Mining 4th Year Research Trip

Chile

February 14-29, 2008
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1.0 INTRODUCTION

In recent history mining engineering students at UBC have been working hard to become better global citizens in all senses of the words. Our program teaches us the value and necessity of communication with local stakeholders in the area that we operate. Learning to understand and respect the ideas and cultures of others is an integral part of being a mining engineer in today’s market where there are job opportunities across the world.

The 4th Year Research Trip was borne from this ideology, to allow graduating students the opportunity to experience the industry from an international perspective and to be able to compare and contrast the way that business is done.

This year the class decided that Chile would be the perfect country to visit. Chile is not only one of South America’s most stable and developed countries, it is also the world’s premier copper producing nation and this trait meant that we would be able to visit world class mining operations that are on a completely different scale than we would find in Canada.

The trip took place between February 13th to March 1st, and took months of planning to organize and raise the money to be able to go. During the fundraising process students gained valuable industry contacts and the class was incredibly pleased with the generosity of all the sponsors and the UBC engineering students through the Professional Activities Fund. Without this support the trip would not have been possible and the students would have lacked a piece of their education that, although not required, is very valuable to their professional careers.
2.0 SANTIAGO

Santiago, located in the central Chile, is an integration of old European world and modern cosmopolitan. Together with the development of suburban, it forms Greater Santiago. Therefore in order to make sense of Santiago, an understanding of its history is recommended.

Santiago was founded by Spanish conquistador Pedro de Valdivia in 1541, yet the city was destroyed 7 months later by the Indian forces led by Chief Michimaloco. The city was resurrected with the help of the native Pincunche Indians. However, couple hundreds year later, it was destroyed again in the War of Independent, 1810 to 1818. Santiago remained as a small town until 1880s, when its fertilizer extraction promoted city development and contributed to Chile’s prosperity. Major landmarks were not constructed till 1910, when Chile gained independence from Spanish dominance; for example, the National Library, the Museum of Fine Art and the Mapocho Train Station. Further development had promoted migration from north and south, and then Santiago development had taken off along with problems.

In modern era, Chile had gone through socialist government headed by Allende in the 70s, then dictated by the military figure Pinochet for more than 2 decades; recently, democratic government has the reign. Post Pinochete era, Chile as a whole is developing and growing rapidly.

Santiago is really diversified in architectural aspect. Many landmarks from the past are standing still while new buildings are being constructed. However, there is this district that is nearby an area that is concentrated of colleges and the district becomes student housing. Judging by the visit, the buildings lack maintenance and management. It is rather painful to see the historical landmarks being abandoned by the people and the city. The residences are all old buildings from the 19th century; all the buildings reminisce the wealth of the rising middle class. Most interesting point is that they are all different; one would be French, but the next would be Italian, or English, or other European countries. Their existence allows people to walk through past and to gain an insight to the old community.
Similarly, Santiago is populated with art centers and museums; and it was a feast to visit them or by looking at the buildings and monuments, especially the ground is where a major event had taken place. For example, it is mind blower to know that the Santa Lucia Hill is where, not only thought as a place closest to God, but also a place where Santiago founding ceremony was held. However, one distracting feature is that there is graffiti art everywhere even on the wall of the landmarks. After seeing no end to them, one could just come to accept that it is just part of the culture.

Moreover, due to Santiago’s geography, it is surrounded by wineries. Making a trip or two to the wineries is both stimulating and relaxing at the same time. Drinking wine is a major part of the Chilean life, so it is a cultural experience and why not indulging in luxury when it is ready for one to grab.

Indeed, Santiago offers cultural excitements and relaxing life style. Its integration of the Old and New traces past glories and showcases new advances. It was an eye opening journey for anyone who has not been to South America, and relaxing for those who have.
2.1 Finning

2.1.1 Finning Facility Tours

Three Finning Facilities were visited in Chile: the South American headquarters in Santiago, the Caterpillar mine services and assembly plant, and the Caterpillar Rebuild Plant, both in Antofagasta. The three facilities offered an excellent opportunity to observe the operations of a contractor servicing the mining industry in Chile and throughout South America.

2.1.2 Finning South American Headquarters

Finning is an international distributor of Caterpillar equipment with world headquarters in Vancouver, Canada. The company operates in Western Canada, The United Kingdom, and South America. The South American headquarters is located in Santiago and services Chile, Argentina, Uruguay, and Bolivia.

2.1.3 Caterpillar Mine Services and Assembly Plant

The Caterpillar Mine Services and Assembly Plant services a total of 16 mining operations within the Atacama Desert region. Due to the arid conditions within the region, water for the operation is piped from over 50km away onto site. All sewage is treated onsite and recycled. Due to public pressure and concern about the future of aquifers within the region, businesses including Finning, in the region are in discussion to
construct a desalinization plant on the coast to service the areas water needs.

The plant employs 65 people at the plant with an additional 65 people off site servicing equipment. The plant services both underground and surface mining Caterpillar equipment. All Caterpillar equipment purchased by a client in the region is shipped from the US, Germany, or Brazil to the Assembly plant. 8 mines in the region utilize 777 haul trucks and an additional 8 utilize the larger 797B haul trucks. Once the trucks are constructed, they are driven to site (Farthest mine is Escondida 150km away). The plant constructs some of the largest mobile equipment in the world including 994 loader, 854G dozer and 797 haul truck. A large contained painting booth is located on site as well as a supply of Nitrogen gas for filling tires.

![Above: Construction of a Caterpillar 797B Haul Truck. Truck to be delivered to the Escondida Mine Site.](image)

The plant strives to maintain a high level of health, safety, and environmental standards. Safety boards are available for employs to comment on the operation, all oil is recycled, and work places are kept to the highest of standards.

### 2.1.4 Caterpillar Rebuild Plant

The Caterpillar Rebuild Plant services parts for clients throughout South America. The plant employs 200 people in Antofagasta located in Northern Chile in the Atacama Desert. Rebuilt parts are on average 50% cheaper than the equivalent new parts. The plant’s primary focus is on engines, drive trains, and transmissions, and typically requires 35 days to complete an engine rebuild. Sophisticated dynometers are located on site to test the completed motors for proper motor operation, excess vibration, optimal running temperature, and correct power output.
Equipment is also converted to operate at high altitudes on site by increasing the air:fuel mixture ratio.

From left to right: Plant Manager gives a facility tour to UBC students. Caterpillar’s in house dynometer can test engine and transmission performance. An engine block being refurbished.

Finning also has an SOS Oil Laboratory located on site. 12000 oil samples are processed every year at a cost of $20 per sample. Oil samples are shipped to the laboratory from mine sites within the Antofagasta region. The samples are tested to determine the integrity of the oil composition and for particulate matter greater than six microns. The data from the samples is collected and returned to the client within a 48 hour time period.

All of Finning’s operations in South America continue to expand. With a diversified customer base in the mining, forestry, construction, and the power industry, Finning has large potential to continue to grow in South America. The mining industry continues to be a strongly committed to Caterpillar equipment and Finning looks to benefit from the strength of the industry.

2.2 El Teniente

The El Teniente mine is the worlds largest underground copper mine, employing the block caving mining method. The site is immediately adjacent to the abandoned town of Sewell, approximately 120 kilometers south of Santiago, Chile. To date, over 2500 km of tunnels have been mined inside the Andes Mountains. Current mining production rate at the mine is 37,000 tonnes per day, however Codelco is currently developing new areas to force production over 45,000 tonnes per day.
2.2.1 History

Copper production first began in the pre-Hispanic era of South America when natives of the region extracted copper for local use. Once the Conquistadores arrived in Chile, the Spaniards extracted copper to be sent to Peru to make domestic goods such as kettles, pots etc.

In 1822, the property was acquired by Don Juan de God Strap of Saa and Martinez who was a lieutenant in the Patriotic Army and this is how the property gained its name El Teniente, Spanish for The Lieutenant. He acquired the property through marriage to the granddaughter of Mateo de Toro Zambrano, Nicolasa aristocrat de Toro and Dumont.

Industrialization of the mine began in 1903 when the property was sold to the William Braiden and the Braiden copper company. In 1905 a 250 tonne per day processing plant was built and in 1908 production was increased to 3000 tonnes per day. In the mid 1940s Kennecott Corporation implemented the block caving mining method and increased the production rate to 20,000 tonnes per day.

June 19, 1945 a fire started in a forge inside one of the main accesses to the mine. As a result of the smoke and carbon monoxide produce by the fire, 355 miners died. This was and remains today one of the worst non-coal mining related tragedies in the world. The accident represents a landmark in the development of modern occupational health and safety programs in Chile.

In 1967 the government of Chile bought 51% of the shares of then-owner Anaconda copper company and later nationalized the remaining 49% in 1971. Through nationalization, the Chilean government acquired complete ownership of the El Salvador, El Teniente and Chuiquicamata Mines. Today El Teniente is still owned by the state corporation Codelco.

2.2.2 Ore reserves and geology

At the center of the deposit is a carrot-shaped, barren but very hard and competent breccia where the majority of the mine offices and other infrastructure are located. Surrounding the central breccia is the ore zone, forming a cone-like shape. Ore occurs as a chalcopyrite and molybdenite and is hosted in breccia, with average grades of 1.04% Cu and 0.025% Mo. The ore zone currently measures 2km in width, 3.5 km in length and 2km in height. At current production rates and commodity prices, there is an estimated 50 to 75 years of mineable reserves still
available. The following schematic shows a rough cross section of the geology:

![Schematic Cross Section of El Teniente](image)

**Figure 1. schematic cross section of El Teniente**

### 2.2.3 Mining Method and Layout

As the Ore is hosted inside a very steep mountain and bulk mining began long before the advent of very large open-pit mining equipment, the decision to use block caving was made. The principal behind block caving is that mining starts with drawpoints at the bottom of an ore block, and the weak and fractured nature of the ore allows it to collapse and cave into the drawpoint on its own.

### 2.2.4 Production Level

On the production level, drawpoints are laid out on a pattern every 15m along the access drives with the access drives being spaced 25m apart. On the production level, LHDs (underground scoops) are used to dig the ore from the base of the drawpoint and transport it to an orepass leading to the level below. In case there is any large boulders that require additional breaking, there are pneumatic hammers at the top of each orepass available to break the ore. In the mine, there are 16 LHDs each with a 7 yd³ capacity and 32 pneumatic hammers that can be moved to