add more titles would simply labour the point for the emphasis on economic geology, particularly on gold, should be exceedingly clear.

We read in the last chapter what an effect the bush pilot was having on both the mining industry and the work of the Geological Survey. Gold mining was booming and companies whose holdings were all in base metal mines that were shut down, entered a frantic search for new gold deposits to take their place. With air transportation no likely spot need be overlooked and the earlier reports of the Survey were studied as never before. Again and again in the Departmental Annual Reports we find mention of the steadily increasing demand for all the Survey reports. Coupled with this was a demand for information on areas as yet little or not at all known. Thus there was an anomalous demand for two demetrecal[ly] (sic) opposed types of work. One was to fulfill the wishes of the operators working in an established camp who needed to find new ore shoots on the bodies being worked on or new ore bodies nearby, and who could best do this if they had the results of a detailed geological survey of a restricted area. The other was in compliance to the urgent demands of those searching for new camps in areas as yet unprospected (sic) and who needed geological maps and reports to direct them into the most likely areas. Since most of Canada was yet unmapped geologically the task confronting the Survey was formidable and, when its appropriations were drastically cut, impossible to fulfill. Nevertheless the Survey did what it could, and with the aid of the airplane made a start on the systematic mapping of the vast areas north of the thin belt of settlements along the southern border.

As heretofore the concentration was on 4-mile and 1-mile mapping, the former generally regarded as the smallest scale on which adequate detail could be shown for general purposes and the latter large enough for the portrayal of most detailed studies. Collins, however, departed from the earlier system in two particulars. He originated the compiling of a series of 8-mile maps in the west, the Calgary sheet, the Vancouver sheet, and so on. These were largely based on previous work but a good deal of field work was done for revisions and to fill in some blank areas. No attempt of course was made for complete coverage but the maps served a useful purpose for many years.

Under Collins, too, a number of 2-mile maps were prepared. Their purpose was to show more detail than was possible on the 4-mile maps but without the need for the fine detail of a 1-mile map that was so time consuming to get. The production of 2-mile maps continued intermittently for many years but rather fell between two stools and before long were used only for special purposes and no longer as part of a general mapping program.

Mineralogical Division

During the depression the field work of the officers of the Mineralogical Division virtually stopped. Demands for information were however reaching at (sic) higher and higher levels and during 1934 more than 4,000 specimens of rocks and minerals were reported on. In the same year 1,464 educational collections were assembled for distribution to the public.

All this and other routine work left little time for the small staff to devote to primary research. Nonetheless Ellsworth continued to devote every available moment to his two related studies: that of rare-element minerals, and the determination of the age of radioactive minerals.

At this time, too, an interesting enquiry came Poitevin's way. The Ontario Department of Health was greatly concerned about the high incidence of silicoses among the Ontario miners. It was obvious that it was caused by the rock dust being breathed but were some minerals more harmful than others? Samples of human lung tissue were accordingly sent to the Geological Survey to see if their mineral content could be determined and Poitevin, Chief of the Division undertook the investigation. The results were most interesting. It was easily possible to recognize both the mineral species contained in each lung and to make a reasonable estimate of their proportions. It was indeed possible to recognize in which of the mines or mining camps the victim had worked. Recognizing the differences in the mineral content of the lungs from each area it was necessary only to gather the statistics on the incidence of silicons (sic) from each district to obtain a pretty good idea which minerals were the culprits.

Poitevin tells an amusing story. Wishing for comparison to have a completely uncontaminated lung, he asked for and received the sample from the lung of a week old baby. On treating it by the usual procedure he found to his dismay that he was left with a very considerable mineral residue. The mystery was explained when examination revealed that the mineral was talc, evidently introduced as talcum powder. It would seem that the grosser hazards of air pollution follow us from the cradle to the grave.

In 1935 these studies were extended to the asbestos mines of the Eastern Townships, this time with the cooperation also of the Quebec Department of Health and the Banting Institute.

BC Office

The BC Office with W E Cockfield in charge continued to demonstrate its usefulness. In 1934, for instance a total of 6,224 visitors sought for information an all time high. In addition to the information given directly in this manner, a very large number of rock and mineral specimens were identified and a number of microscopic determinations made to aid mining companies to solve particular problems.

The Million Dollar Year

In 1935 occurred an event that left its mark on the Survey for some years. The depression was clearly receding and the mining industry back to its pre-depression level. There was still, however, considerable unemployment and students and young graduates in particular were having a hard time.

It was said earlier that the availability of air travel had put within reach vast new tracts and maps, particularly geological maps, were urgently needed for the efficient prosecution of prospecting and exploration. With the meager appropriation of the past few years and its diminished staff the Survey had been able to make no more than a token attempt to supply the demand. With both factors in mind the Survey with little warning found itself in 1935 with a million dollar appropriation and, if this be compared with the ? appropriation of the preceding year (I haven't this figure but you probably have), the problems of the administrative staff of the Survey can well be imagined.

In one jump the number of parties put in the field rose from 25 to 65, and men and equipment must be found. Every geologist considered at all capable of leading a field party was contacted and if available hired; every university was canvassed for students; the country was scoured for cooks, packers, and canoe men. No less a problem was the demand for equipment. Horses, canoes, cars, tents, stoves, hammers, and compasses and all the paraphernalia without which a geological party cannot work efficiently.

It must be very clear that one of the purposes of the appropriation, to give employment and to stimulate the economy, was accomplished. Cooks, packers and labourers who had been out of work got jobs, students who lacked the funds could now finish their education. Graduates could now hold out until there was a place for them. The Survey itself got s great boost, a chance to look at a lot of new men, some of whom continued on and became its leading figures, and a broader outlook. Desperate conditions require desperate measures and many a surgical experiment that was proved successful under the stress of battle would perhaps have never been tried in the clinical atmosphere of civilian life.

The geological objective was less uniformly achieved. Science will not be stampeded into revealing its secrets and rarely to any but to the best qualified. It was in the choosing of party leaders that the administration found their greatest difficulty. Canada simply did not possess that many geologists capable of doing sound field work. Moreover it was difficult even for an experienced field man to do a satisfactory job when all his assistants were completely untrained. (mine that year were a 3rd year mechanical engineering, 2 year commerce and 1st year arts, not one knew the difference between a granite and a diorite). Many were University Professors and some did excellent work, others with little field experience and perhaps with little interest in field geology were less successful. One deserves a measure of fame by organizing a cricket club in a small settlement in B.C.

By and large then the geological results of the effort fell far short of what might have been expected. Nonetheless it was considerable and, although some of the work had to be redone and much was pretty superficial, we now knew something about a lot of previously unknown country and the Survey had been given an impetus that it has never lost.

Geophysics

Like so many studies started as a single ad hoc investigation including in fact the Survey itself, the study of geophysics has never come to an end. The more that was discovered the more it was found remained to be investigated. It's worth was recognized very early in the study, but it was also found that none of the methods could be used in a purely mechanical way by assuming a certain response indicated the presence of ore. The instrument merely responded to certain physical conditions that could arise from a number of causes only one of which was a concentration of ore minerals. The task the Survey set itself was to learn how to interpret these responses in a useful manner and to assist in the development of more sensitive and more manageable instruments.

After the discouragement that followed the first wave of uninformed enthusiasm for geophysical prospecting, and in no small measure due to the Geological Survey who pointed out again and again its proper use and the manifold benefits that might so result, the interest of the mining industry was renewed. The Survey then, throughout much of the depression continued to test new or revised methods under different conditions in various parts of the country its limits being dictated by the slimness of its purse.

One event of no little importance was the publication of Memoir 165 "Studies in Geophysical Methods", which [included] the results of the 1928 and 1929 work of Gilchrist, Maudsley, Eve, Keys, Watson, Swarty, Miller, French, and Wilson. The public it is true had the main results of these investigations already in preliminary form, but nothing can really take the place of a carefully considered, complete account of a study even [if] it is not yet complete. In every investigation there is always a time to stop and take careful stock of the results so far.

In later years the brunt of the geophysical work fell on A H Miller of the Dominion Observatory who worked with C H Cooke at Thetford, with G W H Norman in Nova Scotia, and round Moncton in New Brunswick.

Reports

One never-ending bone of contention is the matter of reports. The public want the results the instant the field season is over, the geologist, as is every good scientist, is reluctant to commit himself on paper until he has carefully weighed his data and is sure that he has all the facts he can get under the circumstances. Only the man who does nothing is never wrong but it is inexcusable for a scientist to be in error through carelessness or by failing to consider a piece of information he already has or might get. In between the public and the geologist is the enormous task of preparation. The writing, the typing, the critical examination by his peers, the rewriting, the editing, the drafting, and finally all the steps of printing, proof reading and binding.

Again and again in the history of the Geological Survey has a change been made from one kind of report to another or a new type of report introduced. In all these changes, and sometimes they bewilder the bystander, there have only been two main objectives; to supply the public with the information as fast as possible, and to provide a vehicle suitable for the dissemination of scientific information, both practical and theoretical, in permanent form.

As these two objectives are not necessarily compatible, throughout much of the history of the Survey there have been two types of report, one designed to serve the first need, the other to serve the second. In 1930 the considered results of a major study was (sic) to appear in the Memoir Series, topical studies of specific ore minerals or similar studies on a national basis and specifically of immediate economic importance were to go in the Economic Geology series, and final reports compassing a smaller subject and primarily of scientific interest came out as a Museum Bulletin.

For immediate release of information in preliminary form there were the annual Summary Reports. By 1933 however it was realized that these were failing to fulfill their primary purpose and primarily for the same reason as the old Annual Reports failed. In any report embodying a number of reports by many authors, each stage of preparing the report for printing is delayed until the last man has completed his assignment. During the depression when money for publication was scarce there was no knowing when a Memoir would appear and some of the men prepared elaborate preliminary reports with many maps and figures. Summary Report for 1932, Part AI, a report of 151 pages, comprises two papers only each on gold deposits. Reports of this length are scarcely preliminary papers in the accepted sense and cannot be processed very speedily. It was therefore clearly unrealistic for a paper of a few pages, containing information warranting immediate release, to have to wait while long, involved reports were being prepared.

One of the first actions of the new Bureau of Economic Geology therefore was to discontinue publication of the Summary reports in 1934 and substitute a series of mimeographed reports and small editions of blue printed black and white geological maps, some to accompany a mimeographed report and some to be issued separately merely with marginal notes. By 1935 the need for some numbering system for reference purposes was recognized and the Preliminary Series Papers and Maps came into being. They had two great advantages; their unpretentious appearance made it absolutely clear that these were in fact preliminary reports, forestalling any tendency for the geologist to expand his manuscript into a semi-final publication, and every step of processing including final distribution was done within the Survey by its own staff, and under its complete control.

The system worked well until, as will be seen in a later chapter, history began to repeat itself.

One other series of publications had its inception in 1935, the Water Supply Papers. As the Survey's new Pleistocene Geology, Water Supply, and Borings Division expanded their efforts to include specific groundwater studies a vehicle was needed for the dissemination of their information. The people this was to serve were totally different from the ordinary users of the Survey reports, being farmers, well drillers, and the like, and it did not seem suitable to bury this information in the general run of Survey publications. The series of Water Supply Papers was designed specifically for this purpose and performed it successfully for 25 years, when changing conditions made a new type of report necessary.

Cordillera

With the appointment of W E Cockfield to take charge of the BC office it was apparent that he could not continue his systematic field work in the Yukon. H S Bostock was therefore transferred there from southern BC and remained in charge of work in the Yukon until his retirement in 1965.

In BC systematic work was continued as far as the Survey's diminished budget would permit but concentrated in areas where the work might bring results that would be of speedy economic benefit. G Hanson finished up his work round the Portland Canal and Alice Arm mining camps, which produced mainly silver-lead-zinc and copper, in 1932 and started work in the Cariboo gold camp. C E Cairnes likewise finished up his work near the Boundary in 1932. The year of 1933 was a year of extreme xxx and Cairnes spent it as assistant to Alcock in New Brunswick. After that he started work in the Bridge River mining camp, again a famous gold producer. J.F. Walker continued his work in southeastern BC, but like the others concentrating of Salmo and Bridge River until he resigned in 1934 to become British Columbia's Provincial Mineralogist and later Deputy Minister of Mines.

FA Kerr finished up his studies in the mountains along the Alaska boundary and began investigating the many mineral deposits along the Prince Rupert line of the CNR, a task that was assumed by E D Kindle in 1935.

Northern Vancouver Island was known to have small, but very rich gold deposits and H C Gunning was sent to investigate these until he was moved to the Quebec gold belt in 1933.

Interior Plains

Despite the depression there was always a need for fuels and, particularly on the Prairies, for water. B R MacKay therefore continued his study of the coal fields in the Foothills of southern Alberta and adjacent parts of BC until 1934. R T D Wickenden in the mean time had been studying the surficial geology farther east near Regina, particularly with respect to groundwater resources. In 1933, the year of the Survey's greatest xxxx, he was taken off this work but returned to it in 1934 and in the great burst of activity in 1935 was joined by MacKay and the two took over the supervision of a great many small parties that spread over the country securing data on the amount of water that was being obtained from wells, of what quality, and from how deep. For the next while the two were busy extracting the meat from the mass of data secured and presenting it in a series of Water Supply Papers.

Throughout this period G S Hume too was busy studying the oil fields all along the foothills and deserves no small share of the credit for keeping the oil industry going.

Collin's new policy of compiling 8-mile maps was very suited to the vast stretches of the Prairies, where the geology was rather simple but exposures very scarce and two sheets were completed during this time, one by L S Russel and one by F H McLean. The latter finished his work in 1931 and, as from then a little money was available for field work, McLaren was able to devote much of the next three years to his studies of Mesozoic palaeontology (sic) which he had been prevented from carrying on by Collins (sic) insistence that everyone should be out in the field doing standard mapping.

Canadian Shield

As might be expected, work in the shield was largely confined to the better known areas where mining was already in progress. Tanton continued his studies round the Lake Hood, Collins round Sudbury, J F Wright and later also Stockwell in Manitoba and Saskatchewan. M E Wilson spent all his time studying in detail the important mining camp that included Noranda mine in Quebec and L. J. Weeks began in 1933 the series of detailed studies along the Quebec gold belt that was going to be the concern of men like H. C. Gunning, J.W. Ambrose, G.W.H Norman and others for some years to come.

There were, however, two important developments in the far north that demanded attention from the Geological Survey. Probably the most significant was the discovery that the silver ores of Great Bear Lake contained important amounts of radium. Although the atomic age was still in the future there was already a considerable and growing demand for radioactive material and almost the only source of supply was in the Belgian Congo. A North American source was an important asset. D F Kidd was therefore dispatched to that remote region in 1931 and 1932 to discover the geology of the region particularly of the pitchblende deposits.

Not so very far south, in the Yellowknife area of Great Slave Lake important gold deposits were being developed. This area was studied by C H Stockwell from 1929 to 1931, and was carried as far as time and circumstances would permit. However to the north of Yellowknife lay a vast, geologically unexplored region containing who knew how many more Yellowknifes. In 1932 Stockwell conducted probably the last of the old route explorations, and, as he made use of some airplane support, really marks the transition between the old and the new. Starting from the mouth of Yellowknife River the party travelled by canoe with plenty of portaging up that river to White Lake, a distance of some 150 miles, thus following in part the route pioneered so many years before by Sir John Franklin. There the Royal Canadian Air Force had cached a supply of provisions for them and, thus restocked, they proceeded to the head of Yellowknife River, across the height of land to Coppermine River, and down it to Point Lake, another 75 miles or more. After exploring in that region for a while and being provisioned once more by the RCAF, they travelled up the Coppermine to its head, across the height of land to the Barnton

River and down it to the east arm of Great Slave Lake, a distance of more than 275 miles. There still remained the trip back by canoe along Great Slave Lake. An epoch making trip.

However this was a long cry from the days of Selwyn, Lowe, and Tyrrell. Gone is the rather dramatic narrative style of the earlier reports. Instead, this is the account of a scientist concerned only with reporting his findings to the people directly concerned. It is dry reading for the general public, but it was not written for the general public, and is full of rich meat for those who are most concerned with developing Canada's mineral resources. Thus the use of the aeroplane, and even more the attitude of the men in charge, marks a pivotal point round which the whole program of the Geological Survey was revolving. There is, of course, neither a clear cut time nor a clear cut event to mark this change, but Stockwell's trip which was in a way almost an anachronism, illuminates the major issues, and things were never again quite the same.

St Lawrence Lowlands and Maritimes

Meanwhile some work continued in the older parts of Canada, all strictly of an economic nature. C S Evans in 1934 and 1935 continued the study M.Y Williams has started, indeed one might almost say that Murray had started, of the oil and gas fields of southern Ontario. The production from these was now overshadowed by that from the western fields, but it was steady and in the heart of industrial Canada. H C Cooke continued his investigation of the asbestos deposits of the Eastern Townships and W.A. Bell of the coal fields of Sydney, Nova Scotia, both of paramount importance to the economy of the nation.

Nor can it be left unmentioned that in 1932 E.R. Faribault retired, thus bringing to a close retired, thus bringing to a close a significant chapter in the history of Nova Scotian geology. In 1929, also, Wyatt Malcolm, who the reader will recall was Chief of the Geological Information and Distribution Division, brought out a second Memoir on "The Gold Fields of Nova Scotia". This was based almost entirely on Faribault's work. It must be noted that in all his years of work Faribault never succeeded in preparing a satisfactory major publication; Malcolm had to ghost write them for him. The reader will recall that Selwyn at the time of the Select Committee was bitterly attacked for delaying publication of Faribault's reports. Surely it is a strong point in Selwyn's defence that none of the succeeding six directors under whom Faribault served, including Bell himself who was Selwyn's most bitter accuser, was able to get Faribault to submit an acceptable manuscript.

HMA RICE

HISTORY OF THE GSC 1936-1945

GENERAL

At the close of the last section the changes that befell the department in the reorganization of 1936 were mentioned briefly. In December of that year the old Department of Mines gave place to the Department of Mines and Resources, which brought together a rather uneasy alliance of five somewhat incongruous branches: Lands, Parks, and Forests; Surveys and Engineering; Indian Affairs; Immigration; and, of primary concern to us, Mines and Geology. Charles Camsell continued as Deputy Minister and John McLeish became first director of the Mines and Geology Branch. This branch consisted of four units: the Bureau of Mines, the Dominion Fuel Board, the National Museum, and the Bureau of Geology and Topography, which was the old Geological Survey of Canada changed only in name. Fortunately, being thus relegated to the part of a small unit in a large and rather unwieldy department in no way adversely affected the amount or the quality of the work the Survey continued to do. F.C.C. Lynch was the Chief of the new bureau while G.A. Young, still as Chief Geologist, continued the technical direction of the Survey.

During the period under review only two changes in the administrative staff need mention. In 1941 McLeish retired and was succeeded by W.B. Timm as branch director. In 1943 Young retired and the post of Chief Geologist was assumed by George Hanson.

Young, "G.A." as he was widely known, cannot be allowed to slip out of the picture without some comment. It was his fate never to become director officially, but he was director of the Survey for many years in all but name, and had perhaps as much effect on its progress as any who held the title.

The circumstances during which he held office must be understood if we are to appreciate the nature and work of this man. The director, Collins, in whose time Young was appointed Chief Geologist, was a man who administratively could not see beyond the details that overwhelmed him. This soon led to dissatisfaction among the more brilliant of his staff, and when he became seriously ill of the kidney ailment that was eventually to prove fatal, it was clear that he must have help. It was then that the position of Chief Geologist was created and Young appointed to fill it. This was fine as far as it went, but many administrative details that Collins either could not or would not do but which were clearly out of the sphere of the Chief Geologist, remained undone. It was then that the Government moved with a sensitivity for which they are rarely given credit. Instead of simply removing Collins as director and appointing a more suitable successor, they rearranged the whole administrative structure. Collins remained as director but most of his administrative duties were assumed by Lynch, as Chief of the Bureau of

Economic Geology. Between them Lynch and Young looked after the political and technical administration of the Survey and Collins was effectively by-passed. Thus, when he died, the position of director disappeared and Young remained Chief Geologist.

Young was a man with some bitter enemies and many ardent admirers – his character was so forceful that you must be one or the other. Two factors dominated his public life: an uncompromising sense of integrity and an intolerance of anyone who gave less than his best. Most of us, alas, have feet of clay and thus incurred his displeasure at sometime (sic) or another, but he was not unreasonable and only after he was firmly convinced that a person was falling down on the job did he receive the full weight of his ire. Unfortunately, once incurred, nothing could change Young's opinion, and several men, realizing this, left the Survey feeling their position to be hopeless.

On the other hand an officer of the Survey, good, bad or indifferent, had Young's full support against the outside world. I recall being in his office once when Lynch phoned to ask if so-and-so, whom he had just seen leaving the front door, had permission to leave the building. The answer in no moderate voice: "Mr Lynch, anytime any geologist leaves the building he has permission", and the crash of the descending receiver could be heard across the street.

Thus Young's faults were: a marked intolerance of what he regarded as less than a maximum effort; and that he, like Selwyn was unable to accept a compromise, so that every issue was a major issue to be defended to the last ditch: and his strength, a conviction that the work of the Survey was of vital importance. It was this that maintained the standard of G.S.C. work when all other influences, Lynch's in particular, were to give the influential powers whatever they asked for, right or wrong, an easy course to pursue.

Young was a man of the highest integrity and a careful worker, but he lacked the scientific vision of Selwyn. Both were dedicated fighters with much in common, but Selwyn tried to win by a process of immovable obstruction whereas Young's method was to blast down opposition. Because he fought equally hard for everything, Young built up an automatic opposition to his every proposal. As a result he was regarded an uncooperative and his opponents conceded to his wished on minor points from shear fatigue but were stubborn on the major issues. This was exactly opposite to Hanlon's policy, when he succeeded him. Hanson gave in gracefully on points he regarded as unimportant, thus building up a reputation for reasonableness and good will, reserving his big guns for major issues, against opponents already partially disarmed.

The year 1942 was the 100th anniversary of the founding of the Geological Survey of Canada and various plans were laid to celebrate this event suitably. However the war was at its height and regular transportation uncertain for civilians. One by one the plans fell through and finally the whole matter had to be shelved until a more suitable time.

POLICY

When this period (1936-45) opened Canada was just recovering from one of the worst depressions in history. Except for a few special minerals like gold, oil and asbestos, most mines had closed down or operated at a very reduced rate. The lack of demand for metals was reflected in prices so low that only in the most favourable circumstances was mining economically possible, and then only by mining out the richest parts of ore bodies already developed. By 1936 industry was recovering and the increased demand for metals and a consequent rise in prices stimulated a parallel recovery in the mining industry. At first this was largely confined to stepping up production in the working mines and reopening those shut down when operation became economically impossible, but active development and exploration had to be initiated to replace the reserves exhausted during the earlier, essentially salvage, operations.

When World War II broke out in 1939 recovery had proceeded to the point where the mineral industry itself had so recovered that the value of its product was nearing half a billion dollars, far ahead of even the years before the depression. This was fortunate, for the effect of World War II on the mineral industry proved to be unlike that of World War I. This was to be a war of materials, products of industry, where the role of the soldier was as much to operate the tools of war as to combat the enemy directly. Industry must make these tools, but the mines must supply much of the raw materials. It was now necessary to step up production drastically, but at a time when labour was scarce and time at a premium. There was no opportunity for exploration to discover new mining areas, and indeed little enough to find and develop new ore shoots in districts already producing to replace those rapidly being extracted. As Timm said in his resumé of the contribution of the mineral industry to the war effort: "The urgent need for production, combined with labour shortage and other wartime factors made it necessary for the industry to largely forego the orderly maintenance of underground development work." (An Rept 1945-46, p. 10). This policy served to meet the emergency but later in this chapter its effect on the mineral industry itself and the work of the Geological Survey will be discussed.

During the 1914-1918 war Canada's mineral industry was essentially a producer of raw materials, but by 1939 much of the product of the mines was being processed in Canada and thus industry was dependent on Canadian mining as never before. Moreover, Canada's position, far from the actual scene of the conflict, made it possible to supply many of the tools of war to her allies whose factories were under bombardment and whose sources of raw materials were at the end of hazardous supply lines or completely cut off. It was clear therefore that the Canadian mineral industry must play a vital role, both in the welfare of Canada and in the entire Allied cause.

GEOLOGICAL SURVEY POLICY

There was scarcely a period in its history throughout the whole of which the Geological Survey was so closely geared to immediate national needs as the one we are considering. All directors to a greater or lesser degree had the needs of the mineral industry in view and always at least part of the program was always directed towards its immediate assistance. It was a rare time however that a substantial part of the Survey's effort could not be devoted to a long range program for the ultimate benefit of the industry rather than to be of immediate service. True, the direction of this long range effort varied according to each director's understanding of the problems, but the principle was essentially the same.

This period however started with the national economy recovering from the depression. The mining industry, in company with industry in general, was struggling to get back to normal, no easy task. Not only were metal prices recovering only slowly, but many mines had been closed down and the cost of reopening them must be faced before any return could be expected. Even more serious were the results of gutting the mines during the depression when profitable operation was only possible at the expense of confining the mining to known and developed, and the richest ore bodies, and forgoing concurrent development and exploration to replace the blocked out ore as it was extracted. Most mines therefore faced a lean period during which known or suspected ore bodies must be readied for mining and, even more urgent, new ore bodies must be found.

It was clearly the duty of the Geological Survey to go immediately to the aid of the mineral industry, and not until it was once more on its feet could it justify starting on projects the results of which, no matter how important, would not be useful for many years. Nobly the Survey responded. Field work was concentrated in areas containing known deposits or where their presence was most likely.

By 1939 the mineral industry had fully recovered and the Survey could at least entertain thoughts of a long range program. And then the war broke out, and never before in Canadian history were the products of the mines so urgently needed.

When the war started the mineral industry was flourishing and there seemed no doubt that it could successfully meet and demands that industry and our Allies made upon it. It was not long, however, before this picture changed radically. The need for an all out war effort made demands on industry never envisaged, and industry in turn depended on the mines for unheard of quantities of metals and mineral products. Mines stepped up their output, and stepped it up again. Soon lack of labour, materials, and most of all time, took its toll and orderly development and exploration once more fell behind. Once again, but for a totally different reason, the discovery and development of new ore fell behind the ore extracted, and the Geological Survey resumed its role of helping directly in the discovery of new ore deposits that could be speedily brought into production.

Moreover, a new factor was added. Besides the standard products of Canadian mines: gold, silver, copper, lead, zinc, nickel, asbestos, oil, gas, and the like, industry was suddenly in need of a domestic supply of such minerals and metals as tin, antimony, mercury, tungsten, chromite, manganese, fluorspar, mica, graphite, talc, quartz crystals, and a host of similar things that the Canadian Mining industry had never considered seriously. Not many Canadian Mining men knew where to look for them or quite what to do if they found them.

Fortunately the staff of the Geological Survey comprised a body of men who were experts on the nature and occurrence of any of these so-called strategic minerals and within the pages of its reports were recorded the position and nature of many occurrences of them. Practically for the first time in its history geologists were assigned the task of searching themselves for actual mineral deposits. One (myself) spent two seasons looking for antimony, mercury, tin, tungsten, and chromite in the Cordillera and at the same time supervising the exploratory diamond drilling of a base metal deposit in Banff National Park. Another searched the vast swarms of pegmatite dykes north of Yellowknife for tungsten and certain badly needed rare-element minerals. Two others combed eastern Canada for chromite, and one supervised the exploratory drilling of the New Brunswick oil shales. Similar work was undertaken by other geologists and all field men were warned to keep an especially wary eye open for possible deposits of strategic minerals.

Throughout all this time regular field mapping was continued, mainly on scales of 1 inch to 1 mile and 1 inch to 4 miles. This was essentially part of the regular work of the Survey, and the only concession to events was to confine the work to areas most likely to contain mineral deposits close enough to transportation for speedy development. Systematic geological studies of more remote parts of Canada and scientific investigations were necessarily deferred, although few any longer were prepared to dispute the importance of this type of work. For many decades now it was clear to any thinking man that the immediate benefits of the mineral industry to Canada in times of emergency was in no small way dependent on the help it could get from geologists, both its own and those of the Federal and Provincial Surveys. It was equally clear that these would do little speedily unless the basic geological information, both practical and theoretical, was readily available. The long range programs of Selwyn, Dawson, Low, and Brock, considered at the time by many to be ' ivory tower diversions of impractical scientists' were realized to be the essential foundation for future programs. In this time of crisis, however, long range plans must be temporarily set aside.

By the end of 1943 the tide of battle was definitely taking a favourable turn and the strategic mineral situation was no longer critical. As it seemed fairly certain that newly discovered ore deposits could not now be brought into production in time to affect the armed conflict, this aspect of the Survey's work could be discontinued and its overall policy be reassessed.

With the end of the war in sight much consideration was being given by the Government to the return of thousands of demobilized service men. As speedily as possible civil employment must be found for these men, and not all could be absorbed by the normal civilian requirements, at least not fast enough.

Since the start of the war a great change had come to northern Canada. Parts of this remote region had dramatically become accessible by the building of the Alaska Highway, the Canol Road, and the construction of airfields. Moreover, the very need to build and maintain these as well as certain military bases and the exploitation of the Norman Wells oil field had resulted in a degree of development far beyond normal expectations. It was natural for those planning rehabilitation to consider the possibilities of this part of Canada, now that access has unexpectedly become so much easier.

The first step naturally was to inventory, at least roughly, it's possible natural resources and in this the Geological Survey was to play a major role. First, topographic maps were essential and the Survey's topographers set to work on this task. Both they and the geologists who followed or worked concurrently used the Alaska Highway as a base and soon Survey trucks were rolling up and down the road and Survey camps were pitched along it. By the end of the war reconnaissance geological maps were available for a strip ten miles or more wide along the Alaska Highway from near peace River in British Columbia to far into the Yukon, along such main waterways as the Liard River, and along much of the Canol road across the heart of the Yukon.

Not until 1945 was the Survey finally operating once more on a normal peace time basis, almost for the first time in nearly three decades. This long period of facing one emergency after another with little time to draw breath left its mark. The constant need to establish a short range, immediately useful program had gradually become an entrenched policy, so that a return to longer-ranged plans and particularly to studies of a basic scientific nature was slow to come. Many of the Survey men, particularly its Chief Geologist George Hanson, clearly recognized the need, but the higher authorities had to be re-educated to the idea. As a result, well beyond the end of this period, the emphasis was on standard geological mapping on 1-mile and 4-mile scales, except for the reconnaissance mapping referred to above.

The Survey palaeontologists were kept busy making preliminary reports on fossils collected by the regular field men but had little opportunity or time to collect themselves or to make the basic studies that must be done before any refinement in the age determinations of fossil collections was possible. At that time the higher authorities could see no advantage in a more refined dating, but it was soon to be shown that the precise determination of stratigraphy and structure upon which the successful development of the oil industry in large measure depends required just this very thing.

It is perhaps unfair to say that this was entirely ignored, for in 1942 and '43 F.H. McLearn was permitted to return to his studies, started before the war, of the Triassic section so well displayed in the Peace River Canyon. Thus was completed the field work for a project that has since been recognized all over the world as a scientific contribution of outstanding importance and to oil geologist as of immense practical value.

Officers of the Mineralogical Section were even less fortunate. Ellsworth, whose scientific capacity had been so amply demonstrated in his study of radio active (sic) minerals and his pioneer work in isotopic age determinations, was forced to waste his abilities identifying rock and mineral specimens submitted by the curious but often ill-informed public. This fate, alas, was to pursue him to the end and he was to die not long after, a bitter and frustrated man (and my very good friend). (He bought several of my pictures and had a remarkable cactus garden).

The Borings Section was, however, extremely busy. Never before had the search for oil been so intense with the result that more and more wells were being drilled. Samples from this drilling in ever-increasing numbers flooded the Survey and the facilities of the Borings section to process, catalogue, and store these was (sic) taxed to the utmost. Because it did not fail, an immense amount of information that might so easily had been lost is still available.

NATIONAL AIR PHOTO LIBRARY

The advent of the airplane in Canada meant more than rapid and easy transportation into remote areas for both men and equipment, important though that was. During the war the science of taking and interpreting aerial photographs made great strides, photogrammetry was born. This, in part, is the science of producing accurate topographic maps by the use of air photographs with a limited amount of ground control; it revolutionized topographic mapping. Moreover the geologist, too, soon found a direct use for air photos. Not only could he often locate himself in the field more precisely by using them than with a map alone, but he could sometimes trace belts of distinctive rocks in detail across his area with only a few ground traverses to study the rocks directly in critical areas. By no means the least useful feature of air photos is to enable a geologist to form in advance an idea of the kinds of rocks he might encounter, the structures developed in them, and where to concentrate ground effort to obtain the maximum information in the shortest time.

By the end of the war there was already a considerable accumulation of air photos and a new organization, the National Air Photo Library, had been set up, administered by the Geological Survey, to maintain and catalogue a complete set. By this means prints of air photos of any area for which they were available could quickly be obtained.

GEOGRAPHIC BOARD OF CANADA

By one means or another more and more of Canada was being mapped and the problem of naming the geographic features was becoming critical. Thus far it had been the responsibility of the map maker to name features, using as far as possible names already in use. However, the multiplicity of Fish Lakes, Bear Creeks, Bald Mountains and the like was compounding confusion. To effect some control the Geographic Board of Canada was created in 1937, the first chairman being W.H. Boyd, Chief Topographer for the Geological Survey. Other board members were F.C.C. Lynch and G.A. Young, also of the Geological Survey, and representatives from the provinces. The board was to rule on all geographical names and has been performing this useful function ever since.

PUBLICATIONS

From the earliest time it has been recognized that the public image of the Geological Survey was largely based on its publications, and primarily on three factors: quantity, quality, and speed of publication.

The reader will recall that Selwyn was called into account on the first and the third counts. Again and again the Select Committee of 1884 flung in his face the meagre size of the Annual Report for 1882-3-4, as well as the delay in printing this and other reports, notably Faribault's. Quantity is hard to regulate but actually is largely self-determining. A scientist, by and large, is known by his writings and, while it is hard to persuade him to publish his accounts early before he feels that his ideas are fully mature, most good scientists will publish their findings sooner or later. We are left then with the problem of quality versus time and this has always been the hardest to resolve. Logan complained that he had to rewrite all Richardson's reports; Selwyn said that many were impossible to publish as submitted, indeed, as was pointed out earlier, Faribault never succeeded in producing a satisfactory major report as long as he lived – Malcolm had to write them for him. Always it fell to the director to be responsible for the quality of the Survey reports, and thereby the reputation of the Survey itself.

In the period we are considering the responsibility for this fell on Young, who was director in all but name. The Survey's activities were by now far broader than heretofore, and Young was overwhelmed by many pressing requirements. The need for close scrutiny and technical editing of all manuscripts was the last straw, especially for a man as conscientious as Young, who would never let second best do. Manuscripts began to pile up on his desk and their authors to complain about the delay.

It was at this time (1937) that C.E. Cairnes suffered a heart attack which precluded him from further field work. Cairnes, an indefatigable worker, found himself confined to the office, and soon Young was persuaded to turn over to him some of his critical editorial work. The uniformly high standard of the reports processed by Cairnes soon resulted in his assuming charge of the critical review and scientific editing of all reports and he became the Survey's first Chief Scientific Editor, although the name was not officially approved until 1965.

The nature of the reports published during this period naturally reflected the nature of the work being done. Almost all were descriptions of the geology of specific areas accompanied by a 1-mile or 4-mile geological map. During the war, of course, when so many geologists were examining occurrences of strategic minerals the results were embodied in office reports, primarily for the metals Controller, who together with the Oil Controller, was charged with assessing the actual and potential supply of metal and mineral products and assigning priorities in minerals for the operations and for the destination of their products.

By 1944 the need for a single-minded concentration on immediate mineral production was over and more attention could be paid to matters of scientific interest. Not yet were project undertaken solely to gain scientific information, but some time could be spared to investigate problems that arose during the course of normal field and office work. It was soon apparent that a new publication series, rather after the style of the old Museum Bulletins, was needed to release the results of these limited studies. By 1944 therefore the Geological Survey Bulletin were (sic) started and have steadily grown in number and importance ever since.

WORK OF THE GEOLOGICAL SURVEY

(Note. There is a good account of the G.S.C. contribution to the war effort in the Annual Report 1945-46, pp. 17, 18. Perhaps a quotation from this might replace some of my earlier rambling remarks.)

Cordillera. Only Bostock worked in the Yukon, except for the surge of route reconnaissances at the end of the period. From 1936 to 1941 he carried on standard 4-mile geological mapping, but in 1942 and '43 he was involved in the search for and evaluation of occurrences of strategic minerals.

Throughout the period the B.C. office was maintained under the supervision of W.E. Cockfield and was of ever increasing value to the mining public.

Under the circumstances, naturally, no work was done in the remote parts of north and central British Columbia, but J.E. Armstrong throughout the period and A.H. Lang, E.D. Kindle, and J.G. Gray before the war or in its early stages and C.S. Lord near the end did 4-mile geologing (sic) mapping along the Prince Rupert line of the C.N.R. Similarly H.M.A. Rice did 4-mile mapping in southern B.C. except for three seasons spent on special investigations relevant to the war effort. In southern B.C., too, worked C.E. Cairnes until stopped by a heart attack, and S.H. Crickmay and W.E. Snow before the war.

(I doubt if names are really relevant here unless they are of some special significance, indeed I rather doubt if most of this section is needed at all, except for Shaw's Eastmain reconnaissance.)

Mining camps, like old soldiers, never die. It is interesting that once again an officer of the Survey. A.F. Buckham, spent a total of 4 years of the period in a detailed study of the Vancouver Island coal fields, steadily active since Richardson worked there when the Survey was still in its youth.

Canadian Shield. In the northern Shield before the war much of the work consisted of 4-mile and 1-mile geological mapping, mostly in areas already known to be economically important. During the war this work was considerably curtailed and several of the geologists were diverted to investigations of various strategic minerals. Tanton continued his studies of the iron deposits along the north shore of Lake Superior, Gunning, Cooke, Norman, and others made detailed studies along the Quebec Gold Belt, and from time to time in various parts of the southern Shield investigations promising immediate benefit to the war effort were carried out.

One project, however, deserves special mention. Early reconnaissance had shown that a belt of Archaean greenstone and metamorphic rocks extended eastward from near James Bay along Eastmain River. Elsewhere it is in these rocks that many of the important mineral deposits of the Canadian Shield occur, but of this belt virtually nothing was known. In 1941 George Shaw took charge of an experimental new type of reconnaissance. By now air transportation was an established method in the Geological Survey of moving camp or even single traversing units from one place to another and air photos, particularly where vegetation was sparse, were much used for tracing rock formations. Shaw's party, however, used the airplane not merely for these purposes but as a platform for actual observation. Flying at a low altitude the geologist attempted to trace out the formations from the air, landing from time to time to confirm his interpretation of the rock types, to collect specimens for later study, and to take measurements possible only from on the outcrop. This was supplemented by traverses of the conventional type in places of particular interest or where air observations had failed to provide sufficient information. The success of the venture was striking; 30,000 square miles of virtually unknown country was mapped geologically on a scale of 1 inch to 8 miles in a single season. This was strictly reconnaissance mapping but now it was possible to say that none of the area showed much promise under the present circumstances, this saving many seasons of regular work that would have discovered little more. The use of fixed wing aircraft for such a purpose was of course only possible in suitable terrain, and was of rather limited applicability, but it was the forerunner of the helicopter operations that were to be such a major part of the Survey's program in the decades to follow.

The names of two men received their first mention in the Departmental Annual report for 1943-44, both of whom were to become directors of the Survey in the years ahead. In 1943 J.M. Harrison started 1-mile geological mapping in Manitoba under the supervision of J.D. Bateman and Y.O. Fortier began the 1-mile mapping of the Ross Lake area, N.W.T. supervised by A.W. Jolliffe.

EASTERN CANADA

Work in the older parts of Canada continued, but was primarily confined to geological mapping of mineral areas and the solution of problems of direct economic concern.

HMA RICE

PERIOD 1946 – 1959

At the start of this period, Canadian economy had recovered from the effect of the war but the mining industry was still having some troubles. “The past year had been both a challenging and difficult one for the industries dependent, either in whole or in part, on the mineral…, and other natural resources of the Dominion. To the difficulties of post-war readjustment was added the disturbing effect of work stoppages with a consequent loss in production of much needed materials” (A.R. 46, 47; p.1). “Were it not for shortages of labour and the difficulty of obtaining supplies and equipment production would have been much higher, for seldom in the history of the industry, was there a greater demand for the products of the mines.” (A.R. 46-47; p. 10)

Fortunately these difficulties were partly overcome and by 1951 mineral products were 27% of Canada’s export trade (there were also new records in domestic consumption), which by 1953 was up to 30%.

This up surge continued and the Government department (of which the GSC was an important part) was required to meet the challenge.

General Development and Policy

In 1946, despite the efforts of Young and Hanson, from their position as Chief Geologist, had not made much progress in convincing the senior administration that the needs of the mineral industry could best be served by devoting most of the Survey’s efforts to basic or near basic research. Industry by now employed a huge number of well-qualified geologists who were more than able to map the geology of their holdings and work out in detail the controlling structures. But to do this they had to know the general geological framework of the whole region and this was clearly a government responsibility. Moreover, and perhaps of even greater importance, it was rarely that a commercial geologist was able to work on the basic principles of geology on which any real advance in our knowledge of ore deposition hinges. At this time, therefore, all attempts at basic research had to be veiled behind a cloak of respectability. That is it must be excused because “this is an area in which copper deposits are likely to occur”, or something of this nature.

Relief was however in sight. In 1946 Lynch retired and G.S. Hume, a good geologist, became Chief of the Bureau of Geology and Top[ography] at first and later of the GSC. He was followed in 1950 by W.A. Bell, who was at heart a dedicated palaeobotanist (sic) and who abdicated the post in 1953 to return to his scientific work. The position of director was then assumed by George Hanson, who, one must believe, had supplied all along the motivation towards research. Alas, Hanson’s tenure of office was too short for him to see the full fruition of his years of quiet planning and gentle persuasion, indirectly as Chief Geologist and more directly, when he became Director. Hanson's contribution indeed went far to paving the way for the tremendous surge in research that was to ensue, led by Hanson's young and vigorous successor J.M. Harrison.

Perhaps the most important factor in the change of attitude that, for the first time, lent an aura of glamour to the word "research" was the unmistakable contribution made by science to winning the war; starting with radar and culminating in the atom bomb. Almost overnight scientists became respectable and not necessarily "mad". The year 1957 brought out two facts concerning the Department's work: "first, that fundamental research must play a more dominant role in the development of the Canadian mineral economy if Canada is to maintain its present position as a leading source of the products of the mines; and secondly, that the fast moving pace of development both on this continent and in outer space have placed new importance and new value on that part of its work not so directly related to mining — " (An Rept 1957, p.1).

One of the first steps was a reorganization of the Department of Mines and Resources in1947 by which "all the basic research activities and all the survey and mapping responsibilities of the Department" (An Rept 1948, p.7) were brought together as the Mines, Forests, and Scientific Services Branch, the Geological Survey being one of the Bureau (sic). This was an improvement but clearly not enough. On Jan 20, 1950 the cumbersome Dept. of Mines and Resources was split into three, one being the Dept. of Mines and Technical Surveys. This was "an integrated organization whose primary function is to provide technological assistance in the development of Canada's mineral resources through studies, investigations, and research in the fields of geology, mineral dressing, and metallurgy, and…surveys (An Rept 1950, p. 7). The mining industry would thus have a Minister "who would devote his full attention to the fields of mines and mining." (idem)

In the Department the GSC once more gained the stature of a Branch (one of five) charged with the following responsibilities, which clearly show the change from the days when it was regarded as an exploring, mapping, and ore-finding organization. Its functions now "comprise: Geological studies in the field and office to promote the discovery and development of mineral resources and underground water resources; to contribute geological information as an aid in the construction of such public works as dams, bridges, tunnels, foundations, etc.; to make mineralogical and palaeontological (sic) studies in the field and office that assist in promoting the study and development of mineral resources; to collect minerals and materials for study, exhibition, and distribution; to make geophysical surveys; and generally to add to the knowledge of the geology of Canada…" (An Rept 1950, pp. 7-8).

It will be noticed that, almost for the first time, the functions of the Survey included "office work" in various specialties. Much of this "office work" was in fact done in laboratories for many scientific advances made for war purposes, particularly in the fields of physics and chemistry, were found to have applications to geology. Much research was still necessary to adapt the new discoveries to problems peculiar to geology and much scheming to devise methods of making their utilization practical. All this work demanded lab facilities and lab facilities at the Victoria Memorial Museum were almost non-existent. A modern building with modern facilities was clearly necessary to house the Geological Survey and plans for such a building were completed by 1955 and the building itself ready by 1959.

The impetus for the Survey to go ahead had, however, been given and must not be allowed to die from lack of nourishment. Labs filled with the most modern equipment began to appear in the antiquated tiled rooms in the basement of the old Museum. Conditions were scarcily favourable but the flame was kept alive and more than one delicate instrument outgrew its teething pains in this inhospitable environment. As a result a much sounder piece of equipment found itself in 1959 in the more modern labs of the new building at 601 Booth Street.

Some of the special pieces of research will be detailed later and it is unavoidable that the more exotic studies like palaeomagnetism (sic) or palynology should catch the eye but let us not forget that the charge for the Survey is the geology of Canada and geo-logy is the study of the earth. It is fine to bring pieces of the earth's crust back to the lab for study but the application must be made out in the field where the rocks are. The principal work of the Survey must therefore be in the field, exactly as a doctor's ultimate diagnosis is made from the patient's body. Science Fiction suggests we may get beyond this and perhaps this may [be] true of geologists too – but not yet.

The first task facing the Survey was to complete its original assignment; to make a geological survey of Canada. By 1948 only 27% of Canada's land surface had been geologically mapped at all and by then new methods and new ideas had made much of the early work already obsolete. In that year a plan was approved to increase the staff to the point where 100 parties could be sent in the field. At the time this seemed to be a completely unrealistic goal for there were not that many properly qualified geologists available in all Canada, and the new products of the Universities were scarcely able to keep up with the natural wastage. [I remember Hanson saying this to me when feeling pessimistic].

The basic problem was transportation. The airplane had opened up the north and geological parties could now get in and out of remote regions easily but for the day to day grind there was no better method [other] than those (sic) of Logan and Dawson. Where waterways were present you paddled a canoe, in the mountains you walked, often carrying your food and lodging. But relief was in sight. A totally new type of aircraft was coming into operation – the helicopter. The Topographic Survey had already tried them for operations in the shield, for which it (sic) was ideally suited as their main problem was to get from one observation point to another as fast and easily as possible. The geologist's problem was a bit more difficult, for he was just as interested in the country in between. However, in the Barren Lands, a helicopter could fly slowly at low altitude and a geologist on board could carefully observe the ground being covered. Moreover, he could be landed almost anywhere to take a closer look at an outcrop, to measure attitudes, and to collect specimens. It seemed a promising tool and in 1952 the first attempt, operation Keewatin, proved most successful and some 57,000 square miles of the Barren Lands was covered.

A new method of reconnaissance geological mapping had been devised and was indeed sorely needed. “On the one hand, for instance, there is the increasing interest in Canada’s large northern regions and on the other, the fact that, despite more than a century of effort, about two-thirds of the country’s 3.6 million square miles of land area still lacks even reconnaissance geological maps” (An. Rept. 1955, p. 13). In 1950 it seemed certain that the task could never be completed in the foreseeable future. On the one hand there seemed no hope that enough properly trained geologists for the task could ever be available, and on the other new methods and especially new ideas were making the old work obsolete about as fast as new work was done. A method had to be found whereby a few geologists could cover a huge area in a single season and the helicopter proved the answer. More about the reconnaissance work in a later section.

Despite this impetus for reconnaissance work the Survey’s duties were many and varied. At first the use of the helicopter was confined to the treeless parts of the far north but work must continue amid the forests and mountains of the rest of Canada and for some years still, until machines were improved and new methods devised, the work of standard geological mapping must be continued by the time honoured methods. Moreover in 1948, Newfoundland entered confederation and the Geological Survey was charged with the added task of working out the geology of this new Province. Some serious work had been done on a rather hit and miss basis by students and Professors from Universities in the United States. Manuscript reports on much of this work was (sic) handed over by the Newfoundland Government to the Survey who was expected to prepare these for publication. In most cases this required one or more field seasons by GSC staff to complete the area and to revise the work to modern standards. Besides this the need to make the geological coverage compatible with that of the other settled parts of Canada and to demonstrate the Federal Government’s intent to honour its commitment threw a consideral (sic) strain on the resources of the G.S.C.

Besides all this the Survey was at last publicly committed to a program including fundamental geological research. Some of this was developing in the embryonic laboratories in the Museum but most of it was work done in the field – studies of mining camps, studies to establish type sections of stratified rocks, studies of the complex structures and relationships of the Precambrian rocks, and the like. Now too surficial geology was assuming an important role in the Survey's field program as well as geophysical and geochemical studies and problems of engineering geology. The nature of some of these newcomers will be discussed later.

The importance of the Survey's contribution to the material economy was clearly recognized and in 1954 the Survey's estimate amounted to 2.2 million dollars, more than twice that of the famous " million dollar year". But now the Survey had been growing and this sum, undreamed of in Selwyn's day, could be more efficiently used. Nonetheless, not only was it difficult to recruit professional staff but it was not always easy even to retain them. By now there was a steadily increasing demand for well trained geologists in industry, especially oil geologists, and salaries there were far higher than any the Survey was allowed to pay. This, of course, had always been the case, and accounted for by the security, pensions, and other benefits peculiar to the government service. Those charged with setting salaries were slow to realize that by now this inducement no longer existed for industry too had pension plans and many fringe benefits while the inequality in salaries remained. Some of the more dedicated scientists were prepared to overlook this discrepancy if able to carry on their scientific studies, but among the younger, more ambitious men there was considerable unrest. This came to a head in 1952 when, after efforts to present their case to the Deputy Minister without satisfactory results, thirteen of them resigned and gained employment in industry without difficulty. As industry continued to press for the expansion of the Survey and extension of its services, the government had no choice but to increase salaries to a more equitable level.

GSC and Public

Most of the results of Survey work has always been communicated to the public through reports and maps, although small items of international interest have appeared from time to time in various professional journals. Moreover, Survey geologists have always been in demand as speakers at various conferences and conventions both in and out of Canada. The Survey's contact with the public did not stop there, however, and anyone coming to Ottawa or meeting one of the geologists in the field could always get first hand information on matters that were his direct concern, although great care was taken to ensure that there should be no leak of confidential information and no advance information of direct economic importance. This, of course, greatly favoured operators in or near Ottawa and it will be recalled an office was opened in Vancouver, B.C. to make this service available to operators in the far coast. During this period three more offices were opened to extend still father this service: one in Yellowknife in 1947, one in Calgary in 1950, and one in Whitehorse, in 1954.

The Survey had always been careful to avoid trespassing in fields in which the commercial geologist earns his living. This is a proper distribution of effort as the Survey is responsible to the country as a whole and the consulting geologist to his employer. However government departments were coming to recognize the value of geological work in their fields. The Dept of Agriculture was using the maps of the surficial geology, for the materials lying on bedrock were the parents of the overlying soils and an important factor in their nature. Even more directly between 1953 and 1959 the authorities charged with constructing the St Lawrence Seaway were greatly aided by the work of Survey geologists, which enabled them to find the most desirable gravel deposits and to plan construction work more efficiently. So useful did they find this work that at their request one of the Survey's engineering geologists was transferred to their staff for the duration of the project. In 1959 the Water Resources Branch, Dept of Northern Affairs and Natural resources undertook the construction of dams on Yukon River (sic) and in

British Columbia for power and other purposes. Many possible sites were investigated and the Survey was invited to carry out the necessary geological studies.

For one other new service the Survey was charged with a considerable responsibility. Beside, at the Survey, geological studies were being made at many of the Universities, most by or under the direction of very able men. Universities are perennially short of funds and some worthwhile investigations could not be carried out for this reason. Government was by now fully aware of the ultimate value of research and decided to sponsor those efforts. A grant of money for the purpose was given to the National Research Council to administer, and the National Advisory Committee on the Geological Sciences set up to distribute it. [Fen Henderson had better check on the facts here, I am not too sure]. This committee included geologists from the universities, the provincial departments, and industry. It met periodically at the GSC in Ottawa the meeting being chaired by the Director, and the permanent Secretary J.F. Henderson was a member of the Survey's staff. It was one of the secretary's duties to determine all the geological research being undertaken or contemplated in Canada so as to enable the Committee to allocate their funds in the most beneficial way, and to discourage duplication of effort on similar studies. There is no doubt as to the value of this task.

GSC Divisions

Ever since Brock had organized the Survey into some sort of working units some structure of this type had been retained. So far this had been a flexible organization entirely for the purposes on internal administration. As long as the Survey remained a small compact unit in itself, as it did until the early 40's, any effort at rigid compartments with its inevitable internal friction and empire building was rigorously eschewed. By the 50's however the Survey was too big and too complex to remain a single compact unit, one for all and all for one, that Logan had created. A divisional organization, like Topog[raphy], had growed (sic); although still without rigid definitions and official sanction. The outcome, no matter how deplored by the old guard who were proud of belonging to the Geological Survey, period, was inevitable. By 1950, for the first time, clear cut and defined divisions, eight in number, each with its designated acting chief in charge, were set up. These were operational units but as yet had received no outside recognition. Indeed it was not until 1955 that the scheme was officially sanctioned and the positions of the chiefs recognized, and the eight divisions reduced to six to conform to other similar Departmental Branches. The divisions were: Precambrian, Post Precambrian, Fuels and Stratigraphic Geology, Mineralogy, Mineral Deposits, and Geophysics. Probably there is no better way to discuss the work of the Survey than by considering the work of each component division, but it will be evident that this arbitrary curtailment of the number lead to some uneasy bedfellows.

Helicopter Operations

Perhaps one of the most striking feature of the Canadian Shield is its immense size and a season`s work by one field party, or for that matter four or five, illuminated only a tiny part of this vast, unknown area. A century or more appeared to be necessary to complete the first reconnaissance, that is until the first helicopter supported operation, operation Keewatin, was so strikingly successful. The procedure required thorough and detailed advance planning with a carefully devised schedule laid down. As much advance geological information as possible was obtained from a study of airphotos and determined to a considerable extent the proposed schedule of operations. During the winter, when freighting over the frozen land was relatively easy, caches of gas and supplies were established at pre-determined points and early in the spring the party was flown in to the first base camp. Two helicopters were used for the actual work with the support of a fixed wing aircraft. The helicopter would fly out from camp with a pilot and geologist on board along a determined course, out, across, and back, the geologist mapping the rocks as they passed close beneath him. Where a change in their nature or structures appeared the geologist would direct the pilot to land, he would take readings and specimens and make a direct examination of the outcrop, before continuing on his way. This procedure, in principle, has been followed ever since in the subsequent operations in the Canadian Shield, almost one a year. Modifications have of course been dictated by experience and the cost per square mile covered, never more than for standard reconnaissance work, reduced year after year. Between 1952 and 1955, in three field seasons 185,000 square miles of the shield had been covered by high quality reconnaissance geological mapping.

In Operation Fort George, on the east side of James-Hudson Bay, a somewhat different procedure was tried. In 1956, after preliminary study of the airphotos, the area was flown by a geologist in a fixed-wing aircraft. The speed was of course much faster and at higher altitude so that only the general features of the terrain could be determined. Moreover ground checks could only be made where suitable lakes provided landing spots. This was not regarded as a geological survey in itself but the information so gained greatly increased the efficiency of Operation Fort George, the following year, and led to a considerable decrease in the cost per square mile covered. Moreover the work was done with only one helicopter and three geologists, a party half the size of the earlier operations. No standard procedure can be adopted suitable for all of Canada. Not merely is it that Canada is a vast land with much diversity of topography and forestation, but the nature of the geology itself dictates to a great extent how it must be studied.

No better illustration of this perhaps can be found than Operation Franklin, undertaken in 1955. Operation Franklin covered about 120,000 square miles of the Arctic Archipelago, an area covered for the most part by flat-lying Palaeozoic (sic) strata. On the air photos some of these beds could be seen to pass from one island to the next and all that had to be done was to determine the nature and age of the sequence at one place and to make enough similar observations at intervals to detect lateral changes in the beds. These changes do occur and may indeed be of great economic importance; these sedimentary beds were formed in shallow seas and not everywhere were the seas equally deep or abutting similar land. The task of Operation Franklin was to drop geologists, preferably familiar with the rocks and fauna of the strata exposed, at spots where air photos showed that a well exposed section could be examined. After their task was completed they could be picked up and returned to camp, together with the loads of fossils they had collected. There was no need to trace out the connection between one section and the next, it was perfectly clear in the air photos of a land almost ~~quite~~ devoid of vegetation.

Operation Mackenzie, carried out in 1957 in the southwest corner of that District, had something in common with Operation Franklin. It too was concerned largely with fossiliferous stratified rocks but there the strata had been folded and faulted all along the east flank of the Richardson Mountains and strata must be traced round these folds and across faults. The general procedure was much the same, to drop geologists at selected points where good, well exposed sections seemed to be accessible. However the work was more exacting as not only must the complexities of the structure be worked out but even for a helicopter landing on timbered slopes was not everywhere practical. However, once again the experiment was a great success.

The method was given an even more severe test in 1956 when a helicopter supported operation was attempted in the mountains of central British Columbia; Operation Stikine. Problems of landing there were even more acute and the best that could be done was to land as near the desired point as possible which might, in fact be some distance away. The geology in this region is very difficult and exposures sparse and often covered with moss and lichen so that recognition from the air or from air photos is generally uncertain. Much closer ground observation was necessary and this is just what the difficulty of landing made impossible. It was found to be necessary to use the helicopter as a device for moving a working party to some point far up a mountain from which to start their day's traverse and to pick them up at the end of it. The traverse itself was conducted on foot in the time honoured way but the tremendous advantage of being able to start the day fresh at the top of a mountain instead of tired after an ascent of several thousands of feet can be imagined by everyone but fully realized only by those who have had to do it. The operation was moderately successful but important because it clearly demonstrated what the helicopter can and cannot do in mountainous regions. Since then full scale helicopter operations in the Cordillera have been carried out only in the Yukon, over much of which the mountains are lower and less rugged and timber less dense, but the helicopter has proved its usefulness in geological work in the Cordillera as it has elsewhere. The procedure finally adopted was to do a season or two`s work in an area in the traditional manner but concentrating on the more accessible parts of the area. By then the general nature of the geology was pretty well understood and one season or more often part of a season with the help of a helicopter could rapidly fill in the inaccessible parts of an area, the parts which by the old methods were so time consuming to complete.

In 1958 an entirely new mode of transportation was tried in the far north, for doing the geology of some of the islands in the western Arctic. It must be realized that much of this region has a generally smooth surface. True much of it [is] covered with cobbles and boulders but it is not hard to find a stretch without hillocks or ravines. Moreover there is no vegetation more than a few inches high. To take advantage of this situation a party of two geologists and a pilot used a light Piper Super Cub with a very low landing speed. This was fitted with extra large, very low pressure tires and was successfully landed on unprepared land at about 300 different places. The geologist would indicate a spot he wished to examine, the pilot would circle it a few times and select a nearly flat area, and land. The geologist would complete his examination and the plane take off for the next place. The experiment was a great success, a vast amount of country was covered very quickly, simply, and inexpensively, and has been repeated by the Survey wherever the terrain is suitable. A helicopter could, of course, perform the same service but is vastly more expensive to operate, is slower, and the far greater gas consumption and maintenance requirements calls (sic) for much greater logistic problems.

[Note. As I go over your chapter V it is clear that you can make little use of my attempts to organize my notes as if it were a complete report in itself. As this takes a good deal of time and thought, I shall abandon the practice and revert to my original idea of presenting aspects I feel should be considered without trying to string them together into a connected sequence.]

Standard Geological Mapping

The tremendous strides being made in reconnaissance geological mapping was such an exciting matter that there is danger of losing sight of continued progress in 1-mile and 4-mile mapping, which for a long time still must form the backbone of the Survey's work. Recognition of the sequence and relative ages of the rocks in an area, of the succession of deformations that have affected them, and their physical and chemical nature is primarily a matter of thorough field investigation, and on them the economic potential of an area is largely based. True, lab work based on specimens collected in the field was p[l]aying a rapidly increasing role in elucidating problems, but in the end, in almost all cases the ultimate application of these solutions was in the rocks of the earth's crust as they occur in nature.

It is not surprising therefore that standard geological mapping on scales most suited to the nature of the geology continued to form the bulk of the GSC field program throughout the Cordillera, in the Appalachians, including Newfoundland, and in those parts of the Canadian Shield where earlier work indicated that most benefit from such work might accrue.

Detailed Work

Much of the standard field work was naturally centered round mining camps or areas where ore in commercial quantities was known or suspected to exist. This led directly to one type of detailed study; that of specific ore-bodies or groups of ore-bodies. The emphasis shifted from general coverage with the distribution and relationships of all the rocks in the area of primary concern, to a concentration on the why and the wherefore of a specific type of ore-body. Geological mapping as always remained a powerful tool but was strictly a means to an end and scarcely at all any part of the end. This type of investigation was carried out in the mining camps at Rouyn and along the Cadillac-Larder Lake gold belt in Quebec, round the Beaverlodge mining camps, and the new copper discoveries at Bathurst, New Brunswick.

Special attention was paid to the rocks of the Labrador trough, where Low's pioneer discoveries had led to the outlining of immense deposits of iron and where several large mining companies were attempting to block out sufficient ore to justify construction of a railway all the way from Seven Islands on the Gulf of St Lawrence. The Surveys (sic) contributions ranged all the way from standard 4-mile geological mapping to detailed studies designed to elucidate the sequence of strata of which the iron deposits form an integral part.

It is interesting to note that old problems die hard. During the last three years of the period the attack on the "Huronian" problems in southwestern Ontario, the scene of so much important early work, was renewed. New methods and new hypotheses were brought to bear on obscure aspects of the problem, so many of which still remained. Nor was the Grenville neglected, Logan's first contribution to the Precambrian geology of the world. Reconnaissance had shown it to comprise a strip along the southeastern margin of the Shield following the course of the St Lawrence River and Gulf from Georgian Bay to the coast of Labrador. This important belt of rocks, of which the type areas formed only a minor part still posed riddle after riddle and attempts were started in 1959 to devise a method whereby at least the major components of the complex series could be mapped more rapidly and over larger areas than the tedious detailed work that had so far proved necessary.

<u>Special Studies</u> (Palaeocurrents) (sic)

Most sedimentary rocks originate as sediments laid down in bodies of water. If the water is a flowing body, the fabric of the coarser sediments, sand and gravel, often leaves a clear imprint of the nature and direction of flow of the parent water. Enquiring and observant minds recognized this and some recognized that these fabrics would be preserved in these sediments even after they were transformed into solid rock. The study of "palaeocurrents"(sic) was born.

A very suitable object for such a study were the sandstones of the Athabasca Group, and by application of the principles the nature of the body of water in which they were laid down and the direction in which it flowed [were] discovered. True facts are never valueless, but as yet the economic value of this information has escaped us, its application in another field is very differen).

In Chapter ? it was pointed out that Collins, working west of Sudbury, had mapped geologically an area round Blind River. A prominent unit in his area was the basal conglomerate of the ? series [I haven't the information here but I mentioned it in my earlier notes]. At the time interest in these beds centered mainly in their value as a marker horizon, by means of which the structure of the area could be worked out. In 19??, however, parts of these conglomerates were found to contain economic deposits of uranium and suddenly they became important. In no time Collin's map went out of print and the Survey was able quickly to issue a reprint which, too, was gobbled up. The entire outcrop area of the conglomerate was staked, using Collin's map, before the winter snows were gone.

However, not all produced ore-bodies and the need to know why they [~~there?~~] were here and not there and what controlled this became a very practical issue. It was soon recognized that the nature of the conglomerate was an important factor, and the nature of the conglomerate – originally gravel – depended on the nature of the water in which it was formed and the strength and direction of the flow. Clearly a study of the palaeocurrents (sic) was needed, and this was begun by the Survey in 1954. The uranium mining industry can but testify to the value of the work performed.

Isotopic age determination

It will be recalled that for years before his death in 1952, H.V. Ellsworth had been largely instrumental in developing techniques for determining the age of radioactive minerals. This was of immense value to Precambrian geologists for there was no other way of relating Precambrian rocks or determining the sequence of events except on a very small local scale. Rocks that looked very much alike but a couple of hundred miles apart might have resulted from the same processes or from similar processes operating at times separated by 100 million years with a whole host of events taking place in the interim. Fossils in the younger rocks gave the clue but life in the Precambrian was so scarce and ~~was~~ so rarely fossilized that it was of no use for correlating formations.

Radioactive dating suggested that there might be an answer but a determination using Ellworth's techniques could only be made on a strongly radioactive substance like uranium, occurrences of which were very rare, and besides were so slow and exacting that only a few determinations could be carried out in a year. This was of very little help to the Precambrian geologist, although it did confirm the immense age of some of the Precambrian rocks and the tremendous span of Precambrian time.

But help was at hand. During the great surge of scientific discovery of the war and post-war years, a practical mass spectrometer was developed by which it was possible rapidly and accurately to measure the quantity of the various isotopes of a gas in a mixture. It was thus possible to distinguish, for instance, minute quantities of the argon produced by the decay of potassium, a weakly radioactive element, from the natural argon also present in minute amounts in all rocks. By this means the time that elapsed since the formation of a potassium-bearing mineral could be rapidly and accurately determined. And (sic) potassium-bearing minerals are common in most Precambrian rocks and on all of them determinations could be made. It was now a matter of getting to work on a big enough scale and learning how to interpret the results. The first part was easy. By 1954 the Survey had assembled the equipment and operators and a lab was in operation in the basement of the old Museum, and soon hundreds of determinations were being made annually.

Interpretation was a horse of a different colour, and study and cooperation between the field geologists and the physicists was necessary. Not all minerals gave equally reliable results and a mineral found to be suitable at one place proved unreliable at another. This had to do with the nature of the crystal lattice and like mysteries understood only by physicists. Besides this another vexing question was giving grave concern to the geologists. The date determined in the laboratory, granted that it was accurate from the viewpoint of physical science, was in fact the date of formation of that particular mineral crystal, say a mica. Now if the rock, say a granite crys[tallizes] as a whole, the mica being a part of the original rock, and if nothing of geological or geochemical significance had happened to that rock since, it could safely be assumed that the age of the mineral was the age of the rock. Unfortunately this was a rather rare occurrence, particularly in the long span of Precambrian time. A mica crystal might form as part of a granite body and immediately embark on the [?] decay of its potassium. But at some stage of its history this rock is reheated and, while it may not melt, chemical action is renewed and the old mica is replaced by new in which the process starts all over again. The age now determined will be the age of this change, not the age of the original rock. Even more perplexing, the change may not be complete so that mica of both generations may be present and the age determined a compound of both, but really true of neither. Problems are being worked out one by one but science, you see, never hands out a gilt edged solution and never dares a scientist to take anything for granted.

Oil and Gas

Since the discovery of the Turner Valley oil field in the Rocky Mountain Foothills western Canada had been a steady producer of natural oil. By 1946 however the Turner Valley field was nearing exhaustion and at the same time domestic consumption was rising steadily. Discoveries of other oil fields along the extension of the Turner Valley structures were few and fields small. It was true that to the east of the Foothills lay a vast stretch of Prairies underlain by potentially oil-bearing rocks but these strata were notably flat-lying and those broad dome-shaped structures of the type in which oil pools accumulated all over the world were absent or at best very rare and hard to find. Fortunately it had recently been recognized that other ancient features might also permit the accumulation of oil and gas into workable sized fields, and one group were coral reefs. Where these had formed in the Devonian seas and had gradually been buried to become integral parts of the strata, they might form traps for oil driven along porous beds by the pressure of water from the side or from below.

In 1946 as a result of geophysical investigations followed by deep test borings an oil field was discovered at La duc (sic), Alberta, and soon proved by further drilling to be of major proportions, for exceeding the potential of all Turner Valley. At a single stroke a vast area of plains, extending from the International Boundary to the Arctic Ocean – now even including the Arctic Archipelago – and from the mountains to the edge of the Canadian Shield, became potential oil land. Strike followed strike and new fields we[re] being brought in almost monthly: Canada's position among the world's great oil producing nations was assured.

But drilling a test well 8,000 feet deep or more is a slow and costly matter, and, plentiful as the oil fields have proved to be, the proportion of the land underlain by workable pools is actually very small. To drill for oil at random is to invite financial disaster. The odds against failure, drilling a dry hole, must be reduced by every means humanly possible. The new geophical (sic) devices, invaluable though they are, are not by themselves sufficient, and can only supplement the work of a man using his eyes, his experience, and his brain. Once again the Survey played no small part in the develop~~ed~~[ment] that followed.

Strata under the Prairies were laid down, as elsewhere, in an orderly sequence and once this sequence was known, and a few beds in a new area recognized, the depth to a potentially productive bed could be predicted with reasonable accuracy. It will be recalled that in the previous decades Survey geologists had worked carefully along the Foothills piecing together type sections of the Palaeozoic (sic) strata where the upturned edges of the beds so deeply buried under the plains came to the surface. Some of these beds could be recognized in the chips worked to the surface. By the water pumped into the wells during drilling. The position of the drill bit at that moment in the stratigraphic section could thus be determined.

Alas, as everywhere in natural science, things are never quite so simple. Sedimentary beds are laid down in seas and a sea may be shallow in one place and deep in another and the material laid down in the deep part quite different from that laid down in the shallow part. In a succession of marine strata followed very far in any direction, some of the beds will soon show changes in character and before too far the character of the whole succession may have changed so much that correlation with strata of the type section be difficult or impossible. The type sections which in the Foothills could be used directly for wells drilled on the edges the plains, they were useful in parts of the succession farther away, but were of little use in the more remote sections. It was clearly necessary to establish type sections progressively across the Prairies so that the progressive changes could be noted and the character and the history of the Palaeozoic (sic) Seas deduced. How economically essential this information is will shortly be shown.

There are, of course, no places in the Prairies where these Palaeozoic (sic) rocks can be seen and the only way is by the study of the drill cuttings mentioned above. This is a painstaking, tedious job. The chips, washed clean and dried, are examined under a microscope and generally the nature of the original rock can be recognized. Sample after sample is examined and when a change occurs it can be assumed that the drill passed from one bad to another. By starting close to a type section a basis for comparison is established and, if wells are suitably spaced, the succession and its modifications traced across the country.

In 1950, the Survey began the formal studies of this kind. Geologists in the Calgary office specialized in beds of certain ages and soon became specialists in their field. Companies too soon realized it was essential to employ geologists to determine where to drill and where, stratigraphically, the head of the drill was at any moment. It was now that the work of the Borings Section of the GSC realized its full potential. By 1949 one and a quarter million samples were housed in the Survey offices in Ottawa and available for study. Company geologists found this material so essential that it became necessary to provide them with room to work and the space set aside [~~in~~] for them in the Museum was rarely vacant.

So far we have discussed only the stratigraphy – the succession and nature of the strata. In certain types of beds oil may be produced, in others it may accumulate into usable amounts, but only if conditions are right to produce the required concentration. We have already pointed out how important reef and reef structures are to oil accumulation in the flat lying strata of the Prairies, but where and how do they form and by what clues can we tell where they may have grown 10,000 feet below today's land surface. One GSC geologist spent the summer of 1953 examining Palaeozoic (sic) reefs as exposed in the Rocky Mountains, observing their nature and the nature of the surrounding rocks. Then in 1954 he went to Florida and, donning Scuba gear, made a close examination of a modern line coral reef. How pleased Hutton's ghost must have been to see so striking an example of his theory of Uniformaterranism.

A start had been made. The basic work is still going on with much of the details in the hands of the company geologists. But we cannot leave the subject without mention of another, and important contribution the Survey made. Sometimes from borings, more often from type sections they made in parts of the mountains near their company holdings, the company geologists made collections of fossils for stratigraphic reasons; they needed to know the age of the beds from which the collections came. The beds might be of any age and clearly it was impractical for each oil company to have a staff of palaeontologists (sic) expert in every field. It was arranged therefore that the oil companies were free to send their collections to the Survey for immediate preliminary identification – generally all they desired. After that the material remained the property of the Survey to be used later for detailed palaeontological (sic) studies. Thus both parties were benefited, although many a palaeontologist (sic) was heard to moan about the diversion of his time to unrewarding routine identifications from original scientific research.

So rapidly was production increased by the new strikes that the necessary facilities were hard pressed to keep pace. However by 1950 the main pipe line for the transportation of petroleum products was completed from Edmonton to the Lake Head from where tankers could carry it to the rest of the world. This with secondary feeder lines from the main oil fields made a start towards solving the problems of distribution and refineries, operating or being built in half a dozen of the main Prairie centres, attacked the problem of processing the crude oil as it came from the wells. By 1953 for the first time the dollar value of petroleum products exceeded that of gold in the national economy.

One last matter of great potential importance must be mentioned. In the process of drilling for oil, vast quantities of natural gas were discovered; in some exploratory holes gas was found with oil and in others gas alone. At the time the gas was of limited local use and gas wells were mostly capped to conserve this potential national asset. It was clear that a use could be found for this valuable material, but first a great deal of money must be spent to provide the means of getting it to a market. Was there enough gas to justify the enormous expense. G.S. Hume of the Geological Survey was appointed head of a Commission to estimate the resources of gas presently developed and in 1952 came up with the staggering figure of seven trillion cubic feet! A pipe line to transport this gas to markets to the south and east was built, but not until later.

The exciting developments on the Prairies has (sic) perforce held the spotlight but all this while the oil fields of Ontario have been quietly producing their quota. The potentials there were limited but locally small new pools could be found wherever suitable structure existed. As these structures were in beds many thousands of feet below the range of man's vision they must be deduced from indirect evidence. In this too the GSC played its part. Careful examination of the cuttings from the many wells that had been drilled in this rather limited area the position in the wells of certain significant horizons could be ascertained. Then by determining the exact elevation of the top of the hole the elevation of each of these horizons could be determined. Each of these could be regarded as a hidden land surface and a contour map of this surface drawn. Hills and valleys in this surface were thus revealed and the position of potential oil structures clearly indicated. The reader is again asked to recognize that to drill holes at random over even so small an area as the Ontario Peninsula would be financially disastrous: oil fields are so small and the acres of barren land so huge.

Note [It occurs to me that you might consider in an appendix listing the various types of GSC Publications – Memoirs, Ann Repts, Papers, A series maps, etc etc – a) when started, b) when and why stopped, c) and the intended purpose. This would only be half a page and I could easily secure the information. I have had many people, particularly foreign geologists, register considerable confusion.]

Coal

Not very surprisingly, as the fortunes of oil rose those of coal declined. Oil was a much easier fuel to use for transportation, and railway and marine engines were rapidly converting from coal to oil. Furthermore Canadian known coal fields were being worked out and new discoveries were few and far between. For Canada as a whole the value of the oil being discovered far outweighed the decline in coal production, but in places coal mining was the mainstay of local prosperity, even of existence. Principal among these was Nova Scotia much of whose wealth came from the Sydney and Cumberland coal fields and already most of the easily accessible coal was gone. To help in the task of finding productive seams in areas more costly to explore, the Survey established an office in Sydney in charge of an expert on coal petrography by means of which seams in detached areas could be correlated and the best methods of beneficiation of the coal in particular seams devised. Nothing could save Nova Scotia’s coal industry but at least the final blow was deferred.

In Alberta and British Columbia the Survey also came to the aid of the declining coal industry, doing what lay within its power. Perhaps the greatest contribution was to supply a geologist to head a Royal Commission to inventory all of Canada's coal resources, for without this essential information no long range planning was possible.

Geophysics

At the end of the last chapter mention was made of experiments made with a magnetometer mounted in a low flying aircraft. Different kinds of rock contain different amounts of magnetic material, generally iron, and, although these differences are small they could be detected by a suitably sensitive instrument, and the trace of distinctive beds below marked out even under a cover of drift. Moreover the vicinity of certain orebodies was marked by an increase in the iron content of the rocks involved. The general procedure is to fly a series of lines a predetermined distance apart and at a constant distance from the ground, and to record changes in the magnetic field about the aircraft which are largely determined by the nature of the rocks below. When these readings are plotted on a suitable map high and low magnetic areas appear, just like mountains and valleys on the land and in just the same manner can be depicted by contours (lines of equal readings) on the map. The pattern on the map thus represents the pattern of conditions below. If the basic geology is known this pattern can be interpreted to present a very meaningful picture and augment enormously the data resulting from ground observations. The initial experiments proved so successful that in 1947 a Geophysical Section was established to continue these tests and in 1948 started on an operational basis.

But an aeroplane (sic) flies very fast and huge sections of Canada were covered very rapidly. Moreover the problem of reducing the raw data to usable form was monumental. Remember with the best navigators in the world winds change force and direction and an aircraft may drift substantially off course before the error can be detected in the air and the course corrected. Furthermore it is almost impossible to fly at an absolutely constant elevation and even if it could be done the land rises and falls below. Since the intensity of the magnetic effect depends on the absolute distance to the ground and the readings must, of course, be plotted on exactly the right place o the map, a huge amount of work must be done before a "geophysical" map can be produced. It was no time before the compilation part of the new Geophysics Section was hopelessly bogged down. The staff was doubled but this only held back the deluge temporarily and by now all available space in the Museum was occupied. The section moved to one of the war time temporary buildings not yet torn down and struggled on to keep its head above the flood of new data that continued to pour in. Ultimately the computer had to be called in and with its aid the problem was solved.

Nonetheless so much progress was made that by 1956 many geologists starting on the study of a new area had a geophysical map ready to aid them, what a far cry from Dawson's day when for the geologist to have a topographic map available seemed to be an unrealizable dream.

The efforts of the Geophysical Division was (sic) not, however, confined to operating the airborne magnetometer. Major and successful efforts were made [to] improve the designs of the equipment to increase its sensitivity and ease of operation as well as to increase the accuracy with which the position of the aircraft in the air could be pinpointed at all times.

Soon too the Survey's geophysicists were involved in experiments with seismic devices to determine the depth to bedrock in areas of heavy drift as well as i~~s~~[n] ground magnetometer experiments and in laboratory tests of the magnetic qualities of various rock formations. Even further ground work was done with the collaboration of a field geologists in areas covered by aeromagnetic maps for the specific purpose of determining the relationship between ground geology and the state of the earth's magnetic field in the air above as measured by the airborne magnetometer.

One interesting new project was started; a study of palaeomagnetism (sic). All rocks are formed of minerals and the crystals of some minerals act like tiny magnets. Mostly these magnets are very weak but given an opportunity they will orient themselves in the direction of the earth's magnetic field like a compass needle. If then, after the crystals have been so aligned the medium holding them solidifies to solid rock the direction of the earth's magnetic field at that place and time can be determined. This would be of no great consequence were it not that the positions of the magnetic pole has during the course of geological time wandered to its present position from thousands of miles away. By determining the position of the magnetic pole from the Palaeomagnetism (sic) of rocks of different but known ages, a trace of this polar movement has been determined and if the position of the pole for a rock of unknown age can be determined, the age of the rock can be deduced from the position of this pole on the standard polar curve. In this way a new means of correlating unfossiliferous rocks was discovered.

It was found, however, that the polar wandering curves determined from rocks of different continents, while similar in shape, were not in the same place, diverging farther and farther as the age increased. As it is impossible for the magnetic pole to be in two places at once the only conclusion possible is that the continents have changed position with respect to each other. This idea of continental drift was proposed many years ago on geological grounds but fell into disfavor when geophysicists were unable to imagine a force that would produce such a drift. Now with new ideas as to the internal structure of the earth the necessary forces are possible and with the evidence of palaeomagnetism (sic) the theory of cont[in]ental drift seems to [be] well established.

<u>Quebec–Labrador Iron Belt</u>

The prosperity of a nation in the modern world is in no small manner conditioned by the extent of its workable iron deposits. In its early stages iron deposits were known in various parts of Canada and some were exploited. But, all important as they were locally, were too small to form the basis of a substantial iron industry. But when Low discovered the iron deposits of the

Labrador trough and this discovery was confirmed and augmented later, the situation became vastly different. It was now certain that huge amounts of iron-bearing rock were present and that some was of commercial grade. The area was however very remote and only an immense operation would be economically feasible. The costly equipment, not to mention a railway from the Gulf of St Lawrence to the heart of the Labrador Peninsula, could only be undertaken if enough ore was certainly present to justify it. This first stage was attacked by a number of large mining interests working jointly or severally, and by 1948, 300 million tons of workable iron ore had been blocked out, enough to justify construction of the railway. This railway, through 360 miles of untracked wilderness, was finished in 1954 and two million tons of iron ore shipped.

But now a new factor changed the whole picture. So far iron-ore, to be usable had certain stringent minimum restrictions on grade and composition. At the southern end of the Labrador trough were deposits of ore meeting the specifications and it was on these that the enterprise had been undertaken. Research had been active, however, on devising practical methods to beneficiate low grade ores and produce a product that could compete with the high grade ores, both in price and quality. These efforts were remarkably successful and soon immense quantities of low grade, hitherto worthless iron-formation, all up and down the trough and its southwestern extension became valuable ore.

Iron-formation is part of the sedimentary sequence, subject to the vagaries of sedimentation and the complexity of later structural deformations. These are geological problems and the Geological Survey quickly came to the aid of the mine geologists. Several Survey geologists were soon at work doing regular 4-mile geological mapping along the belt to determine the overall nature and trend of the formations – the larger picture. At the same time other parties undertook a detailed study of the stratigraphic sequence right across the trough. As might be expected it was soon found that the original simple picture of a straightforward sequence of beds lying in a trough shaped structure had no foundation in fact, The story is too long and complicated to detail here, but the efforts resulted in the establish[ment], with the aid of some of the company geologists, of erecting a series of rock units by means of which the complex structures and the course of the important iron-formation could be worked out. It is nice to report the accord of geologists working for industry and those working for the government and here, as in the western oil fields the combination achieved results impossible to either working alone, and so free of jealousy so apt to attend Dominion-Provincial relations.

Marmora Iron Deposit

[This should be included under Geophysics]

It has been said that the airborne magnetometer is not an ore-finding device, and mostly, contrary to popular opinion, this is true. However, just as a Survey geologist sometimes finds an ore-body, so the airborne magnetometer can sometimes point directly to one's presence. Here and there in the Precambrian of southern Ontario are small bodies of high grade, magnetic iron ore, quite different from the iron deposits of Quebec-Labrador and more like most of those that occur in B.C. Several of these had been mined years ago but none was of more than local importance. These bodies do however have a profound effect of the earth's magnetic field at that point and are readily detectable by the airborne magnetometer. One such "anomaly" was observed in southern Ontario, but in an area completely covered with Palaeozoic (sic) limestone. The anomaly must represent a deposit, and a large one, in the Precambrian beneath the limestone. This clue was followed up by industry and drill holes were poked down through 600 feet of limestone to find that below was indeed an important body of magnetite. This ends the story from the Survey's point of view, but we must record that machines stripped off the 600 feet of overlying Palaeozoic (sic) limestone, and the underlying iron ore, which could never have been seen by human eye, is presently being mined.

Pleistocene & Groundwater

The days when the study of the unconsolidated drift overlying bed rock was the incidental chore of regular field geologists, except for occasional dedicated individuals like Chalmers and W.A. Johnston was rapidly coming to an end. The disaster of the Kansas dust bowl and several examples in the US during the war drove home the lesson that the water within the ground was no more inexhaustible than the water on the surface and its uncontrolled exploitation could just as surely turn a fruitful land into a desert. At last studies of the engineering aspects of the problem were being made and Universities were giving courses on Pleistocene geology and groundwater.

~~The Geological Survey too undertook a series of studies in parts of the country where the need was most apparent, particularly on the Prairies, in southern Ontario, and in B.C. Once again, except where specific objectives were in mind, the principal purpose was to inventory the groundwater resources so that proper controls could be established. This is of course an immense task in a country the size of Canada and even yet has been little more than started.~~ [Deleted by author]

~~The results of Pleistocene studies have far wider application than just for groundwater. Some of the most important structural materials are the products of glacial and post-glacial processes – products like sand and gravel. Pieces of rich ore in glacial drift can only be traced to their source if the movements of the vanished glaciers that brought them there can be accurately traced. Heavy construction – dams, buildings, and the construction of the St Lawrence Seaway – all required a sound knowledge of the Pleistocene deposits round about, how deep they are, and how they were formed.~~[Deleted by author]

The Geological Survey was fully conscious of its responsibilities in this field of geology and geological engineering. Already a number of Water Supply Paper[s] covering a large area in the Prairies had been published but primarily these merely indicated at what depth water might be expected, largely based on extrapolation from nearby wells.

In 1947 a more advanced study was started, this time in southern Ontario. Gradually as more trained men became available, indeed many Pleistocene geologists in training got their field experience with the Survey, more work was undertaken and by 1951 the Pleistocene and

Engineering Geology Section fielded sixteen parties and reported that: “Studies of the widespread Pleistocene or glacial drift materials that cover the greater part of Canada are becoming increasingly important as a result of the rapid growth of the country. These materials are a source of road and ballast metal, industrial clays, and cement. They are a principal source of underground water supply that is in increasing demand…where a convenient or adequate surface supply is lacking” (AR 1952, p.58). Studies were made from coast to coast and : “It may be of interest to note that ground-water surveys in lower Fraser Valley,…, have shown that ground reservoirs of potable water could supply several times the quantities now being used; that proper irrigation… in Surrey municipality alone, could result in an annual increase in the value of the mixed crop of upwards of $5,000,000…, and that an adequate system of water wells would serve to control local streams and flood conditions more effectively than dykes.” (AR 1952, p.59). By 1957 the science had advanced to a degree that a party in Alberta was able to report that: “It recognized five distinct till sheets representing major glacial advances, and possibly three different glacial ages, and found that…(parts)… of the map-area were not overridden by glacial ice. It outlined, over considerable distances, several buried valleys that are potential sources of ground water.” (AR 1957, p. 31).

A Pleistocene geologist was now being attached to each helicopter operation and by this means information on the glacial history of Canada over much of the far north was rapidly being amassed. It is interesting to note that the old idea that Hudson's Bay was once a source of ice for the continental glaciers received substantial support.

Knowledge, any knowledge, has unsuspected ways of proving useful. At Chalk River, Ont[ario], the centre of Canadian nuclear research, the problem arose of disposing of radioactive byproducts. The first idea of simply letting them soak into the ground until in the natural course of events they became harmless, raised the question of how long they would stay put and where would they come up. The Survey was asked to supply the answer and an investigation by one of the Survey's Pleistocene geologists determined the direction and rate of flow of the groundwater in various parts of the Chalk River area and showed at what place these poisonous materials could be allowed safely to enter the system.

<u>Radioactive Mineral Deposits</u>

The World was by now fully embarked on the nuclear age in which Canada had already played a part, for Canada is richly endowed with deposits of Uranium and Thorium, two of the principal radioactive minerals, and indeed the Eldorado Mine at Great Bear Lake played its part in producing the early atom bombs. At first of course the whole matter was top secret but as soon as it became public knowledge immediate attention was focused on finding new deposits. But finding uranium mines is very different from other forms of prospecting. Few uranium minerals are easily recognizable in the field and can best be detected by use of a Geiger counter, an instrument that detects the particles being emitted by ~~a~~ radioactive mineral decay. It is of passing interest to note that probably the first Geiger counter to be built in Canada was made before the war by H.V. Ellsworth of the Survey. However even when equipped with one of these comparatively costly instruments a prospector needed a considerable amount of specialized knowledge. Nonetheless, it was soon apparent that radioactive minerals occurred much less infrequently than had been supposed and the problem became more one of evaluating occurrences than finding them.

As yet there was no open market for uranium ores of uranium mines. The Canadian Government was the sole purchaser of radioactive products and the only operator of a uranium mine, although this last restriction was later withdrawn. Moreover, while a Geiger counter would detect the presence of radioactive minerals, there was no commercial way in which a prospector could find out how much uranium was actually present in his ore. To do this, new and highly sophisticated instruments were necessary. The need was apparent and in 1949 the government appointed the Geological Survey as agent for the Atomic Energy Control Board to list and evaluate all occurrences of radioactive minerals, which included measuring the radioactivity of all specimens submitted, in that year more than 6,800. New instruments for the purpose must be purchased and installed, and in fact new ones designed and built, and staff trained to operate them. By 1952 a new division was organized which "conducts field and laboratory investigations on Canadian resources of radioactive raw materials, maintains free testing and advisory services for uranium prospectors, and compiles and publishes data on Canadian radioactive deposits." (AR. 1953, p.56).

In one other field the Survey was to play a part that deserves mention. In 1954 the basal conglomerates of Logan's Huronian at Blind River were found to contain important deposits of uranium. It was winter and no one could follow the intricate distribution of these conglomerates under the snow. But years before Collins had mapped the geology of this region and he had indicated on his map every twist and turn of all the rock units. Copies of Collins map were exhausted within days and a new edition had to be given top priority. When the snow left every exposure of the conglomerate was staked and detailed prospecting began. Perhaps, somewhere, Collins could enjoy the [excitement?].

Palaeontology (sic)

Palaeontology is pursued for two prime purposes, biological and chronological. In the first the emphasis is on the fossil creature itself, its nature, its classification, and its position in the progress of evolution. This is one of the principal means of learning about the ancestry of modern creatures, their relationships to each other, and the origin of certain parts and customs. This is strictly zoological or botanical and its study as such is not properly a function of the Geological Survey. However the chronological aspect of palaeontology, probably the most powerful stratigraphic tool yet available, most assuredly is and the two cannot be wholly divorced. Palaeontological (sic) chronology depends on the fact that the evolution of one species to another was a logical but time consuming process. Species B was therefore always younger than species A and ~~alway~~s developed at about the same time all over the world. A structure that contained a fossil of species B was therefore younger than one that contained species A and the same age as another that contained species B. But before those facts could be used the fossils present must be identified or if not previously described, studied, named, and descriptions published. Only then could type assemblages for each geological age be determined. This, of course, involved the stratigraphic palaeontologists in the study of the morphology and evolutionary changes in groups of fossil animals and plants and thus willy nilly the GSC became involved in both branches of Palaeonlology (sic).

At first the stratigraphers were satisfied if a palaeontologist could tell them if the fossils collected were Silurian or Devonian, or Triassic or Jurassic, and for this a few recognizable guide fossils were sufficient. But as more detailed field work was done a more refined chronology was demanded and this required basic research on certain fossil groups and during specific intervals of geological time. In 1950, then, special studies were begun on the cretaceous, Jurassic, and Triassic each by its own specialist, to be followed later by studies in the Palaeozoic (sic) eras as men became available.

Important and fundamental though these studies were, they remained only a small part of the duties of the Palaeontological (sic) section which "gives chief attention to the systematic study of Canadian stratigraphy based on the study of palaeontological (sic) material collected by the Geological Survey of Canada and by oil and mining companies and through other sources. It prepared eighty-nine reports covering thousands of fossil specimens, thirty-two of these reports being for oil companies.

"Considerable time was given to research projects, based largely on field work and on Geological Survey fossil collections and related to geological explorations and economic development." (An Rept 1953; p58).

Palynology

[This is perhaps too small a field to warrant mention, though it is interesting]

By 1955 a new branch of palaeontology (sic), palynology, had been started at the Survey. Although most sedimentary rocks comprising the earth's crust were laid down in the sea and therefore contained the remains of sea creatures, some were deposited on land or in fresh or brackish water, among them those layers of organic remains that became coal. Some of these contained plant fossils, but these were rare. Moreover, anyone who has walked throu (sic) the country knows how very different the plant assemblages living today may be at one place from those at another, perhaps quite nearby. He may not, unless he suffers from hay fever, realize that some plants shed huge quantities of pollen or spores into the air and these tiny objects may float for miles before settling to earth. By an amazing provision of nature these tiny

[Three line illegible deletion by author at this point] grains are among the most durable of natural objects. They may collect in the mud of a lake or sea, resist the changes by which the mud turned to solid rock, and remain in the beaker after the rock itself was disintegrated in boiling acids. These spores and pollens are then like other fossils although they are so minute that identification, though often possible, is difficult. Their one great advantage is their widespread and uniform distribution, indeed in few unaltered upper Palaeozoic (sic) and later rocks can some at least not be found. The GSC in contributing (sic) its share to the description of the spore and pollen faunas of Canadian formations thus establishing the geological range of the identified forms.

Geochemistry

See Boyle's paper attached. The first 9 pp are probably not applicable, as the subject matter has been pretty well covered already, e g Sterry Hunt [and] Ellsworth which make up most of it. Should you ask Boyle to expand p 10 ¶1 to several pages? These new aspects of geochemistry are a basic part of the story of the scientific expansion of the GSC which is much of the subject of this Chapter. I could write it up but Bob Boyle could do it much more easily and accurately, and I am sure he would be glad. Bob gets things done.

Economic Geology

There should, I think, be a little more on the attack on the economic geology. This took two forms.

1. Detailed studies of mining camps or areas. This is not radically different from the earlier approach to the problem but by now men far more highly qualified available and new theoretical concepts and laboratory techniques could be employed. The approach more than ever was directed towards discovering fundamental principles of ore deposition of universal application, leaving to the commercial geologist the task of applying them to particular ore deposits. (Lang will I am sure be glad to supply you with examples of studies of this nature made at this time).

2. Canada-wide studies of specific minerals and metals. The purpose being partly to evaluate Canada's resources and ~~ly~~[to] indicate the geological nature and distribution of the different types of deposit in which the ore might be found. The results of these studies contributed to the Economic Geology Series of reports. (Lang may wish to add to this, I mention it here so that it be not overlooked)

[Document ends here]