WEFTA - BOLIVIA TRIP REPORT

July, 2011

Prepared by Scott McKitrick

ORURO-AREA MINING CONTAMINATION (local partners CEPA & CORIDUP)

I traveled with Jason Obergfell, Maryknoll lay missioner of Cochabamba. Jason has worked with WEFTA and Suma Jayma for many years, and has an outstanding understanding of Bolivia and its politics. We met Thomas Van Humbeeck, a CEPA volunteer from Belgium. Both aided me greatly with Spanish translation and general help. We toured the mining areas near Oruro with Felix Layme of CORIDUP and Johnny Terrazas, who were both very helpful.

I've included an excerpt from Jason Gehrig's trip report of March, 2011 for background, and also as a place to start in detailing my visit in July, 2011. Consistent with Jason's report, here's a little background info on CEPA and CORIDUP, from Evan Cuthbert's 2010 Huanuni case study write-up:

> *When CEPA opened in 1995 their main focus was providing education and leadership formation for marginal communities, especially those of indigenous peoples. In their work, they emphasize the value of indigenous knowledge, environmental protection and intercultural respect and dialogue...*
>
> *In August 2006, CORIDUP was officially founded to organize local communities (over 60+) in the Desaguadero River and Uru Uru and Poopó Lakes Watershed to unify their collective action to address contamination of local waters and lands.*

As Jason stated in his report, CEPA and CORIDUP very much welcome WEFTA's technical expertise, asking that WEFTA's work be carried out in close coordination with CORIDUP, and that WEFTA be open to collaborating with other sources of external support, such as CATAPI, which is a Belgian NGO with ties to academia there dedicated to providing technical support in environmental issues. In summary, CEPA/CORIDUP sees technical support from WEFTA being channeled toward two primary efforts, addressing mining contamination from:

- The state-owned Huanuni tin mine
- Two gold mines (formerly Newmont-owned)

I. Huanuni Tin Mine (State-Owned) Downstream Watershed Contamination

Background on Huanuni watershed contamination, from Evan Cuthbert's 2010 Huanuni case study write-up:

> *There are several mining operations in the Huanuni watershed. Many are small-scale, artisanal mining operations which include anywhere between one and thirty miners. The largest and most problematic is the Posokoni Mine owned by Empresa Minera Huanuni, S.A. (EMH), a subsidiary of the Bolivian state-owned mining company Oruro. This sub-surface mining operation holds one of the largest tin deposits in the world. There are also sizeable quantities of other minerals such as lead, zinc, and silver. Currently, EMH employs approximately five thousand workers at the site. Active mining at Posokoni has been going on since the year 1745.*
>
> *The minerals are processed at two mills on the shores of the Huanuni River: the Santa Elena mill, located at the mine in Huanuni, and the Machachamarca mill, approximately 25 kilometers downstream. Combined, they process approximately 1,400 tons of minerals per day, with the Santa Elena mill processing the bulk – 1,200 tons per day. Neither mill uses tailings ponds to deposit and contain its contaminated tailings after processing. Instead, the operations dump their untreated tailings directly into the Huanuni River...*
>
> *In response to growing conflict over environmental degradation and public health problems, the Government of Bolivia in 2009 declared an emergency zone in the Huanuni watershed (a first in Bolivian history).*

In this Emergency Declaration, specific objectives are outlined for beginning to address the problem. One of these is a short-term tailings retention that is 98% complete according to CORIDUP members, which should serve for 3 to 4 years. Pumping, hoses, etc. have yet to be installed.

I visited the Santa Elena and Machacamarca millsites. Santa Elena is located next to the Posokoni Mine at Huanuni, while the Machacamarca millsite is located approximately 26 kilometers northwest (down-river) of Huanuni, approximately 10 kilometers from Lago Uru Uru and Lago Poopo. Mineral separation is completed by grinding the ore to a small grain size, adding a chemical flotation agent (xanthate) and sulfuric acid, and physically separating the tin and silver minerals from ore. Recovery of tin and silver is about 65% effective (meaning 35% of the tin and silver remain in the tailings). Mill tailings are the waste product remaining after the tin and silver minerals have been removed. The tailings contain silicate minerals (innocuous) as well as pyrite (not innocuous). Pyrite (iron sulfide) generates acidity (sulfuric acid), commonly known as acid mine discharge or acid rock discharge (ARD) through the oxidation of sulfide to sulfuric acid. ARD leaches heavy metals (cadmium, lead, nickel, zinc, etc.) from rock that it comes in contact with, causing damage to human health and the environment, particularly the down-stream watershed (surface water contamination, groundwater contamination, sediment and soil contamination). Pyrite in the tailings from the Posokoni Mine would naturally produce ARD over time, but the use of sulfuric acid in the mill process catalyzes the generation of ARD, making the timing of ARD generation quicker (i.e. changing the kinetics of the ARD reaction, for you scientists), as well as increasing the total volume of acidity generated. In addition to heavy metal contamination, the xanthate used as a flotation agent also is toxic to aquatic biota.

Tailings are deposited directly into the river at Huanuni as well as at Machacamarca, and are carried down-river by the river itself, or moved by heavy equipment to allow additional tailings to be deposited. The mining company (EMH) employs people who then re-process tailings to recover a percentage of the tin and silver that are not removed in the primary processing. This process is similar to what takes place in the Santa Elena mill, but is conducted on a smaller scale and without mechanization (hand shovels only). The same chemicals (xanthate and sulfuric acid) are used in the small-scale processing. The small scale processing takes place within the flood plain of the river. In addition to reprocessing done by EMH, small scale artisanal miners also conduct reprocessing.

The Posokoni Mine discharges water to facilitate underground mining. This water is likely low pH, based on its yellow-orange iron coloring.

Figure 1 – Santa Elena Mill with tailings deposited in Huanuni River at Posokoni Mine

The floodplain of the river near the millsites is devoid of plant life, likely due to the low pH of sediments and the river, as well as metal toxicity. The river is reported to have a pH of 3.5 proximal to the millsites.

A review of aerial photography indicates the Huanuni River is impacted for a distance of in excess of 30 kilometers down-stream of Huanuni, and likely impacts Lago Uru Uru and Lago Poopo, where the Huanuni River flows into the lakes. Tailings have also been deposited outside the watershed, both above the mine and to the east of the Huanuni River.

Figure 2 - Huanuni River, all yellow-brown material is acid generating tailings

Impacts to human health are likely happening through several pathways, including direct contact with contaminated surface water and sediment, breathing of contaminated sediments (dust), and ingestion of contaminated shallow groundwater. Health impacts from mining related contamination are more pronounced in populations with other potential health issues, such as malnutrition.

Figure 3 - view to East across Huanuni River (much trash) to tailings deposited on banks of river

The scale of mine-related contamination in the Huanuni area is staggering. Addressing the problems can be broken into two processes: 1) stopping the deposition of tailings into the river; and 2) addressing historical contamination.

The initial step has begun, as EMH has constructed a temporary tailings impoundment above Huanuni. The impoundment is reported to have capacity to contain tailings for 3 or 4 years. We did not inspect the impoundment. It is located topographically higher than the river, which will require that tailings be pumped up to the impoundment. The pumps have not been installed, and the tailings impoundment is not in use. I have concerns relating to the location of the impoundment. It is important that tailings impoundments be operated correctly in order to ensure stability. Improper operation can cause catastrophic failure of the impoundment and associated flooding. If the impoundment were to be put into service and fail, the town of Huanuni would be directly in the flood path.

A larger tailings impoundment, likely located down-river from Huanuni, will be required for long-term tailings storage. Proper operation and closure of the tailings impoundments will be required to protect

human health and the environment. A tailings impoundment will keep tailings out of the watershed, but will still pose a threat, as the same contaminants will be present, but in a more controlled location.

The second process required is to address tailings and associated contamination in the Huanuni watershed. This problem is enormous, and will require many years and many millions of dollars to address. The traditional method to address the contamination would be to remove tailings from the river using heavy equipment and place the tailings in a repository outside the flood plain. The repository would be covered with soil, and revegetated to limited infiltration of water. The watershed would need to be re-graded in order to function as a self-sustaining natural ecosystem. An investigation of groundwater to determine the extent of impact would also be required, in order to ensure protection of human health. The down-river extent of contamination may extend to Lago Uru Uru and Lago Poopo, which would require an investigation to determine the effects of these lakes and potential remediation.

Figure 4 - Machacamarca millsite tailings discharge with Huanuni River in background

We met with **Gerardo Zamora Echenique,** Director de Postgrado e Investigación Cinetífica en Universidad Técnica de Oruro. He has a strong understanding of the mineral processing and environmental issues at

Huanuni. He has developed a strategy for clean-up of the area based on recovery of residual tin from the tailings deposited in the watershed. He has completed preliminary work which indicates that the river sediments contain 0.14% tin, and that approximately 20% of the remaining tin can be recovered through use of traditional methods. He proposes to build a pilot-scale tin recovery system capable of processing 300 tons per day. The process for the pilot and full scale plant would include screening of oversize material, followed by flotation of pyrite for separation, centrifugal and magnetic separation of tin minerals, and some sort of traditional tailings impoundment. Pyrite would be separated to some extent to allow it to be dealt with separately. The full-scale plant would process 500 to 1,000 tons per day. He projects it would take nine years to dredge and process all the material in the watershed. He projects equipment cost of $3.2 million, total cost approximately $9 million. He projects the value of tin recovered to be up to $100 million, and that the project would employ up to 20,000 workers. He proposes that profits be put back into local communities.

This is an ingenious proposal which funds environmental cleanup through by-product of the cleanup itself. Given the scale and complexity of the project, it will require much investigation and planning, and commensurately substantial amounts of funding to complete the investigation and planning. I believe the proposal to be plausible on first pass, and worthy of further study.

Jason Gehrig postulated WEFTA's potential role in the area as follows:

WEFTA's potential role: To visit this facility and see if its construction is adequate to meet stated goals. Note: To date, CEPA has not been able to obtain a copy of the project design, although they think they may be able to do so.

We were not able to inspect the tailings impoundment, but this is a viable role for WEFTA. However, I am not convinced that the tailings impoundment will ever be utilized, given the high cost of capital equipment (pumps, piping) as well as high cost for operation and maintenance of the facility. A copy of the project design would be necessary in order effectively review the project.

A permanent tailings retention facility is being planned, although resistance from a nearby local rural community is being encountered slowing down the land acquisition process.

WEFTA's potential role: To provide technical input toward design/construction of facility, perhaps in the form of review/comment of design documents under the overall umbrella of CEPA/CORIDUP's social oversight of the Huanuni mining reclamation effort.

This is a viable role for WEFTA. We would likely pull in other technical experts in order to bolster our capabilities, as we have not been actively involved in engineering and design of tailings impoundments, but are experienced in many of the elements of tailings impoundment design.

The European Union is providing significant funding in seven downstream municipal jurisdictions, to be complemented by local and regional government funding (30%) to improve access for water supply and irrigation purposes and other related projects. 36 projects have been identified for the first round of funding.

WEFTA's potential role: CORIDUP members also asked WEFTA to consider supporting them in their efforts to prepare project design proposals for safe water supply projects, necessary to seek funding for implementation. This would be similar to the work WEFTA is supporting in the northern Bolivian Altiplano being carried out by Suma Jayma, and which Suma Jayma may be able to help out with.

This would be an outstanding use of WEFTA and Suma Jayma expertise. We did not discuss this during my visit, but it should be explored.

Other potential roles for WEFTA:

The source of potable water for the population of the towns of Huanuni and Machacamarca and all other villages in the area may be impacted by mine waste. It is believed that most potable water is obtained from shallow wells in the area. A first step in protecting human health in the area is to determine if water sources are contaminated. This should be done through an investigation to determine the sources of drinking water throughout the area, followed by sampling and analysis of drinking water to determine if it is contaminated. This type of study would traditionally be the responsibility of the government, and as such I suggest that CORIDUP begin a dialogue with government representatives to determine if this work can be completed by the government, potentially as part of the Emergency Declaration. If the government is not able to complete the work, it may be feasible to organize the current interested parties (CORIDUP, CEPA, CATAPI, local universities, WEFTA, Suma Jayma, etc.) to complete the work. In the event that water is found to be contaminated, WEFTA and Suma Jayma could aid in finding clean water sources and construction of distribution systems for water.

II. Inti Raymi/Newmont Kori Kollo and Kori Chaca Gold Mines

In 1982 Inti Raymi (Newmont) began extracting gold at its open pit mine, Kori Kollo "Golden Mountain". Since October 2003 a closure and rehabilitation process is being deployed. In 2005 Inti Raymi started a second mining project, Kori Chaka **"**Golden Bridge", a goldmine which is located in the urban zone of Oruro.

CORIDUP, which represents 60+ downstream communities demanded an external environmental audit of the Inti Raymi mines and their downstream impacts. CORIDUP explained that they have very little confidence in the Inti Raymi internal environmental audit, based on the company's deceptive practices and stall tactics in the past. The company completing the audit is PCA, a Bolivia based consulting firm. For that reason, CEPA/CORIDUP are carrying out an external environmental audit in coordination with the public university of Oruro, including the sampling of soil and water for analysis.

We toured the Kori Kollo area, including the towns of La Joya, Nuevo Chuquina and Toma Toma. The Kori Kollo mine is approximately 42 kilometers northwest of the city of Oruro. Kori Kollo is a modern open pit gold mine which started in the early 1980s. Battle Mountain Gold eventually purchased an 88% share in the mine, which was later transferred to Newmont Mining. Newmont sold its share of the mine in 2009.

At that time, they booked a $13 million trust to fund closure of the mine when operations eventually cease.

Kori Kollo is an open pit mine, with a total depth of approximately 270 meters. The mine is located proximal to the Desaguadero River, in places as close as 60 meters from the river. After mining, the pit was allowed to re-fill with water. Several small pits have been excavated since mining ceased in the main Kori Kollo pit, the most recent being the Llallaguita pit. The first ore extracted from the deposit was oxidized and amenable to heap leaching. Heap leaching is the process where ore is crushed and piled on HDPE (plastic) lined pads, dilute cyanide solution is discharged onto the crushed ore to dissolve gold and silver, and the precious metals are removed from solution using either carbon or other process. Cyanide solution is then recycled to the leach pads. Precious metals are smelted and poured into bars (dore, a mix of gold and silver), which are exported for refining. The Llaguita ore is oxide, and is therefore being processed in this manner. Heap leach pads take tens of years to complete precious metal leaching. Following leaching, several years are required for the leach pads to "drain down". Oxide ore may contain small amounts of pyrite and may generate ARD and mobilize heavy metals. The spent ore will also contain residual cyanide.

Figure 5 - Kori Kollo cyanide leach pad with historic hacienda and Desaguadero River in foreground

Following completion of mining of the oxide portion of the deposit, development of the underlying sulfide ore body was completed. The sulfide mineralogy of the deposit required a different metal recovery technology, known as carbon in leach (CIL). In this process, ore is ground to a fine powder using a crusher and large ball mills. Ore is then mixed with cyanide solution in large tanks. Once precious metals have been mobilized into solution, carbon is added to the solution to precipitate precious metals onto the carbon. The carbon is then separated from the waste rock (tailings). The carbon is acid rinsed to remove contaminants, and smelted to form dore, which is exported for refining. Tailings at Kori Kollo were discharged to a large, circular tailings impoundment approximately 2,400 meters in diameter. The tailings impoundment was constructed with a clay liner, overlain by oxide material. The tailings are pyrite-bearing, and have the potential to generate ARD and mobilize heavy metals. The tailings also contain residual cyanide.

Figure 6 - Kori Kollo Mine with Desaguadero River in foreground, pumping station on right

During mining, a large waste rock dump was constructed (approximately 1,000 by 1,800 meters). This rock is pyrite bearing, and has the potential to generate ARD and mobilize heavy metals.

Dewatering of the pit was required to facilitate mining, as the depth to groundwater at the mine is shallow (several meters). Water pumped from the mine is reported to be extremely saline, with total dissolved solids (TDS) concentration approaching 60,000 ppm. The water was pumped into evaporation ponds. The ponds have the potential to cause salinization of underlying and surrounding soils. Salinization causes a detrimental effect on plant growth and yield, can cause damage to infrastructure (roads, bricks, corrosion of pipes and cables), causes reduction of water quality for users, sedimentation

problems, and causes soil erosion ultimately, when crops are too strongly affected by the amounts of salts.

We also toured the Kori Chaca area, which is proximal to the city of Oruro. The mine is located approximately 5 kilometers northwest of the the center of Oruro, with a line of low mountains running between the city and the mine. The Kori Chaca mine is an open pit mine. Ore is oxide in nature, and is processed through heap leaching. A waste rock dump containing pyrite-bearing waste rock has been constructed. Dewatering of the mine to facilitate mining below the water table is necessary at Kori Chaca, as it was at Kori Kollo. The evaporation ponds at Kori Chaca are extremely large (approximately 1,800 meters by 1,800 meters, one square mile). Potential environmental issues are consistent with those at Kori Kollo, specifically ARD generation from spent ore and waste rock and associated heavy metal mobilization, cyanide from spent ore piles, and salinization from evaporation ponds. Additionally, a trench has been dredged from the Desaguadero River to the mine to provide process water. This water would normally flow to Lago Uru Uru.

We met several officials from the Kori Chaca Mine. They were curious about what we were doing, we explained. They offered to give us a tour of the mine, which we gladly accepted. They agreed to call Johnny of CEPA the next day to organize, but then backed out, blaming the fact that we hadn't let them know in advance, and that all mine staff were busy. Thomas tells me this is how the mine usually works – lip service, no action.

People in local villages talk about what they believe are mine-related contamination issues, including wells that were fresh becoming saline, and mutation of livestock.

We visited the San Jose Mine, which is located at the top of the hill within Oruro. It is a collective-run underground mine. Water is pumped from the mine and discharged directly into a ditch that flows into Oruro. Water flows at 25-50 gpm, and has a pH of 1 to 1.5 (extremely acidic). The banks of the ditch have yellow elemental sulfur precipitate, consistent with low pH water. A European engineer has proposed to put this discharge into pipes to convey it through town, then buffer it in some sort of wetland.

Figure 7 - Drainage from San Jose Mine, yellow material is elemental sulfur precipitated from pH 1 water

CEPA has a library with publications on a large variety of subjects, including mine issues. I briefly reviewed their holdings, and read selected publications. One of interest was a quasi-baseline study of the Altiplano near Oruro and south by the Swedish Geological AB from 1996. It wasn't comprehensive or detailed enough in the areas of the mines to be overly useful, but at least gave some actual data (groundwater and surface water analyses, etc.). Also of interest was the design report for the Kori Kollo Mine facilities prepared by Knight-Piesold, a U.S. mining consulting firm. Additionally, I reviewed some of the baseline investigation of the Kori Kollo mine prepared by Inti Raymi. It contained the right type of information (groundwater analyses of monitoring wells near mine facilities, etc.), but was not comprehensive. It should have contained more information from more points to define pre-mining conditions, but it was a start. I expect there is much more information like this somewhere (CEPA, government agencies, at the mine), but it seems to be hard to find.

CEPA was contacted by an Oruro government committee (state equivalent, I believe) to give input on environmental laws to be enacted by the state. We were invited to meet with both groups. Not speaking Spanish, I was mostly lost. We did discuss potential environmental regulation types with CEPA. CEPA seemed to support the formation of a group of local stakeholders to address environmental issues. This seemed like a good starting place to me.

WEFTA's potential role: Review Inti Raymi's draft environmental audits, its Kori Kollo mine closing plan, CEPA's earlier review comments and assist with the independent environmental audit. Need technical assistance from WEFTA to help understand what is a technically viable mine closure & reclamation plan for these open-pit gold mines employing the use of cyanide. Assist CEPA in implementing the alternative, independent environmental audit planned to be completed by August of this year.

This is a good use of WEFTA resources. The mine published much of the preliminary environmental assessment on-line. I downloaded much of it, and reviewed the data to the extent I could with google translate. Much is understandable, as science is science and numbers are numbers. I also reviewed CEPA's response to the preliminary information to the extent possible. My understanding is that the second draft was due out long ago, but had been delayed. I will follow up with Thomas to see what the status is.

The parallel audit being conducted by CEPA and a local university did not seem to be going well, and some conflict between the groups was discussed. CEPA expects some results from UTO, the university doing the work, this month (November).

I understand that CEPA received a response to their comments on the second phase of the Kori Kollo environmental audit. I am in the process of reviewing them now, and will respond back to CEPA.

Thomas Van Humbeeck contacted me to ask if I would look into the current relationship between Inti Raymi and Newmont. He tells me one or two Inti Raymi staff fly to Newmont's operations at Yanacocha, Peru on a weekly basis. I have called Newmont to discuss, but they haven't called me back. Newmont said in a press release that they have a $13 million trust to fund closure of Kori Kollo when it finally ceases operations. This showed up on their 2009 Annual Report as well. I'm curious as to how this money will be spent, and when. When we visited, there were trucks hauling soil from surrounding areas onto the large tailings impoundment at Kori Kollo. This seemed like a good idea in theory, but I'm not sure if it was. The soil was being stripped from the surrounding Altiplano, which was therefore completely devegetated, with nothing growing at all. The soil looked relatively saline, given the white precipitate around any former pools of standing water. I question the ability of the soil to be vegetated on the tailings impoundment, or for the area where soil was removed to be re-vegetated. I'll continue to contact Newmont to find someone to talk to about environmental issues in Bolivia.

Figure 8 - soil being removed for use as tailings cover, note salt

SUMA JAYMA VISIT IN EL ALTO

I spent a single day with Suma Jayma. We inspected the water system at Machacamarca, which is now complete. The system looks great. It is made up of a surface water collection system, storage tank, chlorination system, distribution piping, and tap stands.

Braulio explained that Suma Jayma is exploring all potential funding opportunities, as work has slowed and they're in need of additional funding. He has explored potential projects with an NGO interesting in training Bolivians to construct bridges, as well as a Swiss group looking to fund construction of hand pump projects.

Suma Jayma is also excited about the potential of obtaining a drill rig to drill water supply wells. They are working with Jason Gehrig on this project.

Figure 9 - Machacamarca water storage tank with security fence

Figure 10 - Machacamarca water storage tank with chlorination system in structure