Report of the

CANADIAN NON-FERROUS METALS MISSION TO PEOPLE'S REPUBLIC OF CHINA

March 3 to 17, 1979

Government of Canada | Gouvernement du Canada
Industry, Trade and Commerce | Industrie et Commerce

CANADIAN NON-FERROUS METALS MISSION

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REPORT TO THE MISSION

This report has been compiled by the
Resource Industries Branch
Department of Industry, Trade and Commerce

OTTAWA MAY, 1979

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INTRODUCTION

The objectives of the Non-Ferrous Metals Mission were as follows: -

Primary

(1) To maintain Canada's high profile with the Chinese metal industry and to better acquaint the Chinese with Canada's technological capabilities in the non-ferrous metals industry.

(2) To establish the groundwork for possible sales of technology.

Secondary

(1) To enable the Canadian participants to obtain a better appreciation of China's non-ferrous metal productive capabilities and thus, indirectly, of China's requirements for technology and metals.

(2) To reiterate Canada's interest in becoming a long term supplier to China of non-ferrous metals.

The mission was originally planned for November but owing to a number of problems involving primarily transportation to Peking from Tokyo, the 14-day mission did not commence in China until March 3rd. Unfortunately, because the Chinese itinerary was not made available to the mission delegates until several days before departure, they were hindered in making detailed preparations. Not knowing where they were going to be taken until just prior to departure gave them little time for prior study of the areas they were to visit and thus possibly the mission was not as beneficial as it might otherwise have been.

However, the delegates did see the type of plants in which they were interested and they did find the Chinese most helpful in endeavouring to meet their special interests.

The mission members were most appreciative of the Chinese decision to divide the mission into three groups. This enabled the members to see more of the Chinese non-ferrous metals industry than they would otherwise have done. The routes followed and the plants visited by the three groups are shown on the attached maps.

The mission members found their hosts most hospitable and accommodating. For the most part they were forthcoming in supplying information but at the same time they expressed much interest in Canada's technological capabilities and in many cases appeared well informed. The seminars held in Peking and other locations to discuss papers presented by the mission members were well organized and, based on the questions asked, the Chinese appeared to have carefully studied the papers which were given to them some months prior to the commencement of the mission.

Following the return of the mission, a debriefing session was held in Toronto, on April 17th, to enable the delegates to present their views on the Chinese situation as it applies to the non-ferrous metal industry, to industry and provincial government representatives. In addition, A.T. Eyton, Director General of the Pacific, Asia and Africa Bureau, and M.D.J. Bakker, Regional Manager - Far East Area, Export Development Corporation, respectively addressed themselves to "Canada/China Trade Relations" and "The Role of the Export Development Corporation at it relates to China". The agenda and a report of this meeting are included in this report.

On their return each of the mission members prepared a report on their observations. These reports have been included in this report as written and therefore some duplication will be noted.

For those readers who have not the time to read the individual reports, it is suggested that they read the report of the debriefing meeting. This report provides a summary of the impressions and observations of the mission members as presented at the meeting.

MISSION MEMBERSHIP

Government Members

Mr. G. Nash (Head of Mission),
Director, Metals and Minerals Group,
Resource Industries Branch,
Department of Industry, Trade & Commerce.

Mr. Ho Yu-Lin
Interpreter,
Department of the Secretary of State.

Industry Members

Dr. G.A. Crawford,
Manager, Patents & Licensing,
Falconbridge Nickel Mines Limited.

Mr. H.C. Garven,
Manager, Process Development Group,
Inco Metals Company.

Mr. G.D. Hallett,
Assistant Manager - Continuous Smelting Division,
Noranda Mines Limited.

Dr. G. Harden,
Manager Exploration - Western District,
Cominco Limited.

Mr. V.N. Mackiw,
Executive Vice-President,
Sherritt Gordon Mines Limited.

Dr. E.A. Manker,
Vice-President,
Niobec Incorporated.

Mr. W.W. Robertson
Senior-Consultant - Smelting Technology,
Alcan International Limited.

Dr. O. Sivilotti,
Vice-President - Technology, Rolled Products,
Alcan Canada Products.

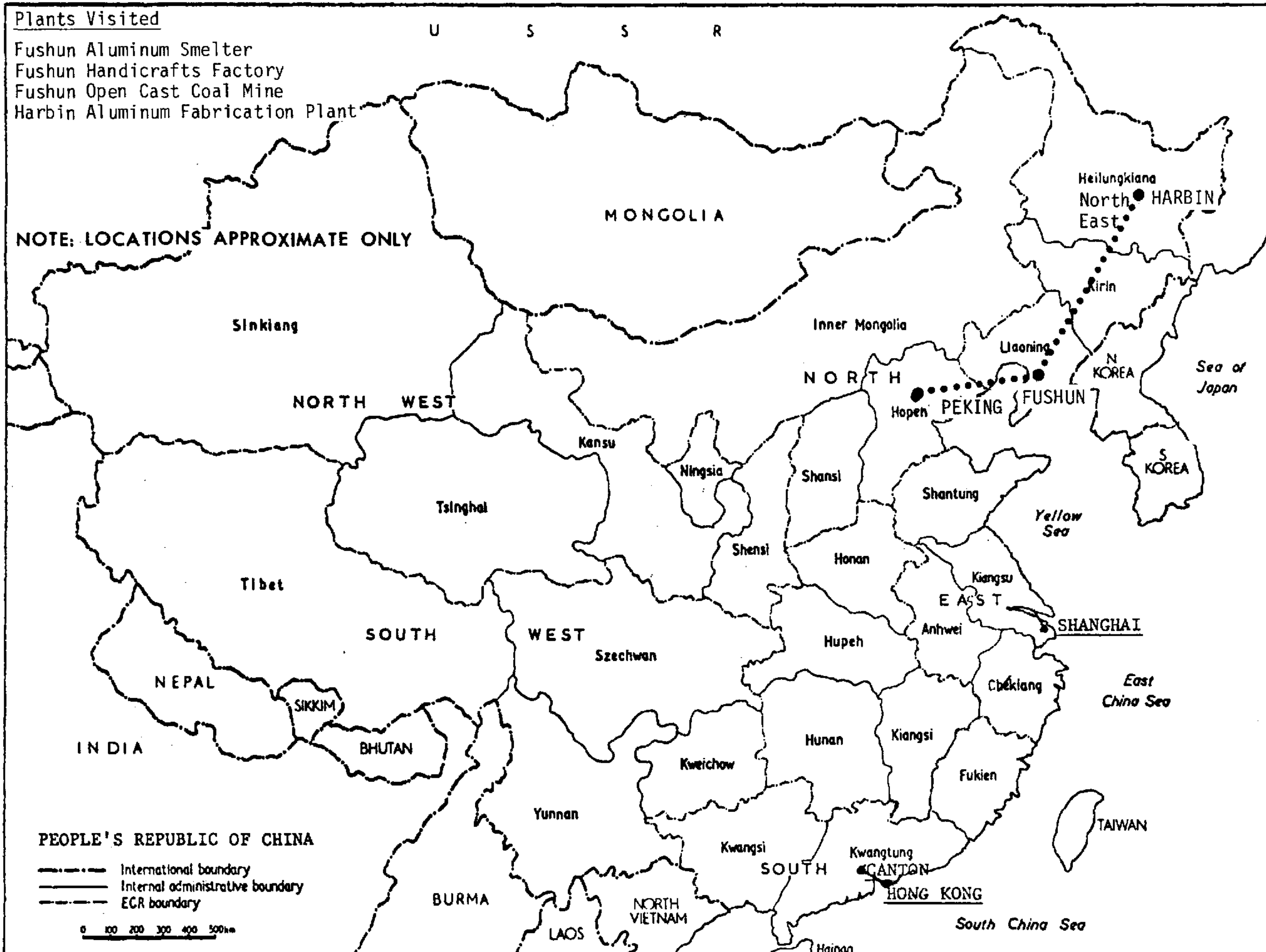
ITINERARY

As noted below the mission was divided into three groups.

Group I	- O. Sivilotti, Alcan Canada Products - W.W. Robertson, Alcan International Limited
Plants Visited	- Aluminum Smelter, Fushun, Liaoning Province - Open Cast Coal Mine, Fushun, Liaoning Province - Handicrafts Factory, Fushun, Liaonong Province - Aluminum Fabrication Plant, Harbin, Heilungklang Province
Group II	- G. Nash, Industry, Trade & Commerce - Y.L. Ho, Secretary of State Department - G.A. Crawford, Falconbridge Nickel Mines Limited - H.C. Garven, Inco Metals Company - G.D. Hallett, Noranda Mines Limited - V.N. Mackiw, Sherritt Gordon Mines Limited
Plants and Government Offices Visited	- Bai Yin Copper Mining & Smelting Complex, - Gansu Province - Jinchuan Nickel Mining and Smelting Complex, Gansu Province - Ministry of Metallurgical Industry, Peking
Group III	- G. Harden, Cominco Limited - E. Manker, Niobec Corporation
Plants and Government Offices Visited	- Baiyun Iron Mine, Inner Mongolia - Baotou Iron and Steel Plant, Inner Mongolia - Jilin Ferroalloy Plant, Kirin Province - Geological Bureau, Peking

Locations of the Plants visited are shown on the maps which follow.

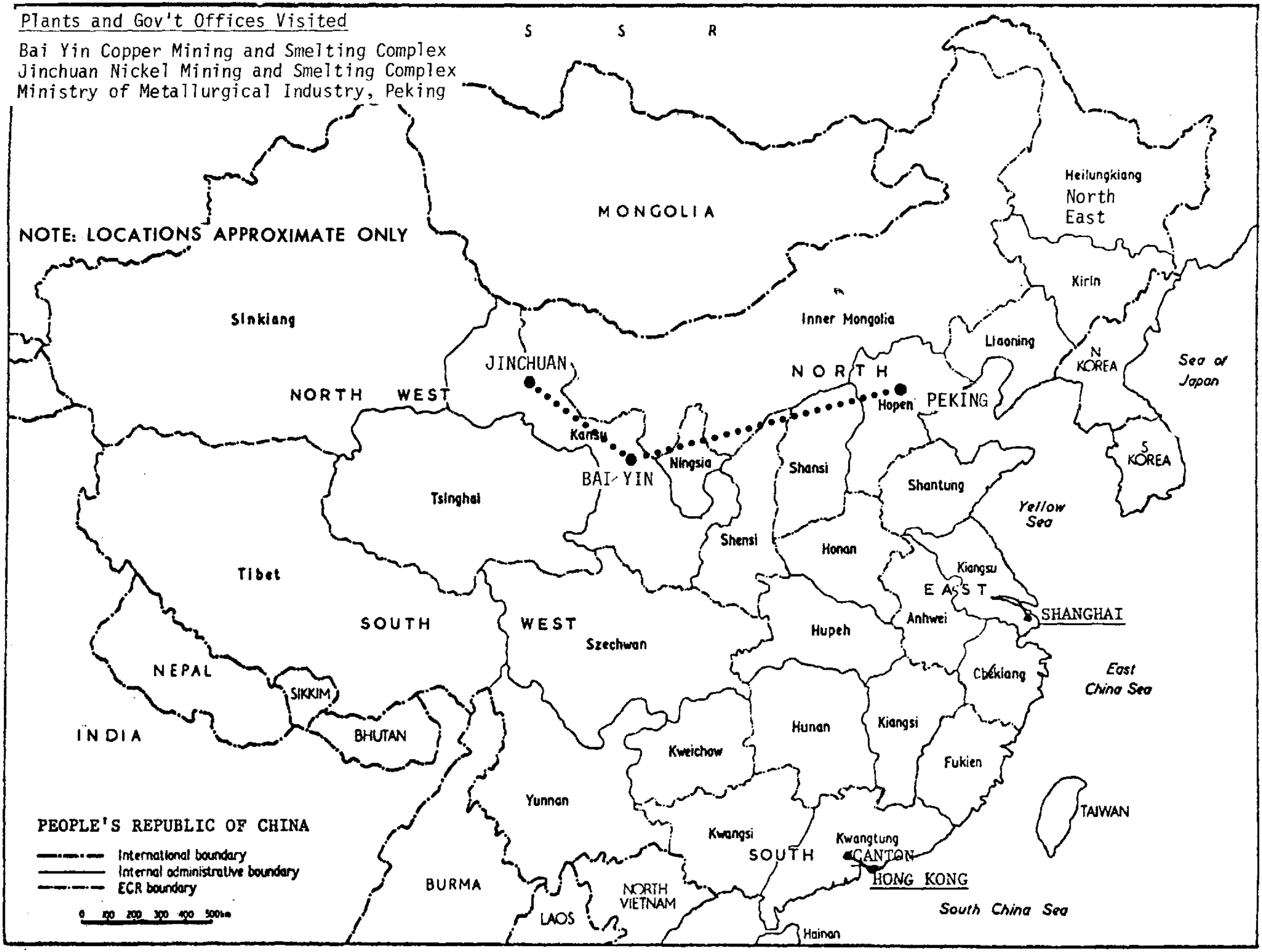
GROUP I (W.W. Robertson, O. Sivilotti)



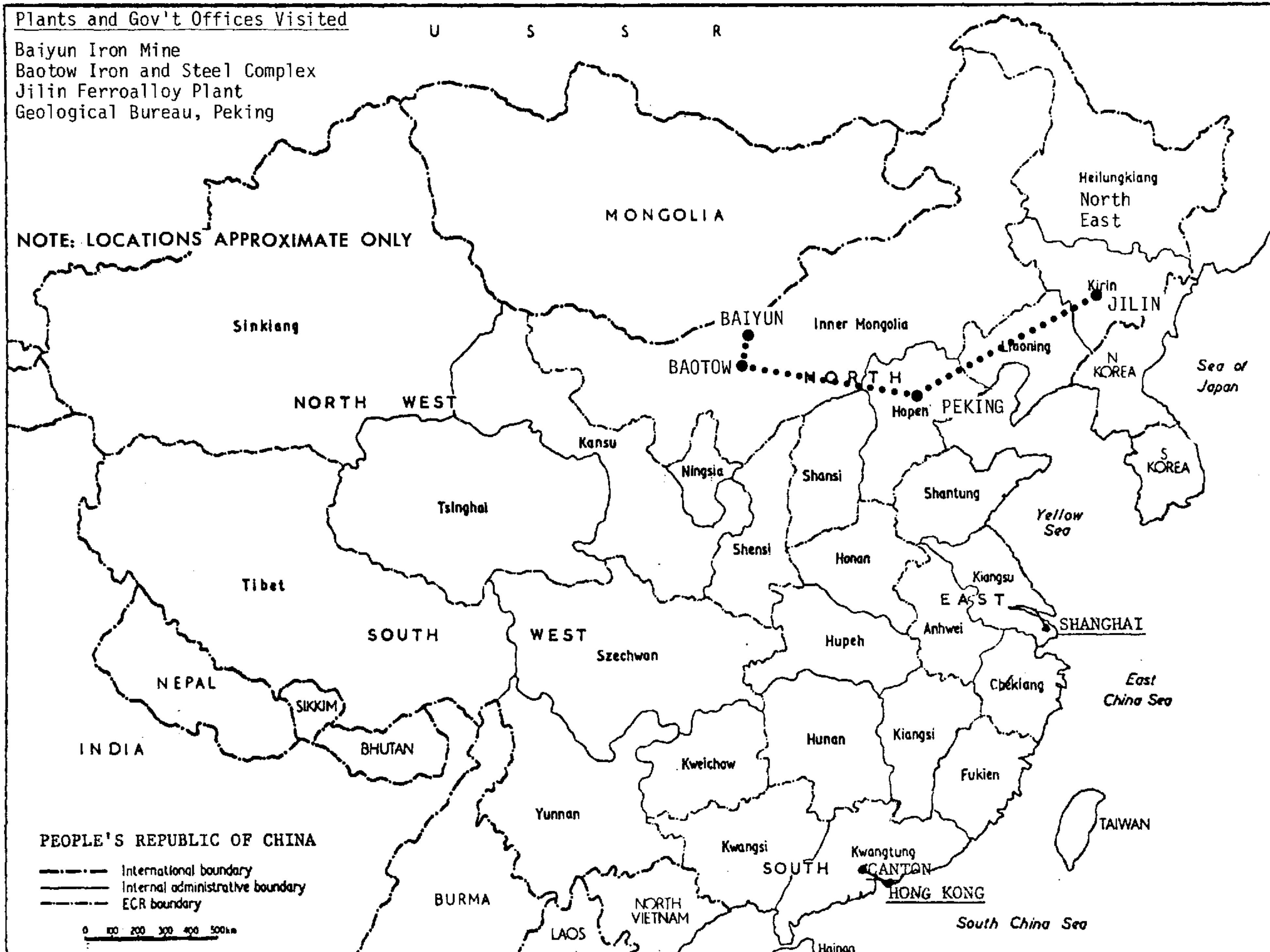
GROUP II (G. Nash, Y - L Ho, G.A. Crawford, H.C. Garven, G.D. Hallett, V.N. MacKiw)

Plants and Gov't Offices Visited

Bai Yin Copper Mining and Smelting Complex
Jinchuan Nickel Mining and Smelting Complex
Ministry of Metallurgical Industry, Peking



GROUP III (G. Harden, E. Manker)



REPORT

by

G. Nash, Director, Resource Industries Branch

While other members of the delegation were presenting their papers at seminars arranged by the Chinese, I called on officials of the Ministry of Metallurgical Industries. A summary of the discussions held during this visit and my general observations made while in China follow:-

Ministry of Metallurgical Industries

Organization

The Ministry of Metallurgical Industries, headed by Minister Tang Ke, is divided into three industry divisions - Non-Ferrous Metals, Construction and Iron and Steel. In addition, there is a foreign Relations sector of the Department which is responsible for incoming and outgoing missions, travel, hospitality and interpretation services. It also includes a technical import/export company, which should not be confused with the National Import/Export Corporation of the Foreign Trade Ministry which normally handles business arrangements. The Foreign Trade Corporation may take on a secondary role in relation to the technical import/export company of the Metallurgical Industries Ministry. The Corporation, for instance, would take on responsibility for a complete package of technical equipment information and exchange, whereas negotiations involving a single piece of machinery or specific plant equipment, would be handled by the Ministry of Metallurgical Industries. In general, therefore, there are two channels which might be used to make contact with the Chinese government on matters pertaining to the metal industry; namely, the Corporation or the Foreign Relations sector of the Ministry of Metallurgical Industries.

The Non-Ferrous Metals Division is organized under the direction of Vice-Minister Li-Hau; the Director General is Sun Hong Ru; the Deputy Director is Jiang Feng; the Director, Non-Ferrous Metals Fabricating is Li Zhiying; and the Engineer, Aluminum Fabricating/ Ore Dressing and Processing is Sung-Min-Wen. The Vice-Minister of Foreign Relations and also Vice-Chairman of the Metals Society is Liu-Hsieh Hin. It should be noted that the Vice-Director of the Technical Import/Export Corporation of the Ministry is Jiang Feng as mentioned above, who is also Deputy Director-General of the Non-Ferrous Metals Division and, hence, would be an appropriate contact for businessmen. All of the metal companies in China are the responsibility of this Ministry.

The Ministry also has research institutes, whose main interests are in the field of applied research, directed to increasing production. This contrasts with the Academy for Research and Development which has a metallurgical research group but which concentrates more on basic research. The Ministry is now getting more involved in economic research.

Vice-Minister Li-Hau hopes to increase work in this area and plans to conduct economic surveys for both ferrous and non-ferrous metal groups, which will be carried out by the planning and design institute of the Ministry, located in Beijing. Economic research is undertaken by the Planning and Design Institute. The institut responsible for the review and evaluation of specific projects indeed, is responsible for the review of a plant's operations, production and planning. Also, it should be noted that each p mine has its own planning and design group, which reports to t Ministry's Planning and Design Institute in which Mr. Liu Tian Deputy director. The Ministry delegates responsibilities for from the commencement of a project to its completion to the Pl and Design Institute.

The Ministry of Metallurgical Industries also has a Geological Section which does specific studies of mine areas t developed, but usually refers to the National Bureau of Geolog for assistance and advice on major projects i.e. regional nati geological work. Often, the Ministry will request that NBOG t responsibility for large-scale investigations. The Ministry h problems of overlap between its areas of responsibilities and other ministries. For example, in some cases the Machinery In Ministry would handle cable and wire, while in other cases the Metallurgical Industries Ministry might handle it.

A list of some of the officials in the Ministry of Metallurgical Industries and in other organizations met by the delegation follows:-

Partial List of Officials met by Members of the Delegation.

Ministry of Metallurgical Industries, Beijing(Peking), China

Li Hau	-	Vice Minister
Sun Hong Ru	-	Director General - Non-Ferrous Metals Div.
Liu-Hsieh Hin	-	Vice Minister - Foreign Relations and Vice Chairman of the Metals Society
Jiang Feng	-	Deputy Director-General, Non-Ferrous Metals Division
Li Chunfu	-	Director, Foreign Relations Dept.
Li Zhiying	-	Director, Non-Ferrous Metals, Fabricating
Wang Jun	-	Engineer, Non-Ferrous Metals Division
Qu Boming	-	Deputy Chief Engineer, Harbin Light Metals Fabrication Plant
Hua Zhengfang	-	Superintendent, Research Office, Beijing(Peking) Non-Ferrous Metals Research Institute
Sung-Min-Wen	-	Engineer - Aluminum Fabricating/Ore dressing and processing
Chang Yusen	-	Staff Member
Liu Tianbin	-	Vice Superintendent of the Technical Dept of the Beijing(Peking) Non-Ferrous Metals Design and Engineering Institute
Gong Hongxiang	-	Engineer - Non-Ferrous Metals Design and Engineering Institute
Li Tianyuan	-	Engineer - Non-Ferrous Metals Design and Engineering Institute
Yin Dehong	-	Engineer - Non-Ferrous Metals Design and Engineering Institute
Mdm. Chou Meiling	-	Interpreter from Institute
Hou Jianping	-	Interpreter from Ministry

Chang Yinfeng	-	Engineer, Shenyang Aluminium Magnesium Design Institute
Mdm. MA Wenyuan	-	Interpreter
MA Shoukang	-	Interpreter
Jiang Wenjie	-	Interpreter

Jinchuan Nickel Mining & Smelting Complex

Senior Management

Wang Wenhai	General Manager
Chao Chuankeng	Vice Manager
Chen Shixian	Vice Manager
Huang Jianshi	Deputy Chief Engineer
Li Shouwen	Director, Technical Depa

Baiyin Copper Mining and Smelter Complex

Chao Ching	General Manager
Chen Yunlin	Vice Manager
Chen Bochi	Engineer

Project Priorities

Vice-Minister Li-Hau said that their priorities in the Non-Ferrous Metals area in order of importance are - (1) copper, (2) aluminum, (3) lead and zinc, (4) nickel. These priorities are in part determined by the nature and extent of Chinese mineral reserves, which they have yet to determine with a reasonable degree of accuracy. In the case of nickel, they see it tied to the domestic demand for steel; they expect that by 1985 they will be producing 65 million tons of steel and about 50,000 tons of nickel.* The Jinchaun Company in Gansu Province covered in the report prepared by G.A. Crawford and V.N. MacKiw is expected to meet the requirements of the steel industry. The plan is to develop a large mining, smelting and refining complex at Jinchaun. They indicated that the nickel will be for domestic use and not for the international market.

Vice-Minister Li-Hau referred to China's large surpluses of tin, molybdenum, tungsten and antimony, but once again indicated that most of the production would continue to be for domestic consumption. For example, domestic use of tungsten will be given first priority; only the surplus would be directed to the world market which they would endeavour to develop as required. They indicated that they have yet to better understand the mechanics of world markets and are looking for experience in the field. It was the view of the ministry, that stockpiling was not economic.

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* Recent information suggests that steel production targets have been revised down to 45 million tons by 1985, hence nickel would be in the order of 40,000 tons per year.

International Lead Zinc Study Group

On my inquiry as to the interest the Chinese Government might have in participating in the Lead Zinc Study Group, the Vice-Minister indicated the Government would be pleased to have officials attend as observers and would welcome any initiatives that could be taken to have an invitation issued by the Group.*

Contract Arrangements

Before contracts are entered into it was indicated that there was a need for much contact, mutual understanding, many exchanges and considerable study. This stage allows for in-depth appraisal of each other's capabilities. Although China prefers self-reliance, it will welcome utilization of foreign technology if and when necessary. However, it is stressed that financing was a problem and they are very concerned about being able to pay for what they buy. As a result, they study each project very carefully to determine the benefits to China's economy and its ability to realize enough revenue to finance the undertaking over a reasonable period of time. They would prefer not to borrow money from others. Vice-Minister Li-Hau stated their in-depth studies for certain projects are quite involved and complicated. He believes China has reached the mutual understanding stage with Canada and are now prepared to enter into detailed discussions on certain projects but warned that the process is slow, principally because of

* At the International Lead-Zinc study Group meetings held in London during April it was agreed that an invitation would be extended to the People's Republic of China.

financing considerations. They have some projects in play now; namely, the Pao Shan iron and steel project in Shanghai. While they appear to have decided to go ahead with this project, they are still negotiating the financing terms. They have not yet signed contracts for the construction of an aluminum smelter and copper refinery. Preliminary discussion on the copper refinery, which is considered as a smaller project, has been initiated and feasibility studies are being conducted. After the completion of the studies, detailed negotiations will take place.

For the Jinchaun nickel mine project, there are at least four foreign companies in contact with the Ministry. The Chinese are waiting for cost estimates, and so there is still time for other companies to bid.

Second stage negotiations which involve specific costs and production details can be expected to be slow, because the Chinese will undertake studies comparing each of the project submissions. Three factors are important namely;

1. The Chinese preference for dealing with friendly countries
2. Financing
3. Method of payment

The Chinese prefer that payment for technology, equipment and services be made through compensatory trade (payment in products produced) or through a joint venture arrangement. Where cash is involved, they may request that such payments be deferred.

Under a compensatory trade or joint venture arrangement, the Chinese will expect the foreign company to assist or handle initial marketing aspects, since they have limited marketing experience. There are three negotiation stages - (1) the attainment of mutual understanding, (2) letter of intent, and (3) a firm contract covering all phases. (It should be noted that contracts may involve a series of sub-contracts i.e., covering the various phases and facets of a commercial arrangement.)

A joint-venture agreement will in most cases cover a ten-year period. During the first five years, the foreign participant will be reimbursed for his investment; over the remaining five years, he will be allowed a reasonable profit and presumably after the end of the ten-year period, the Chinese will, depending on the circumstances, endeavour to obtain full ownership of the project. While management of the project would be shared during the ten-year period, ultimate control must be with the Chinese. The Chinese indicated that they are still at a fairly early stage in their consideration of joint-ventures and that a commercial legal framework governing such arrangements is presently being developed.

General Observations

One of the recurring themes that evolved in almost all conversations with Chinese officials was the concept of "doing business with friendly countries" and the importance of "friendship". It appears as though these phrases have very specific meanings to the

Chinese and are not used in loose fashion. Although it is difficult to give a concrete definition of these phrases as used by the Chinese, it might be helpful to make an attempt. Friendship to the Chinese implies that a country's international posture regarding political and general grade matters should not be seen to be inimical to Chinese interests. Certainly, Canada's early recognition of China would be perceived as a major step in that direction as well as the above reported initiative of arranging for the Chinese to participate in the International Lead Zinc Study Group. Although many of the companies involved in dealing with the Chinese are unnerved by the amount of specific information that the Chinese attempt to gather during their dealings with them, this again appears to be another test of friendship. The number of missions that Canada would accept and that companies will host would also be considered. While in China, we noted large photographs and books about such personages as Stalin and Norman Bethune. They obviously consider these people as having been friendly to China; that was an indication to me "that they do not forget their friends". In summary, therefore, their concept of friendship and their continued efforts to maintain the links resulting from that friendship is a determining factor in laying the basis for increased trade and investment relations. Moreover, I believe that personal relations can become a very important factor in developing trade or business relations. On a number of occasions this proved valuable in that protocol was ignored for the sake of satisfying our requests.

Business Potential

The Chinese Government has a ten-year development plan, the details of which are not made available. They have, however, announced a series of projects which they intend to pursue. A number of factors suggest that there are severe constraints on their abilities to meet these goals, particularly since they wish on the one hand to be self-reliant and to minimize their dependence on foreign capital and on the other hand have inadequate foreign exchange reserves to make necessary purchases. It is my view that the Chinese will progress in a moderate fashion and in a fairly controlled manner with only limited opportunity for participation by Canadian interests. Any marketing effort will have to be sustained for long periods of time in those areas where Canada has clearly established itself as being at the forefront of technology and commercial capability. Currently, only one contract in the area of non-ferrous metals had been signed. This contract given to Fluor Mining and Metals Incorporated calls for an engineering-financial study for a large copper complex in Kiangsi Province.

THE ALUMINUM SMELTER AND THE WEST OPEN CAST COAL MINE, FUSHUN, LIAONING PROVINCE

W.W. Robertson, Alcan International Limited

Preamble:

Messrs. W.W. Robertson and O.G. Sivilotti were received by the management of the Fushun smelter from March 7 - 9, 1979. The program was as follows:

March 7	AM -	Visit to Smelter & Development Center.
	PM -	Technical paper "Modernization of Horizontal Stud Soderberg Cells for Aluminium Production presented by W.W. Robertson to a group of about 25 technical personnel.
March 8	AM -	Continuation of questions on Technical Paper.
	PM -	Visit to West Open Cast Coal Mine.
March 9	AM -	Further visit to smelter including diode manufacturing facilities.
	PM -	Visit to Handicraft Factory.

The party returned to Peking on Saturday March 10th. The above mentioned technical paper was again presented on Monday, March 12th and further discussions took place on March 13th. In these latter meetings, the group was considerably smaller (about 8) and the participants were primarily from "Design Centres" (engineering departments).

In the following write-up, observations made in the smelter are covered in Part I. Part II covers the visits to the open cast coal mine and handicraft factory. Part III summarizes impressions obtained from the question and discussions following the presentation of the technical paper in Fushun and in Peking.

PART I

Observations: Fushun Primary Aluminum Smelter

Introduction

The primary aluminium smelter at Fushun (105,000 tonnes) is reportedly the largest in China. It is located about 40 Km east of the city of Shenyong, 650 Km northeast of Peking. In the words of our hosts, it is one of the eight "Friendship" factories presented to the PRC by the U.S.S.R. in the early 1950's, "while Joseph Stalin was still alive".

Fushun is described as "Coal City". There are several major coal mines in the vicinity, one of which was visited by the party. There is a high level of industrial activity including steel, cement, oil shale treatment and power generation. Atmospheric pollution is very reminiscent of some of the worst areas in the Ruhr. Proximity to the energy supply is presumably the reason for location of the smelter. More information is available on the Fushun smelter than on any other in China. It has been visited by a number of Western delegations over the past few years.

Plant Description

The basic technology in the plant is the Horizontal Stud Soderberg Cells of a design developed in the U.S.S.R. in the early post-war period. There are 4 pot lines each with 160 cells in 2 buildings. The cells are of the so-called "Channel-less" design with anode dimensions 1,800 mm x 3800 mm, 10 rows of contact studs along the length and 5 on each end. In order to facilitate servicing the studs on the ends of the anode, the longitudal inter cell distance is relatively large (about 2 meters). The buildings have high ceilings and the space between rows of cells and between the cells and outer walls is quite ample. Internal atmosphere was very poor.

Each pair of potlines had a casting facility in a building of similar section to the potroom buildings, located between them with the principle axis in the same direction. Path of metal flow is from both sides to the center. In the buiding visited, the casting equipment only occupied about 50% of the area at one end. The rest of the building contained service shops and equipment. There were 4 relatively small (15 T.) furnaces in the casting area, two feeding a straight line ingot casting machines equipment with rudimentary automatic stackers, and two feeding DC machines casting 100 mm x 100 mm wire bar. The DC machines had a capacity of 10 ingots, the moulds were disposed radially about the pouring basin. The length of the stroke on the machine was 6 meters.

Table I shows some of the performance data for the plant.

TABLE I

FUSHUN SMELTER

OPERATING TARGETS AND RESPONSES

Targets		Responses	
Amperage ka	64	Faraday Eff.%	87-88
Current Density a/cm^2	.94	DC Power kwh/tonne	15000
Electrolyte Ratio	1.35	Electrode kg/tonne	545
CaF_2%	3.5	Electrolyte kg/tonne	40
Metal Height (Cms)	25.	Lining Life Days	1800
Electrolyte Height (Cms)	15	%Fe	.06
Tapping Interval (Days)	3	%Si	.08
Crust Breaking Interval Hours	3	Anode Effects/Day	2.
Al_2O_3 Type	Floury		

In general, the results compare favourably with that obtained in similar vintage equipment elsewhere in the world.

Organization

A number of interesting insights into the social organizations in China was provided by the labor distribution as given by the plant manager (Table II).

TABLE II

Fushun Smelter Organization:	Number of Employees
Potlines (including Casting)	2019
Carbon Plant	253
Electrolyte (AlF_3, Cryolite)	240
Electrical Operations (Including Mtce) (of which 70 are engaged in diode manufacture)	420
Instrument	60
Mechanical Shops	360
Major Maintenance & Construction	328
Laboratories & Quality Control	120
Transportation	260
Welfare Services (Including Hospital 250)	740
Administration	180
	4980

Technical Staff: 11 Chief Engineers, 3 Deputy Chief Engineers, 70 Engineers, 130 Technicians (included in above).

For comparison, the payroll in a North American plant of similar capacity would be 500 - 700 (150 - 200 tonnes per man year) as compared to 20 in Fushun. However, the scope of activity encompassed by the organization goes beyond simply running the smelters.

Early in the visit, it was mentioned that beginning in 1970, the plant had replaced the mercury arc rectifiers with silicon diodes, and that all of the work had been done in the plant including diode manufacture. Following detailed questionning to ensure that there had been no misunderstanding through translation, it appeared that the statement was true and that they were still engaged in this manufacture. As the last event in our visit, we were taken to the plant where this operation was in progress. We were shown a number of the steps of this very high technology operation and were assured that this work was only for the Fushun smelter and not for other locations.

We formed the impression here and in other locations that one purpose of an industrial establishment was the need to be as self-sufficient as possible. This included not only manufacture of their own spare parts, specialized components and minor raw materials, but also the operation of services for employees such as housing, schooling, hospitalization, recreation, adult education, etc.

Pilot Plant Project

One of the most fascinating aspects of this visit was the tour of their pilot plant facility. This was in a separate building of the same section as the regular potroom buildings and the other buildings. Current supply was obtained by a parallel connection with two regular potrooms.

Since 1974 they have been experimenting with the development of high amperage prebake cells. Space was available for 4 cells in the side by side configuration. One could follow the evolution of the development from the equipment still in place. Phase I was an unhooded side break cell of relatively high current density while Phase 4 (under construction) is a hooded, low current density cell with automatic crust breaking. A special purpose crane (similar to ECL Crane in wide use throughout the world) has been built to service the experimental cells.

Judged by any standards, the progress they have made in reaching the present stage of development is most impressive. They have admittedly copied widely from information available in the published literature. Nevertheless, the skill and ingenuity required to transform these ideas into operating units, without benefit of contacts with people conversant with the technology, can only be admired.

Appreciation of Technical Capabilities

The quality of the electrolytic operations in the plant is quite good. Energy and raw material consumptions, metal purity and potlining life are all comparable with world standards. In fact the DC power consumption is 15 kwh/kg is very commendable. The metering equipment for DC current is not too precise (DC transformer on each rectifier cubicle) so there might be a slight bias. However, considering the operating voltage and the quality of operations as judged by cell appearance, the error cannot be too great.

It appears, however, that they have been content to operate the cells more or less according to the procedures as passed on by the Russians. Very few changes have been made, either in operating parameters or in servicing equipment. They almost seem to have given up on the technology and express a very negative attitude towards it. In general the standard of maintenance in the potroom is poor. The conditions of superstructures had been allowed to deteriorate and consequently atmospheric conditions were very bad.

It is difficult to pass judgement on the organizational structure. The labor productivity is obviously very low compared to Western World standards. However, comparisions are difficult in view of the concept that the entity strives to be more or less self sufficient. It must be very inefficient to carry out some of the operation on the small scale required (such as diode manufacture).

Concerning this technical capability the example provided by the work they have done in the experimental pilot plant is noteworthy. Relying completely on published literature they have been able to construct quite sophisticated servicing and production equipment. This speaks very highly for the quality of their engineering talent.

PART II

Visit to West Open Cast Coal Mine at Fushun, Liaoning Province

The West Fushun Open Cast Mine originally began production 65 years ago when the area, as Manchuria, was under Russian occupancy. It was later operated by the Japanese for about 32 years. The present operations under the PRC began in 1948. The plant equipment was modernized (presumably with assistance from the USSR) in the early 1950's.

The mine covers an area 6 km long and 2 km wide. The overburden thickness is about 290 meters. The coal seam varies in thickness from 40 - 120 meters averaging 80. The coal seam is overlain by an oil shale about 90 meters thick which contains 7% hydro-carbons.

Recent production figures comprise coal (used for fuel and chemicals) 5 million tonnes, oil shale (processed nearby) 8 million tonnes and overburden 39 million tonnes. The overburden (hardness 6) is brought to grade level by diesel trains and dumped in 3 different spoil areas. There are fifty 3 and 4 cubic meter shovels used for coal and overburden loading. The coal is brought to a loading facility at the lower level by a narrow gauge railway. The coal is dumped into fairly large skips which run on wide gauge rails from the mining level to the surface. There are sufficient reserves to operate the mine at present output for at least 30 years.

The total employment in the mine is 16,000 of which 1,200 are women. About 70% of the work force is engaged in the mining operation and 30% in the surface plant. There were 8 grades in the labour organization, a new comer receiving about 30 Yuam ($ US 20) per month while the maximum (a shovel operator at the face) would earn 108 Yuam per month ($ US 72).

The mine had two interesting secondary products, pure coal and amber. The pure coal is a very stable substance. An associate factory was organized to produce coal carvings. The same factory also processed the amber recovered into jewellery and ornaments. These materials were identified at the mine face and recovered separately.

Visit to Handicrafts Factory, Fushun - 9th March, 1979

The handicrafts factory at Fushun was established about 20 years ago with a complement of 10. The present work force is about 400; 70% are women. About three quarters of the work force is engaged in artistic activities, the remainder in service occupations. There are 4 main products; jade carving, amber shaping and polishing, coal carving and silver filagree work.

"Pure" coal from the nearby West Open Cast Mine is very stable to air. It is relatively soft (MOHR = 2) and only hand tools are used. In general the pieces were relatively simple but there were some which were more complex such as a trio of "Tong" horses priced at $200.

The amber is formed into relatively small pieces of either rectangular, circular or similar profiles to be made into necklaces or pendants. The first step is to separate the pieces from adhering coal. The pieces of appropriate size are then formed to the desired shape using very primitive equipment. Files and sand paper were used to form flat surfaces. Holes were drilled with a small diameter pointed mandrel between two pieces of wood to achieve the desired drilling action.

For circular profiles, the piece is then mounted on a mandrel, after drilling rotated in the same manner and the desired surface obtained using abrasive paper.

For jade carving, the principal tool was a belt driven mandrel about 12 mm dia. mounted on two relatively simple bearings. The required tool, chosen from a variety of shapes, (small conical cutters, flat discs, etc.) is mounted on the end of the mandrel. The work piece is held by hand and an abrasive (chromium oxide) is fed manually to the rotating tool.

The silver work was primarily filagree to make mountings for jewellery. The starting material was small diameter silver wire or thin plate. The wire was formed into spiral coils which in turn were intertwined to form. Here again, the equipment was quite old and the operation characterized by the amount of work requiring very close visual attention.

In all operations the approach used was that each artist carried through the work on a given piece from start to finish. They did not use an assembly line approach.

PART III

Comments on Questions and Discussions folllowing the presentation of the Technical Paper.

The paper was titled "Modernization of Horizontal Stud Soderberg Cells for Aluminium Production". It proved to be quite relevant to the interests of the personnel at the Fushun smelter as it dealt with a very similar technology to their own. The audience totalled about 25 (all male) and included the deputy plant manager, chief engineer and a senior member of the Metals Society from Shenyong (Liaoning Province).

Although copies of the paper had been forwarded to China well in advance (September 1978) no copies or translations were available in Fushun. The paper was presented by reading about two sentences more or less literally from the text followed by translation.

The paper highlighted improvements which have been made in cell productivity, labor productivity (mechanization) process control procedures (including application of process control computer) and internal and external environmental performance. The subject areas most commonly covered in the discussion periods were related to the environment (both external and internal). They were obviously aware that their standards in those areas lagged significantly behind the rest of the world. They were particularly interested in information on scrubbing of exhaust gas from alumina cells.

The subjects of labor productivity and process mechanization did not evoke a great deal of interest. Although in general discussion, the need to improve productivity was mentioned, there seemed to be relatively little curiosity for details of mechanized equipment even though 35 mm slides giving examples of some of this equipment were shown.

Another subject of interest was comparative properties of major raw materials particularly petroleum, coke and pitch.

The audience, during the presentation in Peking, was significantly smaller (6-8) and primarily representatives of the smelter "design bureau" (engineering). Following a number of questions on environmental subjects, the emphasis shifted to matters dealing with more modern prebake electrode technology. These included methods of baked anode manufacture (anode forming and baking), coke calcination, alumina feeding methods, amperage levels, etc.

Most likely, this particular group of engineers are more concerned with future plants rather than existing ones, hence the different emphasis.

In both locations, there was a friendly spirit of "quid pro quo" in the discussions. Although they asked many questions, they seemed quite willing to exchange information on related subjects when asked.

THE ALUMINUM FABRICATION PLANT IN HARBIN, HEILONGJIAN PROVINCE

By

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Objectives

To present to the Chinese aluminum industry a view of Alcan's aluminum fabrication technology in support of current ingot sales.

To assess the technical capability of the Chinese aluminum industry and gather information useful in potential technology sales and/or joint ventures.

Conclusions and Recommendations:

(1) The long term effects of the modernization efforts by the Chinese have implications of great international significance. The active participation by private enterprises in the Chinese modernization program has to be justified and subject to such implications. It is recommended that the Canadian Government, having assessed such implications and having developed a coherent policy, provide a set of specific guidelines as to how best the national objectives could be met and define what incentives and/or supporting devices would be available to the private enterprises when pursuing their activities beyond the natural boundaries of their marketing goals.

(2) The short term situation in China is characterized by the fact that there is more enthusiasm about modernization by acquisition of international equipment and technology than actual capacity of doing so. Financial organization and communication difficulties will restrict the viability of the projects to those of the highest priority, will make the negotiating process slow and expensive, and will make the acceptance conditional upon the availability of complete financial-equipment and know-how packages.

It is recommended that the Canadian Government within the context of the long term policy, facilitiate the formation of joint ventures where a consortium of financial institutions, equipment suppliers and operating companies could complement each other in providing bids that are competitive internationally.

(3) The level of individual competence of the technical staff in China seems adequate to operate difficult technological processes and complex machinery. The technology is maintained and affected by the policy of self-sufficiency that is imposed on the operation of the plants.

It is recommended that the Canadian Government encourages the Chinese Government to participate in the international agreements dealing with patent protection of know-how.

OBSERVATIONS:

(a) General

In China there are Chinese everywhere and the trains run on time. In this great resource of people and their discipline one finds the strength and vulnerability of the country and the key to its future. Present Chinese directives are to catch up with the rest of the industrialized world as quickly as possible. The effort is strongly oriented towards the western world and it starts with the learning of languages on a vast scale. In the aluminum fabrication plant we visited in Harbin in the north-east province of Heilongjian, two-thirds of the employees working in the factory are learning English on company time twice a week, one hundred members of the staff are learning German and one hundred Japanese. Most of these people supplement the formal lectures by listening to radio and TV programs. The emphasis on education is exemplified by the institution of a popular university, run by the company on behalf of the employees. This is one of the manifestations of the communal approach taken by China where the production organization is the integrating factor of the social structure. The plant we visited is their most modern aluminum fabrication plant run by the Ministry of Metallurgical Industries. It was built in the early 50s with equipment and technical help from the Russians.

It is located in a satellite community of 40,000 people, not far from the city of Harbin which has a population of about 2,000,000 people. The community is run as an integral entity with the plant. The 10,000 working members of the community are employed by the company, but only 3,000 work in the factory. The rest are deployed in the community farm, the school, the nursery, the hospital, the hotel, the housing system, etc. Both spouses are usually employed and the community provides services and accommodation at nominal fees.

The party committee of the plant is in charge of education, health, recreation and welfare of the employees and their families, while the plant administration runs the production activity and its support functions. The workers' wages are scaled from 33 yuen to 108 yuen/month (1 yuen = 0.80 Can. $) in 8 grades of skill, established after examinations run by the administration. The salaries of staff and managers were said to be three times higher. (The cost of a bicycle goes from 100 to 250 yuen and a dinner in Peking from 5 to 20 yuen.) The accommodation provided to the employee (typically for a staff member, two very spartan rooms totally 20 m^2) could be bought for 1,000 yuen and rented for 3.70 yuen/month including heating and maintenance; additional fees are charged for lighting

(1 yuen/month) and water (0.06 yuen/month/family member). Education, health and welfare are free, with entrance to university subject to passing examinations. At the death of an employee, the family continues to receive support from the plant. The transfer of staff to a different job or location is decided by the administration and with the transfer of the job goes the transfer of living privileges; families can be separated for long periods of time if husband and wife are assigned to different plants. However it does not seem that the transfer of people from one location to another is a frequent event and one has the distinct impression of job stability and long term assignments at all levels of the organization.

(b) Technical

The deployment of labour inside the plant is far in excess of the requirements of the tasks being performed. Although labour saving equipment such as transfer conveyors and other mechanized material handling devices are used extensively in the plant, the degree of automation of the equipment is limited and manual intervention is widespread, employing large crews of people with lots of standby capacity. The utilization of the equipment is also well below its design capacity and a discipline of time and methods management could increase throughput by more than a factor of two without equipment modifications.

The following production and labour statistics were given to us:

Department	Production (Tonnes/year)	Employees (including supervision)
Casting	52,000	600
Rolling	20,000	900
Extrusion	6,000	750
Forging	300	600
Foil	600	400
Powder	500	400
Salvaging		150

The product mix is rather sophisticated as the plant is 60% loaded with aircraft products. The sheet mill produces 4,000 tonnes of plate. The typical aircraft sheet product is 1 mm thick, 1200 mm wide, solution heat treated and clad AA2024 and AA7075 alloys. Other alloys are 1100, 3003, 5154, 5456, 6063, for uses in the chemical, cryogenic, and mechanical industries.

The extrusion products include thin walled, small diameter tubing for heat exchangers (20%), heavy shapes for aircraft (30%) and rod for aircraft rivets, screen wire and electrical (50%).

The hot rolling mill is preceeded by homogenizing pit-type furnaces, ingot flattener, saw, scalper and 4 tunnel-type preheat furnaces. The mill is a 3 m/sec, 700 x 1250 x 2000 mm reversing stand, with edge guides on both sides and an edger mill on the entry side. An unusual feature is the two ingot pusher blocks mounted above the tables and driven by rack and pinion assemblies; the feature is seldom used. The other most unusual element of the layout is the feeding arrangement of the warm/cold mills. These are two reversing mills located in line with the hot mill and connected to it by roller tables, one of which is looped above the top of the nearest mill.

The mills are operated in push-pull and the four passes usually required to reach final sheet gauge from 6-7 mm down to 1 mm are performed in twice the time it takes the hot mill to roll one ingot. The rate of production is 4-5 ingots/hour for hard alloys and 8-10 ingots/hour for common alloys. The ingot weight is 2 tonnes. Although the system is run with good recoveries and low metal inventories, its operation is cumbersome and inefficient.

The extrusion operations use two extrusion presses of Russian design, one 10,000 and one 5,000 ton capacity. The manufacture of tubing starts with milled and drilled billets which are double extruded, first into blooms by the 10,000 ton horizontal press and, after sawing, by a single tube vertical press. Conventional drawing and solution heat treat operations follow.

Two small Japanese presses of modern design are being installed and they seem the only new additions to the plant's original equipment. We were also told that a new Achenbach foil mill has been ordered to replace the present antiquated foil mills; these are narrow two-high mills and require 21 passes to produce the final foil gauges.

The forging plant with two large presses has a capacity of 2000 tonnes/year but it is operated at 300 tonnes/year because of lack of orders. Materials handling around the presses is rather inadequate to serve the operation.

Our technical presentation was attended by about 100 people. A local interpreter, visibly familiar with the subject and very fluent in English, helped substantially in the success of the meeting. The questions by a few members of the staff showed that the subjects were understood and of interest to them.

(c) Commercial

For companies that are prepared to put up a package made of technologically and externally financed capital goods and management know-how, the Chinese offer their labour and natural resources and are prepared to give up temporarily a share of the product, while retaining control of the equity and management of the operation.

They are presently preparing guidelines and submitting them for approval by the National Assembly, which will set the limits of joint ventures with foreign partners. Vice Minister Li-Hua, Ministry of Metallurgical Industries, indicated that for capital intensive projects like the ones in the metallurgical industry, 50% of the product for 10 years could be the ceiling for the viability of a project. As an extra, for the suitable partners, the Chinese offer their friendship which may mean continuing business and participation in a large consumer market that may develop in the future. The value of these future opportunities is dependent on judgements as to long term stability and maintenance of recent open door policies. The present reality is influenced by a very low purchasing power, a very difficult business environment due to communication and organizational barriers and long bargaining processes. The prospects of successful technology sales are affected by the strong bias the Chinese have for self-sufficiency when confronted with a buy-or-make option. However, we had the opportunity, while attending the mission, to make arrangments for the sale of a large plate stretcher that the Harbin plant needed. Notwithstanding the communication difficulties, the Chinese showed themselves to be sound, and articulated business with a high degree of perseverance, diligence and conservative practices. They stressed the importance of trust in their business relationships, which are first based on mutual understanding and reliance on carefully negotiated verbal commitments. This seems to be in contrast with the February announcement in the press of a massive cancellation of projects already agreed with the Japanese. We have no way to know if these contracts were agreed in principle only, if the move was due to "financial force majeure", or if it was a true about-face due to new opportunities created by the recent normalization with the U.S.A. Our Japanese associates who have been negotiating for a large aluminum smelter contract, report of no breach of contractual obligations by the Chinese.

In conclusion, it seems to us that any undertaking with China, especially in the technology field, must be approached with a high degree of caution; that patience will be a necessary asset and only in cases where a high mutual advantage is inherent in the nature of the project, the outcome could justify the effort. There is certainly little room for the foolish, the fast buck operators or the simply naive to participate in the action. Since the justification and the practices used are conditioned by political realities, it is essential for the Canadian Government to develop sound policies and clear guidelines for the private businessman to follow and provide supporting tools for him to be successful in specific deals with China.

THE NICKEL COMPLEX AT JIANCHUAN* GANSU** PROVINCE

By

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V.N. Mackiw, Sherritt Gordon Mines Ltd.

Introduction

Jianchuan was said to be the only significant source of refined nickel in the PRC with an annual capacity of 10,000 M.T. of electrolytic nickel. It was said to be operating at capacity, although it did not look like it while we were there for a three day visit, March 6-9. The ore is mainly sulphide in olivine/pyroxene host rock and the process is basically concentration, roasting, electric smelting, converting and sulphide anode refining. The Plant was designed and built by the Chinese based solely on publications from the west and has been in operation since about 1966.

Location

The orebody is located on the southwest side of the Dragon Head mountains in Gansu Province while the plant and townsite are on level ground adjacent to the mountains and eastern end of the Gobi Desert, about 1,300 miles west of Peking and some distance beyond the western extremities of the Great Wall. There is a population of some 50,000-70,000 people at Jianchuan supporting a total workforce that was variously said to be between 10,000 and 16,000 people (?).

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* Previously spelled Chin Chuan and Jingchuan, pronounced "Ginchuan"

** Formerly Kansu; pronounced "Cgansu"

Geology and Reserves

The deposit was apparently first reported in 1958 and the mineral resources were detailed by exploration over the next 15 years. Total ore reserves were said to be 513,000,000 M.T. with the following total metal contents:

Ni	5,450,000 M.T.
Cu	3,440,000
Co	160,000
Pt	120
Pd	61
Au	73
Ag	1,270

There were also said to be recoverable quantities of Se, Ir, Os, Ru, Rh, In, Ge and Te.

The principal host rocks of the deposit are marble and serpentine marble (precambrian). A complete list of the rock types displayed in the rock collection at the Mine Laboratory is given in Table 1.

The host rocks immediately adjacent to the mineralized zones are olivine/pyroxene ultrabasic generated during "hercynian movement in the Devonian period".

The mineralization is serpentized pyroxene/peridotite and massive sulphides, notably pentlandite, violorite, chalcopyrite and pyrrhotite, and some pyrite.

The total area of mineralization is 6,500 m x 500 m and there are 4 separate Mine Areas, numbering from west to east #3 - 1 - 2 - 4. The biggest is #2 followed by 1 and then 3 and 4. Some characteristics of these Mine Areas and orebodies in them are tabulated in Table 2.

Mining and Mine Development

All mining to date has been in Mine Area #1, by both open pit in the west and underground in the east. The whole deposit has been subjected to 4 major geologic upheavals and is highly stressed and fractured making mining difficult. Mine Area #2 is by far the largest and is presently under development. There are many orebodies in Area 2 but orebodies #1 and 2 constitute 90% of the total in this area.

Open Pit, Mine Area #1

In operation for 14 years in the west portion of Mine Area #1, the pit is now 168 m deep with the rim at 1688 m above sea level and the bottom at the 1520 m level. It is planned to mine down another 60 m in the next 2-3 years. The top opening is now 1300 m x 736 m and the highest point adjacent to the pit area is 1830 m above sea level.

The dip angle of the hanging wall is 30 - 33° and consists of marble and granite schist, highly faulted. The foot wall dips at 34°. The design slope was 41°, but was changed on experience to 34°.

Table I

Mine Laboratory, Rock Collection, Jianchuan

Host Rocks (Precambrian)

issite	serpentine marble
garnet-chlorite schist	marble
chlorite-quartz schist	diorite porphyry
biotite-chlorite schist	granodiorite porphyry
migmatite (granitic injection)	biotite granite
migmatite (gneiss matrix)	alaskite
quartz vein	sinaite
grammatite marble	pegmatitic granite

Rocks Near Ore (hercynian movement in the Devonian period)

host olivine

peridotite carbonated sulphide (carbonated peridotite with sulphide?)

augite

olivine pyroxinite

fine diorite

talc pinolite

serpentine chlorite (chloritic serpentinite?)

anorthase peridotite (anorthositic?)

lamprophase dyke (lamprophyre ?)

Ore (Rocks)

Oxidized ore (serpentinized)

massive ore (sulphide)

disseminated ore (in olivine)

breciatted ore

pentlandite

chalcopyrite

pyrrhotite

violorite

TABLE 2

Mine Data, Jianchuan

Details	Mine Area #1 Total	Mine Area #1 Pit	Mine Area #1 Underground	Mine Area #2 Total	Mine Area #2 Ore #1	Mine Area #2 Ore#2	Areas 3&4
overburden, m					220-280		
length, m	1,100-1,300			3,000	1,600	1,300	
width, m	20-80				15-205 (ave 98)	2-200 (ave 118)	
depth, m	700-800		1,000	1,000			
dip angle°			8-10		60	25-65	
ore, millions M.T.	100	58	6-8	330	213	117	
grade, % Ni	0.87	0.5	1.5-1.8	1.25	1.53	0.8	
grade, % Cu		0.3	1.0-1.2	0.81	1.05	0.43	
Ni, thousands M.T.	900			4.100	3,100		470
Cu, thousands M.T.	490			2,280			270
Proportion of Total Reserves, %	16			75			

Present mining rate is 10,000 cu/m/day or 27,500 MTPD, of which 5,150 MT is ore. Stripping ratio in the mining area is 1.5 and thus present stripping rate is about 20,000 MTPD. Lifetime ratio of rock/ore is about 5.5. Rock and ore are separated on basis of drill core analysis with a drilling interval of 75 or 100 m.

Blast holes are drilled electrically to depths of 180 or 220 m and are charged with a mixture of ammonium nitrate plus oil that is made by the Chinese. Consumption is about 2 MTPD. About 50,000 MT of "ore" is blasted in ½ hr every 2 days.

There are 10 shovels with capacity of 1 million tons/yr and a bucket size of 4 cu m. Ore and rock are hauled in 60 - 32 MT dump trucks a distance of 2.2 km to the storage bin and waste dump. The ore then goes to the concentrator by train, another 2-3 km.

The average grade of the ore is 0.5% Ni with the cut-off at 0.3% Ni.

About 1,000 employees work in this operation including 3 geologists, 5 other engineers and other maintenance and supervisory personnel. New drivers and machine operators are trained for 6 months-1 year in a special school.

Dragon Head Underground Mine, Area #1

This mine is about 300 m long, narrow and highly fractured in the western portion, wider and firmer in the eastern section. The hanging wall is olivine, the footwall marble and magmite. The surface is at 1703 m above sea level and ore extends down to the 1200 m level.

In the western area they mine from the surface downwards, because of the fracturing, backfilling as they go with Gobi Desert sand mixed with cement. There are 8 levels, the first at 1640 m and the last at 1250 m. The first two are exhausted, the 3rd is being mined and exploration is completed on the 4th.

In the eastern section they are mining upwards starting at the 1400 m level and are now on the 1520 m level.

There are presently 3 shafts, each 5.5 m in diameter and to mine below the 1400 m level they will put down another shaft in more competent rock.

The stopes are 5 m wide and 2.5 m high; the pillars 5 m wide.

They drill 11 holes, one at a time, 42 mm x 2.5 m and blast whenever they are ready. The ore is mucked by drag scoop into an ore pass, conveyed in 2 cu m rail cars hauled by a 7 ton locomotive, and lifted to the surface in rail cars.

The drift walls and roof are completely lined by brick and mortar or reinforced concrete arches.

The Gobi Desert "sand" (?) used for backfill containing stones as large as 40 mm, is carried by train to the shaft and transported underground by conveyor belt to the backfill preparation area. Cement slurry is pumped underground, mixed with the sand in electric mixers, and dragged by scraper to the backfill area.

The mine is presently producing at 1,100 - 1,150 MTPD of ore running 1.5 - 1.8% Ni; and will be exhausted to the 1,250 m level by 1981. Thereafter the mining rate will be 700,000 MTPY. They have already taken a total of about 48 million M.T. from Mine Area #1 and there are 50 million M.T. below the 1250 m level.

There are 1,000 employees underground and 300 on surface including 1 geologist, 3 mining engineers and 4 other engineers.

Mine Area #2, Development

The ore is deep and not as oxidized as in Mine Area #1, particularly the rich ore. Sulphides account for 90% of the total nickel and recovery was said to be 92% on beneficiation.

They have put down 7 shafts, 4 - 5 m in diameter, are preparing a ramp and conveyor belt and have completed 32 km of drifts.

This development is aimed at a nickel production in excess of 100,000 MTPY with low pollution and products of international standards. By 1985 Chinese nickel demand is expected to be 60 - 70,000 MTPY.

Milling/Concentrating

There are 2 mills, Concentrator #1 with a capacity of 1,200 MTPD for treatment of the rich ore from the Dragon Head Mine, and Concentrator #2 with a capacity of 6,000 MTPD for the lean open pit ore from Mine Area #1.

The mineralogy of both ores is similar and in addition to the principal sulphide minerals referred to earlier, includes magnetite and minor pyrite, the principal gangue minerals being olivine, serpentine, chlorite, talc and mica. The rock phase is medium coarse grained pure olivine. The lean open pit ore is highly weathered and recovery is only 55 - 60%. Recovery from the richer underground ore was said to be 90%.

Some details noted during our tour of the concentrators are reported below:

Concentrator #1 (Underground Ore)

There are 14 mills, each rated at 6.5 MTPH.

There are 2 flotation circuits with 8 - 5.8 cu m roughers and 40 - 2.8 cu m scavengers.

Reagents include Na_2CO_3, Xanthate and pine oil. Natural pH is 7, controlled to 9.

Grade of the bulk concentrate is 5.5% Ni, 3.0% Cu with recoveries of 90% Ni, 86% Cu and 50% Co.

Concentrator #2 (Open-Pit Ore)

The primary jaw crusher at the mill reduces open pit ore from 1.5 m to 35 cm. There are then 2 stages of cone crushing, no gyratories, the first crushing from 400 to 75 mm and the second to 25 mm.

There are 3 rod and 7 ball mills, each 2.7 m diameter x 3.6 m long. Grinding is taken to 60 to 65% - 200 mesh for rougher flotation. (Scavenger regrind is to 75% - 200 mesh.)

Roughers cells have 5.8 cu m capacity and are of Russian design (Mechenobor?). The scavengers have 2.8 cu m capacity, as in concentrator #1.

We saw 8 cu m large diameter cells under construction in the yard for eventual use in their expanded operations.

Sliming (talc?) is somewhat of a problem. Concentrate grade is 3.5% Ni, 2.0% Cu and recoveries are only 55% Ni and 48% Cu.

Concentrate Feed to Smelter

The present generally poor concentrator performance is attributed primarily to the fact that about 30% of the total nickel is in silicate and also to the presence of talc, magnesite and violorite in the ore.

The concentrates are blended, thickened and filtered but drum filter performance is poor due to the high MgO content of the concentrate and the filter cake roaster feed contains 25% moisture with the following dry composition in wt. %:

Ni	Cu	Co	Fe	S	MgO	SiO_2	Talc
4.5-6	2.5-4	0.3	23	10	18-20	20	3

Kiln Roasting

Roasting is performed in 2 brick-lined rotary kilns 52 m long x 3.6 m in diameter. Brick life was said to be 2 yrs. The Chinese claim to have successfully tested both fluid bed and kiln roasting but settled on the kilns because they already existed and were more readily available.

The kilns are operated counter-current with concentrate being fed at 500 DMTPD and 25% moisture at one end and oil at 4-5% of calcine weight being fired at the other. Matte grade is controlled by adjusting oil and secondary air. Retention time is 40-50 min. Temperature at the firing end is 900°C and at feed end is 200-250°C.

Roaster gases are passed through 2 stages of cyclones and then to stack at 1.5% SO_2 and 1 - 2% dust loss. They had a venturi but trouble with plugging and are now planning to instal an electrostatic precipitator.

There are 80 people on 3 shifts for feed preparation/fluxing/roasting, 15 maintenance personnel and 8 supervisors including some engineers. Dust recycle is about 4-5%.

While we were in the plant one of the kilns was down for "minor repairs". The calcine contains approximately 10% sulphur.

Electric Smelting

There are 2 electric smelting furnaces, 21.5 m x 5.5 m x 4 m with 6 in line Soderberg electrodes 1 m in diameter and 3 m apart. Each furnace is rated at 16.5 MVA with a capacity of 500 MTPD calcine.

Hot calcine from the roasters at 600°C is transported in 10 ton insulated cars and hoisted to a large feed bin where it is mixed with sand flux at 90% SiO_2 and 8 - 12% of the calcine weight, coke powder equal to 1% of calcine, and revert dust. The mixture is moved by drag conveyors to small feed bins for gravity flow through 24 ports, 12 per side. Feeding is intermittent and controlled manually about once per hour to maintain a charge depth of about 1 m above the slag. Solids charge temperature is about 550°C. Converter slag is recycled molten to the furnace.

The furnaces are operated at 400 volts, a power density of 140 KW/sq m and power consumption is 600 KWH/M.T. calcine. Electrode consumption is 4-4.5 kg/M.T. calcine.

The roof is sealed and the freeboard, at about 500°C, is under suction. There are 5 gas uptakes to a cyclone and electrostatic precipitator. Dust is about 4% of the feed and is recycled to the furnace.

Matte is tapped at 1200-1300°C and slag at 1350-1400°C, with the folllowing compositions in wt. %:

	Ni	Cu	Co	Fe	S	Fe_3O_4	SiO_2	MgO
matte	13-15	8-9	0.6	49	24-25	3-4	nil(?)	
slag	0.14	0.08	0.06					18

The furnace is lined on the hearth and walls below the slag line with magnesite brick, above the slag line with Al_2O_3 fireclay brick, and the roof was castable. Hearth life was said to be 10 yrs., walls 2-3 yrs., and roof 4-5 yrs. There is a shutdown every 3 yrs. in August for minor maintenance and 8-10 yrs. for major maintenance. There is no water cooling in the sidewalls. All equipment was manufactured in China.

Converting

There are 4 Pierce-Smith converters but only 1 was operational and the Chinese claimed it can handle all the matte from both electric furnaces. It is 23 ft. long x 12 ft. in diameter and has 28 x 42 mm tuyere pipes, punched by hand, 4 men per shift. They are experimenting with automatic punching. They have 3 x 50 M.T. cranes with 6 and 4 cu. m. ladles.

The converter takes 100 M.T. matte per charge and there is one cycle per shift with 70% blowing time at an air rate of 400 cu m/min.

Converter matte and slag compositions are, in wt %:

	Ni	Cu	Co	Fe	S	SiO_2
matte	48	25	0.8	2-3	20-31	
slag	1-2		0.2-0.6	50		28
at end of blow	2		0.5-0.6			

Slow Cooling and Matte Separation

The matte is cast into 7-8 M.T. moulds, slow-cooled under cover for 3 days, crushed, and ground in closed circuit with screw classifiers to - 200 mesh with a substantial - 325 mesh fraction. The Ni-Cu alloy phase is separated from the slurry by rotary drum magnet and the nickel and copper sulphide phases are separated from one another by flotation, all basically à la Inco practice.

	Ni	Cu
Ni matte	63%	3.3-3.4%
Cu matte	3.5-3.7%	69-70%

Nickel Sulphide Smelting

The nickel sulphide concentrate is charged as a filter cake at 8% moisture to an oil-fired reverberatory furnace with a hearth area of 22 sq. m. The furnace gases were being discharged directly into the building but we were told gas flow was controlled to ensure a low SO_2 concentration in the gas. (?) They intend to put a flue on the end of the furnace as soon as possible (?).

Anodes are cast and slow-cooled for 48 hrs under cover.

Copper Sulphide Smelting

The copper sulphide concentrate is smelted in a reverberatory furnace with air blowing to reduce sulphur to 1% in anodes. The Chinese are unhappy with this operation and we were not shown it or the copper refinery. They have tested a Kaldo converter on a pilot scale and are going to put in a commercial oxygen plant and go this route.

Matte Anode Refining

The tankhouse contains 168 production tanks in 2 circuits, 20 tanks for starting sheets and 48 tanks for nickel makeup. There are 35 anodes and 34 cathodes in each production tank, the anodes consisting of 2 x 70 kg castings hung side by side and the cathodes being 820 x 900 mm in size and weighing 30 kg after 4-5 day plating cycle. Anode and cathode compositions were said to be as shown below in wt. %:

	Ni	Cu	Co	Fe	Pb	Zn	S
anodes	63	7(?)	1	1.8	tr	tr	bal.
cathodes	99.9	0.02	<0.1	0.03			0.001

Starting sheets are made on titanium mother plates for ease of manhandling relative to stainless steel.

The tanks are operated at 170 A/Sq. m, 55-60°C, 85% anode current efficiency, and with a nickel depletion of 11-12 gpl. There is a 25% anode recycle. Slimes are removed every 3-4 days and each tank is scraped every 3-4 months.

The composition of purified electrolyte feed to the tanks and of the impure anolyte from the tanks is shown below in gpl, except as otherwise indicated:

	Ni	Cu	Co	Fe	Pb	Zn	Na	Cl	H_3BO_4
feed, gpl	55-60	0.003		0.003	0.00045	0.003	35-40	35-45	5%
anolyte, gpl		0.65-0.7	0.15-0.2	0.35	0.001	0.001(?)			

Electrolyte purification is done in 3 stages:

(1) Iron Removal

The iron is oxidized with air, the pH adjusted with $NiCO_3$ to 3.5-4, and the iron precipitated to 0.01 gpl, followed by filtration.

(2) Copper Removal

The solution is treated with elemental sulphur and with Ni_3S_2 from matte flotation in an amount 3.5-4 times greater than the weight of copper present. The copper is precipitated at pH 2-2.5 to 0.001 gpl and filtered.

(3) Cobalt Removal

The pH of the solution is adjusted by Na_2CO_3 and $NiCO_3$ to 4.5-5 and cobalt is precipitated by chlorine as cobalt hydroxide and filtered.

The cobalt precipitate is treated for recovery of electrolytic cobalt but we did not see this operation. Overall cobalt recovery at Jianchuan is poor and the Chinese would like very much to increase it.

Ni-Cu Alloy Treatment

The magnetic phase from matte separation is mixed with the copper sulphide precipitate from nickel electrolyte purification and smelted to anodes containing about 15% S. These are electrorefined for nickel recovery and the copper sulphide sponge goes to the copper circuit. We did not see this operation.

Precious Metal Recovery

The nickel anode slimes were said to be treated by "the Inco method" for recovery of PM's and sulphur but we were not shown this operation. Again, PM recoveries are "low", and the Chinese are clearly anxious to improve this situation.

Research

There is a laboratory with about 70 people including 8 - 10 engineers and about 60 technicians. We were not taken to this facility.

Production Cost

We were told the cost of making nickel at Jianchuan is 11,000 Yuan/M.T. At 1.5 Yuan/US$, this is equivalent to $3.33/lb nickel.

Short-Term Improvement and Expansion Plans

In addition to the changes planned as referred to in the description above, other intended changes include the following:

1. Expand Concentrator #1 from 1200 to 1500 MTPD.
2. Expand one of the three - 2,000 MTPD circuits in Concentrator #2 by 1500 MTPD.
3. Expand roasting kilns (add another?)
4. Add 3 driers before the kilns to decrease moisture in roaster gas and increase SO_2 concentration for acid production.
5. Add 1 electric furnace at 30,000 KVA.
6. Add 2 converters with water-cooled hoods.

7. Increase magentic separation of Ni-Cu alloy.
8. Increase current density in the cells
9. Increase the number of electrodes in the tanks.
10. Improve electrolyte purification (?) - all the above in the aid of doubling the capacity of the plant and of pollution abatement.
11. Add 2 slag cleaning furnaces, each at 500 KVA for cobalt recovery.
12. Consider treating alloy and matte by hydrometallurgy to increase recovery of both cobalt and PMs. They have tested such approaches, some in pilot scale, with successful results(?).
13. Build new plant for differential flotation to produce high grade nickel sulphide with low MgO content for flash smelting, copper sulphide for electro copper, and iron sulphide to treat by the Inco or Falconbridge processes to recover Ni, Cu, Co and produce iron pellets and a high quality steel alloy (?).

Finally, they have tested atmospheric HCl leaching (cf. Falconbridge) and pressure H_2SO_4 leaching (cf. Sherritt Gordon) and are quite keen on pursuing the possibilities of using such technology for treatment of converter matte in future large-scale expansion to 100,000 tonnes of nickel per year.

THE BAI YIN COPPER COMPANY

By

G.D. Hallett, Noranda Mines Limited, and

H.C. Garven, Inco Metals Limited

SUMMARY

During the period March 8-9, 1979, G. Nash, G.D. Hallett and H.C. Garven, visited the Bai Yin Copper Company facilities located some 90 km north-east of Lanzhou in Gansu Province. This facility, with an initial capacity of 30,000 tonnes per year of refined copper, was built with Russian assistance during the period 1955-1960. Subsequently its capacity was increased, by the Chinese themselves, to the present level of 50,000 tonnes per year, making it presently the largest in the Peoples' Republic of China.

The program for March 8th consisted of a presentation by the Bai Yin operating personnel on their existing facilities, followed by one hour presentations by Noranda and Inco on their continuous and oxygen flash smelting processes. On March 9th, a short plant visit was arranged which included only the smelter and refinery. This was followed by about 3 hours of joint discussions with plant personnel on the Noranda and Inco processes. The Chinese answered our questions freely and were very persistent in their questionning on the Canadian processes.

The Bai Yin facilities include two open pits, located some distance from the plant, which deliver 0.8% and 1.3% Cu ores at a total rate of about 12,000 mtpd to their concentrator. This facility

produces at 18% Cu, 32% Fe, 37% S copper concentrate at a rate of about 750 mtpd at a stated recovery of about 90% Cu. The smelter consists of three fluid bed roasters, a coal fired reverberatory and three Peirce Smith type converters. They also operate two oil fired anode furnaces, each with its own casting wheel. The roasters were not operating during the visit, however, they stated that typically 20-25% of the concentrate is calcined to remove about 90% of its sulfur content while the remaining concentrate is green charged to the reverberatory. This furnace produces a 25-30% Cu matte and a discard slag containing 0.34 to 0.40% Cu, while the converters yield a blister copper containing about 98.5% Cu. The anodes produced appeared to be of good quality and weighed about 220 kg each. The copper refinery consists of 400 production cells and produces 60 kg cathodes which are trimmed and bundled for shipment. The stated copper recovery from concentrate to cathode was 96.5% for an overall copper recovery from ore of about 87%. Sulfuric acid is produced from the roaster and converter gases at an annual rate of 180,000 mtpy at a stated overall sulfur recovery from concentrate of 60%. Details of the plant operation and other observations are included in the body of this report.

General Introduction

The following sections of this report combine data supplied and observations made during the verbal presentation on the Bai Yin Company copper production facilities by their operating personnel, the actual plant visit and the discussions held subsequently. The facility has a capacity of 50,000 mtpy of refined copper and 180,000 mtpy of sulfuric acid and also produces Au, Ag, Se, Cd, Pt, In, Tl, $CuSO_4$,

$ZnSO_4$, $FeSO_4$ and crude lead. Overall copper recovery from ore to refined copper was given as about 87%, while sulfur recovery to acid was stated to be 60%.

Plant Description

Mining

There are two open pit mines locatd about 10 km from the Bai Yin smelter complex. These pits, which use downhill drilling, 4 m^3 electric shovels and 27 mt trucks, produce about 12,000 mtpd of ore. One pit contains "oxidized" ore stated to contain 0.85 Cu, 10% Fe and 10% S while the second yields 1.3% Cu and 36% S ore with a very high pyrite content. The mined ore is delivered by rail to the concentrator which is adjacent to the smelter. None of these facilities were visited.

Beneficiation

In the concentrator, which also was not seen, it was stated that there are three stages of crushing, down to minus 25 mm, followed by two stages of grinding, to 85% passing 200 mesh. Flotation, using lime and pine oil, produces both a copper and a pyrite concentrate. The copper concentrate typically contains 18.3% Cu, 31.95% Fe, 37.24% S, 3.61% SiO_2, 0.5% Al_2O_3, 0.32% MgO, 0.04% As, 1-3% Zn, 0.19% Pb, 0% Sb, 0.006% Ni, and 2-3% CaO. Bi, Se and Te assays were not supplied though Se was reportedly produced in the refinery. Antimony was claimed to be zero, however some is present in the matte. The concentrate moisture after drying is 5-6%. Mineral species in the concentrate were given as 40% chalcopyrite, 45% pyrite, 5-10%

chalcocite with no bornite. A total of 700-800 mtpd of local concentrate is delivered to the smelter, which also processed some 200 mtpd of outside concentrate. This second feed stock, which has a lower copper and iron content due to a higher silica content, could have come from the Ch'ilien Shan deposit also located in Gansu Province. A 35-40% S pyrite concentrate is also produced at the Bai Yin concentrator. It is apparently roasted in the smelter for the production of sulfuric acid.

Smelter

This facility, which was visited, consists of three fluid bed roasters, one reverberatory furnace, three Peirce Smith converters and two anode furnaces, each with its own casting wheel. It was constructed during the period 1955 to 1960 using Russian design and mixture of Russian and Chinese equipment. The initial design capacity was 30,000 mtpy of refined copper; however this has been increased to the current stated level of 50,000 mtpy by the Chinese, without foreign assistance.

a. Roasters

There are three fluid bed roasters, each 6.6 m diameter by 16 m high, with only two in normal use; however on the day of our visit none were operating. One however was being heated up. The roaster hearth area was given as 36 m^2 (versus 34.2 m^2 on the 6.6 m diameter basis), with a stated throughput of 7 mtpd/m^2 of hearth. The off gas system consists of a waste heat boiler followed by four cyclones. There are also boiler tubes in the roaster bed area. Only 20-50% of the copper concentrate is processed in these units, the remainder being green charged directly to the reverberatory furnace. This minor portion of the concentrate, at 5-7% moisture, along with a very fine 70% SiO_2 flux is fed to the roaster 2.2 m above the hearth. The bed, which was stated to be normally 1 m in depth, is held at a temperature of 750-800°C. The resulting calcine, of which about 70% is discharged as bed overflow with the remainder from the dust collection system, has a sulfur content of 5%. Sulfur removal in the roasters was stated to be about 90%. The off gases, at the roaster exhaust fan inlet, contain 7-8% SO_2 and are delivered to the acid plant. The discharged calcines, at about 700°C, are collected in two ton uninsulated bins which are transferred to the reverberatory furnace on rail mounted, battery powered, buggies.

b. Reverberatory Furnace

The pulverized coal-fired reverberatory furnace is 31 m long 8.6 m wide by 5.2 m high outside, and was said to have a hearth area of 110 m^2 though it is probably closer to double this figure. The stated smelting rate was given as 5-7 mt of dry solid charge per m^2 per day. The larger area is confirmed by a stated dry solid charge figure of at least 1,000 mtpd to the reverberatory furnace. This unit has been operating for about 10 years without major repairs. The side walls and steelwork around the furnace, which has a suspended roof, were in good condition. After lowering matte and slag levels, cast iron is charged monthly to control magnetite build up on the hearth. The practise of blowing air through steel pipes, as at Noranda, is not used. The pulverized coal, which is ground to 90% minus 200 mesh, has a calorific value of 6800 cal/g (12,250 BTU/lb) and contains 20% ash. The furnace is fired through five end burners using ambient air. Fuel consumption was stated to be less than 20 MT per 100 MT of dry solid charge or 1.36 x 10^6 K Cal/MT (4.9 x 10^6 BTU/ST) of dry solid charge.

The wet concentrate is charged into hoppers along each side of the furnace by two tripper conveyors. The roaster bed calcine and dust is also fed into similar hoppers from the two ton transfer bins. We were told that limestone was also added to the furnace though none was in evidence during the vist. Matte is tapped through a syphon while slag is skimmed, through an open hole at about 1150°C, into rail mounted pots for disposal. Converter slag, containing a stated 1-2% Cu, is reverted to burner end of the reverberatory, which has its long side parallel to the converter aisle, rather than at right angles as at Copper Cliff and Noranda. There are two waste heat boilers on the furnace with surface areas of 1,200 and 850 M^2 on separate flues. The second boiler was added subsequent to the intial installation possibly due to increased throughput or to their practise of adding substantial quantities of green charge to the reverberatory. This practise requires higher fuel inputs with consequently higher waste gas flows and heat contents.

The analysis of typical matte and slag are given below:

	Matte	Slag
Cu	25.6 (up to 30)	0.35 (up to 0.40)
Fe	30.5	37.6
S	25.35	1.95
SiO_2	0.78	33.8
Al_2O_3	-	2.01
MgO	-	1.57
CaO	-	4.84 (up to 7)
Sb	0.017	-
Zn	1.95 (up to 4)	1.84 (up to 3)
Pb	0.37	0.069
Ni	0.012	0.0045
As	0.064	-

c. <u>Converters</u>

The converter aisle contains three 3.66 m diameter by 7.1 m long (12' x 23') Peirce Smith type converters. Two of these units are normally operational and can be blown simultaneously. The aisle has a large roof monitor that gave fair building ventilation to very poorly drafted converters. Presumably this is deliberate to give higher gas strengths for the acid plant as each converter has a separate exhaust fan and damper. The converters have a capacity of 50 mt of blister copper in a twelve hour cycle. Calculations indicate that production rate of 50,000 mtpy of copper requires the daily processing of about 140 tonnes of fresh blister. For two converters, with the capacity and cycle stated above, this production requires about 70% blowing time versus a stated 85%, which appears to be unusually high.

There are 33 tuyeres of 47 mm (1.85") diameter, which are manually punched. The blowing rate is typically 25,000 to 26,000 m^3/hr (15,000 SCFM) at converter operating temperatures of 1250-1300°C (2280-2370°F). Refractory, which is a Chinese produced chrome magnesite, has a campaign life of only 5,000 mt of blister. Converter gas strengths were given as 6-8% SO_2 at the electrostatic precipitator inlet.

We were told that direct copper recovery in the converters was 93-94% and that the blister contained 98.5% Cu. In the aisle, there are two cranes of 50 mt and one of 75 mt, all using double lipped ladles with a capacity of $6m^3$ (about 200 cu. ft.). The crane rail was a good height above the converters so that the slope of the water cooled hoods was at an angle of about 50 degrees. The hoods were in fair shape and the moveable door looked to be operable, although it had not been lowered five minutes after commencing a blow. The converter appeared to be blowing evenly and splash was not a problem, as the mouth and apron looked clean. There were 4 I-beams across the converter head and the riding rings were about three feet in from the heads.

d. Anode Furnaces

There are two hearth-type anode furnaces each 7.6 m long by 3 m wide with hearth areas of $21 m^2$ and capacities of 120 mt. The furnaces, which have a cycle time of 14 hrs including 5 hours for casting, are used alternately. Both heating and reduction are carried out using oil. The reduction oil, in the form of an oil/steam mixture, is supplied by two to four steel lances at a quoted rate of 74 Kg of oil per tonne of copper. This mixture was reported to give an acceptable effluent gas, without too much black smoke. Anode furnace gas leaves through a waste heat boiler and then proceeds to a 1.4 m diameter stack. Each furnace is fitted with a 7.4 m diameter casting wheel, one with 12 moulds and the other with 14, which incorporates graphite mould spraying. The anodes, which weight 216 $\pm$ 5 Kg, are cast at a rate of 25-26 mtph. These casting wheels are very well vented in comparison to the rest of the smelter. The anode quality appeared to be good.

Between the smelter and the refinery there was a stockpile of anodes, which was estimated to contain about 1,000 MT of copper.

Refinery

The electrorefinery has a total of about 400 production cells approximately 1.1 m wide, 1.1 m high and either 4.3 or 5.0 long, and 40 liberator cells. They are arranged in two identical bays. Current density was given as 250-300 amps/m^2, cell over voltage as 0.3-0.4 and current efficiency as 96% while copper production was stated to require 350-380 kwh per mt. About half of the cells, which are all of lead-lined concrete construction, contain 35 anodes and 36 cathodes and the remainder 41 anodes and 42 cathodes. The cathode hangers are square section copper bars. The production cathodes, weighing about 60 Kg, are pulled after 4 days growth, while the starting sheets, which are prepared manually, are grown on titanium mother plates. Anode scrap was stated to be 20% of anode input. Animal (bone) glue is used for levelling in the electrolyte, which is handled through a purification circuit for impurity level control at a stated rate of 40 m^2 per day. The tops of the cells are about 0.6 m above floor level and are serviced by 10 mt overhead cranes. The building atmosphere was heavily polluted with acid mist during the visit. We were unable to establish whether "periodic current reversal" was being practised. The product copper, about 750 mm x 750 mm, was not very smooth and appeared to vary substantially in thickness. The edges are trimmed prior to bundling and shipment of the full sized sheets. No remelt facility for the production of shapes or wire bar is installed at Bai Yin.

Acid Plants

These were not visited but we were told that they produce a total of 180,000 mtpy of sulfuric acid as 93, 98 and 104.5% H_2SO_4. The acid is manufactured from a mixture of the copper and pyrite concentrate roaster gases, at 7-8% So_2, and the converter gases, at 6-8% SO_2 treated at a rate of about 90,000 m^2/hr. This gas mixture was stated to pass through an electrostatic precipitator, a wet scrubbing system, a secondary acid washing and drying tower, an SO_3 converter, using V_2O_5 catalyst, and an absorption system. The SO_2 to SO_3 conversion efficiency was given as 98% and the absorption efficiency as about 97%.

General Observations

Plant Operation

The entire facility appeared to be well managed with the plant in a generally tidy condition without garbage, reverts or old equipment lying around. Although dust and gas control appeared to be only fair, the plant equipment seemed to be receiving adequate maintenance. This contrasted sharply with the Jinchuan nickel facility which was quite dirty and appeared to be under maintained.

On questionning why a larger portion of the concentrate was not calcined the operators stated that the Ministry of Metallurgical Industry in Peking sets the plant copper recovery targets. To achieve the current target, furnace matte grades must remain low to maintain low copper levels in the reverberatory slag. Other reasons given were the poor (and dusty) transportation system between the roaster and the furnace and that the furnace charge sloughs across the bath if it is too dry.

Copper recovery from ore to concentrate was stated to be 90-91% and from concentrate to cathode 96.5%, for an overall recovery of about 87%. This figure may be being achieved though it is questionnable whether design throughputs are. The plant did not appear to be runnning at 50,000 mt/y of copper during the visit. During the visit, it was also doubtful whether the stated 60% S recovery to acid was being achieved.

Other Items

There were about 60 people in attendance at the two talks given between 8 and 10 pm on March 8/79, by Noranda and Inco on their continuous and oxygen flash smelting processes. Mr. Chao, the very dynamic General Manager of Bai Yin and a number of other plants, who is expected to replace the aging Vice Minister of Metallurgical Industry, Mr. Li-Hua, attended these talks and hosted a luncheon banquet on March 9th.

The stay at Bai Yin was only a little over 24 hrs duration. The plant visit was extremely short, perhaps 45 minutes, presumably to permit time for the Chinese engineers to question both Noranda and Inco on their copper smelting processes.

Bai Yin engineers told us they are developing a new copper smelting process, presently in the pilot plant stage, which they claim will smelt up to 10 tons of concentrate per m^2 per day. Up to 30% of their local copper concentrate is being treated in what must be a fairly large pilot unit of about 20 m^2 hearth area. They stated this process was like neither the Inco nor the Noranda process. It was said to be a stationary furnace more like a reverberatory, which they hope will be fully operational in about two years. They also stated that they expect to treat Jinchuan copper concentrates at Bai Yin once differential flotation is implemented at the nickel facility. Total sulfur recovery as acid is also one of their major objectives.

BAIYUN IRON MINE, BAOTOU, IRON & STEEL COMPANY, PEKING GEOLOGICAL BUREAU

By

G. Harden, Cominco Ltd.

The following is a brief record of observations made and impressions gained on the recent Non-Ferrous Metals Mission to China in which the writter represented Cominco Ltd. of Vancouver, B.C.

(1) Company Represented

Cominco Ltd. is the world's largest producer and marketer of lead and zinc and is also an important integrated producer of fertilizers and chemicals. Products include concentrates of zinc, lead, copper, tin, and tungsten; refined zinc, lead, silver, indium, cadmium, bismuth and gold; potash, sulphuric acid, electronic materials and a complete range of chemical fertilizers. Cominco's best-known facilities are the Sullivan Mine and the Trail metallurgical complex, both in southeast British Columbia. Its other most important non-ferrous metal producer is the Pine Point Mine in the N.W.T., operated through Pine Point Mines Ltd.

Abroad, Cominco operates lead-zinc mines in the United States, Greenland and Spain, tin and tungsten mines in Australia, and participates in the operation of smelters in India and Japan.

(2) Mission Objectives

(a) To sound out possible opportunities for Cominco involvement in China as consultants or Managers in the design, planning or execution of exploration programs and/or mine and smelter modernization or expansion programs.

(b) To develop data on Chinese non-ferrous metal production and consumption and to assess the country's potential for meeting its future requirements and for possible impact on world trade in metals.

(3) Observations

(a) Relating to the presentation of a paper by the writer on Mineral Exploration in Canada

The Chinese do not appear to have a real interest in exploration or the mining industry in Canada except in so far as particular, specific, procedures might apply in China. Discussions of a general nature were probably of little practical interest to the Chinese I talked with - this may result from the fact that my discussions were with technical personnel, each with a limited technological field of operation. Activities outside of such fields are judged to have little relevance to work in hand. I detect a "compartmentalized" approach in the attitudes of the various exploration personnel I met with.

(b) Plant Visits

I visited the Baiyun iron-ore mine in Inner Mongolia and a portion of the Iron and Steel complex at Baotou where the mine production is treated. Only very cursory visits were accomplished and virtually no maps or sections were exhibited or available on the mine visit. The outstanding impressions gained were (i) the Chinese are exploiting an enormous deposit, or series of deposits, at a rate well below potential - more than 1 billion tons of ore supports a 40,000 tons per days operation which, in addition involves far more heavy equipment than would be used in a mine of comparable size elsewhere (ii) by-product possibilities are not aggressively pursued. Major quantities of fluorite and rare-earths are removed by flotation at the Baotou concentrator and essentially all is sent to the tailings disposal area. Limited experimentation in niobium recovery and production of ferro-niobium alloy is being pursued using otherwise obsolete equipment (iii) safety standards in this iron and steel complex appear to be virtually non-existent. The plant, built with Soviet assistance in 1957-59 was under maintained.

(c) General

During the visit I was almost totally unsuccessful in attempts to acquire hard data on China's mineral potential and the level at which it is being exploited. No doubt this lack of success stemmed largely from a combination of (i) the apparent unwillingness of the Chinese to divulge specific pieces of information without prior warning of what is required and (ii) a genuine inability to answer for lack of knowledge. The difficulties presented by the Chinese system to a preliminary mission of the nature concerned are also compounded by the evident restriction of vision of technical personnel, to precisely what they are particularly dealing with, rather than to an overview position. One suspects that no overview position could in fact have been expected from the level of representation with which the individual Mission members were able to hold discussions. As as additional observation, I would record that in conversations with Chinese exploration personnel in Peking - particularly a group of senior supervisors from the Geological Bureau of the Ministry of Metallic Industries - one kept being made conscious of the effects of differing economic parameters guiding exploration for mineral deposits in the West and in China. To the Chinese, "ore reserves" are whatever they have been told to find (ultimately by the National Planning Commission). Although in discussions the Chinese profess to have an economic basis for definition of the ore reserves they are seeking, the conversations clearly suggested to me that we do not share the same set of criteria for exploration and mining success. Consequently, I feel pessimistic that any meaningful joint venture in the exploration field can be developed between the Chinese and a foreign company. I also detected an unrealistic attitude as to how a foreign company would be prepared to operate as a consultant in China and as to the methods of payment which would be acceptable to such a company.

(4) Potential Business Opportunities

(a) Joint Ventures

As recorded above, I am not optimistic that mutually satisfactory joint ventures can be developed between the Chinese and Canadian (or other western-world) companies in the field of exploration and mining, at least for the next several years. I do not believe the Chinese are yet interested in joint ventures of such nature. Only when the other avenues of acquisition of technological expertise are exhausted (e.g. information gleaned from visiting experts, data gathered by Chinese missions to Western countries) will the Chinese be prepared to pay for technological help.

(b) Sales of Equipment, Technology, Materials

I can conceive of deals for the sale of equipment, materials and some advanced patented technologies being consummated with the Chinese earlier than joint ventures but again I believe these will come only where the Chinese have satisfied themselves that they can go no further in a particular direction by gaining technology, through the means noted above.

(5) Action and Follow-Up Required

(a) Government and the Peking Post

Continuous monitoring of activities and advice to Canadian industry of deals which reach the signed contract stage, and also intelligence as to the probable reasons for the foundering of various deals between the Memorandum of Agreement and the Contract stages.

(b) Company

I am recommending that my company maintain contact by mail with key personnel in the Ministry of Metallic Industries to the extent that such persons are now identified. Participation in any further missions would be worthwhile perhaps after 2 or 3 years.

BAIYUN IRON MINE, BAOTOU IRON & STEEL COMPLEX, JILIN FERROALLOYS PLANT

By

E.A. Manker, Niobec Incorporated

Company

Niobec is a Canadian company, which began producing columbium in early 1976 from a deposit near St-Honoré, Québec.

Niobec is the second largest producer of columbium minerals supplying about twenty per cent of world demand, and is also the only significant producer outside of Brazil. Columbium (or niobium) is mainly used in steel alloys, and most major steel producing areas are important users. About half of columbium consumption goes into the so-called "microalloyed" (or low-alloy) steels used in oil and gas pipelines, structural steels for buildings, bridges, automobiles, heavy equipment, and the like.

At the same time, columbium has some special properties as a superconductor (a conductor which loses all of its electrical resistance at very low temperatures) and applications of columbium in superconductor devices has considerable potential. There are numerous programs underway in nuclear fusion, magnetohydrodynamics, magnetic trains, ship propulsion, etc., which depend upon superconductor magnets, motors and generators. We follow these areas fairly closely and currently have a program to participate in more specialized columbium markets.

Mission Objectives

China currently has substantial steel production, and definite plans to make major increases in steel capacity during the next few years. As their steel production grows, it is more than likely that China will become a significant user of columbium in steel alloying. They thus may be a potential purchaser of ferrocolumbium or columbium concentrates.

We also know that in 1976, China exported a small quantity of columbium concentrates to Japan and they are thus a potential producer of columbium. We have no information or ideas about their potential. Since this export was apparently not repeated, one could presume that they may have some difficulty in producing. Since we have our own patented technology for the separation and concentration of columbium minerals, we also view China as a possible buyer of the specialized technology that we possess.

While we have been necessarily brief in trying to describe some rather complex topics, we can summarize by defining these possibilities for business with China:

a) The sale of columbium concentrates (or ferrocolumbium made from concentrates) to China.

b) The possible sale of columbium process technology, since columbium minerals apparently are found in China.

c) In the medium term, they could become a buyer of more specialized columbium products which we are likely to produce.

d) It is also conceivable that Niobec could become a processor (and reseller) of crude columbium materials produced in China.

We believe that China may have interest in some aspects of columbium "superconductor" technologies, since they offer the possibility of "taking a giant step forward" into new technology while by-passing the need to learn and develop some existing technologies.

Presentation of Technical Papers

The presentation of any technical informaion was very well received, in fact, demanded at every visit and location. While audiences were interested and attentive, many of the questions raised during presentations were directed toward some "magical solution" to very complex and involved technical problems. The range of questions was very wide, and there was in general disbelief, or perhaps even suspicion, when the writer said that he did not know the answer to a particular question.

In every case, there seemed to be great difficulty in the translation of numbers, even when the numbers should have been "stock in trade" for people who are supposed to be working in, and familiar with some technical areas. For example, anyone who has an even passing acquaintance with steels, would know that "yield strengths" are (in metric system) typically from 30 to 60 kg/mm^2.

Yet questions were raised; "Did he say it was 16 kg/mm^2 (or 200 kg/mm^2)", which are essentially "impossible" questions within the context of the discussion. In most cases, people who were technical specialists gave the impression that they had only a very limited awareness of their "specialty".

The exception to these general experiences was the Ferralloy Plant at Jilin (Kirin) in the northeast of China. The staff there seemed to be well prepared, and quite cognisant of their own technology. They raised sound questions, and presented a list of well thought out "discussion" questions of their own, including a request for information about the cause or causes of a serious accident at a ferroalloy plant in Beauharnois, Quebec.

There seems to be a truly admirable and diligent "thirst for knowledge" in China, but a corresponding lack of awareness and understanding of how knowledge (coupled with imagination) can be applied to solve really practical problems. One gets the impression there is a general belief that knowledge itself, if accumulated sufficiently, will somehow create the solutions to problems.

Baiyun Iron Mine

The Baiyun iron mine is located about 150 km by "road" north and a little west of Baotow in Inner Mongolia. The mine is also perhaps 40-50 km south of the current border between Inner Mongolia (China) and Outer Mongolia (Russia). The mine is the source of ore for the Baotow Iron and Steel Company, and appears to be operated as a "division" of the Iron and Steel Company. The name Baiyun is said to mean "Rich Mountain", and based upon the writer's observations, seems to be an appropriate name.

Discovery and Geology

It was explained that the iron mine was originally discovered by "Aircraft Magnetic Anomalies". This probably means that an aircraft noted substantial compass "deviations" while flying over, or near the mine. The mineralization runs roughly east-west which would tend to create large deviations in the vicinity of the mine.

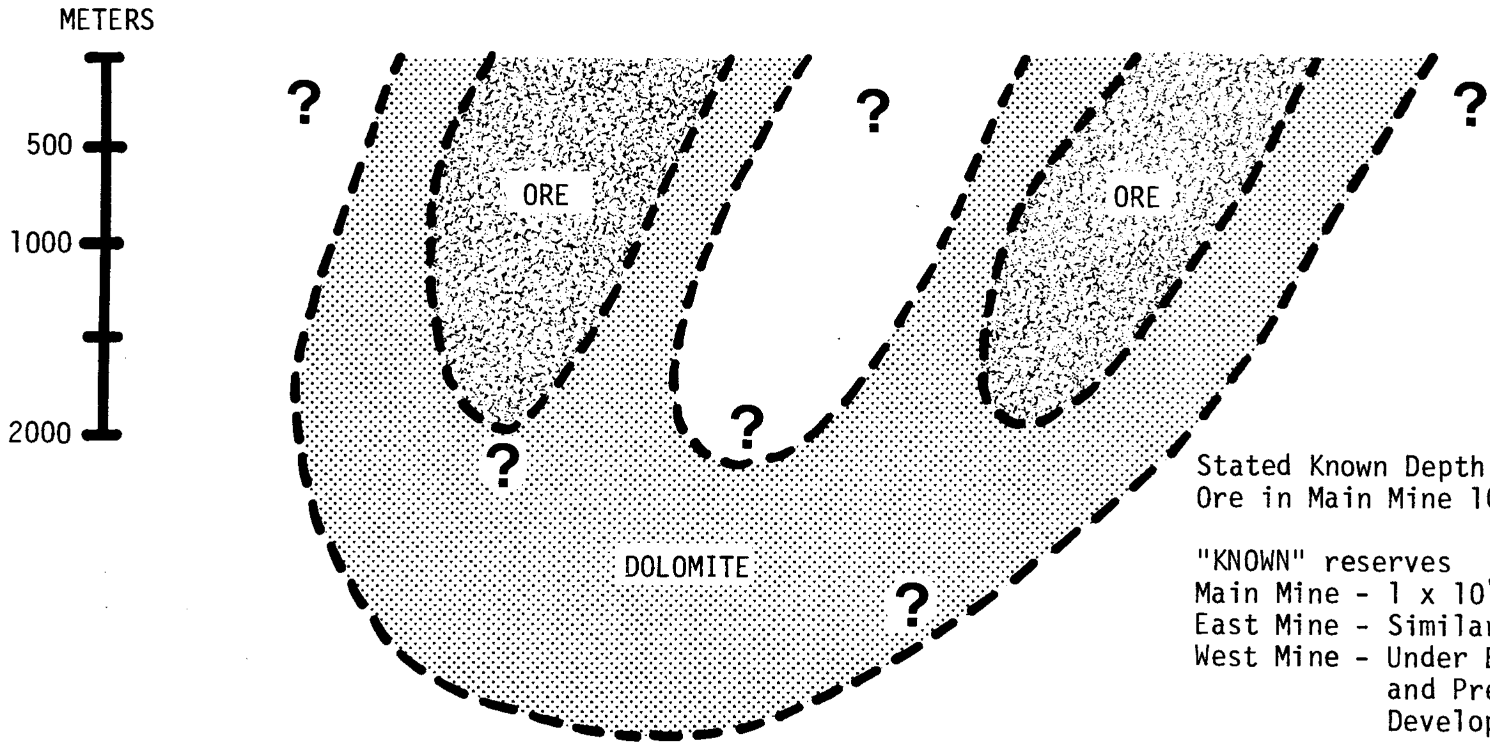
The mineralized zones were then defined by drilling guided by physical prospecting and magnetic surveys. Two main zones (now known as the "Main Mine" and "East Mine" were defined and developed first. When asked about the origins of the deposit, geologists at the mine suggested that the deposit may be related to massive granite formations east of the mine, and also suggested that it may be a synclinal folded deposit. An approximate geological cross-section (drawn from memory of more detailed drawings shown at the mine) is shown on the next page. The southern side of the "folding" is relatively minor in the case of the Main and East mines, but the West mine (now under development) seems to be a better example in support of this concept. It was stated that radioactive dating procedures had established the age of the deposit as 1.3 billion years.

The principal metal of interest is iron, which ranges from 20-90% of the ore content, with mined ore averaging 30-40% Fe. The Main Mine has the highest iron content, the East a little less, and the West mine has the lowest iron content. The ore also contains rare

BAIYUN IRON MINE

Approximate Cross Section of West Mine
(Main and East Similar); North-South Section

Massive Granites East
of the East Mine



Stated Known Depth of
Ore in Main Mine 1000m.

"KNOWN" reserves
Main Mine - 1 x 10^9 tons plus
East Mine - Similar
West Mine - Under Exploration
and Preliminary
Development

earth oxides varying from 5-9%, 5-8% fluorite, and about 0.1% Nb205. (The experimental Nb recovery operations at Baotow suggest that the ore also contains perhaps 0.3 to 1% Mn, and 0.2 to 0.4% V.

Iron is found as magnetite and hematite and in several accessory minerals. Rare earths are mostly bastnasite, but also some exotic minerals including "huonghotte", a mineral originally discovered at Baiyun. They have identified 12 niobium minerals, but most of the Nb is in the form of columbite (60-70% of Nb), also pyrochlore, eschynite, ilmenorutile (5-15% of Nb), etc.

Mine operations

From an overview, the mine seems to be a reasonably good compromise of several factors. The region of the mine is quite dry, with an average annual rainfall of 237 mm ($<$10 inches per year). Summer temperatures seldom go above 20°C and winter temperatures can go to -30°C, with substantial wind factors.

The lack of a concentrator at the mine seems to be mainly due to lack of water. It was stated that water used at the mine and in the mine town (perhaps 20,000 population) is brought by pipeline from a large well 26 km west of the mine.

Ore and waste haulage is done by trains with electric engines. Again, running power lines for 150 km is probably a lesser evil than continuous hauling of coal for steam powered engines, a local generating plant, etc. Significant coal is used for heating and cooking purposes in the mine town. The limited hauling from the west mine is done by a fleet of about 15 trucks which appeared to be of 30-40 m. ton capacity.

Much of the equipment at the mine has been made in China including most of the power shovels and the blast-hole drilling machines. The number of broken-down drilling machines in a "yard" area appeared to be two to three times the number at working faces in the Main and East mines.

The Main and East mine are both open pit mines, and it was clear that very substantial amounts of ore have been taken from these mines. The stated production is 20,000 t./day of ore from the Main mine and 20,000 t./day from the East mine, both with an ore-to-waste ratio of about 1:1. In operation, track is laid at the base of a "bench", and the bench is then drilled and blasted, and the ore (and waste) are loaded into rail cars for haulage. Power shovels (approx 30 in all) are of relatively small (1.5-3 m^3) capacity, and the largest shovel (working East mine) is an American Bucyrus-Erie "280" with a 4.5 m^3 bucket. The mine should have much larger shovels, in the 30-40m^3 capacity range.

The main products of the mine were stated to be a 50% Fe ore which goes directly to the steel operation at Baotow, a 33% Fe ore which goes to the "ore-dressing" plant at Baotow, and a 7% Fe ore which goes to another small plant in Baotow.

The Main mine was opened in 1957, and the East mine in 1959. The West mine is currently under development, with approximately 50 vertical drilling rigs working in this area. Pictures were not allowed, but the mine is clearly portrayed on the back of the "5 yuan" note used throughout the P.R.C. A tour of the mines was impressive in terms of the sheer size of the deposits and in visualizing the ore that has already been mined.

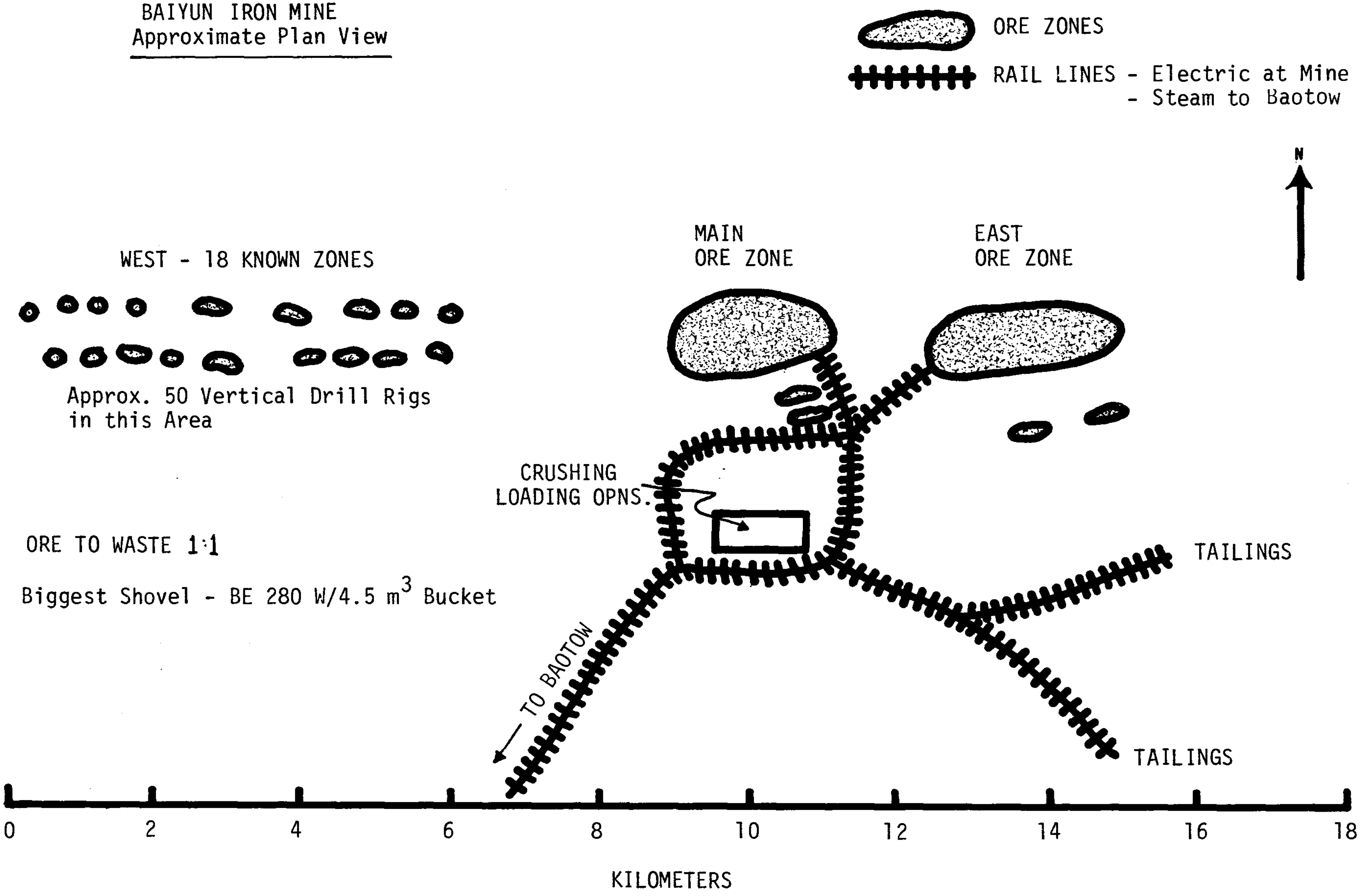
A rough sketch layout of the mine is shown on the next page, and it was stated that the mine employs about 3,000 people, roughly broken down as follows:

Main and East Mines	500 workers
Transportation	500 workers
Waste rock handling	200 workers
Crushing operations (and loading?)	100 workers
Maintenance and Repair	800 workers
Office	300 workers
Staff, schools, clinic, hotel etc.	600 workers
	3,000 workers total

The mine operates 3 shifts per day (24 hrs) for 6 days per week on a year-around basis. Little food can be produced locally, so food is brought from other parts of the region.

The available ore reserves and the fairly easy mining methods suggest that this mine could probably produce 100,000 or more tons/day. Additionally, the West mine may eventually show reserves equal to or greater than the Main and East mines together.

BAIYUN IRON MINE
Approximate Plan View



Baotow Iron and Steel Company

On March 8, 1979 Dr. Geoff. Harden and myself were shown through a "concentrator" plant and an experimental niobium recovery plant, both within the complex of the iron and steel plant.

The concentrator plant processes the iron ore from the iron mine at Baiyun. The principal function of the plant is to make a rare-earth fluorite concentrate. The concentrator is large by any standards and includes a single line bank of 24 to 30 ball mills of about 3m. by 4m. dimensions. (When I suggested that they had about 30 ball mills, the response was "more than twenty".) Each ball mill was set up with its own screw classifier, which were paired for feed and output, and the classifiers seemed to be performing mainly a dewatering operation as at Niobec. When we visited the plant about six or seven of the ball mills were in operation, with the rest apparently awaiting repairs.

We were not shown any flow sheet of the plant (in contrast to the very detailed explanations that were given of our own operations), but there is apparently another section that does secondary crushing before the ore is sent to the ball mill circuit, since the mine does only a primary crushing of the ore. After the ball mills the ore is sent to a rare earth and fluorite rougher float, and "finger-dipping" in the cells suggested that the "grind" was on the order of 65 mesh as a maximum size.

The primary float cells were of conventional design, with a double paddle froth removal system. Cell dimensions were approximately 2.5 meters by 2.5 meters. The cells seemed to be operating stably with plenty of froth. Reagents were not discussed, but considering the variety of minerals present in the ore, there is probably little selectivity in the float and it is mainly depressing magnetite and hematite. There is a second "cleaner" stage of cells again floating the rare-earth and fluorite fraction, and after this, the rare-earth concentrate is sent to a separate "tailings" reservoir to be kept until needed. It was stated that when this reservoir becomes full, the overflow is sent to the regular tailing reservoir which "is more like a lake". I asked if they had ducks in their tailings pond and they replied "no, only fish".

Considering that the iron ore contains 5 to 9 percent REO's, the "concentrate" probably is on the order of 15 to 30 percent REO's. It is noteworthy that a mining rate of 40,000 tons per day (as stated by mine personnel) corresponds to 2,000 to 3,600 tons of REO's per day, of which at least half are going into the REO "reservoir".

After the rare earth flotation, the ore is treated by magnetic separation. There is a stage of horizontal cylinder (0.5 mD x 3.0 m. length) permanent magnet separators and a stage of "horizontal pan" magnetic separators with pole type magnets. It seems probable that there is some further flotation to recover iron ore, but we were not shown any other flotations and it was not clearly stated that this was done.

The niobium content of the ore is apparently carried along with the iron-ore portion, but there is probably some niobium content in the rare-earth fraction as well.

Safety precautions, by Canadian standards, are nonexistent. There was no sign of a hard hat or safety glasses anywhere in the plant. Drive belts have no covers or "guards" and bare electrical wires (presumably unenergized) were laying around here and there. Upper floors in the concentrator are made of wood slats, about 4 cm by 4 cm which in many cases were not fastened at the ends. There was only natural lighting in the plant when we visited, although there were lighting fixtures high in the ceiling of the plant. Ladders and stairs were bent and uneven with narrow steps and steep angles.

Niobium Recovery at Baotow

An experimental niobium recovery operation is also in operation at Baotow, using slag from the open-hearth steel furnaces. While we were not given any specific data, one presumes that this slag contains the majority of the niobium from the original ore.

This slag is first treated in some small, ancient blast furnace equipment to produce an iron-niobium intermediate product. It was stated that 80 tons per day of slag was being treated to produce 20 tons per day of the iron product. The molten iron is then taken to a converter where it is "blown" to produce a slag containing most of the niobium. The slag contains about 5% Nb, and some samples of the slag were obtained (our sample showed 2.11% Nb). This slag is then smelted in an electric furnace. The furnace used was a three electrode (three-phase) type with a "pot" capacity of 1 or 1.5 cubic meters. It appeared that the power rating was on the order of 1,000 Kw.

The "melt" from the furnace is poured into a refractory cinder pit and allowed to cool with a scrap electrode end in the centre to serve as a later "lifting hook". The product is a ferroalloy with a stated composition of:

Nb - 10-13%

Mn - 35%

V - 2%

P - substantial

Fe - remainder

A sample of this product was presented by the "manager" of this pilot plant operation(it analysed 17.5% Nb). In an earlier "technical discussion" the Baotow people said that they had great difficulty crushing their "ferroniobium". With the composition of their product approximating that of a high-alloy steel, it is not surprising that they have difficulty with crushing.

This pilot plant was using outmoded and "left-over" equipment, and the safety standards were similar (or below) those in the concentrator plant.

Jilin (Kirin) Ferroalloys Plant

On March 11, 1979 the writer visited the ferroalloy plant at Jilin (Kirin). Jilin is located in northern China, formerly known as Manchuria, and is approximately 400 km west of Vladivostok, Russia. Information in this report is based on technical data presented by Mr. Tsung, the plant "Director" at the "Brief Introduction" and upon observations made during a plant tour. Where possible, production capacities are estimated on the basis of observed operations in addition to the stated capacities.

The Jilin plant is a "world-scale" ferroalloys plant, employing 5,000 workers according to Mr. Tsung. He pointed out that this includes all repair and maintenance, in-house construction of most equipment and preparation of most materials including roasting of MoS_2, roasting chrome ore, and even "burning" the lime used as flux in some operations. The plant was established in 1956 and expanded in 1958. There are 4 main "shops" and many auxiliary buildings and operations.

Total output was stated to be 180,000 tons per year with product distribution as follows:

FeSi	60,000 t./yr
FeSiMn	50,000 t./yr
FeCr	50,000 t./yr
FeW	8,000 t./yr
FeMo	4,000 t./yr
FeNb	20 t./yr

The production breakdown does not exactly total 180,000 t./year, but it should be noted that there seems to be great difficulty translating numbers from Chinese to English (and the reverse) so that even when a number is questioned and repeated there is considerable probability that something has gone wrong in the translation.

The numbers above are a "consensus" of what was stated most frequently, and where possible that could be roughly verified by observation.

During the "Brief Introduction" it was noted that Mr. Tsung, the plant Director, had a neatly prepared 3-4 page "write up" on each operation which included basic technical data, product analyses, etc., and data presented was read from these prepared reports.

FeSi

One furnace room is devoted entirely to FeSi production, and consists of 12 furnaces of "open-hearth" type with power rating of 12,500 kva each. Power consumption was stated to be less than 8,500 kw. hrs per metric ton of FeSi. During the plant tour we observed one furnace, and it appeared that the shop was in normal production, with perhaps 8 or 9 furnaces operating. The product was stated to be a FeSi with 75% Si content. In this shop the ladder from the main floor up to the furnace level floor was actually fairly new, and had level steps without dents or bends in them.

FeCr and FeMn

One "shop" is devoted to FeCr, FeMn, FeSiMn and FeSiCr. This shop has five furnaces, one open type, one semi-closed, two closed furnaces and one under maintenance, apparently being converted to a closed type. Furnaces are rated at 25,000 kva each.

FeSiMn and FeCr (high carbon) are made in closed furnaces. It was stated that a low grade (30% Mn) ore is used for the FeSiMn. The claimed power consumption is <4,700 kw-hrs per metric ton. Medium carbon FeCr is also produced (closed furnace) and FeSiCr is done in the open furnace. Power consumption for the other alloys was not stated. When we visited the plant all of the four "on-line" furnaces were in operation.

Extra Low Carbon (ELC) ferrochrome is also produced in a "Simplex" process using vacuum furnaces. The technology appeared similar to that developed by Union Carbide in the 1950's, although the equipment at Jilin looked like it was not more than 10-15 years old. The production plant has two "Simplex" furnaces of approximately 4m. diameter and about 20m. length. The furnaces are heated with carbon electrodes across the upper portion of the furnace, with external, water-cooled electrical connections.

The two furnaces are operated in rotation, since there is a single vacuum pump system for the two furnaces. The vacuum system is of European or American origin, since it included belt guards, some instrumentation and control equipment, and vacuum pumps which appeared to be beyond the scope of Chinese technology.

Chrome ore is roasted in a rotary kiln (approx. 2m. diameter by 20m. length) which is adjacent to the "Simplex" operation. It was stated that the roasting removes most of the carbon (?) and sulfur in the chrome ore. Roasted ore, along with iron, etc, is formed into "bricks" about the size of conventional construction bricks. The bricks are piled on "cars" which can be rolled into or out of the furnaces on a railroad "track" system. It appeared that a single furnace cycle could produce 40-60 tons of Low Carbon (0.03C) ferrochrome.

Visual observation during the "plant tour" suggested that a single furnace load had a bulk volume of about 2.5 m. width by 0.5 m. height by 15 meters length of bricks. This would give a volume of 18.75 m^3 and assuming a "bulk density" of about 4 gm/cc, this would be equivalent to 75 metric tons of FeCr. If a furnace operating cycle is 3 days, two furnaces operating 300 days per year would give:

$$\frac{300 \text{ days}}{3 \text{ day}} \times 2 \text{ furnances} = 200 \text{ cycles} \times 75 \text{ tons} = 15{,}000 \text{ t./yr}$$

this seems roughly consistent with the stated total for all types of FeCr production of 50,000 t./yr.

FeMo

The Jilin plant produces FeMo with a conventional aluminothermic process. A molybdenum sulfide concentrate, produced somewhere in China, and containing about 45% Mo, is used as a starting concentrate. This concentrate is roasted in a gas-fired, 8-shelf, "Herreshoff" roaster. The roaster appeared to be 8-9m. diameter and was stated to produce a roasted concentrate with about 75% MoO_3 and less than 0.05% S. No MoO_3 is produced in "briquette" form.

FeMo reactions are carried out in a refractory-lined steel shell placed in a large pit of refractory sand. A "hollow" is made in the sand for the FeMo produced, and the reaction mixture is placed in the hollow and reaction shell, then ignited at the top. A hood and fume stack can be rotated over the reactor, and it appeared that two reactions could be run in close succession by rotating the hood and fume stack from one to the other. A second reactor shell was not noted, though, in the immediate shop area.

After the reaction is completed, the reaction shell is raised, and the slag from the reaction flows through a channel in the sand to a receiving "skip", with the FeMo "button" remaining in the depression in the refractory sand.

The reaction shell appeared to be about 2.5 m. high and about 2.5 meters diameter, with an internal diameter of perhaps 2 meters. Some crushed FeMo "buttons" suggested that the button produced was about 20 cm thick. Assuming an average button thickness of 15 cm, and a button density of 7 gm/cc would give buttons weighing

$$(\pi r^2)\ (h)\ (\rho)$$

$$(3.14)\ (1^2)\ (.15)\ (7.0) = 3.3 \text{ metric tons}$$

the claimed production of 4,000 t./yr would require

$\frac{4,000}{(50wk)(3.3)}$ = 24.2 buttons per week or about four buttons per day. The equipment setup suggested perhaps two "buttons" per day on average, and unless there was additional equipment we were not shown, the 4,000 t./yr production seems a little "optimistic".

FeW

The Jilin plant produces ferro tungsten in a continuous electric arc furnace operation, and this operation was the most interesting technology we noted during our visits and tours in China. During our "Brief Introduction", this was described as a "special process" electric furnace method, using a 2,500 kva furnace. The advantages of this process were stated to be low refractory "losses" or consumption and a high operating efficiency.

When observed during the plant tour, the FeW operation was quite impressive and definitely appears to be an unusual and perhaps unique technology. The electric furnace appeared to be of fairly conventional design, but it was constructed so that it could be tipped and rotated forward to pour or "tap" slag from the furnace. The reducing agents were not described, but with the arc furnace power input, a reducing agent less powerful than aluminum is probably used.

Molten FeW is removed from the furnace with large "spoons" or ladles. A "spoon" is about 40-50 cm in diameter, somewhat dished, and with a "handle" about three meters long. Every 20-30 seconds a spoon is dipped into the furnace, and a small amount of FeW (estimated to be 20 kg for each "spoon") is removed. The handling of the spoons is done by two pneumatically powered machines with metallic "hands" that can grasp the looped handle end of a spoon. One machine picks up empty spoons, dips them in the furnace and places them on the edge of the product "skip". The second machine picks up a "cooled" spoon, bangs it on the edge of the skip to knock loose the FeW and replaces the empty spoon in a position for the first machine to pick it up for another "dip" into the furnace. There are two pairs of the spoon handling machines, one operating on each side of the furnace. The handling machines seemed to be a fairly sophisticated design, since the metal "hands" could "grasp" and rotate, and coupled with machine motion, were capable of three-axis movement.

The operating capacity, with two sets of machines operating, appeared to be 4-6 spoons (80-120 kg) per minute. This would give a daily production of about (80kg) (60 min/hr)(24 hrs/day), or 115 tons per day. The stated output of FeW is 8,000 tons/yr. This would require about 70 operating days per year. While all figures above are rough estimates, it does appear that the ferrotungsten operation can produce the claimed output of 8,000 t./yr. The product FeW was stated to contain about 70-75% tungsten, and power consumption was stated to be less than 3,000 kw/hr per ton of ferrotungsten.

FeNb

FeNb is also produced at Jilin in small quantities. They stated that their current production is about twenty tons per year. The facility for FeNb is separate (several km) from other parts of the plant, and appeared to be in an area which may be used for laboratory and pilot plant work.

The raw material used comes from Shanghai, where it is processed, after originating at a mine "in China". No more precise location of the mine was forthcoming. From the description of the reaction mixture and the stated product analysis, the "concentrate" seems to be definitely a columbite, with significant tantalum content and relatively little calcium oxide content.

The aluminothermic process is used, and the reaction mixture was stated to be niobium concentrate, aluminum, iron in the form of scrap steel, sodium chlorate ($NaClO_3$), lime (CaO) and fluorspar (CaF_2). The concentrate is pelletized in a simple "rotating-pan" pelletizer, using sodium silicate as a binder. During the plant visit, white powder residue was noted in the pelletizer, suggesting that the lime, and perhaps also the fluorspar is mixed with the concentrate during pelletizing. The pellets are 10-20 mm diameter, and are dried at 400°C after pelletizing. The stated purpose of the pelletizing was to improve recovery in the FeNb reaction by reducing smoke and fume losses.

The "batch" for a single reaction was said to contain 400 kg of Nb205, and the reaction heat used was stated to be 700 cal/gm of reactants. This is higher than typical, but the stated product analysis has a rather high aluminum content, tending to confirm that a fairly high heat is used. The equipment for the production operation was rather old, and not too elegant, but sufficient for the necessary operations.

The reactor is charged with a small quantity of reactants and moved into position (out-of-doors) under a hood and stack. The reaction is started in the bottom of the reactor, and additional material is fed into the reaction from an elevated hopper and chute apparatus. The reactor seemed to be more than large enough for the size of the reaction, so there is probably very little loss from sputtering or splattering during the reaction. The claimed recovery of niobium is 95-96%, which seems possible with the high reaction heat (and high Al content in the FeNb) used.

The product is a "clean looking" FeNb, with the following stated composition:

Nb	>	68%
Ta	≈	1.5%
Al	<	7%
Si	≈	2.5%
Ti	≈	2.0%
S		0.04
P	<	0.05
C	<	0.2
Cu	<	0.01
Sn, As, Sb, Bi	<	0.002

While this "ferro" is quite satisfactory for most steel alloying applications, some impurity contents; particularly aluminum, are much higher than current commercial standards, so that this FeNb would not be readily saleable in international markets. The overall composition does suggest that the basic concentrate could probably be used to produce "commercial standard" FeNb without great difficulty.

General Comments

The Jilin Ferroalloy Plant and the general lack of safety standards noted in other operations, but with some small signs of progress (a recently replaced ladder has been previously noted), and at least basic attempts at smoke and fume control. The plant personnel were aware of the accident (5 fatalities) with the FeMn furnace at the Beauharnois, Québec plant of Union Carbide Corporation, and specifically asked if the writer had any information about the cause of this accident. Since it will be several months before any "cause" is determined, the writer agreed to forward any information that became available.

While the plant staff (5,000 people) is large, the plant is semi-self-contained, and includes many operations that would be performed by other companies in a more economically oriented society. At the same time, compensation levels in China are very modest, and the average plant "wage" is probably about $65 Ca per month or a little less. Thus, the annual payroll is about (5,000)(65)(12) or $3,900,000 per year. This is a labor cost of about $21.67 per ton of ferroalloy produced, or about 1¢ per pound of ferroalloy. This is probably quite competitive with other operations.

The management and technical staff at the plant seemed to be alert, inquisitive, and well-organized. The plant director, Mr. Tsung seems to be doing an excellent job of getting true production from relatively old equipment under less than ideal economic circumstances. In the writer's opinion, he would be a good plant manager under any set of rules.

The Jilin plant seemed to be much closer to "modern technology" than other operations visited in China, mainly because they seemed to be "getting the job done". If the senior people at this plant have the opportunity to get more technical information, and more importantly to "compare and exchange notes and ideas" with their counterparts in other parts of the world, they seem to have the basic interest and ability to make their operations and their products competitive in world markets.

Potential Business Opportunities

1. China is apparently willing to undertake joint ventures as a means of accelerating economic and technical development. In this writer's opinion, these offer the best potential of doing substantial business in and with China. The minerals and metals industries are well situated for this kind of venture, since they are in a relatively good position to take and utilize future production (Cu concentrates, aluminum, etc) as a means of recouping their investment and hopefully putting some numbers in the profit column.

It is quite clear that China's financial resources are limited, so that ventures requiring the least, or better yet, no capital input from China would probably be the most attractive. These also of course make the greatest risk for the foreign partner if he has all or most of the capital commitment. Aside from business risks, there are always "force majeure" events such as floods, earthquakes and the like which could necessitate a "rapid write-down" (or "-off") of an otherwise sound investment.

2. It appears that financial limitations will necessarily limit purchases of equipment, technology and materials on any payment terms of 5 years or less. In rough terms, it appears that the "foreign purchased equipment" for a really large modern mining project could represent perhaps 5% of China's available foreign currency in a given year, and thus clear that equipment sales are necessarily limited. When one considers that this mining

project and its capital requirements must be balanced against all of the needs and desire of a country of 900 million people, this kind of project will obviously not be done two or three times a year.

Based upon our visit, one has the impression that the typical middle and upper-middle managers (age 50 and under) have little knowledge and experience with the business practices of the outside world. Such very practical questions as what is a reasonable return on investment, reasonable profits, etc., could present significant difficulties in assembling a venture, and perhaps even greater long-term difficulties in the case of a highly successful venture.

Action and Follow Up

The writer did notice possibilities (at least from a technical viewpoint) for joint ventures which might be of interest to Niobec and its associated companies. As time permits, we will try to develop these concepts and discuss them within our company. If there is a consensus that one or more of the possibilities seems to have some merit, we would then try to pursue it further with the Chinese.

In the eventual pursuit of the establishment of any venture with China we would look to the Government and the Peking Post for essentially the same kind of assistance that they provided in organizing and executing this Non - Ferrous Metals Mission. In an actual venture proposal we would have some kind of concepts and some general strategy for developing the venture. We would look to the Peking Post for frank comments, based upon their more intimate experience, as to the probable reactions by China to any concepts and strategies that we might develop.

AGENDA AND REPORT OF DEBRIEFING MEETING

The agenda of the meeting is on page 112.

The principle reason for this meeting was to give industry and provincial government representatives an opportunity to meet with the mission delegates and to hear their views on Chinese developments in the non-ferrous metal industry. Another reason was to give consideration to the next step Canada should take to encourage the Chinese to purchase Canadian equipment and engineering know-how.

Following opening remarks by G. Nash, Leader of the Delegation, contributions were made by A.T. Eyton, Director General, Pacific Asian Bureau of the Department of Industry, Trade and Commerce, and M. Bakker, Regional Manager for the Far East, of the Export Development Corporation. The notes on which Mr. Eyton based his presentation follow this report.

Some forty senior officials from Industry and Government attended this meeting among which were included representatives of some of Canada's most important non-ferrous metal producers - Alcan, Cominco, Falconbridge, Inco, Noranda and Sherritt Gordon. Engineering firms, banks, and mine machinery manufacturers were also represented.

It was generally agreed that business (particularly in the capital projects field) is obtainable in China over the long run. However, it was observed that the Chinese Government intends to become self-sufficient in the production of industrial products by the year 2000. According to knowledgeable members of the audience and also to most of the mission delegates, the Chinese are prepared to make the necessary sacrifices to enable funds to be allocated to capital projects and thus forego major improvements in their standard of living to ensure better living conditions for future generations. As they have done in the past, the Chinese will abide by the decisions of their leaders.

Reference was made to China's 10-year plan to complete 120 projects of which some of the largest involved mining and metal industries. It was felt by some of the government and company representatives present that China has now realized that it cannot complete all the projects by 1985 and accordingly has deferred some of the major projects covered in the plan. Financing is undoubtedly an important obstacle as technology to meet the needs of the Chinese is available, but at a price the Chinese under present circumstances may not be able to afford. For example, it was pointed out that the cost in United States funds of erecting a copper complex proposed by the Chinese is $1.5 billion, whereas Chinese foreign reserves are said to total $2 billion.

Joint ventures and compensating financing were mentioned as being two ways financing could be undertaken. The latter is rather nebulous and to date no such agreements have been signed. As far as could be gathered by the delegates, under a joint venture agreement during the first five years the foreign participant would be allowed to recover his investment; during the second five-year period, he would be allowed a profit and at the end of the ten-year period, renegotiation presumably would be allowed but there is no clear understanding that would actually be the case. One of the problems likely to arise when arrangements are being made to undertake a joint venture activity, is the notion of what constitutes a reasonable profit. Under the compensatory agreement proposal, the foreign participant would be expected to take his payment for goods and services in the form of Chinese produced products which he would be expected to market internationally. Such products could be the end result of the project e.g. copper or nickel or there could be other products unrelated to the project which are available in China such as textiles or rosewood furniture. A requirement for Canadian companies involved in this activity could be the retention of the services of an international trading house on the scale of Mitsui or Mitsubishi. Mention was made of the potential role for such firms as Interimco and the Canadian Commercial Corporation. Nonetheless, in spite of the foregoing it was thought possible by participants at the meeting that Canadian firms through assistance of the Export Development corporation* could complete acceptable arrangements for financing.

From all reports the Bank of China is quite knowledgeable concerning matters related to international finance and the various forms of credit. The Bank does an excellent job in collecting information from other countries. To assist British firms to negotiate sales, a group of British banks arranged a five-billion-dollar stand-by credit until 1985 at 7½ per cent. This in fact,

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* Since the Debriefing Meeting, the Export Development Corporation has negotiated and agreed with the Bank of China to establish a line of credit which will assist Canadian firms wishing to undertake capital projects in China.

represents a subsidy by the Exports Credits Guarantee Department of the British Government to the extent of the difference between the London Euro Dollar rate and the stated 7½ per cent.

With regard to overall financing for capital projects, it was observed that foreign Government involvement in financing in some cases will be somewhat restricted until China becomes a member of the International Fund and other related organizations.

There are two aspects related to China's aspirations to increase its output of industrial products with the assistance of foreign companies. First, it was pointed out by a member of the delegation, China does not possess a commercial code which would guarantee the rights of the foreign participants in agreements, i.e. in such matters as patents, and trade marks, shipping law and financial matters. However, it was noted that a group of United States lawyers and others from Europe were currently in Peking drafting a commercial code which was expected to be published in about six months. The other aspect mentioned was the view that compensatory agreements by their very nature would generate sales on world markets. Thus it was felt by the meeting that exports of copper and nickel eventually may well take place which would compete with Canadian exports. In fact, a mission delegate and a participant at the meeting, who had spent sometime in China, agreed that China, after 1985, could potentially emerge as a major competitor to Canada's non-ferrous metal producers.

With regard to the efficiency of the Chinese non-ferrous metals industry, it was noted repeatedly that the manpower required to produce a quantity of metal similar to that in North American scale operations was extremely high. For example, the integrated aluminum smelting and fabrication complex at Harbin, Kirin Province, has 5,000 employees versus 500-700 in the Canadian Alcan operation having approximately the same output. At most of the plants visited, few labor-saving devices were noted and there was little instrumentation. Working conditions for the most part were poor. Wages vary from a low of $40 per month to $120 covering eight levels of skills. The Chinese place a lot of stress on high metal recovery, even though a lower recovery might make economic sense. They are fully capable of making use of technical papers to erect plants and make modifications to improve recovery as was observed by several of the delegates when visiting the nickel complex at Jinchuan in Gansu Province. Construction of this complex was based entirely on published information most of which originated in Inco's engineering offices.

During their tours of mines and government offices, the delegates observed that the Chinese do not share our criteria for defining ore reserves. Grades and tonnages do not appear as important as the contained metal. Their conception as to how a firm should be paid for exploration activity differs markedly from that of Canadian firms. Consequently, it is difficult to visualize Canadian firms being interested in undertaking exploration consulting activities in China unless their views on exploration activity measurement are modified to more closely approximate those of Canadian geologists.

It was brought out at the meeting that very few definite contracts have been negotiated by the Chinese. However, a number of

"Letters of Understanding" have been instituted. The "Letter of Understanding" appears to have less authority than a "Letter of Intent" as used in the West and may be no more than a license to continue negotiations, which can be carried on over protracted periods, ultimately leading to signing a contract. In the metal field, the only contracts known to have been concluded are those covering the first phase of Kaiser's involvement with an iron ore mining project and the first stage feasibility study being made by Fluor on a copper mine project. On the subject of the possibility of the sale of Canadian technology, it was generally agreed that given the lengthy negotiating period and limited financial resources and returns to Canadian operating companies for the sale of technology per se, that such sales would more properly be handled by Canadian engineering firms. These companies could sell not only the technology but could endeavour also to sell the capital equipment which would utilize the technology. Thus, Canada would be in a position to realize subsequentially higher returns.

DEBRIEFING - NON-FERROUS METALS MISSION TO CHINA - MARCH 3-17, 1979

Date: April 17, 1979

Place: Essex Ball Room
Sheraton Centre
123 Queen Street West
Toronto

Agenda:

Time	Topic	Speaker
1000	OPENING REMARKS	G. Nash, Director Metals and Minerals Group Resource Industries Branch Dept. of Industry, Trade of Commerce and Leader of Mission
1010	CANADA/CHINA TRADE RELATIONS	A.T. Lyton, Director General Pacific Asian Bureau Department of Industry, Trade and Commerce
1025	THE ROLE OF THE EXPORT DEVELOPMENT CORPORATION AS IT RELATES TO CHINA	M.D.J. Bakker, Manager Far East Area Export Development Corporation
	Questions	
1100	OBSERVATIONS OF DELEGATES	
	Visits to aluminum fabrication plant and smelter at Harbin, Kirin Province and Fushun, Llaoning Province	Dr. O. Sivilotti, Vice-President Technology Rolled Products Division Alcan Canada Products W.W. Robertson Senior Consultant Smelting Technology Alcan International Limited
	Visits to nickel mine and smelter at Jinchuan and copper smelter at Beijing both in Gansu Province and research institutes.	H.C. Garven, Manager Process Development Group INCO Metals Company G.D. Hallett Assistant Manager Continuous Smelting Division Noranda Mines V.N. Mackiw Executive Vice-President Sherritt Gordon Mines

Debriefing - Non-Ferrous Metals Mission to China - March 3-17, 1979

		Dr. G.A. Crawford, Manager Patents & Licensing Falconbridge Nickel Mines
	Visits to iron ore mine and niobium recovery facilities at Paotow, Inner Mongolia, ferrous alloy plant at Kirin, Kirin Province and Geological Survey at Peking.	Dr. E. Manker, Vice-President Niobec. Dr. G. Harden Manager-Exploration Western Division Cominco
1220	LUNCH	
1345	OVERVIEW OF MISSION AND VISITS TO GOVERNMENT OFFICIALS.	G. Nash
	QUESTION PERIOD	
1530	POSSIBILITIES FOR ACTION AND WRAP-UP.	G. Nash

CANADA/CHINA TRADE RELATIONS

China's Position in World Trade

Although China is a large country in size and population, its international trade has not been large by world standards totalling less than one-quarter of Canada's international trade and less than 1 percent of world trade. Annex I compares the size of the import market in China with that of other selected countries in the area.

International trade has played only a minor role in Chinese economic development (less than 6 percent of Chinese GNP); the basic policy of the Chinese has been one of self-reliance which means that they only import what they cannot produce from their own resources. China's imports have traditionally been limited to sophisticated capital goods, essential technological processes and goods required to compensate for shortfalls in domestic production.

Since the latter part of 1977, China has embarked on a new program of rapid economic development with emphasis on the modernization of agriculture, industry, science and defense. While the Chinese continue to insist on their adherence to self-reliance in trade matters, they announced in early 1978 their intention to construct or complete 120 large-scale plants by 1985 which, it was estimated, would involve purchases of more than $60 billion of foreign capital goods including plants and technology in the following sectors: steel, coal, oil, ports and ship construction, petrochemicals, nuclear and conventional electric power, non-ferrous metals, transport and fisheries.

Contracts for foreign plants worth at least $7 billion were awarded in 1978, over half being allotted to Japanese firms. In early 1979, the Chinese initiated a pause in their buying activities and a number of contracts with Japanese firms, especially in the steel sector, were deferred. Indications are that the Chinese are reappraising their economic plans and that there may be some shift of emphasis from heavy to light industry. The Chinese have also indicated some concern about their ability to earn foreign exchange to pay for their proposed capital imports and they are exploring various alternative methods of payment; e.g., compensation trade, co-production, joint ventures, in addition to becoming more receptive to foreign loans, both private and government.

Legal Basis for Canada/China Trade Relations

A most-favoured-nation trade agreement between Canada and China was negotiated and signed during the Prime Minister's visit to China in October 1973; an exchange of notes extending the agreement for a further three years was signed in October 1976. Renewal of the trade agreement will be required this fall. The Trade Agreement provides for a Joint Trade Committee which meets annually to discuss trade between the two countries and to decide on the market development program for the forthcoming year.

Discussions are continuing with Chinese authorities on an economic cooperation agreement which would provide a mutual commitment to work toward closer cooperation in a number of specified sectors which are outside traditional items in our bilateral trade.

Canada/China Trade

Canada usually ranks within the first half dozen foreign suppliers to China and we supply about 3 percent of the total Chinese import market (there are very few foreign markets for which Canada supplies more than 1 percent of the total import requirement). Canada has traditionally had a large trade surplus with China because of our wheat exports which have in any one year represented over 2/3 of our total sales to that market. China, following the U.S., Japan, the U.K., West Germany, Venezuela, the U.S.S.R. and the Netherlands, was our eighth largest export market last year. The value of Canada/China trade in 1978 amounted to $0.6 billion.

In 1978, Canadian exports to China totalled a record $503 million - up 36 percent ($134 million) over the level recorded in 1977. While wheat remains the largest individual commodity export to this market, the relative share of wheat as a percent of our total sales to China in 1978 declined to 69 percent (84 percent in 1977). The bulk of our remaining exports consist of industrial materials and semi-finished products. Sales of the latter to China in 1978 were valued at $147 million - an increase of 66 percent ($89 million) over the previous year. Leading items include aluminum ($90.0 million), wood pulp and newsprint ($28.5 million), and sulphur ($8.9 million). Exports of end products (manufactures) were valued at $7.1 million in 1978 - up $6.0 million over the 1977 total and represented about 1.4 percent of our total sales to China (0.3 percent in 1977). Major items are geophysical aircraft including assemblies equipment ($3.1

million, construction machinery (mining trucks) $1.3 million and metal working machinery ($0.6 million).

Imports from China in 1978 amounted to $95 million - up 15 percent or $12.4 million over the same period in 1977, representing the largest level on record. Chinese shipments to Canada are made up essentially of textiles and clothing, agricultural foodstuffs and handicraft goods. Leading individual import items include nuts ($10.3 million), pants and slacks ($10.0 million) and gloves ($6.5 million). Imports of end products (manufactures) from China in 1978 totalled $51.0 million and represented about 54 percent of total Canadian imports from that market. Detailed trade statistics are attached (Annex II).

Although the Chinese have not insisted that balanced bilateral trade is necessary, they have indicated that a decrease in deficit would be desirable. China's trade deficit with Canada increased considerably in 1978 and amounted to $408 million ($287 million in 1977). While we welcome Chinese efforts to increase their exports to Canada, we have indicated to them our hope that this can be done within the framework of arrangements designed to avoid market disruption. Moreover, we have stated we are prepared, on an informal basis, to help them make initial contacts with potential Canadian buyers. The point has been made to the Chinese, however, that commercial decisions in Canada are made by the private sector and it is to Canadian companies that Chinese marketing efforts must be directed.

Trade Development

Canada's trade development policy for China is to maintain our market for wheat while seeking to increase exports of other products, especially manufactured goods. This objective has been pursued through: (a) the Annual Joint Trade Committee meetings (established under the Canada-China Trade Agreement); and (b) an active market development program designed to introduce Chinese trading corporations to Canadian manufacturing and technological capabilities and to familiarize the Canadian businessman with the modalities of trade in China.

In the early years after recognition (1970), Canada launched a number of high profile events in China; e.g., Canadian Solo Fair in Peking (1972) and Canadian Electronics Exhibition in Shanghai (1974) which served to acquaint potential Canadian exporters with opportunities in the Chinese market as well as to make known to the Chinese, in general terms, the capabilities which Canada has to offer. Since that time, we have pursued an active market development program which has concentrated on industry sectors where the Chinese have a significant import requirement and where Canada has a demonstrated export capability. This program has included about 80 missions from Canada to China. This activity has been supplemented by a series of technical seminars given in China by representatives of Canadian firms which have enabled these firms to present an outline of their areas of expertise to Chinese end-users. Major opportunities have been identified for Canadian industry in the Chinese capital goods sector with respect to: agricultural mechanization, resource development (ferrous, non-ferrous, forestry, petroleum) and infrastructure upgrading (power generation, communications, transportation). A number of initiatives by Canadian companies in these fields are currently before the Chinese.

ANNEX I

TABLE A

TOTAL IMPORTS OF SELECTED PACIFIC/ASIAN MARKETS[1]

$ Billions

	1971	1972	1973	1974	1975	1976	1977	1978
Australia	5.2	5.1	7.7	12.4	11.1	12.5	13.6	NA
China	(2.3)	(2.9)	(5.2)	(7.4)	(7.4)	(6.0)	(7.1)	(10.4)[2]
India	2.4	2.2	3.2	5.1	6.2	5.5	6.0	NA
Japan	19.8	23.9	38.4	62.1	57.9	64.9	71.3	NA
Korea	2.4	2.5	4.2	6.9	7.3	8.8	10.8	NA

1 International Financial Statistics, International Monetary Fund, Washington, 1979. C.I.F. values.

2 Estimated.

TABLE B

CANADIAN EXPORTS TO SELECTED PACIFIC/ASIAN MARKETS[1]

$ Millions

	1971	1972	1973	1974	1975	1976	1977	1978
Australia	180	156	214	300	247	364	408	412
China	204	264	288	438	376	196	369	503
India	143	99	156	125	202	153	136	246
Japan	829	959	1,807	2,225	2,129	2,385	2,506	3,051
Korea	23	33	62	71	79	116	144	216

1 Statistics Canada. F.O.B. values.

MAJOR CANADIAN EXPORTS TO CHINA[1]

(\$ Millions)

	1977	1978
Wheat	309.6	347.4
Aluminum pigs, ingots	10.3	90.0
Wood pulp	17.1	17.8
Newsprint	2.3	10.7
Sulphur	8.5	8.9
Copper, refinery shapes	6.1	8.2
Aircraft	–	2.4
Man-made fibres, excluding nylon	4.8	2.2
Lead pigs, blocks	0.3	2.2
Tallow	4.1	2.2
Total Commodities Listed (Percent of Total)	363.1 (98%)	492.0 (98%)
Total Exports (Percentage Change)	369.1	503.4 (+36%)

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1. SC, Trade by Countries, Ottawa.

ANNEX II

CANADIAN TRADE WITH CHINA[1]

($ Millions)

	EXPORTS	(WHEAT/% OF EXPORTS)	IMPORTS	NET TRADE BALANCE
1967	91	(89/98%)	25	+ 66
1968	163	(158/97%)	23	+140
1969	123	(120/98%)	27	+ 96
1970	142	(122/86)%	19	+123
1971	204	(191/94%)	23	+181
1972	261	(234/90%)	48	+213
1973	273	(187/69%)	53	+220
1974	438	(334/76%)	61	+377
1975	376	(307/82%)	56	+320
1976	196	(143/73%)	88	+108
1977	369	(310/84%)	82	+287
1978	503	(347/69%)	95	+408

1. SC, Trade by Countries, Ottawa

MAJOR CANADIAN IMPORTS TO CHINA[1]

($ Millions)

	1977	1978
Nuts	7.8	10.3
Plants and slacks	10.0	10.0
Gloves	5.2	6.5
Shirts including knitted	5.5	4.6
Print cloth, sheeting	1.0	3.8
Corduroys, cotton	2.6	3.2
Towels	4.0	3.1
Sweaters	3.1	3.0
Broad woven fabrics, cotton	3.3	3.0
Polyester - cotton broad woven fabrics	0.7	2.2
Total Commodities Listed (Percent of Total)	43.2 (53%)	49.7 (53%)
Total Imports (Percentage Change)	82.2	94.6 (+15%)

1. SC, Trade by Countries, Ottawa.