UBC 4th Year Mining Engineering
Trip to Brazil
Sponsor Report Package

Canadian Sponsors:

PLACER DOME INC.

UBC

DIAVIK DIAMOND MINING INC.

AMS

Highland Valley Copper

VANCOUVER HARVIES

Brazilian Sponsors:

AngloGold Ashant

CETEM

CBMM

UFMG

Universidade Federal de Minas Gerais

Companhia Vale do Rio Doce

Fosfertil
# Table of Contents

Table of Contents........................................................................................................................................ i  
Trip Overview............................................................................................................................................... ii  
Trip Itinerary................................................................................................................................................ iii  
CVRD Research Centre .............................................................................................................................. 1  
Universidade Federal de Minas Gerais ....................................................................................................... 2  
CBMM Niobium Mine ................................................................................................................................ 3  
Uses and End Users of Niobium................................................................................................................ 9  
Fosfertil’s Tapira Mining Complex ............................................................................................................ 11  
Anglogold Ashanti’s Cuiabá Mine ................................................................................................................ 15  
AngloGold Ashanti’s Morro Velho Gold Processing Plant ........................................................................ 18  
Companhia Vale do Rio Doce .................................................................................................................... 26  
Overview of CVRD Iron Ore Operations .................................................................................................. 28  
Sossego Copper Mine ............................................................................................................................... 34  
Azul Manganese Mine ............................................................................................................................... 39  
Brazilian Mine Food Services.................................................................................................................... 41  
Centro de Tecnologia Mineral (CETEM) .................................................................................................... 44
Trip Overview:

The trip could be summed up in one word: AMAZING. It wouldn’t be an exaggeration to say that for many students it was probably one of the best experiences of their lives. Most of the students had never even been outside of North America, let alone to a country like Brazil.

The students visited two major mining regions during the trip. The first was in the south of the country in the province of Minas Gerais, translated to English this means “General Mines” so as you can expect it is a big mining region and has a history of mining dating back to when Brazil was a Portuguese colony. The trip included a visit to the city of Ouro Preto, a UNESCO world heritage site which was the centre of the Brazilian gold rush in the mid-18th century. The city has some of the most beautiful baroque architecture including numerous churches whose interiors are draped in gold, demonstrating the incredible wealth the city once had.

Modern day mining in Minas Gerais is also booming. The students visited 3 operating mines within the region. The first mine visited, Companhia Brasileira de Metalurgia e Mineração’s (CBMM) niobium mine, supplies over 80% of the world’s niobium metal. Niobium metal is used to produce high strength steels for the automobile and jet engine industries. Incidentally, it is also used in such products as Mach 3 razors. Other mines visited in the region were Fosfertil’s phosphate mine and AngloGold Ashanti’s underground gold mine. The gold mine is located in a very mountainous region and since it was not possible to build the processing plant right next to the mine, a ski lift type tram system was constructed to transport the ore 2km away to where the processing plant was built on flatter terrain.

The second major mining region the students visited is in the Amazon, near the town of Carajas in Para state. This leg of the trip was probably the most interesting. In some areas they visited, the students were the first foreigners the locals had ever seen. The region contains several mines operated by Companhia Vale do Rio Doce (CVRD). The 4th years visited Mina N4, the largest iron ore mine in the world, which produces a total of 60 million tonnes of iron ore per year. Other mines visited were Azul manganese mine and the new Sossego copper project which represents CVRD’s entry into the copper industry and has a 38’ SAG mill, one of the largest in the world.

The students would sincerely like to thank all of the sponsors for their support for this trip. Without your help this great trip would not have been possible. Within this package is a report by each student about a particular topic of interest they learned about on this trip. Thank you all. Sincerely,

Wes Kitura
Brazil Trip Organizer
Trip Itinerary

February 9th:
- AA Flight from Vancouver, 7:06am

February 10th:
- Arrive in Sao Paulo Intl. Airport, 9:56am
- Connecting Bus to Congonhas Airport, 11:30am
- TAM Flight to Belo Horizonte (BH), 4:00pm

February 11th:
- Visit CVRD Research Facility in BH
- Visit University Federal de Minas Gerais (UFMG) – UBC Mining Department Presentation

February 12th:
- Travel to Ouro Preto
- Visit mineral museum

February 13th:
- Travel to BH
- Travel to Araxa 5pm

February 14th:
- Mine Visit (CBMM Niobium Mine)

February 15th:
- Mine Visit (Fosfertil Phosphate Mine)
- Travel Back to BH

February 16th:
- Mine Visit (AngloGold Ashanti Morro Velho Gold Processing Plant)

February 17th:
- Mine Visit (AngloGold Ashanti Cuiaba Underground Gold Mine)
- TAM Flight to Maraba, Para 6:00pm

February 18th:
- Travel to Carajas Delayed due to Bridge Being Washed Out by Heavy Rainfall.

February 19th:
- Travel to Carajas
- Mine Visit (Sossego Copper Mine)

February 20th:
- Day Off
- Visit Carajas Zoo

February 21st:
- Mine Visit (CVRD Azul Manganese Mine)

February 22nd:
- Mine Visit (CVRD Iron Ore Mina N4)
- Travel to Maraba

February 23rd:
- TAM Flight to Rio de Janeiro, 5:00am

February 24th:
- Day off

February 25th:
- Visit CETEM Processing Research Facility
- UBC Mining Department Presentation

February 26th:
- AA Flight from Rio to Vancouver, 7:25pm
CVRD Research Centre
Wes Kitura

Companhia Vale do Rio Doce (CVRD) owns and operates a major mineral processing research centre near the city of Belo Horizonte in Minas Gerais State, Brazil. The centre conducts bench and pilot scale tests on CVRD operating mines and projects that are in their development phase.

One of the recent projects undertaken at the centre has been the testing of the copper leach plant which will be installed at CVRD’s Carajas copper operations and uses Cominco Engineering Services Ltd. (CESL) technology.

The research centre was the first visit on the field trip itinerary and the students were impressed with the degree of technical knowledge and wealth of equipment that the facility demonstrated. The centre had a large process mineralogy laboratory which contained a scanning electron microscope (SEM) and a diffractometer, which uses x-ray diffraction to determine the mineralogical characteristics of an ore. Some of the other equipment the centre had was a carbon-in-pulp pilot scale plant, a carbon-in-column pilot scale plant and a kaolinite research facility. The kaolinite research facility was built to conduct tests on new processes for upgrading the quality of product produced at CVRD’s kaolinite mines.

The CVRD research centre was a surprise for students who did not expect to see this type of facility in a developing country such as Brazil. The visit was a great introduction to the Brazil mining industry, showing the degree of knowledge and technology that it has.
Before our visit to the Universidade Federal De Minas Gerais (UFMG) many of us were wondering how a mining school would compare the UBC Mining Engineering Department. This experience quickly enlightened us on how a great mining engineering school could be run. From an X-ray diffraction laboratory to rock mechanics in the classroom; it was very interesting to notice the styles and methods of teaching in Brazil.

Through our tour of UFMG it was quickly noticed that there are many similarities between UFMG and UBC’s Mining Engineering program. The courses and course load we take for a degree in mining engineering are nearly identical. Similar to UBC, UFMG also has exchange programs to mining schools in the United States and Brazil. As Brazil is on the different side of the hemisphere from Canada, their academic year starts in February and ends in December. I did not notice a Co-op program at UFMG and quickly realized why there wasn’t one. It is apparent that Brazil has industry support that rivals if not surpasses that of Canada, where 100% of their recent graduates are hired out of school, and everyone of the students that I talked to has internship positions in the mining industry.

There are many qualities of the UFMG student experience that I found to be very desirable. First of all, tuition is fully funded by the government of Brazil where students must compete in government exams to be accepted into universities like UFMG. I’m sure that most of us have headaches from thinking about how to pay the ever increasing tuition prices here at UBC. Secondly in Brazil, the politics in mining is much different from that of Canada where there are operating mines located very close to the cities. This allows mining engineering students to work part-time positions in a mine site. This is an invaluable opportunity to apply knowledge gained in the classroom to an actual mining environment after a lecture. It is not uncommon for students to work at a mine site in the morning and go to classes in the afternoon as part of their undergraduate program. Further more UFMG is equipped with state of the art metallurgical equipment including X-ray diffraction and Scanning Electron Microscope. This equipment provides a learning experience, jobs as well as a resource for the mining industry where students conduct lab work for mining companies.

UFMG was a great experience defining the great quality of mining and mining engineers in Brazil.
Overview

Companhia Brasileira de Metalurgia e Mineração’s (CBMM) Niobium (Nb) Mine is based in Araxá, Brazil and is by far the largest Nb producer in the world. It supplies 85% of the global demand and they can nearly double their production in a very short period of time. This mine has been in operation since 1961 and has taken out approximately 15.5 million tons of ore since then. This averages to 800,000 tons/year. Current production is about 2,000,000 tons/year. The mine directly employs 300.

Ownership

CBMM is a privately owned company and has three subsidiary companies around the world to ease logistics. Niobium Products Company GmbH in Dusseldorf, Europe; Reference Metals Company Inc. in Pittsburgh, USA; and CBMM Asia Co. Ltd in Tokyo, Japan all help to create central locations for their worldwide market. Distribution of Niobium products are as follows: 33% North America, 30% Europe, 22% Japan, 7% Brazil, and 8% other.
The niobium ore body is shared with the state-owned CODEMIG. CODEMIG owns 25% of the orebody and mines simultaneously with CBMM. All the state mined ore is sold to CBMM where it is processed. CODEMIG receives 25% of net operational profits from CBMM in return for their product. CBMM has 257 million tons of reserves while CODEMIG has 200 million tons of reserve. The mining rate and estimated mine life for CODEMIG was not available.

**Mine Operations**

CBMM’s orebody is composed of two types of ore. Their “primary” ore is a competent rock starting several hundred meters deep. This ore is unweathered, however they do not anticipate mining this ore for nearly 200 hundred years. The ore they are currently mining is weathered and does not require blasting. This is the mainstay of their current operations and will be able to feed their processing plant for two centuries. The pit slopes are at 32 degrees with 10m bench heights.
Niobium ore is mined with a truck and shovel open pit method. The mine equipment consists of 2 CAT D8’s, 1 CAT D6, 8 Volvo 25T trucks, 4 Volvo L 120C front end loaders and a few other various support vehicles. The pit operates 7 days a week during the day time hours only. The trucks haul their load to a 3.2km long conveyor belt that heads to the processing centre. The average ore grade at this point is between 2.5 and 3% Nb₂O₅. Since no production drilling is done, assays are taken from the conveyor belt stockpiles. The assays are then compared to the extensive exploration drilling being done on the site.

**Mill/Smelter Operations**

The concentration plant has an annual capacity of 84,000 tons/year and can be nearly doubled in just a couple months. The Nb Ore goes through 4 stages in the plant: wet grinding, magnetic-process separation, desliming and flotation. The wet grinding separates pyrochlore crystals from ore. The ore particles at this stage are reduced to less than 104 microns. The magnetic separation then eliminates the magnetite, which has a high phosphorous content. Hundreds of small, 25mm hydrocyclones are then used to remove the -5 micron material. The flotation cells are then used to recover the Nb₂O₅. The flotation product contains approximately 60% of the Niobium Oxide. The underflow is sent to the tailings dam.
The pyrometallurgical plant has been in operation since the beginning of 2000 and has a production limit of 75,000 tons/year of refined concentrate. The refining process uses a pyrometallurgical process which includes palletizing and sintering the floated concentrate followed by reductive melting, which substantially reduces the phosphorus. The slag is then transported to a cooling area where water is used to granulate the concentrate and wash the gases during the sintering phase.

Throughout the process, several different Niobium products are created. Standard Grade Ferroniobium is produced by the process up to this point and makes up the vast majority of CBMM’s products. The annual production is approximately 30,000 tons/year. Vacuum Grade and Nickel Niobium, also known as Masteralloys, are created in the special alloys plant which has a capacity of 1,000 tons/year of both products. Finally, an electron beam furnace is used for the production of pure niobium metal and 1% niobium-zirconium alloy. These are the mine’s most sophisticated products and only 60 tons/year are produced.
CBMM facilities are capable of completing the entire process for niobium. Right down to extracting the ore from the ground to packaging the product for the manufacturers.

Environmental

CBMM plays an active role for all environmental aspects at the mine and the surrounding area. They have been ISO 14001 certified since 1996. In addition to dealing with standard environmental concerns such as tailings and water effluents, they have taken an active role in ensuring that both area plants and animals are also taken care of. An onsite education center is used to help teach nearly 3,000 local students and teachers about the environment and sustainable development every year.

CBMM is implementing a new completely impermeable tailings pond dam that will go into operation this year. The entire pond is lined with high-density polyethylene plastic which is 2.5mm thick and is designed to retain the inert residues create by the metallurgical slag. They recycle 85% of their water through standard water treatment methods.

The mine runs several recycling programs as well including: oil and grease, batteries (common, cell phone, industrial and automotive), cardboard, printing cartridges, tires and even grass clippings and leaves. All of the recycling is done by companies with environmental licenses for their specified products.

The majority of their outsourced services are for a company to perform checks and controls on diesel-powered vehicle exhaust emissions. Additionally, regular inspections are done on supplier’s vehicles to ensure that their vehicle emissions are also kept low.

CBMM runs both a plant and animal nursery on site. The prime objective is to reproduce species that are being threatened with extinction. Additionally, they are taking part in controlled reintroductions of animals to the wild. Some of the species include the Guará wolf (Maned wolf), giant anteater, multiple species of birds and monkeys as well as the Brazilian
ostrich. The animal nursery program started in 1991 and contributed to nearly a dozen publications. The plant nursery currently produces 110 different species and has the capacity to produce nearly 50,000 seedlings/year. Since the beginning of the plant program, nearly half a million trees have been planted on the grounds and in the vicinity of CBMM. In conjunction to their own program, they also supply a local drug rehab that has recovering drug addicts tend a farm. This farm produces nearly 25,000 seedlings native to the region as well as 25,000 eucalyptus seedlings yearly.

Educational Centre (Left) and Guará Wolf (Right)

At this time, CBMM does not have a mine closure program. With 200+ years of operation just with their weathered material, they have placed the closure details as a low priority. They have, however, seemed to understand that whatever they do will be there for a long time but are unsure of what to do at the end of mine life.

Uses and End Users of Niobium
James Hansen

Introduction

Niobium’s importance as an alloy gained significant importance in 1959 when it was developed for strengthening of alloys. First developed by INCO in Suffern, New York, the strengthening mechanism is the result of precipitation of an inter metallic compound (Ni$_3$Nb) in a nickel matrix. Niobium alloys also exhibited a unique ability to avoid strain cracking during fabrication of the final components. This property is very important especially during welding of alloys, where Nb alloys exhibited fewer signs of strain cracking. Another property of niobium is that it has a slower age response and therefore parts can be thermally stress relieved before they crack. This allows the alloys to be applied in the hot section of aircraft gas turbine engines and similar high temperature applications. As an element itself niobium exhibits superconductive properties below a critical temperature. It is also very susceptible to oxidation degradation however.

Uses and End Users

The primary application of niobium is alloy strengthening of high strength low alloy steels that are used in automobiles and high pressure gas transmission pipelines. Carbon is the traditional strength hardening additive however it also lowers the toughness, weld ability and formability of the steal. Micro alloying is an economically viable solution to obtain the strength as well as acceptable secondary properties. Almost 90% of the Nb consumed goes into production of micro alloyed and heat resistant steels.

Flat products such as niobium micro alloyed high strength steel plates are used largely in gas transmission pipelines as its weld ability makes it suitable for construction and the high pressure application. Plates are also used for ships and offshore platforms. Niobium has a very low density so when applied to ship construction the overall weight of the ship is reduced and can therefore carry a greater payload. Civil construction also makes use of niobium strengthened alloy plates in bridge and building applications.

Super alloys are the second largest use of niobium after the steel industry. The most important involving niobium is Inconel 718 a nickel based alloy. Initially used as disk material for aircraft gas turbines, alloy 718 has become a fundamental of commercial and military jet engine manufacturing. Other uses as a superconductor are in applications such as particle accelerators and magnetic resonance imaging scanners.

Niobium based alloys exhibit further engineering properties when alloying niobium in combination with titanium and or vanadium. Applications such as refractory materials for aerospace applications because up to 1300 degrees Celsius the niobium alloy will still maintain excellent strength characteristics.
Minor applications are utilizing niobium as a ceramic. High purity niobium oxide can be applied to ceramic capacitors and lenses. Another area for ceramics is heat and abrasion resistant materials. Further projects look to develop this market for niobium as an engineering material.

**Conclusion**

Niobium is primarily consumed for micro alloyed steels, as well as heat resistant, super alloys and ceramics. Its important characteristics include high strengthening as an alloy additive, creep strength, high thermal strength and abrasion resistance. In some forms it suffers from being susceptible to oxidation however it is amenable to oxidation prevention coatings. Niobium demand will further increase as further advances in understanding its application as an engineering material increases. Most of the world’s niobium is produced in Brazil at the Araxa CBMM operation; however Canada also has a niobium mine that is currently in production.

**Bibliography**

“Usos E Usuarios Finais de Niobio” by Companhia Brasileira de Metalugia e Mineracao. 1999
Company Overview

Fosfertil is a major producer of high analysis phosphatic fertilizers for Latin America. They supply 34.6% of Nitrate solutions and 36.7% of Phosphate products to the Brazilian market. Fosfertil owns and operates several industrial complexes throughout Brazil. This allows them to take their product from the ground and see it through the entire refining process. The retail products at the end of the process include nitric and sulphuric acid, ammonia, phosphate fertilizers as well as other phosphate and nitrate solutions. The majority of the revenue from these products comes from the fertilizers (80%) with chemicals taking most of the rest (18%) and services the remainder (2%). Gross sales in 2003 were $691 million US. Fosfertil’s ownership structure is complex. While Fertifos owns the majority of the shares (56.21%), Bunger and Fertibrás has majority stakes in Fertifos while also having their own share of Fosfertil. See below for the ownership structure.
Mine Overview

The Tapira Mining Complex (CMT) is located in the state of Minas Gerais near the city of Araxá. It began production in 1978 under the control of CVRD, the 3rd largest mining company in the world. In 1992, privatization of Fosfertil came about under the Federal Program of Denationalization. The complex covers nearly 80 million m² and mines 14.1 millions tonnes per year of phosphate ore. They also mine 27.9 million tonnes per year of waste and titanium ore. The titanium ore is stockpiled separately as part of an agreement with CVRD. CMT produces 1.74 million tonnes per year of standard concentrate and 93,000 tonnes per year of ultrafine concentrate. The total reserves are about 780 million tons which gives a mine life of over 40 years. The average grade of the ore is 6.89% P₂O₅.

Mining

The following figure shows a typical slice of the geology and how the ore and waste are laid out. From the information given, we see that a typical bench height is 13m while the average layer thicknesses range from 30m to 70m. To mine this open pit, CMT uses 13 – 120 ton trucks and 7 – 170 ton trucks. They mine 350 and 600 tons per hour each respectively. To load the trucks, CMT uses several shovels: Four Marion 151M, which have 12 and 8 yd³ buckets, one Bucyrus 195B, which has a 13 yd³ bucket, two P&H 1900 AL, which has an 18 yd³ bucket and one Le Tourneau L1100HL, which has a charge capacity of 23 yd³. CMT’s productivity makes it the 5th largest open pit in Brazil.
As seen on the following page, CMT has greatly increased their productivity since the mine started, especially in the previous few years.
Processing

CMT’s process is a fairly typical one. Ore first goes through primary, secondary and tertiary crushing and is then sized to separate friable and granulated ore. Both go through grinding, magnetic separation, desliming and flotation. 4% of the granulated ore is magnetite while the friable ore has 10%. In the desliming phase, the granulated ore loses another 4% due to slimes while the friable ore loses 16%. The slimes from the friable line become an ultrafine concentrate and are shipped, via lorry transport, to the chemical complex Uberaba. The flotation phase sees 14% of the granulated ore and 37% of the friable ore going to tailings. The two concentrates are then mixed, regrindend and sent via pipeline to Uberaba.

The diagram on the next page gives a simplified version of the overall process. This process starts from the mined rock and how it eventually becomes a retail product such as Triple Superphosphate (TSP) and Ammonium Nitrate. This is done using both the mine, mill and chemical complexes owned and operated by Fosfertil.

Mine Closure

The mine closure plan has not been looked at in detail since their mine life is 40+ years. There is still more available as well that they haven’t looked into either. Other environmental data was not available at the time of this writing.
Anglogold Ashanti’s Cuiabá Mine
Nick Kwong

Overview

Anglogold Ashanti is a global gold producer with 22 operations on four different continents. In 2004 they produced a total of 6 million ounces at a cost of $268 per ounce. The site we visited was Anglogold Ashanti’s Cuiabá Mine. It is a 2400 tons per day underground mine 1050 meters deep. They are Brazil’s leading producer in Gold producing over 200,000 ounces in 2004. The mine site is in Brazil’s southern Minas Gerais State.

Mining Process

The company utilizes a hydraulic cut and fill mining method averaging seven to eight grams per ton. There are areas of the mine where gold grades as high as 50 grams per ton have been mined. At a current depth of 1050 meters, there are good rock conditions for the first 9 levels which have a spacing of 66 meters. Beyond that, the rock conditions are significantly lower where the level to level spacing is reduced to 22 meters. They are currently using swellex and cable bolts (9.6m long) with mesh using 1.5 X 1.5 m spacing in their permanent openings. In the upper levels with 66 meters level spacing the rock conditions are so good that they are able to open 12 m wide openings. Furthermore they go through 1 drill bit per hole for...
blasting. This is a clear indication of the rock mass in the Cuiabá Mine. As the rock conditions degrade with depth, further support is necessary. The increased presence of fractures and discontinuities in these depths require the addition of shotcrete. The mine’s equipment is state of the art similar to those found in an underground mine in Canada. Everything is mechanized and their operation methods are very safe.

Figure 2: Typical gold ore and ground support found in the Cuiabá Mine

Due to strict environmental regulations they do not have permission to further develop the surrounding area and have no room for a processing plant or waste dump. Therefore the ore is transported to a processing plant 15 km away through an aerial ropeway that is similar to a chair lift on a ski resort. Furthermore to operate a hydraulic cut and fill method, the hydraulic fill is actually waste from a CVRD mine which is free minus the transportation costs. Most surprising was the underground garden found in the maintenance area. They are experimenting with the growth of plants in an underground environment. Furthermore they are very conscious of the environment where they have started reclamation of the environment. Much of the surrounding environment on the surface was an old open pit mine. It was pleasing to see that the reclamation was obviously successful due to the minute foot print left behind from the mine.
Anglogold Ashanti’s Cuiabá Mine is another example of an excellent mining company that is environmentally responsible, has high safety standards and makes money at the same time.
AngloGold Ashanti's Morro Velho Gold Processing Plant
Andrew Lyon

Introduction

Morro Velho is located close to the town of Nova Lima which grew up rapidly around the mighty gold mine which was for many years the deepest in the world. Now the mine and the mill are separated by many kilometers, and the ore is carried to the mill by converted chairlifts. The mill is a standard mill, with milling in ball mills, gravity concentration and flotation. The ore needs to be roasted, and then sent through a standard cyanidation plant, with leaching, and carbon adsorption. Then the gold is recovered by Merrill Crowe method, and smelted.

Company History

The mine was originally formed in 1834 by the St. John Del Rey Mining Company, which encouraged families and miners to live around the mine, most of the miners coming from Britain. This caused the city of Morro Velho to grow up around the mine. Then in 1960, a Brazilian banking group took over the gold assets of the mine, and the iron ore assets were taken by a local mining group in the region.

By 1975, Anglo American group acquired MMV (Mineração Morro Velho) and took over operation. This lasted until the assets were sold to AngloGold in 1999, and then finally in 2004 AngloGold Ashanti was formed, who are now the principle operators.
Location

The mill is situated in a low valley close to the town of Nova Lima in the tropical highland state of Minas Gerais Brazil, about 20 kilometers from the modern city of Belo Horizonte.
Company

Since the formation of AngloGold Ashanti, the company sets their missions and goals out very specifically for the world to see. Their mission is “AngloGold’s business is gold” and they believe in creating value for everyone with a stake in the company by finding and mining gold and by developing a market for their product.

Values

The company also believes strongly in their values and safety. They try to create competitive shareholder returns and conduct their affairs with honesty and integrity. The company gives their employees the opportunity to develop their skills, and to share risks and rewards in the workplace, which they believe will promote innovation, teamwork and freedom with accountability.

The company gives scholarships to employees, and have many programs in place to help the community and the company. For instance, all the wives of the company can get involved with a program called “golden wives” where they raise awareness in the community about gold mining. Their social responsibility program includes things like giving support to local sports teams, building the Harry Oppenheimer Environmental education center, and donating money to several institutions around the area.

Safety

The company has a strong safety program in place also. They work hard at the Australian NOSA program and worked hard towards gaining five star level, which is the top level. By doing this, they have lowered their lost time incidents, and greatly improved their safety records.
Metallurgical Plant

The Metallurgical plant at Ashanti was built in 1983, and startup began in 1985. It was designed for 1500tpd, but has been upgraded to be able to handle 2400tpd in 2004. The entire processing site holds about 268 employees in total.

Process
The process plant processes the refractory gold ore which is mined at the underground mine. The process is milling, gravity concentration, flotation, roasting, cyanide leaching, carbon in pulp and zinc precipitation.

Below is a picture of the entire plant site.

Aerial Ropeway
The mine is situated so far away from the mill, in an urban setting, that it would be better not to have to haul the ore from the mine to the mill. At Ashanti a novel approach has been used,
where carts on a ski lift type mechanism are used to haul ore to the mill. The whole length traverses only over jungle and up and down some pretty steep hills. The method works very smoothly, with only the cable being exchanged every few months.
**Mineralogy**

The typical mineralogy of the refractory gold ore is as follows. The ore has 7.5g/t gold, 10% pyrite, 2.5% pyrrotite, 1% arsenopyrite, 40% Silica, 6% carbonate, 6.5% sulfur and about 33% other minerals.

**Flowsheet**

Process flowsheet for Ashanti
**Process Description**

Two ball mills are used in the milling circuit, with an old type of gravity recovery system of triangles, which are fed by the cyclone underflow. These triangles are long triangular boxes, which have horizontal groves that run the length of the box on the two sides. The slurry is fed at the top of the triangle, and as the slurry passes down the side of the triangle, the heavier gold particles fall into the groves, whereas the gangue keep flowing. The gravity recovered gold is sent straight to smelting, after getting cleaned up by shaking tables.

The mill plans on replacing these triangle gold recovery systems with Knelson’s in a future upgrade, because Knelson’s use much less water than their current system does. Both perform the same, but the water consumption is a big problem for them.

The milled material is then floated by regular sulphide flotation. That material is then sent to roasting after filtration. The roasters have very specific feed requirements, so filtration is monitored closely. The roaster then allows the refractory gold to be leached later on in the circuit. In recent years, an acid plant was built where they are able to produce sulfuric acid, which greatly reduces the cost of the gold roasting.

The cyanide leaching is a normal circuit of adding cyanide to the slurry, leaching for 24h per tank, and they used 6 tanks. Then the slurry moved onto carbon adsorption, where carbon is mixed into the slurry, and the carbon adsorbs all the gold which the cyanide took into solution. The carbon is then stripped of the gold using acid and an elution is formed. Zinc is then added to this elution for the “Merrill Crowe” zinc precipitation recovery of the gold out of the elution. Then the gold is also sent to smelting.

In 2004, Ashanti’s gold production was around 6639 kg for the year. They also produced about 131 kilo tonnes of sulfuric acid. Their metallurgical recovery was around 93%.

**Environmental**

Since the metallurgical plant is very close to cities, the company has to pay close attention to what it discharges into the environment. The company takes about 2700 samples per month, and has forty piezometers installed in the surrounding area. They have an audit committee that performs both internal and external audits of the company’s environmental policies and results.

Around the tailings dam, pH, conductivity, Arsenic, Cyanide and other base metals are monitored closely. On line SO2 monitoring equipment is used at the acid plant and an additional five monitoring stations are surrounding the plant.

In order to manage all this environmental testing information, software is used that helps control all this information for the mine. It is able to record the values from the monitoring equipment, and data can also be entered. This allows the company to perform on-line emission control for many of the pollutants being tested.
Tailings pond

References

http://www.anglogold.com
http://www.projects.ex.ac.uk/cornishlatin/morrovelho.htm
Anglo Gold Power Point Presentation (AngloGold fev2005)
UBC Mining Brazil Field Trip
Companhia Vale do Rio Doce
Ehsan Dana

Companhia Vale do Rio Doce (CVRD), NYSE: RIO and RIOPR, was created by the Brazilian Federal Government on June 1st, 1942 and privatized on May 7th, 1997, when the Consórcio Brasil (Brazil Consortium), led by the National Steel Company - CSN, won a bid held at the Rio de Janeiro Stock Exchange, acquiring 41.73% of the Federal Government’s common stock for US$ 3.338 billion. Throughout its history, CVRD’s activities, once restricted to the Southeast, were expanded to the Northeast, Central-West, and North of Brazil, diversifying its mineral product portfolio and consolidating logistics services.

CVRD is the largest diversified mining company in the Americas and the fifth largest company in the global mining and metal industry, with a market capitalization of approximately US $20 billion. Present in 13 Brazilian states and in four continents, it is supported by more than 9,000 kilometres of a rail network and eight port terminals. CVRD currently has operations in the following 13 states: Pará, Maranhão, Tocantins, Sergipe, Bahia, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Goiás, Mato Grosso do Sul, Rio Grande do Sul and Santa Catarina. Abroad, it has controlled and affiliated companies in the United States, Argentina, Chile, Peru, France, Norway and Bahrain, and offices in New York, Brussels, Tokyo and Shanghai.

CVRD possesses vast mineral resources, with large reserves of iron ore, bauxite, copper/gold, kaolin, manganese, nickel, potassium and 11% of the estimated world reserves of bauxite and mineral rights over an area equivalent to 2.5 times the size of Belgium. In addition it is the largest logistics company in Brazil where it owns and operates various railways and ports.

Having a 33% share of the trans-oceanic market, CVRD is the largest producer and exporter of iron ore in the world, the second largest world producer of manganese and iron alloys and one of the largest integrated producers of aluminium (bauxite, alumina and primary aluminium) with the lowest costs in the world. It also produces a large quantity of kaolin, used for coating paper, and potassium, a raw material for the fertilizer industry.

Currently, CVRD conducts prospecting and research activities in many Brazilian states and other countries of Latin American, Asia, and Africa. The purpose behind developing this widespread mineral prospecting program is to seek out high-quality business opportunities in-line with CVRD’s growth strategy, and provide new mineral reserves for the future. Geological and technological research are of strategic importance in CVRD’s operations in the mineral sector, and its target is to be one of the three largest diversified mining companies in the world by 2010. Responsible for the largest geological research company ever carried out in Brazil, the Company is also present in countries such as Mongolia, Mozambique, Argentina, Cuba, Venezuela, Peru, Chile, Bolivia, Gabon, Angola and China.
The amount assigned to new projects as well as to amplify the existing enterprises’ capacity in 2005 is US$3.332 billion. Major efforts include the expansion of the iron ore, bauxite, alumina and potassium production capacity; conclusion of the Sossego Copper Project; initial development of the 118 Project; electric power generation; and the acquisition of locomotives and train cars for transporting iron ore and cargos in general.

For further information on CVRD or for contacts in the company and the Brazilian mining industry, please feel free to contact me at ehsan.dana@gmail.com
Overview of CVRD Iron Ore Operations
Blair Woodhurst

Brazilian Production of Iron Ore

Brazil, the most prolific producer of iron ore, is endowed with some of the largest and most rich iron ore reserves in the world (see Table 1).

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>RESERVE BASE*</th>
<th>PRODUCTION*</th>
<th>EXPORTS*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mt</td>
<td>%</td>
<td>Rank</td>
</tr>
<tr>
<td>Brazil</td>
<td>11 000</td>
<td>6.9</td>
<td>5</td>
</tr>
<tr>
<td>Australia</td>
<td>25 000</td>
<td>15.6</td>
<td>2</td>
</tr>
<tr>
<td>CIS</td>
<td>63 000</td>
<td>39.4</td>
<td>1</td>
</tr>
<tr>
<td>China</td>
<td>15 000</td>
<td>9.4</td>
<td>3</td>
</tr>
<tr>
<td>India</td>
<td>4 000</td>
<td>2.5</td>
<td>7</td>
</tr>
<tr>
<td>USA</td>
<td>14 000</td>
<td>8.8</td>
<td>4</td>
</tr>
<tr>
<td>Canada</td>
<td>2 500</td>
<td>1.6</td>
<td>8</td>
</tr>
<tr>
<td>South Africa*</td>
<td>1 500</td>
<td>0.9</td>
<td>9</td>
</tr>
<tr>
<td>Sweden</td>
<td>5 000</td>
<td>3.1</td>
<td>6</td>
</tr>
<tr>
<td>Venezuela</td>
<td>1 500</td>
<td>0.9</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>17 500</td>
<td>10.9</td>
<td>10</td>
</tr>
<tr>
<td>TOTAL</td>
<td>160 000</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Sources: * USGS, Mineral Commodity Summaries, January 2001 (for Reserve Base in iron units)
+ UNCTAD, Trust Fund on Iron Ore, 2001 (in equivalent gross ore mass)
* Minerals Bureau (except for Reserve Base)

Notes: China produced 212 Mt of low-grade ore which has been converted to an equivalent average World iron content by UNCTAD

CVRD

CVRD is the largest iron ore company in Brazil and the largest iron ore exporter in the world. Furthermore the company’s’ annual production and sales have been growing steadily.

CONSOLIDATED SALES – IRON ORE AND PELLETS (In millions of tons)
Production

CVRD produces and delivers its iron products through two systems, namely North and South, each consisting of a mine, a railway, a pelletizing system, and a maritime terminal.

Mining

The iron deposits that compose the North and South systems are arranged in a vaguely quadrilateral shape.
North System

The first geological researches began in 1967 and by 1978 work had begun concerning the implantation of the Carajás Project.

This system is constituted by the Mining Complex of Serra dos Carajás, transport of the iron ore through the Estrada de Ferro Carajás - Railroad of Carajás and the Maritime Terminal of Ponta da Madeira (TMPM).

The Mining Complex of Serra dos Carajás has reserves (in 12.31.02) of close to 1.5 billion tons of iron ore and is located in the State of Pará, between the cities of São Félix do Xingu and Marabá and between the rivers Tocantins and Xingu. The individual components of this complex are the operating areas are called N4E, N4W-N, N5W and N5E.

Mining began in 1981, seeing the first iron ore transported by train in 1985, and then in 1986, the first iron ore was shipped at the TMPM. The startup sales from the North System total in that year 13.5 million tons of iron ore.

The mine utilizes the conventional open pit extraction methods of drilling, blasting, loading and hauling.
South System

Four mining complexes collectively form the South System: Itabira, Mariana, Minas Centrais and Minas do Oeste. These complexes together comprise more than 15 pits.

The oldest complex of the South Systems is Itabira, that includes the mines of Cauê and Conceição, its operations began in the beginning of 1942. With the acquisition of Ferteco in 2001 and its recent incorporation in the Companhia Vale do Rio Doce (CVRD), the South System began to operate the third productive system of CVRD: the one encompassing the mines of Fábrica and Córrego do Feijão.

Processing

Mined material is crushed and size classified, the final product designation is based upon this classification. Lump refers to material, the majority of which is over 4.75mm, fines then being that material less then 4.75mm. Pellets are the third product produced, made of very fine iron ore and a binder such as clay. The iron and clay are mix and rolled into balls and then passed through a furnace to form hard balls.

Although fines and lump ores cost about the same to produce, fines fetch lower prices than lump because they must be sintered by the steel mill before they can be charged to the blast furnace. This is done to improve permeability of the furnace burden and to prevent loss of fines up the stack. Pellets can be charged directly into the blast furnace as can lump ore, but the latter can decrepitate in the furnace, thereby lowering its value to the steel mill operator. Pellets are usually the most desirable form of iron ore because they contribute the most to the productivity of the blast furnace. Lump ore is the next most desirable ore in terms of blast furnace productivity. The least desirable form is fines, which must be agglomerated (sintered), usually by the steelmaker, before being charged to the blast furnace.

CVRD’s production and product break down has been:
Pelletizing Capacity

In order to make the utilization of the ore fines generated from the exploration of the mines in the South System economic, CVRD began late in the 60’s, to install a complex of pelletizing plants in Vitória (Espírito Santo). The pelletizing facility currently consisting of seven pelletizing plants, with a total production capacity of 25 million ton of pellets per year.

Two plants belong exclusively to CVRD and the others were implemented as joint ventures, with steel groups from Japan, Spain, Italy and South Korea.

In August of 2002, the operation of a new plant was started, with a production capacity of 6 million tons of pellets/year, built in the area of the Maritime Terminal of Ponta da Madeira (TMPM) in São Luis do Maranhão.

Furthermore as of the incorporation of Ferteco Mining S.A at the end of the month of August 2003, CVRD started to operate one more plant located in Minas Gerais, with a production capacity of 4.5 million tons of pellets/year.

Relevant Information

![Annual Brazilian Iron Ore Pellet Price (U.S. dollars per metric ton contained iron)](chart.png)
Annual Brazilian Iron Ore Fines Price
(U.S. dollars per metric ton contained iron)

Source: TEX Report Co. Ltd., Iron ore manual, [various years].
Introduction

During the beginning of the 1990s, a Companhia Vale do Rio Doce (CVRD) exploration team conducted geological mapping in the Carajas mineral province of Para state in northern Brazil. The team was searching for gold, but instead identified more than one hundred magnetic anomalies revealing the existence of chalcolpyrite (copper) mineralization in the area. Subsequent exploration campaigns confirmed the existence of major copper deposits. Today, there are 5 major copper ore deposits in the Carajas area which CVRD plans to bring into production by 2010. There names are Sossego, Salobo, Area 118, Alemao and Cristalino (see FIGURE 1). The first CVRD copper mine to come into production so far is the Sossego mine. This report will focus on the Sossego mine.
Geology

The Sossego mine deposit is located in the Carajas Mineral Belt, which is typified by granitic magmatism. This belt is part of a much larger, intracratonic magmatic province that extends over much of the Amazonian Craton. The mine contains two distinct areas of copper-gold mineralization identified as Sequeirinho and Sossego Hill. Both outcrop as a series of copper-oxide bearing hills along a strike length of 3 km. The upper layer of weathered oxide material is approximately 25m in depth below which is the sulphide primary ore mineralization. Sulphide copper mineralization is in the form of chalcopyrite. The resource totals 600Mt and contains mineable reserves of 190 Mt with an average ore grade of 1.00% copper and 0.29g/t gold.
Mining

Production at Sossego mine began in the Sequeirinho pit in June 2004. The open-pit truck and shovel, drilling and blasting mining method employed, uses 3 shovels; two 3601 P&H 40 ton bucket shovels and a P&H 4100 80 ton bucket shovel. Incidentally, the P&H 4100 is presently the largest shovel in the world. These shovels load 11 caterpillar 793C 240 ton haul trucks, which haul an average of 38,000 tons per day of ore and an average of 150,000 tons of waste (4:1 stripping ratio). Ore is crushed in a gyratory crusher near the pit and is then conveyed 4km to the Sossego beneficiation plant. The overlying weathered oxide material which contains economical amounts of copper is stockpiled for future processing (discussed later). The Sequeirinho pit will reach roughly 1,000 meters in width and 2,800 meters in length with a depth of 450 meters. The smaller future Sossego pit will be roughly 800 meters by 800 meters in diameter and up to 350 meters in depth. The mine life of the Sossego copper mine is 17 years.

Processing

Grinding

Primary grinding at Sossego is conducted with a 38’ semi-autogenous grinding (SAG) mill. This SAG mill is the 2nd largest in the world and is gearless driven by a 20MW motor. The SAG discharge passes over a vibrating screen with oversize being recirculated to be crushed by two MP800 cone crushers and fed back into the SAG mill. The undersize from the screen is mixed with water, split and fed to two parallel reverse ball mill circuits. The ball mills measure 23’ x 18’ and the cyclopacs consist of 33” cyclones.

Flotation

Flotation is conducted in 2 parallel banks of 160m³ Outokumpu tank cells. Each bank consists of 7 cells in series. Sossego uses both Amyl Xanthate and Esther
Xanthates as collectors and Methyl Isobutyl Carbinol and Glycol Propylene as frothers. The rougher concentrate, grading approximately 21% copper, is then pumped to 4” regrind cyclones. The overflow from these cyclones is pumped to 6 column cleaner cells, while the underflow is pumped to two vertimills to be reground and fed to a bank of 6 160m³ Outokumpu tank scavenger cells. The tailings from the column cleaner cells are also fed to the bank of scavenger cells. Tailings from both the rougher and scavenger circuits are discharged into a 4.2km tailings dam. The column concentrate is thickened and filtered to produce a final product.

**Production Numbers:**

- Cu Recovery: 92-96%
- Cu Concentrate Grade: 30%
- Au Grade in Concentrate: 6.5g/t
- Cu Concentrate Production: 140,000t/yr
- Cu Production: 42,000t/yr
- Au Production within Concentrate: 910kg/yr

**Weathered Oxide Material:**

The stockpiled upper layer of copper mineralized oxide material from the Sossego mine will later be processed by a beneficiation plant at the future CVRD Area 118 mine located approximately 30km away from the Sossego mine. The Area 118 mine, in its permitting stage and scheduled to begin production in 2006, contains a 75m layer of oxidized copper mineralization. A copper leach plant will use Cominco Engineering Services Ltd. (CESL) technology to process both the Area 118 and Sossego oxidized ores, producing an estimated 45,000 tons of copper per year for 13 years. Sulphide copper mineralization below the Area 118 oxidized material will be transported to the Sossego beneficiation plant for processing.

**Concentrate Shipments:**

Concentrate product from the Sossego mine is trucked 130km north to the city of Parauapebas where it is loaded onto rail cars and transported 892km to the CVRD owned Ponta da Madeira port located in Sao Luis, Maranhao state. Concentrate is then shipped to overseas markets.

**Social Issues:**

The town site of Canaa dos Carajas (pop. 16,000) is the nearest community to the Sossego mine. It is located approximately 40km away and was founded by the Brazilian government in the early 1980’s to encourage farming and ranching in the area. CVRD has invested significantly in the town’s infrastructure, building a 130km paved road to Parauapebas and a 20km sewage system. Drinkable water is now available in the city. A school, hospital and day care centre were also built. More than 70% of the nearly 500 employees of the Sossego project are originally from Canaa dos Carajas and its neighboring municipalities.
**Environmental Issues:**

The Sossego mine is located within the Amazon rainforest and much of this forest in the surrounding Carajas region has been cut down for use as cattle ranching land. On either side of the road from Canaa dos Carajas to Parauapebas and on to the regional centre of Maraba (a distance of approximately 300km), it is impossible to see the Amazon rainforest. All of this region would have been rainforest 30 years ago. In an effort to protect 411,950 ha of remaining forest in the area, CVRD worked with the Brazilian government to set up the Carajas National Forest in 1998. CVRD is the leading private supporter of Brazil's Environmental Protection Agency (IBAMA) which is responsible for surveillance and protection activities in the Carajas National Forest. The company is permitted responsible usage rights for mineral exploitation in certain areas of the forest, but they are not immune from the authority of IBAMA. In May 2004, IBAMA verified, that a great quantity of Sossego tailings had been dumped in the area of the Carajas National Forest. CVRD was fined R$ two million (US$ 700,000). The company originally contested the charge, but later recognized its error and decided not to appeal against the IBAMA decision.

**Brazil’s Copper Mining Future:**

As CVRD brings on stream its other 4 copper projects, the company plans to produce 650,000 tons/year of copper by the end of this decade. This will bring Brazil from a net importer of copper to one of the largest net exporters of copper in the world. This is part of CVRD’s strategy of diversifying into additional mineral markets besides its core business of iron ore. With copper prices at the highest they’ve been in years, CVRD is in an advantageous position.
Azul Manganese Mine
Marcello M. Veiga

Introduction

The Azul manganese ore body was discovered in September 1971, about 30 km W of Carajas village. The indicated reserves account for 65 million tonnes of manganese ore: 53.7 million tonness of metallurgical ore and 11.4 million tonnes of manganese dioxide (ICEE, 1998). Proved reserves are 12 Million tonnes of metallurgical grade ore (for ferroalloys), and around 6 Million tonnes of manganese dioxide (γ-nsutite) for electrolytic batteries. Due to high purity and electrolytic activity, the manganese dioxide, with almost 75% Mn, also finds application as brick and tile colorant, as pigment and dryer in paint, in fertilizers and animal food, as well as in chemical industries. The Azul manganese deposit displays unusual ore mineralogy, dominated by nsutite, cryptomelane lithiophorite and todorokite, rather than by the usual pyrolusite (ICAM, 2004). The metallurgical ore grade has typically 46.4% Mn

Mining/Processing

The manganese ore at Azul is mined in open pits, as overburden and the ore itself are soft enough to be scraped and loaded directly. About 4 million tonnes of material is mined annually in which around 2.5 million is Mn product. The ore is mined with front loaders and transported for 3 km by truck to the processing plant. The ore is then crushed and screened to provide 4 products:
Coarse Lump: +75 mm
Lump: -75 +25 mm
Medium lump: -25 + 9 mm
Sinter feed: -9 +0.5mm

The production started in 1985 and in 2004 reached 2.3 Million tonnes. CVRD expects to increase the total Manganese ore production in 2005 to 2.5 Million tonnes in which 90% is Mn ore of metallurgical grade and 10% Mn dioxide.

The material finer than 0.15 mm is discarded into the tailing dam and 80% of the water is recycled. The tailings contain material with 35 to 50% Mn and there are about 9 million tonnes of this material in the dam. CVRD is thinking to float the Mn minerals from the tailings. The overall processing recovery ranges from 63 to 65%.

All the ore is transported (30-tonne trucks) to the loading facility, 34 km away, and then by the single track rail to the port of São Luís (ICAM, 2004)

Price

The Mn dioxide (nsutite) has a price of US$ 1000/tonne and CVRD controls 35-40% of the world market. The metallurgical ore consists of cryptomelane with 43 to 49% Mn, 0.09 – 0.1% P and most of the products are exported to Norway, France and China. This latter receives 70% of the Mn ore exports from CVRD. In Norway, CVRD counts with its subsidiary, Rio Doce Manganese Norway (RDMN), acquired in February 2003 to produce about 21,00 tonnes/a of manganese ferro-alloys (Surfwax, 2005).

Reference


Brazilian Mine Food Services
Ian McKechnie

Introduction

Mines across the world require a number of services to ensure both their successful operation and the welfare of the workers within. Many services are often of a fixed or inflexible nature, such as the cost of electricity or fuel, and are typically considered beyond the control of the mine. Others may require extensive capital expenditures to improve camp facilities or provide additional subsidies or incentives. However, one service that Brazilian mines seem to uniformly excel in involves food delivery improvements implemented at a minimal cost.

Situation and Comparisons

Brazilian food services share both a number of similarities and significant differences when compared to their Canadian counterparts. In particular, Brazil tends to avoid the remote mining methods that have become more prevalent in many mines in Canada. This trait reduces stresses on food service providers, as many employees will only require two meals due to taking the remaining meal with their families. Nearly all mines share this advantage, as social time at the home is required by Brazilian laws limiting the number of consecutive work hours to eight in a shift. Close proximity to cities will also typically reduce costs of food delivery while expanding the potential meal selections.

As a drawback, Brazilian mine sites typically host larger workforces than Canadian mines and are faced with the difficulties inherent in serving hundreds of employees during restricted meal periods. Many serverys have adapted to this by using company ID cards to regulate admission through a turnstile system. Depending on the site, companies either tracked when employees preferred to dine and adapted accordingly, or ensured that various groups were eating at scheduled periods.

Food selection and variety tended to be much more limited at Brazilian mines when compared to Canadian versions. An example of both menus is shown below.

Canadian

Baked Ham  Roast Beef Stir-fry
Battered Cod  Caesar/Garden Salad
Corn on the Cob  Mashed Potatoes
Fries  Green Beans
Pop / Fruit Juices / Milk  Pastries / Ice Cream
Soup of the Day
Nutritional Information

The first of these improvements involves simple labels that are placed above each meal item, listing information about the food. Often this would include the name of the food, recommended serving size, calories per serving, and grams of fat per serving. These cards were prominently displayed on sneeze-shields or directly in front of the food and provided immediate health related information in an easily understandable fashion. Nearly all mines had labels on every item served, including the various juices.

The beneficial effects of these labels were immediately visible when they were placed on similar foods stationed next to each other. For example, some students when faced with a decision between roast beef and chicken opted for the chicken which was lower in both calories and fat for the same serving size. It is particular interest to note that this happened in spite of their typical preference towards roast beef.

Implementing this system at Canadian mines would involve minimal costs, largely involving researching and laminating cards to label the meal offerings. Some work would also be required on the food service provider’s part to place the cards before each meal. However, for this simple investment, mines can make significant strides towards encouraging employees to eat healthier and provide extra information for those already watching what they eat.

Service Improvements

Perhaps the most impressive features of Brazilian food services are those that would take the least effort to implement in Canada, yet provide real and meaningful benefits to worker health. All of the topics listed below should require minimal, if any, financial commitments, and have the potential to further improve worker health, satisfaction, and processing times.

Feedback Collection

Many Brazilian mines also adopted a novel method of collecting feedback on the quality and selection of meals. The staple of a “feedback” box in a mine cafeteria is familiar to any camp employee, but is rarely used except in extreme circumstances. Brazilian providers have instead opted for an electronic box with five numbered switches on the front, placed close to
the dish depository. As a diner passes by, they are presented with a scale from 1 to 5, accessible through the switches to rate their meal. Pushing a switch causes it to light up, and for the feedback to be recorded digitally for later retrieval by the service provider. The system was admirably simple, and participation was extremely high, with nearly every worker passing by taking the two seconds required for their opinions to be heard.

This system was further enhanced at select mines by a small two-line LCD screen that listed a specific dish of the meal. The feedback given, instead of applying to the whole meal, applied only to the dish displayed. This simple change allows the provider to refine their menu after having collected broader opinions on the overall quality of service. Some mines also had a small information whiteboard above the box which was updated to display the results of the previous day’s poll, letting workers know how their opinions stood compared to the remainder of the mine.

While not an improvement that will impact the physical health of mining employees in Canada, it is a system that can benefit both caterer and worker by accurately and continuously sampling diner’s opinions.

**Waste Separation and Worker Pre-Cleaning**

The final recurring improvement seen at Brazilian dining facilities involves the waste collection and cleaning stages after diners have finished eating. Instead of placing trays directly on carts, diners are encouraged through means of chutes and garbage containers to separate cutlery and trash before depositing the tray for processing by servery staff. The division of these simple tasks among the diners can provide significant relief to the washing/cleaning stage of a meal for a small time investment per diner.

**Conclusion**

As Canadian mines move forward, one of the paramount concerns will always be the welfare of the employees. In an age where companies strive to encourage workers to remain healthy and fit, so as to better perform their duties, it is important to give effective tools to assist in healthy eating. Food services can also be further improved by providing simple methods for feedback from the diners that is both timely and responded to. Hopefully some of these Brazilian methods can be easily integrated into Canadian mining culture, and a better work environment will result.
Introduction

Rio de Janeiro’s Centro de Tecnologia Mineral (CETEM) (Center of Mineral Technology) is a Brazilian Government research institute connected to the Ministry of Science and Technology. The centre was created in 1978 on the campus of the Federal University of Rio De Janeiro. The facility has numerous laboratories and pilot plants which are used by its 125 professors and students to forward the centre’s research goals. Funded fifty percent by the Brazilian Federal Government, the centre is currently working on a wide range of projects, ranging from innovative mineral processing techniques, to environmental technologies and financing programs for small scale and artisanal miners. The 4th year class of the University of British Columbia’s Mining Engineering Department visited CETEM as the final stop on its field trip to Brazil in February of 2005.

Description

Located on the campus of the Federal University of Rio De Janeiro, CETEM is both a school and one of South America’s premiere mineral research institutes. With 60,000 square meters of floor space, 15 laboratories and 3 pilot plants, it has the facilities and specialized equipment to perform an amazingly wide variety of streams of research. The centre is staffed by 51 researchers, 34 undergraduate students, and 32 technical students. Of its 51 researchers, 39 are doctors and 7 have master’s degrees. The remainders are graduate students. Since its establishment in 1978, the centre has worked on more than 700 technological projects. The Centre gets 50% of its funding from the Ministry of Science and Technology, with the balance coming from industry and other government grants. CETEM is distinguished by the high level and wide range of expertise its staff and facility can offer.

Research and Current Projects

CETEM has a wide set of goals, summed up by their mission statement: “To promote the Brazilian technological development of innovative solutions to the sustainable use of non-renewable resources and to the preservation of the environment, thus contributing to the social welfare and economical progress of the country.” The major ways that the centre works towards its mission is by the giving support to small and medium scale private commercial initiatives, promoting the utilization of processing technologies to add value to exports, developing feasible industrial recycling processes, and studying alternatives methods of environmental protection. CETEM also does a great deal of research in the development and application of innovative metallurgical processes.

CETEM has been involved in more 700 technological projects since its establishment. The centre releases a new operating program every two to three years. A short description of the major programs and projects CETEM will be working on for next few years follows.
• The program aimed at increasing the value of Brazilian mineral products includes projects researching issues concerning improving technological properties of materials such as muscovite, kaolin and vermiculite, developing and improving techniques for using mineral additives in agriculture, and researching optimization techniques for the processing of ferrous, non-ferrous and precious metal containing minerals.

• The environmental studies program is running projects that include education programs for teaching about modern mining techniques and practices, economic projects for eliminating barriers to clean small scale mining technology, and research projects involving reclamation technologies, recycling technologies, and effluent treatments.

• There is an economic program dedicated to job creation and income improvement in small scale mining, with projects concerning developing organizations, market creation, and technological innovations for small scale miners of gems and decorative stones.

• The Special Topics in Mineral Processing program is running research projects aimed at reducing water and energy consumption in the mining industry.

• The Technical Support and Managerial Quality program is developing new mineral analysis techniques and new information technology applications, as well certifying other labs in Brazil and publishing technical books and papers in Portuguese.

Technological Services

CETEM gets a significant amount of its funding by providing services to the mineral and aggregate industries. The following services are offered:

• Characterization of ores and industrial minerals
• Gemology
• Process Mineralogy
• Characterization of industrial residues
• Inorganic chemical analyses
• Organic chemical analysis
• Molecular modeling
• Crushing and grinding tests
• Ore concentration
• Beneficiation of industrial minerals
• Ore leaching tests
• Pilot scale process development
• Metals recovery and materials recycling
• Land Reclamation
• Treatment of industrial wastes and effluents

The centre also provides information and consulting in the following fields:

• Technical support to small scale miners
• Environmental auditing
• Environmental impact assessments
• Economic analyses for the mineral and metallurgical sectors
• Mineral and environmental legislation
• Mercury emissions
• Technical standards and regulations
• Process simulation and optimization
• Applications of minerals and rocks

U.B.C’s Visit

The 4th year class of the University of British Columbia’s Mining Engineering Department visited CETEM on February 25, 2005 as the final stop on its field trip to Brazil. The group was served a delicious lunch and given a tour of the facilities. We met a number of the facility’s researchers and students, spoke to them, and learnt about their projects and how they came to be studying or working at CETEM. We also gave a presentation to students and staff about the U.B.C. Mining Engineering Department and the Canadian mining industry.

During our tour we saw grinding, flotation and leaching experiments, simulations testing new environmental technologies (including bio-filters and new uses of carbon for water treatment in natural systems) and visited various microscopy facilities. We also toured their grinding and gravity recovery pilot plant, and met researchers involved in the global mercury project who had developed a new simple and robust technology for measuring mercury contamination in water, food and human tissue samples.

The general impression we were left with is that CETEM is first class facility that is working on many interesting projects. Many of these projects have the potential to lead directly either to developing new commercial operations that will help with economic development in Brazil’s rural areas, or towards improvements to the health of both the people and the natural environment in regions where mining has had detrimental effects. CETEM gives the Brazilian Government much to be proud about regarding its approach to the Brazilian mining and aggregates industry. Much was learnt about how governments can become more proactively involved in adding value to, and promoting sustainable growth in, their mineral industries.