No. _____

CANADA

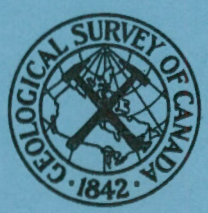
DEPARTMENT OF ENERGY, MINES AND RESOURCES

GEOLOGICAL SURVEY OF CANADA
TOPICAL REPORT NO. 125

REPORT ON A VISIT TO THE U.S.S.R.

May 17 to July 6, 1966

N.R.C. – Soviet Academy of Sciences
Exchange Agreement: Report No. 39



OTTAWA
1967

NOT TO BE QUOTED AS A PUBLICATION
FOR DEPARTMENTAL USE

REPORT ON A VISIT TO THE U.S.S.R.

by

G.A. Gross

Geological Survey of Canada

Department of Energy Mines and Resources

May 17 to July 6, 1966

N.R.C. - Soviet Academy of Sciences

Exchange Agreement: Report No. 39

TABLE OF CONTENTS

ABSTRACT

STUDY OF IRON ORE IN THE SOVIET UNION

The writer spent seven weeks in the Soviet Union, between May and July of 1966, studying iron ore deposits and related geological research. More than ten Research Institutes and two major iron ore mining regions were visited during travel to Moscow, Leningrad and the Kursk area in Russia; Novosibirsk in Siberia; and Kiev and Krivoy Rog in the Ukraine. The trip was sponsored under the scientific exchange program of the National Research Council of Canada and the Soviet Academy of Sciences and provided opportunity for association with the scientific community of the Soviet Union and observation of their research methods and way of life.

More than one hundred scientists, including a large number of specialists, described their work on the geology of iron ore deposits and compared results with recent studies in Canada and other major iron ore producing countries. Scientific work was discussed freely in a stimulating and cordial atmosphere and the conversations enabled exchanges of ideas that would normally require years for transmission by publication in scientific journals. A very extensive literature with exhaustive detail on the iron deposits has been published in the Soviet Union. It is not fully appreciated outside the country because of language difficulties, limited translation services or limited distribution of small editions of scientific publications. Because of these circumstances, Soviet geologists are anxious to exchange publications with geologists in other countries and are inserting lengthy summaries of their work in English in their scientific papers.

Visits to iron mines in the Krivoy Rog and Kursk areas were particularly interesting and instructive as the writer

was one of the first foreign geologists in the exchange program permitted to examine mineral deposits in the field. The naturally enriched iron ores, or the magnetite taconite types of ores which are concentrated and pelletized, are very similar to iron ores mined in Canada and present similar problems in mine development and ore production. Comprehensive detailed geological work is completed in advance of mine development and methods similar to those developed in North America are being adapted for processing the ore. Technological methods and operating efficiency in many phases of the iron ore industry would not meet the standards required in our competitive industry, but adequate ore production is being achieved for a rapidly expanding industry.

All major kinds of iron ore occur in abundance in the Soviet Union and geological work has demonstrated ore reserves that are greatly in excess of anticipated future domestic requirements. Large deposits of good quality ore are widely distributed geographically and can supply ore for steel industries in all potential market areas. In spite of this wide distribution of good ore, much interest is given to ore deposits of marginal quality where considerable metallurgical skill will be needed for their development and use. Low grade ore with undesirable constituents is being mined or developed for local use, and special metallurgical processing costs seem to be accepted as an alternative to extra transportation charges for better grade ore.

A week was spent at Science City, a new research community located about 10 miles from Novosibirsk in Siberia. It has been established within the past six years to serve the eastern part of the country and research in seventeen institutes in this community ranges in scope from nuclear physics to most fields of natural science. The Institute of Geology and Geophysics has been investigating fundamental geological problems

encountered in the exploration and development of the large magnetite ore bodies in the Ural Mountains and those near the Kuznetzk basin. A very congenial and cooperative atmosphere prevails in this modern community where a free exchange of ideas and communication between scientists of different disciplines is encouraged and promoted.

All the travel facilities seem to be operating at full capacity in the Soviet Union, but comfortable plane and train accommodation was arranged for this visit and no difficulties were encountered travelling alone. Motor journeys through the steppe country of the Ukraine and around Novosibirsk were particularly interesting and many differences were observed between the way of life in the Soviet Union and Canada. As well as a full work itinerary, arrangements were made during the visit for numerous sightseeing tours, visits to art galleries, museums and theaters, and the hospitality extended at a few apartment homes made a lasting impression of the sincerity and good will of the hosts.

REPORT ON VISIT TO USSR

May 17 - July 6, 1966

G.A. Gross

Department of Energy Mines and Resources

CHAPTER I

INTRODUCTION

An application and travel itinerary for a visit to the U.S.S.R. to study the geology of iron ore deposits was sent to National Research Council, Canada in January of 1965. The proposed itinerary for the spring and early summer of 1966 included visits to a number of Scientific Institutes and examination of some of the principal kinds of iron deposits in the field. The application specified particular interest in the geology of iron-formations with special emphasis on sedimentation, their origin and metamorphism. Study of the metallogenesis of iron, especially geological processes which affect the concentration of iron and ferride elements in igneous and metamorphic rocks, was requested in the plan of the visit.

NRC accepted the proposed plan for the visit in March 1965 and forwarded it to the Academy of Sciences, U.S.S.R., Moscow for approval. Under the agreement the Soviet Academy was expected to reply within three months as to whether the visit was acceptable. A reply was received by NRC from the Academy in November, more than 7 months later, advising that they would be able to receive me in the spring of 1966 for one month and that the duration of the visit might be extended after my arrival in the Soviet Union and clarification of scientific interests. May 1966 was proposed for departure from Ottawa and the Soviet Academy approved this time in a letter on January 25, 1966. Further detailed arrangements for the travel were made within

the next three weeks, including reservations for air travel, and a detailed itinerary was submitted to my Branch and Department with a request to use my official passport and for assistance in obtaining the necessary visas and travel documents.

A travel grant was received from National Research Council for this Exchange Visit on April 1 and a specific travel itinerary was sent on April 29 along with the titles of 3 scientific lectures that I was prepared to give. Letters of introduction, signed by Dr. J.M. Harrison, Assistant Deputy Minister, Department of Mines and Technical Surveys, were sent to a number of senior scientists a few weeks prior to my arrival in Moscow. These letters proved to be an important part of the preparation for the visit. They were evidently the first word that the Scientific Institutes received about my visit and special interests. Regret was expressed at the Institutes that this correspondence had not been sent to them earlier with more detail about my proposed itinerary. I conclude from my experiemce that such correspondence should be exchanged at as high a level as possible as the Academy administrators in the U.S.S.R. are sensitive about the support and backing given to an exchange candidate by his home organization. The scientists at the working level in the institutes however do not seem to be sensitive about such matters of protocol and were only too pleased to discuss their work and to exchange ideas with a foreign visitor interested in their special field.

I arrived in Moscow on May 19 on an Aeroflot IL 104 Jet plane and was met at the airport by Dr. A.A. Glagolev, Secretary of the Institute of Ore Deposits, Petrology, Mineralogy and Geochemistry (known as IGEM) and by Mrs. K.V. Podlesskiy, wife of a Scientific Secretary at IGEM who came along to be our interpreter. I was taken to the Academy of Sciences Hostel at 22 Profsojusnaja near Moscow University where I was given a room

with private bath; poor public facilities existed in this area for obtaining meals.

Dr. Glagolev met me the next morning and took me via the Metro System (subway train) to IGEM where I met Dr. G.A. Sokolov, the Acting Director. I received a very warm and friendly welcome at IGEM along with serious apologies about the poor standard of living accommodation at the Academy Hostel. It had been impossible to obtain better accommodation for me at an Intourist Hotel because of crowds of tourists, official visitors, and several congresses meeting in Moscow at that time. Although I was living in the Hostel with a number of other foreign scientists and research fellows and was reasonably comfortable, there was no doubt that the scientific personnel were embarrassed about this accommodation and said so emphatically but could do nothing about it.

The interview with Dr. Sokolov was directed toward further exploration of my specific interests and consideration of the program I had proposed. A new itinerary was proposed that seemed to be mutually satisfactory and this was to be submitted for approval to the Academy of Sciences and parts of it pertaining to field work and travel to the Ministry of Geology. Since approval for travel would require some time I was asked to be patient for ten days to two weeks while this itinerary was considered and approved. In the meantime I was to visit at IGEM and other Institutes in Moscow. The Academy of Sciences was very considerate and hospitable and provided an automobile and interpreter guide for sight seeing in the Moscow area on weekends.

A summary of my itinerary in the U.S.S.R. is given below. I was able to visit most of the Institutes that I had requested but only 2 of the 6 mine areas suggested for field inspection were granted. This did not compare favourably at all with the field itinerary granted to the two Russian Geologists

Drs. Shipulin and Semenov who were in Canada at the time of my departure for the U.S.S.R. Definite regret, if not embarrassment, was expressed before I left Russia by these two geologists as well as senior scientists at IGEM about their not being able to provide a comparable field itinerary for me in the U.S.S.R. to that provided in Canada.

It is most significant however that I was very well received at all the Scientific Institutes I visited and the interest by the U.S.S.R. scientists seemed to increase as the work progressed. Very fruitful exchanges of ideas and discussions of iron deposits developed and the visit was very useful, informative and satisfactory. Although field inspection of iron deposits was limited to two major and well-known areas, Krivoy Rog and Kursk, I was apparently one of the first foreign geologists to be permitted to visit mineral deposits since the last war. Other field areas requested are apparently still in zones where travel is restricted, in some cases even for Soviet geologists and citizens.

SUMMARY OF TRAVEL ITINERARY IN THE U.S.S.R., 1966

May 19	Arrived in Moscow from London via Aeroflot jet.
May 20	Taken to the Institute of Ore Deposits, Petrology, Mineralogy, and Geochemistry, IGEM, Moscow. Pm spent in sight-seeing in Moscow.
May 21	Touring Moscow: Academy of Sciences provided car and guide-interpreter. University of Moscow, Leniniski Prospect, the Kremlin.
May 22	Sunday. Academy car and guide provided for drive out of Moscow. Visit to Archangeliski Estate-10 miles from Moscow.
May 23	IGEM-Review of Iron Deposits of Soviet Union with Prof. G.A. Sokolov. Visit to some of IGEM laboratories.
May 24	IGEM-study of Kursk area with Dr. Kalganov. IGEM-Library

May 25 — Academy of Sciences Mineralogical Museum.
A.E. Fersman, Museum of Mineralogy.
Received by Mr. Gri Orlov, Director.
IGEM-Geochronology Laboratory - Dr. Leo Shanon.

May 26 — IGEM-Dr. Alexander Yanitskiy - Sedimentary ores of Kustanay Area.
Dr. Glagolev-Kursk area.
Dr. Nikitia Konstantin-Mineral Separation Laboratory.

May 27 — Institute of Geology, Academy of Science, Moscow.
Dr. V.A. Vakhromejer - Cretaceous rocks.
Dr. Mark Markov - Kamchatka area, volcanism and tectonics of East Siberia and Pacific.
Prof. Rauser Tschernousova - micro palaeontology.

May 28 — IGEM-Prof. D.G. Saposhnikov, Dr. Kalinin - Iron and maganese deposits of Karadgal.

May 29 — Sunday-Academy car and guide.
To Zagorsk Monastery - 70 kilometers north of Moscow.
History Museum of Moscow.

May 30 — IGEM-Dr. Chukrov, Director of IGEM.
Prof. I.A. Ostrovsky - Mineral synthesis and high pressure experiments.
Prof. B.P. Belikov - Rock mechanics.

May 31 — Vernadsky Institute of Geochemistry, Academy of Sciences, Moscow.
Prof. Nicholos I. Khitarov, Corresponding member.
Prof. A.I. Tugarinov - Sedimentation and origin of iron-formations.
Prof. A.B. Ronov - Sedimentation and origin of iron-formations.
Prof. Manskaya - Organic chemistry of iron compounds.
Dr. D. Drozdova - Organic chemistry of iron compounds.
Dr. Pavlenko - alkali metasomatism of iron-formation and sediments.

June 1 — Moscow University, Museum of Geology.
Director - Dr. M.D. Karitomov.
Akademician Smirnov - Professor of Economic Geology.

June 2 — IGEM.
Dr. T.N. Shadlun-Ore Microscopy Laboratory.
Dr. A.A. Filimonova-Ore Microscopy Laboratory.
Dr. A.D. Genkin-Ore Microscopy Laboratory.
Dr. L.I. Shabynin-Iron ores of S. Yakutia.
Lapidary Laboratory.

June 3 — University of Moscow - Went to ore microscopy laboratories.

June 4 — IGEM-Dr. Glagolev, Dr. Ostrovsky.
Museums in Moscow-pm.
Late evening - To Domodedava Airport and night flight to Novosibirsk.

June 5
Sunday — Arrived Novosibirsk via Il-18 turboprop jet.
Met by Dr. Pospelov, Director, Dr. S.S. Lapin - Institute of Geology and Geophysics and an Interpreter from Siberian Branch of the Academy of Sciences.
Dr. Tankred Golenpolsky - Interpreter - Prof. of Mathematics.
Sight seeing around Novosibirsk.
Dinner party at home of Dr. Pospelov.

June 6 — Institute of Geology and Geophysics, Novosibirsk - Prof. Prospelov, - interviewed. Prof. Kusnetsov, - interviewed.
Dr. Irina Nikolayeva, - Cretaceous Iron Deposits of West Siberian Platform.

June 7 — Institute of Geology.
Dr. S.S. Lapin - Magnetic susceptibility studies; instrumentation.
Museum - to photograph Angara Ilim iron deposit specimens.
Akademician Yuri A. Kuznetsov - Iron Deposits of Altai Sayan.
Dr. G.V. Polyakar, - Iron Deposits of Altai Sayan.
Dr. Alexander Dimkin-Urals - contact metasomatic deposits, Sarbay.
Ballet-Esmeralda - at Novosibirsk.

June 8 — Institute of Geology; Laboratory for studying liquid diffusion in rocks.
Dr. A. Lapuchov.
Lecture at University Auditorium - Iron Deposits of Canada.

June 9 — Institute of Geology.
Dr. Arkady Pavlov - Solution chemistry.
W.E. Sacharov.
Dr. N.H. Belous - Ministry of Geology - Sedimentary Iron Formations.
Art Gallery Novosibirsk - 1st Canadian visitor at gallery.

June 10 — Institute of Geology, Novosibirsk.
Dr. W.N. Scharapov - Contact metasomatic deposits - physicsl chemistry.
Prof. A.C. Kalugan - Jasper iron formations of Altai Sayan - Mongolian border area.

Geological Research Branch, Academy of Sciences.
To airport - Novosibirsk - return flight to Moscow.
Moscow Academy car and Dr. Glagolev - drive from airport to railway station - boarded Red Arrow-night train to Leningrad.

June 11 — Arrived Leningrad 8:15 AM.
To Muskovskia Hotel near rail station.
To Institute of Precambrian Geology, Academy of Sciences.
Met Director, Dr. K.O. Kratz - discussed itinerary for Leningrad visit.
Visit to Hermitage - Art Gallery and Museum.

June 12 — Sunday - Visited Peterhoft Museum, Summer palaces of Czars near Leningrad, with guide from Institute of Geology.
To theatre - Variety of ballet in evening.

June 13 — Institute of Precambrian Geology.
Dr. Boris V. Timofejev - work on Precambrian spores.
Seminar on iron-formations and Kola area.
P.M. - visit to Hermitage to see collection of gold from Scythian and early periods and collection of jewellery and precious stones collected by Czars.

June 14 — Institute of Precambrian Geology. Seminar on iron-formations and Precambrian Geology. Present were Dr. Kratz, Dr. M.D. Krilova, Dr. L.A. Prijatkina.
Gave illustrated lecture on iron-formation in Canada.
P.M. - Dr. D.A. Michailov - Aldan Shield.

June 15 — Gorni Mining Institute, guided by V.A. Glebovitsky from Institute of Precambrian Geology.
Director - L.N. Kell
Prof. A. Gorlikov - Professor of Economic Geology.
Prof. E.E. Tickomirova - interpreter.
Museum of mineralogy - one of finest if not the best in U.S.S.R.
Visit to St. Isaacs Cathedral.
Theater and ballet in evening.

June 16 — Mailed parcels of books home.
To University of Leningrad
Prof. Kukharenko - Economic Geology, ring dykes of Kola Peninsula.
Visit to museum.
Prof. V.I. Ledédév - Director of Geology Dept.
Visit to various laboratories of university.

June 17 Institute of Precambrian Geology with Dr. Kratz.
Dr. C.M. Kolesnikov - Organic compounds and acids.
To: All Union Geological Scientific Research Institute (VSEGEI) - Director L.I. Borovikov.
Seminar with number of geologists interested in iron deposits and Precambrian - Dr. A.S. Ostroumova, Dr. V.N. Mashkin.
P.M. - Visit to Museum at VSEGEI. Director of Museum - Mr. P.N. Varfalameev.
Mrs. N.A. Telrebotareva of museum acted as interpreter.

June 18 Institute of Precambrian Geology - Dr. Dagelaiski, Dr. Glebovitsky.
Visit to Geochronology Laboratory.
Talk with Dr. Gerling.
P.M. to museum of Russian Art.
Old Cathedral - Museum of Religion.
Departed Leningrad on night train to Moscow.

June 19 Sunday arrived Moscow by train about 9:00 AM.
To Ukraina Hotel; to Canadian Embassy to pick up mail.
Visit to Novodevichy Convent guided by Igor Mishin from IGEM.
Rest at hotel.

June 20 To IGEM - Met Dr. Valentina Gonschakova.
Met Dr. Shipulin and Dr. Semenov who had returned from exchange visit to Canada.
Dr. L.R. Bozisenko, Institute of Rare Elements, Mineralogy and Alkaline Rocks (IMGRE).
Evening - Ballet at theater and dinner as guest of Dr. Semenov.

June 21 Left Ukraina Hotel at 5 AM.
Departed Moscow on 1L-104 aircraft on flight to Kriboy Rog.
Met at Krivoy Rog Airport by Mr. A.D. Govelia - Manager of Geological Trust, Krivoy Rog, Prof. J.N. Belevtsev - Chief of Ore Department of Geological Institute, Academy of Sciences of Ukraine, and Mr. D.S. Lepky, Geologist, Assistant to Belevtsev and Interpreter.
To hotel - Krivoy Rog
P.M. To Geological Trust Headquarters.
Review of Geology of Ukraine Shield and Krivoy Rog.
A seminar with a large active and interested group.
Reception at Director's office and official welcome.
Further discussions in evening at Hotel with Prof. Belevtsev and party.

Late dinner with Mr. Lepky and Mr. Malutin, Chief Geologist of the Geological Trust.

June 22 — Visit to open pit mine - naturally enriched iron ore derived from iron formations.
Visit to site of deep exploration drilling and development drilling, Krivoy Rog.

June 23 — Visit to Krivoy Rog. Main taconite Mine.
To concentrator plant and Pilot plant for reduction roasting of iron.
Lecture given to large group at Geological Trust headquarters on (Iron deposits of Canada).

June 24 — Motor trip, Krivoy Rog to Gubkin, via Nikopol Zaporazh'ye, Novo Moscovsk, Kharkov, Belgorod.

June 25 — Geological Research Institute for KMA - Kursk Magnetic Anomaly.
Met Director S.F. Borisov.
Seminar to discuss Geology of KMA and iron ore deposits.
Present for visit were - Prof. N.A. Plaksenko - Veronez University
Prof. Tochilin - Veronez University
Dr. A.A. Illarionov - Gubkin
P.M. - Visit to mine, Lebedin Quarry Mine

June 26 — Rest - picnic in P.M. to woods near Gubkin.
Observed street dance in front of hotel in village square in evening.

June 27 — Visit to Gubkin Mine. Underground to see cross section of folded iron-formations.
P.M. Lecture on iron deposits of Canada. Large attendance.
Reception and meal at Director's office.

June 28 — Motor trip from Gubkin to Belgorod and to Kharkov.
Arranged to take night train from Kharkov to Kiev.
Review of work of Dr. Klagish in Kursk area at Belgorod.

June 29 — Arrived in Kiev by train 9:15 A.M.
Met at station by Secretary of Ukrainian Academy of Sciences.
To Geology Institute.
Met Prof. V.Y. Klimenko - chief of Geology Museum.
Interview with Prof. Schevchenko.
Tours of Museum.

June 30 — Meeting with Akademician Semenenko at Geology Institute, Ukrainian Academy of Sciences.
Prof. A.S. Povarennykh - Dept. of Mineralogy present.
Late P.M. and early evening spent sight-seeing in Kiev.

July 1 — Visit to Lavra Monastery in Kiev.
Sight-seeing.
Car offered in late P.M. for sight-seeing and trip to railway station. No vehicle available at Institute earlier in day.
Left Kiev by train to Moscow.

July 2
Sat. — Arrived Moscow.
Rest, shopping.
Dinner with Dr. and Mrs. Shipulin and family.

July 3
Sunday — To opera at Bolshoi Theater from 11: A.M. to 3: P.M.
Boat ride on Moskva River.
Rest.

July 4 — To IGEM in Moscow.
Discussion of travel reservations for my departure from U.S.S.R.
Interviews with several senior scientists.
Discussion with Prof. Sokolov and talked about the possibility of having an International symposium on cherty iron-formation.

July 5 — Most of the P.M. straightening out travel reservations with In-tourist with assistance of Mr. Semenov from Academy.
Ballet at Bolshoi theater in evening.

July 6 — Departed Moscow at 12:20 P.M. by IL-104 Aeroflot jet for Copenhagen.

CHAPTER II

SCIENTIFIC WORK, GEOLOGICAL INSTITUTES

The institute of Ore Deposits, Petrology, Mineralogy, and Geochemistry, IGEM, 35 Staromonetniy, Pereulok, Moscow, of the Academy of Sciences took charge of planning and arrangements for my visit in the U.S.S.R. and looked after liaison with other Institutes and organizations. The research work at IGEM covered many of my major scientific interests in the U.S.S.R. and I am grateful to the staff of this Institute and particularly to Prof. G.A. Sokolov for their keen interest, consultations and advice in preparing a revised work itinerary that could provide optimum opportunity for pursuing my interests and for meeting outstanding geologists who specialized in iron deposits. Introductions and description of my specific interests and requests were forwarded to colleagues in other Institutes by IGEM staff and tentative plans were presented on my arrival at these Institutes for making optimum use of the allocated period of the visit. In the case of my visits at Novosibirsk and in field areas at Gubkin and Krivoy Rog, a number of geologists came from neighboring Universities and Institutes to participate in seminars and discussions. The response of the Russian geologists to my visit was most gratifying and I felt that this was an acknowledgement of their esteem for the Canadian geologists represented.

MOSCOW ORGANIZATIONS VISITED

IGEM This Institute, directed by Prof. Chukrov, is organized mainly for fundamental research on formation of ore deposits. It aims to study all geological factors pertaining to the nature and origin of mineral deposits and the complex inter-relationship and significance of these factors in producing mineral

concentrations in the earth's crust. The Institute is organized in nine Divisions for study of 1) endogenic ore deposits 2) exogenic ore deposits 3) non-metallic deposits 4) magmatic petrography 5) metamorphism and metasomatism 6) mineralogy 7) geochemistry 8) physical chemistry, experimentation in high temperatures and pressures conditions and 9) laboratories. Laboratory facilities are provided to support these fundamental studies and include extensive technical equipment for Absolute Age Determinations using K/A, Rb/Sr, Ur/Pb, methods, electron microscopy, x-ray diffraction, optical mineralogy, infra-red microscopy, DTA analysis, magnetic nuclear resonance, stable isotope studies of Pb, S, B; chemical analyses, microprobe investigations, and equipment for study of physical and mechanical properties of rocks, for separation of mineral components of rocks and for lapidary and specimen preparation work. The Institute has a small but very efficient scientific library where compilation of bibliographies of both foreign and domestic work is done in support of staff research. A small petrology museum for display and study of reference collections is an additional facility. There are about 800 persons on the staff of this organization with senior scientists making up about 25%, another 25% have university degrees and the remainder are technicians and scientific support staff.

Scientists at IGEM seem to have a reasonable amount of equipment for their studies but most work under very crowded and uncomfortable conditions where lighting and ventilation is often poor in comparison to what we are accustomed to having. Research teams led by senior scientists are a feature of the organization here as at most other Institutes visited and seem to function quite well as a medium for combining training and research objectives. Equipment seems to be allocated for the team and its project needs and duplication of some apparatus was

noted. For example, high pressure and temperature experiment laboratories and age determination laboratories have the appearance of small machine shops since they build much of their equipment and apparatus and machine tools with skilled operators are part of the set-up. The research team and laboratory organization at IGEM was typical of that observed at other Institutes.

During the first two weeks of my visit, while in Moscow, I commuted daily by Metro (subway train) from my hostel to IGEM. A ten minute walk from the subway station to the Institute through an older part of Moscow was an interesting and enjoyable part of each day. Along my way I observed much architecture of earlier periods including the very ornate edifices of the French Embassy, a working church, the church where Ivan the Terrible was married, and a library. Local people at the vegetable market and children at the primary school seemed to respond to the new vigor of a spring morning in about the same way the world over.

Study sessions with Dr. G.A. Sokolov, Acting Director of IGEM, during the early part of the visit were particularly stimulating and informative; after making a revised itinerary for my travel and work he reviewed the organization and scope of interest of IGEM and I was asked to outline the general organization of my Branch and Department and where my project on iron deposits fitted in our national scheme of work. Prof. Sokolov proceeded to give me a briefing on the metallogenesis of iron in the U.S.S.R. and to describe characteristic deposits in major tectonic regions. What was especially revealing to me was the vast extent of some of the Mesozoic sedimentary iron formations in the West Siberian Platform, the similarity of younger marine and continental iron beds, the magnitude and distribution of replacement type iron deposits in the Urals and Siberia, and special factors which seem to control the formation and distribution

of the magnetite deposits in volcanic pipes and diatremes that pierce the sedimentary rocks and trap assemblage of the East Siberian Platform.

A lengthly discussion was held on the metallogenesis of iron in the Soviet Union and factors to be considered in the development of maps depicting metallogenic features. An adequate classification of mineral deposits is an essential step in these studies and it was agreed with emphasis by Prof. Sokolov that empirical data and descriptive information was the proper basis for initial classifications. Categorizations based on empirical data usually suggested the general nature of mineral origin and formation and provide a sound basis for orienting specific studies on genetic processes and for the utilization of data obtained from laboratory studies carried out under controlled conditions. Comparison of classification of iron deposits used in Canada and the U.S.S.R. showed that we were using a similar basis but that Prof. Sokolov has used more subdivision for both sedimentary deposits and those related to igneous processes and that much consideration of genetic processes is inherent in his classification.

Several sessions were held with Dr. Kalganov of IGEM, a specialist on the geology of iron ores, who has done extensive work on the deposits in the Kursk area and at Kerch. This was a particularly valuable briefing for me and helped to show that there was very great similarity between the naturally enriched iron ore at Kursk and that in the Knob Lake area of Canada. Examination of specimens revealed that the iron formation and rocks at Kursk are more highly metamorphosed than at Knob Lake and some of the enriched ores have been metamorphosed. The iron ore formed prior to the Devonian, apparently in the early Proterozoic, and some very ancient bauxite zones are present in the stratigraphic section. Discussions of the origin of the ore and

of more fundamental problems concerning the origin of the quartz iron sediments occupied much of our time and provided a good preparation for my field visit to the Kursk area.

The Oligocene marine oolitic iron beds at Kerch on the Black Sea were the subject of another discussion with Dr. Kalgonov and examination of his specimens was very useful. These beds are believed to be formed from iron derived from deep weathering of rocks in the Ural Mountains and transported in particulate, colloidal state and in organic solution.

Dr. A.A. Glagolev described his work on the Kursk area in some detail. He has studied alkali metasomatism in the iron-formation and has found that it takes place in the highly folded and deformed zones and postulates that the alkali constituents migrated from the deeper basement rocks during one period of metamorphism.

A very interesting discussion was held with Prof. D.G. Saposhnikov and Dr. V.V. Kalinin on the cherty iron-formation at Karadgal, located about 400 miles east of the Aral Sea in Kazakh S.S.R. The iron-formation in this area is Devonian in age and extends for about 16 miles along strike. Massive magnetite beds in the west end of the range occur with red chert or jasper in a stratigraphic sequence up to 170 meters thick. The east end of the chert formation is composed of hard manganese-rich beds and jasper. Sedimentary sulphide facies in this rich succession were mentioned as well as very thick barite beds in the lower part. Primary sedimentary features could be seen in the specimens examined. It is accepted beyond doubt by those who have studied this iron manganese formation that it is the product of volcanic exhalations during a period of extensive vulcanism. This deposit is perhaps unique in that it contains many features which have been attributed to vulcanism in other places but never found associated directly in one formation. The publications

presented to me describing the association of cherty manganese and iron beds are of very special value in our studies of iron formations.

Dr. Alexander Yanitsky provided a very good briefing on the oolitic continental or river bed iron ores located near Kustanay east of the Urals. These beds up to 25 meters thick are Oligocene in age and iron derived from the deep weathering of basic and ultrabasic rocks has been deposited along old river courses. Much was learned from examination of the oolitic iron ore specimens. Nickeliferous laterite material from weathered crust overlying ultrabasic rocks from the Urals was also examined. The heavy crust of brown limonite masked much of the relict texture of the serpentine rock, and streaks of garnierite in these specimens. The publication he presented to me documents much of the information that we discussed.

Akademician D.S. Korzhinskii at IGEM took considerable interest in my visit and discussed some of his work on post-magmatic processes and their significance in the study of alkali metasomatism. He elaborated on some of his ideas about mobile components and processes of mineral formations which were presented in a review of lectures given in the U.S. and Canada in 1963-1964. He extended his hospitality the day before I left Russia and took me to lunch at the Academy of Sciences dining room on Leniniski Prospect. His discussions of the problems of planning and promoting good research programs tempered with numerous humorous stories certainly helped me to put my experiences in the U.S.S.R. in perspective and to appreciate the fact that we have common problems.

Dr. Valentina Gonschakova works on the petrology of basic and ultrabasic rocks and was anxious to discuss some of the problems about the origin of the extensive basalt sills and volcanic pipes in the East Siberian Platform. She was very much

concerned about the relative timing of the intrusions of ultrabasic and basalt rocks and whether alkali constituents were concentrated mainly by differentiation processes in the magma or by the assimilation of sediments. She challenged the ideas held by many of her colleagues concerning the assimilation of salt beds by basic magma, and doubted whether the chlorides in the resultant volatile fraction of the magma were an important factor in transportation of iron and in the formation of magnetite in the breccia pipes of East Siberia.

Dr. L.I. Shabynin discussed his work in the Aldan Shield and the magnetite areas in the highly metamorphosed gneisses and granulite rocks of South Yakutia. A large potential of iron ore is present in magnetite deposits which are associated with pyroxene and amphibole skarns in dolomite rocks. Tourmaline and barite minerals are often abundant. The source of the iron is still not determined beyond doubt. The deposits are similar to many in adjacent areas in China, and will likely be brought into production in about 10 years when railway construction is completed.

A description of some of the laboratories at IGEM and discussions with scientists in charge will be given in more detail in a later report. Only brief mention of some of these contacts are included here.

Dr. R.V. Bojarskaya described her work using electron microscopes to investigate iron-titanium oxide and clay minerals. She has three instruments in the laboratory, one made in Japan, one in Germany, and another of Russian or Hungarian origin.

Mr. A.I. Gorshkov described his x-ray diffraction studies and special work with single crystal studies. He has investigated the mineral antigorite and clay complexes in considerable detail.

Dr. G.O. Piloyan operates differential thermal and

differential gravity analysis equipment over a wide range of temperature conditions at atmospheric pressure. The objectives of his project are to provide fundamental thermal and gravity data on all common minerals. In the course of his work he has discovered some mineral phases such as Cr_2SiO_4 that was not previously recognized.

Mr. Leo Shanin, a physicist, is in charge of the Geochronology laboratory and has designed and constructed much of his equipment. He is producing large numbers of analyses and is satisfied that his analytical accuracy is good but expressed serious doubts about much of the interpretation and meaning of the isotope data in geochronology.

Prof. I.A. Ostrovskii, a senior scientist, has been working on high pressure systems. He has synthesized a large number of mineral phases including mica where ferric iron has substituted for all the alumina in atomic structure. High pressure phases of SiO_2 are of current interest. He suggested that the role of hydrogen in the metamorphism of quartz magnetite rocks may be much more significant than realized at present. He has also found that mica minerals can absorb large quantities of argon and that potassium-argon ratios in minerals may be a function of rock pressure.

Prof. B.P. Belikov has a staff of 10 to 15 who are experimenting in rock mechanics and the elastic properties of rocks. He started his work on monomineralic rocks and has now studied a large number of polymineralic igneous rocks. He has investigated the stress and strain characteristics of most common rock-forming minerals and pointed out that previously only data on physical constants for quartz and olivene were available in American literature. He has produced a vast amount of data which is being prepared for presentation at the next International Geological Congress.

Dr. Nikita Konstantin operates the mineral separation laboratory at IGEM. He has a wide variety of equipment, and small scale apparatus of nearly every type is used ranging from high speed centrifuges, various electrostatic separators to flotation cells. He described complex flow sheets for the complete separation of rock specimens into single mineral fractions. More than 2000 samples a year are given routine treatment to provide monomineralic fractions for each sample. Much of the equipment has been designed by Dr. Konstantin and he says that his methods and laboratory has been used as a model for laboratories in Leningrad, Poland and many other places.

The ore microscopy laboratory at IGEM is operated by Dr. S.I.N. Shadlun, Dr. A.A. Filimonova and Dr. A.D. Genkin. We discussed specimen preparation and polishing techniques and I judge from the specimens I examined and what I saw that our laboratories in Ottawa are well in advance of theirs. Nevertheless they were producing good surfaces for study using cloth laps for final stages of polishing; rarely is diamond paste or dust used, which is probably still in short supply. Dr. Genkin spent considerable time showing his x-ray diffraction equipment and his microspectrometer. This laboratory has done considerable work on nickel-sulphide ores; those from Norilsk were mentioned, as well as polymetallic sulphide ores and various magnetites. This team was very familiar with the minerography work done at Queen's University in Canada and they asked particularly about the late Dr. J.E. Hawley. They had been very pleased with Dr. L.G. Berry's Moscow visit and Dr. Genkin met Prof. Joliffe at the Prague conference.

The lapidary laboratory at IGEM is staffed mostly by women, and thin-sections of rocks are ground in the final stages by hand. Twenty or thirty rock chips are mounted on a metal disk with balsam and the whole lot are ground to a flat surface

in the power machine. The specimens are then remounted for grinding the second side flat before the 2-4 mm thick slices are taken for hand grinding. Diamond saws are only used for cutting certain large or special specimens. I believe the technique of mass mounting of specimens on a wheel for rough grinding may be a hang-over from the time when diamonds were not available in the U.S.S.R. The technician in charge informed me that they found Siberian balsam much superior to Canada balsam for mounting thin sections!

MOSCOW - Institute of Geology, Academy of Sciences, May 27.

Part of a day was spent at this Institute where research on fundamental geological problems is carried out. I was received by Prof. V.A. Vachromejera, senior geologist studying Cretaceous stratigraphy, and Dr. Mark Markov, an Institute secretary. Because of my interest in the Kuril Islands and thermal springs on Ebeko Island, described by Zelenov, which are rich in iron and give rise to modern iron rich sediments, Dr. Markov a specialist in the tectonics of this region briefed me on the geology of the Kamchatka, Sea of Okhotsk and far eastern Siberian region. He was of the opinion that there was nothing distinctive about the vulcanology of the Kuril Islands to account for the iron rich thermal solutions and little else was known about the iron sediments outside of Zelenov's reports.

An interview was held with Prof. Rauser Tschernousova and two of her associates who are studying micropalaeontology and who have zoned late Precambrian sediments using spores. I was particularly interested in exploring the subject of microfossils in cherty sediments including any occurrences in cherty iron-formations. They believe that cherty iron rocks in the Soviet Union are all too highly metamorphosed for the preservation of microfossils and since they seemed to be unfamiliar with recent work

in Canada and the U.S. on microfossils in cherty iron-formation nothing further of special interest was gained in the interview.

MOSCOW - Vernadsky Institute of Geochemistry, Academy of Sciences of U.S.S.R., Moscow B-334.

I was received at this Institute by Prof. Nicholas I. Khitarov, a corresponding member of the Academy of Sciences, who has extensive laboratory facilities for studying the effects of different solutions on rocks under high pressure and termperature conditions. I was briefed on the organization and work of this Institute and shown a number of the laboratories.

Discussions were held with Prof. A.I. Tugarinov, a geochemist, and Prof. A.B. Ronov, a sedimentologist, on problems concerning the source of iron in cherty iron-formations. Prof. Tugarinov discussed his study of minor elements in iron-formations which apparently has the same objectives as work initiated in my Canadian project. He claimed to have convincing isotope geochronology data to show that all Precambrian iron-formations were deposited in one brief period abour 2500 million years ago. I found that his lack of basic information about the occurrences of these rocks throughout the world left his thesis open to challenge and dispute. He further stated that they found that sulfur isotope ratios in Precambrian sediments were consistly similar to ratios found in meteorites and that work in Canada (Dr. Thode's name was mentioned) seemed to be incomplete because work had been done on samples collected at random. Prof. Ronov favored a sedimentary source for the iron in cherty iron-formations but admitted that his work had been more in general sedimentology and that he had not been involved in special studies of cherty iron rocks. Our discussions proved to be very stimulating and references were made to considerable supporting data but time did not permit them to show or discuss this data. In spite of extensive laboratory facilities for providing data on

these sediments I doubt whether any new concepts or ideas on the genesis of iron sediments have been advanced at this Institute.

Dr. Manskaya, an organic chemist, is writing a text-book on organic chemistry relating to uranium, ferride elements and germanium and is concerned with the study of properties of organic compounds. Neither Dr. Manskaya or her associate, Dr. Drozdova, seemed to be particularly interested in the application of their work in studying geological processes and they assured me that transportation of ferride elements by organic solutions and their sedimentation was of more concern to soil chemists. Geological application of their work was obviously beyond their field of interest.

Dr. Pavlenko discussed his studies of alkali metasomatism in the Kursk iron-formations. His thesis is that a large group of elements including some ferride elements originally occurring in the sedimentary succession containing iron-formation are mobilized during metamorphism and replaced at the base of overlying dolomite beds. He finds evidence for the accumulation of metallic elements at the base of dolomite beds in many parts of the Soviet Union.

Geology Department, Moscow State University.

An interesting interview was given by Prof. V.F. Smirinov, an Akademician and Economic Geologist in this faculty. He described the work of his faculty, their facilities, and showed me maps and charts on iron-deposits, some for Canadian deposits, which he uses in his lectures. We discussed ore deposit studies in general and his new text book on the subject. His special interest is lead and zinc and polymetallic sulfide deposits and I returned another day to visit his minerography laboratory and to inspect facilities used by graduate students. Their microscopy equipment and the quality of prepared specimens

was not as good as that used in Canada. Apparatus for measuring electrical conductance of rock and mineral specimens is installed in his laboratories and it is significant that measurement of conductance properties seems to be a routine part of mineralogical investigations of ore. Considering the amount of space allocated to scientists in many of the Institutes I visited, this university department seems to be highly favoured.

In spite of the great crowd of visitors in the university attending the International Oceanographic Congress, I was given a special conducted tour of the earth sciences part of the university museum, by the Museum Director, Dr. M.D. Karitomov. This section of the museum is housed on the 25th, 26th, and 27th floors and is one of the finest displays of mineralogical and geological material to be seen anywhere. This museum is used extensively for teaching purposes, and exhibits illustrating geological processes are outstanding. The formation and occurrences of mineral deposits is given special emphasis in the museum and the very large display area devoted to the geology of iron ores impressed me greatly. The exhibits showing and depositional environment for various iron sediments were particularly well done and metallogenic maps for iron and manganese in the Soviet Union based on Prof. G.A. Sokolov's work, which was previously presented at the International Geological Congress in India, made a very forceful and revealing exhibit.

Displays in this museum of topographical, ecological, and geographical zones in the Soviet Union are outstanding and the soil profiles from different parts of the country were most impressive. An upper floor, which had been used mainly for displays and general geology, is now being utilized as a working area for graduate students and for research.

Fersman Mineralogical Museum, Academy of Sciences of U.S.S.R., Moscow.

Dr. Gri Orlov, Director, conducted me on a tour of the museum. An exceptionally fine collection of meteorites is displayed, including meteorites containing diamonds which were first discovered and investigated by Dr. Orlov. The display of material from diamond pipes in Siberia is also very impressive. The exceptionally large specimens of gems, precious and semi-precious minerals, and decorative minerals and rocks are outstanding features in this museum. The well-organized and imaginative display setting for a very remarkable collection makes this one of the world's finest mineral museums and it was a rare privilege to see it and have the benefit of Dr. Orlov's comments and guidance.

NOVOSIBIRSK - THE INSTITUTE OF GEOLOGY AND GEOPHYSICS, Siberian Branch of the Academy of Sciences of the U.S.S.R.

June 5th to 10th was spent at this Institute in Science City, a research and educational center located about 10 kilometers from the city of Novosibirsk in Siberia. The direct night flight from Moscow to Novosibirsk on an Ilushia 18 turbo-prop airplane took about 4½ hours and I received a warm welcome at Novosibirsk airport from Prof. G.L. Pospelov, Director of the Institute, an Institute scientific secretary, Dr. S.S. Lapin, and an interpreter from the Siberian Branch of the Academy of Sciences. We drove directly to a very comfortable modern hotel in Science City where I relaxed for a few hours after the all-night journey and was able to adjust to the 4 hours' difference in time between there and Moscow. Later in the day Prof. Pospelov and Prof. Tankred Golenpolsky, a mathematics professor who interpreted for us, took me for a motor trip to see the Novosibirsk area with its hydro power development on the Ob River, and crowds of people on

the beaches of the lake, known locally as the "Ob Sea", formed by the power dam. Many people were swimming while others enjoyed sailing and water skiing on a protected part of the lake which was being developed (for water sports and a marina) by the Trade Union of Scientific Workers. I had an interesting conversation with the trade union leader, comparing our Civil Service Recreational Association with their recreational association.

A number of sights of historical interest were observed in the area, including a few reminders of the unhappy experiences of many people sent to this area in the past. Prof. and Mrs. Pospelov invited me to dinner at their apartment home in the evening along with Prof. Golenpolsky and his wife, and Akademician Yuri Kuznetsov. This was one of the most pleasant occasions of my U.S.S.R. visit and conversation roamed from comparison of life in Canada and the U.S.S.R., to modern practices in education, from the increased interest and need felt in the U.S.S.R. for teaching subjects in the humanities in the science curriculum, to interests in literature and the arts. I certainly gained a fuller appreciation of life in the Soviet Union and better understanding of the people I was working with and their problems. I sensed that there was much more concern in the Soviet Union about the individual, his personal aspirations and spiritual well-being than I had previously imagined.

Novosibirsk is a center for the government of the state, for manufacturing heavy machinery, agriculture, and for cultural interests in Siberia, as well as an important administrative center for much of the scientific work in the eastern U.S.S.R.

Science City near Novosibirsk has been constructed during the past 6 years and much of the natural wooded environment has been preserved in the layout of this modern city developed solely for the scientific community. At least 17 scientific

institutes and a university are located here where nearly all kinds of basic research are carried out ranging from nuclear physics to most branches of the natural sciences. One of the basic purposes behind this development is to foster a close relationship between scientific personnel in different fields and improve personnel communications among research scientists. I judged from my experiences in Novosibirsk that they are achieving success in these objectives.

I enjoyed very kind and attentive hospitality while in Novosibirsk from everyone I met and some of the younger geologists accompanied me on the ten minute walk from my hotel to the Institute in order to be able to talk about geological field work, to compare opportunity for career development in our two countries or simply to practice their English. An evening excursion to Novosibirsk to see a ballet performance at their theatre, rated next best to Leningrad and Moscow, was most enjoyable. My visit to the Art Gallery showing art of Siberia was turned into a special occasion because I was reported to be the first Canadian to visit this gallery and its establishment has been a project dear to the heart of Prof. Pospelov. It is interesting to note that this gallery is staffed entirely by women, a fact they proudly point out.

A. SCIENTIFIC WORK AT THE INSTITUTE OF GEOLOGY AND GEOPHYSICS AT NOVOSIBIRSK

Much of the activity at this Institute is centered on the study of geological processes related to the formation of epigenetic ore deposits. Extensive experimental work is carried out on the chemistry, physical chemical properties and thermodynamics of ore forming solutions and the geological environment in which mineral deposits form. Studies range from mineralogical and petrographic descriptive work on the ore zones and internal features of deposits, to theoretical consideration, to experimental testing of hypothesis which may involve mineral synthesis and study of phase relations, liquid diffusion and solutions under high pressures and temperatures.

I started on Monday morning at this Institute with discussion of geological work of interest in the area with the Director, Prof. Dr. G.L. Pospelov and an itinerary was prepared for the week.

Prof. Pospelov, with a number of his colleagues, gave a very informative seminar on the unique type of magnetite deposits, in breccia pipes and diatremes which penetrate the Paleozoic sediments and basalt sills along the Yenisy River in the Eastern Siberia platform. Six different stages of alteration are recognized in the genesis of these pipes which include a period of soda metasomatism followed by metasomatic alteration processes which produce a rock that in many ways looks like a tectonic-breccia. It was demonstrated that the magnetite of these deposits, which has a distinctive spheroidal, orbicular or colloform texture, formed under low pressure conditions during a late stage of alteration. I was disappointed that a field visit to one of these deposits could not be arranged but I was permitted to photograph specimen material in the Institute Museum and some very useful coloured photoslides were obtained.

Some of the experimental work was described at this Institute on the diffusion of liquids in rocks and the synthesis of magnetite. Many typical textures of vein minerals, vein structures often attributed to structural deformation, and laminated mineral textures have been synthesized by having solutions of different chemical composition diffuse or permiate porous rock or sand media. It was demonstrated that some of the small scale primary features observed in siliceous iron sediments form as concretions and by diffusion of solutions in the rock.

A later visit to their special laboratory for the study of liquid diffusion in rocks, where Dr. Alexander Lapuchov is in charge, was a most instructive experience. The technique used is very interesting. Rectangular flat transparent containers are filled with monomineralic sand or whatever granular medium is selected and solutions of different composition such as NaOH, $FeCl_3$, $KCrNO_3$, and PbI, etc. are introduced in separate sides of the container. Solutions giving a coloured precipitate have been selected and the migration of each solution and resulting formation and crystallization of precipitates are recorded using time-lapse photography. The results of some of these experiments seen in the motion-pictures were fascinating. A full description of this work cannot be given here, but some of it has been published and the film gave a vivid record of the formation of, styolites, concretions, laminated vein structures, the development of fractures in rocks by forces exerted during the crystallization of some minerals, and other patterns of laminated mineral zones formed without any structural dislocation taking place.

CONTACT METASOMATIC DEPOSITS OF EASTERN U.S.S.R.

Discussion on the contact metasomatic iron deposits in the area southeast of the Kusnetz coal basin were held with Prof. Pospelov, Akademician Yuri Kusnetsov and Dr. Gleb V. Polyakar. Detailed maps and cross sections of some of these deposits were examined and geological similarities between these deposits and some in Canada are found. The U.S.S.R. deposits are, however, much larger than any of this type found in Canada and many ore bodies have more than 100 million tons of ore.

Prof. Pospelov emphasized that these deposits are present in geological structures in the vicinity of, or subsidiary to, very deep structural dislocations which extend down to the Morovicik discontinuity zone in the earth's crust. The magnetite and hematite deposits were formed from solutions which came from deep in this structural zone and were emplaced in the subsidiary structures where the physical and chemical environment was most suitable. He emphasized that their genetic studies had been very significant in the exploration for ore and demonstrate how their knowledge of genesis and structure of these ore zones had led to the discovery of huge ore bodies that were isolated from the ore zones previously explored near the surface. Akademician Kusnetzov and Dr. Polyakar described and emphasized some of the more detailed ore controls and factors in ore formation. Soda metasomatism is important and deposits south of Abakan are related to albitized gabbro, those south of Artemovsk and east of Abakan to a soda rich syenite rock, and those east of Stalinsk are related to granite rocks.

Another group of contact metasomatic magnetite deposits in the eastern Urals was described by Dr. Alexander Dimkin. The deposits occur in a narrow belt less than 60 kilometers wide, west of the steel center at Kustanay, and he showed a number of detailed charts and cross sections. The deposits are good exam-

ples of selective replacement in dolomite rocks with complex skarn mineral development. The largest deposit in this belt and perhaps the largest of its kind in the world is Sarbay which contains more than 800 million tons of ore.

Dr. S.S. Lapin described some of his work on special methods of computing iron ore reserves in deposits of the contact metasomatic type. He evidently does considerable consultation for the iron ore industry in estimating ore reserves and in grade control in the mines. He showed me a number of small magnetic susceptibility meters that he had made that are especially adapted for indicating the magnetite content of the ore in the mine stopes. With the use of empirical data compiled for each kind of ore zone he can predict the amount of magnetite that can be recovered with a fair degree of accuracy.

SEDIMENTARY DEPOSITS

Dr. I.V. Nikolayeva described her work on the very extensive Cretaceous oolitic iron beds distributed around the eastern and southern margin of the West Siberian Basin. All aspects of the nature and origin of these sediments were discussed with the benefit of an excellent collection of material in the museum. There seems to be no doubt that the iron in these rocks is derived from the weathering of older rocks and her work on sedimentary facies, direction of transport of sediment, and identification of old river beds and estuaries around the border of the basin, is most revealing. Her work is a classic example of its kind. The total thickness of iron formation is several hundred meters and one of the greatest concentrations of sedimentary iron in the world is found in this West Siberian Basin. The quality of the material is such, however, that it would not meet our specifications for iron ore.

Dr. N.H. Belous is one of the Soviet Union's out-

standing specialists on sedimentary iron ores, especially those in the eastern part of the country. She is currently doing special studies on iron ore and mineral resources for the Ministry of Geology at Novosibirsk. During the course of our afternoon discussion she showed me very interesting charts relating various kinds of iron formation to different geological periods. She demonstrated that cherty-jasper iron-formation younger than Devonian age is not found in the Soviet Union and that oolitic non-cherty iron formations of our Clinton and Minette types are not found in rocks older than Upper Precambrian. She is satisfied that cherty iron-formations are the product of volcanic sedimentary processes and the iron in non-cherty beds is derived by deep weathering of rocks. This opinion, I found, is widely held in the Soviet Union but the evidence cited for support of this thesis was no more convincing than that considered in North America and no new lines of evidence were presented. I concluded that Dr. Belous had probably done more on the origin of iron sediments than any other specialist I met and she demonstrated an exceptional grasp of the whole complex problem. It may be regretted that she has been diverted to mineral economics studies and is not in a position to make her fullest scientific contribution to the development of mineral resources.

Prof. A.C. Kalugan of the Geological Research Branch of the Siberian Academy of Sciences in Novosibirsk is another outstanding specialist on iron-formations. He presented documentary work on a Devonian jasper iron-formation associated with volcanic and ignimbrite rocks that extend for 600 kilometers in the Altai-Sayan mountains and eastward into Mongolia. His pictures and specimens illustrating primary sedimentary features in these cherty rocks indicated that this formation is similar in many respects to the Snake River iron-formation in Yukon, Canada. His work on primary sedimentary features was particularly in-

teresting and he indicated that a catalogue of sedimentary features in iron-formations is to be published very soon. Comparison of illustrations of Canadian material I had with me was most valuable and we found close agreement in our interpretations.

GEOLOGY DEPARTMENT, UNIVERSITY AT NOVOSIBIRSK

I was asked to give a lecture on the iron deposits and iron metallogeny in Canada, which was held in the auditorium of the university. This was very well received by a group of 30 to 40 geologists from various organizations. I illustrated my talk with numerous colour pictures to help bridge the language barrier, and good language interpretation as well as good projection facilities, the best I found in my whole time in the U.S.S.R., seemed to make the venture successful.

LENINGRAD - June 11-18

Very good travel arrangements were made for my trip from Novosibirsk to Leningrad. I left Novosibirsk in the early evening on an Il-18 aircraft and the direct flight to Moscow took about six hours. Dr. A.A. Glagolov of IGEM met me at the airport and we drove with an Academy car to the railway station where I boarded the Red Arrow, a fast night train for Leningrad. I was met at the railway station at Leningrad in the morning by a representative from the Academy of Sciences and taken across the street to the Muskovskia Hotel where I relaxed for a few hours.

Later in the morning a young laboratory technician called for me at the hotel and took me to the Institute of Precambrian Geology where I met the Director, Dr. K.O. Kratz. We discussed plans for my itinerary for the week in Leningrad as well as possibilities for entertainment and sight-seeing over

the weekend.

A geochemist from the Institute accompanied me to lunch and then took me on a guided tour of the Hermitage art gallery and museum. On Sunday another young lady from the Institute took me by train to Peterhoft the old summer residence of the Czars near Leningrad and we returned in the late afternoon on a hydrofoil pleasure boat. I went to the theatre in the evening where a variety program of classical ballet provided delightful relaxation.

INSTITUTE OF PRECAMBRIAN GEOLOGY - LENINGRAD

Dr. Boris V. Timofejev at this Institute works on spores and micro-fossils in Precambrian rocks. He described some of his material and has been able to establish stratigraphic zones in Proterozoic rocks as old as 1700 million years by using spores. Most of his microfossils are recovered from phyllitic rocks, and only a few chert rocks have yielded organic forms. His work is still considered to be at a preliminary of exploratory stage. He expressed doubt as to whether the fossil forms found in our Gunflint iron-formation would prove useful for establishing stratigraphic zones and he also doubted whether the organisms represented by these fossil forms played any significant role in the deposition of the iron-formation.

A seminar was held at this Institute to discuss Precambrian iron-formations, especially those in the Kola Peninsula and Baltic Shield Area. Prof. Kratz, Drs. M.D. Krilova, L.A. Prijatkina, V.A. Glebovitsky, V.B. Dagelaiski and several others were present and our discussions were concerned mainly with characteristics of highly metamorphosed iron-formations and the physical-chemical conditions that bring about their recrystallization. The iron-formations in granulite metamorphic facies in the Kola Peninsula, judging by their specimens, are oxide facies

of our Algoma type but are not as coarse-grained as our Wabush iron-formation, and the magnetite grains could be liberated at 100 mesh size or perhaps coarser. The seminar group consisted mainly of petrographers who had worked on metamorphic iron formations. They agreed that metamorphism of these rocks in their experience was an isochemical phenomenon which included alkali constituents, that each layer or bed behaved as a separate chemical system during metamorphism, and that the state of oxidation of the iron minerals did not change appreciably during metamorphism. These principles have been accepted for some material in the course of our work in Canada and I was interested in finding corroboration in the work of this group. There is one area however in the vicinity of a diorite intrusion where iron from the iron-formation has been remobilized and the whole mass is highly altered. I was asked by this group to give a short lecture on the iron-formation in Canada which I illustrated with colored pictures showing lithology of typical metamorphosed iron-formation. The pictures were an excellent medium and stimulated discussion and comparison of these rock types. The group was also highly impressed with a map of the Labrador Geosyncline I displayed which shows the extension of this iron belt into the Grenville orogenic belt. Apparently this group had still considered the Grenville as an Archean province and seemed fascinated with the effects of the Grenville orogeny on the older iron-formation.

On another day Dr. Dagelaiski presented more detailed geological information on the Kola Peninsula iron-formation and the geology of this area. Iron ore concentrate is being shipped to western Europe from this iron range and it could become a major source of iron ore for export in the future.

Dr. D.A. Michailov described some of his work in the Aldan Shield. He described magnetite occurrences which are

mostly small and the magnetite usually contains up to one half percent magnesium. Rocks consisting of phlogopite, diopside and magnetite are of special interest. He believes that solutions dissolved magnesium and iron from rocks in the deeper zones, permeated the structure along faults and fissures, and have deposited iron and magnesium where they come in contact with limestone or amphibolite. Scapolite and tourmaline are abundant in the altered zones around the magnetite deposits but apatite is not a prominent constituent.

Dr. C.M. Kolesnikov is working on the properties of organic compounds and acids in rocks. He is setting up a laboratory for work and expects to study organic constituents in fossilized material. He is not interested in the role of organic compounds in transporting metallic ions in surface or ground water.

GEOCHRONOLOGY

A very brief visit was made to the geochronology laboratory at the Precambrian Institute and Prof. Gerling gave a short account of their work. Potassium-argon and rubidium-strontium isotope ratios are used for most of the geochronology work but more equipment is being set up to use Pb isotopes for age studies. Xenon and other inert gases are being studied in this laboratory. Biotite, muscovite, hornblende and pyroxene minerals are used for age dating of rocks. Data from hornblende is favored as giving a more reliable indication of the actual age of the rocks. Dates from hornblende indicate 2400 million years for the age of some rocks while dates obtained from micas for the same rock are in the 1800 million year range. The oldest dates obtained for any rocks were obtained from pyroxene samples. Reference was made to the geochronology work on pyroxenes carried out in Sweden.

Considerable work has also been done in this laboratory on dating meteorites. The laboratory is very crowded and poorly housed and I judge that 6-8 scientific staff are directly involved in the analytical work in this laboratory.

ALL UNION GEOLOGICAL SCIENTIFIC RESEARCH INSTITUTE - (VSEGEI), Sredny PR 72-6, Leningrad, U.S.S.R.

I was received at this Institute, which comes under the Ministry of Geology, by Vice-director, Dr. L.I. Borovikov, Prof. A.S. Ostroumova an iron specialist, Mr. V.N. Mashkin a geologist and information officer and a number of other geologists. After outlining my main interests and work on iron-formations the seminar discussions led to major aspects of Precambrian geology. Tectonic divisions of the Precambrian shield in Canada were reviewed as given on Dr. Stockwell's recent Geological Survey of Canada map, a copy of which was available in the Institute. The group was very interested in our Canadian work in Precambrian studies. The classification and distribution of iron-formations in Canada which I presented was discussed in considerable detail and accepted favorably.

Prof. Ostroumova continued the discussion on iron-formations after the first seminar period. She discussed the iron geology of the Krivoy Rog and Kursk areas and indicated that there is good evidence for believing that one major iron belt in the Precambrian platform extends from Krivoy Rog through Kursk, north under the Russian Basin, and crops out in the Baltic Shield. Prof. Ostroumova held strongly to the belief that there were probably only two periods during the Precambrian when cherty iron-formations were deposited and these were also periods of extensive vulcanism. I pointed out that the two Precambrian eras, Archean and Proterozoic, represented a very great part of the earth's history and that we still haven't dated actual

periods of sedimentation so really don't know whether iron deposition took place during 2 or more periods in the Precambrian. Outside of Prof. Ostroumova's work of several years ago I don't think that iron formations are studied in any detail at this Institute.

During the latter part of my visit at this Institute, Dr. Borovikov asked about the general organization of geological work and research in Canada and we compared our organization set-up with that in the U.S.S.R. It was pointed out to me that much more fundamental research in geology in the U.S.S.R. is sponsored by the Ministry of Geology than by the Academy of Sciences. Some of the studies on iron that I have carried out in Canada were thought to be more closely related to their work sponsored in the Ministry of Geology and that I would probably have gained more from a visit arranged directly with the Ministry of Geology. A certain amount of internal rivalry between the two organizations may have helped to sponsor this suggestion.

In the course of our lunch meeting and again in the late afternoon Mr. Mashkin, an Institute gologist who works as an information officer and advisor on their library accessions, asked about our translation service in Canada. He was anxious to know what Russian publications were received in Canada and to what extent they were used. He also asked about our library facilities, bibliography services and so forth. They had heard in the U.S.S.R. that all geological data in Canada was being systematized for machine handling, storage, and retrieval and they were interested in our methods. I indicated that we had a National Committee working on methods and systems for handling geological data but that bibliography of geological work would probably be co-ordinated with an International scheme. I was asked for the names of our specialists in Canada on Precambrian geology, and anorthosite rocks. They also wanted to know what

maps showing aeromagnetic and gravimetric data were published in Canada and were referred to our publication lists. Discussion followed on the availability of such data in Canada compared with that in the U.S.S.R. Detailed geophysical and geological maps are not released to the public in the Soviet Union and they were quite surprised to find that publication of this information in Canada was regarded as a normal part of government service to the industries and the public.

Geology and Mineralogy Museum at VSEGEI

This is one of the largest geological museums in the country and the organization and display of material is excellent. The specimen material is organized according to geological regions, and the ore minerals according to mineral commodity. The fossil collection is considered to be outstanding. More than 400,000 thin sections from all parts of the U.S.S.R. are available at this museum for study by Soviet and foreign scientists.

The extensive collection of iron ores from various parts of the country was especially interesting and is one of the largest exhibits of a mineral commodity. Large specimens of iron-formation from the Kola Peninsula and from other places where I was not able to visit were examined with great interest.

I was given a tour of the Museum by the Director, Dr. P.N. Varfalameev and by his assistant Mrs. N.A. Chebotareva, who interpreted for us. They are both very dedicated to their museum work and most enthusiastic about showing its value and content. They were very anxious to arrange an exchange of iron-formation specimens with me. I assured them of my interest and in doing this suggested that we arrange for this exchange between our respective Institutes. They showed me a number of shipping cases that were being packed with specimens for display at Expo 67 in Canada next year. I can sincerely recommend that anyone interested

in petrology and mineralogy in the Soviet Union should not fail to visit this museum. A most comprehensive collection of material is available along with good study facilities.

THE GORNI MINING INSTITUTE - 21 Line, V.I. Leningrad

This is one of the oldest mining institutes in Europe with a famous history and tradition. I was received by the Director, L.N. Kell; by Prof. Gorlikov head of the Geology Department, and Prof. E.E. Tickomirova who interpreted for the visit. I was particularly interested in seeing their mineral and geology museum where one of the oldest and most outstanding mineral collections in the U.S.S.R. is kept. The systematic collection gives comprehensive coverage of most mineral groups, and large exhibits of very exotic material are displayed. Large polished slabs of ore from Cobalt, Ontario caught my eye. Their famous museum on mining methods and equipment is being reorganized and the space for this is being reduced. The geological display of nepheline syenite ring dyke complexes in the Kola Peninsula near the town of Apatity was most informative.

The problem of syngenetic versus epigenetic polymetallic sulphide deposits and their relation to vulcanism was discussed with Prof. Gorlikov. He indicated that this subject is being discussed and debated at length and is one of the most controversial geological topics in the Soviet Union today.

THE UNIVERSITY OF LENINGRAD

A short session was held with Prof. Kukharenko who studies metasomatic processes and mineral deposits. He described his work on carbonatite complexes in the Kola Peninsula and alkaline rock complexes similar to those at Oka, Quebec. His description of sequences of alteration and magnetite emplacement in these complexes was most interesting. He was proud of their

mineral museum and showed me rooms where Vernadsky and Fersman had worked and where he claimed geochemistry was born.

A large part of the afternoon was spent with Prof. Lebedev, Director of the Geology Department. He is especially interested in the study of minerals under high pressure and temperature conditions and made reference to common interests with Prof. Saulls at McGill University, Canada. He has been investigating a thesis concerning the storage or accumulation of solar energy in minerals and expects to publish a major work on this subject in the near future.

During a tour of their laboratories he indicated that a very wide range of geological processes is being investigated. Their laboratories include a mass spectrometer, numerous analytical methods, atomic adsorption analytical methods, spectrographic equipment and liquid diffusion apparatus as well as a number of other modern techniques for studying geological processes. Discussions with Prof. Lebedev were very stimulating and he expressed keen interest in our exchange program and the opportunities it provided for personal communication. I was presented with one of his publications that gives new data on the sizes of atoms which he believes helps to account for some of the present discrepancies in the study of isomorphism in atomic structure of crystals.

THE INSTITUTE OF RARE ELEMENTS, MINERALOGY AND ALKALINE ROCKS - IMGRE

Moscow HC 127, Sodornitcheskaya 71

Dr. E.I. Semenov, head of the mineralogy laboratory at this Institute, and Dr. L.R. Bozivenko came to IGEM in Moscow to see me after Dr. Semenov returned from Canada. We talked about the minor element content in different kinds of iron ores and I learned that their work refers mainly to ore deposits

affiliated with igneous rocks. They described titaniferous magnetite and ulvospinel in deposits in the Urals and deposits occurring within a long belt of ultrabasic rocks along the east side of the Urals. They indicated that large low grade titaniferous magnetite deposits are to be mined and the titanium content will be reduced to less than 2% in the magnetite concentrations. The ore concentrator to be built will be the largest in the world and most of the 20 million tons of ore concentrate each year will come from the Kachkanar deposit.

They indicated that their studies of scandium in iron ore has been very interesting and rewarding and that much more work should be done on the distribution of germanium in basic rocks.

KIEV. INSTITUTE OF GEOLOGICAL SCIENCES - ACADEMY OF SCIENCES OF THE UKRAINE S.S.R.

LENIN ST. 15, KIEV 30, U.S.S.R.

I was received by Akademician N.L. Semenenko for a very interesting session on Precambrian geology. Prof. A.S. Povarennykh from the department of Mineralogy sat in on our discussions. Akademician Semenenko is a member of the International Geological Congress Committee working on a tectonic map of the world and was very anxious to discuss recent work in Canada in Precambrian geology. He seemed a little critical about the apparent lack of detailed mapping in the Canadian Shield but after I showed him the relative sizes of the Ukrainian and Canadian Shields with his home territory tucked away in a small corner of our Grenville Province, he acknowledged the magnitude of our task. He is convinced that granitic rocks are predominantly intrusive in origin and that the source of heat for regional metamorphism of rocks is from intrusive bodies and not from a general rise in the thermal gradient over broad areas in the

earth's crust.

Akad. Semenenko is convinced that iron in the iron-formation is from a volcanic source and believes this is also true for the Oligocene iron sediments around Kerch in the Black Sea Area where the iron is thought to come from thermal springs in the ocean floor. His work on the chemical and mineralogical classification of iron-formations was discussed as well as more recent work in relating different kinds of iron sediments according to various types of volcanic or sedimentary rocks associated with them. Some of his information on stratigraphic relationships was not very convincing as it was necessarily based on bore hole data from very complex geological structures. Sulphide facies of iron-formation were discussed but only scanty data was shown and I am not sure that his comments were confined to stratiform types of deposits.

The publications on iron-formation in the Ukraine given to me by Akad. Semenenko are very valuable and I learned much about the geology of the Ukrainian Shield from our conversation. Our interview was stimulating and we enjoyed a useful exchange of ideas even though his enthusiastic discourse seemed to offer more opinion than scientific fact on some subjects.

During my visit to the Institute of Geology at Kiev I met Prof. U.Y. Klimenko, Chief of the Geology Museum, who is famous for his work in the past in exploration for oil. He described their mineral museum briefly and then turned me over to Prof. Schevchenko, a petrologist who is studying the physical chemistry of magmas who conducted me through the museum and discussed some of the mineral deposits.

Excellent collections of ore specimens of the Nikopol manganese deposits and Oligocene iron beds at Kerch were examined. The Kerch specimens of vivianite, an iron rich phosphate, were spectacular and I was told that some are to be sent to Canada in

exchange for iron-formation samples. I also learned that recent exploration of the Kerch iron beds has shown a much wider distribution of this material than was realized previously. Skin divers are exploring the underwater exposures of the Kerch iron beds around the shores of the Azov and Black Sea. These divers are, I believe, pioneers in underwater exploration and prospecting of an iron-formation.

CHAPTER III

Visits to Iron Ore Mines at Krivoy Rog and Kursk Magnetic Anomaly Area - June 21 to 29

Krivoy Rog, U.S.S.R.

An early morning flight from Moscow to Krivoy Rog in the Ukraine on an Ilushia 104 plane was very comfortable and required about two hours. The plane stopped at the side of the runway where a reception party, consisting of Prof. Dr. Jacob N. Belevtsev, Chief of the Ore Department at the Institute of Geological Research, Academy of Sciences of the Ukraine S.S.R., Kiev, Mr. A.D. Govelia, Manager of the Geological Trust, Krivoy Rog, and Mr. D. Stanislav Lepky, a geologist from the Institute in Kiev who was my interpreter for the duration of my field visit in both areas, and a number of other staff from the Geological Trust, welcomed me to Krivoy Rog. I was taken to a small modern hotel in Krivoy Rog in a limousine provided for my field visit, escorted by a heavy duty field van! I was served a good breakfast in the spacious, comfortable hotel apartment assigned for my convenience and after a short rest our party assembled at the Geological Trust Headquarters at 30 Karl Marx St. to plan my visit in detail.

The afternoon was spent in briefing me on the geology of Krivoy Rog and in group discussion with the staff on iron ore

geology. Following a period of intensive study of maps, specimens and models of geological structure in the area, further serious scientific discussions were set aside and the group assembled in the Director's Office for refreshments and a social gathering. My hosts expressed their pleasure and satisfaction in having me visit their working area and confirmed their sincere wishes for a beneficial and enjoyable visit. I believe our work together during the next few days fulfilled their hopes, and good relations and hospitality prevailed throughout the visit. Prof. Belevtsev, Mr. E.G. Malutin, Chief Geologist of the Trust, and Mr. Lepky visited with me for a few hours in the evening at my hotel apartment when we discussed developments at Krivoy Rog and the iron ore industry in Canada and abroad. We concluded our day with a small supper party in the hotel restaurant.

I was asked to give an illustrated lecture on the geology of iron deposits in Canada and spoke to a group of about 30 in the afternoon before I left Krivoy Rog. My coloured pictures of different lithological types of iron-formation raised considerable interest and comment and numerous questions were asked about the depositional environment for our Precambrian iron-formations, metamorphism and the mining of iron-formation for production of ore concentrates.

The Geological Trust - Krivoy Rog

Volumes have been written on the geology of the Ukraine Precambrian Shield and the famous iron belt at Krivoy Rog, and several recent ones were presented to me which document most of the information described in the briefing. In this report I can only mention some of the highlights and impressions gained during my visit. Unlike most Precambrian iron ranges in other parts of the world, the topography at Krivoy Rog has little relief and there is very little natural exposure of the rocks. The

geology of the area was demonstrated very well with maps, charts, ore and rock specimens and with large models of the geological structure and ore zones.

Prof. Belevtsev described the detailed stratigraphy of the iron-formation which he defined 25 years ago and which still forms the basis for present mine geology and exploration. Seven distinctive lithological types of magnetite and iron-silicate quartz iron-formation occur in 7 stratigraphic members of the formation. Magnetite-quartz facies are predominant throughout the formation and the iron content ranges from 30 to 35 percent. The beds are thinly layered to delicately laminated and alternating layers with varying amounts of magnetite, grey, black or red chert are distinctly defined. Bands and layers are generally straight, uniform in composition and have a minimum of small scale crenulation. The lithology is more similar to oxide facies in our Algoma type formations than in our Superior type and is remarkably uniform in character in each stratigraphic member throughout the area. The iron-formation is between 300 and 1,000 feet thick with some interlayering of quartz chlorite mica schists and green argillaceous sedimentary beds.

The iron-formation is repeated by tight folding and by numerous thrust faults and the regional structure is reminiscent of that seen in our Knob Lake area in Quebec and Labrador.

The iron-formation is enriched to ore by natural processes of oxidation and martitization of magnetite, leaching of silica and replacement of silica by hematite. Enriched ore extends to depths greater than 4,000 feet according to the mine models and charts, and controversy still exists about the nature of the ground waters which caused enrichment of the iron-formation to soft ore. Prof. Belevtsev interprets the geology of the range with soft ore extending to great depth. The soft ore he believes formed by thermal waters which rose from a deep seated

source and circulated through the iron-formation causing leaching of silica and enrichment of iron. Others in the party held the view that the ore was formed by oxidizing ground water which permeated the structure from the old surface zone and that ore formation was an extension of deep weathering processes. I was pressed for comment and opinion on this classical problem of iron ore genesis and found myself in the midst of stalwart advocates of the two different schools of thought. After citing conclusions from work on this problem in North America, India and Brazil we agreed that further exploration of the ore zones at depth was an essential step in resolving this problem of the mode of origin of the ore. It was interesting to note that work and thought on this problem by the Soviet geologists followed well known and conventional patterns, and study techniques in no way surpassed those used in North America.

The principal zone of naturally enriched iron ore at Krivoy Rog is a long irregular tabular sheet-like mass that extends down dip from surface in steeply dipping monoclinal structures of iron-formation. Most of the ore is mined underground and an impressive row of about 20 mine head frames located along the main structure zone extends for a distance of about 5 miles and towers over the prairie landscape. There is very little exposed rock and most of the geology is interpreted from bore hole data, underground workings, and surface mine pits.

Two relatively small open pit mines were visited at Krivoy Rog, where naturally enriched hematite-goethite ore could be examined in its geological setting. Practically all of the ore had been mined from the first pit area we examined and the other pit, where no ore was being produced, was reported to be one of the oldest in the area and was first worked in 1874. These two pit mines were a good choice for geological study as wall rock and unaltered iron-formation could be seen in relation

to the ore, but a visit to underground mines which produce most of the soft ore in the area was not offered. The soft ore in these mines is directly comparable to that found in many parts of the world in similar geological settings, and minor variations in the ore could be directly related to differences in the stratigraphic members of the iron-formation from which they were derived. The ore zones appeared to contain a high proportion of grey hematite with coarse fragmented and hard lump structure which would have an average grade of 60 to 64 percent iron. Good evidence of direct replacement of silica by hematite with the development of only a minimum of porosity is seen in this ore.

Even the brief and limited examination of ore in the open pit mines was invaluable for me and gave a basis for inferring quite a lot about the nature and characteristics of iron ore in the Krivoy Rog district. The voluminous descriptive literature on the naturally enriched ore zones in this area can now be appreciated more fully and used much more effectively after first-hand information and observation of typical material in the field.

Large zones of unoxidized magnetite iron-formation have been located in the Krivoy Rog area and they form the basis for an extensive taconite industry where the iron ore concentrate produced is sintered or pelletized. One of the largest open pit mines, the Southern Krivoy Rog, was visited and there the seven different stratigraphic members of iron-formation are being mined. The mine opening is more than 1000 meters wide and is located in a large fold of iron-formation which plunges north. The iron content in the formation is about 35 percent and 6 million tons of concentrate grading 63 to 65 percent iron and 8 to 10 percent silica is obtained from 12 million tons of crude ore. The mining operation is most interesting. Modern methods including jet piercing drills are used, the ore is loaded directly into rail-

way cars, hauled by electric locomotives and the mine seemed to be operated efficiently. About one million tons of crude ore are blasted from 15 meter benches in one blast and the ore fragmentation appeared to be uniform and exceptionally good. This mine provided the best opportunity for studying the iron-formation, and very useful photographs were obtained of the different types of iron ore. Other photographs of the mine pit and operation were taken for reference.

A brief visit was made to the Central Krivoy Rog concentrator plant, one of the largest in the area, where about 6 million tons of concentrate are produced per year. The crude ore is crushed to minus 25 cm. size and passes through rod mills, 3 or 4 stages of grinding in ball mills where 90 percent of the material is reduced to 300 mesh size, the magnetite is recovered in wet magnetic drum separators, and disc type filters reduce the moisture content to about 10 percent.

An experimental pelletizing plant was visited, where an attempt was being made to produce self fluxing pellets. I was asked about the proportions of dolomite used in our practice to produce pellets of good structural quality, but research on pellets is outside my field and I avoided comment on the subject. I understood that considerable difficulty was being experienced with the use of dolomite in self-fluxing pellets. Disc balling apparatus and grate roasters are used.

The Central Krivoy Rog pilot plant for the reduction roasting of iron ore to convert iron minerals to magnetite was visited briefly. Fifteen rotary kilns, 11' by 150' in size, are being operated with soft coal and natural gas, and 4 to 5 million tons of iron ore are treated in a year. This is one of the largest reduction roasting plants operated anywhere and it was stated that the plant will be doubled in size in the near future.

Since much of the geological data at Krivoy Rog is

acquired from bore holes, I inquired about their drilling and sampling methods. A visit to one of the exploration areas at the south end of the iron range was suggested to see a demonstration rig operating. There appeared to be at least 10 drills distributed at 500 meter intervals on a square grid pattern laid out amid the wheat and pasture fields. The steel towers were about 70 feet high which permitted hoisting of 18-meter lengths of drill rods and they were set over permanent looking whitewashed brick buildings which housed the drilling machinery and reminded one of a comfortable cottage. The floor of the drill house was freshly scrubbed and the machinery was carefully polished until the grey paint gleamed. The driller in charge sat at an impressive console lined with control levers for the electrically powered and hydraulically operated drilling machine. I was taken to a small room behind the drill rig, presumably the field office, where faded charts and logs on the walls revealed data from the drill operation, and a large imposing portrait of Lenin, bordered with broad red banners, seemed to monitor our conference. Two robust women geologists arrived on the scene, each carrying a roll of maps, and they gave a brief outline of the program. They were in charge of the development work, logged the drill core from all the machines, and seemed to be very proficient at their task.

The drill crew consisted of three people, the driller and two helpers, one of whom was a young woman. I remarked to the Chief Geologist of the Trust that diamond drilling was one vocation in Canada where women were still absent. He replied that they found women on the job were good for morale and they kept the place clean and tidy. I also observed that when they started up the rig that the young lady occupied the high level position on the top of the derrick and the man stayed on the ground deck, which seemed to be in keeping with the Soviet's way

of allocating work between men and women. The feminine touch prevailed at the drill-site in many ways, including freshly laundered lace curtains on the windows, and again one realized how vastly different our outlook is in Canada compared to the U.S.S.R.

The greatest surprise came when I inquired about the kind of drill bits or tools being used and was informed that they used a rotary bit. The core was 4 to 5 inches in diameter and better than 90 percent recovery was reported. I expected to see some kind of tool with tungsten carbide inserts on the cutting face, but instead was shown a simple piece of drill casing with a notched facing on it and hardened steel chips in thick grease. To my surprise, I realized that they were using a calyx or shot drilling method, and when I mentioned what we call this method everyone brought out his notebook and I spelled out the name. I was informed that this drilling method had been used throughout the history of mining in the area, and although slow, they had good core recovery and it was the most effective except for diamond drilling for penetrating the very hard iron-formation and for obtaining core and geological information. They reminded me that it was only very recently that the Soviet Union had a source of industrial diamonds and that diamond drilling was still not widely used there. Considering their positive results with the old method, one couldn't be too critical. I understood that the bore holes were advanced about 2 meters per day and that this first one was to go to a depth of 2,000 meters. It was started vertical but would deflect toward the inclined strata and the curved trajectory would reveal a good cross section of the geological structure. Other drill sites visited were arranged similar to the first one with the same working procedures. The country cottage atmosphere prevailed where the crews had made themselves comfortable for a long boring campaign!

Motoring in the Ukraine

I welcomed the announcement that we would motor from Krivoy Rog to Gubkin in the Kursk Magnetic Anomaly area, a distance of about 360 miles. Stanislav Lepky, my geologist interpreter from Kiev, V.V. Alekseev, Manager of Expeditions of the Geological Trust at Krivoy Rog, the driver and I set out in the old Zim limousine which was remarkably comfortable, considering road conditions and the warm summer day. We travelled via Nikopol and stopped at the hotel at Zaporazh'ye for lunch. I noted the large piles of waste rock as we passed by the manganese mines at Nikopol but a stop at the mines for a look at the ore bed was not suggested, in spite of my comments about interest in bedded manganese deposits. We crossed the Dnieper River on a composite railway and highway bridge near Zaporozh'ye and the famous dam and hydro power station, the first in the modern Soviet hydro power network, could be seen from the bridge.

North from Zaporozh'ye we followed one of the most modern highways in the country, which runs from Moscow to Simferopol in the Crimea and the Black Sea resort area. The highway had been constructed on a direct route across the country and the right-of-way was well graded but the two lane asphalt road was narrower than most of our highways and the surface was generally rough. Much of the route was lined by trees or low bushes which obstructed one's view of the country. Traffic consisted mainly of trucks, private automobiles carrying holidayers to and from the resort areas in the south, motorcycles and horse-drawn vehicles. We averaged less than 30 miles per hour when on the road and traffic was slow because of the trucks and farm vehicles. The absence of service stations and business places or service facilities along the route was conspicuous. Only five filling stations on our route were shown on the wall chart at one service station, and our limousine required them all as it was averaging

less than 10 miles to the gallon of gas. Most of the drivers serviced their own vehicles, and facilities were very sparse or inadequate compared to our standards. The women attendants spent most of their time collecting gasoline vouchers or cash from the drivers and considerable time was spent in the queue waiting to get to the pumps. Tools were borrowed at the service station by drivers who fixed their own flats.

Our highway was considered to be an international route and signs with place names and directions were printed in both Russian and English. English is regarded as the next most important international language after Russian by the Soviet Union.

We travelled through Novo Moscovsk, Kharkov and Belgorod on our way to Gubkin. My associates were not familiar with the road and we had to ask for directions on several occasions. Our driver made a wrong turn in the congested traffic in Kharkov and was called to the guard box where, I gather, the militia man or traffic officer gave him some sarcastic advice. A little sight-seeing was achieved in Belgorod while we drove around looking for the road to Gubkin, which didn't seem to be recognized by many on the streets, including several militia.

Points of special interest on this motor journey were a view of Scythian burial mounds in the Southern Ukraine, the wheat fields and farm lands of the famous steppes, country life and agricultural methods, many villages which have probably not changed in appearance in fifty years, the famous church edifice at Novo Moscovsk built without the use of any steel, reconstruction in the city of Kharkov and motoring habits in the country in general.

Gubkin and the Kursk Magnetic Anomaly Area

We arrived at Gubkin after dark and my colleagues

spent considerable time inquiring about the location of the hotel and the Geological Research Institute and in finding our way about. At one stage we were directly across the town square from the hotel where we eventually stayed, but the militiaman directed us to the Institute where numerous telephone calls were made. When we returned to the hotel I was asked to remain in the car while Lepky and Alekseev spent nearly half an hour in the hotel. They returned to the car full of apologies that the hotel did not have a room with running water, and I would have to share facilities. I assured them that I had no objections to this arrangement so they took my passport and departed for another long period. When they came back they informed me that we must hurry to the public restaurant before it closed at 11 p.m. becuase the hotel dining room was closed. At the restaurant we met Prof. Tochilin from Veronez University and a groundwater geologist who had come to Gubkin for my visit and both extended a special warm-hearted welcome to me after spending most of the evening at the bar. When we returned to the hotel I was shown to an apartment that was furnished in good taste and included a full bathroom unit, bedroom, large living room and dining room and a stereophonic radio set. I succeeded in getting a foreign broadcast in English on the radio and it was quite a lift to my morale as I had not heard any foreign news or seen a newspaper, except for a copy of the Morning Star (the successor to the Daily Worker) since I arrived in the country more than a month previously. I enjoyed my stay at Gubkin and the hotel was quiet and comfortable and the food served to me in my room was good, with the quantity usually far in excess of my appetite. The inadequacy of my diet and irregularity in eating habits or frequently missing meals in the past weeks was beginning to wear down my stamina, and a bout of indigestion while in Gubkin detracted from my enjoyment of the place. The Sunday spent at Gubkin was an occasion for a picnic

in a nearby woodlot with a number of the visiting geologists, and we returned late in the evening in time to witness the last part of a street dance in front of the hotel, where hundreds of people had gathered to enjoy folk dancing. A number of militia with a sound truck were rather conspicuous in the crowd.

The morning after I arrived in Gubkin, I was taken to the Geological Research Institute for KMA - Kursk Magnetic Anomaly - where I met the Vice Director, Dr. S.F. Borisov and some of his staff. Mr. Alekseev from Krivoy Rog departed after delivering me into new hands.

Dr. Borisov inquired about my background and interests and about my parent organization and then gave the usual description of his Institute and its activities. This Institute comes under the Ministry of Geology and is responsible for geological research on the Kursk Magnetic Anomaly area. Experimental research is carried out in 14 different fields of interest, relating geology to engineering and metallurgical problems. They are experimenting with briquetting processes for iron ore and wanted opinion on the merits of different ore agglomerating processes used in North America. My reply was that ore pellets had gained decided favor and would likely be a preferred product for a long time - i.e. witness the vast development and investment in the pelletizing industry. As for ore briquettes, I suggested that this process might facilitate the mixing of flux and coke fines with the ore and held great promise for blending and controlling a furnace feed. The work at this Institute is of an applied nature and stands between theoretical studies and industrial application of new methods. I noted with some disappointment that they talked about their general objectives and interests but did not mention any specific research project or show me any experimental apparatus. Later discussions with the group of geologists and visits to the mines emphasized factual and descrip-

tive geology and geological interpretation. Discussion was avoided concerning the implication of geological features in mining and processing of the ores. Some of this attitude, I believe, was due to the narrow compartmentalized way of thought that prevails with many Soviet Scientists and part of it may have been for industrial security reasons as they were well aware of my interest in applied geology in the field of mining and ore processing.

After an introduction at the Institute, we moved to another building in the town which they described as their geological museum. It was a compository for technical records, specimens and some display material, but was used mainly as a working area for drafting of geological records and research. A number of geologists had assembled for my visit and participated in briefing me on the iron deposits and geology of the Kursk area. The latter part of the session was spent in a general seminar when many aspects of the nature and origin of iron-formations were discussed. I was pressed for comment and opinion on many topics and was shown microphotographs and data illustrating their studies. In all, this was a most enjoyable and stimulating seminar and a useful guide to ways of thought and interests concerning iron-formations.

Later in the day we visited Lebedin mine, a large open pit where naturally enriched iron ore was being mined. On Monday I went underground at the Gubkin mine to look at unoxidized magnetite quartz iron-formation that is being mined and concentrated to provide a high grade ore product.

I was asked to give a lecture on iron-formations in Canada late on the last day at Gubkin and about 40 geologists attended. We had a very interesting question and discussion period and Prof. Borisov had some very kind words to say when he introduced me and spoke of their appreciation of my visit and the

benefits of the exchange program. A group of about twelve assembled in the Director's office, where a dinner party was held in my honour. A very congenial atmosphere prevailed and toasts were exchanged confirming our mutual interests in successful research and development of iron ore deposits.

Among the specialists on iron ore geology who came to Gubkin for my visit were Professors N.A. Plaksenko and M.S. Tochilin and an assistant from Voronez State University; Dr. Bernarda Klagish from the Belgorod Geological Expedition; geologists from the Institute at Gubkin including Dr. A.A. Illarinov, Dr. I.E. Kurenkina and Dr. Ed. P. Isvekov; and Mr. Yuri S. Stchekin, Chief Geologist of Lebedin Mine, and Mr. Ivan I. Khaltobin, Chief Geologist at Gubkin Mine.

Kursk Iron Belt

The Precambrian iron-formations of the Kursk-Belgorod region are completely covered by Oligocene, Cretaceous and older sedimentary rocks. The magnetic anomaly of regional extent in this area has been known for many decades and the magnetic iron-formations which cause this anomaly were identified about 40 years ago and since that time the distribution of iron beds has been defined within an area one hundred miles wide and more than 300 miles long. Very large bodies of naturally enriched hematite-goethite iron ore within the iron-formation have been located and vast zones of iron-formation suitable for mining and concentration have been delineated. The iron-formations are part of a Proterozoic succession of rocks which form domes and prominences on the surface of the Precambrian rock complex known as the Voronez massif.

The iron-formations occur near the base of a stratigraphic succession of Proterozoic rocks which is divided into three groups consisting of volcanics, phyllites and greywacks at

the bottom, dolomite, quartzite, black slate and iron-formation in the central part, and dolomite phyllites and volcanics in the upper part. These rocks are tightly folded in a broad syncline which trends northwest, and folded belts of iron-formation are prevalent along the eastern and western margins of this synclinorium. Mines in naturally enriched hematite-goethite ores and unoxidized magnetite iron-formation were visited at Gubkin on the eastern belt. The iron-formation in this area is 400 to 500 feet thick and consists predominantly of thinly banded to laminated magnetite and quartz or magnetite iron-silicate and quartz with argillaceous zones. It is cut by thin intrusive masses of diabase which are altered to ore in some places.

Mine plans and cross-sections on a working scale were studied before visiting Lebedin open pit, where naturally enriched ore is mined. Prior to mining, the ore bodies were covered by Mesozoic sandstone, chalk beds, clay and bentonite clays that have a total thickness of 40 to 200 meters, and severe water problems are encountered because of the sandstone aquifer. The ore occurs in a broad fold of iron-formation which plunges north and is exposed over a width of 1,000 meters in the present mine pit. The ore will be followed down the plunge of this fold as mining progresses and eventually the open pit will cover an area of 3 square kilometers. The average grade of blue ore was reported to be 62 to 63 percent iron and 8 percent silica, and some parts of the orebody contains 8 to 11 percent alumina with correspondingly lower silica content, in the range of 2 to 3 percent. The phosphorous content varies and is as high as 0.09 percent and there is no problem with manganese. I believe the average grade for all types of ore may be lower than the figures given.

Two principal kinds of ore reflect the nature of the iron-formation members from which they are derived. Blue hematite-rich ore is derived from magnetite, hematite or martite rich-iron-

formation, and the brown goethite-rich ore is derived from silicate carbonate and argillaceous iron-formation. It was reported that 20 percent of the ore in the mine is of the blue type and 80 percent of the brown type, and most features of the ore are remarkably similar to the blue and brown ores of the Knob Lake area of Labrador and Quebec. The mine geologists seem to be doing an excellent job in guiding the mine development and controlling the grade of ore extracted, and the engineering work appears to be very commendable considering the problems they have had to deal with in this huge pit.

Gubkin mine is an underground operation where magnetite iron-formation is mined for the production of ore concentrate. The mine is located in the crest of a very complex fold structure which plunges 75 to 85 degrees south. The iron-formation is repeated several times in this fold and the ore zone is about 1,200 by 1,200 feet in plan, extending down the plunge for a great distance. It was possible to examine the iron-formation in detail along a drift that crossed the fold structure and gave a good section of ore. The iron-formation seems to be fairly uniform in physical character and iron content and contains very little silicate or carbonate material. The iron content ranges from 30 to 35 percent and is present in magnetite and up to 4 percent in hematite. About 1.4 million tons of ore concentrate grading 65 percent iron or better is recovered from 3 million tons of crude ore. The iron-formation has a fine grained texture and must be ground to nearly 300 mesh for good liberation and recovery of the magnetite. The mine is opened on two levels and about 60,000 tons of ore is broken in each blast from stopes 50 meters high where a room and pillar mining method is used. Underground mining of taconite type ore is an expensive and ambitious undertaking under economic conditions in North America, but all seemed enthusiastic and convinced at Gubkin that this mine would

be operated successfully for a long time.

Geological Work at Gubkin

Considering the fact that most of the Precambrian iron deposits in the Kursk area are deeply buried by younger sedimentary rocks and that exploration work has been done mainly by drilling and geophysical methods, the geology of the iron belt has been defined remarkably well. The quantity of potential ore of both types is very large and is estimated in many billions of tons. A very large geological program is maintained with geologists from many different Institutes participating.

I was especially interested in Prof. Plaksenko's study of the distribution of different sedimentary facies of iron-formation. He believes that all of the iron-beds originally contained much organic carbon and ferric oxide and that the silicate and carbonate minerals formed during diagenesis of the sediments when the carbon was oxidized and much ferric iron was transformed to ferrous iron and formed silicate and carbonate minerals. His interpretation of the distribution of different facies of iron-formation in the Kursk syncline is based on this hypothesis.

Dr. Bernarda Klagish is doing a detailed study of the stratigraphy of the Kursk iron-formation and is interpreting the environment of deposition. She has obtained very considerable data on the chemical composition of both the iron sediments and associated rocks and finds that the composition of the rocks is compatible with a sedimentary source for the material. Some anomalous characteristics such as high potash content in the slate rocks are attributed to later metasomatic alteration processes.

Prof. Tochilin is a strong advocate of a volcanic source for the iron and silica in the iron-formation and extends his arguments to cover all banded cherty iron-rich sediments.

Dr. I.E. Kurenkina is a specialist in the study of

the geochemical processes in lateritization and deep weathering of the earth's crust. She is studying the origin of the naturally enriched ores at Kursk.

CHAPTER IV

SUMMARY OF IMPRESSIONS AND RESULTS OF VISIT TO U.S.S.R.

Members of the scientific community contacted in the course of the visit were very interested and cooperative and were anxious to discuss their research work and current ideas. They were particularly interested in making contact with scientific personnel outside their country who shared their interests and who would exchange publications. They took obvious pride in presenting copies of their work, which covered subjects discussed in the interviews. About 100 scientific volumes and papers were received during the visit.

Many senior scientists were very conscious and concerned about organization and administration of scientific programs and wanted comparative discussions wherever possible. The fact that Canada did not have an Academy of Sciences or an organization directly comparable to their Academy seemed to be difficult for them to understand. They found it hard to appreciate the scope and extent of our scientific accomplishment without our having their Academy and Institute type of organization.

The function of research teams or groups led by senior scientists in the various Institutes was an impressive feature of their organization. Both training and research objectives are achieved by this kind of association and although domination of thought and ideas by the senior scientist could easily exist in this situation, depending on the individual, I saw no direct evidence that this was the case or a problem.

The establishment of Institutes for research on special subjects or very restricted fields in the earth sciences is an impressive feature of organized research in the Soviet Union. In some respects they reflect a preoccupation with organization and foster unnecessary specialization.

Research Institutes, in keeping with most accommodations in the country, are poorly housed, overcrowded and austere to the extent of being uncomfortable or depressing.

Research equipment and facilities are generally adequate, not elaborate in design or construction, and some duplication of equipment in a single Institute was observed. The technological standard of equipment was generally far below that available in West Europe and North America.

The importance of adequate supporting staff for research scientists is recognized in the Soviet Union and a large number was observed on most projects.

Assignments and projects covered by individual geologists and their associated teams are not as broad in scope and content as most assignments in Canadian organizations.

Scientific productivity of individual scientists is difficult to assess or define withour considerable qualification, but in general it appeared to be lower in the Soviet Union than in Canada, and in many cases it was obvious that less was expected from an individual for a given period of work.

It is doubtful whether communication of scientific and technical information and ideas is as good or as rapid within the Soviet Union as in most developed countries. They do not seem to have meetings, conventions, and technical symposia organized to the extent we have, to bring research people together at the working level. Exchange of information between Institutes, except for formal publications, may be rather strained or limited. On the other hand, the Institutes generally have effective library service, including compilation of very specialized bibliography of both foreign and domestic publications. More than 18 months to 2 years for the publication of a manuscript is considered intolerable, but editions and circulation are frequently limited and copies do not reach all interested people in the country.

A very extensive literature with exhaustive detail on the iron deposits of the Soviet Union has been published; it is not fully appreciated outside the country because of language differences and limitations in circulation. No restrictions appear to exist on the communication of basic geological information, except for the circulation of detailed maps. Pertinent geological information for specific economic evaluations of iron deposits and tabulation of ore reserves is not published for general distribution, although some information of this kind is published.

Descriptive and definitive work on the iron deposits and related geology in the Soviet Union, judging from the detailed maps, charts and documents examined, seems to be of very good quality and thorough in its coverage. Overall, the documentary record may be more comprehensive and detailed for iron deposits in the Soviet Union than in Canada and much more descriptive data has been accumulated. This was to be expected considering the much larger number of geologists working in this field of geology.

Their descriptive work on iron deposits and interpretive studies were very good. Data accumulated and studies pertaining to the mode of origin of the various kinds of iron deposits are very extensive, but few concepts and ideas were discussed which had not received considerable attention in our English geological literature. Some of the working concepts in the U.S.S.R. have been considered obsolete for some time by our associates. Many classical concepts of ore genesis are receiving critical examination and elaborate study, and definite advancements can be expected from this research.

Fundamental geological studies are emphasized, especially by the Academy of Sciences, but I judged that practically all of the work was chosen and oriented to support mineral dis-

covery and development of mineral resources or to support some part of national planning. Geological mapping and integrated programs in earth sciences are all directed and promoted in conformity with requirements of the National Plan for developing the natural resources of the country. It is seriously doubted whether scientific objectives alone are adequate bases for gaining sponsorship of a research project. Although the Academy with its senior scientific opinion and advisory role is a highly influential body in the affairs of the country, one gained the opinion that national expenditures were directed for very specific purposes, sometimes these were not particularly farsighted, and there are no philanthropic agencies or foundations to support intellectual curiosity.

No serious language difficulties were experienced in the course of scientific interviews because of my lack of knowledge of Russian. Interpreters were provided by the Academy of Sciences, or junior scientific personnel assisted, and many of the geologists were fluent in English or knew English terminology from use of English literature. English is accepted as the major international language and is used extensively by scientific personnel in the Soviet Union. A few Russian courtesy words and the ability to transliterate were a decided asset.

SIGNIFICANT FACTS ABOUT THE GEOLOGY OF IRON DEPOSITS AND RELATED RESEARCH

All of the major kinds of iron deposits which occur in Canada also occur in the Soviet Union and some kinds are more extensively developed there. There are also some unique occurrences in the Soviet Union such as the magnetite in breccia pipes in the East Siberian platform and the jasper iron-formation grading into jasper manganese formations of Devonian age in Kazakhstan.

The iron ranges of Krivoy Rog, Kursk area, and some in Karelia and the Kola peninsula are believed to be parts of one great Precambrian belt of iron-formation. Lithologically these iron-formations resemble oxide facies material in many of our early Precambrian or Algoma type iron-formations, but many features such as their widespread distribution and uniformity within a belt is more comparable to the Proterozoic beds of Superior type iron-formation. Evidently they were deposited in a deeper water continental shelf environment than the Superior type iron-formations of the Labrador-Quebec belt but marginal to a eugeosynclinal type of environment that is typical for Algoma type iron-formations. They have good concentration and beneficiation qualities and are the basis for a large and developing taconite industry in the Krivoy Rog and Kursk areas. The oxidized, leached, and enriched iron-formations of these areas provide naturally enriched ore that is similar in most respects to soft ores mined around Schefferville, Canada, and in the Lake Superior belt of the U.S.A.

Most geologists in the U.S.S.R. are convinced that the iron and silica in the cherty banded iron-formations are the product of volcanic activity and not of sedimentary origin. The evidence presented for this mode of origin is, however, no more convincing than that considered in North America. In contrast, the iron in the oolitic goethite-chamosite-siderite iron-formations extensively developed in the Cretaceous and Oligocene periods is believed to be derived by processes of deep weathering of the earth's crust and of sedimentary origin. Only a few geologists suggested different modes of origin than these or felt uncertain about the problem.

Cherty banded iron-formations occur in the Soviet Union in rock successions as young as Devonian and are associated with volcanic rocks, ignimbrites or acid tuffs, argillites and

phyllitic rocks. One of these Devonian iron-formations in the Altai-Sayan Mountains has been mapped over a distance of several hundred miles.

Highly metamorphosed magnetite quartz iron-formations in the Kola Peninsula near Murmansk resemble some of the iron-formation in the Wabush Lake area of Canada.

Cretaceous oolitic goethite-chamosite-siderite iron-formations along the eastern and southern margins of the West Siberian Platform form one of the largest single concentrations of iron in the world. This material, containing 35 percent iron, would not be iron ore under our standards and specifications but some of it is mined in the U.S.S.R.

Paleogeographic studies of the sedimentation and depositional environment for oolitic goethite-chamosite-siderite iron-formation in the West Siberian Platform and Kerch areas have been very detailed and revealing and are classical contributions on this kind of sedimentary rock. Recent work shows that the Kerch iron-formations extend over a much larger area than previously realized.

Very large iron deposits of contact metasomatic and replacement types associated with igneous rocks occur in the eastern part of the Ural Mountain belt and east of the Kuznetsk basin. These deposits are decidedly larger than those of similar type in Canada. Saraby, for example, contains 800 million tons of ore and is the largest of its kind in the world. Iron ore reserves from these deposits are measured in billions of tons and these deposits are a major part of the iron resources of the Soviet Union. Extensive research programs cover all aspects of the geology of these deposits and large research teams composed of geologists, chemists, and physicists are coordinated in comprehensive investigations of ore-forming processes.

Extensive geological work is accepted as a large

essential phase of mine planning and development. Detailed geological work was carried out at all of the operating mines visited and geologists were responsible for guiding mining and controlling ore grade and quality. The working geological records were detailed and of good standard.

Bore holes for geological exploration at Krivoy Rog were drilled with modern types of machines, but surprisingly the old method of calyx or shot drilling was used. Large cores were recovered from holes as deep as 6,000 feet by this time-consuming method. Until recently, industrial diamonds have been in short supply in the Soviet Union and diamond drilling methods are not used in all areas for exploration and may not be well developed.

More than half of the 150 million tons of annual production of iron ore in the Soviet Union comes from the Krivoy Rog area in the Ukraine. Other very significant iron ore production or development areas are Kursk Magnetic Anomaly area, Murmansk in the Kola Peninsula, Kustanay area with contact metasomatic and low grade deposits in the eastern Urals belt, Cretaceous iron beds of the West Siberian Platform and Oligocene river bed ores, deposits east of the Kuznetsk basin, Kerch area on the Black Sea, deposits in Eastern Siberia near the Pacific coast, and the Aldan Shield.

CHAPTER V

TRAVEL AND IMPRESSIONS OF LIFE IN THE U.S.S.R.

A brief look from the plane window on arrival at a Moscow airport brought startling awareness that one had arrived in a country which is decidedly different from Canada, yet with terrain and weather remarkably similar to that south of Ottawa. The airport seemed neglected in spite of the long row of modern airliners on the tarmack, and the long grass and apparent absence of people brought the same sense of abandonment one feels after being deposited in the Arctic barrenlands with the plane disappearing over the hill. The man in uniform at the entrance to the covered passage to the air terminal looked like the pictures of Ivan in the last war, and a woman in a black skirt, with kerchief and heavy shoes, was sweeping the tarmack. The terminal building with modern lines seemed to need paint or a touch of colour somewhere and there were no signs except the terminal name in blue neon. The few passengers seemed reluctant to leave the airplane, as though they wanted to prolong their past experience before plunging into the new. This was Moscow, capital of the largest country in the world, center for so much news and comment, and symbol of many things to many people. It seemed like a dream that in a few hours of jet flight one had passed into that other world beyond the curtain, and one wondered if all the weeks of planning had been sufficient preparation for the unpredictable and bewildering time ahead.

The women in white smocks in the covered passage eagerly seized my inoculations book but seemed to stamp it and return it with some disappointment; men at the passport desk cleared me without hesitation and pointed toward a stand which contained customs declaration forms. After checking three stands I found a form in English. By that time an Englishman, whom I had met at London airport, and who expected to buy horses near

Moscow caught up with me and wanted to know how I had avoided having a needle administered with such great satisfaction by our white smocked friends in the corridor. The fellow at the passport desk gave a broad smile and seemed to think that our comments about the health check were amusing. He obviously understood English well, but had spoken only in Russian when requesting our papers. Before I had completed my customs declaration, a man and woman from the Institute in Moscow approached and asked my name and I was relieved to make contact with people who were expecting me.

For the next seven weeks my life seemed to consist of a sequence of surprises, a constant impression of differences in environment, and continued development of new interests and curiosity which all led to a strong feeling of physical and mental fatigue before the visit ended. The time actually seemed to pass very quickly, with every day bringing new interests or some special satisfaction from interviews, which added up to a very informative and stimulating experience. I felt somewhat insecure because I did not speak Russian and was not able to express my wishes or needs when on my own after work. One was constantly alert for any signs or suggestions of special attention being given to one by unknown persons. I saw no evidence that I was being watched and don't think I was, but it was hard to relax fully when you felt uncertain about your environment. Adjustment to the new way of living was not difficult, and my scientific itinerary and as much sightseeing as could be arranged after work were no grounds for attracting any more attention than the thousands of tourists could expect. Furthermore, I don't talk in my sleep and was alone in my room so none could monitor my thoughts or become suspicious about my assessment of the day's events. I felt even less conspicuous as a foreigner when a local inebriate at the corner cafe by my hostel insisted on telling me his

troubles in Russian; when I interjected, in my newly practised phrase book idiom, that I didn't understand Russian he was even less inhibited and told me more with even greater enthusiasm. This experience was repeated several times during the first two weeks and I concluded that I must have looked and reacted like a well-to-do Muscovite and so stopped being self-conscious. I must confess, though, that I finished a few meals on such occasions without delay and hustled off on some errand where I was less likely to become involved. People in general were friendly and courteous to you as a visitor and were obviously curious when you didn't stay at an Intourist Hotel.

Adjustment to living and working habits and customs in Moscow came almost as a shock when I found myself in a hostel in a new residential area south of Moscow University, and not in an Intourist Hotel with its special facilities for foreigners. Living among the local residents was itself a very interesting part of the exchange experience, even if it was difficult to manage a good diet at the local cafeteria. One certainly learned more of interest by observing the Russians in their daily customs than by mixing with the procession of visitors at the Intourist Hotels.

It is impossible to relate the details of many interesting and revealing episodes of the visit, but I hope that the following general impressions will be helpful to another visitor who decides to have a look at the work of his counterparts in the Soviet Union.

Transportation

All the public travel facilities in the Soviet Union are crowded and road traffic, though light, is very slow. The cross-section of people travelling on the planes and trains seemed to include about the same proportion of families, couples,

young and old as we see elsewhere, except for many more military personnel, and all seats or berths were usually filled. It was interesting to speculate how long people had to wait before obtaining passage and the frequency or purpose of travel for many.

I was repeatedly advised to remind my hosts at forthcoming stop-overs to wire back my return times as soon as possible in order that I might get a booking. The merit in this advice was well illustrated when an interpreter and I wanted to travel on the train from Kharkov to Kiev. When I learned that we would motor from Gubkin to Kharkov, via Belgorod, I enquired about telephoning or wiring Intourist at Kharkov concerning our reservations but was assured that this would not be necessary. Later we spent about seven hours of uncertainty at Kharkov while the young lady at Intourist struggled over our request and finally earned our sincerest gratitude when she presented us with railway tickets, with a feeling of real triumph. I would have been equally as happy if we could have stayed at the modern Intourist Hotel at Kharkov and seen more of the city. The interpreter admitted that he had no idea that travel reservations were so difficult and I believe that the Intourist staff had given him a very positive briefing on the current travel picture. The Intourist office at Kharkov was crowded with African and other foreign students and I overheard their discussion in English of travel frustrations and some revealing comments.

I judged that the railways were the most efficiently operated transportation system in the country, and obviously the most popular. The trains are not operated at as high a speed as here but are very comfortable with less space allocated per passenger than in North America. Sleeping compartments were clean, had modern appointments, and bed linen for the four bunks in a compartment was of a coarse durable weave. For the uninitiated traveller in the Soviet Union the sharing of a compartment

with mixed company may come as a surprise, but the arrangement is accepted as normal and practical with no evidence of complications. Music and commentary is piped to each compartment and the porters were efficient, serving biscuits or open faced sandwiches and fresh tea from the samovar in the corner of the aisle. Passengers on the trains were congenial and gave themselves over to travel in a spirit of good humored resignation. Some read, others played cards or chess, while other compartments seemed to have more exciting parties. One couple nursed a sick man who was delivered by hospital attendants on a stretcher because he was partially paralyzed. One evening I spent considerable time in discussion with a Bulgarian medical doctor and his family who shared the compartment. He had learned English from medical literature and when he saw Canada on my bags mentioned several Canadian specialists on coronary diseases who practised in his field. All of the passengers, including several military officers who shared compartments on different occasions, seemed to be accustomed to foreigners travelling and most exchanged a friendly Dobri Utrah and greeting before parting in the morning. I slept well on the trains, usually better than in the hotels, and this I attribute to smooth track, comfortable coaches and relatively few stops.

Air terminals for domestic flights were crowded with people and seemed to be operating at full capacity if not overtaxed. There was obviously not the same punctuality in the arrival and departure of flights as known in Canada and this had much to do with the accumulation of waiting crowds in the terminals. The aircraft were comfortable but the Il 104 jet plane was very noisy, and all were modestly appointed. The flight attendants paid very little attention to the passengers and none checked seat belts before take-off or landing. About the only personal service I noted, except for the delivery of fruit, water or meals,

was distribution of protective plastic bags for fountain pens to avoid leakage of ink at higher altitudes. Obviously the ball point pen has not reached the masses. Flight attendants were casual about the announcement of flight stops, and I doubt that more was said in Russian; if I had followed instructions and waited until the second stop on my flight east I would have arrived in Irkutsk instead of Novosibirsk. The Il 18 turboprop aircraft is an excellent plane and I must agree with the Moscow Aeroflot attendant who assured me that I would find it "solid when it flies."

Buses used in any of the cities were packed full and travel on them was a difficult ordeal, especially when place names were not always announced or easily recognized. The whole transportation system seemed to be operating at the very limit of its capacity and any expansion in pattern of living or national development will be directly dependent on improvements in transportation facilities.

Living Accommodations

In spite of the tremendous building program being carried out in the Soviet Union, it is doubtful whether enough new housing is being provided to keep up expanding needs and to replace the very old private dwellings. Evidence of inadequacy in housing development is shown by the sprawl of small menial houses that has grown up in some areas at the border of Moscow, Leningrad and other larger cities, while many country places are devoid of any kind of new buildings. The amount of living space allowed per individual is still unbelievably small by our standards but one is given to understand that conditions have improved greatly over the past five to ten years.

Five to six story buff brick apartment houses of almost identical design are rising in all cities of the country and

the monotony and austerity in design has little attraction for a westerner with individualistic tastes. The workmanship in the construction and decoration, or lack of it in new buildings, leaves much to be desired even for functional requirements. The climb up uncovered concrete steps to a fifth floor home provides a built-in fitness program as a bonus for the lucky tenants who rate an apartment where kitchen and water facilities do not have to be shared with other families. Obviously no provision is made for private automobiles or garages and the use of these will have to be discouraged for some time to come. The road and highway systems observed would be quite inadequate to accommodate even a small fraction of the per capita road traffic we have in Canada.

Rooms in tourist hotels were mostly of a standard with comfortable and adequate facilities, but requests for room service would not be encouraged. The water facilities functioned well in all the rooms occupied, in fact very well indeed, and the water circulation in one piece of apparatus never stopped day or night. One was reminded of an old camping lesson, never to camp by a waterfall if you want peace and quiet! This was such a common feature in all hotel rooms that one speculated about the colossal water waste because of unsatisfactory plumbing. A constant supply of hot water was a much appreciated feature.

Many of the villages in the country do not appear to have changed much in many decades. Streets are not paved or gravelled and there is little evidence of modernization of buildings although private dwellings are generally kept in good repair. New single dwellings were seen in a few villages but apartment houses are built in most places where there has been an appreciable increase in population. Every square foot of land around the cottages was used for garden or fruit trees and large areas of the right-of-way along the roads are divided into garden plots. The good agricultural land has been amalgamated in the expansive

collective farms.

Restaurants

The difference in diet and eating habits comes as a surprise to a westerner, especially if you do not live in an Intourist Hotel. There is an adequate supply of simple plain food, but it is difficult to obtain the balanced diet to which we are accustomed. Fresh milk and dairy products are not used to the same extent as in Canada. Butter is available, if specially requested, and one kind of cheese is usually offered. Sour cream is a staple with salads or potatoes, and cottage cheese is good. Fresh milk was not obtained during the entire visit and a breakfast of yogurt and a bun before an early morning flight (all that was obtainable at the air terminal cafe) will not easily be forgotten. Fresh fruit juice or fruit is not commonly offered except for local fruits in season, and the fresh cherries in the Ukraine were a real treat. The luscious oranges from Morroco displayed in all the restaurants were not much of an attraction at fifty to sixty cents each. People were very conscious about the new spring vegetables which began to appear about the time of my arrival in Moscow. A tray of salads brought a rush of patrons to the cafeteria table and the large bowls full of sliced radishes in sour cream exceeded my moderate habits. Both the cold sliced and cooked meats were usually very good and some of the roasted lamb was excellent. Potatoes were offered with considerable variety and cooked vegetables were usually available. Turnips seemed to be a vegetable staple. Desserts were not very popular or emphasized and many people used a lot of wine with their meals. In general, the heavy staple varieties of food were most abundant, with black and very heavy white bread. The excellent tea with lemon was one of the most enjoyable parts of a meal.

If one expects to dine well in restaurants in the

Soviet Union he must be made of patience because the service is slow and the attendants have no real incentive for caring about your needs. In many places the dining room staff does a good job and is not always responsible for delays. Travelling alone brings difficulty in some hotels, particularly those which cater to tourist groups and have restricted or special menus all prepared in advance. At one hotel the waiter refused to serve me as an individual until after 9 p.m. in the evening and at another hotel in a different city I was refused lunch and given the same after 9 p.m. routine about dinner. On both occasions I went to the service bureau immediately, identified myself and my sponsor and inquired where I could find a good restaurant that they would recommend to their guests. This tactic brought immediate investigation and someone accompanied me back to the dining room and straightened out the staff about meal hours for hotel guests and possibly for foreigners travelling alone. This worked well and I got a good meal, but to my surprise I had to go through the same ritual the following evenings at both the hotels where I had originally been refused service. At the Leningrad hotel, on the third evening, the head waiter showed me a table, kept an eye on the service, and in good humour extended several courtesies that were reminiscent of dining rooms at home. This difficulty was encountered in Leningrad and Kiev in hotels catering to groups of tourist guests from the iron curtain countries; as a Canadian I don't quite know how I happened to be sent there. In one case I was told by a scientist that I didn't belong in that hotel, which was considered third rate, and that I belonged in some others which are the well known stopping places for westerners. I learned from these experiences that one occasionally had to be just as positive as those around you and play on a factor that would embarrass them, if necessary. Many difficulties in travelling arise becuase the hotel staff is also trying to beat or

improve a bad bureaucracy.

Shopping would be relatively easy in the new self-serve grocery store in Novosibirsk, as only one variety of each grocery item was displayed. A large number of wines were shown at inexpensive prices. The variety of candies and space used for these seemed out of proportion to that allocated for cereals or vegetables. Sweets were very expensive, with a bar of chocolate costing about one dollar. It appeared that food products and prices were similar in different parts of the country.

Consumer Goods

Most items of consumer goods are available, although varieties of separate items are very limited and the quality seems to vary from good to much that would not be easily sold in Canada. Cameras, transistor radios, television sets and the like are available for prices comparable to ours and the throngs of people buying these items suggest that the purchasing power is there for acquiring all the luxury items made available. Household appliances are generally scarce and of poor or old design, and gadgets have no established place in their way of living. The quality and variety of clothing for both men and women are changing and improving, but prices in my estimation were high considering the quality offered.

Cultural Pursuits

Achievements in the Soviet Union in many cultural fields are widely recognized outside the country and their high standards in ballet, music and some entertainment are not disputed. One gets the impression that many of these activities are limited to a few large cities and only reach a relatively small number of people. The ballet performance at Novosibirsk was excellent and in my opinion rated with performances in Leningrad

and Moscow; these are considered to be the three top ballet companies in the country. Cinemas are popular but not many were seen in smaller towns.

Numerous television aerials in the larger cities suggested that this is a popular entertainment and communications media, but it was not possible to view programs over a period of time. The technical quality of the pictures was very good. Radio speakers in all the rooms occupied provided considerable serious or classical music, dramatic works, and lengthy commentary of just talk. One multichannel radio set seemed to have all the foreign frequencies blocked. Music from the west is popular and much is heard because of the availability of portable radios.

The Soviets are voracious readers and book stores are very popular and crowded. Even book vendors on the streets draw large queues. Most interpreters asked about current publications and literature in Canada and wanted to know who the most popular writers were. They were particularly anxious to get books which used current idiom and expression as they felt that much of the English literature available to them belonged to earlier periods and was not "living English." A few paper-back books taken for diversionary reading were accepted enthusiastically by associates who more or less intimated that they longed for modern foreign reading. One excellent fairy-tale book in English was given to me in exchange as a present for my children. Books are inexpensive in the Soviet Union, particularly technical and scientific works, and although the printing and lithographic work is not of high standard there seems to be an endless variety of material.

The Soviet people, as well as many tourists in their country, take a sincere interest in their art galleries and museums. There are many galleries with outstanding collections of paintings by the old masters and they continually attract large crowds. This part of the people's heritage is cherished very

deeply and their intense interest in pre-revolutionary works was conspicuous in the many galleries visited. I had to agree with their choice. The historical value alone, to say nothing of the esthetic merits of many of the older paintings, provided a rewarding experience and as many galleries were visited as time permitted.

Most of the galleries and museums are very well housed and the displays are maintained with considerable effort and care. It was often difficult to gain full benefit and appreciation of very outstanding classical works because of poor lighting or perspective for viewing the work. In many cases direct lighting from the windows or partial side lighting created unnatural glare or highlights on the oil surfaces which forced one to manoeuver until a place was found where paintings could be seen and appreciated in their entirety. In many cases well controlled indirect or artificial lighting would have been a decided help.

The art treasures of the country provide some of the greatest pleasure and satisfaction a traveller finds and the people are justly proud of their galleries.

Churches and Religion

When I first arrived in the Soviet Union I was told that there was complete freedom of religion but that people were no longer interested in these matters. A visit to Zagorsk Monastery, the headquarters of the Russian Orthodox Church near Moscow, on a Sunday revealed a very different situation. The worship services at three churches were crowded and people knelt on the entrance steps. Young and old participated in the services and a guide told me that this monastery is maintained entirely by donations from church people and that more than 200 young men are training at the Academy for the priesthood or for church service.

If complete freedom exists it is hard to reconcile the fact that no religious instruction is permitted for young people before the age of eighteen and that church influence in a community is restricted to worship.

Most of the church buildings seen throughout the country were maintained in good condition or were being redocorated and repaired. Many churches which are still used for Christian worship and are known as working churches are kept in excellent condition and large family groups were observed at many of these on Sundays. In contrast, many other church buildings have been taken over by the government and are maintained as architectural monuments, museum churches, or as religious museums. The religious museums are usually renovated inside and have a strange collection of exhibits dealing with anthropology, astronomy, religious history, abuses and defects of past organized churches, strange religious sects, medieval torture and new exhibits of the space program. I remarked to one associate that I didn't care for one of these museums because its exhibits did not show authentic materials, I doubted the historical veracity of much of what was depicted, and in short could see without a knowledge of the language that the display consisted of a polyglot of fantasy, fiction, fallacy and fact which were basically meaningless in this context. His reply was that most would agree and he felt the same way about these exhibits.

With regard to the churches, it is interesting to note that the present government has recognized the very great concern of the Soviet people for their heritage and the deep respect they hold for much of their past history and culture. For this reason church buildings have not been destroyed or converted for other uses and many are maintained by the state.

The Russian people have been devoted to their religious faith throughout their history and I judge many are still deeply

religious. Concern and interest were expressed on different occasions about man's spiritual well being and many are thinking seriously about this aspect of life. A display of modern American architecture, which showed a number of modern church edifices, was referred to several times and much interest was expressed in the role of the church in our society. Part of my reply to this interest was to point out that the Bible is still the best seller in the English language and it was regarded as good reading from a literary viewpoint, if not as a guide to religious faith. I was told that the newer translations of the Bible are only available to the authorized or approved clergy in the Soviet Union. One had to think of medieval time when the scriptures were chained to the pulpits in western cathedrals.

Recreation

Most people have a high regard for life and activity in the outdoors and the beaches attract tremendous crowds on the week-ends. Fishing is a popular sport and ardent anglers were observed wherever opportunity existed, from the banks of the Moskva River in Moscow to rivers in the Ukraine or the Ob Sea at Novosibirsk. Some of the geologists spoke about vacation trips with their families when they went hunting and fishing. One man's picture album showed scenes of rivers, lakes, rock and forest in Siberia that were vivid reminders of northern Canada.

Organized and professional sport has wide appeal but playing fields and stadiums are not numerous or well developed, and participation in sports by people in general is probably not as great as here.

Gardening is an attractive hobby and many professional people spoke of their country dachas and looked forward to spending week-ends tending their garden plots, shrubs and flowers. Other city people acquire garden plots in the country along the

roads or railways, which provides a recreational outlet and also fresh vegetables. The impression is gained that many of the urban people still feel a strong attraction to the country and soil that was tilled so faithfully by their forebearers.