Study conducted by Corporación Terrae
Tv. 15b #46-16, Bogota, Colombia
terraegeoambiental.org | +57 13402462

SUMMARY ON THE INFEASIBILITY OF THE LOMA LARGA MINING PROJECT IN THE QUIMSACOCHA PÁRAMO

The Loma Larga mining project plans to extract primarily gold and copper using underground exploitation techniques in the Quimsacocha páramo over the course of 16 years. The rate of extraction is 3,000 tons per day, which amounts to more than 14 million tons over the life of the project. Part of the waste will be disposed of underground, back-filling the galleries and tunnels, but another part – 5.5 million tons of tailings – will remain exposed on the surface forever.

The area for the Loma Larga mining project is located in the highest part of the Amazon slope, almost in the watershed divide with the Pacific, and as a result, has an extremely high potential to contaminate water used for human consumption and for agriculture. The project also intersects, and would affect, areas that are key for biodiversity conservation in the region, such as the Macizo de las Cajas Biosphere Reserve and the Quimsacocha National Recreation Area, as well as the Quimsacocha páramo or 3 Lagunas, which is characterized as a high-altitude wetland and forms part of the Macizo del Cajas Biosphere Reserve.

Metallic mining is an activity which permanently impacts the land. Impacts include, among others, modification to the water cycle, contamination from the release of toxic chemicals, modification of landscapes, and risks associated with the failure of mine waste (tailings) storage.

As an ecosystem, the páramos also play a fundamental role regulating the water cycle for the region and are key water recharge zones for the Andes in a global flow of matter and energy that involves dust from the Sahara, the Atlantic Ocean, and the Amazon rainforest. The páramos accumulate and regulate this cycle and allow infiltration from the condensation of meteoric waters. Vegetation, soils, rocks, and slopes all interact to form the sources of surface water and the areas for infiltration and groundwater recharge.

The mining-páramo interaction is highly complex. Not only is the vegetation cover and soil affected, but also the subsoil – meaning the impacts are felt throughout the entire ecosystem-geosystem. The formation of tunnels and galleries affects the interaction between surface water and groundwater, both shallow and deep.

Rocks containing metals and minerals such as gold and copper also contain arsenic (a highly-concentrated metalloid in the volcanic rocks of Quimsacocha) and other heavy metals such as zinc, nickel, copper and lead, which, after a certain limit, are extremely toxic to most animals.

The extraction of volumes of rock affects the accumulation of and lowers groundwater levels, generating acidification due to the entry of oxygen (air) into the subsoil. The accumulation of rocks on the surface also allows for this acidification to take place, which in turn facilitates the leaching of heavy metals and arsenic into surface water and soils.

The physical and chemical processes that dictate the transformations in the rocks exposed to the elements and air in the tunnels and galleries are laws of nature that cannot be modified. Therefore, these environmental impacts cannot be avoided or remedied and instead, become environmental liabilities whose costs are borne by the communities. These impacts translate into permanently contaminated water, soil, and air. Mining companies only operate in the territory for a fraction of the time, at a moment when these physical and chemical processes are just beginning. But these processes tend to be perpetual and the companies will not be held accountable for the long-term consequence of their activities.

In the case of the Loma Larga project, the impacts and harm to the water cycle caused by potential mining operations have not been properly assessed, nor have the risks been considered to the lives of people living downstream from the tailings deposit.

TERRAE has focused its analysis on these issues; the absence of arguments surrounding the irreversible effects on soils as agro-ecological elements, or on the vegetation, fauna, or air, is due to this geo-environmental focus. Our assessment is based on the Environmental Impact Study (EIS) but has not included the annexes, given the restrictions on accessing information from environmental records – restrictions which severely limit the knowledge of interested parties and is something that should be reviewed in a country obliged to comply with the UN provisions regarding the fundamental right to a healthy environment.

The uncertainties tied the mining project and its Environmental Impact Study are so significant that the project should not be allowed to go forward, given that it has the potential to collapse the water supply for human and ecosystem consumption. These uncertainties are related to the deficiencies in the deficiencies in rainfall studies, the limited understanding (or the complete lack of knowledge) of how water enters and moves in the rocks that make up the subsoil, and deficiencies in understanding the complex relationship between surface water and groundwater. The mining company has not evaluated where the groundwater recharge takes place or how it feeds streams and rivers.

Nor has the mining company understood that its activity can surface rocks with high arsenic content, concentrate the arsenic, release it through acidification, and contaminate the streams, rivers, air, and soil. The company knows that absent mining activities, arsenic is already present in certain quantities in the water. But the company has not forecasted that its activity will exacerbate this situation, resulting in a possible scenario in which the water could no longer be fit for human consumption.

The mining company has not studied the risks posed by its 5.5-million-ton tailings deposit. They have not studied in a responsible manner the earthquakes nor the rainfall that could destabilize the deposit they intend to leave in the territory forever. They have not studied the response this toxic sand could have to an earthquake, nor is there a model for how far these tailings would reach – with what speed or depth of flow – if there was a breach. Breaches in tailings facilities have caused the death of thousands of people when they have failed and the tragedies in Brazil, Chile, and Canada cannot be forgotten.

This project is located upstream from the city of Cuenca. Many of the people from the canton of Azuay also access their water here and could be affected, not only by water contamination but also by an avalanche of toxic mud should the tailings system fail. Mining activities should not be prioritized if they endanger the drinking water supply for tens of thousands of people and put their lives at risk.

There also exists the results of a popular referendum in which the majority of residents of the municipalities of Cuenca and Girón expressed their opposition to mining in the Quimsacocha páramo. There is also legal jurisprudence from Colombia's highest courts that point to the unsuitability of mining in the páramos – particularly metallic mining – and highlight the urgency of prohibiting these activities within these strategic ecosystems.

Even though the mining contract was signed prior to the consultations, it is important to highlight that many of the mining activities that will take place will affect all future generations, due to their permanent and irreversible nature (impacts in perpetuity), among them:

i) The permanent disposal of tailings in the upper part of the basin pose a perpetual risk that the tailings could collapse and subsequently flow downstream to an undetermined location – "undetermined" due to the absence of risk and vulnerability studies. Similarly, there will forever exist the possibility that pollutants could leach into the water as the tailings undergo geochemical changes.

ii) The mining company minimizes the impact on groundwater, basing its analysis on an apparent disconnection between the páramo waters and the groundwater that flows through the rock formations. However, due to the intense fracturing of these formations, the interconnection of water and its recharge in the páramo is obvious. Later in this report, we will see in more detail that the mining company's environmental studies do not address key issues such as the location and spatial and temporal dynamics of water recharge, nor do they show a minimal understanding of the tectonic stresses and fractures in the rocks. The company's assessment is entirely lacking in an analysis on the impacts that preventing this water recharge would have, or the impacts of disposing toxic materials such as tailings in water recharge zones. In some instances, an evaluation is non-existent (or contains significant deficiencies) regarding the impacts of mining activities on the entire water cycle.

HOW MINING AFFECTS THE WATER CYCLE IN THE PÁRAMO

Groundwater and surface water make up a single hydrological system. Mining activity has a high potential to modify the relationship between groundwater and surface water by extracting significant volumes of subsoil and extracting groundwater to flood galleries and tunnels.

This is highly relevant given that throughout the Environmental Impact Study for the Loma Larga project, the company insists on a total disconnection between the páramo and the groundwater, suggesting that the impacts of excavation will be restricted to a certain depth without affecting a vital ecosystem such as the páramo.

What is evident in TERRAE's independent assessment is that there is no evidence to support this assumed disconnection and, on the contrary, the hydrological, tectonic, hydrogeological, and geochemical evidence all point to the fact that the connection between the páramo and groundwater does effectively exist.

This is of great significance because mining could affect the flow of the streams that originate in the páramo by lowering groundwater levels. It is necessary to highlight that the EIS is contradictory in its statements: it asserts that there is a total disconnection between groundwater and surface water, but also recognizes the possibility of affecting the flow of the Quinuahuaycu stream (Irquis River) as a result of excavation (which will be done at depths generally deeper than 150 meters below the surface) and the consequent lowering of the water table. However, TERRAE's independent analysis suggests that the company may be largely underestimating the impacts due to a lack of rigor in characterizing the hydraulic properties of the rocks that make up the subsoil (how fractured the rocks are, what the fracture network is like, how the fracture network was formed, and how easily water moves through them), the regional geochemical characterization of the springs, and errors in the hydrological modeling, where the flow rates used are systematically lower than the measured flow rates.

In addition to the uncertainties regarding potential impacts to the water availability for the communities of Azuay, scenarios for possible contamination from exploitation activities also go unexplored. Due to the volcanic origin of the Quimsacocha páramo, arsenic is a naturally-occurring substance of special interest with a high potential to be released from mining activities. While the company's environmental studies argue there is a total disconnection between groundwater and surface water – basing their argument on inadequate evidence to support that groundwater moves very slowly (hardly moving at all, according to the studies) – the mobility of the arsenic in the subsoil would be very slow, given the low velocity of the groundwater (which is still a very serious situation).

If we consider that groundwater has a significant degree of connection with surface water (for example, it contributes a significant volume of water to the streams) and that the speed of movement of groundwater is greater (some of TERRAE's calculations give results of velocities 10,000 times greater than those reported by the mining company) these types of toxins immediately become present in the environment, with the potential to affect communities within a very short time frame. This is true even without considering the risks of contamination associated with the storage of tailings.

HOW THE MINING COMPANY CONDUCTED THE GROUNDWATER STUDIES FOR ITS ENVIRONMENTAL IMPACT STUDY

The methodology used by the company can be considered limited, and its errors may mislead environmental authorities tasked with making legal decisions.

Not only are the inconsistencies identified in the study considered technical errors, but also seem to be motivated by a desire to underestimate the real impacts of the Loma Larga mining project. This is why in countries such as Colombia, governmental agencies are proposing that environmental impact studies should not be prepared by consultants directly contracted by mining companies.

This is exemplified by the biased assertions that the numerical groundwater model "*calculated*" or "*produced*" results showing the percentage of rainfall that recharges the soil is 1% – a central argument in the alleged harmlessness of the mining project on the water cycle. This value was assigned by a professional modeler hired by the mining company and, as demonstrated by TERRAE's independent assessment, does not constitute an objective value nor a model output.

Similarly, the company's study makes an unsupported assessment that the rocks beneath the páramo's soil are of low permeability:

> *"The páramo system is hydraulically disconnected from the deeper groundwater system (underlying rock) because of the underlying rock's low permeability."*

The volcanic rocks present in the Quimsacocha territory can only have a low permeability if they are not very fractured and if there is no cross-cuttings in the fracture systems. These inconsistencies and contradictions in the company's assessment regarding the water flow along the fractures is revealing, given the study includes in its geotechnical sections the following considerations:

> *"Interpretations of the structural data show that the Loma Larga rock mass contains a significant number of subvertical faults with various orientations. Iron-colored staining, visible on the surfaces of recovered core fragments, indicates the presence of groundwater. This suggests that the faults at Loma Larga are likely conductive and may serve as conduits for groundwater to enter the mine's underground galleries."*

On the one hand, the study says that the rocks are of low permeability, but on the other hand, it says the rocks are fractured and the geological faults are "likely conductive." At minimum, these contradictions reveal major uncertainties that should render the project infeasible, given that it could irreversibly affect the water cycle.

Similarly, there are totally subjective and unsupported assessments such as the following:

> *"Because the amount of water in this deep underlying rock exists primarily in fractures and crevices and is small, it does not meet the definition of an aquifer and is not a major source of groundwater supply to rivers and streams."*

It is not technically sound for a professional to give an opinion on what is small without providing verifiable and comparable figures, and it is unacceptable for him or her to define – based solely on opinion – what is or is not important when it involves a vital element in the preservation of life and the possibility for people to continue to inhabit a territory.

The omissions are also very serious, as they ignore fundamental aspects the Environmental Impact Study should take into account. The chosen area of influence is entirely subjective and the company makes a very biased spatial characterization of the area – concentrating the measurement points for hydrogeological data to an area corresponding to 1% of the total modeling area, which is clearly an insufficient, non-technical, and reckless approach. There is also a total absence of fracturing data (direction, inclination, openings, stress tensor and conductivity, among others) and of data related to hydrogeochemistry, a survey of springs, among others.

Likewise, the levity with which matters related to arsenic contamination are approached poses a risk to the region's inhabitants and their health should mining go ahead – underscored by an absence of any modeling that explores scenarios for the leaching of heavy metals that exist in the rocks and soil and that can be easily released by mining activities, such as arsenic, lead, and copper. (The company has not evaluated the existence of other toxic heavy metals such as cadmium). There is already a precarious balance in the area with regards to the release of arsenic and certain aforementioned heavy metals; burdening it with the waste of millions of tons of rocks and tailings with the potential to further release these metals, could throw off this balance in water quality and cause unquantifiable social impacts. The levity with which the mining company treats these major impacts should render this project unviable.

DEFICIENCIES AND ABSENCES OF RAINFALL AND SURFACE WATER STUDIES

Hydrological systems are so sufficiently complex that in each case, the person analyzing the system will establish a biased perception of how it functions. The hypotheses proposed in the EIS demonstrate a lack of understanding of the hydrological relationship between the surface and subsurface systems; for the inhabitants of the Quimsacocha páramo and those who live in the surrounding areas, however, it is both a spatial and temporal fact that surface water and groundwater are physically connected, and understanding these connections provide great opportunities for their management and conservation.

On the one hand, the amount of rainfall calculated and used by the company for its hydrological modeling, infrastructure calculations and tailings design, as well as for its hydrogeological modeling, is lower than the amount of rainfall measured. This leads to errors and assumptions that minimize impacts and lead to improper management. On the other hand, the relationships between groundwater and surface water in these watersheds cannot be ignored, since groundwater represents a water source that is equally important to any watershed as surface water. Ignoring these relationships could jeopardize both the quality and quantity of water reserves in the Quimsacocha páramo region.

The study omits the importance of the areas previously defined by ETAPA as recharge zones, dismissing their importance to the water supply for the region. There is not even a plan to determine possible impacts on ground cover and drainage patterns in these basins, which would potentially affect the flow and regulation of water sources downstream from mining operations.

DEFICIENCIES IN THE STUDY OF HOW MINING MAY AFFECT WATER QUALITY

It has already been mentioned that mining makes possible the extraction, concentration, and release of toxic elements that are extracted and released as tailings on the surface, and that in the subsoil (absent oxygen), exist in a geochemical equilibrium.

To that effect, it is of particular relevance that the Loma Larga mining project – or any project that intends to extract rocks from the subsoil in the Quimsacocha páramo – could increase the amount of arsenic, which is already present in detectable concentrations in both the water and soil around the area to be mined. Unwarranted and reactionary approaches to the precautionary principle may exist, which argue that since arsenic is already present, mining would therefore not generate problems distinct from those that already exist naturally. However, mining has the potential to extract and expose very high quantities of these toxins into the environment and to generate the conditions for their release (acid drainage). This type of activity should not be allowed in an area where the naturally-occurring chemical elements are already present in the water in concentrations close to allowable limits for human use, either for direct consumption or for agricultural and livestock use.

Although the Environmental Impact Study acknowledges that in Loma Larga, there is already the presence of arsenic, copper, and lead, there is insufficient analysis to rule out the presence of other heavy metals such as mercury, cadmium, selenium, molybdenum, bismuth, and tellurium, among others that are also recognized as hazardous to human and ecosystem health.

Omission of key information and technical knowledge throughout the EIS underscore that for the company, the presence of arsenic is not an issue of concern, as the study does not explore the subject in depth nor does it explain why arsenic and other heavy metals are present in the environment – let alone how to control them, if that were possible.

This is made apparent by the failure of the EIS to comply with the required monitoring time in studying surface water quality, or through the company's justification for not evaluating the content of arsenic and other toxic elements in the active sediments of bodies of water within the project area. We can only conclude that the mining company does not really know the current conditions of the area they intend to operate in, with respect to water quality and toxic elements present in the environment which may be released through their activity.

This lack of knowledge is also reflected in the EIS' assessment of possible impacts, as there is no specific evaluation on the behaviour of toxic elements such as arsenic and other heavy metals, which have been identified globally as being present in areas where metallic mining takes place. It is well-understood that the release of these elements cannot be evaluated using the same criteria as any other pollutant, given their chemical characteristics and the risk they pose to human and ecosystem health.

Although Ecuadorian regulations do not explicitly require studies to include this type of evaluation, it is the responsibility of experienced mining companies to take into account basic and widely-known concerns in their environmental studies, such as the presence and possible release of arsenic and heavy metals through mine drainage.

Given the severity of a situation should contamination occur – restricting access to water fit for human consumption with possible public health impacts – it is in no way responsible for the EIS to recommend that:

> *"(...) in the future, more detailed studies to explain the presence of high concentrations of these elements (As, Cu and Pb) (...)"*

This type of recommendation by the mining company reveals, on the one hand, there is not enough consideration for the serious risks posed by this project, such as possible water contamination by mining activities. On the other hand, it shows that for the mining company and its consultants, public health is not upheld as a primary concern in the environmental study which seeks to make mining possible in a páramo that supplies water to tens of thousands of people.

DEFICIENCIES AND SHORTCOMINGS IN ADDRESSING RISK ASSOCIATED WITH THE MINING PROJECT, PARTICULARLY REGARDING THE STORAGE OF TAILINGS

The project is located in areas where there is evidence of ground instability (large movements of land mass). The tailings facility is located (at least partially) in a medium-to-high hazard zone due to this movement; however, the mining company's studies do not include a registry of these movements to calibrate the regional instability models presented. If a tailings deposit shifts due to issues with ground support, the changing pore pressure may cause the structure to collapse.

Particularly relevant are the deficiencies in the study of the waste generated from the extraction of minerals, called tailings. Tailings are the byproducts that remain following the crushing and grinding of metal-containing rocks to extract those metals and minerals (such as gold and copper). The byproduct is a grit – grains the size of very fine sand and coarse silt – that can be disposed of in a deposit with varying amounts of water. In the case of Loma Larga, a type of "filtered tailings" is being proposed (sometimes the adjective "dry" is used in a biased way in the environmental study), where the percentage of water varies between 15 and 20%.

Since the project is designed for underground extraction (tunnels and galleries), it is critical to correctly characterize the rocks in terms of their (in)stability. As previously mentioned, the fractures were not characterized in terms of their importance as a repository and pathway for groundwater, nor were they characterized in terms of their resistance and stability.

There is no mechanical characterization of the materials (natural soils or tailings), leaving the geotechnical analysis to the judgment of the expert. Rainfall and/or seismic activities were not included in the modeling for what could occur to the tunnels, galleries, open pit cuts or the tailings facility. As such, environmental or mining authorities cannot fully establish whether the mining project has been designed in a responsible manner.

Parameters have not been set for the geological material, meaning they have not been assigned resistance characteristics based on field and laboratory measurements that would establish their geotechnical stability. This applies to underground excavations and tailings. The host materials have not been studied. A cartography analysis (unit mapping) has not been presented in the EIS, nor the fracture characterization of the rocks and their relationship with the characteristics of rock formations.

THE TAILINGS FACILITY AND A LACK OF KNOWLEDGE ABOUT ITS BEHAVIOUR AND DANGERS

Filtered tailings have been promoted by mining companies as alternatives to the disposal of tailings with high water content (slurries), and generally in saturated conditions. When filtered tailings are deposited, the water content ranges from 15 to 20%.

Golder Ltd., the largest mining consulting company in the world, has said this type of tailings has limitations when rainfall in the area exceeds 50 mm per month. In the case of Loma Larga, data from 7 hydrometeorological stations presented in the Environmental Impact Study exceed the critical amounts in all months (with the exception of station PMLL001 where in July, August and September it rains between 36 and 42.7 mm and station PMLL09 where it rains 46 mm in August and 45 mm in September).

Golder also emphasizes the inadvisability of locating this type of tailings in areas with moderate to high seismic activity. The Environmental Study's analysis of these issues are inadequate, despite recent records of earthquakes in the area with magnitudes greater than 6.0. In this context, stability analysis should include near-source effects that would affect the mine's infrastructure. However, earthquakes recorded prior to 2012 and historical earthquakes are not included in the study.

There are also deficiencies in the drainage design for these tailings facilities, with no apparent design included for the sub-drainage networks. The channels are designed for return periods of 100 years, which is not sufficient to ensure stability, especially in areas of high precipitation like the area in question.

It is important to note that the worst case scenario is a collapse of the tailings deposit, with the materials flowing downstream at a high velocity. Such a scenario must be modeled as this waste will remain in the territory forever.

The absence of an analysis for a tailings deposit failure means the possible trajectory of the material was not evaluated, nor the area affected or the elements which would be exposed and, therefore, the possible impacts on the environment and the community. Additionally, this means there is no clear roadmap if an emergency should occur as a result of this risk scenario. Even if one considers that classifying the risk of a tailings failure as 'irrelevant' is based on eventual good engineering practices, taking this approach in this case is irresponsible given the risk – although it could be considered reduced – does exist and extreme scenarios should be evaluated when building such a dangerous structure in the territory.

The irresponsibility of the mining company is even greater when considering climate change, given that according to the Intergovernmental Panel on Climate Change (IPCC)'s report, "The frequency of extreme events related to temperature and precipitation will change with warming (...) and extreme precipitation will become more frequent in most places (very likely)."

Relatedly, it is important to note that there was no analysis of the geotechnical stability of the tunnels, the galleries, nor the tailings facility to guarantee the project's safety. Numerical criteria exists that allow us to estimate whether the approaches taken are safe or not. They can be safety factors or the probability of a failure derived from modeling geologic and anthropic materials, using parameters based on laboratory and field data and modeled using normal or critical (rainfall and/or earthquakes) scenarios. All of this is missing in the studies presented by the mining company.

There is no maintenance and monitoring plan for the project, with no clarity on the implementation of a contingency plan. The parameters to be measured are not established, nor is there location or frequency. This lack of foresight is likely to turn any incident into a disaster, given the absence of a clear definition of the threats to both the land and the mining project.

CONCLUSIONS AND RECOMMENDATIONS

The main conclusion is that a mining project located in a páramo that is fundamental to providing fresh water for tens of thousands of people is not viable. Mining exposes large quantities of rock extracted from the subsoil and disposes of it on the surface (waste dumps and tailings) at such a rapid rate that it generates environmental disturbance and contamination. There are unacceptable uncertainties regarding the knowledge of the water cycle in the area and the likelihood that mining activities can contaminate a geosystem that involves rocks which contain arsenic and heavy metals.

The páramos are ecosystems recognized as fundamental to the water cycle. In Quimsacocha, they serve a double function as an area of accumulation and as an aquifer recharge zone. Given that this last aspect is of constitutional importance in Ecuador, it should not be possible that studies resting on assumptions about the disconnection between surface and groundwater – without any supporting data – could put in jeopardy the water supply for ecosystems such as high Andean forests and for tens of thousands of people. This damage would be perpetual.

Tailings are waste from metallic mining that contaminate water and soil and become time bombs located upstream of human settlements in the region. The Ecuadorian authorities should take a preventative approach and prohibit the open disposal of tailings.

For the aforementioned reasons and others related to the ecosystemic impact and the change in land use, as well as the symbolic and spiritual effects on a territory where mining is not compatible with its uses and traditions, the environmental licence for the project should be denied.

**Original report written in Spanish. Unofficial English translation by MiningWatch Canada.*

REPORT AUTHORS

Julio Fierro Morales. Geologist. MSc Geotechnical Engineering
Eduardo Quintero Chavarría. Civil Engineer. MSc. Geophysics
Carlos Román Reina Leal. Ing. Civil MI - Geotechnical Engineering
Erika Cuida López. Geologist MSc (a) Tropical Hydrogeology
Lorena Barreto Gutiérrez. Civil Engineer, Specialized Hydraulics and MSc (a) Ecohydrology
Luisa Alvarado Reyes. Civil Engineer, Specialized in Water Management and MSc (a) Ecohydrology
Miguel Cáceres Gaitán. Geologist
Jeremy León Linares. Geographer (a)