Cananea Copper Mine

An International Effort to Improve Hazardous Working Conditions in Mexico

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A team of international occupational health and safety professionals evaluated the working conditions and health status of miners at a giant open-pit copper mine in Cananea, Mexico. Workers in the ore processing plants were exposed to levels of crystalline silica 10 times the Mexican regulatory limit, high levels of acid mist and noise, and numerous safety hazards, including unguarded machinery and malfunctioning 10- and 15-ton cranes. Lung function testing and interviews with physicians showed a substantial percentage of miners with adverse respiratory symptoms including shortness of breath (46%), wheezing (12%), coughing (12%), and elevated sputum production (10%). The mine owner, Grupo Mexico, violated Mexican law by failing to conduct an industrial hygiene survey sufficient to identify, evaluate, and control health hazards including exposure to mineral dust (including silica), acid mists, airborne solvents, high noise levels, high vibration levels, and extreme temperatures. *Key words*: Mine operations; silica exposure; respiratory illnesses; Mexico; international OHS.

INT J OCCUP ENVIRON HEALTH 2009;15:14–20

Occupational health and safety conditions at a giant open-pit copper mine in Cananea, Mexico were assessed by a multinational occupational health and safety (OHS) team in October 2007 after workers went on strike on July 30, 2007, motivated by health and safety concerns. Cananea is a small town in Sonora mountains, 35 miles south of the U.S. border. The copper mine is owned and operated by the transnational conglomerate Grupo Mexico, which ranks among the most important companies in Mexico and is a significant player in the world mining industry with operations in Peru and the United States.[1] The Cananea Mine has 1200 workers represented by the Mexican National Union of Mining, Metallurgical and Similar Workers, Local 65. In addition to the union workers, approximately 400 outside contractor employees also work on site.[2] After thorough consideration, the OHS team decided to move forward with the health and safety study without Institutional Review Board (IRB) approval. The situation at the Cananea copper mine was urgent and did not allow us the time to wait for the process involved; in addition, the fact that the mine was closed meant that workers did not have any ongoing exposures. We obtained informed consent from workers to do spirometry testing. Workers were informed of spirometry results, and notified orally and in writing that participation in the study was voluntary.

As of December 2008, the Cananea miners had been on strike for 17 months with no end in sight. Grupo Mexico attempted to have the strike declared illegal and to resume full production at the mine, but these efforts were rejected by the Mexican courts.[3] In late April 2008, Grupo Mexico threatened to permanently end production at the mine, even though it has a long term lease from the Mexican government. In response, the Mexican Miners Union called on the Mexican government to end Grupo Mexico's contract and lease the operation to another employer committed to complying with Mexico's workplace health and safety regulations.[4]

The United Steel Workers (USW) union in the United States launched a solidarity campaign with the Mexican miners when the strike began.[2] On behalf of Local 65 of the Mexican Miners union, USW asked the Maquiladora Health and Safety Support Network (MHSSN) for an independent evaluation of the working conditions in the Cananea mine and the health status of the mine workers. The MHSSN organized a volunteer team of eight occupational professionals to go to Cananea to conduct extensive interviews with 70 miners, perform lung function tests (spirometry) on the miners, and conduct a walk-through inspection of the open-pit mine and the processing plants.

The OHS team consisted of three Mexicans (two occupational physicians and an industrial hygienist), four U.S. citizens (an occupational doctor, a registered

Received from: Labor Occupational Safety and Health Program, University of California, Los Angeles, CA (IXZ), the Maquiladora Health and Safety Support Network, Berekely, CA (GB), the Division of Pulmonary Medicine/Critical Care, Stroger Hospital of Cook County, Chicago, IL (RC), and Alliance Consulting International, San Diego, CA (EM). This article is based on a report by the Maquiladora Health & Safety Support Network, "Workplace health and safety survey and medical screening of miners at Grupo Mexico's copper mine in Cananea, Sonora, Mexico." The full report is available at http://mhssn.igc.org/CananeaOHSReport.pdf. Address correspondence to: Ingrid X. Zubieta. Mailing address: 10945 Le Conte Avenue, Suite 2107, Box 951478, Los Angeles, CA 90095; email: <ixzubieta@ucla.edu>.

Disclosures: The authors declare no conflict of interest.

Figure 1—View from the control tower on top of the open-pit copper mine with the ore processing plants in the foreground and the town of Cananea. Photos by Garrett Brown and Heather Barr.

nurse, an industrial hygienist, and a Mexican-American pulmonary technician), and a third industrial hygienist from Colombia. The OHS survey team spent a day and a half interviewing and testing mine workers, who were recruited by Local 65 of the Mexican Miners Union, at the miners' union hall in downtown Cananea. The afternoon of the second day was spent in a walk-through inspection of the open-pit mine and associated ore processing plants.

BACKGROUND

Operations at Cananea are divided into five main areas or departments: Mine, Concentrator, ESDE, Quebalix, and Services. Each of the production departments has operator and maintenance job classifications, and the interviewed production workers were evenly split between operations and maintenance. The major processes in each department are described below.

Mine. Operations in the huge open-pit mine began in 1901, and another 70 years' worth of copper ore is reported to remain at the site. The ore is mined by a sequence of steps involving drilling 20-meter deep holes for explosives to create the carefully maintained "shelves" of the ever-widening pit, called the "Tajo."

Explosions produce large boulders of rock that are loaded into 300-ton dump trucks by giant mechanical shovels. The shovels are electrically powered, and thick high voltage electrical cables snake across the ground between the shovels and the power generator. Once loaded, the dump trucks drive up and down ramps from the active excavation site to the first of the series of "Concentrator" ore processing plants. Operations for the mine are controlled by radio from a glass-enclosed tower at the highest spot in the mine.

Concentrator. This department is actually a series of processing plants, called "areas," that process rocks with high metal content. The mine trucks dump the large boulders into the primary crusher; conveyor belts are used to transport the rock through a series of three crushers. The crushing process reduces refrigerator-sized rocks to a fine, powdery dust. The dust is then sent through a series of wet and dry milling processes in multiple buildings to be refined into highly concentrated copper ore. This ore also includes other metals and minerals.

QUEBALIX: This department's acronym describes the three stages of the operation: QUE for "quebradora" or crusher, BA for "banda" or conveyor belts, and LIX for "lixiviado" or leachate. To extract copper from low-grade ore, the QUEBALX operation uses heavy machinery to form large terraces composed of rock trucked directly from the mine and partially crushed rock delivered by conveyor belt. An extensive spray irrigation system is arrayed on the top of the terrace, and a weak sulfuric acid solution is sprayed onto the ore via long hoses. The acidic water leaches through the rock terrace, extracting copper and other metals as it percolates downward through the layers. At the foot of the terrace is a holding pond that captures the now-black, highly-acidic water containing copper ore. The black liquid is then pumped to the two ESDE plants for further processing.

ESDE (Extracción de Solvente por Deposición Electrolítica—Solvent Extraction by Electrolytic Deposition): There are two ESDE plants on site, one older than the other. Both plants contain dozens of concrete-lined dip tanks (1.8m 0.9m 6.0m) that receive the liquid from the QUEBALIX holding ponds. Inside the dip tanks are 15-20 solid lead plates (0.9m 1.5m 0.025m) hanging from 6m horizontal racks. Electricity is passed through the dip tank and metallic copper deposits onto the lead plate from the acidic QUEBALIX solution. Once sufficient copper has adhered to both sides of the lead plates, the rack of plates is lifted out of the dip tank by an overhead crane. The copper-coated plates are then moved either to a machine that automatically strips the copper coating from the lead plate, or to an open area where workers manually strip the copper coating from the lead plate by striking the plates with 1.5m long metal bars.

Services: This category includes security guards, drivers of personnel buses, and laboratory technicians.

METHODS

The OHS team's three industrial hygienists conducted the exposure and safety hazards assessment with members of the Miners' Union. The union recruited volunteers among its members to participate in the OHS study. Miners were from different work departments and represented both production and maintenance units. Participants were interviewed using a standardized qualitative questionnaire, and underwent spirom-

etry testing. We also viewed workers' chest x-rays when available.

In addition, we carried out a four-hour walk-through inspection of key areas of the non-working, struck facility. The hazard assessment focused on physical, chemical, and safety hazards in various mining operations, as well as evaluation of working conditions to the extent possible.

Spirometry Test. Participants received instructions and coaching on how to properly perform a forced expiratory volume maneuver. Height, gender, race, and age were entered into the spirometer. The hand held spirometer (Puritan Bennett, Renaissance II Spirometer, Tyco International, Inc. Princeton, NJ) was programmed to use the American Thoracic Society (ATS) and European Respiratory Society Criteria (ERS) for spirometry screening. [5] The spirometer was calibrated daily and after every 20th test.

Forced expiratory vital capacity maneuvers were performed with subjects in the seated position. Up to 8 maneuvers were performed to obtain at least three acceptable trials.

Timed expiratory volumes were based on the back-extrapolation method for determining time zero. Repeatable spirometry values were defined as those having the second largest values within 150 ml of the largest for both FVC (forced vital capacity) and FEV_1 (forced expiratory volume in one second).[6]

Inspection. A bulk sample of the accumulated dust encountered in large quantities throughout the facility was taken in October 2007 and analyzed by three AIHA-accredited laboratories in the United States for silica content, metals content and percentage of respirable particles. Bulk samples of approximately 200 milligrams of settled dust were collected by hand at each of four locations in the two Concentrator Department buildings. Active air sampling was not conducted during the walk through because the mine was not working.

RESULTS

Worker Interviews

Two miners were excluded from analysis because of inability to complete spirometry testing. Of the remaining 68 miners, the average age was 45 years. The length of employment ranged from two years to more than 30 years, with an average of 21 years. Participants had worked in various areas of the mine (see Table 1).

Exposure assessment. "High dust" and "low dust" categories were created by the survey team's industrial hygienists based on a qualitative evaluation of the workers' dust exposure from the workers' job descriptions and assigned job duties as reported in one on one interviews. Workers in the enclosed Concentrator Department buildings, and the blasters, shovel operators, truck drivers and field mechanics in the mine itself, were all placed in the "high dust" category. Shop mechanics, lab technicians, and gate house security personnel were placed in the "low dust" category. The dust exposure categories are best estimates of actual employee exposures.

TABLE 1 Number of interviewed workers from different work areas

Work Area	N (%)
Open-pit mine	38 (56%)
"Concentrator" crushing and processing plants	16 (24%)
ESDE plants	5 (7%)
QUEBALIX	5 (7%)
Services	4 (6%)
Total	68 (100%)

N = 68

Workers reported exposures to dense clouds of rock dust due to the fact that dust collectors were dismantled by Grupo Mexico, and the ductwork laid out on the ground outside the plants, nearly two years prior to the strike. Workers described visible dust constantly suspended in the building air when machines were operating or when workers disturbed deposited dust by walking through various mine areas. Workers reported that visibility inside the plants, when operating, was limited because of the dense clouds of airborne dust.

Workers in the ESDE plants were exposed to a wide range of hazards. These hazards included exposure to acid mist as the only ventilation in the facilities is general dilution ventilation provided by large fans mounted in the walls of the buildings; lead exposures arising from handling, maintaining and servicing the lead plates, and from clean-up operations when the dip tanks are drained and lead dust is removed from the bottom of the tanks. Hazards from working at elevated

Figure 2—Pulmonology technician Moises Ortega conducts a spirometry test with a copper miner following the industrial hygiene interview.

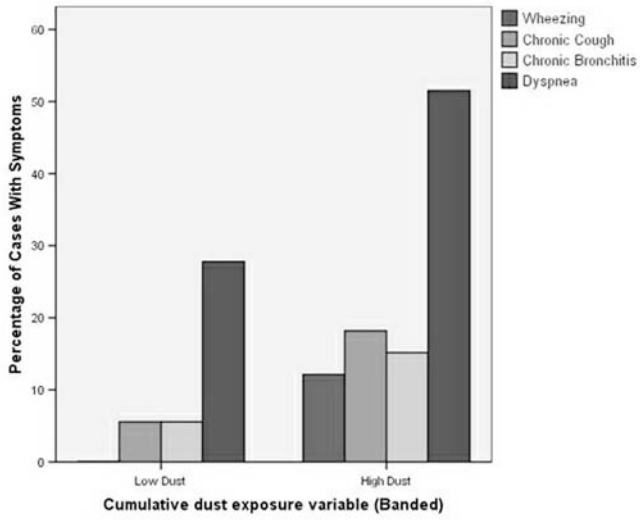

Figure 3—Workers with respiratory symptoms, by dust exposure category.

locations during crane repairs and related to repairing and servicing energized equipment were also reported by maintenance workers.

Most workers in this open-pit mine and processing plants are exposed to safety hazards from slips, trips and falls, overhead cranes, and other equipment that are not adequately maintained or unguarded.

Health Effects. According to the health survey, a substantial percentage of miners reported significant respiratory symptoms that included shortness of breath (46%), wheezing (12%), coughing (12%), and elevated sputum production (10%).

Figure 3 shows the adverse health effects in the two dust exposure categories. The symptoms appear to be related to dust exposure estimates; however, they likely underestimate the burden of disease that will occur in this population if exposures were to continue at the same level after re-opening of the plant.[7–9]

Of our sample, 60% had never had spirometry before. Obstructive patterns were found in 23% of miners and 3% had significant lung function impairment. The data set was too small to determine associations between work place exposure and lung function impairment.

Training and Monitoring. Based on interviews, workers who were exposed to regulated hazards (chemical, noise, and electrical hazards) or utilized mandated safety procedures (lockout/tagout procedures, use of respirator) have not received the safety training required by Mexican regulations. Figure 4 shows the percentage of workers reporting that they have never received health and safety training on regulated hazards and procedures.

Those who reported being trained (64%) indicated that they had received general training, primarily in five-minute safety talks.

Workers reported that hazard monitoring was either not performed at all, or was only performed at irregular intervals, and that workers are not informed of the results as required by Mexican law.[10]

Inspection

Safety hazards described in the worker interviews were confirmed by the OHS survey team during the plant walk-through.

During the site walk through, the OHS team also observed reduced visibility due to rock dust clouds created by simply walking through work areas in the Concentrator Department buildings. We observed that large piles of settled dust that had accumulated throughout the plants, including blocking stairwells and passageways (see Figure 5).

In addition, lack of adequate ventilation and engineering controls in the ESDE plant has meant that the acid mist inside the plant has literally eaten away the concrete floor and structural steel beams holding up the roof, presenting serious respiratory hazard for workers (see Figure 7).

The settled dust collected and analyzed by the OHS team contained:

- 23% quartz silica, which is a serious respiratory system hazard that can produce silicosis, lung cancer and related diseases;
- A particle size distribution with 51% of the dust in the respirable range of 10µm or less and 75% of the dust in the thoracic range of 25µm or less; and

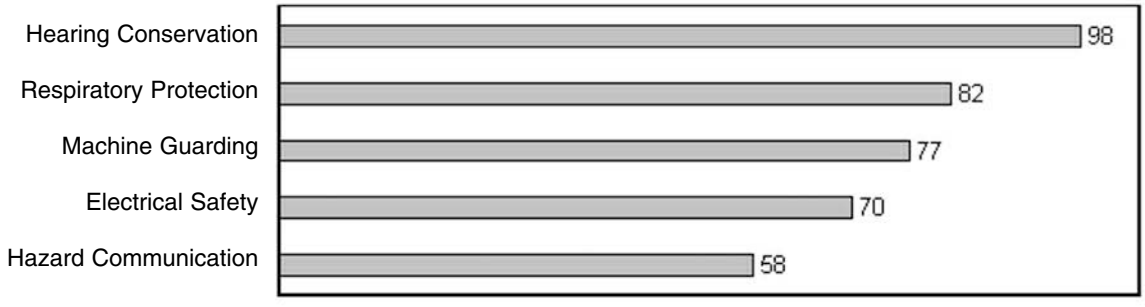

Figure 4—Percent of workers reporting no training, by topic of concern.

- High mineral content, including iron, copper, aluminum, zinc, molybdenum, cadmium, arsenic magnesium, chromium, and lead.

Visible dust indicates workers are exposed to levels of at least 10 milligrams per cubic meter of air (mg/m^3).[11] Dust levels of at least 10 mg/m^3 in the Concentrator area would mean airborne concentrations of respirable silica of at least 1.17 or 1.2 mg/m^3 (117,000 mg/Kg 0.00001 Kg/m^3). Based on our analysis of bulk dust samples, the respirable quartz silica component of this dust would be at least 1.2 mg/m^3, or 10 times greater than the Mexican Maximum Permissible Exposure Limit of 0.1 mg/m^3. [10] The 2007 American Congress of Governmental Industrial Hygienists (ACGIH) recommends a Threshold Limit Value (TLV) of 0.025 mg/m^3.

DISCUSSION

The multinational OHS team was struck at the level of disrepair and non-existent housekeeping in such a large facility operated by a major transnational corporation. Miners are exposed to a wide range of hazards that put their lives at risk on a daily basis. The team found that Grupo Mexico, in violation of existing Mexican workplace safety regulations, failed to conduct sufficient industrial hygiene survey to identify, evaluate, and control health hazards including exposure to mineral dust (including silica), acid mists, airborne solvents, high noise levels, high vibration levels, and extreme temperatures. The few workers who have been medically examined by Grupo Mexico contracted physicians have not been informed by the employer of the results of their medical tests as required by Mexican law.[10]

Workers were exposed to high concentration of silica-containing dust. Exposures to airborne silica can lead to fatal respiratory diseases including silicosis and lung cancer.[12] At the estimated concentrations, and absent engineering controls to reduce dust levels, workers in the concentrator areas must be provided with powered air-purifying respirators (PAPRs), or supplied-air respirators operated in continuous flow mode. Grupo Mexico has provided only paper filtering face piece respirators. In addition, medical evaluation, fit testing, and training have not been provided to respirator users. Instead of installing engineering controls to eliminate or reduce exposure to airborne chemical hazards, the company has provided personal protective equipment (specifically N-95 respirators) only in the ESDE plant.

Figure 5—Piles of settled rock dust blocked passageways and emergency exits in the multi-building Concentrator department.

Figure 6—Disassembled ventilation systems in the Concentrator plants created worker exposures to airborne silica inside the buildings at levels at least 10 times the Mexican regulatory limit.

Grupo Mexico has failed to train employees to recognize and understand workplace hazards; to analyze jobs and inspect work areas to identify all possible hazards; and to keep alert for these hazards while they work. Grupo Mexico has billboards about safety in various areas at the facility, but has failed to provide the specific training required by Mexican law.[10]

In 2007, health and safety inspectors from the Mexican Secretaria del Trabajo y Provisión Social (STPS) conducted a two-day inspection of the Cananea mine and processing plants and issued a report with 72 required corrective actions.[13] The corrective actions included re-assembling disconnected dust collectors in the Concentrator buildings, repairing malfunctioning brakes on a 10-ton and a 15-ton crane in the Concentrator Department, and undertaking a massive clean-up of settled silica dust throughout the facility. The OHS survey team was not able to visit all the locations cited by the STPS inspectors in April, but as of October 2007, the STPS corrective orders for visible hazards in areas visited by the OHS survey team had not been implemented.[13]

Figure 7—Lack of effective ventilation in the ESDE #2 building resulted in high levels of sulfuric acid mists which corrode structural steel beams supporting the roof.

The OHS survey team released its preliminary report in November 2007 in Mexico City.[14] Members of the team and national leaders of the Mexican Miners Union met with high-ranking officials from the STPS. The delegation urged the STPS to form a commission including representatives from the Mexican Department of Labor, Grupo Mexico, the Mexican Mine Workers union, the U.S. United Steel Workers union, the International Metalworkers Federation, and occupational health professionals from the MHSSN to visit and inspect health and safety conditions in Cananea to determine what remedial measures Grupo Mexico must undertake to provide a safe and healthful workplace for both the unionized and non-unionized workers. The following day, the STPS issued a statement declaring the OHS survey team's report was "not legally valid," as only the STPS is authorized to conduct OHS surveys in Mexico.[15]

In April 2008, STPS Secretary Javier Lozano Alarcón revealed that STPS inspectors had conducted an "extraordinary inspection" of the mine following the January 2008 release of the OHS survey team's final report. Lozano said STPS inspectors issued 200 corrective actions, but said that none of the corrective actions involved serious hazards ("nada de gravedad").[16]

A remarkable aspect of the Cananea mine project is its international character, emblematic of the efforts required to protecting workers' health and safety in the globalized economy. The employer in Cananea is a Mexican-owned transnational corporation with operations in Mexico, Peru, and the United States. The Mexican Miners Union is strongly supported by the United Steel Workers union in the United States and the International Metalworkers Federation based in Europe. The Mexican union requested, and the U.S. union funded, a multinational team of OHS professionals to conduct the health survey.

Moreover, the MHSSN is working with the Mexican and U.S. unions to file a complaint under the Labor Side Agreement of the North American Free Trade Agreement (NAFTA), charging the Mexican government with failing to implement its own workplace safety regulations in Cananea.

CONCLUSIONS AND RECOMMENDATIONS

The OHS survey team concluded that there are serious health and safety hazards at the Cananea mine operation that require immediate and long-term corrections in order to protect workers from both accidents and chronic exposures. Grupo Mexico failed to develop and apply health and safety programs to provide a safe and healthful workplace for the miners, including failure to comply with hazard communication, air monitoring, noise and vibration regulations established by Mexican Government in order to protect workers' health.

The recommendations of the OHS survey team include:

1. When the mine reopens, a massive clean-up operation will be required to eliminate the most immediate hazards to workers' health and safety, including repair of malfunctioning equipment, installation of adequate guards on moving machine parts and energized electrical circuits and panels, and a thorough housekeeping of the facilities.
2. Grupo Mexico must initiate a comprehensive health and safety remediation plan for the facility, led by the Joint Management-Labor Safety Committee (a legally required plant-level safety committee composed of an equal number of managers and union-designated workers). In Cananea, the mine's safety committee consists of three managers and three union workers. The remediation plan would establish an ongoing program to oversee the immediate repairs and clean-up, as well as implementing a long-term strategy of preventive maintenance, hazard identification and evaluation (through inspections, accident investigations and industrial hygiene monitoring), hazard correction, medical surveillance of workers, and employee training.

3. Grupo Mexico should initiate a comprehensive medical surveillance program of the current working population including chest radiography of all workers, spirometry test of the entire workforce, and a respiratory symptom evaluation including spirometry every two years to look for development of significant pulmonary symptoms which may necessitate early intervention.
4. The Mexican government must ensure, through its regulatory and consultative functions, that workers at the Cananea mine are protected against all regulated hazards, and that Grupo Mexico complies with Mexican workplace safety standards and its responsibilities under Mexican labor law.

The authors acknowledge the work of the other Cananea OHS team members: Heather Barr, RN; Octavio Castro, MD; Marian Fierro, MD; Moises Ortega, MLT-R, RPFT.

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